AN

ELEMENTARY, PRACTICAL AND THEORETICAL

TREATISE ON NAVIGATION:

WITH A

NEW AND EASY PLAN

FOR FINDING

DIFF. LAT., DEP., COURSE, AND DISTANCE BY PROJECTION.

BY M. F. MAURY,

LIEUT., U. S. NAVY.

SECOND EDITION, REVISED AND CORRECTED.

PHILADELPHIA:

EDWARD C. BIDDLE, NO. 6 SOUTH FIFTH STREET.

1843.

NOTICES

OF FIRST EDITION OF

MAURY'S NAVIGATION.

"*U. S. N. S., New York, January* 19, 1836.

"Dear Sir,—I have had much pleasure in the perusal of your "New Theoretical and Practical Treatise on Navigation;" the plan and arrangements of which are original; it contains little or nothing superfluous, and every part of it appears to be as clear and intelligible as the nature of the subject will admit. Such a work has long been wanted in our Naval Schools, and on board our vessels of war. I intend to make use of it in the Naval School on this station; and I recommend it to be used by all the professors of Mathematics, and Nautical Science in the Navy of the United States.

Yours respectfully, EDW. C. WARD.
Prof. Math. U. S. Navy."

"Passed Midshipman M. F. Maury.
U. S. Navy."

"*U. S. Navy Yard, Gosport, March* 7, 1836.

"I have examined a Treatise on Navigation written by M. F. Maury of the U. S. Navy; and have no hesitation in recommending it to the students of that science. The explanations are clear, the rules are illustrated by many examples, and the new arrangement of some of the tables exemplify the calculations of the navigator. Mr. Maury is deserving of great credit for the work, and I wish him every success.

P. J. RODRIGUEZ.

"*Navy Department, April* 9, 1836.

"Sir,—I have to request that you will add the "New Theoretical and Practical Treatise on Navigation," by M. F. Maury, Passed Midshipman, to the list of books furnished vessels of the navy going to sea.

I am respectfully yours.

(Signed,) M. DICKERSON."

"COM. JOHN RODGERS,
President of the Board of Navy Commissioners."

PREFACE.

The object of the present volume, is to place in the hands of students, and especially of the Midshipmen of the United States Navy, a Text Book, in which the theory as well as the practice of Navigation, is explained and taught.

It is not pretended that new theories are set forth, or that new principles are established in this work; but it is believed that those which have already been established, are here embodied in such a form, that the means of becoming a theoretical as well as a practical navigator, are placed within the reach of every student.

For this purpose the works of Bonnycastle, Colburn, Hutton, Legendre, Davies, Bowditch, Lardner, Hassler, Kelly, Keith, and La Place, have been consulted.

Care has been taken to introduce only those theorems upon which the problems in Navigation immediately depend, and which it is necessary to understand, in order, satisfactorily to comprehend the principles of Mathematics and Astronomy, involved in the solution of these problems.

The fear of introducing more than is essentially requisite for this purpose, may have led to an error on the other extreme, by causing something to be omitted, which should have been inserted; but if such a fault be detected in the work, while it will be readily admitted on one hand to be a fault, it can scarcely be unjust on the other, to say that the error is on the safe side; especially when they who judge, are reminded, that there is not throughout the whole work, a single principle laid down which does not serve at once as a rule, or as the basis of a rule, or as reference in some succeeding demonstration, position, or explanation either to prove, establish, or elucidate; and moreover, that there are many, (perhaps the greater number,) of those for whose benefit the work is chiefly designed, who, during the whole period of their service at sea, never have the advantage of instruction from a teacher of Navigation; consequently they have to depend upon their own exertions, and the books before them, for their proficiency as Navigators. How necessary is it then, that the work on Navigation for them, should be an elementary one, adapted to the capacity of all, and that it should not embrace the widest range; more particularly so, as there is not yet any regular system of education provided for the Navy.

The idea of such a work as the present, grew out of the author's own experience, and was suggested to him by his own wants while a student of Navigation; if it be not sufficient for the supply of similar wants on the part of others, it is hoped that it will, at least, serve to provoke some more capable pen to undertake and complete what is here attempted.

A more elementary work than any hitherto published on Navigation is much required as a school book in the United States. The attention of teachers of Navigation throughout the country is respectfully invited to it.

These pages were written chiefly on board of a man-of-war, in the midst of the various calls of duty, and the thousand interruptions incident to such a place; the author trusts that this circumstance will ensure him on the part of his brother officers, and those into whose hands his work may fall, the indulgence usually claimed for inexperienced authors.

CONTENTS.

ALGEBRA.

ALGEBRA.

§ I. ALGEBRA is a method of computation, in which magnitudes, or quantities, are represented by means of the letters of the alphabet. These letters have no positive or fixed value; they only stand for the quantities to be computed.

§ II. In algebra, known quantities are expressed either according to their numerical value, or by the first letters a, b, c, etc., of the alphabet.

§ III. And quantities of unknown value are usually represented by the last letters, x, y, z, etc.

§ IV. In algebraical computations, certain characters, called *signs*, have been introduced, and are used in the place of written words: thus,

$+$ (*plus*) is the sign of addition.
$-$ (*minus*) is the sign for subtraction.
$\times$ or . is the sign for multiplication.
$=$ is the sign of equality.
$\div$ is the sign for division.

$a + b - c \times d = x \div y$, or $\frac{x}{y}$, is read a plus b minus c multiplied by d equals x divided by y.

§ V. $a > b$ signifies that the former quantity (a) is greater than the latter (b).

$a < b$ signifies that the latter quantity (b) is greater than the former (a).

§ VI. (:) *is to* (: :) *as*, represents equality of ratio, and denotes proportion: thus $a : b :: c : d$, (read a is to b as c is to d), signifies that the ratio of a to b is equal to the ratio of c to d, and that these four quantities are proportional.

§ VII. $\backsim$ represents the difference between any two unknown quantities between which it is placed; thus, $x \backsim y$ denotes the difference between x and y.

§ VIII. ∞ signifies that the quantity standing before it, thus, $x\,\infty$, is infinite in value.

§ IX. The numbers 2, 3, 4, etc., placed after a letter, thus, a^2, a^3, a^4, denotes the 2d, 3d, 4th, etc., power of the quantity which that letter represents. The second power is the *square*, the 3d the *cube*, the 4th the *biquadrate:*

$$a \times a = a^2,$$
$$a^2 \times a = a^3,$$
$$a^3 \times a = a^4.$$

§ X. The numbers 2, 3, 4, etc., placed as above, are called the *indices* of the quantities to which they are affixed.

§ XI. The quantity which is a constant multiplier in the involu tion of a power, is called the root of that power: thus, (§ IX.,) a is the cube root of a^3, and the square root of a^2.

§ XII. $\sqrt{}$ is called the *radical* sign; and $\sqrt{x}$, or $\sqrt[2]{x}$, also $x^{\frac{1}{2}}$, denotes that the square root of x is the quantity alluded to; so $\sqrt[3]{y}$, or $y^{\frac{1}{3}}$, denotes the cube root of y: and so on with the other numbers, or with letters thus placed.

The number or letter placed over the radical sign, thus, $\sqrt[4]{}$, $\sqrt[n]{}$, or placed thus, $x^{\frac{1}{4}}$, etc., is called the exponent.

§ XIII. A *surd* is a quantity to which the radical sign ($\sqrt{}$) is prefixed, and whose root cannot be expressed by numbers; thus, $\sqrt{3}$, $\sqrt[3]{5}$, are surds.

§ XIV. A *term* is any quantity that is separated from another by a sign; thus, a, b and x, are terms in the compound quantity $a + b - x$.

§ XV. The number, (5,) or the letter, (c), that is prefixed to any quantity, ($5\,a$, or $c\,a$,) is called the *coefficient* of that quantity.

§ XVI. *Like quantities* consist of the same letters as $a\,b + 4\,a\,b - 2\,a\,b$.

§ XVII. *Unlike quantities* consist of different letters, as $x + 2\,y \times a + b$.

§ XVIII. When a quantity has no sign prefixed to it, +, or *plus*, is understood.

§ XIX. $\sqrt{x^2 + y}$, or $(x^2 + y)^{\frac{1}{2}}$, denotes that these two quantities are as one, and that the square root of their *sum* is alluded to by the radical sign, or the exponent $\frac{1}{2}$. Thus, the square root of $64 + 36$, or $\sqrt{}\,64 + 36$, is $8 + 36 = 42$, but the square root of $\overline{64 + 36}$, or $(64 + 36)^{\frac{1}{2}}$, under a *vinculum*, is 10, for $64 + 36 = 100$, and the square root of 100 is 10.

§ XX. Addition is performed by collecting several quantities in a more simple form: $3\,a + 10\,a + a = 14\,a$, (read *fourteen times a*). 1 is understood to be the coefficient of every quantity that has no coefficient prefixed to it.

§ XXI. When the quantities to be cast up have unlike signs, the problem is solved, partly by addition and partly by subtraction. If the *negative* be greater than the *positive* quantities, the negative sign must be retained in the result. The sum of $6 - 10 + 9$, is 5; for 6 and 9 are here positive quantities, and make 15; and $15 - 10 = 5$: and the sum of $6 - 10 - 9$, is -13; for $-10 - 9 = -19$; and $-19 + 6$, or $6 - 19 = -13$. Every quantity, which has not a sign prefixed to it, is understood to be positive.

To add together, $4\,x - 9\,x + x + 3\,x - 5\,x$. Collecting all the positive quantities into one sum, and all the negative quantities into another, then taking the less from the greater, the remainder, (prefixing the sign of the greater,) is the answer. Thus:

$$\begin{array}{ll} 4\,x & -\ \ 9\,x \\ \ \ x & -\ \ 5\,x \\ 3\,x & \\ \hline 8\,x & -14\,x = -6\,x \end{array}$$

$$\begin{array}{rrrrr}
 & -6\,a\,y^2 & 10\,b\,a & -\;\;a\,c \\
 & 4\,a\,y^2 & 2\,b\,a & 7\,a\,c \\
 & 9\,a\,y^2 & -19\,b\,a & -9\,a\,c \\
\hline
\text{Ans.} & 7\,a\,y^2 & -\;\;7\,b\,a & -3\,a\,c
\end{array}$$

§ XXII. If all the terms be not *like* quantities, the positive and the negative of those that are like must each be added up separately; then these two sums must be subtracted, the one from the other, and the remainder thus obtained, connected by its proper sign to the *unlike* quantities, shows the answer. To add together:

$$\begin{array}{r}
4\,x + 6\,a - \;\;c^2 + 9\,y \\
-10\,x - 5\,a + \;\;c^2 - 5\,y \\
x - \;\;a + 4\,c^2 + 3\,y \\
2\,x + 2\,a \qquad\qquad\quad \\
\hline
-3\,x + 2\,a + 4\,c^2 + 7y
\end{array}$$

The positive x's are, $4\,x + x + 2\,x = 7\,x$; the negative are, $-10\,x$. The difference is, $(7\,x - 10\,x =), -3\,x$. The positive a's are, $6\,a + 2\,a = 8\,a$; the negative are, $-5\,a - a = -6\,a$. The difference is, $(8\,a - 6\,a =), 2\,a$. The positive c^2's are, $c^2 + 4\,c^2 = 5\,c^2$; the negative is, $-c^2$. The difference is, $(5\,c^2 - c^2 =), 4c^2$. The positive y's are, $9\,y + 3\,y = 12\,y$; and the negative are, $-5\,y$. The difference is, $(12\,y - 5\,y =), 7\,y$.

To add together:

$$\begin{array}{r}
\sqrt{a\,b} - a^2 + 2\,x\,y - 6\,x + 10\,a^2 - 9\,x\,y - a^2\,b + y - a \\
-\sqrt{6\,a\,b} + 3\,a^2 + \sqrt{5\,a\,b} - x + x\,y + a^2\,b - 4\,x\,y - 2\,x \\
a - c^2 + 4\,y - \sqrt{2\,a\,b} - 2\,a^2 - 3\,x\,y + 4\,x + 14\,x\,y + a^2\,b
\end{array}$$

$$\begin{array}{l}
\;\;\sqrt{a\,b} - a^2 + 2\,x\,y + 6\,x - a^2\,b + a - c^2 + 4\,y \\
-\sqrt{6\,a\,b} + 10\,a^2 - 9\,x\,y - x - 2\,a^2\,b + a + y \\
\;\;\sqrt{5\,a\,b} + 3\,a^2 + x\,y - 2\,x + a^2\,b \\
-\sqrt{2\,a\,b} - 2\,a^2 - 4\,x\,y + 4\,x \\
\qquad\qquad\qquad -3\,x\,y \\
\qquad\qquad\qquad\;\; 14\,x\,y \\
\hline
-\sqrt{4\,a\,b} + 20\,a^2 + 2\,x\,y + 2\,x - a^2\,b + 2\,a - 2\,c^2 + 10\,y
\end{array}$$

To add together:

$$\begin{array}{l}
y + a\,b + d\,x^3 - z^2\,a \\
y + c\,b + b\,x^3 - z^2\,x \\
\hline
2y + (a+c)b + (d+b)x^3 - z^2(a+x)
\end{array}$$

To add together:

$$\begin{array}{r}
a + b + \;\;c - x \\
2\,a - b - 2\,c - 2\,x \\
-a + a\,b - c - 4\,x \\
\hline
2\,a + a\,b - 2\,c - 7\,x
\end{array}$$

§ XXIII. Subtraction is the reverse of addition. The method of performing it consists in changing, or reversing, all the signs of the subtrahend, (i. e., making the positive negative, and the reverse,) and then proceeding as in addition; viz., by adding together like quantities that have like signs; and subtracting from each other like quantities that have unlike signs. The quantity or the quantities that result from this operation is the remainder.

To subtract $a - b$ from $a + b$.

$$\begin{array}{lr} & a + b \\ \text{Changing the signs of the subtrahend} & a - b \\ \hline \text{The remainder} & = 2\,b \end{array}$$

This will be readily understood by ascribing a numerical value to a and b. Let $a = 6$ and $b = 4$; now subtract $6 - 4$ from $6 + 4$; $6 - 4 = 2$, and $6 + 4 = 10$, and $10 - 2 = 8$ (or twice $4 = 2\,b$.)

To subtract $a + b$ from $a - b$.

$$\begin{array}{r} a - b \\ a + b \\ \hline -2\,b \end{array}$$

To subtract:

$$\begin{array}{r} 2\,x\,y + \,b^2\,c - 3\,a \\ x\,y - \,b^2\,c + \,a \\ \hline x\,y + 2\,b^2\,c - 4\,a \end{array}$$

To subtract:

$$\begin{array}{r} 10\,x - \,y - \,a\,c \\ -\ 3\,x - 2\,y - 4\,a\,c \\ \hline 13\,x + \,y + 3\,a\,c \end{array}$$

§ XXIV. In the multiplication of letters, the product of any two factors is obtained and expressed by prefixing, as coefficients, the several letters contained in the multiplier, to those of the multiplicand. Thus:

$$\begin{array}{rl} & x + y \\ \text{by} & a + b \\ \hline & a\,x + a\,y + b\,x + b\,y. \end{array}$$

§ XXV. Multiplication is denoted thus, $a \times b$; or thus, $a\,.\,b$; or thus, $a\,b$.

† 1. By recollecting that a times b, and b times a, are expressions for the same product, just as 4 times 9, and 9 times 4, express the same number, it will at once be understood how there is no difference in the value of the quantity, whether it be expressed $a\,b$, or $b\,a$. But when several letters are contained in the same term, as $a \times c \times b$, it is generally expressed by the letters arranged in alphabetical order; thus, $a\,b\,c$.

§ XXVI. To multiply $x + y$ by $a - b$. Ans. $a\,x + a\,y - b\,x - b\,y$.

When terms of *unlike* signs are multiplied together, their product is negative, and (—) must be prefixed to it.

§ XXVII. The product of $x + y$ by $x + y$ is $x^2 + 2\,x\,y + y^2$, or $x\,x + x\,y + x\,y + y\,y$. The former, being the shorter method of writing it, is the better. The small figures that are affixed show how many times the letter with which they are connected enters as a factor in the term.

§ XXVIII. The product of $x + y$ by $-x - y$, is $-x^2 - 2\,x\,y - y^2$.

§ XXIX. The product of $x + y$ by $x - y$, is $x^2 - y^2$; for $x\,y$ occurring twice in the product, and with unlike signs, (+ and —), cancels itself.

$$\begin{array}{ll}
\text{To multiply} & x^2 - y^2 + 3\,x\,y \\
\text{by} & \underline{x \quad + y \qquad\qquad} \\
 & x^3 - x\,y^2 + 3\,x^2\,y \\
 & \qquad x^2\,y - y^3 + 3\,x\,y^2 \\
 & \hline x^3 + 2\,x\,y^2 + 4\,x^2\,y - y^3 \\
\end{array}$$

§ XXX. Unless the quantity be under a vinculum, the index applies only to that letter with which it is in juxta-position. The term $x\,y^2$ denotes the product of x and y^2; and $x^2\,y$ denotes the product of the two factors x^2 and y. The term $(x\,y)^2$, or $\overline{x\,y}^2$, denotes the square of the product of the two factors x and y. Let $x = 4$ and $y = 3 : x^2 = 16$ and $y^2 = 9$. The value then of the first term $(x\,y^2)$ is 4×9 (= 36;) of the second, $(x^2\,y)$, it is 16×3 (= 48;) and of the third, $(\overline{x\,y^2})$, it is the squareof the product, (12), of 3 and 4, (= 144).

$$\begin{array}{ll}
\text{To multiply} & a\,x + a\,b - a^2 \\
\text{by} & \underline{a + x + b \qquad\qquad} \\
 & a^2\,x + a^2\,b - a^3 \\
 & \qquad a\,x^2 + a\,b\,x - a^2\,x \\
 & \qquad\qquad a\,b\,x + a\,b^2 - a^2\,b \\
 & \hline \qquad a\,x^2 - a^3 + 2\,a\,b\,x + a\,b^2 \\
\end{array}$$

$$\begin{array}{ll}
\text{To multiply} & -5\,a - 4\,x \\
\text{by} & \underline{\quad 2 - a - x} \\
 & -10\,a - 8\,x \\
 & \qquad 5\,a^2 + 4\,a\,x \\
 & \qquad\qquad 5\,a\,x + 4\,x^2 \\
 & \hline -10\,a + 5\,a^2 - 8\,x + 9\,a\,x + 4\,x^2 \\
\end{array}$$

§ XXXI. When the same letter enters into both factors, the product is obtained by adding the indices or exponents of the letter, as $a^3 \times a^2 = a^5$; for $3 + 2$ is 5. And $x \times x$ is x^2; 1 is the index and coefficient of every letter which has no other index or coefficient expressed.

§ XXXII. Division is the converse of multiplication.

4 times b divided by 4 gives b. So a times b divided by a gives b.

$$4\,a\,x \div 2\,x = 2\,a$$
$$4\,a\,x \div 2\,a = 2\,x$$

§ XXXIII. Division being the converse of multiplication, the product of the divisor by the quotient gives the dividend. Thus, $2\,x \times 2\,a = 4\,a\,x$.

§ XXXIV. When the dividend and divisor are powers, or are roots, of the same quantity, the index, or exponent, of the divisor, minus that of the dividend, is the quotient. Thus, $x^3 + x^6 \div x^2 = x + x^5$.

§ XXXV. When all the terms of the dividend have letters that are common to the divisor, the operation of dividing is performed by striking out from the dividend the letters of the divisor, and dividing the coefficients. Thus,

$$8\,x\,y \div 2\,y = 4\,x$$
$$12\,a\,x\,z \div 3\,a\,x = 4\,z$$
$$6\,x\,y^2\,z \div 2\,x\,y = 3\,y\,z.$$

§ XXXVI. Division is sometimes expressed without being performed, as $x + y \div a$, or $\frac{x+y}{a}$.

§ XXXVII. This last quantity is a fraction. Fractions in algebra are multiplied, divided, etc., after the same manner by which such operations are performed in common arithmetic.

§ XXXVIII. Two or more quantities, with the sign ($=$) of equality between them, constitute an equation; as $x + 10 = 14 + 6$.

§ XXXIX. All the quantities or terms that are on either side of the sign ($=$) constitute a *member* of the equation; $x+10$ is the *first*, and $14 + 6$ is the *second*, member of the equation $x + 10 = 14 + 6$. The two members, neccssarily, are always equal to each other.

§ XL. In the process of solving, or reducing, an equation, the known quantities, or terms, of the equation, are all collected and arranged with their proper signs, in one member of the equation, and the unknown quantities in the other member, as $x = 14+6-10$ The value of x in this equation, is therefore equal to 10.

§ XLI. In transposing a term from one member to another, the equality of the two members of the equation is preserved, by *changing* the *sign* of the term transposed. By transposition, *positive* terms become *negative*, and the reverse; also the sign ($\times$) of multiplication becomes ($\div$) the sign of division, and vice versâ. Thus, in the equation above $x + 10 = 20$, (or $6 + 14$:) by transposition, $x = 20 - 10$. Also, in the equation $12 \times 4 = 8 \times 6$, by transposing we have $\frac{12}{8} = \frac{6}{4}$; and the equation $a \div b = x \div y$, by transposition, becomes $a \times y = x \times b$.

To find the value of x in the equation $a + x - c = b + 14$; by transposing a and $-c$, and changing their signs, the value of x is obtained: it stands thus, $x = b + 14 - a + c$.

Ex. $a - x^2 + y = 90 + a - 40$. To find y; a being in each member, and having the same sign, cancels itself, and may therefore be stricken from the equation; for if transposed, the expression would be $a - a$, which two balance each other. The value of y is obtained then, by transposing $-x^2$, when the equation stands thus, $y = 90 - 40 + x^2$; in its most simple form, thus, $y = 50 + x^2$.

Ex. $8\,x - 10 = 80 + 2\,x$. To find x; transposing and placing the known and unknown quantities on opposite sides, the equation stands, $8\,x - 2\,x = 80 + 10$. Subtracting and adding, it becomes $6\,x = 90$; and $x = 15$, (by division).

Ex. $x \div 2 + 10 = 14 + 8$. To find x; $\frac{1}{2}x$ or $\frac{x}{2} = 14 + 8$

-10. The value of the second member of the equation is 12; therefore $\frac{x}{2} = 12$; and by multiplication, $x = 24$.

From the two last examples, this general conclusion may be drawn, viz.:

§ XLII. When a multiplier of either member is transposed, it becomes divisor to the other member; and vice versâ.

Ex. $8x^2 + ax - 10x = 14x + 4x^2 + 16x$. To find x. x is common in every term of each member of the equation. Then, dividing by x, the equation becomes $8x + a - 10 = 14 + 4x + 16$; transposing and placing all the x terms alone in one member, $8x - 4x = 14 + 16 + 10 - a$; subtracting and adding, $4x = 40 - a$; dividing, $x = 10 - \frac{a}{4}$.

Ex. $3bx - 9ab = 3y$. To find x. Transposing, $3bx = 3y + 9ab$; dividing, $x = \frac{3y + 9ab}{3b} = \frac{y}{b} + 3a$. Therefore, $x = \frac{y}{b} + 3a$.

Ex. $\frac{x}{3} + \frac{x}{2} = 10$. To find x. Clearing the equation of fractions; 1st, $x + \frac{3x}{2} = 30$; 2d, $2x + 3x = 60$; adding, $5x = 60$; dividing, $x = 12$.

§ XLIII. Thus an equation is cleared of fractions *by multiplying every term* (except the fraction itself) *by the denominator.*

Ex. 1. The commander of a man-of-war is desirous of having his ship calked, that he may proceed on his voyage. His own calkers can finish the job of calking in 10 days. But he employs a gang from the shore, that could finish the whole work in 6 days, to assist his. How many days' job are there for both gangs together?

Let x denote the job of work. Then $\frac{x}{10}$ is one day's work for the ship's calkers; $\frac{x}{6}$ is one day's work for the shore gang; and $\frac{x}{10} + \frac{x}{6} = 1$ day's work for both gangs together. Clearing this equation of fractions, $6x + 10x = 60$; and $16x = 60$, or $x = 3\frac{12}{16}$, the number of days.

Ex. 2. A vessel, after an engagement, could muster only 238 able bodied men; on examining her list of sick and wounded, she found her loss in killed to be $\frac{1}{5}$ of her whole crew, and in wounded $\frac{1}{3}$ of the whole crew. What crew had she when she went into action?

Let x denote her crew when the action commenced. Thus, $\frac{x}{5} + \frac{x}{3} + 238 = x$. Clearing the equation of fractions, $3x + 5x + 3570 = 15x$; transposing, $3570 = 7x$, or $510 = x$, the whole crew when the action commenced.

§ XLIV. When the value of more than one unknown quantity is required, the problem, if definite, comprises conditions for as many equations as there are quantities required. In such cases the unknown quantities (x, y, z, etc.) have the same value in all the equations; i. e. x in one equation is equal to x in another of the same set. When the value of x, y, or z, is found, its value is substituted in its stead.

Ex. $\left.\begin{array}{r} x + y = 44 \\ x - 3y = 36 \end{array}\right\}$ To find x and y; $x = 44 - y$, and $x = 36 + 3y$; thus $44 - y = 36 + 3y$; transposing, $4y = 8$, or $y = 2$; and substituting, $x = 44 - y$, or $x = 42$.

Ex. $\left.\begin{array}{r} x + y + z = 60 \\ x + 4y + 3z = 144 \\ 2x + y + 8z = 132 \end{array}\right\}$ To find x, y, and z; $x = 60 - y - z$; $x = 144 - 4y - 3z$; and $x = 66 - \frac{y}{2} - 4z$. Eliminating x; $60 - y - z = 144 - 4y - 3z$; and $144 - 4y - 3z = 66 - \frac{y}{2} - 4z$. Transposing, to find the value of y; $3y = 144 - 60 - 2z$, or $y = 28 - \frac{2z}{3}$; again, $7y = 288 - 132 - 8z + 6z$, or $y = \frac{156 - 2z}{7}$; eliminating y, $28 - \frac{2z}{3} = \frac{156 - 2z}{7}$; clearing the equation, $14z - 588 = 468 - 6z$; transposing, $20z = 120$ or $z = 6$.

For z, in the equation $y = 28 - \frac{2z}{3}$, substituting its value (6), $y = 28 - \frac{12}{3}$, or $y = 24$. And for z and y, in the equation $x = 60 - y - z$, substituting their values (24 and 6), $x = 60 - 24 - 6$, or $x = 30$.

§ XLV. There is another manner of expressing certain equations which do not involve more than 4 terms, and when thus expressed the terms are said to be *proportional*. Thus the proportion $3 : 4 :: 6 : 8$, is but another method of expressing the equation $3 \div 4 = 6 \div 8$, or $\frac{3}{4} = \frac{6}{8}$. The dots (:) being an abbreviation of the sign ($\div$) of division; and the dots (: :) being another form for expressing the sign (=) of equality, to show that the *ratio* between the quantities on each side of it is the same.

§ XLVI. Whence it may be inferred as a general rule, that, *if the quotient of two quantities be equal to the quotient of two others*, these four quantities are proportional. And,

† 1. That the ratio between either divisor and its dividend, is equal to the ratio between the other divisor and its dividend.

§ XLVII. By this rule we have $4 : 3 :: 8 : 6$, for $\frac{4}{3} = \frac{8}{6}$. This form of expression for the proportion $(3 : 4 :: 6 : 8)$ first quoted, is called "*invertendo*," (from inverting the divisor and dividends,) thus $3 \div 4 = 6 \div 8$, and *inversely* $4 \div 3 = 8 \div 6$.

§ XLVIII. By the same rule we also have $3 : 6 :: 4 : 8$. This form of expression for the proportion $(3 : 4 :: 6 : 8)$ is called "*alternando*," for by taking the terms *alternately* we have $3 \div 6 = 4 \div 8$.

§ XLIX. Whence also another general rule in proportions: that, if four quantities be proportional, they are also proportional when taken *inversely*, or when taken *alternately*.

§ L. $3 \div 4 = 6 \div 8$, by transposition $3 \times 8 = 6 \times 4$; wherefore, also, if the product of two factors be equal to the product of two other factors, those four factors are proportional, as $3 : 6 :: 4 : 8$.

GEOMETRY.

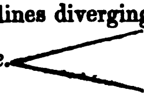
PART I.

GEOMETRY.

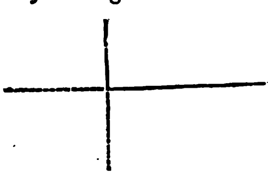
DEFINITIONS.

§ 1. *A point* is an atom of space.*
§ 2. *A line* (———) is length without breadth.
§ *a*. The track of a moving point would be a line.
§ *b*. The extremities of every line are points.
§ *c*. A line may be of any length.
§ *d*. Lines are either straight or curved.
§ 3. *A straight* or *right line* (———) is the shortest line that can be drawn from one point to another.

§ *a*. If two lines meet each other they form an angle. 

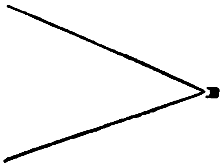
§ 4. *A plane* is an extent, (as the surface of this page), on which the straight line will lie that joins any two points which are in that extent.
§ *a*. A plane is without thickness, and it may be of any length and breadth.
§ *b*. The limits of every plane are lines.
§ *c*. If two planes cross each other, the line of their intersection is a straight line.
§ 5. Two lines diverging from, or meeting in, the same point, form an *angle*. 

§ *a*. The point in which the lines join or cross each other, is called the *angular point*.
§ *b*. Angles are either right, acute, or obtuse.



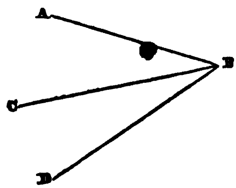
§ 6. When one straight line stands upon another, without inclining to either side, the angle, or angles, which these two lines form, are called *right* angles.
§ *a*. All right angles are equal, and every one contains 90° (*degrees*). (Vide § 49, § *d*.)

* According to the *atomic* theory of matter, all bodies are composed of indivisable and impenetrable particles, called atoms; an atom then is to matter what a point is to space; hence the idea of an atom of space.

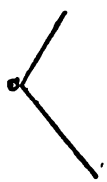


§ *b.* Straight lines that form right angles with each other, are said to be *perpendicular* the one to the other; and those that are perpendicular are at right angles with each other.

§ 7. Every angle which is *less* than a right angle, is an *acute* angle.



§ *a.* Angles are generally particularized by means of letters; as the angle B. But when there are more angles than one at the same angular point, the angle to be particularized is made known by placing the letter at the angular point *between* the letters which stand for the lines that form the angle. As the angle A B C, or C B D.

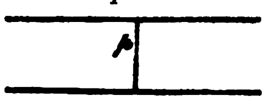


§ 8. Every angle which is *greater* than a right angle is an *obtuse angle;* as the angle C.

§ *a.* An *oblique angle* may be either acute or obtuse.

§ *b.* Two angles are equal, when they contain the same number of degrees (°), minutes (′), and seconds (″), or when the lines which form an angle have the same divergence from each other, which the lines have that form the other angle.

§ *c.* The difference between an oblique angle and a right angle is the *complement* of the oblique angle.



§ 9. *Parallel lines* are lines that have always the same distance between them. They lie in the same direction, and if lengthened, *ad infinitum*, would neither approach, or recede from, each other.

§ *a.* The distance of two parallel lines from each other is measured by any straight line (p) that may be drawn between them, perpendicularly from one to the other.

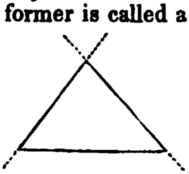
§ 10. *A figure* is any extent bounded by one or more lines, or surfaces.

§ *a.* The space included by a figure is called its *area.*

§ 11. *A superficies* is the surface of a figure.

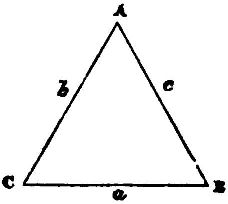
§ *a.* A superficies and a plane coincide, when a straight line, that joins any two points in the superficies, lies on that surface. The superficies of a figure is limited to the extent of the surface of that figure; but its plane is infinite.

§ *b.* When the superficies and the plane of a figure coincide, the former is called a *plane* superficies.



§ 12. *A plane triangle* is a figure that is formed by the intersection of three straight lines, any two of which intersect the other in different points.

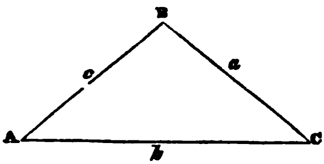
§ *a.* The intercepted parts of these lines are called the sides of the triangle.



§ *b.* Every triangle has six parts; viz., three sides, and three angles.

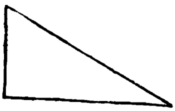
§ *c.* Triangles, with regard to their sides, are either equilateral, isosceles, or scaline; with regard to their angles, they are either acute, right, or obtuse angled.

§ 13. *An equilateral triangle* has its sides all equal to each other; viz., *b* equal to *a* or *c.*



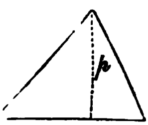
§ 14. An *isosceles triangle* has two equal sides; as, *c* and *a.*

§ *a.* An isosceles triangle may be either acute, right, or obtuse angled. Its third side (*b*) is its base.



§ 15. A scaline triangle has none of its sides equal.

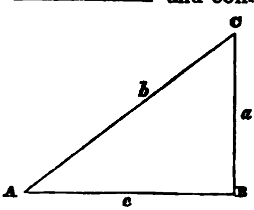
§ *a.* A scaline triangle may also be right or oblique angled.



§ 16. An *acute* angled triangle has each of its angles less than a right angle.

§ *a.* The *vertex* of a triangle is the angle that is opposite to the base of the triangle.

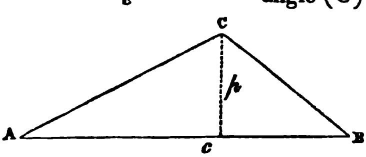
§ *b.* Any angle may be called the vertical angle, and consequently any side may be made the base.



§ 17. A *right angled triangle* has an angle (B), that is, a right angle.

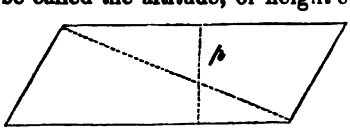
§ *a.* The side (*b*) which subtends the right angle, is called the *hypothenuse;* the two other sides (*c* and *a*) are called *legs.*

§ 18. An *obtuse angled triangle* has an angle (C) that is obtuse.



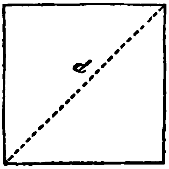
§ *a.* The *altitude* of a triangle is the perpendicular distance (*p*) of the vertical angle (C) (§ 16, § *b.*) from the base (*c*). The base must be produced to meet the perpendicular, if the perpendicular fall without the triangle.

§ *b.* As any side (§ 16, § *b.*) may be made the base of a triangle, the perpendicular distance of any angle from its opposite side may be called the altitude, or height of the triangle.



§ 19. A *parallelogram* is a right lined (§ 3.) quadrilateral figure, the opposite sides of which are equal and parallel.

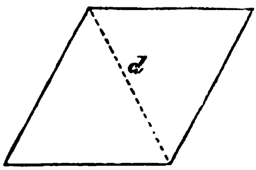
§ *a.* The *altitude* of a parallelogram is the distance (*p*) (§ 9. § *a.*) between either pair of its opposite sides. To show the altitude of a parallelogram, either of two opposite sides may be produced until it meets at right angles, a perpendicular from the other side.



§ *b*. The measure or *area* of a parallelogram, is the product of its length and breadth, or of its base and altitude.

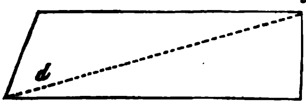
§ *c*. Any side of a parallelogram may be made its base.

§ 20. A *square* is a parallelogram of which all the sides and angles are respectively equal.



§ *a*. Every angle of a square is a right angle.

§ 21. A *rhombus* is a parallelogram that has all of its sides equal to each other; but its angles are not right angles.



§ 22. A *trapezoid* is also a four-sided figure, but only two sides of it are parallel, though they are not equal.

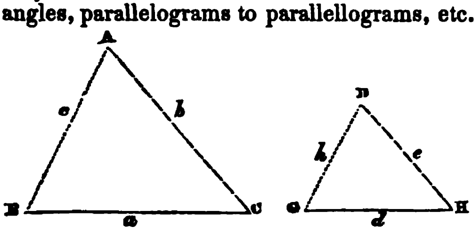
§ *a*. A diagonal is a straight line (*d*) that joins two opposite angles in a four-sided figure.

§ *b*. The space included by a parallelogram is called (§ 10. § *a*.) its area, or measure, and is expressed (§ 19. § *b*.) by the product of its base and altitude.

§ 23. Two figures are *equal* when every *part* in one is equal to the part in the other, which corresponds to it; and two equal figures are always of the same magnitude.

§ *a*. And two figures are of the same *magnitude* when their areas are equal: a triangle and a parallelogram may be of the same magnitude, but they cannot be equal. A triangle only can be equal to a triangle; a parallelogram to a parallelogram, etc.

§ *b*. Two figures are *similar* when every *angle* in one is equal to the angle which corresponds to it in another figure. Figures only of the same class are similar, viz.: triangles are similar to triangles, parallelograms to parallellograms, etc.



§ *c*. *Homologous* sides, or angles, are the sides, or angles, which, in two equal or similar triangles, correspond by their relative positions to each other; thus *c* and *h* are homologous sides, also *b* and *e*, and *a* and *d*.

§ *d*. Homologous angles are equal to each other. B and G are homologous angles; so also are A and D, and C and H.

AXIOMS.

§ 24. *Axioms* are self-evident truths, such as:

§ *a.* Things that are equal to the same, or to equal things, are themselves equal.

§ *b.* If equals be added to, or subtracted from, or substituted for, multiplied or divided by, the same or equal quantities, the sums or remainders, quotients or products, will be equal.

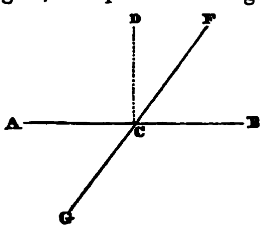
§ *c.* A part is less than the whole.

§ *d.* All of the parts are equal to the whole, and the whole to all of its parts.

PROPOSITIONS.

PROPOSITION I.

§ 25. Two straight lines which cross each other, make the two angles that are on the same side of either line, either two right angles, or equal to two right angles.

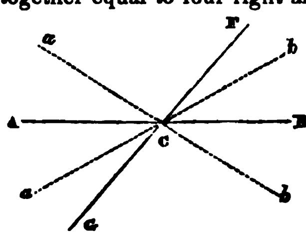


§ *a.* Let A B and F G be two straight lines that cross each other in C; the two angles (F C A, F C B) on the same side of either line (A B) are either two right angles, or are equal to two right angles.

§ *b.* If A B and F G be perpendicular to each other, they cut each other at right angles (§ 6. § *b.*); and consequently each of the angles F C A and F C B is a right angle. But if A B and F G be not perpendicular to each other, from C, the point of their intersection, draw C D, which shall be perpendicular to (A B) one of them, then will D C A and D C B, the whole angular space from C, on one side of A B, be two right angles (§ 6. § *b.*); F C A and F C B, together, also comprehend the same angular space; therefore they are equal to D C A + D C B (§ 24. § *c.*), which are two right angles. In a similar manner, it may be proven, that B C F + B C G, or G C B + G C A, or A C G + A C F, are equal to two right angles.

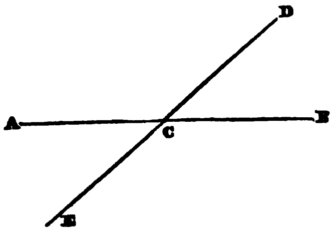
PROPOSITION II.

§ 26. All the angles, that any number of straight lines, which cross each other in the same point, make with each other, are together equal to four right angles.



§ *a.* Since the two angles (§ 25.) F C A, F C B, are equal to two right angles, and also G C B, G C A, equal to two right angles; the four angles F C A, F C B, G C A, G C B, which two straight lines make by crossing each other, are equal to four right angles. If these four angles be divided into any number of other angles, by straight lines *a b*, *a b*, crossing in the point C, the sum of the divisions thus made will be equal (§ 24. § *d.*) to four right angles.

PROPOSITION III.

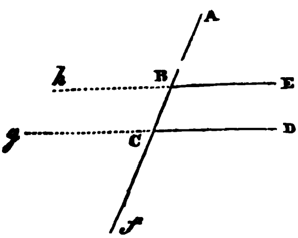


§ 27. When two straight lines A B, D E, cross each other, they make the angles D C B and A C E, or A C D and B C E, that are vertically opposite, equal to each other.

§ *a.* The angles A C D and D C B, (§ 25.) are together equal to two right angles; by the same proposition A C D + A C E, are also equal to two right angles; wherefore (§ 24. § *c.*) A C D + D C B = A C D + A C E; and A C D is a term in each member of the equation, and being taken away or cancelled, we have (§ 24. § *b.*) D C B = A C E.

§ *b.* It may be demonstrated in a similar manner, that the vertical and opposite angles A C D and B C E, are equal to each other.

PROPOSITION IV.



§ 28. When a straight line (A C) crosses two others (B E and C D) that are parallel, it makes the angles (A B E and A C D), which are on the same side of the two lines, equal to each other.

§ *a.* If the straight line A C cross the two others perpendicularly, the proposition becomes evident, for the angles formed would be (§ 6. § *b.*) right angles, and consequently equal.

§ *b.* But if they cross obliquely, it is obvious that if two lines be parallel to each other, they must have the same divergence from any straight line which crosses them; wherefore (§ 8. § *b.*) A B E = A C D; for B E and C D have the same divergence from A C.

§ *c.* In the same manner it may be shown that E B *f* is equal to D C *f*.

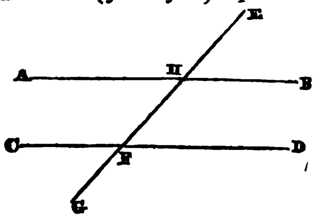
§ *d.* The angles (A B E, *h* B *f*, A C D, *g* C *f*, etc.) taken alternately on each side of A *f*, are called *alternate* angles.

§ *e.* The angles (A B *h*, A B E, *f* C *g*, and *f* C D,) on the outside of the two parallel lines are called the *external* or *exterior* angles.

§ *f.* And the others are called *internal* or *interior* angles.

PROPOSITION V.

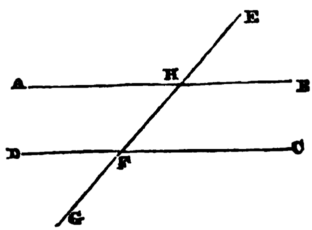
§ 29. A right line that crosses two others which are parallel, makes the interior angles (§ 28. § *f.*) (A H G and D F E) that are alternate (§ 28. § *d.*) equal to each other.



§ *a.* A H G and E H B are opposite and vertical angles, wherefore (§ 27.) they are equal to each other, and E H B (§ 28.) is equal to D F E; therefore (§ 24. § *a.*) A H G is equal to D F E.

§ *b.* In the same manner it may be proven that the alternate and interior angles B H F and C F H are equal to each other.

PROPOSITION VI.



§ 30. If a straight line cross two others that are parallel, it makes the sum of the two internal angles (B H F and H F C) that are on the same side of it, equal to two right angles; and the alternate (§ 28. § *d.*) angles (E H B, A H F, H F C, and D F G) equal to each other.

§ *a.* The angles B H E and B H F (§ 25.) are together equal to two right angles, and (§ 28.) B H E is equal to H F C, therefore (§ 24. § *b.*) the internal angles (B H F and H F C) that are on the same side of E G, are together equal to two right angles.

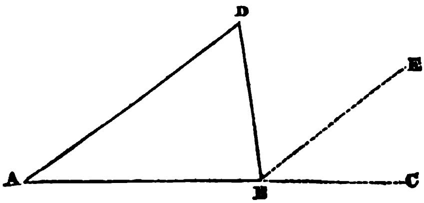
§ *b.* The alternate angle E H B = A H F, and H F C = D F G, because (§ 27.) they are vertically opposite; and (§ 29.) A H F = H F C; wherefore (§ 24. § *a.*) the alternate angles E H B, A H F, H F C, and D F G, are equal to each other.

§ *c.* After the same manner of demonstration, it may be proven, that the alternate angles A H E, B H F, H F D, and C F G, are equal to each other.

§ *d. Cor.* If a straight line (E G) cross two others (A B and D C) so as to make the sum of the internal angles (§ *a.*) (B H F and H F C) on the same side of it, equal to two right angles; or the alternate angles (§ *b.*) (E H B, A H F, H F C, and D F G,) equal to each other; or an exterior angle (§ 28.) (E H B) equal to its alternate and internal angle (H F C), these two straight lines are parallel.

PROPOSITION VII.

§ 31. The exterior angle (D B C) which is formed by producing any side (A B) of a triangle, is equal to the two interior and remote angles (A and D) of the triangle.



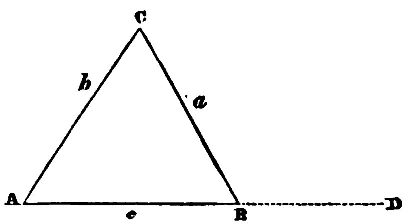
§ *a.* From B let B E be drawn parallel to A D; also let A B be produced to C.

§ *b.* Because A D and B E are parallel (§ *a.*) and A C crosses them, the angles A and E B C (§ 28.) are equal to each other; moreover D B, by crossing the same two parallels (D A and B E), makes (§ 29.) the alternate and interior angles (D and D B E) equal to each other; the exterior angle D B C is made up of D B E and E B C, then substituting the whole for its parts (§ 24. § *d.*) we have (§ 24. § *b.*) the exterior angle D B C $=$ A $+$ D, the two interior and remote angles in the triangle A D B.

§ *c.* If either of the two other sides be produced, the proposition is proven in the same way.

PROPOSITION VIII.

§ 32. The sum of the angles of a triangle is 180°, or two right angles.



§ *a.* Produce a side (*c*) of any triangle to D. Then C B A and the exterior angle C B D (§ 25.) are equal to two right angles: and the exterior angle C B D, (§ 31.) is equal to the two remote angles C and A: therefore (§ 24. § *b.*) C, A, and C B A are equal to two right angles: and C, A, and C B A are the three angles of the triangle (A C B) proposed.

§ *b. Cor.* If two angles of one triangle be known, the third is also known. It is found by subtracting the sum of the two known angles from 180°.

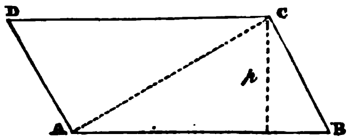
§ *c. Cor.* And the two acute angles of a right angled triangle (§ 17.) are together equal to one right angle.

§ *d.* Wherefore the acute angles of any right angled triangle are the complements (§ 8. § *c.*) of each other.

§ *e.* It is also evident from the above, that if two angles in one triangle be equal to two angles of another, the remaining angles are also equal to each other.

PROPOSITION IX.

§ 33. A diagonal (A C) of a parallelogram divides the parallelogram into two equal (§ 23.) triangles (A C D and A C B).



§ *a*. The opposite sides of a parallelogram (§ 19.) are parallel and equal to each other; wherefore D C = A B, A D = C B, and A C is common to the two triangles (A C D and A C B); therefore their sides are equal, those of the one to those of the other. The angles D C A and C A B are equal to each other (§ 30.), for they are alternate angles (§ 28. § *d.*) made by A C crossing the two parallels D C and A B. For the same reason the alternate angles D A C and A C B made by A C with the parallels A D and C B, are equal to each other. Wherefore, the two angles (D C A and D A C) in one triangle being equal to two angles (A C B and C A B) in another, the remaining angles (D and B) (§ 32. § *e.*) are also equal to each other. Therefore, the triangle A C D having its sides and angles respectively equal to the sides and angles of the triangle A C B, is equal (§ 23.) to the latter, and the diagonal (A C) divides the parallelogram D A B C into these two equal triangles.

§ *b*. Scholium. The area (§ 10. § *a.*) of a parallelogram (§ 19. § *b.*) is the product of its base and altitude. The triangle A B C and the parallelogram D A B C have the same base (A B) and altitude (*p*), and the triangle is proven to be *half* of the parallelogram; Therefore,

§ *c*. *Cor*. The area or magnitude of a triangle is the product of its base by *half* its altitude.

§ *d*. *Cor*. The triangles into which a diagonal divides a parallelogram are both equal and (§ 23.) of the same magnitude.

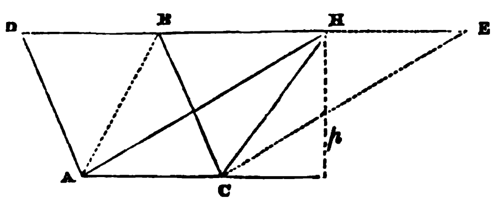
§ *e*. Scholium. D A C + B A C (§ *a.*) = D C A + B C A, and D = B. Therefore,

§ *f*. *Cor*. The opposite angles of a parallellogram are equal.

§ *g*. *Cor*. If the opposite angles of a quadrilateral figure be equal, figure is a parallelogram.

PROPOSITION X.

§ 34. If a parallelogram (D A C B) and a triangle (A B C) stand upon the same base (A C), and between the same parallels (D B and A C), they have the same altitude (*p*), and the triangle is equal to *half* the parallelogram.



§ *a*. If one side (A B) of the triangle be diagonal to the parallelogram, the triangle falls within the parallelogram, and (§ 33.) the proposition is proven.

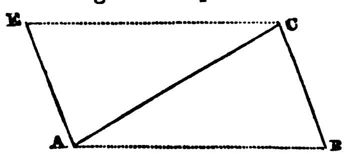
§ *b.* But if the vertex (H) of the triangle proposed, fall without the parallelogram, as A H C, continue one of the parallels (D B) on, through the vertex H, to E; and upon the base A C construct the parallelogram A H E C, to which the side H C of this triangle is diagonal (§ 22. § *a.*), therefore A H C (§ 33.) is half of the parallelogram A H E C. The parallelograms A H E C and D A C B (§ 19. § *a.*) have the same base (A C) and altitude (p), and the area of each (§ 19. § *b.*) is the product of A C by p; wherefore (§ 24. § *b.*) these two parallelograms are of the same magnitude; therefore (§ 24. § *a.*) the triangle A H C is also equal in *magnitude* to half of either parallelogram, say D B C A; and p (§ 18. § *a.*) is also the altitude of the triangle A H C.

§ *c. Cor.* If a triangle and a parallelogram have their bases and altitudes equal, the triangle is equal in magnitude to half the parallelogram.

§ *d. Cor.* Triangles which have the same or equal bases and altitudes, are of the same magnitude.

PROPOSITION XI.

§ 35. When two sides (A C and C B) of any triangle (A C B) are equal to two sides (E A and A C) of another (A E C), if the angles (A C B and C A E), which these sides contain, be equal, the two triangles are equal.



§ *a.* Let one of the equal sides (A C) be made common to the two triangles proposed, by constructing them on opposite sides of it; the figure A E C B, thus formed, will be a quadrilateral.

§ *b.* By the conditions of the proposition, the angle E A C = A C B, and they are alternate angles, made by A C with the equal lines E A and C B, therefore (§ 30.) E A and C B are parallel; and the opposite straight lines (E C and A B) which join their extremities are also parallel, wherefore (§ 30.) the alternate angles E C A and C A B are equal to each other.

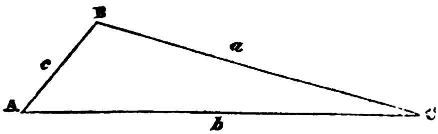
§ *c.* E and B are the remaining angles of the two triangles, and (§ 32. § *e.*) they are equal to each other, for (§ *b.*) E A C + E C A = A C B + C A B, therefore the angles of the two triangles proposed are equal to each other.

§ *d.* Now, since E A C + B A C = E C A + B C A the whole (§ 24. § *d.*) E A B is equal to the whole E C B; and (§ *c.*) E = B; these four are the opposite angles of the quadrilateral A E C B, which therefore (§ 33. § *g.*) is a parallelogram, and (§ 19.) E C = A B, and (§ 33.) A C divides the parallelogram into the two equal triangles A C B and A E C.

§ *e. Cor.* If the opposite sides of a quadrilateral figure be either parallel or equal, the figure is a parallelogram.

PROPOSITION XII.

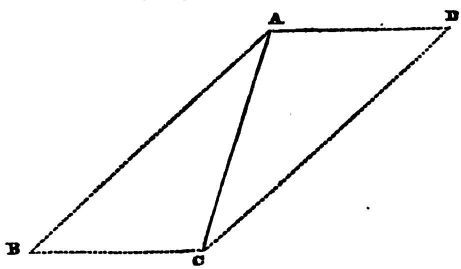
§ 36. Either side (b) of any triangle is less than the sum of the two other sides (a & c).



§ a. The straight line b, which joins the two points A and C, is less than the two straight lines c and a which join the same two points, because the shortest distance between any two points (A and C) (§ 3.) is the straight line (b) which joins them; wherefore b is less than the sum of the two other sides of the triangle, or of any two lines that can join A and C.

PROPOSITION XIII.

§ 37. Any two triangles (C A B and D C A) are equal, if a side (A C), and the two angles (B A C and B C A) adjacent to it, in the one, be respectively equal to a side (C A) and the two angles (A C D and C A D) adjacent to this side in the other.



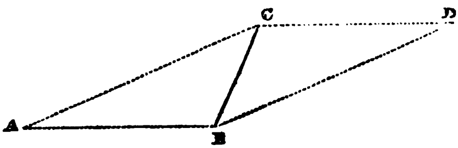
§ a. Let the equal side (A C) be made common, by constructing the two proposed triangles upon it, so that one of them may be on each side of the common line A C; the figure (B A D C) thus formed is a quadrilateral, and the side A C, which is common to the two proposed triangles, is a diagonal of it.

§ b. By the conditions of the proposition, the angles B A C and A C D are equal, and (§ 28. § d.) they are alternate angles, wherefore (§ 30. § d.) the two opposite sides (B A and C D) of the quadrilateral, are parallel. By supposition also, B C A and C A D are equal, and they are likewise alternate angles, wherefore (§ 30. § d.) the other two opposite sides (B C and A D) of the figure, are parallel.

§ c. If the opposite sides of a quadrilateral figure (§ 35. § e.) be parallel, the figure is a parallelogram; therefore B A D C is a parallelogram, and it is divided by the diagonal A C into the two proposed triangles C A B and D C A, which (§ 33.) are therefore equal to each other.

PROPOSITION XIV.

§ 38. Any triangles (B C A and D B C) are equal, if two angles (A & A B C) and an opposite side (C B), in one of the triangles be respectively equal to two angles (D & B C D) and the corresponding side (B C), of the other triangle.



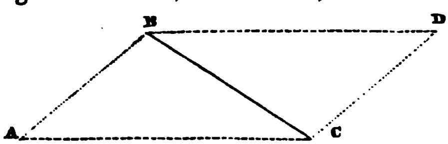
§ *a.* Let the equal side (C B) be made common to the two triangles, by constructing them so that one will be on each side of C B. Then C B becomes diagonal to the quadrilateral figure A C D B, which is formed by thus constructing the two proposed triangles.

§ *b.* By supposition, A = D, and A B C = B C D; wherefore (§ 32. § *e.*) the remaining angles A C B and C B D are equal to each other, and they are alternate angles, therefore (§ 30. § *d.*) the two opposite sides, C A and D B, of the four sided figure, are parallel; the other two opposite sides, C D and A B, are also parallel, the alternate angles A B C and B C D being equal, by the conditions of the proposition. Therefore, the quadrilateral A C D B (§ 35. § *e.*) is a parallelogram, and is divided by the diagonal B C, (§ 33.) into the two equal triangles B C A and D B C.

§ *c.* *Cor.* Hence it is inferred, that if two angles and a side of one triangle be equal to two angles and a side of another, the two triangles are equal.

PROPOSITION XV.

§ 39. Any two triangles (B A C and B D C) are equal, if every side of the former be equal to its corresponding side in the latter: *e. g.* A B = D C; A C = B D; and B C = C B.



§ *a.* Let one of the sides (B C) be made common to the two triangles proposed, by constructing one of them on each side of B C; the figure (A B D C) thus formed is a quadrilateral, and the common side B C is a diagonal of it.

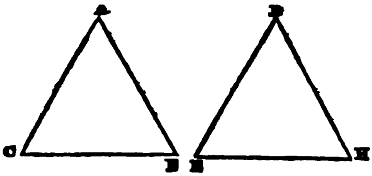
§ *b.* By the conditions of the proposition A B is equal to D C, and A C to B D, and they are opposite sides of the quadrilateral figure A B D C; and if the opposite sides of a quadrilateral figure be equal (§ 35. § *e.*), the figure is a parallelogram; therefore A B D C is a parallelogram, and its diagonal B C divides it into the two proposed triangles B A C and B D C, which (§ 33.) are therefore equal.

§ *c.* Scholium. Since the corresponding parts in equal figures (§ 23.) are equal, it follows:—

§ *d.* *Cor.* That, if the sides of one triangle be equal to the sides of another triangle, the angles opposite the equal sides are equal.

PROPOSITION XVI.

§ 40. Every equilateral triangle (A B C) is also equiangular.



§ *a*. Let an equilateral triangle (E D H) be drawn, having its sides equal to those of the proposed triangle. The two triangles (§ 39.) are then equal, and the angles A and D which correspond, (§ 39. § *d*.) are equal to each other.

§ *b*. By the conditions of the proposition each side of A B C is equal to the same thing, and by construction, equal to either side of E D H; then A B = E H; and the two triangles (§ *a*.) being equal the angles D and C, which are opposite to those equal sides (§ 39. § *d*.), are equal. Wherefore A and C are each equal to D, and, therefore, (§ 24. § *a*.) equal to each other. In the same manner B and A may be proven to be equal to each other. Wherefore C and B are each equal to A, and consequently the equilateral triangle A B C is equiangular.

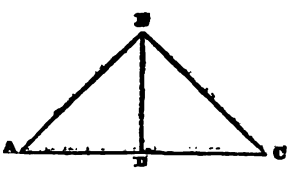
§ *c*. *Cor*. Every equiangular triangle is also equilateral.

§ *d*. Scholium. Since the three angles of any triangle (§ 32.) are together equal to 180°, and the three angles of an equilateral or equiangular triangle, are equal to each other:

§ *e*. *Cor*. Every angle in any equilateral or equiangular triangle, contains 60°.

PROPOSITION XVII.

§ 41. The angles (A & C) at the base of an isosceles triangle A B C (§ 14.), are equal to each other.



§ *a*. Let the base (A C) of the proposed triangle, be divided into two equal parts (A D & D C) by a straight line (B D) drawn from the vertex (B) of the triangle.

§ *b*. This line (B D) divides the isosceles triangle into the two triangles A B D and D B C, in which every side of the one, is equal to the side which corresponds to it in the other; viz: A B = C B (§ 14.) for they are the legs of the isosceles triangle A B C; A D = D C (§ *a*.), by construction; and B D is common to both of the triangles; therefore (§ 39.) these two triangles (A B D and D B C) are equal, and the corresponding angles A and C, being opposite to the common side B D, are therefore (§ 39. § *d*.) equal to each other.

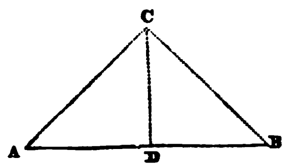
§ *c*. Scholium. A B D = C B D, because (§ 39. § *d*.) they are opposite to the two equal sides A D and D C; for a similar reason B D A and B D C are also equal to each other, and (§ 25.) these are together equal to two right angles, therefore each of them is a right angle, and the right line B D (§ 6. § *b*.) is perpendicular to the base (A C) of the isosceles triangle A B C; wherefore:—

§ *d*. *Cor*. A straight line drawn from the vertex, so as to bisect the base of an isosceles triangle, is perpendicular to the base, and it divides the vertical angle (A B C) into two equal parts, and the isosceles into two equal triangles. Also;

§ *e*. *Cor*. A straight line (B D) that is drawn perpendicularly from the vertex, to the base of an isosceles triangle, bisects the vertical angle and the base.

PROPOSITION XVIII.

§ 42. If only two angles (A & B) of a triangle (A C B) be equal, the triangle is isosceles.



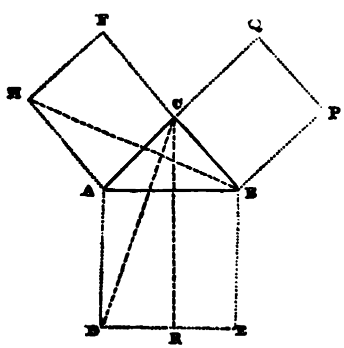
§ *a*. Call the other angle (C) (§ 16. § *b*.) the vertex of the proposed triangle; and from it, let the straight line C D be drawn, so as to bisect the vertical angle (C) and divide the proposed triangle into the two C A D and C B D, in which, by construction, the side C D is common, the angles A C D and B C D equal, and (§ 42.) A = B; wherefore in these two triangles (C A D & C B D), two angles and a side of the one are equal to the homologous angles and side of the other, and therefore (§ 38. § *c*.) these two triangles are equal to each other; consequently (§ 23.) the corresponding sides, C A & C B, are equal, and hence, (§ 14.) the triangle A C B is isosceles.

PROPOSITION XIX.

§ 43. In every right angled triangle (A C B), the square (D A B E) of the hypothenuse (§ 17. § *a*.) is equal in magnitude to the squares (A C F H & B C Q P) of the two legs.

§ *a*. Let D A B E represent the square (§ 20.) of the hypothenuse (A B), and A C F H & B C Q P, the squares of the two legs A C and B C; then (§ 43.) D A B E = A C F H + B C Q P.

§ *b*. From the right angle (A C B) let C R be drawn parallel to the parallels (§ 20. & § 19.) A D & B E, join C D and H B.



§ *c*. The angles of a square (§ 20. § *a*.) are right angles, and all right angles (§ 6. § *a*.) are equal, therefore H A C = D A B; to each of these equals add the angle B A C, and the sums H A B and D A C (§ 24. § *b*.) will be equal; also H A = A C, because (§ 20.) they are sides of the same square A F; and D A = A B, because they also are sides of a square A E.

§ *d*. Wherefore, in the two triangles A H B and A D C, the two sides H A and A B of the one, are respectively equal to the two sides C A and A D, of the other, and the angles H A B and D A C, contained by these sides, are also equal (§ *c.*), therefore (§ 35.) the two triangles are equal.

§ *e.* The triangle A D C is equal in magnitude (§ 34.) to half of the parallelogram A R, for they stand upon the same base D A, and between the same parallels (§ *b.*) C R and A D. And the triangle A H B is equal in magnitude to half of the parallelogram A F, because they stand upon the same base A H, and between the same parallels H A and F C B.

§ *f.* The parallelograms A F and A R, being each double of either of the equal triangles (§ *d.*) A H B and A D C, are therefore (§ 24. § *b.*) equal to each other in magnitude; but the parallelogram A F (§ *a.*) is the square of the leg A C; wherefore the square of the leg A C, and the parallelogram A R, are of the same magnitude.

§ *g.* By joining A P and C E, it may be demonstrated in the same manner, that the parallelogram B R, and the square (B P Q C) of the other leg B C, are of the same magnitude.

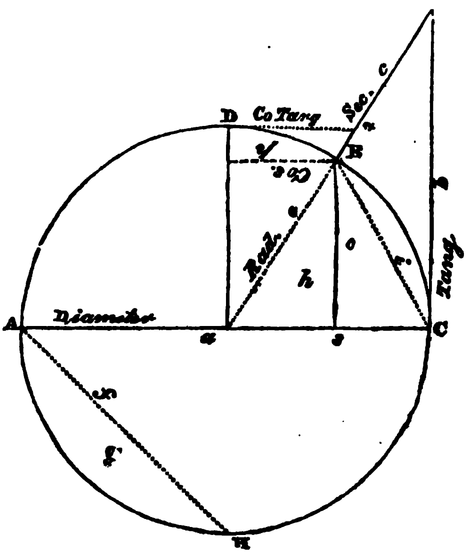
§ *h.* The parallelograms A R and B R make up the square (D A B E) of the hypothenuse (§ *a.*) A B, therefore (§ 24. § *a.*) the square of the hypothenuse (A B) is equal in magnitude to the sum of the squares of the two legs (A C & C B).

GEOMETRY.

PART II.

GEOMETRY.

DEFINITIONS.



§ 49. *A circle* is a figure that is bounded by a line of uniform curvature: all parts of this line are equidistant from a point (*a*) within it, which is called the *centre.*

§ *a.* If a straight line of any determinate length were to revolve in a plane, and on the point at one of its own extremities, its other extremity would describe the *circumference* (A D C H) of a circle; the point (*a*) on which the line would revolve would be the *centre* of the circle; the length of the revolving line would be the *radius* (*a* B) of the circle; and the plane in which the line would revolve, would be the *plane* of the circle.

§ *b.* The circumference (A D C H) of every circle is divided into 360 equal parts, called degrees (°); every degree is divided into 60 equal parts, called minutes (′); every minute is divided into 60 equal parts, called seconds (″); and these, when calculations are performed in which great nicety is required, are divided into halves, tenths, or hundredths.

§ *c.* Whether the circumference of a circle be infinitely great, or infinitely small, a degree is still the same; and the circumference of the smallest is equal to the circumference of the largest circle, when the two circumferences are compared in degrees, minutes, and seconds, to each other; for a degree is the 360th part of the circumference of every circle.

§ *d.* Degrees (°), minutes (′), and seconds (″), are the terms in which the value of angles is expressed.

§ *e.* When the straight lines which contain an angle, are produced to the circumference of any circle that may be described from the angular point as a centre, that part of the circumference which the two lines intercept, contains the degrees, etc., which express the value of said angle. An angle is said to *stand* upon the part of the circumference that is thus intercepted. Neither the length of the lines which contain the angle, or the distance of it from the circumference by which it is measured, affects its angular value.

§ 50. *The radius* of a circle is a straight line (*e*) that extends from the centre to the circumference of the circle.

§ *a.* All the radii of the same, or equal circles, are themselves equal.

§ 51. *The diameter* of a circle is a straight line (A C) that passes through the centre of the circle, and is terminated at each end by the circumference of the circle.

§ *a.* Either of the two parts (A B C & A H C) into which the diameter divides the circle, is a *semicircle.*

§ *b.* *A segment* of a circle is any part (*g*) cut from the circle by a line (*f*), or a plane, which crosses the circle.

§ 52. *An arc* of a circle is any part of its circumference. That part (A H) of the circumference which bounds a segment (*g*) is an arc; and the straight line (*f*) which joins the extremities of an arc, is a chord.

§ *a.* The *complement* of an arc, or angle, is the difference between either and 90°; and the *supplement* is what either wants of being 180°.

§ *b.* The radius and centre of a segment, or of an arc, are the radius and centre of the circle, of which the segment, or the arc, is a part.

§ *c.* Every arc or angle has its sine and co-sine, tangent and co-tangent, secant and co-secant, besides its versed sine and semi-tangent.

§ *d.* The "*co*" is an abbreviation for *complement:* the co-sine, co-tangent, etc., of an angle or an arc, are the sine, tangent, etc., of the *complement* of that arc or angle.

§ *e.* The sine, tangent, secant, etc., of an arc, are also the sine, tangent, secant, etc., of the supplement of that arc.

§ 53. *A chord* is a straight line (*i*) (§ 52.) that joins the extremities of an arc (B C).

§ *a.* Every arc has its chord.

§ *b.* When a chord passes through the centre of a circle, it becomes a diameter, and the arc it subtends is a semicircle.

§ 54. *A sine* is a straight line (*o*) that extends from one extremity (B) of an arc (B C) perpendicularly to the radius (*a* C) that joins the other extremity.

§ 55. *A versed sine* is that part (*s* C) of the radius which is intercepted between the sine and the extremity of the arc.

§ 56. *A tangent* is a line (*b*) that touches one extremity of an arc (B C), is perpendicular to the radius (*a* C) at that extremity, and extends to another radius (e) produced through (B) the other extremity of the arc.

§ 57. *A secant* (a B c) is the produced radius (e) that intersects the tangent.

§ *a*. The co-sine, co-tangent, and co-secant, of the arc B C, are p, D t, and $a\,t$; and p (§ 19.) is equal to $a\,s$.

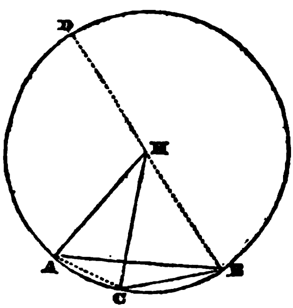
§ *b*. The sine, co-sine, tangent, co-tangent, etc., of an angle, is the sine, co-sine, tangent, co-tangent, etc., of the arc which subtends that angle.

§ *c*. These are sometimes called ***trigonometric functions***.

§ 58. *A sector* is a figure (h) contained by two radii (a B, a C), and the arc (B C) between them.

PROPOSITION I.

§ 59. An angle (A B C) at the circumference, is equal to half of an angle (A H C) at the centre, if they stand upon the same arc (C A), of a circle.



§ *a*. Draw the chord A C, and from B let a diameter (B H D) be drawn. The radii H A, H C, and H B (§ 50. § *a*.) are equal, and the triangles A H B and C H B (§ 14.) are isosceles. The exterior angle C H D (§ 31.) is equal to the two interior angles (H B C and H C B) of the triangle C H B; for the same reason the exterior angle (A H D) of the triangle A H B, is equal to its two interior angles H A B and H B A, which are equal to each other, because (§ 41.) they are at the base of the isosceles triangle A H B; therefore A H D is double of either of them, say of H B A. For the same reason H B C and H C B are equal to each other, and C H D is double of either, say of H B C.

The difference between C H D and A H D, is C H A, and the difference between their equals, viz., twice H B C and twice H B A, is twice A B C. Wherefore C H A (§ 24. § *b*.) is equal to twice A B C; or, which is the same thing, the angle (A B C) at the circumference, is equal to half of the angle A H C at the centre of a circle, and both of them stand upon the same base.

§ *b*. An angle at the centre of a circle, is measured (§ 49. § *e*.) by the arc it stands upon; Wherefore—

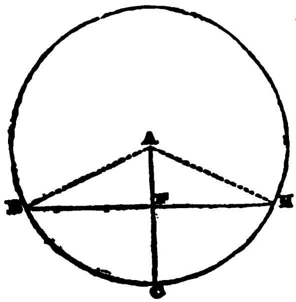
§ *c*. *Cor*. An angle at the circumference of a circle is measured by half the arc which subtends it.

§ *d*. *Cor*. All angles are equal that are at the centre, or all angles are equal that are at the circumference, if they stand upon the same, or equal arcs.

§ *e*. *Cor*. An angle that is at the circumference, and that stands upon a semicircle (§ *c*.), is a right angle.

PROPOSITION II.

§ 60. If the radius (A C) of a circle cut a chord (B H) at right angles, it bisects that chord and its arc (B C H).



§ *a.* Let the radii, A B and A H, be drawn to join to extremities of the chord (B H). The triangle (B A H) thus formed (§ 50. § *a.* & § 14.) is isosceles. And the straight line A F C bisects the vertical angle H A B (§ 41. § *e.*); for by the conditions of the proposition, A C is perpendicular to the chord B H, which is the base of the isosceles triangle B A H. Wherefore (§ 41. § *d.*) the two triangles B F A and H F A are equal, B H is bisected, and the angles B A C and H A C are equal to each other, and being equal (§ 59. § *d.*) they stand upon equal arcs (B C & C H). Therefore the chord (B H), and its arc (B C H), are bisected by the radius A C.

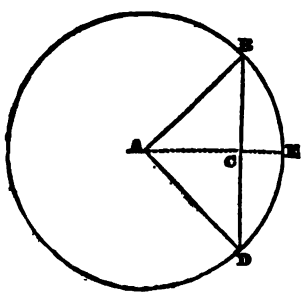
§ *b. Cor.* If a radius bisect an arc, it also bisects the chord of that arc, and cuts the chord at right angles.

§ *c. Cor.* If a radius bisect a chord, it also bisects the arc of that chord, and cuts the chord perpendicularly.

§ *d. Cor.* If a radius bisect a chord, or its arc, it also bisects the angle at the centre, which stands upon that arc.

PROPOSITION III.

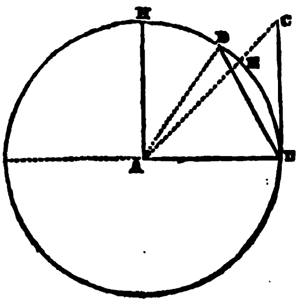
§ 61. B C, half the chord (B D) of an arc (B E D), is the sine of C A B, half the angle (D A B) which that arc subtends.



§ *a.* Let the chord be bisected at C, and through C let the radius A C E be drawn, then this radius (§ 60. § *c.*) bisects the arc B E D, cuts the chord B D at right angles, and also (§ 60. § *d.*) bisects the angle (D A B) which this arc subtends. Wherefore, B A C is half of the angle D A B, B C is half the chord of B E D, and it is perpendicular to the radius A C E; therefore (§ 54.) B C, half the chord of B E D, is the sine of C A B, which is half of the angle (D A B) proposed.

PROPOSITION IV.

§ 62. In any circle, radius (A D), the sine (A H) of 90°, the chord (B D) of 60°, and the tangent (D C) of 45°, are all equal to each other.



§ *a*. Let A be the centre of the circle, the arc H B E D = 90°, the arc B E D = 60°, and the arc E D = 45°, and join B A and C A. The angles at the centre (A) (§ 49. § *e*.) are measured by the arcs they stand upon; therefore the angle D A C = 45°, D A B = 60°, and D A H = 90°; A H then (§ 6. § *b*.) is perpendicular to A D, and A H (§ 54.) is the sine of the arc H B E D = 90°, it is a radius, and therefore (§ 50. § *a*.) equal to A D.

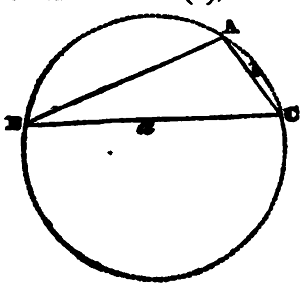
§ *b*. The radii A B and A D being equal (§ 50. § *a*.), makes the triangle B A D (§ 14.) isosceles; consequently (§ 41.) the angles A B D and A D B are equal. The angle D A B = 60° (§ 49. § *e*.) because it stands upon the arc B E D; wherefore (§ 32.) A B D + A D B = 120°, and being equal, the value of each is 60°; therefore the triangle B A D is equiangular, and (§ 40. § *c*.) also equilateral; consequently (§ 13.) the chord (B D) of 60° is equal to radius (A D).

§ *c*. C D is the tangent of E D = 45°, and consequently (§ 56.) is perpendicular to A D; wherefore (§ 6. § *b*. & § *a*.) the angle C D A = 90°, and (§ 17.) the triangle A D C is right angled. The angle C A D = 45° (§ 49. § *e*.), because it stands upon the arc E D, therefore (§ 32. § *d*.) the angle A C D is also equal to 45°, and is equal to C A D, and (§ 42.) the triangle A D C is isosceles, and (§ 14.) the tangent (D C.) of 45° is equal to radius (A D).

§ *d*. Therefore the tangent of 45° (§ *c*.), the chord of 60° (§ *b*.), and the sine of 90° (§ *a*) being each equal to radius, are (§ 24. § *a*.) equal to each other.

PROPOSITION V.

§ 63. In every triangle, the angle (A) that is opposite to the greatest side (*a*) is the largest, and (B), that which is opposite to the smallest side (*b*), is the smallest angle of the triangle.



§ *a*. Describe a circle (A C H B) about the proposed triangles B A C, the circumference of which touches the three angular points (B, A, & C) of the triangle. Each side of the triangle then becomes the chord to the arc, which subtends the angle that is opposite to it.

§ *b*. The angle A stands upon the arc B H C, which is greater than either of the arcs (B A, A C) upon which the two other angles (C & B) of the triangle stand. Each of these three angles (§ 59. § *c.*) is measured by half the arc that subtends it. Therefore A, which stands upon the greatest arc, and subtends the greatest side (a), is the largest angle of the proposed triangle.

§ *c.* Half the smallest arc (A C) (§ 59. § *c.*) measures the angle (B) that stands upon it; therefore B (the angle that is opposite to the smallest side) (b) is the smallest angle of the triangle.

DEFINITIONS.

§ 64. The *multiple* of a magnitude is the product of this magnitude and any other factor.

§ *a.* *Equimultiples* of magnitudes are the product of each of these magnitudes by the same or equal multipliers.

§ *b.* Thus, 15 and 30 are equimultiples of 3 and 6; for $3\times5=15$, and $6\times5=30$. Consequently (§ 24. § *b.*)—

§ 65. The same or equal multiples of equal magnitudes are equal to each other.

§ 66. *Ratio* is the relation which the value of any magnitude bears to that of another, and it is shown by dividing one magnitude by the other.

§ *a.* Thus, the ratio of a to b is $a \div b$, and is expressed thus,— $a : b$.

§ *b.* And if the ratio between two quantities (a & b) be equal to the ratio between two other quantities (c & d), this equality of ratio is expressed (§ XLV. Algebra) by writing the sign (: :) between the two former and the two latter quantities, thus,— $a : b :: c : d$.

§ 67. *Proportion* consists in the equality of the ratios between magnitudes.

§ *a.* Thus, the ratio (§ 66.) of 3 to 4 is $\frac{3}{4}$; and the ratio of 6 to 8 is $\frac{6}{8}=\frac{3}{4}$; and these quantities are proportional; *i. e.* $3 : 4 :: 6 : 8$.

§ *b.* Four quantities are in *direct* proportion, when the 4th is equal to the quotient, which arises from dividing by the 1st quantity, the product of the 2d and 3d. Thus ($3 : 4 :: 6 : 8$), $4 \times 6 = 24$, and $24 \div 3 = 8$. So, also, $a : b :: c : d$, which in Algebra (§ XLV.) is but another form for expressing that $a\div b=c\div d$; and by transposition $a \times d = c \times b$; also, $(c \times b) \div a = d$.

§ *c.* The first and third (a & c) of four magnitudes that are in direct proportion, are called *antecedents;* and the second and fourth (b & d) are called *consequents.*

§ *d.* Also the first and fourth (a & d) are called *extremes;* and the second and third (b & c) are called *means.*

§ *e.* It is a rule in proportion, that the quantities for calculation be so arranged that the product of the two extremes be equal to the product of the two means. Thus, $a\times d=b\times c$; and as $a\times d=d\times a$. (§ XXV. †1. Algebra), $d\times a=c\times b$. Wherefore the means may be made extremes, and the extremes means; as, $b : a :: d : c$ (§ XLVIII. Alg.); the antecedents may be made consequents and the consequents antecedents; as, $d : c :: b : a$, without interrupting the harmony of the proportion between the quantities.

§ *f.* Hence if the value of three magnitudes be known, the unknown value of the fourth, which is in the same ratio of proportion, is determinable. It is the quotient that arises (§ *b.*) from dividing the product of the two means by the known extreme. Thus, 3 : 4 : : 6 — ; a 4th quantity, $4 \times 6 = 24$, and $24 \div 3 = 8$, the 4th quantity. Generally speaking, the magnitude whose value is required is expressed last in the order of proportion.

AXIOMS.

§ 69. Among quantities that are proportional, equals may be substituted for equals.

§ *a.* Magnitudes that are proportional to the same two, or to other magnitudes equal to these, are proportional to each other.

§ *b.* Equal magnitudes have the same ratio to the same magnitudes.

PROPOSITION VI.

§ 70. The same, or equimultiples (C and D), of any two magnitudes (A and B), are to each other as the magnitudes themselves.

§ *a.* Let C be the same multiple, say the 5th, of A, that D is of B; then (§ 64. § *a.*) $A \times 5 = C$, and $B \times 5 = D$; by transposition $C \div A = 5$, and $D \div B = 5$; wherefore (§ 24. § *a.*) $C \div A = D \div B$; then (§ XLVI.) C : A : : D : B, and alternately (§ XLVIII.) C : D : : A : B. Therefore, the equal multiples are as the magnitudes.

§ *b.* Scholium. The magnitude of a triangle (§ 33. § *c.*) is the product of its base and half of its altitude.

§ *c.* Wherefore the magnitudes of triangles of the same altitude, are equimultiples of their bases. And so of parallelograms of equal altitudes; and therefore,

§ *d.* *Cor.* Triangles, or parallelograms, that have the same altitude, are, in magnitude to each other as their bases; or those that have equal bases are to each other as their altitudes.

PROPOSITION VII.

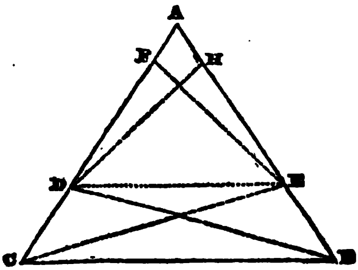
§ 71. When the product of any two quantities (a & b) equals the product of two others (c & d), the ratio of the greater multiplicand to the greater multiplier, is equal the ratio of the less multiplicand to the less multiplier; and the four quantities are proportional.

§ *a.* Let $a \times b = c \times d$ be the four quantities proposed, and let a be the greater multiplicand, then d will be the greater multiplier, b the less, and c the less multiplicand; and (§ 71.) $a : d :: c : b$.

§ *b.* By the conditions of the proposition $a \times b = c \times d$, and by transposition (§ XLII.) $a \div d = c \div b$; therefore these quantities (§ XLV.) are proportional; *i. e.*, $a : d :: c : b$, and consequently (§ 67. § *a.*) their ratios are the same.

PROPOSITION VIII.

§ 72. If a straight line (D E) be drawn parallel to the base (C B) (§ 16. § *b*.), and so as to cut the two sides (A C and A B) of any triangle (A B C), the sections (A D, D C, A E, & E B) of these two sides will be proportional; *i. e.*, A D : D C :: A E : E B.



§ *a*. Join D B and C E; and let E F be drawn from the vertex (E) of the two triangles A E D and C E D, perpendicularly upon A C, then (§ 18. § *a*.) E F is the altitude of each of these two triangles. In the same manner, by drawing D H perpendicular to A B, it is shown that the two triangles A D E and B D E have the same altitude (D H).

§ *b*. The triangles A E D and C E D, having the same altitude (E F), are to each other (§ 70. § *d*.) as their bases; *i. e.*, A E D : C E D :: A D : D C. And the triangles A D E and B D E are to each other also as their bases; *i. e.*, A D E : B D E :: A E : E B.

§ *c*. The triangle A D E is a magnitude in each set of these proportions; and the triangles C E D and B D E are of the same magnitude (§ 34. § *d*.), for they stand upon the same base (D E), and between the same parallels (§ 72.) D E and C B.

§ *d*. Wherefore A D and D C, A E and E B, are proportional to the same or equal magnitudes; they are therefore (§ 69. § *a*.) proportional to each other; *i. e.*, A D : D C :: A E : E B.

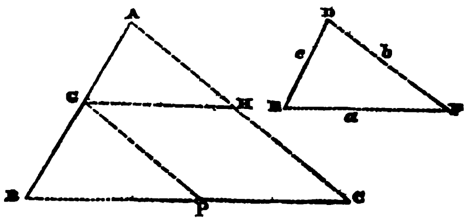
§ *e*. By drawing a straight line from the vertex B, perpendicularly upon A C, as a base; and another from C as a vertex, perpendicularly upon A B, it may be proven in the same way, that A C : D C :: A B : E B. And also that A C : A D :: A B : A E. Wherefore,—

§ *f*. *Cor*. If the two sides of a triangle be crossed by a line that is parallel to the base, these two sides will be proportional to their sections.

PROPOSITION IX.

§ 73. The homologous (§ 23. § *c*.) sides of similar triangles (A B C & D E F) are proportional to each other, viz., A B : *c* :: A C : *b* :: C B : *a*.

§ *a*. By the conditions of the proposition, the triangles A B C and D E F are similar, wherefore (§ 23. § *b*.) their corresponding angles are equal, viz., B = E, A = D, and C = F. Upon the two sides A B and A C of the greater triangle, (A B C) let A G be set off, equal to *c*, and A H = *b*; let G H be joined, then (§ 35.) the two triangles A G H and D E F are equal to each other; therefore (§ 23.) G H = *a*, the angle A G H = E, etc.



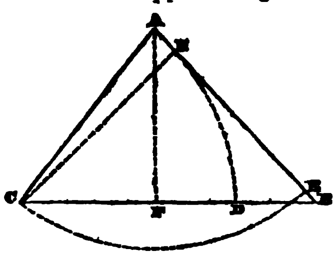
§ *b*. The angle A G H (§ *a.*) = E, and B=E, therefore (§42, § *a.*) A G H = B, and (§ 30. § *d.*) G H is parallel to B C. Consequently (§ 72. § *f.*) A B : A G : : A C : A H; by construction A G = *c*, and A H = *b*; then substituting for A G and A H their equals, we have (§ 69.) the proportion A B : *c* : : A C : *b*.

§ *c*. Then by drawing from G, G P parallel to A C, the parallelogram G P C H (§ 35. § *e.*) is formed; and (§ 72. § *f.*) we have A B : A G : : C B : C P. But (§ 19.) C P = G H, and (§ *a.*) G H = *a*; also A G = *c*. Therefore (§ 69.) A B : *c* : : C B : *a*.

§ *d*. *Cor.* Whence it may be inferred, that if a straight line be within a triangle and parallel to its base, the ratio of the base to this line will be equal to the ratio of the sides to their sections.

PROPOSITION X.

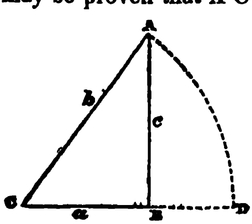
§ 74. In every triangle (A B C) the sides are proportional to the sines of their opposite angles.



§ *a*. From C and A, as centres, and with A C as the radius, let the arcs A D and C E be described, and draw A F perpendicular upon B C, and C H perpendicular upon A B, then (§ 54.) A F is the sine of the angle A C B, and C H is the sine of the angle C A B.

§ *b*. Of the two triangles B H C and B A F, the angle at B is common, the right angles A F B and C H B are equal, wherefore (§ 32. § *e.*) the remaining angles H C B and F A B are equal, and (§ 23. § *b.*) these two triangles are similar.

§ *c*. The homologous sides of similar triangles (§ 73.) are proportional; wherefore A B : C B : : A F : C H; and A F & C H (§ *a.*) are the sines of the angles A C B and C A B; therefore A B : C B : : sine A C B : sine C A B. In the same manner it may be proven that A C : C B : : sine A B C : sine C A B.



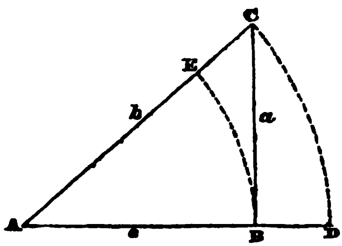
§ *d*. If the proposed triangle be right angled, and the hypothenuse be made radius, the hypothenuse becomes (§ 62. § *a.*) the sine of the right angle, and the legs (*c* and *a*) the sines of their opposite angles (C & A), whence we have a self-evident truth, viz., A B : C B : : *c* : *a*; but *c* and *a* are the sines of C and A, therefore A B : C B : : sine C : sine A. Also A C : A B : : *b* : *c*;

but b is the sine of B, and c of C, therefore A C : A B :: sine B : sine C; and (§ 62.) the sine of B is equal to radius. By like reasoning, it is shown that A C : C B :: sine B : sine A. Wherefore,

§ *e. Cor.* If an hypothenuse be made radius, that hypothenuse is to either leg as radius is to the sine of the angle opposite that leg.

PROPOSITION XI.

§ 75. In every right angled triangle, the sides are proportional to the several *trigonometric functions* (§ 57. § *c.*) of the two acute angles.



§ *a.* Let the hypothenuse (b) of the proposed triangle, be made radius (A C) to an arc C D = A. Then (§ 54. & § 57. § *a.*) C B is the sine, and A B the co-sine of A; likewise A B is the sine, and C B the co-sine of C.

§ *b.* Now (§ XXV. †1.) $b \times a =$ C B $\times$ A C; then (§ 71.) b : A C :: C B : a; by construction (§ *a.*) A C is radius, and C B is sine A or co-sine C; therefore b : radius :: sine A or co-sine C : a. Again, $b \times c =$ A B $\times$ A C, and A B (§ *a.*) is the co-sine of A, and sine of C; therefore, b : radius :: co-sine A or sine C : c. And these quantities (§ XLVII.) are also proportional, when taken inversely or alternately.

§ *c.* Let either of the legs (c) be made radius (A B) to another arc E B = A. Then C B becomes tangent (§ 56.) to A, and (§ 57. § *b.*) co-tangent to C; and A C (§ 57.) the sec. of A, and co-sec. of C. And (§ XXV. †1.),

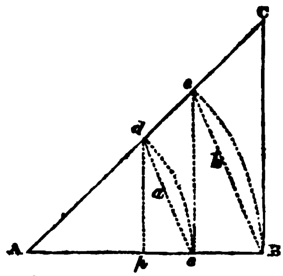
1st. A B $\times a =$ C B $\times c$, and (§ 71.) A B : c :: C B : a.
2d. A B $\times b =$ A C $\times c$, „ A B : c :: A C : b.
3d. A C $\times a =$ C B $\times b$, „ A C : b :: C B : a.

Now (§ *c.*) A B is radius, C B is tangent A, or co-tangent C, and A C is sec. A, or co-sec. C. Therefore in these three sets of proportions, the first is, radius : c :: tangent A, or co-tangent C : a. The second is, radius : c :: sec. A, or co-sec. C : b. And the third is, sec. A, or co-sec. C : b :: tangent A, or co-tangent C : a. And (§ XLVIII.) these quantities are also proportional, when taken inversely, or alternately.

§ *d.* If B C be made radius, the same method of demonstration will show that radius, the tangent and secant of C, and of its complement, are proportional to the sides (a, b & c) of the proposed triangle.

PROPOSITION XII.

§ 76. The chords (a & b), sines ($d\ p$ & $e\ s$), tangents ($e\ s$ & B C), etc., of equal arcs ($d\ s$ & e B), which have different radii (A B, A s), are to each other, as the radius of one of the arcs is to the radius of the other.



§ *a*. The proposed arcs (*d s* & *e* B) are concentric; *e s* is the tangent of *d s*, and C B of *e* B; by the definition of a tangent (§ 56.), they are perpendicular to A B; they are therefore parallel; and (§ 73. § *d*.) *s e* : B C :: radius A *s* : radius A B.

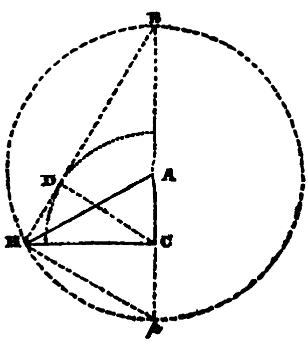
§ *b*. The sines (*d p* & *e s*) of these two arcs, are also parallel, and by the same proposition (§ 73. § *d*.) *d p* : *e s* :: A *s* : A B.

§ *c*. The chords *a* and *b*, are also parallel, and, for the reason above, are to each other as, A *s* : A B.

§ *d*. By similar methods of demonstration the secants, co-secants, co-sines, co-tangents, etc., of the two arcs, may be proven to have the same proportion to each other, which the two radii A *s* and A B have.

PROPOSITION XIII.

§ 77. The sum (B C) of two sides (C A & A H) of any triangle (A C H), is to the tangent of half the sum of their adjacent angles (H & C), as the difference (C *p*) between the same two sides, is to the tangent of half the difference between the same two angles; or B C : tangent $\frac{1}{2}$ (A C H + A H C) :: C *p* : tangent $\frac{1}{2}$ (A C H $\backsim$ A H C).



§ *a*. With the greatest side (A H) of the proposed triangle, as radius, describe the circle B H *p*, about the centre A. The side A C is extended both ways, until it forms the diameter (B *p*) of the circle. Join B H, H *p*. D C is drawn parallel to H P.

§ *b*. Because A H = A B (§ 50. § *a*.); C A + A B, or C B is the sum of the two sides C A & A H. And because A H = A *p*; A *p* — A C, or C *p* is the difference between the same two sides.

§ *c*. The angle B H *p* (§ 59. § *e*.) is a right angle; then C D is perpendicular to B H, for it is drawn parallel to H *p*; therefore (§ 30.) C D B is a right angle; and B D is tang. of B C D.

§ *d*. The exterior angle H A B (§ 31.) is equal to the sum of the adjacent angles (A C H & A H C); H *p* B (§ 59.) is equal to half of H A B, for they stand upon the same arc (B H); then (§ 24. § *a*.) $\text{H}\,p\,\text{B} = \frac{\text{A C H} + \text{A H C}}{2}$. Because D C and H *p* (§ *a*.) are parallel, B C D (§ 28.) is equal to H *p* B; therefore B C D is equal to half the sum of the two angles A C H and A H C. And in the right angled triangle B D C, C B is the sum (§ *b.*) of the two sides A H, A C of the proposed triangle A C H, and B D (§ *c.*) is the tangent of B C D, which is half the sum of A C H and A H C.

§ *e.* By § 31, the angle A C H $=$ C *p* H$+$C H *p*. Because A H$=$ A *p* (§ 50. § *a.*), the triangle H A *p* (§ 14.) is isosceles; and (§ 41.) C *p* H$=$A H *p*. Then (§ 24. § *a.*) A C H$=$A H *p*$+$C H *p*; from this sum, subtracting A H C, the remainder is twice C H *p*, which is the difference between the two angles A C H and A H C; then C H *p* is *half* this difference. And (§ 29.) C H *p* $=$ H C D; therefore H C D is half the difference between the angles A C H and A H C. Now making C D radius, D H (§ 56.) becomes tangent of H C D.

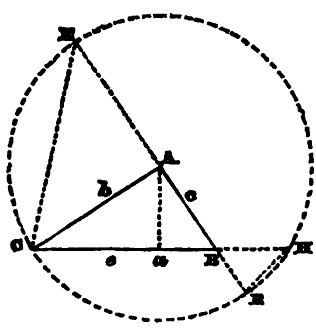
§ *f.* Now C *p* being the difference (§ *b.*) between the two sides A H and A C; and D C being parallel (§ *a.*) to the side H *p* of the triangle H B *p*; we have (§ 72.) B C : B D :: C *p* : D H. Or,

$$\text{C A} + \text{A H} : \text{tangent } \frac{\text{A H C} + \text{A C H}}{2} :: \text{C A} \backsim \text{A H} : \text{tangent } \frac{\text{A H C} \backsim \text{A C H.}}{2}$$

§ *g.* Scholium. The half sum (§ *d.*) B C D added to the half difference H C D (§ *e.*) makes the greater angle A C H; and the half difference C H *p* (§ *e.*) subtracted from the half sum A H *p* (§ *e.*), gives the less angle A H C. Wherefore,

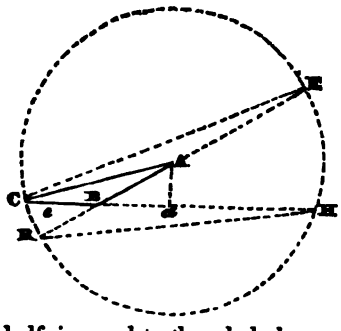
§ *h.* *Cor.* Half the difference and half the sum of any two magnitudes being added to each other, give the greater, and being subtracted from each other, give the less of the two magnitudes.

PROPOSITION XIV.



§ 79. The base (*e*) of any triangle (A B C) is to the difference between the two sides (*b* & *c*), as their sum is to twice the distance from the middle of the base to a perpendicular (A *a*) falling upon the base from its opposite angle (A); that is, $e : b \backsim c :: b + c$ is to twice the distance of *a* from the middle of the base.

§ *a.* With a radius equal to the longer side (*b*) of the proposed triangle, the circle E C R H is described about the angle (A) that is opposite to the base. Then *b* (§ 50. § *a.*) is equal both to A E and to A R; and the difference between the two sides *b* and *c* is (A R — *c* $=$) B R; and their sum is (*c* $+$ A E $=$) B E;



§ *b*. Because the perpendicular A *a* is drawn from the centre of the circle upon the chord C H (§ 60.), it bisects it. Then the distance of the perpendicular at *a* from the middle of the base (*e*), *plus*, half the base, makes up (C *a*) half the chord C H. Double this, and we have the whole chord C H, which is made up of twice the distance from *a* to the middle of the base, and twice the half of the base *e*. Twice the half, is equal to the whole base *e*. Therefore subtracting the base *e* from the chord C H, the remainder (B H) is twice the distance of the perpendicular at *a* from the middle of the base.

§ *c*. The two sides C B, B E of the triangle E B C, are the base (*e*), and the sum of the two sides (*b* & *c*) of the proposed triangle. And the two sides B R, B H of the triangle H B R, are the difference between those sides (*b* & *c*,) and twice the distance (§ *b*.) from the perpendicular to the middle of the base (*e*). These two triangles (E B C & H B R) (§ 23. § *b*.) are similar; for the vertical angles E B C & H B R (§ 27.) are equal; and H C E = H R E (§ 59. § *d*.), they stand upon the same arc (H E); and the remaining angles C E R, C H R, (§ 32. § *e*.) are equal. Therefore (§ 73.) the homologous sides of these two similar triangles are proportional; that is, C B : B R :: B E : B H; or, $e : b \backsim c :: b + c :$ twice the distance of the perpendicular at *a* from the middle of the base.

§ *d*. Scholium. Then if the distance of the perpendicular from the middle of the base be added to *half* the base, the sum will be the greater segment (C *a*); or, if it be subtracted, the difference will be the smaller segment (B *a*) (§ 77. § *h*.).

§ *e*. The distance of each angle from the perpendicular are the segments of the base.

LOGARITHMS.

LOGARITHMS.

§ 80. The purpose of logarithms is to facilitate arithmetical calculations. The term is derived from two Greek words (*logos* and *arithmos*), and may rightly be called the language of numbers; for by means of logarithms, not only multiplication and division, but also the tedious operations of involving powers, extracting roots, etc., are simplified. They are performed by the simple process of addition and subtraction, multiplication and division.

§ *a.* Through the intervention of logarithms, angular and linear magnitudes are compared with each other, as quantities of the same denomination are in common arithmetic; and the unknown value of a line, arc, or an angle, may be deduced from the known ratio between other lines and angles.

§ *b.* Before the invention of Lord Napier had introduced into mathematical calculations the use of logarithms, the solution of trigonometrical problems was referred to synthesis, and obtained by construction. The process of finding the value of unknown quantities in trigonometry was tedious; and the result, owing to the mechanical manner in which the operation was conducted, was subject to partial inaccuracies.

§ *c.* If the logarithms that correspond to a series of numbers in geometrical progression, be taken out and noted down, they will be found to constitute another series of numbers in arithmetical progression. And if two series of numbers be arranged, one in the order of geometrical progression (the first term of which shall be unity or 1, and the common ratio 10), and the other in the order of arithmetical progression, (the first term of which shall be zero (0), and the common difference 1), these two series will constitute a basis, or the ground work for forming a table of logarithmic numbers, like those most generally used.

§ *d.* By arranging the two series of numbers, the one in geometrical, the other in arithmetical order of progression, thus,

Geometrical progression.		Arithmetical progression.
1	- - - -	0
10	- - - -	1
100	- - - -	2
1000	- - - -	3
10000	- - - -	4
100000	- - - -	5
1000000	- - - -	6
10000000	- - - -	7
100000000	- - - -	8
1000000000	- - - -	9
10000000000	- - - -	10,

the relation and connexion between the orders of the two series will appear. The terms in the order of arithmetical progression, are the logarithms of those in the geometrical order: each the logarithm of the term to which it is opposite; *i. e.*, 0 is the logarithm of 1; the logarithm of 10 is 1, of 100 is 2, of 1000 is 3, of 10,000 is 4, and of 100,000 it is 5, etc.

§ *e.* By observing the different relations which exist between the terms in the two series above, it appears,—

1st. That the logarithm of any whole number has for its index the figure, which expresses the number of digits, *minus one*, that are in the natural number for which the logarithm is required. Thus 1 is the logarithmic index of 10, which has two digits; 2 is the logarithmic index of 100, which has 3 digits; 3 of 1000; 4 of 10,000, etc.

2d. That the logarithm of any number intervening between 1 and 10, must be a fraction less than unity; for the logarithm of 1 is 0, and of 10 it is 1; then the logarithm of any number between 1 and 10 must be less than 1. The logarithm that corresponds to any number between 10 and 100, must be greater than 1 and less than 2, etc.

3d. That the product of any two numbers in the series of geometrical progression, answers to the sum of the two numbers in the arithmetical order, which correspond to them. Thus; 100,000,000 in the geometrical, answers to 8 in the arithmetical order, and 100,000,000 is the product of $1000 \times 100,000$, which two numbers correspond with 3 and 5 in the arithmetical series; and in this series $3 + 5$, or $8 = 100,000,000$ in the geometrical series. Now 3 is the logarithm of 1000, and 5 of 100,000. Hence, therefore, if the logarithms of any quantities whose product is required, be added together, this sum will be the logarithm of the required product.

4th. That the difference (4) between any two numbers (2—6) in the series of the arithmetical order of progression, is the logarithm of the quotient (10,000) which arises from dividing by each other, the two numbers ($1,000,000 \div 100$) that correspond, in the geometrical order, to the two said arithmetical terms (2 and 6). And,

5th. That logarithms of numbers are a series of terms in the order of arithmetical progression, which series corresponds to another series of numbers in the order of geometrical progression.

§ *f.* The logarithm of 10 is not necessarily 1. Any other number as well as 1 may be assumed as the logarithm of 10. But if any other number were taken as the logarithm of 10, it would establish another base for calculating a table of logarithms, and this change would effect the logarithm of every other number in the same ratio. From this it appears that the value of a logarithm is entirely conventional. But in order to simplify, and facilitate their application to practice, mathematicians have assumed, in the order of geometrical progression, a series of numbers in the ratio of 1, 10, 100, 1000, 10,000, etc.; and as logarithms to these, they have assigned, in arithmetical progression, a series of numbers in the order of 0, 1, 2, 3, 4, etc., having 1 for the common difference. The latter numbers, taken in the order in which they stand, are called the logarithmic *indices*, or *characteristics*, of the former, taken in the same order. Whence (§ *e*. 1st) the logarithmic index of every whole number, is made always to express *one less* than the number of digits contained in the whole number. Thus, the characteristic of 100 is 2, as the number of digits or figures in 100, is 3. The number of digits in 1000 is 4, and the logarithmic characteristic of 1000, is 3.

§ *g*. The logarithmic signs and tangents, co-sines and co-tangents, etc. of degrees, minutes, and seconds, are also of conventional value. They are expressed in parts of the radius of a circle; the value of which radius is assumed to be equal to 10,000,000, etc., with as many ciphers affixed as the compiler intends the *mantissa* shall consist of digits.

§ *h*. The *mantissa* is the decimal part of a logarithm; or the part which is not the index. The logarithm of 250 is 2 .397940; 2 is the index, and .397940 is the mantissa.

§ 81. The characteristic of a logarithm depends upon the number of digits which are contained in its *geometrical* * number; being one less than the number of digits, it is known by counting the figures of the geometrical number, and writing down one less than their number for the index.

§ 82. The mantissæ have been previously calculated and arranged in a tabular form, and in such a manner that the mantissa for any geometric number, (however great or small), may be determined with readiness.

§ 83. The first column of the tables (I.) is marked N. (Numbers.) It contains the geometrical numbers, from 1 to 999. The mantissa of each term in this series, is in a line with its geometrical number, and in the next column which is marked 0. The nine other columns, headed with the cardinal numbers 1, 2, 3, etc., to 9, also contain mantissæ; but these are of geometrical numbers that have *four* digits; the last figure of which, being found at the head of one of these columns, and the three first in the first column (N), show at their angle of meeting, the proper mantissa. Thus, the logarithm of 3681 is 3.565966; 368 being found in the first column, N., the mantissa for 3681 is found in a line with 368, and in the column, at the top and bottom of which, stands 1.

§ 84. To take from the table (I.) the mantissa for any geometrical number less than 1000.

§ *a*. Find the given number in the first column (N.); its mantissa is opposite to it in the next column (0).

§ *b*. The mantissa for 9 is .954243; for 14 it is .146128; and for 964 it is .984077.

* The natural numbers, which correspond to, or are represented by, a logarithm, are here called *geometrical* numbers, from their being terms in the geometrical series' of progression. Thus 419, of which 2.622214 is the logarithm, is the *geometrical* number of log. 2.622214.

§ *c*. These mantissæ, with the proper characteristics prefixed, constitute the logarithms of those numbers; thus, logarithm of 9 = 0.954243; of 14 = 1.146128; and of 964 = 2.984077.

§ 85. To take from the tables, the mantissa for any geometrical number that is greater than 1000, but less than 10,000.

§ *a*. Find, in the first column (N.) of the tables, the three first figures of the proposed number; in a line with them, and in the column over which the fourth figure stands, is the proper mantissa.

§ *b*. The mantissa (.973590) for 9410 is found in the column marked (0), and opposite to 941 in the first column; and the mantissa (.954918) for 9014, is found in the column marked (4), and opposite to 901 in the first column (N.).

§ *c*. The geometrical numbers in this case have four digits; 3, then, is the characteristic of their logarithms; which are, 3.973590 = 9410; and 3.954918 = 9014.

§ 86. To take from the tables the mantissa of any geometrical number that has more than *four digits*, or that is greater than 10,000; say of 43568.

§ *a*. Take out the mantissa for the four first digits (§ 85. § *b*.), and subtract it from the mantissa next in order. Then say,—If unity (1), prefixed to as many ciphers as there are digits remaining of the proposed geometrical number, give this mantissal difference, what mantissal difference will the remaining digits of the geometrical number, give? This last mantissal difference being added to the mantissa for the four first digits, produces the required mantissa.

§ *b*. The mantissa for the four first digits (4356) of 43568 is .639088; the mantissal difference between this and the next (.639188) in order, is .000100; one digit (8) of the proposed geometrical number remains; and unity (1) (§ *a*.) must be prefixed to one cipher (0), which makes (10); then the order and terms of the proportion are, 10 : .000100 :: 8 : .000080. This last term, *plus* the former mantissa, (or .639088+.000080)=.639168, the mantissa required.

§ *c*. The geometrical number (43568) in this example has *five* digits; then (4) being prefixed as an index to the mantissa (.639168) makes the logarithm of 43568 = 4.639168.

§ *d*. The mantissa for the four first digits (7419) of 741946 is .870345; the difference between the mantissa of 7419, and of 7420, is .000059. And the order and terms of the proportion are, 100 : 000059 :: 46 : .000027. This last term being added, and the characteristic (5) being prefixed to the mantissa (.870345), makes the logarithm of 741946 = 5. 870372.

§ *e*. The mantissa for the four first digits (5941) of 594106734 is .773860; the mantissal difference = .000073; the remaining digits (06734) are *five* in number. Prefixing 1 to *five* ciphers, the proportion is 100000 : 000073 :: 06734 : 000004. Prefixing the characteristic (8) to .773860 + 000004, makes the logarithm of 594106734 = 8.773864.

§ *f*. The mantissa for 124, and the mantissa for 1240000000 are the same (.093422). But the logarithm of 124 = 2.093422; and the logarithm of 1240000000 = 9.093422. Hence,

§ *g*. The effect of final ciphers in a geometrical number, on its logarithm, is confined to the characteristic of the logarithm, for the logs. (§ *f*.) of 124 and 1240000000 have the same mantissa.

§ 87. To find the logarithm of a geometrical number that is mixed with a decimal fraction.

§ *a*. The mantissa is found as it would be, were the proposed number integral; but the characteristic of the logarithm must express one less than the number of digits in the *integral* part of the number proposed. Thus;

Mixed Geometrical Nos.		Their Logarithms.
9414.5	- - -	= 3.973797
941.45	- - -	= 2.973797
94.145	- - -	= 1.973797
9.4145	- -	= 0.973797

§ 88. As the logarithm of unity, or (1), is 0, it follows that the logarithm of any quantity less than unity, or the logarithm of a fraction, must be less than 0; that is, it is a *negative quantity*. Thus,—

Logarithm of	1 =	0	.000000
Logarithm of	0.1 =	—1	+.000000
Logarithm of	80 =	1	.903090
Logarithm of	0.08 =	—2	+.903090

§ *a*. But the use of negative and positive quantities (such as the logarithms of integers and of fractions, as just quoted above), in the same operation, has a tendency sometimes to perplex the calculator. It is better, therefore, that all quantities in the same sum should be affected with like signs. This may be effected with the logarithms of fractions by means of a little artifice, by which negative quantities are made to change their signs, or become as positive quantities.

§ *b*. This artifice consists in borrowing and applying 10, or 20, or 100, etc., to the logarithmic index of the fraction, and restoring the borrowed quantity again during the progress of the calculation. Thus, in the summing up of the logarithms of 80, and of 0.08, instead of adding the mantissæ and subtracting the characteristics of the two logarithms (1.903090 — 2 +.903090 = 0.806180), the operation may be performed entirely by addition, if the arithmetical complement of — 2, which is 8, be used as the index; thus, 1.903090+8+.903090=10.806180; rejecting the 10, which was borrowed in the logarithmic index of 0.08, there remains 0.806180.

§ *c*. Any quantity with the sign (—) prefixed, may be commuted into a positive quantity by substituting for that quantity its *arithmetical* complement. In this way subtraction may be performed by addition, as we have seen (§ *b*.) in the case of the negative index — 2.

§ *d*. The *arithmetical complement* of a number, is the difference between that number, and the first number that ends with a cipher, and is one scale higher in the decimal order of notation. The arithmetical complement of 6, is 4, (10 — 6 = 4); of 77, is 23, (100 — 77 = 23); of 115, is 885, (1000 — 115 = 885), etc.

§ *e*. If it be required to subtract 6 from 9, the result is the same, whether we say 9 — 6 = 3, or take the arithmetical complement (4) of 6, add it to 9, (4 + 9 = 13), and reject the borrowed (10) from their sum (13 — 10 = 3).

§ 89. To find the arithmetical complement of a logarithm.

§ *a*. Prefix (1) to as many ciphers as there are digits in the proposed logarithm; then from this number subtract the proposed logarithm, and the remainder will be the required arithmetical complement.

§ *b*. Thus, the arithmetical complement of 1.903090 is 8.096910; for 10000000.

$$\begin{array}{r} 1.903090 \\ \hline 8.096910 \\ \hline \end{array}$$

§ *c*. The same result may be obtained by beginning at the left, and subtracting from 9, every figure except the last significant one, which must be subtracted from 10.

$$\begin{array}{ll} \text{Thus—} & 9.9999(10)0 \\ & 1.9030\ \ 9\ \ 0 \\ \cline{2-2} & 8.0969\ \ 1\ \ 0 \\ \cline{2-2} \end{array}$$

§ *d*. If the index be greater than 9, it must be subtracted from 19.

§ 90. To find the logarithm of a decimal fraction.

§ *a*. The mantissa for the proposed fraction is taken from the table, as for an integral geometrical number of the same significant figures which the fraction has.

§ *b*. The logarithm for the same figures expressed both integrally and fractionally, differs only in the characteristic; the mantissa is the same in both cases. Therefore we have only to teach how to determine a *positive* characteristic, or the logarithm of a decimal fraction.

§ *c*. The characteristic is determined by means of the number of ciphers which precede the first significant figure of the decimal, for the number of these subtracted from (9), gives the required characteristic.

Thus, logarithm of the decimal .301 = 9.478567
Logarithm of the decimal .0301 = 8.478567
Logarithm of the decimal .000301 = 6.478567

§ 91. To find the logarithm of a vulgar fraction that is less than unity.

§ *a*. Take from the tables the mantissa for the numerator, and for the denominator, separately, and as if each were a whole number expressed by the same figures. Then, from the logarithm of the numerator, *plus* 10 to the index, subtracting the logarithm of the denominator, leaves the logarithm of the proposed fraction. Thus,

§ *b*. To find the logarithm of $\frac{25}{100}$.

$$\begin{aligned}\text{Logarithm of } 25 &= 1.397940\\ \text{Logarithm of } 100 &= 2.000000\\ \hline \text{Logarithm of } \tfrac{25}{100} &= 9.397940\end{aligned}$$

To find the logarithm of $\frac{3}{8}$.

$$\begin{aligned}\text{Logarithm of } 3 &= 0.477121\\ \text{Logarithm of } 8 &= 0.903090\\ \hline \text{Logarithm of } \tfrac{3}{8} &= 9.574031\end{aligned}$$

§ 92. To find the logarithm of a mixed number.

§ *a*. If the number proposed (9.05) consist of a whole and a decimal fraction, take from the tables the mantissa for the mixed number as if it were a whole, and then prefix the index, *which expresses one less than the number of digits in the integral part* of the mixed number proposed. Thus, the index of the logarithm for 9.05 is 0, and for 90.5 it is 1; the mantissa (.956649) is the same for each number; because it is taken out for the figures (905) as though they stood for a whole number.

Then, the logarithm of 9.05 = 0.956649
The logarithm of 90.5 = 1.956649

§ *b*. But if the proposed mixed number consist partly of a vulgar fraction, let it be reduced to an improper fraction; then find the logarithm of the numerator, and of the denominator, as if they were separately whole numbers; and the remainder of logarithm of the numerator, *minus* logarithm of the denominator, is the required logarithm.

Thus, logarithm $12\frac{2}{3}$ = 1.102663; for $12\frac{2}{3}$ reduced to an improper fraction is $\frac{38}{3}$; and

$$\begin{aligned}\text{Logarithm } 38 &= 1.579784\\ \text{Logarithm } 3 &= 0.477121\\ \hline 1.102663 &= 12\tfrac{2}{3}\end{aligned}$$

§ *c*. The index to the logarithm of an improper fraction, is always a *proper* index; for the numerator, being greater than the denominator of such a fraction, the logarithm of the latter can be subtracted from that of the former, without borrowing 10 in the index.

§ 93. To find the geometrical number which corresponds to a logarithm.

§ *a*. The number of digits in the geometrical number for a logarithm, is known by the characteristic of the logarithm; for 1 added to the *characteristic* tells the number of digits.

§ *b*. Find, in the table, the mantissa of the proposed logarithm. The figures in the first column (N.) being prefixed to the figure that stands at the top of the column in which the mantissa is found, compose the geometrical number that is required.

§ *c*. The geometrical number of log. 3.759214 = 5744.
The geometrical number of log. 2.759214 = 574.4.
The geometrical number of log. 1.759214 = 57.44.
The geometrical number of log. 0.759214 = 5.744.

This mantissa is found in the column (4) of the table, and opposite to 574 in the first column (N.).

§ *d*. Had the index of the logarithm been greater than (3), the number of digits for the geometrical number required, would have been made up by affixing ciphers to the numbers (574 and 4) found above, and opposite to, the mantissa. Thus, the geometrical number for 4.976854 is known (§ *a*.) to consist of *five* digits, because of the index (4). The mantissa (.976854) is found opposite to 948 (in the column N.), and under 1; making up with ciphers, the proper number of digits.

The geometrical number for 4.976854 = 94810
The geometrical number for 5.976854 = 948100
The geometrical number for 6.976854 = 9481000

§ *e*. If the proposed mantissa cannot be found in the tables, take that mantissa in the tables, which, being less, comes nearest to it, and affixing any number of ciphers to the difference between these two mantissæ, divide it by the difference between said tabular mantissa and the one next in order after it; the quotient, being affixed to the numbers opposite to, and at the head of the column of, said least mantissa, comprise the figures of the required geometrical number. The digits for the integral part of the geometrical number are determined by the index of the proposed logarithm (§ *a*.), and the figures which are to the right of these digits, constitute the fractional part of the geometrical number. Thus,

§ *f*. Geometrical number for 4.979744 = 95443.
Geometrical number for 2.979744 = 954.43.
Geometrical number for 0.979744 = 9.5443.

The proposed mantissa (979744) cannot be found in the tables. The difference between the next less (.979730) and the next greater (979776) found in the tables, is 46; and the difference (14) between the less of these two and the proper mantissa being prefixed to any number of ciphers, (14000 - - - -), and divided by the tabular difference (46), gives 3 + to be affixed to the four figures 9544, from which the required digits for the integral part of the geometrical number, are to be separated according to the index of the logarithm proposed.

§ *g*. If the index of the logarithm proposed be an *improper* characteristic, the geometrical number of the logarithm is a decimal fraction. And the difference between this characteristic and (9), tells how many ciphers must intervene between the decimal point (.) and the first significant figure of the fraction. Thus (the indices being *improper*),

The geometrical number for 7.911424 = 0.008155.
The geometrical number for 9.897627 = 0.79.
The geometrical number for 5.698970 = 0.00005.

§ 94. To perform multiplication by logarithms.

§ *a*. Add the logarithms of the factors together; the sum of these is the logarithm of the product. Thus,

§ *b*. To multiply 3 by 4; 20 by 2.5; and .25 by .30.

Logarithm 3	= 0.477121	Logarithm 20	= 1.301030
" 4	= 0.602060	" 2.5	= 0.397940
	1.079181 = 12		1.698970 = 50

Logarithm 0.25	= 9.397940
" 0.30	= 9.477121
	8.875061 = 0.075

§ 95. To perform division by logarithms.

§ *a*. Subtract the logarithm of the divisor from the logarithm of the dividend, the remainder will be the logarithm of the quotient.

§ *b*. To divide 36 by 3; 8941 by 19; 50 by .05; and 82.7 by 70.91.

Log. 36	= 1.556302	Log. 8941	= 3.951386
" 3	= 0.477121	" 19	= 1.278754
	1.079181 = 12.		2.672632 = 470.57+

Log. 50	= 1.698970	Log. 82.7	= 1.917506
" .05	= 8.698970	" 70.91	= 1.850708
	3.000000 = 1000		0.066798 = 1.16+

§ 96. To perform involution by logarithms.

§ *a*. Multiply the logarithm of the proposed geometrical number by the index (§ X.) of the power to be involved; this product will be the logarithm of the required power.

§ *b*. Raise 8^2 17^3 112^4 516^9.

Log. 8	= 0.903090	Log. 17	= 1.230449
	2		3
	1.806180 = 64		3.691347 = 4913

Log. 112	= 2.049218
	4
	8.196872 = 157351936

$$\begin{array}{r} \text{Log. } 516 = 2.712650 \\ 9 \\ \hline 24.413850 = 25932674841320831763087 36 \\ \hline \end{array}$$

§ *c.* If the geometrical number that is proposed to be raised, be a decimal fraction, the difference between the characteristic of the logarithm of the power, and the product of 10 by the index of the power involved, expresses *one* more than the number of ciphers, that must precede the first significant figure of the required power.

§ *d.* To raise $.17^3$ $.05^2$ $.064^5$.

$$\begin{array}{r} \text{Log. } 0.17 = 9.230449 \\ 3 \\ \hline 27.691347 = 0.00491+ \\ \hline \end{array} \qquad \begin{array}{r} \text{Log. } 0.05 = 8.698970 \\ 2 \\ \hline 17.397940 = 0.0025 \\ \hline \end{array}$$

$$\begin{array}{r} \text{Log. } 0.064 = 8.806180 \\ 5 \\ \hline 44.030900 = 0.000001073+ \\ \hline \end{array}$$

§ 97. Evolution is the converse of involution.

§ *a.* To perform evolution by logarithms.

§ *b.* The quotient, obtained by dividing the logarithm of the power proposed, by the exponent (§ XII.) of the root to be extracted, is the logarithm of the root required.

§ *c.* To evolve the square root of 196, the $\sqrt[3]{}$ of 81, and the $\sqrt[7]{}$ of 128.

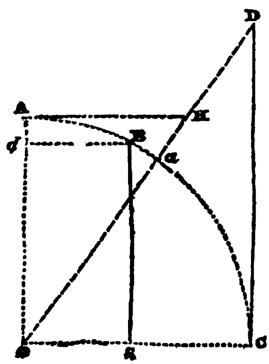
Log. 196 = 2.292256 ÷ 2 = 1.146128 = 14.
Log. 81 = 1.908485 ÷ 3 = 0.636161 + = 4.326+.
Log. 128 = 2.107210 ÷ 7 = 0.301030 = 2.

§ *d.* If the geometrical number whose root is to be evolved, be a decimal fraction, in order to obtain the logarithm of the root required, the exponent, less *one*, of the root to be extracted, must be prefixed to the characteristic of the logarithm of the number proposed; and then the quotient, that arises from dividing this quantity by the exponent of the root to be evolved, will be the logarithm of the power required. Thus, to find the cube root of .27. The logarithmic index of 0.27 is 9; now, to 9, prefixing *one* less (2), than the exponent (3) of the root to be evolved, makes the logarithm of 0.27 = 29.431364 ÷ 3 = 9.810454 + = 0.646+. To find the square root of 0.00776, the logarithmic index of which is (7); prefixing to 7 *one* less (1) than the exponent (2), makes the logarithm of 0.00776 = 17.889862 ÷ 2 = 8.944931 = 0.088 +.

§ 98. In the tables (II.) containing logarithms for sines and co-sines, tangents and co-tangents, the logarithms are calculated from the ratio between the radius and the sine, or the tangent of an arc.

§ *a*. In these tables, as in all others, the logarithmic value of a sine or a tangent is conventional, as are the logarithms of geometrical numbers.

§ *b*. In forming these tables, radius is taken as the base, or the ground work for the calculations; and its value is assumed to be 10.000000. The logarithmic value of the sine of 90°, or of the tangent of 45° (§ 62.), shows that this is the value with which radius enters this system. Wherefore, in every calculation, radius = 10.



§ 99. If an arc of 90°, or if a right angle, be divided into any two parts, the sine or the tangent of either part, is the co-sine or co-tangent of the other. Thus, in the quadrant A B C; A B=30°, B C = 60°, A *a* = 35°, and *a* C = 55°; P B is the sine of A B = 30°, and co-sine of B C = 60°; B S is the sine of 60° (B C), and co-sine of 30° (A B); therefore the co-sine of A B, is B S, which is sine of B C, and the co-sine of B C is B *p*, which is sine of A B. In the same manner A H and C D are reciprocally the tangents and co-tangents of A *a* and *a* C. Wherefore the tables, by being calculated as far as 45°, answer for the whole circle, or for two right angles.

§ 100. The logarithmic value of the sec. of an arc, or an angle, is the arithmetical complement of the logarithmic co-sine of the same arc or angle.

§ *a*. The logarithmic co-sec. is the arithmetical co. of the logarithmic sine, and the logarithmic co-tangent is the arithmetical co. of the logarithmic tangent, and *vice versâ* (Vide § 109. § *h*.).

§ *b*. Wherefore in logarithmic tables of the trigonometric functions, it is only essential that the logarithms of the sine, co-sine, and tangent, or of the sec., co-sec., and co-tangent, should be given, for the first three are the arithmetical co. of the latter, and *vice versâ*; but to facilitate beginners in their calculations, the logarithmic sine, co-sec., co-sine, secant, tangent, and co-tangent, for every degree (°) and minute ('), are given in the tables (II.), as well as for every hour (H), minute (*m*), and four seconds (*s*), of the day.

§ 101. In trigonometrical calculations, when any logarithm is to be subtracted, the proper result may be obtained by adding the arithmetical co. of such logarithm.

§ *a*. This method of changing subtraction into addition is found very convenient in practice. After a little exercise in it, the arithmetical co. of a logarithm may be read from the logarithm, as readily as the logarithm itself is read from the tables.

§ *b*. Wherefore in the solution of trigonometrical problems, subtraction need never be performed, for (§ 101.) instead of subtracting a logarithm, the same result is obtained by substituting, for this logarithm, its arithmetical co., and adding this arithmetical co. in the calculation; therefore (§ 100. § *a.*),

When
- A logarithmic sine of an arc or an angle is to be subtracted, add its co-sec., and *vice versâ.*
- A logarithmic co-sine of an arc or an angle is to be subtracted, add its sec., and *vice versâ.*
- A logarithmic tangent of an arc or an angle is to be subtracted, add its co-tangent, and *vice versâ.*

§ 102. To find in the tables (II.), the logarithmic value of the sine of an arc or an angle.

§ *a.* If the proposed arc or angle be an *extreme* one, the number of *degrees* contained in it, is at the top of the page. But if the one proposed be a *mean* arc or angle, the *degrees* contained in it, are to be found at the *bottom* of the page.

§ *b.* An *extreme* arc or angle is one that contains *less* than 45°, or *more* than 135°. A *mean* arc or angle contains *more* than 45° but *less* than 135°.

§ *c.* If the proposed arc contain *less* than 45° or 3 H, or having more than 90° or 6 H, contain *less* than 135° or 9 H, the odd minutes of it are to be found in the proper minute column at the left of the page. But if it be *greater* than 135° or 9 H, or being greater than 45° or 3 H, contain less than 90° or 6 H, the odd minutes of it are contained in the minute column, that is at the right hand side of the page.

§ *d.* The columns marked at the bottom, Cos., Sec., Sin., Co-sec., Co-tang., and Tang., contain the logarithmic co-sine, secant, sine, co-sec., co-tang., and tang., of the degrees, etc., that are at the *bottom* of the page. And those marked Sin., Co-sec., Cos., Sec., Tang., and Co-tang., at the top, contain the logarithmic sine, co-sec., co-sine, secant, tangent, and co-tangent of the degrees, etc., at the *top* of the page.

§ *e.* To take out of the tables the logarithmic sine of an extreme arc, that is *less* than 45°, say of 34° 40′. The degrees (34°) of the arc proposed being found at the top of the page, and the minutes (40′) in the minute (′) column at the left of the page, the logarithm (9.754960) which, in the column of Sin. stands opposite to the minutes (40′), is the required logarithm. In the same way the logarithmic co-sine, or tangent, etc., is found in its proper column, and opposite to the given minutes.

Co-sine 21° 14′ logarithm = 9.969469.

Tangent 19° 56′ logarithm = 9.559491.

§ *f.* If the arc (179° 7′) proposed be extreme, and greater than 135°, the odd minutes (7′) must be found in the last minute (′) column on the page; the required logarithm (8.187985) is then found opposite, and in the column marked (Sin.) at the top.

§ *g.* The odd minutes of a mean arc, say 61° 12′, that is *less* than 90°, are found in the last minute (′) column; and those of one, say 114° 59′, that is *greater* than 90°, are found in the first minute

(′) column of the page; and the character (Sin., Cos., Co-tang.) of the column is taken from the bottom of the page.

Sine 61° 12′ = 9.942656.

Co-tangent 114° 59′ = 9.668343.

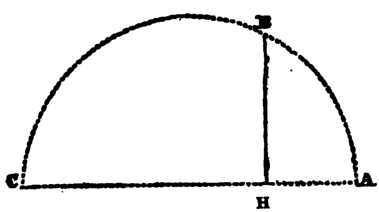
Tangent 114° 59′ = 10.331657.

§ *h*. The trigonometric functions of hours, minutes, and seconds, are taken from the tables in the same way.

§ 103. To find the degs. etc. for a log. sine.

§ *a*. The minutes, in the minute (′) column, which are found opposite to the proposed logarithm, and the degrees, which stand where the column in which the proposed logarithm is found, is marked Sin., are the degrees and minutes required. The same directions answer for taking out the tangent, secant, co-sine, etc., of a logarithm. Thus,

Logarithm 9.627300 sine = 25° 5′ or 154° 55′.
„ 9.956566 cos. = 25° 12′ or 154° 48′.
„ 9.831709 tang. = 34° 10′ or 145° 50′.
„ 9.745494 cos. = 56° 11′ or 123° 49′.
„ 10.377793 tang. = 67° 16′ or 112° 44′.



§ 104. An arc (A B) and its supplement (B C) have the same sine (B H); therefore the same logarithm answers either to the sine of A B or B C. But, for the most part, in calculations, there is some circumstance connected in the operation, which determines whether an arc or its supplement be required. If not, the case or the solution is called *doubtful*. The same remarks apply to co-sines, secants, tangeants, etc.

PLANE TRIGONOMETRY.

PLANE TRIGONOMETRY.

§ 105. Plane trigonometry is that branch of mathematics by which, with certain data, the unknown parts of triangles are determined.

§ *a*. Plane trigonometry is divided into right, and oblique, angled trigonometry. The solution of right angled triangles pertains to the former; and that of oblique angled triangles to the latter. The methods of solving problems in either, in most cases are similar.

§ 106. Every plane triangle consists of three sides and three angles; which, in a general term, are called *the six parts* of a triangle.

§ *a*. If the value of any three of these six parts (the *three* angles excepted), be known, the value of every one of the remaining parts is determinable by trigonometrical operations.

§ *b*. When the angles constitute the only data, the sides cannot bé determined (except in *species*); because there may be any number of triangles which are equiangular to each other, and their homologous sides may all be unequal, as the sides of the two triangles under § 73. are.

§ 107. In order to solve a trigonometric problem, the value of three of five parts, viz., two of the angles and the three sides, must be given, and at least *one* of these three parts must be a side.

§ 108. The several combinations of three, which can be formed of five parts, comprise all the cases that are necessary for solving trigonometric problems.

§ *a*. To one of these every problem in trigonometry resolves itself for solution.

§ *b*. These several combinations are reduced to *five* cases; viz.,

1st, When two sides and the angle which is opposite to either of them, are given:

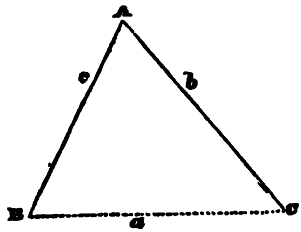
2d, When two angles and the side which subtends either of them, are given:

3d, When two sides and the angle which they contain, are given:

4th, When two angles and the side that is between them, are given:

5th, When the three sides are given.

CASE I.



§ 109. Given the sides (c & b) and the angle (B), that is opposite to (b) one of them:

$c = 450$ yards.
$b = 600$ yards.
B $= 74° 49'$

Required the remaining parts (A, C, & a)?

§ a. First, to find the value of C. By § 74., b : sine B : : c : sine C; and substituting for these given parts (b, c, and C), their values, the proportion is, 600 : sine 74° 49' : : 450 : sine C.

Log. sine of 74° 49' = 9.984569
Logarithm of 450 = 2.653213

12.637782
Logarithm of 600 = 2.778151

Log. sine C = 9.859631 = 46° 22' 15".

§ b. The sum of the two angles B and C (§ 32. § b.) being subtracted from 180°, gives the remaining angle (A) of the proposed triangle A B C. Thus, B + C = 121° 11' 15" — 180° = 58° 48' 45" = A.

§ c. The logarithmic process (§ a.) of finding the value of C, might have been abbreviated, and the operation might have been performed entirely by addition. This abbreviation (§ 101.) consists in using the arithmetical complement of the logarithm of the first term in the order of proportion, in the place of said logarithm. This arithmetical complement, added to the logarithm of the second and third terms, gives the logarithm, (rejecting 10 from the index), of the fourth or required term.

§ d. When one or more logarithms are to be subtracted in the process of a calculation, the operation may be simplyfied (§ 88. § c.) by substituting for such logarithms, their arithmetical complements (§ 88. § e.), and adding these arithmetical complements in the calculation, and then rejecting the borrowed 10 from the index of the sum thus obtained, the remainder is that which would have resulted by adding together the logarithms which were to be added, and then subtracting from their sum, the logarithms which were to be subtracted.

§ e. Hereafter, instead of the logarithm of the first term in the order of proportion being used, its arithmetical complement will be adopted in calculation. This substitution of the arithmetical complement renders the arrangement for calculation uniform; for it changes the process of addition and subtraction, into the simple operation of addition.

§ *f*. Let it be borne in mind that the *arithmetical complement* (§ 88. § *d*.) *of any numerical expression, is obtained, by subtracting the expression proposed from the number which is made by prefixing unity* (1) *to as many cyphers, as there are figures in said expression*. Thus the arithmetical complement of 89 is 11, for 89—100 =11. Or, the arithmetical complement is obtained by beginning at the left, and subtracting each figure from 9 (§ 79. § *c*.), except the last significant figure, which must be subtracted from 10. Thus the arithmetical complement of 9.984569 is 0.015431 (what the former wants of 10.000000), and is obtained thus:

	9.9 9 9 9 9(10)
Logarithm	9.9 8 4 5 6 9
Ar. co.	0.0 1 5 4 3 1

§ *g*. And the arithmetical complement of 3.450000 (§ *f*.) is 6.550000, and is obtained thus:

	9.9(10)0 0 0 0
Logarithm	3.4 5 0 0 0 0
Ar. co.	6.5 5 0 0 0 0

§ *h*. When the logarithmic index of any of the *trigonometric functions exceeds* 9, the arithmetical complement of such index is the difference between itself and 19, (§ 89. § *d*.) and consequently the arithmetical complement is found by subtracting said *index* from 19. Thus the logarithmic tangent of 74° is 10.542504, and its arithmetical complement is 9.457496, which is the co-tang. of 74°.

	1 9.9 9 9 9 9(10)
74° log. tang.	1 0.5 4 2 5 0 4
Ar. co.	9.4 5 7 4 9 6

§ *i*. To find the value of the side *a*; according to § 74, sin. B : *b* : : sin. A : *a*; or, substituting their values, sin. 74° 49′ : 600 : : sin. 58° 48′ 45″ : *a*.

Log. sine 74° 49′ ar. co. = 0.015431 = co-sec. B (§ 100. § *a*.
Logarithm 600 - = 2.778151
Log. sine 58° 48′ 45″ = 9.932208

Log. *a* = 2.725790 = 531.8 yards.

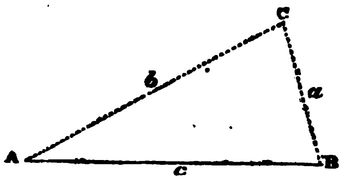
The 10, which was borrowed for the arithmetical complement of the logarithmic sine of 74° 49′, being rejected in the sum, gives 2 for the index of the logarithmic value of *a*.

§ *j*. In the solution of all trigonometric problems by calculation, the *logarithmic* values of the functions employed are always used;

therefore the repetition of the word log. before sine, tangent, etc., will be omitted; and the arithmetical complement of the logarithm of a function or number, is that which is to be understood, and not the arithmetical complement of the number itself.

CASE II.

§ 110. Given two angles (A & C) and the side (c) that subtends one of them.



A = 23° 56′
C = 76° 4′
c = 1760 feet.

To find the other parts (B, a and b),

§ a. The process of solution in this case is a repetition of the methods shown § 109. § b. & § i.; for A + C subtracted from 180° (§ 32. § b.) gives B=80°; and (§ 74.) sine C : c : : sin. A : a : : sin. B : b.

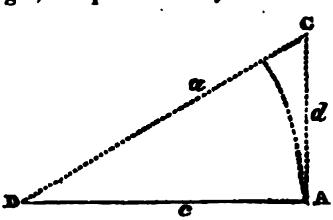
§ b. To find a. Sin. 76° 4′ : 1760 : : sin. 23° 56′ : a.

Sine 76° 4′ ar. co.	= 0.012970=co-sec. C (§ 101. § b.)
Log. 1760	= 3.245513
Sine 23° 56′	= 9.608177
Log. a	= 2.866660=735.6 feet.

§ c. To find b. Sin. 76° 4′ : 1760 : : sin. 80° : b.

Sine 76° 4′ ar. co.	= 0.012970=co-sec. C
Log. 1760	= 3.245513
Sine 80°	= 9.993352
Log. b	= 3.251835=1785.8 feet.

§ d. If, with similar data, the proposed, be a right angled triangle, the problem may be solved as the one above is, by means of the proportion between the sides and sines of opposite angles; or it may be solved by means of the principles involved (§ 75.) in the proportion between the sides and trigonometric functions of a right angled triangle. Thus, the data being,



C=67° 19′
c =1760 feet.

The value of A is known by the rectangularity of the proposed triangle (D A C). To find the other parts (D, d & a),

§ *e*. The third angle (D) is *always* known (§ 32. § *b*.) by subtracting the sum of the two other angles from 180°; A+C — 180° =D, or 22° 41′.

§ *f*. To find the two sides *a* and *d*; making D A radius, the following proportions (§ 75. § *c*.) are deduced, viz.:

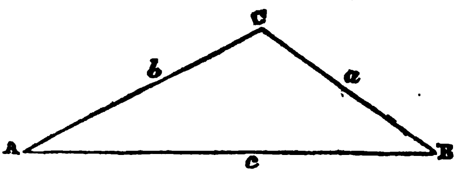
Rad. : *c* : : tang. D : *d*; and Rad. : *c* : : sec. D : *a*.

Radius (*always*, § 98. § *b*.)	=10.000000
c=1760 log.	= 3.245513
D=22° 41′ tang.	= 9.621142
Log. d	= 2.866655=735.6 feet.

Radius	=10.
c=1760 log.	= 3.245513
D=22° 41′ sec.	= 0.034963
Log. a	= 3.280476=1907.5 feet.

CASE III.

§ 111. Given two sides (b & a) and the angle (C) they contain;



b=479 fathoms.
a=419.8 "
C=119° 41′.

To find the other parts (A, B & c),

§ *a*. The solution of this problem is founded upon § 77.

§ *b*. One angle (C) of the proposed triangle being known, the sum of the two other angles (A & B) (§ 32. § *b*.) is obtained by subtracting the given angle from 180°. Thus, 180°—119° 41′=60° 19′, the sum of A & B.

§ *c*. To find the values of A and B; according to § 77., $(b+a)$: tang. $\frac{A+B}{2}$: : $(b \backsim a)$: tang. $\frac{A \backsim B}{2}$. Therefore, by substitution, 898.8 : tang. 30° 9′ 30″ : : 59.2 : tang. $\frac{A \backsim B}{2}$.

$(b+a)$=898.8 log. ar. co.	=7.046337
$(A+B) \div 2$=30° 9′ 30″ tang.	=9.764207
$(b \backsim a)$=59.2 log.	=1.772322
Tang. $\frac{A \backsim B}{2}$	=8.582866=2° 11′ 30″.

Now half the difference (2° 11′ 30″) between A and B, being added to half their sum (30° 9′ 30″) (§ 78. § *h.*), gives B the greater angle; and being subtracted from said half sum, gives A the less angle. Thus 30° 9′ 30″ + 2° 11′ 30″ = 32° 21′, or B; and 30° 9′ 30″ — 2° 11′ 30″ = 27° 58′, or A. A is known to be the less angle (§ 63.), because its subtending side (*a*) is the less of the sides *b* & *a*.

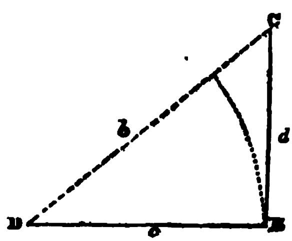
§ *d.* The angles and two sides being known, the value of the third side (*c*) is deducible by means of calculations conducted upon the proportion (§ 74.) between the sides and sines of the angles of plane triangles.

§ *e.* To find *c*. Sin. B : *b* : : sin. C : *c*.

B = 32° 21′ sin. ar. co. = 0.271573 = co-sec. B (§ 100. § *a.*)
b = 479 faths. log. = 2.680336
C = 119° 41′ sin. = 9.938908 (§ 102. § *g.*)

Log. *c* = 2.890817 = 777.7 faths.

§ *f.* If the problem comprise a right angle triangle, with similar data, the process of solving it is much more simple. For the two legs and the right angle being the given parts, the calculations for determining the unknown parts, are founded upon the relations of the sides and trigonometric functions of a right angled triangle, as they are shown § 75.



§ *g.* In the proposed triangle (D B C), right angled at B, the values of the legs, are;

c = 479 faths.; and *d* = 419.8 faths.; to find the other parts.

§ *h.* Making either leg (*c*) radius, (§ 75. § *c.*) the terms and order of the proportion for finding the value of D, are, *c* : rad. : : *d* : tang. D. And for finding the hypothenuse (*b*) they are, rad. : *c* : : sec. D : *b*.

§ *i.* To find D.

c = 479. Log. ar. co. = 7.319664
Radius - - = 10.
d = 419.8 log. = 2.623042

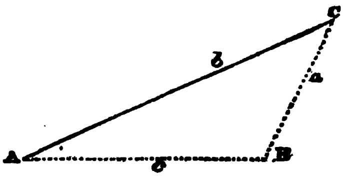
Tang. D = 9.942706 = 41° 13′ 53″

§ *j.* To find *b*.

Radius - = 10.
c = 479 log. = 2.680336
D = 41° 13′ 53″ sec. = 0.123777

Log. *b* = 2.804113 = 636.9 faths.

CASE IV.



§ 112. Given two angles (A & C) and the side (b) between them;

A=26° 1′
C=38° 49′
b=179 chains,

To find the values of the other parts (B, c & a) of the proposed triangle (A B C).

§ a. Two angles being known, the third (B) (§ 32. § b.) is also known; it is B=115° 10′.

§ b. The remaining unknown parts (a & c) of this triangle, are determined by means of the principles involved in the solution of the problem under Case 2. The process of operation in the solution of this, is precisely similar to that of § 109. § i. under Case 1. In the method of their solution, Cases 1, 2, and 4, are only repetitions of each other. For whenever two angles of a triangle are given, the third is also known (§ 32. § b.); and whenever an angle and its subtending side are two of the known parts, the required parts are determinable through calculations conducted upon the proportion (§ 74.) which exists between the sides and sines of angles in all triangles.

§ c. To find the value of a. Sin B : b :: sin. A : a.

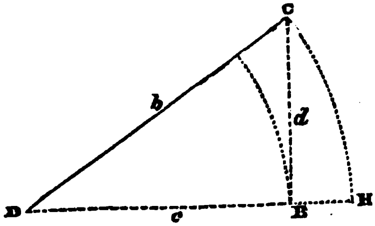
B=115° 10′, sin. ar. co.=0.043316=co-sec. B (§ 101. § b.)
b=179 chains log. =2.252853
A=26° 1′, sin. =9.642101

Log. a =1.938270=86.7 chains.

§ d. To find the value of c. Sin. B : b :: sin. C : c.

B = 115° 10′ co-sec. = 0.043316
b = 179 chains log. = 2.252853
C = 38° 49′ sin. - = 9.797150

Log. c = 2.093319 = 123.9 chains.



§ e. Transferring the conditions of this problem to one in right angled trigonometry, the use of sines may be retained in the calculation for determining the unknown parts (c & d); for by making the given side (b), radius to an arc (C H), the two legs of the proposed triangle (D B C) become (§ 75. § a.) sine and co-sine to the acute angles (D & C);

and (§ 75. § *b*.) rad. : *b* :: sin. D : *d* :: co-sine D : *c*. The parts given are D = 26° 1′, and *b* = 179 chains.

§ *f*. To find the values of *c* and *d*.

Radius	- -	= 10.
b = 179.	log. =	2.252853
D = 26° 1′	sin. =	9.642101
	Log. *d* =	1.894954=78.5 chs.

	Radius	= 10.
b=179	log.	= 2.252853
D=26° 1′	cos.	= 9.953599
	Log. *c*	= 2.206452 = 160.8 chains.

§ *g*. The same result may be obtained by making a radius of either leg (*c*), and introducing different trigonometric functions into calculation, upon the principles shown under § 75. § *c*. Thus; sec. D : *b* :: radius : *c* :: tang. D : *d*.

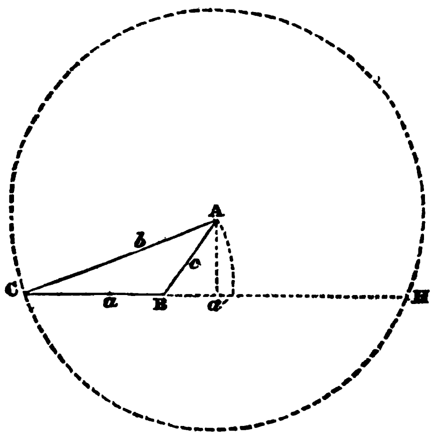
§ *h*. To find *c* and *d* by this method of calculation:

D = 26° 1′	sec. (ar. co.)	= 9.953599=cos. D (§101. § *b*.)
b = 179 chains	log.	= 2.252853
Radius	- - -	= 10.
	Log. *c*	= 2.206452=160.8 chains.

D=26° 1′	cos. (§ 101. § *b*.)	= 9.953599
b=179 chains	log.	= 2.252853
D=26° 1′	tang.	= 9.688502
	Log. *d*	= 1.894954 = 78.5 chains.

§ *i*. The use of sine and co-sine as functions in plane trigonometrical calculations, being more convenient than that of other functions, the former (§ *f*.) is generally preferable to the latter method (§ *h*.) of solving problems.

CASE V.



§ 113. Given the three sides (B C, b, c)

B C = 144 chains.

b = 220 chains.

c = 103 chains.

To find the angles (C, A & B)

§ a. Here is the application to practice of the principles involved in § 79. And in order to determine the value of any one (C) of these angles by calculation, the distance ($a\,a'$) from the middle (a) of the base (C B), to the perpendicular (A a') upon it, must be found by means of the proportion, (§ 79.) the base B C : $b \backsim c$ :: $b+c$: 2 $a\,a'$. Then either of the segments (C a') is found (§ 79. § d.) by applying (C a) half the base (C B) to ($a\,a'$) the distance of the perpendicular at a' from the middle of the base. This segment (C a'), the perpendicular (A a'), and the side (b), adjacent to the required angle (C), form a right angled triangle (C A a'); of which are known the hypothenuse (b) and a leg (C a').

§ b. The value of the required angle (C) is then found according to the principles established under § 75. For by making the hypothenuse (C A) radius, the segment (C a') becomes co-sine to the required angle (C); the value of which may then be determined (§ 75. § b) by means of the proportion, b : radius :: C a' : cos. C.

§ c. Knowing the value of any one (C) of the angles, either of the others (A) may then be determined by means of calculations conducted upon the proportion (§ 74.) of the sides of triangles to the sines of their opposite angles. And the remaining angle (B) (§ 32. § b.) is determinable by subtraction.

§ d. To find the value of the angle C.

1st. Call C B the base, in order to find twice the distance ($a\,a'$) from the middle of the base, to a perpendicular drawn upon the base, from its opposite angle (A) (§ 79.). Twice the length of this distance ($a\,a'$) is evolved by the proportion; C B : $b \backsim c$ :: $b+c$: 2 $a\,a'$.

C B=144, log. ar. co.=7.841637

$b \backsim c$=117. log. =2.068186

$b+c$=323. log. =2.509203

Log. 2 $a\,a'$ =2.419026=262.4

2d. To find the greater segment C a'. One half of 262.4 ($2\,a\,a'$) is equal to the distance ($a\,a'$) of the perpendicular from the middle of the base; and (§ 79. § *d.*) $a\,a' + \frac{B\,C}{2} = C\,a'$. Therefore, $131.2 + 72 = C\,a' = 203.2$.

§ *e.* If twice the distance ($a\,a'$) of the perpendicular from the middle of the base be *greater* than the base, the perpendicular falls *without* the triangle, as in the case before us. But if it be *less* than the base, the perpendicular falls *within* the triangle.

To find the value of C. According to § *b.* we have, b : rad. :: C a' : cos. C.

$b=220$.	log. ar. co.=	7.657577
Radius		=10.
C $a'=203.2$	log. =	2.307924
	Cos. C=	9.965501=22° 32′ 11″

§ *f.* To find the value of A (§ *c.*) we have, c : sin. C :: B C : sin. A.

$c=103$.	log. ar. co.=	7.987163
C=22° 32′ 11″	sine=	9.583504
B C=144.	log. =	2.158363
	Sine A =	9.729030=32° 24′ 2″

§ *g.* To find the value of B. According to § 32. § *b.* C+A—180°=B; therefore B=125° 3′ 47″.

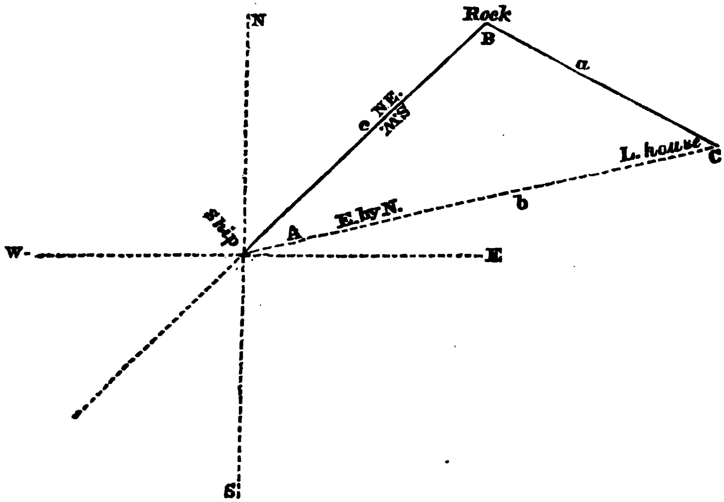
§ *h.* If, when the perpendicular falls *without* the triangle, the obtuse angle (B) be the first part required, the side (c) adjacent to it becomes hypothenuse to the right angled triangle, of which, the perpendicular to the base and the smaller segment (B a') of the base, are legs, and the supplement (A B a') of the required angle (B) is that which is evolved from the proportion (§ *b.*), c : rad. :: B a' : cos. A B a'.

EXAMPLE I.

§ 114. A rock is seven miles from a light-house, and a ship, having the light-house to bear E. by N., is nine miles S. W. of the rock; What is the distance between the ship and the light-house?

Ans. 12.4 miles.

§ *a.* The solution of this problem is conducted after the methods shown under § *a.* and § *i.* (§ 109.) The parts given are the sides a and c, and the angle (A) contained at the ship, between the bearing of the rock and light-house. The value of A is known by converting into degrees, etc., the points contained between the bear-



ing of the rock and light-house, from the ship. The rock bears N. E., and the light-house E. by N. from the ship. Three points intervene between E. by N. and N. E., and each point contains 11° 15′; therefore the angle (A) contained between the lines of these bearings is 11° 15′×3, or 33° 45′.

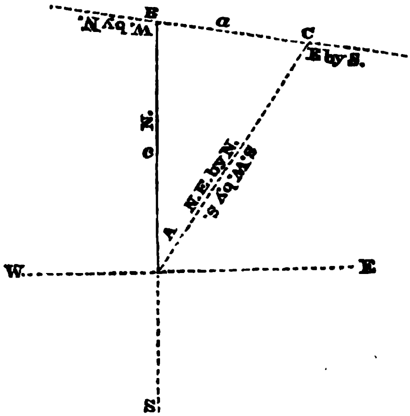
§ *b*. Unless the problem were embraced in a right angled triangle, the value of C must be found, and B known (§ 32. § *b*.) before that of *b* is determined. C is found (§ 109. § *b*.) from the proportion (§ 74.) which exists between certain parts of every triangle; viz., a : sin. A : : c : sin. C. Then C+A—180°=B; and then, sin. C : c : : sin. B : b, affords the solution required.

EXAMPLE II.

§ 115. A ship was steering N. and sailing 10 knots per hour; she made a point of land bearing N. E. by N.; two hours afterwards the same point bears E .by S. What is the distance of it from the ship?

Ans. 12.+miles.

§ *a*. The solution of this problem depends upon the principles which Example 1 involves. The angle (A) between the point of land and the ship's course is three points, or 33° 45′. The angle (C) between the bearing of the ship from the point of land at each station, is six points, or 67° 30′. And the angle (B) between the second bearing of the land and the line upon which the ship sailed,

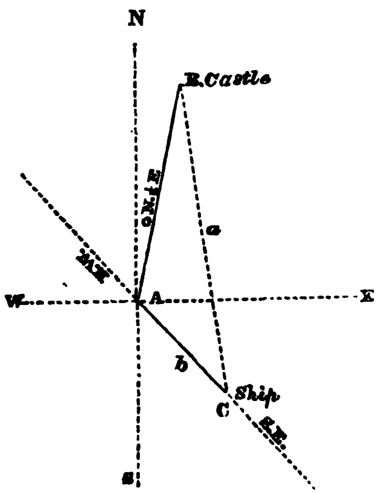


is seven points, or 78° 45′; or it is A+C—180=78° 45′. Then the proportion of sin. C : c : : sin. A : a, determines the value of the part required.

EXAMPLE III.

§ 116. Several boats, intending to cut a ship out from under the guns of a castle, wish to know how far she is off from the castle, which bears N. ½ E. 917 fathoms from a watch-tower, that is 491 fathoms N. W. from the ship.

Ans. 1285.7 fathoms.



§ *a*. The solution of this problem involves in it the principles demonstrated § 77, by which either angle (B or C) is found; and then the length of the required side (a) is determined by the ratio between the sides and sines of opposite angles.

§ *b*. The parts given are, the distances (b & c) of the watch-tower (A) from the ship and castle, and the angle (A) contained at the watch-tower between the lines of bearing from it to the castle and ship. The angle (A) at the watchtowr contains $11\frac{1}{4}$ points, or 129° 22′ 30″. The sum of the angles B and C is found by subtracting A (§ 32.) from 180°. And half their difference is determined by the proportion (§ 77.), $b+c$: tangent $\frac{B+C}{2}$ :: $b \backsim c$: tang. $\frac{B \backsim C}{2}$.

§ *c*. The value of B and of C is then known by § 77. § *h*.; and the solution completed by evolving the value of *a* from the proportion,—sin. C : *c* :: sin. A : *a*.

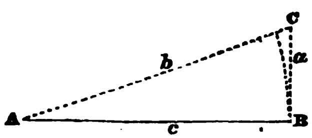
EXAMPLE IV.

§ 117. Wishing to know the height of a Chinese pagoda that stood in a plane, I took the altitude of the sun from an artificial horizon, and at the same time the length of the shadow cast by the pagoda was marked and measured.

The sun's corrected altitude was 21° 10′.

The length of the shadow 347 feet.

Ans. Height of pagoda 134.3 feet.



§ *a*. The pagoda is supposed to stand upright. The angle (A) which is formed at the end of the shadow by an imaginary line drawn thence to the top of the pagoda, is 21° 10′, or whatever be the altitude of the body which causes the shadow. The solution of this problem may be conducted according to the principles shown § 75. § *c*.

§ *b*. The parts given are the length (*c*) of the shadow, the angles A and B. The latter is known from the primitive condition of the triangle, which is right angled.

§ *c*. Making the given leg radius, the other leg (*a*) or height of the pagoda, becomes tangent to the angle (A) of altitude. The value of the required part (*a*) is evolved by means of the proportion, rad. : *c* :: tang. A : *a*.

EXAMPLE V.

§ 118. A road crosses a mountain, the base of which is nine miles across. The distance from the foot to the top of the mountain, is 4.5 miles on one side, and 5.3 on the other.

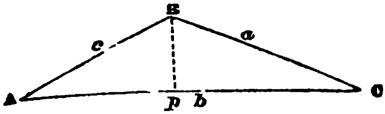
What is the angular ascent of the road on each side of the mountain, and how high is the top above the base?

Ans. Angle of ascent on one side=31° 32′.

Angle of ascent on the other=26° 37′.

Height of the mountain 1.94 miles.

§ *a*. This problem involves in the solution of it, the principles demonstrated § 79. and § 75. The parts given are the three sides (a, b, c).



§ *b*. The operation for finding the ascent of the road, or the angles A and C, is a repetition of the method shown in Case 5, §113, for finding C and B. B p, the perpendicular upon the base (b) of the mountain, shows its height; the value of it is determined (§ 75.) after the angles A & C are determined. $AC : c \backsim a :: c+a : 2pb$; and (§ 79. § *d.*) $pb + \frac{AC}{2} = pC$; and (§ 75. § *b.*) $a : \text{rad.} :: pC : \cos. C$; and (§ 74.) $c : \sin. C :: a : \sin. A$; and $\text{rad.} : a :: \sin. C : Bp$.

EXAMPLE VI.

Wishing to ascertain the breadth of a river, I observed that a cocoa-nut tree, which stood at the water's edge on the opposite bank, bore west of me; then after having walked due south 194 yards, the same tree bore N. W.

How wide was the river?

Ans. 194 yards.

EXAMPLE VII.

Wishing to know the height of a mountain in South America, on the morning of the 22d December, 1832, between eight and nine o'clock, I measured with a sextant the altitude of the sun above the top of the mountain; it was 19° 40′ 15″. The apparent altitude of the sun, measured at the same time from an artificial horizon, was 41° 47′ 45″. Then going from the mountain, I measured 4420 fathoms, and the next day, when the top of the mountain was again in the plane of the sun's azimuth circle, the sun's altitude above the top of the mountain, and from an artificial horizon taken as before, was, from the horizon = 40° 21′ 30″, above the mountain = 25° 14′

What is its height?

Ans. 3564.1 fathoms, or 21384 feet 7 inches.

EXAMPLE VIII.

Supposing that a ray of light is not refrangible, that the earth is a perfect sphere, that its diameter is 7924 miles, and that the height of Chimborazo is 21384 feet, How far can the top of this mountain be seen from the surface of the earth?

* The mean diameter of the earth is about 7923.57 miles.

SPHERICS.

SPHERICS.

§ 119. Spherical Trigonometry is one of the principal branches upon which the science of navigation is founded. The solution of all problems for finding latitude, longitude, variation, etc., from data obtained by means of observations made upon celestial objects, depends upon the principles of spherical trigonometry.

§ *a*. As the figure of the earth is an approximation to that of a sphere, the whole science of navigation, properly speaking, is based upon the doctrines of the sphere.

§ 120. The figure of a *sphere* may be generated by the revolution of a semicircle about its diameter, as an axis. A perfectly round globe or ball is a sphere.

§ 121. Trigonometrically speaking, all lines upon a sphere are curved lines. These lines are either circles, or arcs of circles. Circles are either *great* or *small.*

§ 122. A *great circle* is concentric with the sphere.

§ *a*. The shortest distance between two points on a plane (§ 3.) is the straight line that joins them; and the shortest distance on a sphere, between two points, is the arc of a great circle, that joins them.

§ *b*. Every great circle has two *poles.*

§ 123. The *poles* of a great circle are two points on the surface of a sphere, that are diametrically opposite to each other, and are equidistant from all points at the circumference of their circle. Consequently each pole is 90° from the circumference of its circle.

§ *a*. The north and south poles are the poles of the equator. The equator is 90° from either pole.

§ 124. The straight line, which, passing through the centre of a great circle, joins its poles, is the *axis* of that circle.

§ 125. All great circles cross each other in points diametrically opposite. Therefore,

§ *a*. Two great circles cannot be parallel; but they divide each other into arcs of 180° each.

§ *b*. The space contained between the intersecting halves of two great circles, is called a *lune.*

§ 126. One great circle is perpendicular to another, when the two cross each other at right angles.

§ *a*. When two great circles cut each other at right angles, the axis of either lies along the plane of the other; and they pass through the poles of each other.

§ 127. A *secondary* is a great circle that crosses another, perpendicularly.

§ *a.* A meridian of longitude is secondary to the equator.

§ 128. Every great circle divides its sphere into two equal parts, as the Equator does the earth.

§ 129. A *small circle* divides the sphere into two unequal parts; as the Tropic of Cancer, or of Capricorn, or as a parallel of latitude, does the earth.

§ *a.* If every point at the circumference of a small circle be equidistant from either pole of a great circle, the small is parallel to the great circle.

§ *b.* The centre of a small circle is in the axis of the great circle to which it is parallel.

§ 130. The radius of a small circle, is the sine of the arc intercepted between its circumference and the pole of the great circle, to which it is parallel.

§ *a.* The radius of a parallel of latitude is the co-sine of its own latitude.

§ 131. All spheric, like all rectilineal, angles, are either acute right, or obtuse; and their values are expressed under the same denominations of degrees (°), minutes (′), and seconds (″).

§ 132. Two arcs of great circles, like two straight lines, (§ 25 & § 27.) that cross each other, make the vertically opposite angles equal to each other, the two angles that are on the same side of either, equal to two right angles, and the four angles together equal to four right angles.

§ 133. A spherical angle is at the pole of the circle, upon which it is measured.

§ *a.* And the arc of this circle, which is intercepted between the two arcs forming the angle, is its measure.

§ *b.* The two circles which form an angle are secondaries (§ 127.) to that upon which the angle is measured.

§ *c.* This circle (§ 126. § *a.*) passes through the poles of its secondaries.

§ *d.* The distance between the poles of two great circles that form an angle with each other, measures that angle.

§ 134. Every spherical, like every plane triangle, has three sides and three angles, and any two of the former are greater than the third.

§ 135. The sides of a spherical triangle are arcs of circles. Their values are *always* expressed in degrees (°), minutes (′), and seconds (″).

§ 136. Plane triangles are unlimited as to the value of their sides; the sum of the three sides of a spherical triangle is less than 360°. For if two arcs that form an angle be each 180°, they will intersect each other (§ 125.) in another point, that is diametrically opposite to their angular point; then, if a third arc cross these two, it will divide the lune (§ 125. § *b.*) into two triangles, and be a side to each. This third side is less (§ 134.) than the sum of the two other sides of either triangle, and the sum of these four sides, by supposition, is two semicircles, or equal to 360°; therefore the sum of the two sides of either triangle plus the third side is *less* than 360°; and so with any spherical triangle.

§ *a*. The minimum of the sides of a spherical triangle is without limits.

§ 137. The sum of the angles of a plane triangle is equal to two right angles; the sum of the angles of a spherical triangle, in all cases, is greater than two, but less than six, right angles.

§ *a*. The exterior angle of a spherical triangle (§ 132.), therefore is not, as in a plane triangle, necessarily equal to the sum of the two remote interior angles of the triangle.

§ *b*. Most of the other propositions of elementary geometry which show the ratio, relations, or equality between the parts of plane triangles, are likewise applicable to spherical triangles.

§ 138. Two angles, or two legs, of a spherical triangle, are *alike*, or of the *same affection*, when both of them are either acute or obtuse.

§ 139. In spherical, as in plane triangles (§ 63.), the greatest side and angle subtend each other; so also do the mean and least.

§ *a*. An angle and its opposite side are not always of the same affection.

§ 140. Spherical, besides being, as plane triangles, divided into equilateral, isosceles, and scalene, are either right angled, quadrantal, or oblique.

§ 141. A *right angled spherical triangle* has one right angle.

§ *a*. The side subtending the right angle is the hypothenuse; but it is not, as in a plane triangle, necessarily the greatest side.

§ *b*. If the hypothenuse be less than 90°, the legs are of the same affection; and the oblique angles also.

§ *c*. If the hypothenuse be greater then 90° the legs are unlike, and the oblique angles also.

§ *d*. A leg of a right angled spherical triangle, and its opposite angle, are always of the same affection.

§ 142. A *quadrantal triangle* has a side that is a quadrant, or 90°.

§ 143. An *oblique spherical triangle* has neither a side, nor an angle of 90°.

§ 144. In plane triangles, the sides, and the sines of their opposite angles, have the same ratio to each other; in spherical triangles, the sines of the opposite sides and angles are proportional.

§ 145. In plane triangles (§ 107.), one side, at least, must be among the three parts that constitute the data necessary for finding the other parts; in spherical triangles any three parts are data sufficient for determining the other parts. Therefore—

§ 146. In spherical trigonometry, the three sides of a triangle can be determined by having the three angles as data; and the reverse.

§ 147. For the purpose of facilitating, by logarithmic calculation, the solution of problems in spherical trigonometry that are included in oblique triangles, spherical trigonometry is here divided into right and oblique angled trigonometry.

§ *a.* All the problems that come under the several cases, two excepted, of oblique spherical trigonometry, may be solved by reducing them to analagous cases in right angled trigonometry; this is done by means of drawing a perpendicular from an angle upon its subtending side, of the proposed triangle, and from such an angle, that the proposed oblique triangle will be divided into two right angled triangles, one of which shall contain two of the parts given in the problem.

§ 148. Every problem in oblique trigonometry may be solved without the direct intervention of a perpendicular, and of right angled triangles.

§ *a.* The process of calculation is shortened by solving the problems without conducting the operation upon the principles of right angled triangles. For this reason spherical trigonometry is here divided into right and oblique trigonometry.

§ 149. Problems comprising as data the three angles, or the three sides of an oblique triangle, do not admit of the intervention of right angles for determining the unknown parts; because, in neither case can a perpendicular be so drawn in the proposed triangle, that two of the given parts will fall in either of the right angled triangles, or on either side of the perpendicular.

§ 150. By some, problems that depend upon quadrantal triangles, are included in a separate division of spherical trigonometry, called "quadrantal trigonometry." But knowing three parts, the other three of a quadrantal triangle may be determined by the rules for finding with similar data, like parts that are unknown in a right angled triangle.

§ *a.* In arranging for calculation the trigonometric functions of the parts in a problem included in a quadrantal triangle, the legs must be called *angles*, and their adjacent angles, *legs;* the *supplement* of the angle that subtends the quadrantal side, must be called the *hypothenuse*, and the quadrantal side, *radius*.

§ 151. The side and angle that are opposite in a quadrantal triangle, are of the same affection.

§ 152. The relations between the parts of a triangle in plane, and the parts of a triangle in spherical, trigonometry, are similar; and the formulæ for the solution of problems in the one, are analogous to the formulæ for the solution of similar problems in the other.

§ *a.* As much, with regard to the sides, can be determined from the three angles of a plane triangle, as can be determined from the three angles of a spherical triangle. In the former case, the triangle can be determined in *species;* and in the latter, the sides are determined in degrees and minutes of arcs, which arcs, in *absolute* length, may be infinitely great or small. And the number of miles, or of any units of a positive quantity, contained by any one of these arcs, depends upon the relations of other quantities to it, and not at all upon the relations between it and the other parts of its triangle.

§ *b.* In order then to arrive at absolute values for the sides and angles of a triangle which are submitted for calculation, a third quantity, that will answer the purpose of a common measure for lines and angles, or arcs, must be brought into consideration.

§ c. And this common measure is the *radius* of a circle. When we say that a side of a spherical triangle is an arc containing a certain number of degrees and minutes, we have no reference to the *absolute* length of this arc, or to the number of inches, or fathoms, or miles, contained in it. It may be an arc whose radius is infinitely great or small. But if the length of its radius in inches, or miles, be known, the *absolute* length of the arc also in the denominations of the same dimensions is determinable. But this belongs to another branch of mathematics, which is not relevant to the purposes for which this treatise is designed.

§ 153. The analogy between the formulæ for the solution of problems of like data and quæsita in plane and spherical trigonometry, grows out of the resemblance between the parts of a plane and a spherical triangle.

§ *a*. Suppose that the sides of a spherical triangle should remain of the same *absolute* length, and that the radius of their sphere be increased *ad infinitum*. The angles at the centre of the sphere, which these sides subtend, and the number of degrees contained in these sides, or arcs, will be decreased until they reach the *ultimatum*, when the surface included by these three sides becomes a plane, the triangle a plane triangle, and a *finite* portion of infinity.

RIGHT ANGLED SPHERICAL TRIGONOMETRY.

§ 154. In the trigonometrical solution of right angled spherical triangles, there are *five parts*, (three sides and two angles,) any one of which may be the unknown and required part of the problem.

§ *a*. The right angle is ever known from the condition of the triangle. In calculation the right angle is not called a *part*.

§ 155. Any two of the five parts of a right angled spherical triangle being known, the rest are determinable by means of trigonometrical calculations.

§ 156. In right angled spherical trigonometry, there can be six cases of two different parts as data, viz.:

1. The hypothenuse and a leg.
2. The hypothenuse and an angle.
3. The two legs.
4. The two angles.
5. An angle and its opposite leg.
6. A leg and its adjacent angle.

§ 157. Lord Napier has given *two rules*, by which every problem that can occur in any of these several cases, may be solved. But he has not made known the process of reasoning, by which he arrived at the conclusions, whence he deduced these rules; nor have mathematicians been able to follow the steps of this bold reasoner.

§ *a* The truth of his, called the Catholic Proposition, is sufficiently established by practice, and by its utility, and may therefore be admitted as an axiom or received truth.

§ 158. In his Analytical Treatise on Plane and Spherical Trigonometry, Dr. Lardner observes, "We have thus established *Napier's rules*, by proving separately all the several cases which they include. There is no independent or general demonstration of these remarkable theorems, nor is it easy to conceive the process of mind by which their illustrious inventor arrived at them. Professor Woodhouse justly observes, that there are not, perhaps in the whole compass of mathematical science, rules which more completely attain that which is the proper object of rules, namely, brevity and facility of computation. He might have added, that few, or perhaps no theorems equally general, make such an immediate and permanent impression on the memory."*

§ 159. The *five* parts of a right angled triangle, are called, in Napier's rules, the *circular* parts.

§ *a*. The circular parts are the two legs, and the *complements* of the hypothenuse and its adjacent angles, instead of these three parts themselves.

§ 160. The right angle (§ 154. § *a*.) is thrown out of consideration; and the five circular parts join each other.

§ *a*. The complement of the hypothenuse joins the complement of each of the two angles; each of which angular complements joins its adjacent leg, and the two legs join each other.

§ 161. In every problem two of these parts are given and a third is sought. They are named from their relative position with regard to each other.

§ *a*. One of them is the *middle* part; the two others are *extremes*, either *conjunct* or *disjunct*.

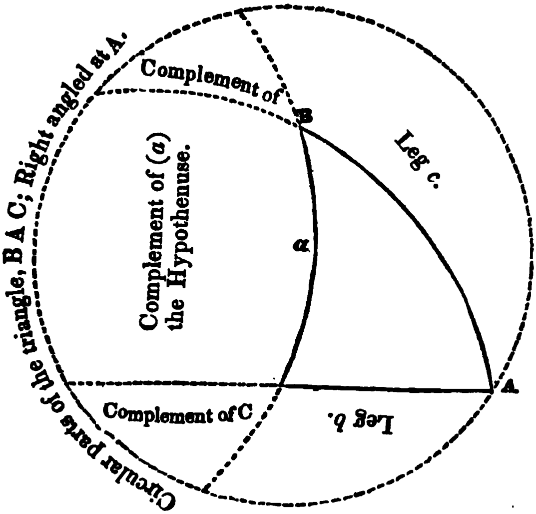
§ 162. If the parts given and the part sought join each other in circular order, the first and last in this order are called *extremes conjunct;* and the part between them connects them together, and is called the *middle* part.

§ *a*. The triangle A B C, represents a right angled spherical triangle, right angled at A; its hypothenuse is *a*, and *b* & *c* are its two legs. The circular parts are the leg *b*, the complement of C, do. of *a*, do. of B, and the other leg *c*.

§ *b*. The three parts, *a*, B, *c*, join in circular order. The complement of B is the connecting part between *c* and the complement of *a*. The complement of B is the middle part; *c*, and the complement of *a*, are extremes conjunct.

§ *c*. Of the parts	Middle part is,	Extremes conjunct are,
B, *c*, *b*.	*c*.	*b*, and complement of B.
c, *b*, C.	*b*.	*c*, and complement of C.
b, C, *a*.	Complement of C.	*b*, and complement of *a*.
C, *a*, B.	Complement of *a*.	Complements of C and B.
a, B, *c*.	Complement of B.	*c*, and complement of *a*.

* See Analytical Treatise on Plain and Spherical Trigonometry, by the Rev. Dionysius Lardner.



§ 163. If the parts given, and the parts sought, be not adjacent to each other in the circular order, that part which stands alone, or is not adjacent to either of the two other parts, is the middle part, and the two others are *extremes disjunct.*

§ *a.* The three parts, *a*, *c*, *b*, do not join each other in the circular order; the complement of *a* is not adjacent to either of the two other parts, being separated from them by the complement of the two acute angles, C & B; it stands alone, and is therefore (§ 163.) the middle part, and the two other parts that do join each other, are the extremes disjunct.

§*b.* Of the parts	Middle part is,	Extremes disjunct are,
B, *b*, C.	Complement of B.	*b*, and complement of C.
c, C, *a*.	*c*.	Complements of C and *a*.
c, C, B.	Complement of C.	*c*, and complement of B.
b, *a*, B.	*b*.	Complements of B and *a*.
a, *c*, *b*.	Complement of *a*.	*b* and *c*.

§ 164. Napier's rules establish an equality of ratio between radius, the *sine* of the middle part, and certain trigonometric functions of the *extremes*. They are,

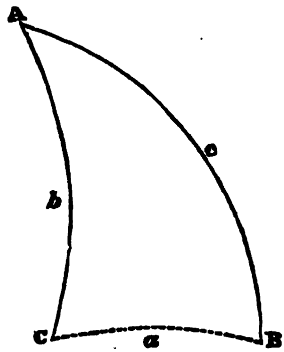
§ 165. The product of radius and sine of the middle part, is equal to the product of the tangents of extremes conjunct. And,

§ 166. The product of the co-sines of extremes disjunct, is equal to the product of radius and sine of the middle part.

§ 167. Every problem in right angled spherical trigonometry can be solved either by the one or the other of these two rules.

§ *a.* They have been put in the following mnemonic form:

"The *product* of radius and middle part's sine
Equals *that* of the tangents of parts that combine;
Or, *that* of the co-sines of those that disjoin."



§ 168. If the data and quæsita be opposite sides and angles, the problem proposed may be solved by the proportion (§ 144.) between the sines of opposite sides and angles.

§ 169. A B C represents a right angled spherical triangle upon a plane; B is the right angle, and b the hypothenuse.

§ a. The circular parts, commencing with c, and naming them in the order around to the right, in which they join; are c, a, cos. C, cos. b, and cos. A.

CASE I.

§ 170. Given the hypothenuse (b) and a leg (c).

The hypothenuse $b = 74° 40'$.

The leg $c = 60° 14'$.

To find the other parts.

§ a. 1st. To find the other leg (a).

The three parts that, in this case, comprise the data and quæsitum of the problem, are the two legs (c, a), and the hypothenuse (b). The complement of b, (§ 163. § a.) is not adjacent to either of the other parts, (c, a.); therefore (§ 163.) it is the middle part, and c and a are extremes disjunct; and (§ 166.) cos. $c \times$ cos. a = Sin. $b° \times$Rad.;* then (§ 71.) cos. c : Rad. : : sin. $b°$: cos. a.

$c = 60° 14'$. cos. ar. co.	=	0.304108 (=sec. c.)
Radius		10.
$b = 74° 40'$. cos. (= sin. $b°$)	=	9.422318
Cos. a	=	9.726426 = 57° 49′.

§ c. In looking in the tables for the degrees, etc., which correspond to the logarithmic co-sine, 9.726426, it will be seen that 122° 11′, the supplement of 57° 49′, also corresponds to it. Which of the two to take, is known (§ 141. § b.) by the affection of the two legs.

§ d. The sine, tangent, secant, etc., of an arc or angle, (§ 52. § d.) are the co-sine, co-tangent, co-secant, etc., of the complement of that arc, and (§ 104,) the sine, tangent, secant, etc., of the supplement of the same arc. Therefore,

§ e. Cor. The logarithmic value of any trigonometric function

* To obviate the necessity of writing *complement*, the circular parts of the hypothenuse and two angles will be denoted in the rest of the work by writing an (°) after the letter which stands for any one of those parts. Thus, $a°$, C°, B°, stands for the complements of a, C, B.

corresponds to two arcs or angles; viz., an angle and its supplement. Thus, log. sine 9.611576 = 24° 8′, or 155° 52′.

§ *f*. There is generally some circumstance connected with the conditions of the problem, or triangle, under solution, which determines the affection of the required part, and thence the arc required; for every one of the sides and of the angles of a spherical triangle (§ 136. & § 137.), may be either greater or less than a right angle, or 90°.

§ *g*. To find the value of *a*. In this case A° is the middle part. It is between, and joins, the two other parts *b*° and *c*. Therefore (§ 162.) *b*° and *c* are extremes conjunct. And (§ 165.) rad. × sin. A° = tang. *c* × tang. *b*°. Then (§ 71.), rad. : tang. *b*° : : tang. *c* : sin. A°.

Radius	=10.
b=74° 40′ co-tang.	= 9.438059 (=tang. *b*°, § 52. § *d*.)
c=60° 14′ tang.	10.242655

Sin. A°(=co-sin. A. (§ 52. § *d*.) = 9.680714=61° 21′ 9″.

§ *h*. 61° 21′ 9″, and *not* its supplement, is known (§ 141. § *b*. & § *d*.) to be the required value of the angle A.

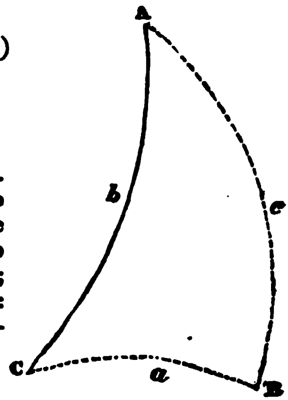
§ *i*. If the angle (C) opposite to (*c*) one of the given sides be required from the data of this case, the ratio (§ 144.) between the sines of opposite sides and angles, will determine the value of it, viz.: Sin. *b* : sin. B (= (§ 62.) rad.) : : sin. *c* : sin. C.

§ *j*. Or the value of C may be determined by means (§ 166.) of the Catholic Proposition; *c* (§ 163.) is the middle part, and *b*° and C° are extremes disjunct; and (§ 166.) cos. *b*° × cos. C° = sin. *c* × rad.; wherefore (§ 71.) cos. *b*° : rad. : : sin. *c* : cos. C°; which is the proportion under § *i*., stated under different denominations, but the same ultimately; for the co-sine *b*° and cos. C° (§ 52. § *d*.) are the same as sin. *b* and sin. C.

b=74° 40′ sin. ar. co.	= 0.015741=co-sec. (§ 101. § *b*.)
Radius	=10.
c=60° 14′ sine	= 9.938547

Sine C = 9.954288=64° 10′ 14″ (§ 141. § *d*.)

CASE II.



§ 171. Given the hypothenuse (b) and an angle (C),

$b=119° 39'$

$C=104° 01'$

To find the other parts.

§ *a*. 1st. To find the other angle (A). The two angles (A, C,) are adjacent to the hypothenuse (b), which is therefore (§ 162.) the middle part, and the two angles (A, C,) are extremes conjunct; then (§ 170. § *g*.) tang. C° : rad. : : sin. b° : tang. A°; and (§ 52. § *d*.) co-tang. C : rad. : : cos. b : cotang. A.

$C=104° 1'$ co-tang. ar. co. $=$ 0.602691$=$tang. (§ 100. § *a*.)
Radius $=$10.
$b=119° 39'$ cos. $=$ 9.694342

Co-tang. A$=$10.297033$=$26° 46′ 36″.

§ *b*. The value of A is known to be less than 90° (§ 141. § *c*.), because C is greater than a right angle.

§ *c*. 2d. To find a, which (§ 141. § *d*.) is also less than a right angle. The three parts, a, C°, and b°, join in circular order; and (§ 162. § *c*.) C° is the middle part, and b° and a are conjunct extremes. Then (§ 170. § *g*.) tang. b° : rad. : : sin. C° : tang. a; and (§ 52. § *d*.) co-tang. b : rad. : : cos. C : tang. a.

$b=119° 39'$ co-tang. ar. co.$=$ 0.244709$=$tang. (§ 101. § *b*.)
Radius $=$10.
$C=104° 1'$ cos. $=$ 9.384182

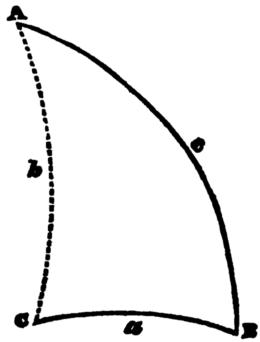
Tang. $a=$ 9.628891$=$23° 2′ 58″.

§ *d*. 3d. To find c; c (§ 141. § *d*.) is greater than a quadrant. The method for finding the value of c in this case, is similar to that (§ 170. § *j*.) of finding C, Case 1.

Rad. : sin. b : : sin. C : sin. c.
Radius $=$10.
$b=119° 39'$ sin.$=$ 9.939052
$C=104° 1'$ sin. $=$ 9.986873

Sin. $c=$ 9.925925$=$122° 31′ 18″.

CASE III.



§ 172. Given the two legs (a, c),
$a = 31° 16'$
$c = 74° 14'$
To find the other parts (A, C, b.)

§ a. 1st. To find the hypothenuse (b); it is less than a quadrant, because (§ 141. § b.) the legs are of the same affection. The three parts, a, $b°$, and c, do not join each other in the circular order; $b°$ stands alone: then (§ 163. § a.) a and c are disjunct extremes, and $b°$ is the middle part; and (§ 170. § a. & § XLIX. Alg.) radius : cos. c : : cos. a : sin. $b°$ = (§ 52. § d.) cos. b.

Radius		$=10.$
$c = 74° 14'$	cos. =	9.434122
$a = 31° 16'$	cos. =	9.931845
Cos. b =		9.365967 = 76° 34′ 12″.

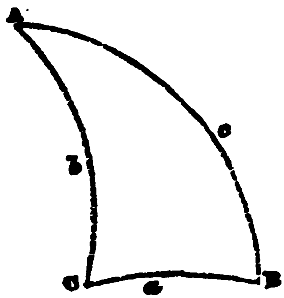
§ b. 2d. To find an angle (C); it is less (§ 141. § d.) than 90°. The three parts C°, a, c, join in circular order; and (§ 162.) C° & c, are conjunct extremes, and a is the middle part: then (§ 165. & § 71.) tang. c : rad. : : sin. a : tang. C° = co-tang. C.

$c = 74° 14'$	tang. ar. co. =	9.450777 = co-tang.
Radius		$=10.$
$a = 31° 16'$	sine =	9.715186
Co-tang. C =		9.165963 = 81° 39′ 47″.

§ c. 3d. To find the other angle (A); it is also less than 90°, and it is an extreme conjoined to a by c, which (c) is the middle part; then (§ b.) tang. a : rad. : : sin. c : tang. A° = co-tang. A.

$a = 31° 16'$	tang. ar. co. =	0.216659 = co-tang. (§ 101. § b.)
Radius		$=10.$
$c = 74° 14'$	sin. =	9.983345
Co-tang. A =		10.200004 = 32° 15′.

CASE IV.



§ 173. Given the two angles (A, C),
A=31° 56′
C=111° 11′
To find the sides *a*, *b*, and *c*.

§ *a*. 1st. To find the hypothenuse (*b*); it is (§ 141. § *c*.) greater than a quadrant; it connects A° and C° in the circular order, which are conjunct extremes; and (§ 171. § *a*. § XLIX. Alg.) rad. : tang. A° : : tang. C° : sin. *b*° ; or, rad. : co-tang. A : : co-tang. C : cos. *b*.

Radius		=10
A=31° 56′	co-tang.	=10.205336
C=111° 11′	co-tang.	= 9.588316
Cos. *b*		= 9.793652=128° 26′ 53″.

§ *b*. 2d. To find the leg *c*; it and A° are extremes disjunct; and (§ 166. & § 71.) cos. A° : rad. : : sin. C° : cos. *c*; or,
Sin. A : rad. : : cos. C : cos. *c*.

A=31° 56′	sin. ar. co.=	0.276600=co-sec. (§ 101. § *b*.)
Radius		=10.
C=111° 11′	cos.	= 9.557932
Cos. *c*		= 9.834532=133° 5′ 32″ (§ 139.)

C and *c* (§ 141. § *d*.) are of the same affection.

§ *c*. 3d. To find the other leg *a*; it is less than a quadrant, and a disjunct extreme; A° is the middle part, and (§ *b*.) cos. C° : rad. : : sin. A° : cos. *a*; or,
Sin. C : rad : : cos. A : cos. *a*.

C=111° 11′	sin. ar. co.=	0.030384=co-sec. (§ 101. § *b*.)
Radius		=10.
A=31° 56′	cos.	= 9.928736
Cos. *a*		= 9.959120=24° 28′ 18″.

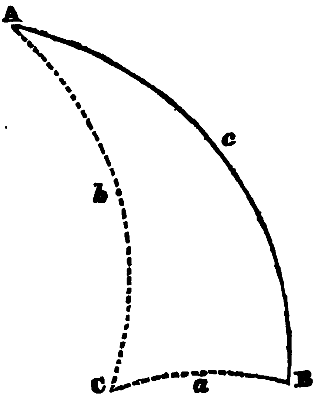
CASE V.

§ 174. Given an angle (C) and its opposite leg (c),

$c=45° 19'$

$C=54° 49'$

To find the other parts (a, b, A).



§ a. This is called the "*doubtful case*," because there is nothing in the condition of any problem that falls under this case, which will determine the affection of the part whose value is sought.

§ b. 1st. To find the other leg (a); it is the middle part, connecting the conjunct extremes, C° and c; and (§ 172. § b.) rad. : tang. C° : : tang. c : sin. a: or,

Rad. : co-tang. C : : tang. c : sin. a.

Radius		10.
C=54° 49′	co-tang.=	9.848181
c=45° 19′	tang.	=10.004801

Sin. a= 9.852982=45° 27′ 54″.

§ c. 2d. To find the hypothenuse (b); it is a disjoined extreme, and is found (§ 170. § j.) cos. C° : rad. : : sin. c : cos. b° ; or,

Sin. C : rad. : : sin. c : sin. b.

C=54° 49′	sin. ar. co.=	0.087612=co-sec. (§ 101. § b.)
c=45° 19′	sin.	= 9.851872
Radius		=10.

Sin. b= 9.939484=60° 27′ 2″.

§ d. 3d. To find the other angle (A); it is a disjunct extreme; and (§ 173. § b.) cos. c : rad. : : sin. C° : cos. A° ; or,

Cos. c : rad. : : cos. C : sin. A.

c=45° 19′	cos. ar. co.=	0.152929=sec. (§ 101. § b.)
Radius		=10.
C=54° 49′	cos.	= 9.760569

Sin. A= 9.913498=55° 1′ 30″.

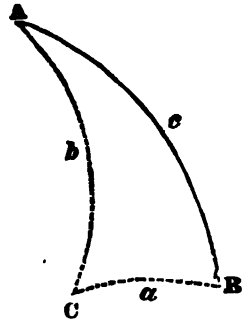
CASE VI.

§ 175. Given a leg (c) and its adjacent angle (A),

c=35° 15' 7″

A=74° 47′

To find the values of the other parts (b, C, a).



§ *a*. 1st. To find the value of the hypothenuse (b); it is (§ 141. § *b*. & § *d*.) less than a quadrant; and the problem is the converse of § *g*., Case I, (§ 170.). Tang. c : rad. : : sin. A° : tang. b° ; or,

Tang. c : rad. : : cos. A : co-tang. b.

c=35° 15′ 7″ tang. ar. co.= 0.150715=cot. (§ 101. § *b*.)
Radius =10.
A=74° 47′ cos. = 9.419080

Co-tang. b= 9.569795=69° 37′ 37″.

§ *b*. 2d. To find the value of the angle C. This is the converse of § *b*., Case IV. (§ 173.), Radius : cos. A° : : cos. c : sin. C° ; or,

Rad. : sin. A : : cos. c : cos. C.
Radius =10.
A=74° 47′ sin. = 9.984500
c=35° 15′ 7″ cos. = 9.912022

Cos. C= 9.896522=38° 00′ 7″.

§ *c*. 3d. To find the other leg a. The calculation for this is the converse of § *c*., Case III., (§ 172.)

Tang. A° : rad. : : sin. c : tang. a; and tang. A°=
Co-tang. A=74° 47′ ar. co.= 0.565421=tang. (§ 101. § *b*.)
Radius =10.
c=35° 15′ 7″ sin. = 9.761305

Tang. a=10.326726=64° 46′ (§ 141. § *d*.)

§ 176. The rules which have been given for the solution of any problem that can occur in right angled spherical trigonometry, are good in theory; but instances may occur in practice, wherein they will not yield the most accurate result. This apparent defect arises from the trigonometric functions by which certain arcs, or angles, that enter into calculation, are denominated. For instance: If the required part be a very small arc or angle, and the result give its log.

co-sine, the solution is not a good one; because a small error in the log. cos. will produce a much larger one in the arc or angle. This arises from the different manner in which an arc and its sine increase.

§ *a.* By referring to a logarithmic table, even of six digits in the mantissæ, it will be observed that an arc of 89° 51′ may increase 18′, or to 90° 9′, and that the value of its sine will only vary .000001.

§ *b.* The same thing is true of the co-sine of the complement of such an arc.

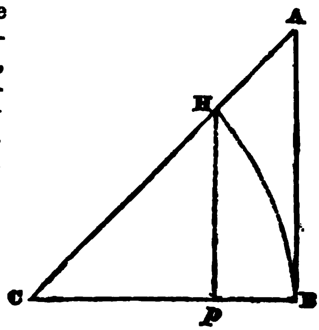
§ *c.* For these reasons, *the sine of an arc near* 90°, *or the cos. of one near* 1′, *should not be used in trigonometrical calculation.*

§ 177. The value of sine and co-sine of such arcs may be substituted by their equivalents in other trigonometric functions.

§ 178. The principles from which such equivalents are obtained, are involved in § 75.

§ *a.* The elements of trigonometry are chiefly contained in the principles of § 43. and § 75.

§ 179. An equivalent for the sine, co-sine, etc., of any angle, may be found by means of the principles developed under § 75.



§ *a.* Let the proposed angle (C) be made an oblique angle in a right angled triangle (A B C); and from it, with its adjacent side (C B) as radius, describe the arc H B, and draw the sine (H p) of the angle (C) proposed; C p is its co-sine, A B its tangent, and C A its secant.

§ *b.* Now, instead of naming these sides by letters, denominate them by the trigonometric functions whose offices they fill; thus, calling H p, sin. C; C p, cos. C; A B, tang. C; and so on; we have (§ 75. and § 73.),

$$\text{Sin. C : cos. C :: tang. C : radius; or, sin. C} = \frac{\text{Cos. C} \times \text{tang. C}}{\text{radius.}}$$

§ *c.* $\text{Cos. C : sin. C :: rad. : tang. C; or, cos. C} = \dfrac{\text{Sin. C} \times \text{rad.}}{\text{tang. C}}$

§ *d.* Equivalents for other trigonometric functions may be found after a similar manner; and the same relations exist between the trigonometric functions of plane and spherical triangles. Therefore—

§ 180. The logarithmic sine of any angle is equal to its log. cosine and tangent, minus radius, or 10. And—

§ 181. The log. cos. of any angle is equal to its log. sine and radius, minus the log. tang. of the same angle.

OBLIQUE SPHERICS.

O

OBLIQUE SPHERICS.

§ 182. In every oblique spherical triangle, there are *six parts*, any three of which constitute sufficient data (§ 145.) for determining the value of any of the remaining parts by means of trigonometrical calculation.

§ 183. Every problem in oblique spherical trigonometry is comprised in one of the six following cases; in which the data are,

1st, Two sides and angle opposite to one of them.

2d, Two angles and the side subtending either.

3d, Two angles and the side between them.

4th, Two sides and the angle they include.

5th, The three sides.

6th, The three angles.

§ 184. When any one of the four first cases, comprises the data of the problem, it may be solved by right angled trigonometrical operations; for this purpose the proposed triangle (§ 147. § *a.*) must be divided into two right angled triangles.

§ *a.* The perpendicular arc must be so drawn, that *two* of the given parts must be on the *same side* of it, and consequently, in one of the right angled triangles, into which this arc divides the triangle of the problem.

§ 185. The rules in right angled trigonometry, for determining *in species* an unknown side or angle, (i. e. whether it be greater or less than 90°), do not hold good in all cases in oblique trigonometry.

§ 186. The opposite sides and angles of oblique spherical triangles, are not necessarily of the same affection.

§ *a.* But if the greatest *side* be greater than a quadrant, it and its opposite angle are of the same affection.

§ 187. The converse of § 186. § *a.* does not hold good; for the sides (§ 136. § *a.*) of a spherical triangle may be indefinitely small, and the sum of the angles (§ 137.) being greater than two right angles, an obtuse angled spherical triangle may be formed of these indefinitely small sides; in which case an obtuse angle and its subtending side will be unlike.

§ 188. In most cases though, there are circumstances connected either with the condition of the problem, or of the triangle it involves, by which the species of the part required may be determined. Some of these circumstances are mentioned below.

§ 189. If an angle of a triangle be greater than 90°, an arc drawn from it, perpendicular to the subtending side, will fall *within* such triangle.

§ *a.* If the angles adjacent to the base, be of the same affection, the perpendicular falls upon it, also within the triangle.

§ 190. If all the angles of a triangle be not of the same affection, and a perpendicular arc be drawn from one of the angles which is less than 90° upon the subtending side, it will fall *without* the triangle.

§ 191. An opposite side and angle of a spherical triangle cannot be unlike, unless the sine of this side be greater than the sines of the other sides.

§ *a*. The sine of the angle opposite to such a side is also greater than the sines of the two other angles.

§ *b*. In an isosceles triangle, each side and its opposite angle are alike.

§ 192. If an obtuse side be opposite to an acute angle in any triangle, the two other sides are unlike; and (§ 191.) they and their opposite angles are of the same affection; consequently, the two angles are unlike.

§ *a*. If an obtuse angle subtend an acute side, the other sides and angles are all alike.

§ 193. Whether the perpendicular fall within or without the triangle, the less segment of the base is next to that angle which, of the two adjacent to the base, is the nearer 90°.

§ *a*. When the perpendicular falls within the triangle, the sum of the segments equals the base.

§ *b*. And when it falls without the triangle, the base equals the difference of the segments.

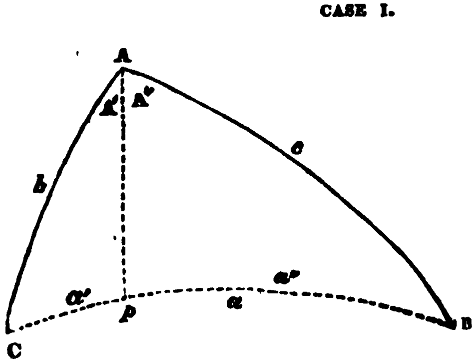
§ 194. If a side and its subtending angle be each less than 90°, a smaller side and its opposite angle, of the same triangle, must be (§ 139.) of the same affection.

§ 195. If the sum of two angles of a triangle be less than 90°, the third angle (§ 137.) is greater than a right angle.

§ 196. By writing co-tang. for the arithmetical complement (§ 101. § *b*.) of the tangent; sec. for the arithmetical complement of cos.; cosec. for the arithmetical complement of sine, etc., greater simplicity and uniformity of calculation will be effected.

§ *a*. The learner will have observed by the reference (§101. § *b*.) appended to the arithmetical complement of sines, etc., in some of the calculations in right angled spherical trigonometry, that by taking from the tables the cosec. of an arc, he obtains at once the arithmetical complement of the logarithmic sine of the same arc. So, co-tang, for arithmetical complement of the tangent, etc.

CASE I.



§ 197. Given two sides (b & c) and an angle (C) opposite to one of them,

$b = 21° 17'$

$c = 74° 14'$

$C = 69° 10'$

To find the other parts (A, B and a) by right angular operations.

§ *a*. If the third side (a) or its opposite angle (A) be computed, the two other remaining parts are determinable by means of the ratio (§ 144.) between the sines of opposite sides and angles.

§ *b.* In order that two (b & C) of the given parts, may be on the same side (§ 184. § *a.*) of the perpendicular A p, it is drawn from A, upon its opposite side a, so as to divide the triangle of the problem into two right angled triangles A p C and A p B; the former of which contains two of the given parts (C & b).

§ *c.* C & B are less than 90° (§ 194.); therefore (§ 141. § *b.*) C p & A p are each less than 90°; the perpendicular upon the side (a) adjacent to C & B (§ 189. § *a.*) falls within the triangle; and makes the sum of the segments of the angle A, equal to A.

§ *d.* The distance (C p) of the given angle (C) from the intersecting point (p) of the perpendicular and the base, is called auxiliary a'.

§ *e.* To compute the value of the auxiliary arc a'.

The method of doing it, is shown under Case II. (§ 171. § *c.*).

$$\text{Tang. } a' = \frac{\text{cos. C}}{cot.\ b} = (\S\ 196.)\ tang.\ b\ \text{cos. C.}$$

§ *f.* b=21° 17′. Tang.=9.590562
C=69° 10′. Cos. =9.551024

Tang. auxl. a'=9.141586=7° 52′ 16″ *

§ *g.* The value of B is calculated from the ratio (§ 144.) between the sines of sides and of angles. Sin. c : sin. C : : sin. b : sin. B; sin. c ar. co. (§ 196.)=cosec. c.

§ *h.* c=74° 14′ cosec.=0.016655
C=69° 10′ sin. =9.970635
b=21° 17′ sin. =9.559883

Sin. B=9.547173=20° 38′ 27″

§ *i.* Now, in the other right angled triangle A p B, the value both of c and of B is known, and the other segment (p B) of the base can be determined; for (§ *e.*) tang. B p=cos. B tang. c.

§ *j.* c=74° 14′ tang.=0.549223
B=20° 38′ 27″ cos.=9.971187

Tang. B p=0.520410=73° 12′ 39″

* Rad. (§ 98. § *b.*), being always equal to 1 or to 10 in logarithmic calculations, is not written down in these formulæ; its value is brought into account by applying it to the log. index of the result, as in the case above. By omitting rad. the formulæ for calculation are rendered more compact and convenient. The proper value will always be given rad. in calculation, by having the log. index of the result to consist only of *one* figure, as in the case above, where radius is taken into the account by simply writing 9 instead of 19 for the log. index of auxl. a'.

§ *k*. The perpendicular falling within the triangle, makes the *sum* of the segments (§ 193. § *a*.) equal to the base *a*; therefore (§ *f*. & § *j*.) $a = 81° \ 5' \ 55''$.

§ *l*. To find the value of A.

Sin. *c* : sin. C : : sin. *a* : sin. A.

$c = 74° \ 14'$	cosec.	$= 0.016655$
$C = 69° \ 10'$	sin.	$= 9.970635$
$a = 81° \ 5' \ 55''$	sin.	$= 9.994738$

Sin. $A = 9.982028 = 106° \ 22' \ 12''$; A is greater (§ 195.) than 90°.

§ *m*. The value of A may also be determined by the Catholic Proposition; for (§ 171. § *a*.) cotang. C A $p = \dfrac{\cos. b}{cot.\ C} =$ (§ 196.) cos. *b* *tang*. C. Also co-tang. B A $p =$ cos. *c* tang B.

§ *n*. B A $p \underset{\infty}{+}$ C A $p =$ A, according as the perpendicular arc A *p* falls within or without the triangle.

§ *o*.

$C = 69° \ 10'$	tang.	$= 0.419611$
$b = 21° \ 17'$	cos.	$= 9.969321$

Co-tang. C A $p = 0.388932 = 22° \ 12' \ 51''$

$B = 20° \ 38' \ 27''$	tang.	$= 9.575983$
$c = 74° \ 14'$	cos.	$= 9.434122$

Co-tang. B A $p = 9.010105 = 84° \ 9' \ 21''$

B A $p +$ C A p (§ *c*.) $=$ A $\quad 106° \ 22' \ 12''$

§ *p*. The process of solution by such methods of calculation as the above, is circuitous. But cases sometimes occur when they may be used with advantage. And in order that the process, by which the required result is obtained from calculations conducted upon the principles of right angled spherical trigonometry, may be made familiar to the learner, the calculations are carried out.

§ *q*. By analysis and the use of a little artifice, rules are deduced, and formula constructed, for obtaining the same result from the application of the same principles to calculation, but by less tedious operations. The *auxiliary arcs* and *angles* used in such methods, are derived from the principles of the Catholic Proposition; and the methods themselves are nothing more than right angled spherical calculations, rendered less circuitous in execution by previous combinations, eliminations, and substitutions of the parts that are contained in the two right angled triangles, into which the oblique one of the problem is divided.

§ *r*. To find the value of A by the help of auxiliaries. Let the angle B A *p* be called auxiliary A″; and let auxiliary A′, be the angle (C A *p*) which is in the right angled triangle in which two (*b*, C,) of the given parts of the primitive triangle are contained.

§ *s*. According to § *m*. co-tang. A'=cos. *b* tang. C.

§ *t*. Now, (§ 165. & § XLV. Alg.); $\frac{\text{Tang. A } p}{\text{rad.}} = \frac{\text{Cos. A}'}{\text{cot. } b}$; also $\frac{\text{Tang. A } p}{\text{rad.}} = \frac{\text{Cos. A}''}{\text{cot. } c}$; wherefore $\frac{\text{Cos. A}''}{\text{cot. } c} = \frac{\text{Cos. A}'}{\text{cot. } b}$; and by transposition, Cos. A'' $= \frac{\text{Cos. A}' \text{ Cot. } c}{\text{cot. } b}$ & (§ 101. § *b*.) $\frac{\text{Cos. A}' \text{ Cot. } c}{\textit{cot. } b} = $ Cos. A' Cot. *c* *tang*. *b*. Therefore, Cos. auxiliary A''=cos. A' cot. *c* tang. *b*. Whence the general rule for finding the value of (A) the angle opposite to the unknown side.

§ *u*. The product (§ *s*.) of tang. of the given angle, and cos. of the given side that is adjacent to it, is co-tang. of auxiliary A'. And,

§ *v*. The *product* of tang. of the same side, and co-tang. of the other given side, *multiplied* by cos. of auxl. A' (§ *t*.), is cos. of the other auxiliary A''. And the sum (§ 193. § *a*.), or difference (§ 193. § *b*.), of the two auxiliaries, gives the required angle.

§ *w*.

		c=74° 14' cot.	=9.450777
b=21° 17' cos. =9.969321	- - -	tang.	=9.590562
C=69° 10' tang.=0.419611			
Cot. A'=9.388932=22° 12' 51''	-	cos.	=9.966506
	84° 9' 21''	- Cos. A''	=9.007845
A=106° 22' 12'' (§ *o*.)			

§ *x*. The formula for the calculation (§ *w*.) is arranged in the most convenient order for operation. The value of auxl. A' is evolved during the process of finding that of the other A''; and the log. tang. and cos. of *b*, are taken out at one opening of the tables; so, also is the value of A' and its cos. System and method in calculation should by no means be neglected. They promote accuracy and facilitate practice. It is therefore the business of every calculator to introduce system in his operations. The habit of arranging the several quantities in the most convenient order for calculation, contributes to accuracy, and makes verification more ready.

§ *y*. To find the value of *a*, by the help of auxiliaries. Call the segment C *p*, auxl. *a'*, and the segment B *p*, auxl. *a''*.

§ *z*. From a train of reasoning analogous to that under § *m*., it is shown that, tang. auxl. *a'*=tang. *b* cos. C.

§ *z a*. Also (166. & § XLV. Alg.) $\frac{\text{Rad.}}{\text{cos. A } p} = \frac{\text{Cos. } a'}{\text{cos. } b}$; and $\frac{\text{Rad.}}{\text{cos. A } p} = \frac{\text{Cos. } a''}{\text{cos. } c}$; therefore $\frac{\text{Cos. } a''}{\text{cos. } c} = \frac{\text{Cos. } a'}{\text{cos. } b}$; and by transposition cos. $a'' = \frac{\text{Cos. } a \text{ cos. } c}{\text{cos. } b}$ =(§ 101. § *b*.) cos. a' cos. c *sec.* b; then $a' \overset{+}{\infty} a''$ (§ *c.* & § *n.*)=a. Whence the general rule for finding the third side.

§ *z b*. The product of cos. of the given angle and tang. of its adjacent side, is (§ *z*.) tang. of auxl. a'. And,

§ *z c*. Sec. of the same side, multiplied by the *product* of cos. of the other side and cos. of auxl. a' (§ *z a*.), is cos. of the other auxl. a''.

§ *z d*. If the two angles adjacent to the base, be each less than 90°, the perpendicular falls within the triangle, and (§ 193. § *a*.) the *sum* of the auxiliaries is the required part.

§ *z e*. But if these two angles be unlike, the perpendicular falls without the triangle; and then (§ 193. § *b*.) the *difference* of the auxiliaries is the required part.

§ *z f*. $c = 74°\ 14'$ cos. =9.434122

$b = 21°\ 17'$ tang. =9.590562 - - - sec. =0.030679

C=69° 10′ cos. =9.551024

Tang. a'=9.141586= 7° 53′ 16″ - cos. =9.995872

73° 12′ 39″ - Cos. a''=9.460673

a=81° 5′ 55″ (§ *z d*.)

§ *z g*. The value of the third side (a), or of its opposite angle (A), may also be determined by another method; but in this, the value of the other unknown angle (B) is necessary.

§ *z h*. To determine the third side (a),

Cos. of ½ the difference of the two angles, (B, C);
Is to the cos. of ½ their sum;
As tang. of ½ the sum of the two sides (b, c);
Is to tang. of ½ the required side.

§ *z i*. ½ (C ∞ B)=24° 15′ 46″ sec. =0.040162
½ (C+B)=44° 54′ 13″ cos. =9.850215
½ (b + c)=47° 45′ 30″ tang. =0.041880

Tang. ½ a=9.932257=40° 32′ 58″

2

a=81° 5′ 56″

§ *z j*. To find the value of A by a similar method.

Cos. of ½ the difference of the two sides (b, c,);
Is to the cos. of ½ their sum;
As tang. of ½ the sum of the two angles (A, B);
Is to co-tang. of ½ the angle required.

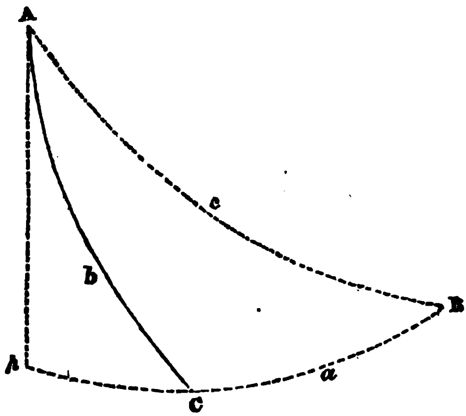
§ *z k.* $\frac{1}{2}$ ($c \backsim b$)=26° 28′ 30″ sec. =0.048114
$\frac{1}{2}$ ($c + b$)=47° 45′ 30″ cos. =9.827537
$\frac{1}{2}$ (C+B)=44° 54′ 13″ tang.=9.998538

Co-tang. $\frac{1}{2}$ A=9.874189=53° 11′ 7″
2

A=106° 22′ 14″

These two last methods are the most common in practice.

CASE II.



§ 198. Given two angles and the side that subtends one of them,
B=29° 16′
C=150° 51′ 50″
b=74° 46′
To find the value of each of the other parts (A, c & a.)

§ *a.* The value of c (§ 144.) is determinable by a direct calculation; Sin. B : sin. b : : sin. C : sin. c.

B=29° 16′	co-sec.	=0.310802
b=74° 46′	sin.	=9.984466
C=150° 51′ 50″	sin.	=9.687427

Sin. c =9.982695=106° 4′ 2″

§ *b.* Suppose the perpendicular (A p) from A, upon the side opposite to A, to fall without the triangle. Then the two known parts in the right angled triangle A p C, are b, and (§ 132.) the supplement of C. The unknown parts of the proposed oblique triangle may be computed by right angled trigonometric operations.

§ *c.* In the triangle A p C, (§ 197. § *e.*) tang. C p=cos. C tang. b. Also in the triangle p A B, tang. p B=cos. B tang. c. Then (§ 193. § *b.*) C $p \backsim p$ B=a.

§ *d.* The value of A also, may be determined by rules of right angled trigonometry.

§ *e.* When the perpendicular falls without the triangle, the difference of the two auxiliary angles B A p, and C A p, is the angle A.

§ *f*. But if it falls within the triangle, B A p+C A p=A, (§ 197. § *n*.)

§ *g*. Co-tang. p A C=cos. b tang. C; and co-tang. B A p=cos. c tang B (§ 197. § *m*.). Then (§ *e*.) A=B A $p \backsim p$ A C.

§ *h*. C=150° 51′ 50″ cos. = 9.941246 (§ *c*.)
b= 74° 46′ tang.= 0.564922

Tang. C p= 0.506168=72° 41′ 3″

B= 29° 16′ cos. = 9.940693
c=106° 4′ 2″ tang.= 0.540585

Tang. p B= 0.481278=108° 16′ 15″

Now (§ *c*.) p B—C p=a= 35° 35′ 12″

§ *i*. C=150° 51′ 50″ tang.=9.746181 (§ *g*.)
b= 74° 46′ cos. =9.419544

Co-tang. p A C=9.165725=81° 40′ 4″

c=106° 4′ 2″ cos. =9.442111
B=29° 16′ tang.=9.748505

Co-tang. B A p=9.190616=98° 49′ 0″

Now (§ *e*.) B A p—p A C=A=17° 8′ 56″

§ *j*. To determine the third angle (A) by the help of auxiliaries. The angle p A C is auxiliary A′; and the angle B A p is auxiliary A″.

§ *k*. Co-tang. A′=cos. b tang. C (§ *g*.).

§ *l*. And (§ 166. and § XLV. Alg.) $\frac{\text{Rad.}}{\text{cos. A}p}=\frac{\text{Sin. A}'}{\text{cos. C}}$; also $\frac{\text{Rad.}}{\text{cos. A}p}=\frac{\text{Sin. A}''}{\text{cos. B}}$; therefore $\frac{\text{Sin. A}''}{\text{cos. B}}=\frac{\text{Sin. A}'}{\text{cos. C}}$; and by transposition, sin. A″=$\frac{\text{Sin. A}'\text{ cos. B}}{\text{cos. C}}$=(§ 101. § *b*.)=sin. A′ cos. B sec. C. Whence the general rule for finding the third angle.

§ *m*. The product of cos. of the given side, and tang. of its adjacent angle, (§ *k*.) is co-tang. of auxl. A′. And,

§ *n*. The *product* of sec. of the same angle, and sin. of auxl. A′, *multiplied* by cos. of the other angle, (§ *b*.) is sin. of auxl. A″. And (§ 197. § *n*.) A′$\underset{\backsim}{+}$A″ is the required angle.

§ *o*.

$C=150°\ 51'\ 50''$	tang. $=9.746181$	$B=29°\ 16'$	cos. $=9.940693$
$b=\ 74°\ 40'$	cos. $=9.419544$	- -	sec. $=0.058754$

Cot. $A'=9.165725=81°\ 40'\ 4''$ sin. $=9.995391$

$98°\ 49'$ Sin. $A''=9.994838$

$A=17°\ 8'\ 56''$ (§ *e*.)

§ *p*. To determine the value of the side (a) opposite to the unknown angle with the help of auxiliaries. Let the segment p C be auxiliary a'; and the other segment p B, be auxiliary a'',

§ *q*. Tang. a' (§ *c*.)=cos. C tang. b.

§ *r*. And by a process of reasoning similar to that under Case I, (§ 197. § *z a*.), it is shown that sin. a''=sin. a' tang. C co-tang. B; for (§ 165.) $\frac{\text{Tang. A } p}{\text{rad.}}=\frac{\text{Sin. } a'}{\text{cot. C}}$; also $\frac{\text{Tang. A } p}{\text{rad.}}=\frac{\text{Sin. A}''}{\text{cot. B}}$; therefore, $\frac{\text{Sin. } a''}{\text{cot. B}}=\frac{\text{Sin. } a'}{\text{cot. C}}$; and by transposition, sin. $a''=$ $\frac{\text{Sin. A}' \text{ cot. B}}{\textit{cot.} \text{ C}}$=sin. a' cot. B *tang*. C. Whence the general rule for finding the value of the side that subtends the unknown angle.

§ *s*. The product of tang. the given side, and cos. its adjacent angle (§ *q*.) is tang. of auxl. a'. And,

§ *t*. Tang. the same angle *multiplied* by the *product* of co-tang. the other angle, and sin. the auxl. a', is sin. the other auxiliary a''.

§ *u*.

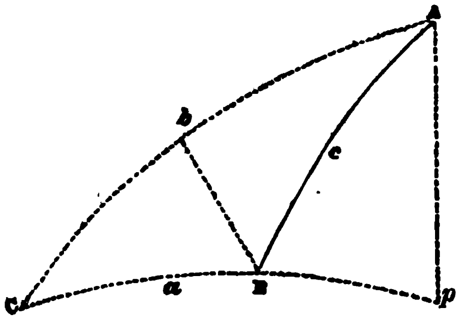
$C=150°51'50''$	cos. $=9.941246$	$B=29°\ 16'$	cot. $=0.251495$
$b=\ 74°46'$	tan. $=0.564922$	-	tang. $=9.746181$

Tang. $a'=0.506168=\ 72°\ 41'\ 3''$ sin. $=9.979857$

$108°\ 16'\ 15''$ Sin. $a''=9.977533$

$a=\ 35°\ 35'\ 12''$

CASE III.



§ 199. Given two angles, and the side between them,

A=19° 41′

B=134° 17′

c=36° 19′

To find the value of the other parts (a, b, & C.)

§ a. The perpendicular (A p) being so drawn that the two given parts B, c, may be on the same side of it, falls without the triangle proposed; and (§ 198. § e.) the auxiliary angle B A p+A, equals the auxiliary angle C A p. Also the difference of the auxiliary arcs p B & p C (§ 193. § b.) is the side a.

§ b. If any one of the unknown parts be determined, the two others may be found from the proportion between the sines of opposite sides and angles.

§ c. To determine the value of C by the rules of right angled trigonometry.

§ d. In the right angled triangle B p A, (§ 165. & § 197. § m.), co-tang. B A p=cos. c tang. B. Also, (§ 166.) sin. A p=sin. B sin. c. And B A p+A=C A p.

§ e. Then in the right angled triangle C p A, the parts C A p & A p are known, and (§ 166.) cos. C=sin. C A p cos. A p.

§ f. c=36° 19′ cos. =9.906204
B=134° 17′ tang.=0.010866

Co-tang. B A p=9.917070=50° 26′ 15″

c sin.=9.772503
B sin.=9.854850

Sin. A p=9.627353=25° 5′ 12″

B A p+A=C A p=70° 7′ 15″ (§ a.)

§ g. C A p=70° 7′ 15″ sin.=9.973318
A p=25° 5′ 12″ cos.=9.956969

Cos. C=9.930287=31° 36′ 10″

§ h. To find the value of the third angle (C), with the help of auxiliaries. The angle B A p is auxiliary A′. Co-tang. A′ (§ d.) =cos. c tang. B.

§ *i*. And (§ 198. § *l*.) $\frac{\text{Cos. A}\,p}{\text{rad.}}=\frac{\text{Cos. B}}{\text{Sin. A}'}$; also $\frac{\text{Cos. A}\,p}{\text{rad.}}=\frac{\text{Cos. C}}{\text{sin. }(\text{A}\underset{\backsim}{+}\text{A}')}$; therefore $\frac{\text{Cos. C}}{\text{sin. }(\text{A}\underset{\backsim}{+}\text{A}')}=\frac{\text{Cos. B}}{\text{sin A}'}$; and by transposition, Cos. C $=\frac{\text{Cos. B sin. }(\text{A}\underset{\backsim}{+}\text{A}')}{\textit{sin.}\ \text{A}'}=$ cos. B sin. $(\text{A}\underset{\backsim}{+}\text{A}')$ *co-sec.* A′.

§ *j*. Cos. C=cos. B co-sec. A′ sin. (A+A′) when A *p* falls without the triangle. And,

§ *k*. Cos. C=cos. B co-sec. A′ sin. (A∽A′) when A *p* falls within it. Whence the rule.

§ *l*. The product of cos. the given side, and tang. of either angle (§ *h*.), is co-tang. of auxl. A′. And, (§ *i*.),

§ *m*. Cos. of the same angle, *multiplied* by the *product* of co-sec. of auxl. A′ and sine of the *sum* (§ *j*.), or *difference* (§ *k*.) of auxl. A′ and the other angle, is cos. of the required angle.

§ *n*.

c= 36° 19′ cos. =9.906204
B=134° 17′ tang. =0.010866 - cos. =9.843984

Cot. A′=9.917070=50° 26′ 15″ cosec.=0.112985

(A+A′)=70° 7′ 15″ sin. =9.973318

31° 36′ 10″ Cos. C=9.930287

To find the value of the two sides (*a* and *b*) with the help of auxiliaries.

§ *o*. According to a train of reasoning similar to that shown under Case I, (§ 197. § *t*.) cot. *b*=cot. *c* cos. $(\text{A}\underset{\backsim}{+}\text{A}')$ sec. A′; for $\frac{\text{Rad.}}{\text{tang. A}\,p}=\frac{\text{Cot. }c}{\text{cos. A}'}$; also $\frac{\text{Rad.}}{\text{tang. A}\,p}=\frac{\text{Cot. }b}{\text{cos. }(\text{A}\underset{\backsim}{+}\text{A}')}$; then $\frac{\text{Cot. }b}{\text{cos. }(\text{A}\underset{\backsim}{+}\text{A}')}=\frac{\text{Cot. }c}{\text{cos. A}'}$; and by transposition, cot. *b*= $\frac{\text{Cot. }c\ \text{cos. }(\text{A}+\text{A}')}{\textit{cos.}\ \text{A}'}=$ cot. *c*. cos. $(\text{A}\underset{\backsim}{+}\text{A}')$ *sec.* A′.

§ *p*. By drawing the perpendicular from B upon its opposite side, and calling the angle A B *b* auxiliary B′, we obtain by a similar process of reasoning. Cot. *a*=cot. *c* cos. $(\text{B}\underset{\backsim}{+}\text{B}')$ sec. B′.

§ *q*. Cot. B′=cos. *c* tang. A. Whence the rule for finding the value of either unknown side.

§ *r*. The product of cos. the given side and tang. of the angle (§ *h*. & § *q*.) opposite to the required side, is co-tang. of the *required* auxiliary which call A′. And (§ *o*. & § *p*.),

§ *s*. The *product* of cot. the given side and sec. of this auxl. A′, *multiplied* by cos. of the *sum*, or *difference* of A′ and the angle adjacent to the required side, is co-tang. of the required side.

§ *t*. To find the value of *b* by this rule.

B=134° 17′ tang.=0.010866
c= 36° 19′ cos. =9.906204 - - - cot.=0.133700

Cot. A′=9.917070=50° 26′ 15″ - sec.=0.195916

(A+A′)=70° 7′ 15″ cos.=9.531528

54° 0′ 27″ Cot. *b*=9.861144

§ *u*. To find the value of *a* by the same rule.

A=19° 41′ tang.=9.553548
c= 36° 19′ cos. =9.906204 - - cot.=0.133700

Cot. A′=9.459752=73° 55′ 15″ - .sec.=0.557576

(B—A′)=60° 21′ 45″ cos.=9.694175

22° 22′ 32″ Cot. *a*=0.385451

§ *v*. A triangle that has a side or an angle greater than 180° must never be used in the solution of trigonometrical problems.

§ *w*. Therefore in the solution of all cases (§ *u*.) where the sum, or difference of an auxiliary, and an arc or angle, is to be brought into calculation, if the *sum* would exceed 180°, the *difference* is the proper quantity to be used.

§ *x*. The two unknown sides may also be determined by a method of calculation differing from that above, but depending on principles analogous to those under § 77. for plane triangles. This method is the most common in practice.

§ *y*. The sine of ½ the *sum* of the two given angles (A, B);
Is to the sine of ½ their *difference;*
As the tang. of ½ the given side (*c*);
Is to the tang. of ½ the *difference* of the two required sides (*a*, *b*,). And,

§ *z*. Cos. of the *same* ½ *sum;*
Is to the cos. of the *same* ½ *difference;*
As the tang. of ½ the given side;
Is to the tang. of ½ the *sum* of the two required sides (*a*, *b*.)

§ *z a.* ½ (A+B)=76° 59′ co-sec.=0.011305
½ (A—B)=57° 18′ sin. =9.925060
½ *c*= 18° 9′ 30″ tang. =9.515844

Tang. ½ (*a* ∾ *b*)=9.452209=15° 48′ 58″

½ (A+B) sec. =0.647365
½ (A—B) cos. =9.732587
½ *c* - tang.=9.515844

Tang. ½ (*a*+*b*)=9.895796=38° 11′ 29″

§ *z b.* The greater side (*b*) is opposite (§ 139.) to the greater angle; and (§ 77. § *g.*) 38° 11′ 29″+15° 48′ 58″=54° 00′ 27″ or *b*; and *a*=(38° 11′ 29″—15° 48′ 58″=), 22° 22′ 31″.

§ *z c.* To determine the value of the third angle (C) with the help of an auxiliary arc *a′*.

§ *z d.* The *sine* of ½ the *sum* } of the two given angles
Is to ½ the *sum* of the sines } (A & B);
As the sine of ½ the given side (*c*);
Is to the sine of auxl. *a′*. Then,

§ *z e.* The product of cos. of auxl. *a′* and sine of ½ the sum of the two given angles, is cos. of ½ the third angle (C).

§ *z f.* B=134° 17′ sin. =9.854850
A= 19° 41′ sin. =9.527400

2)19.382250

9.691125=½ sum of the sines of the two given angles.

½ *c* =18° 9′ 30″ sin. =9.493659
½ (A+B)=76° 59′ co-sec.=0.011305 - sin.=9.988695

Sin. auxl. *a′*=9.196089=9° 2′ 12″ cos.=9.994576

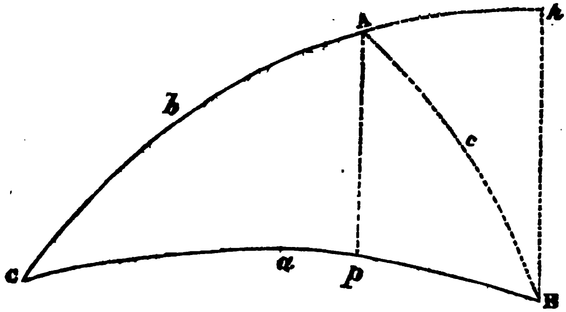
15° 48′ 5″ Cos. ½ C=9.983271

2

C=31° 36′ 10″

CASE IV.

§ 200. Given two sides and the angle they include,



$a = 109° \; 30'$
$b = 60° \; 00'$
$C = 27° \; 06'$

To find the other parts (A, B, c). This is the converse of Case III., for we have to find here what is there given.

§ *a*. If the perpendicular A p fall within the triangle, the sum of the segments (C p+p B) is equal to a; and the sum of the auxiliary angles, C Ap+p A B=A.

§ *b*. Any one of the unknown parts of the triangle proposed, being found, the two others are determinable from the relations (§ 144.) of sides to their opposite angles.

§ *c*. To find B, by the Catholic Proposition. By Case II., (§ 171. § *c*.) tang. Cp=$\frac{\text{Cos. C}}{\text{Cot. } b}$=(§ 101. § *b*.) cos. C tang. b; also (§ 171. § *d*.) sin. A p=sin. b sin. C. Then (§ *a*.) a—C p=p B; and the value of A p, and of B p, in the triangle A p B, being known, that of B (§ 155.) is determinable; cotang. B = (§ 172. § *b*.)= $\frac{\text{Sin. } p \text{ B}}{\text{Tang. A} p}$=sin. p B cotang. A p.

§ *d*. C=27° 6′ cos.=9.949494
b=60° 0′ tang.=0.238561

Tang. Cp= 0.188055=57° 2′ 4″

C sin.=9.658531
b sin.=9.937531

Sin. Ap=9.596062=23° 14′ 8″

109° 30′—57° 2′ 4″ (§ *a*.)=p B=52° 27′ 56.″

§ *e.* p B=52° 27′ 56″ Sin. =9.899267
A p=23° 14′ 8″ Cotang. =0.367204

Cotang. B=10.266471=28° 25′ 54″

§ *f.* To find the value of each of the unknown angles (A, B), with the help of an auxiliary arc (a'). A perpendicular drawn from either of the unknown angles (A, B) fulfils the conditions of § *a.* (§ 184.); suppose the perpendicular drawn from B to the fall without the triangle.

§ *g.* Let the distance (C p or C h) of the given angle from the perpendicular be auxiliary a'. Then whether the perpendicular fall within or without the triangle, the *difference* (§ *d.*) between the side upon which it falls and the auxl. a' is the other segment of that side.

§ *h.* First, to find the value of B, the arc Cp being auxl. a'; tang. a' (§ *d.*)=cos C tang. b.

§ *i.* According to Case II. (§ 198. § *r.*) $\frac{\text{Rad.}}{\text{tang. A}p}=\frac{\text{Cot. C}}{\text{Sin. }a'}=\frac{\text{Cot. B}}{\text{Sin. }(a \backsim a')}$; and by transposition Cot. B $=\frac{\text{Cot. C Sin. }(a \backsim a')}{\textit{Sin. } a'.}$ =cot. C sin. $(a \backsim a')$ *cosec.* a'.

§ *j.* To find the value of A. In the triangle C h B, C h is auxl. a'; and tang. a'=cos. C tang. a.

§ *k.* Also, $\frac{\text{Rad.}}{\text{Tang. B }h}=\frac{\text{Cot. C}}{\text{Sin. }a'}=\frac{\text{Cot. A}}{\text{Sin. }(b \backsim a')}$; and by transposition, Cot. A $=\frac{\text{Cot. C Sin. }(b \backsim a')}{\text{Sin. }a'}$=cot. C sin. $(b \backsim a')$ cosec. a'.

Whence the general rule for finding either angle.

§ *l.* The product of cos. of the given angle (§ *h.* and § *j.*) and tang. of the side *opposite* to the required angle, is tang. of auxl. a'. And,

§ *m.* The sin. of the *difference* between auxl. a' and the side *adjacent* to the required angle, multiplied by the *product* of the cosec. of auxl. a' and cotang. of the given angle (§ *i.* and § *h.*), is cotang. of the required angle.

§ *n.* b=60° 0′ tang.=0.238561
C=27° 6′ cos.=9.949494 - - cot.=0.290963

Tang. auxl. a'=0.188055=57°2′4″ cosec.=0.076240

$(a' \backsim a)$=52° 27′ 56″ sin.=9.899268

28° 25′ 54″ Cot. B=0.266471

§ *o*. Or, to find the value of A;

$a = 109^\circ\ 30'$ tang $= 0.450851$
$C = 27^\circ\ 6'$ cos. $= 9.949494$ - - - cot. $= 0.290963$

Tang. $a' = 0.400345 = 111^\circ\ 41'\ 32''$ cosec. $= 0.031898$

$(a' \backsim b) = 51^\circ\ 41'\ 32''$ sin. $= 9.894699$

$148^\circ\ 47'\ 10''$ Cot. A $= 0.217560$

§ *p*. The value of the third side (c) can be found with the help of the same auxiliary a'.

§ *q*. When the perpendicular falls within the triangle, $\frac{\text{Cos. A}p}{\text{Rad.}}$ (§ 198. § *l*.) $= \frac{\text{Cos. } b}{\text{Cos. } a'} = \frac{\text{Cos. } c}{\text{Cos.}(a \backsim a')}$; by transposition Cos. c. $= \frac{\text{Cos.} b \text{ Cos.}(a \backsim a')}{\text{Cos. } a'} = $ cos. b cos. $(a \backsim a')$ sec. a'.

§ *r*. And when the perpendicular (B h) falls without the triangle, $\frac{\text{Cos. B} h}{\text{Rad.}} = \frac{\text{Cos. } a}{\text{Cos.} a'} = \frac{\text{Cos. } c}{\text{Cos.}(b \backsim a')}$; by transposition, cos. $c = \frac{\text{Cos.} a \text{ Cos.}(b \backsim a')}{\text{Cos. } a'} = $ cos. a cos. $(b \backsim a')$ sec. a'.

N. B. $(a \backsim a') = p$ B, and $(b \backsim a') = $ A h.

Hence the general rule for finding the third side.

§ *s*. The product of cos. of the given angle, and tangent of either given side, (§ *h*. & § *j*.), is tang. of auxl. a'.

§ *t*. Then (§ *q*. & § *r*.) cos. of the same given side, ***multiplied*** by the ***product*** of sec. of auxl. a', and cos. of the ***difference*** between auxl. a', and the ***other*** given side, is cos. of the required side.

§ *u*. $C = 27^\circ\ 6'$ cos. $= 9.949494$
$b = 60^\circ\ 0'$ tang. $= 0.238561$ - - cos. $= 9.698970$

Tang. $a' = 0.188055 = 57^\circ\ 2'\ 4''$ sec. $= 0.264293$

$(a \backsim a') = 52^\circ\ 27'\ 56''$ cos. $= 9.784786$

$55^\circ\ 57'\ 24''$ Cos. $c = 9.748049$

§ *v*. Or, taking the tang. and cos. of a;

$C = 27^\circ\ 6'$ cos. $= 9.949494$
$a = 102^\circ\ 30'$ tang. $= 0.450851$ - - - cos. $= 9.523495$

Tang. $a' = 0.400345 = 111^\circ\ 41'\ 32''$ sec. $= 0.432244$

$(b \backsim a') = 51^\circ\ 41'\ 32''$ cos. $= 9.792312$

$55^\circ\ 57'\ 24''$ Cos. $c = 9.748051$

§ *w*. The difference between the two log. co-sines of *c* arises from fractions of a second ($''$), which are in somc of the parts operated upon. These fractions may sometimes cause an error of a few seconds ($''$) in the value of the part required.

§ *x*. There is a method for finding the value of the two angles (A & B) analogous to that under § *y*. and § *z*. (§ 199.), for finding two sides. In drawing up formulæ, and selecting methods, for trigonometrical calculations, attention should be paid to what is given, as well as to what is required, in the problem; and that method of solution should be adopted, which equally as correct as others, leads most directly to the result required.

§ *y*. To find A and B without the help of auxiliaries.

§ *z*. The cos. of ½ the *sum*, } of the two sides;
Is to cos. of ½ the *difference*, }
As co-tang. of ½ the given angle;
Is to tang. of ½ the *sum* of the required angles.

§ *z a*. The sine of ½ the *sum*, } of the two sides;
Is to the sine of ½ the *difference*, }
As co-tang. of ½ the given angle;
Is to tang. of ½ the difference of the required angles.

§ *z b*. $\frac{1}{2}(a+b)=84° 45'$ sec. $=$ 1.038571
$\frac{1}{2}(a-b)=24° 45'$ cos. $=$ 9.958154
$\frac{1}{2}$ C $=13° 33'$ cot. $=$ 0.617980

Tang. ½ sum (A & B) $=1.614705=88° 36' 32''$

$\frac{1}{2}(a+b)$, co-sec. $=$ 0.001826
$\frac{1}{2}(a-b)$, sin. $=$ 9.621861
$\frac{1}{2}$ C cot. $=$ 0.617980

Tang. ½ diff. (A & B) $=0.241667=60° 10' 38''$

§ *x c*. $88° 36' 32''+60° 10' 38''=\text{A}=148° 47' 10''$ } (§77.§ *h*.)
And, $88° 36' 32''-60° 10' 38''=\text{B}=28° 25' 54''$ }

§ *z d*. The following method of finding the value of the third side (c) with the help of an auxl. a', is useful and of frequent occurrence in nautical calculations.

§ *z e*. Half the *product* of the sines of the given sides, and *twice* the sine of half the given angle, *multiplied* by the co-sec. of ½ the *difference* between the two sides, is the tang. of auxl. a'.

§ *z f*. Then the product of co-sec. of a' and said *half product* of the sines of the *three* said quantities, is the sine of *half* the required side.

§ *z g*.

$a = 109^\circ\ 30'$ sin. $= 9.974347$

$b = \ 60^\circ\ 00'$ sin. $= 9.937531$

$\frac{1}{2}\,C = \ 13^\circ\ 33'$ sin.$\times 2 = 18.739522$

$2\ )\ 38.651400$

19.325700 $\qquad\qquad$ 19.325700

$\frac{1}{2}\,(a \backsim b) = 24^\circ\ 45'$ co-sec.$= \ 0.378139$

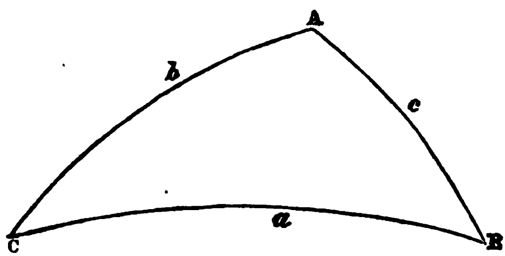
Tang. auxl. $a' = \ 9.703839 = 26^\circ 49' 22''$ cosec.$= 0.345600$

$27^\circ\ 58'\ 42''$ $\qquad$ Sin. $\frac{1}{2}\,c = \ 9.671300$

2

$c = 55^\circ\ 57'\ 24''$

CASE V.



§ 201. Given the three sides

$a = 66^\circ$
$b = 44^\circ$
$c = 30^\circ$

To find the angles.

§ *a*. Neither in this, nor in the preceding case, can the value of any one of the unknown parts be determined by the Catholic Proposition; for the proposed triangle cannot be so divided into two right angled triangles, that two of the given parts shall be contained in either of them.

§ *b*. This, and the case that immediately precedes it, are particularly useful to the navigator. Some of the most important problems, and those which are of most frequent occurrence in navigation, come under one or both of these cases for solution. The problems, for finding azimuths and the time of day at sea, fall under this case. This and the preceding case are both involved in the calculations for findiug the *true*, from the *observed*, lunar distance. Both cases are also involved in finding the latitude by "double altitudes." And by Case IV, the lunar tables in the nautical almanac, are calculated.

§ *c*. In this, as under the other cases, there are several methods for finding the value of the required part. In all cases the methods, which are the best adapted to practical purposes, are given.

§ *d*. To find one of the angles (A). The *product* of the co-sec. of the sides that contain the required angle, *multiplied* by the *pro-*

duct of the sine of half the sum of the three sides, and sine of that *half sum*, *less* the side opposite the required angle, is *double* the cos. of ½ the required angle.

§ *e*. *Twice* the tang. of ½ the required angle, is the *product* of co-sec. of ½ the sum of the three sides, and co-sec. of said ½ sum, less the side opposite the required angle, *multiplied* by the *product* of the sines of the *difference* between said *half sum* and each of the sides that contain the required angle.

§ *f*. $a = 66°$ (§ *d*.)

$b = 44°$ co-sec. $= 0.158229$

$c = 30°$ co-sec. $= 0.301030$

$2)140°$

$\frac{(a+b+c)}{2} = 70°$ sin. $= 9.972986$

$\frac{(a+b+c-a)}{2} = 4°$ sin. $= 8.843585$

Twice cos. ½ A $= 2)19.275830$

Cos. ½ A $= 9.637915 = 64°\ 15'\ 5''$

2

$A = 128°\ 30'\ 10''$

§ *g*. $\frac{(a+b+c)}{2} = 70°$ co-sec. $= 0.027014$ (§ *e*.)

$(\frac{a+b+c}{2} - a) = 4°$ co-sec. $= 1.156415$

$(\frac{a+b+c}{2} - b) = 26°$ sin. $= 9.641842$

$(\frac{a+b+c}{2} - c) = 40°$ sin. $= 9.808068$

Twice tang. ½ A $= 2)20.633339$

Tang. ½ A $= 10.316669 = 64°\ 15'\ 5''$

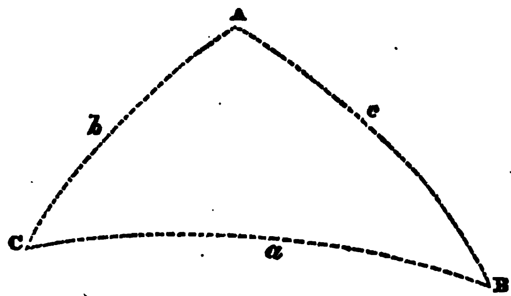
2

$A = 128°\ 30'\ 10''$

§ *h*. In all cases § *g*. is a good solution. But when the required angle (A) is near 180°, (§ 176. § *c*.) solution § *f*. will not carry great accuracy into the result. But this seldom occurs in practice, and in most cases either solution may be adopted with success.

§ *i*. One of the angles being found, the two others (§ 144.) are determinable.

CASE VI.



§ 202. Given the three angles,

A=114°
B= 39°
C= 49°

To find the value of the sides.

§ *a.* This problem is but of little practical utility to the navigator, for problems in which the three angles of a triangle are the data, seldom occur. But there are several methods by which the side required may be found; one of which, being general in its application, is thought sufficient.

§ *b.* The *product* of cos. of the difference between half the sum of the three angles, and each angle adjacent to the required side, *multiplied* by the *product* of co-sec. of each of said angles, is twice the cos of ½ the required side.

§ *c.* To find the value of *a*.

$\frac{(A+B+C)}{2}-B$ =62° co-sine = 9.671609

$\frac{(A+B+C)}{2}-C$ =52° co-sine = 9.789342

B =39° co-sec. = 0.201128

C =49° co-sec. = 0.122220

Twice cos. of ½ *a*=2)19.784299

Cos. ½ *a*= 9.892149=38° 43′ 50″

2

a=77° 27′ 40″

§ *d.* The value of one side being known, that of the others is determinable.

NAUTICAL ASTRONOMY.

NAUTICAL ASTRONOMY.

§ 203. That part of astronomy which treats of the motions and of the positions of the heavenly bodies, is an important branch of navigation. A knowledge of these motions and positions is highly essential to the navigator; for it is by understanding them, that methods have been devised for determining latitude and longitude at sea, by means of observations made upon the heavenly bodies.

§ 204. The figure of the earth is that of an oblate spheroid. It resembles that which would be described by the revolution of a semi-ellipse about its minor axis. It is flattened in at the poles, and elevated towards the equator.

§ 205. To suit the common purposes of navigation, the earth may be considered as a perfect sphere; the sun as the centre of the universe, and the centre of motion in the planetary system; the fixed stars may be considered to be almost stationary, and immeasurably distant from the earth and from each other; from every part of the earth's orbit, they are seen in the same relative positions, with regard to each other.

§ 206. The earth has two rotary motions; one about its axis, which produces day and night; the other in its orbit, and around the sun, which causes the seasons.

§ *a*. The latter is called the earth's annual, and the former its diurnal, motion.

§ 207. In its annual revolution around the sun, the earth describes the periphery of an ellipse.

§ *a*. The centre of the sun is in the plane, and at one of the foci of this ellipse, and the centre of the earth moves on its circumference.

§ 208. The axis of the earth is inclined, from a perpendicular to the plane of its orbit, nearly at an angle of 23° 28′.

§ *a*. If the earth's axis were perpendicular to this plane, there would be no change of seasons, or variation in the length of day and night; and at either pole there would be continual day.

§ *b*. It is this angle of inclination which causes the *declination* of the sun.

§ *c*. In a northern winter, the earth is nearer to the sun than it is in summer; but owing to the sun's declination, or the inclination of the earth's axis to the plane of the earth's orbit, the south pole is turned towards the sun during the former season, and the sun's rays striking the northern hemisphere more obliquely than they do in summer, are in consequence, spread over a greater surface, and are therefore less effective in producing heat.

§ 209. The earth revolves from west to east. It completes one revolution on its axis in a day, and one around the sun in a year.

§ 210. The periphery of the earth's orbit, like the circumference of every re-entering curve, contains 360°.

§ *a*. The earth completes one revolution in its orbit, in 365*d*, 5*h*, 48*m*, and 48*s*.

§ *b*. Therefore, the motion of the earth in its orbit, in one day, is, as 365*d*, 5*h*, 48*m*, 48*s* is to 360°; the ratio of which is 59′ 8″.

§ 211. An *astronomical*, *sea* or *civil*, day, is the time between two consecutive noons, or midnights.

§ 212. A *sidereal* day is the time between two consecutive transits of a star across the same meridian.

§ 213. The intervals of time from the passage of the sun and a star across, until their return to, the same meridian, are unequal. The difference between these intervals, results from the combined effect of the earth's motion about her axis, and in her orbit; for, during the interval between two consecutive transits of a star across the same meridian, the earth advances in its orbit (§ 210. § *b*.) nearly 59′ 8″; so that the transit meridian has to go 59′ 8″ more than one complete revolution around the axis of the earth, before it returns to the sun.

§ *a*. Thus, during the time in which the earth is making one complete revolution in its orbit, a star has one transit more than the sun has, across any proposed meridian.

§ *b*. Sidereal accelerates upon *mean* solar time, 3*m*, 56*s*.55 in 24*h*, or about 9⅚*s* in an hour.

§ 214. The motion of the earth about its axis, is uniform; but the velocity of the earth in its orbit, is irregular. This irregularity is caused by the variation in the mutual action of the centrifugal and centripetal forces upon the earth.

§ *a*. The sidereal day is consequently of a uniform length; and the solar day varies with the velocity of the earth in its orbit.

§ *b*. This variation produces *equation* of *time*.

§ 215. *Apparent time* is the time which is deduced by calculation, from the bearing, or the altitude of the sun.

§ *a*. The time shown by a dial, is apparent time.

§ 216. *Mean time* is the average of apparent time.

§ *a*. Watches, etc., are designed to keep mean time.

§ 217. *Equation* of *time* is the difference between mean and apparent time.

§ 218. If the motion of the earth in its orbit, were uniform, describing equal arcs in equal times, there would always be the same length of time from one transit of the sun to another, across the same meridian; and apparent and mean time would always agree. But from noon to the succeeding noon, there is sometimes more, and sometimes less, than 24 hours.

§ *a*. Twenty-four hours is the average, or mean of the time, in which, during one complete revolution of the earth in its orbit, the sun performs every one of its 365 transits across the same meridian.

§ *b.* This is the time which all good time pieces show. The time shown by them and the sun agrees only four times during a year; when this agreement takes place, then there is no equation of time.

§ 219. All astronomical calculations, such as those in the nautical almanacs, etc., are computed for astronomical time.

§ *a.* Of those in the ephemeris, some are for *mean*, and some for *apparent* astronomical time.

§ 220. An astronomical day commences when the centre of the sun is on the meridian (say of Greenwich), and ends, when it returns to the same meridian.

§ *a.* An astronomical day is divided into 24 hours, which are reckoned in succession, from 1 up to 24.

§ 221. A civil day commences at the midnight, that *precedes* the beginning of the astronomical day.

§ *a.* A civil day is divided into two equal portions; the first is A.M.; it ends at noon, when the astronomical day begins: the latter is P.M.; it ends at midnight, when the succeeding day begins. Each division consists of 12 hours.

§ *b.* Consequently, the day civil, is always 12 hours in advance of the day astronomical. Thus, Dec. 11th, 9*h* 34*m* 44*s* A.M. is, according to astronomical time, Dec. 10th, 21*h* 34*m* 44*s*; and 16 hours of civil time, or Dec. 11th, 4*h* P.M., is Dec. 11th, 4*h*, according to the astronomical time. Therefore, when the civil time is A.M. 12 hours added to it makes it astronomical time.

§ 222. The *ecliptic* is a great circle, the centre of which is that of the earth, and the plane of which coincides with the plane of the earth's orbit. Therefore these planes cut the axis of the earth at the same angle.

§ 223. The sun is always in the ecliptic.

§ *a.* Considering the earth to be stationary in its orbit, the sun appears to perform an annual revolution, moving around the earth, on the periphery of the ecliptic, and crossing the equator twice during the year.

§ 224. The ecliptic is divided into 12 arcs, of 30° each. These divisions, named and marked, are called the Signs of the Zodiac. They are—

§ *a.* Aries (♈), Taurus (♉), Gemini (♊), Cancer (♋), Leo (♌), Virgo (♍), Libra (♎), Scorpio (♏), Sagittarius (♐), Capricornus (♑), Aquarius (♒), and Pisces (♓).

§ *b.* The first six being north of the equator, are called *northern signs.*

§ *c.* The other six are south of the equator, and are called *southern signs.*

§ 225. The points in which the ecliptic (§ 223. § *a.*) crosses the equator, are called the *equinoctial points;* because, when the sun passes through these points, the days and nights are equal.

§ 226. The sun crosses the equator, and enters the first point of

Aries, about the 21st of March. The sun then passes through Aries, Taurus, and Gemini, towards the north; and about the 21st of June, it reaches its greatest northern declination at the first point of Cancer, where it appears to be stationary for a while; it is then said to be in the *summer solstice.*

§ *a.* The first point of Cancer, is a *solsticial point.*

§ *b.* Returning thence, towards the south, the sun passes through Cancer, Leo, and Virgo, and completing its tour, or the north side of the equator, it arrives, about the 23d of September, at the intersection of the ecliptic with the equator, when the day and night are again equal, and the sun is in the *autumnal equinox.*

§ *c.* Recrossing the equator then, the sun enters the first point of Libra, and continuing on towards the south, it *descends* through Libra, and the succeeding signs, and reaches its greatest southern declination, about the 22d of December; then it is at the first point of Capricorn, and again appears to stand still.

§ *d.* The sun is now in its winter solstice; and returning towards the north, it *ascends* through Capricorn, Aquarius, and Pisces, and entering the first point of Aries, completes one annual revolution, and goes on to renew the seasons.

§ 227. The time from the sun's passing the first point of Aries, until its return to that point again, is about (§ 210. § *a.*) 365*d* 5*h* 48*m* 48*s*.

§ *a.* This is called a *solar*, or a *tropical, year*, and it is the year by which the seasons are regulated.

§ *b.* A solar, differs from a sidereal, year, about 20*m* 23*s*.

§ 228. A *sidereal year* is the time from the sun's leaving, until its return to, the same part of the heavens, or to the same fixed star.

§ *a.* A sidereal, is longer (§ 227. § *b.*) than a solar, year, on account of the *precession* of the *equinoxes*, which is a motion contrary to that of the sun through the signs.

§ *b.* While the sun is completing a revolution from left to right through the signs in successive order, they are moving in the contrary direction, or from right to left, and by the time the sun has returned to the first point of Aries, for instance, this point will have retrograded a little more than 51″; and, on account of this motion, the sun comes to this point sooner than it would have done, had the first point of Aries remained stationary.

§ 229. The *zodiac* is a belt in the heavens that extends 8° on each side of the ecliptic.

§ *a.* The orbits of all the primary planets are within the zodiac.

§ 230. The *primary planets* are Mercury, Venus, the Earth, Mars, Jupiter, and Saturn.

§ *a.* There are five other planets, but they cannot be seen with the naked eye. They are called *telescopic* planets.

§ 231. The points in which the orbit of a planet cuts the ecliptic, are called *nodes.*

§ *a.* That node is called the *ascending node* (☊), through which the planet passes, as it crosses the ecliptic, going from the south to the north side of it.

§ *b*. The other point of intersection is called the *descending node* (☋).

§ 232. The *equator*, or *equinoctial line*, is a great circle, whose plane divides the earth into two equal parts.

§ *a*. These parts are called the northern and southern hemispheres.

§ *b*. The centre of the earth is the centre of the equator, and of *all the great circles used in nautical astronomy.*

§ 233. The *poles* (§ 123.) of the equator, also called the *Poles*, are two points on the earth, that are diametrically opposite to each other; each is 90° from the equator.

§ *a*. The one on the north side of the equator, is the *north pole;* and that on the south side, is the *south pole.*

§ 234. A straight line from one pole to the other, passes through the centre of the earth, and (§ 124.) is called the *axis* of the earth.

§ *a*. Around this axis, the earth performs its diurnal revolutions.

§ 235. From the best measurements, the equitorial appears to be about 26 miles greater than the polar diameter of the earth. And the degrees of latitude increase in length from the equator towards the poles.

§ *a*. The surface of the earth (§ 204.) being flattened in at the poles, and elevated at the equator, its meridianal curvature is less near the former than it is near the latter; consequently a degree of latitude near the poles contains more fathoms, feet, etc., than one at or near the equator.

§ 236. Suppose the plane of the equator to be extended to the heavens; it there forms the *celestial equator*, and its poles, are the *poles* of the world.

§ 237. The latitude of places on the earth, is measured from the terrestrial equator; and their longitude is measured on it.

§ *a*. In the heavens, the declination of the bodies are measured from the celestial equator, and their ascension on it.

§ *b*. Declination and ascension are, in the heavens, what latitude and longitude are on the earth.

§ 238. The sun crosses the equator twice in a year.

§ *a*. While the sun is on the north side of the equator, the sun is constantly visible from the north pole, and daylight continues there until after the sun recrosses the equator, when the sun goes below the horizon, and does not rise again, until (§ 226. § *d*.) completing its southern tour, it is approaching the vernal equinox.

§ 239. The year, instead of being divided into seasons at the poles, may, more properly, be divided into day and night; for there is but one day and one night at each pole during the year.

§ *a*. At the north pole, the day commences about the 21st of March, when the sun crosses the equator, and continues until the sun recrosses the equator, which happens about the 23d of September, when night succeeds the day, and day begins at the south pole, and lasts until the sun again returns to the first point of Aries.

§ *b*. Owing to atmospheric refraction, the sun may be seen at either pole for several days previously to its rising above, and after it has gone below, the natural horizon.

§ 240. The morning and evening twilights at either pole, are together about two months and a half long.

§ *a*. When the sun crosses the *crepusculum*, the twilight begins and ends.

§ 241. *Crepusculum* is a small circle parallel to the horizon, and 18° below it.

§ 242. All small circles that are parallel to the horizon, are *almacanthers*.

§ *a*. To an observer at the north, or south pole, the horizon and the equator coincide, and the parallels of declination are almacanthers.

§ *b*. At the north pole, the crepusculum coincides with the parallel of the 18th degree of southern declination, which the sun crosses about the 29th of January, (near 51 days before it rises;) and on the 13th of November, (near 50 days after it has gone down).

§ *c*. On account of such long twilights, the winter nights, in high southern or northern latitudes, are rendered less gloomy than they otherwise would be.

§ 243. The earth is divided into five *zones*; two frigid, two temperate, and one torrid.

§ *a*. The torrid zone is the largest; it extends to the parallels of 23° 28′ north and south latitude; consequently it is 46° 56′ broad.

§ *b*. The small circles which limit it, pass through the solsticial points, and are called *tropics*, from *trepho*, (Gr.); because, when the sun reaches the parallel of declination for 23° 28′ (§ 226. § *b*. & § *d*.) it appears to turn its course, and to recede from the pole which it was approaching, and to retrograde towards the direction whence it came.

§ *c*. That parallel which is north of the equator, (§ 226.) is the *tropic* of Cancer.

§ *d*. And that on the south side of the equator, (§ 226. § *c*.), is the *tropic* of Capricorn.

§ *e*. The sun is vertical twice a year, at every place within the tropics.

§ 244. Each of the temperate zones extends over 43° 4′ of latitude.

§ *a*. That on the north side of the equator, called the north temperate zone, extends from the tropic of Cancer to the arctic circle.

§ *b*. And the south temperate zone extends from the tropic of Capricorn to the antarctic circle.

§ 245. The *arctic* and *antarctic* are small circles, parallel to the equator, and 23° 28′ from the poles.

§ *a*. The arctic is about the north, and the antarctic about the south pole.

§ *b*. They are sometimes called the *polar circles*.

§ 246. The *frigid* zones are between the polar circles and the poles.

§ 247. *Latitude* is distance on the earth, measured north or south, from the equator.

§ 248. *Meridians* are great circles, that are secondaries to the equator.

§ *a*. Therefore (§ 126. § *a*. & § 127.) they cut it perpendicularly, and intersect each other at the poles.

§ *b*. The arc of a meridian that is contained between a place and the equator, measures the latitude of that place.

§ *c*. The meridian of an observer passes through his zenith.

§ 249. *Parallels* of *latitude* are small circles, parallel to the equator.

§ *a*. All places upon the same parallel have the same latitude.

§ *b*. And all places that are on the same meridian, are in the same longitude.

§ 250. *Circles of longitude* are meridians.

§ 251. *Elevation* of the *pole* is the distance of either pole above the horizon of any observer.

§ *a*. This distance is measured on the meridian of the observer; it is equal to his latitude.

§ 252. *Longitude* is the distance, expressed in degrees, etc., between two meridians. It is measured on the equator, and east or west from a meridian.

§ *a*. A meridian from which longitude is measured, is called the *prime* meridian.

§ *b*. The location of this meridian is optional with topographers. The French reckon the longitude of all other places from the meridian of Paris; the Spaniards from Cadiz. The English use the meridian of the Royal Observatory at Greenwich for their prime meridian: and the Americans generally construct their charts from the meridian of Washington City.

§ *c*. But as long as most of the charts and the tables of the Nautical Almanac which we use, shall be constructed and calculated to the meridian of the Greenwich observatory, it will be found more expedient to reckon longitude from this, as the prime meridian.

§ 253. It is to be wished that all nations would fix upon one common prime meridian. One might be established from celestial phenomena, by which all that is arbitrary in its locality, might be made to disappear. La Place recommends the adoption of a universal first meridian, and suggests the propriety of selecting for this purpose, that meridian, upon which it was 12 o'clock when the sun entered the point of the vernal equinox in the year (1250), in which the apogee of the earth's orbit coincided with the solsticial point in Cancer. Such a universal meridian would pass about 8 miles west of Cape Mesurada on the Coast of Africa.

§ 254. The longitude of a place is measured on the arc of the equator, which is contained between the meridian of that place, and the prime meridian.

§ *a*. The angle at either pole, which these two meridians make with each other, is equal to the longitude.

§ *b*. Consequently the arc of a parallel of latitude (§ 249.), which is intercepted between that place and the meridian of any other place, contains, in degrees, the difference of longitude between these two places.

§ *c.* The difference of latitude between two places, is the arc which is contained on the meridian of either place, between the parallels of latitude of these two places.

§ 255. *Declination* is the distance of a heavenly body from the equitorial plane.

§ *a.* Declination is north or south, according as the body is north or south of the equator. It is measured in the heavens, as latitude (§ 248. § *b.*) is on the earth.

§ *b.* The arc of the circle of declination or of right ascension, that is contained between the equator and the centre of the body, measures its declination.

§ 256. *Circles* of *right ascension* or of *declination* in the heavens, correspond with meridians of terrestrial longitude.

§ *a.* They cut the equator at right angles, and intersect each other in the poles of the world.

§ 257. *Parallels* of *declination* are small circles in the heavens, that are parallel to the equator.

§ *a.* They correspond with parallels of latitude on the earth.

§ *b.* The tropics (§ 243. § *c.* & § *d.*) are the parallels of the sun's greatest declination.

§ 258. *Polar distance* is the distance of any celestial body from either pole.

§ *a.* It is the arc of the circle of declination that is contained between the body and either pole.

§ *b.* The complement of the declination of a heavenly body, expresses its polar distance.

§ 259. The *right ascension* of a body is the arc of the equator, which is between the first point of Aries and the circle of the declination of that body.

§ *a.* This arc is always counted in the order (§ 224. § *a.*) of the signs, and its dimensions are expressed in hours, minutes, and seconds.

§ 260. Right ascension in the heavens, is what longitude is on the earth. But the manner of reckoning them is different.

§ *a.* Longitude is reckoned from the prime meridian as far as 180° both east and west.

§ 261. Right ascension commences to be reckoned from the first point of Aries, and goes entirely around, in the direction in which the sun passes through the signs.

§ 262. The ascensional difference of the sun, is the difference between its right and oblique ascension, or between sunrise and 6 o'clock.

§ 263. *Horary angles* are those which meridians, or circles of declination, make with each other at the poles.

§ *a.* The 6 *o'clock hour circle*, is that circle of declination (§ 256. § *a.*) which cuts the equator and the horizon in the east and west points.

§ *b*. It is secondary to the equator and to the meridian of the observer.

§ *c*. Any circle of declination is an *hour circle*.

§ 264. *Celestial latitude* is distance between the ecliptic and any body in the heavens; it is measured from the ecliptic, and upon a secondary to it.

§ 265. The secondaries of the ecliptic, are circles of celestial longitude.

§ *a*. The arc of the circle of celestial longitude, that lies between the ecliptic, and a body in the heavens, measures in degrees, etc., the latitude of that body.

§ 267. The longitude of heavenly bodies is reckoned on the ecliptic, as right ascension is on the equator (§ 259.).

§ *a*. It commences at the first point of Aries, and is reckoned around in the direction in which the sun passes through the signs.

§ 268. The right ascension and longitude of an object are never the same, except when the body is on the solsticial colure, which cuts both the ecliptic and the equator at right angles, and passes through their poles.

§ 269. The *solsticial colure* is that circle of declination which passes through the solsticial points (§ 226. § *a*. & *c*.).

§ 270. The *equinoctial colure* is the circle of declination, which passes through the equinoctial points (§ 226. § *b*.).

271. The equinoctial and the solsticial points are the four *cardinal* points of the heavens.

§ 272. The four *cardinal* points of the horizon are the east and west, and the north and south points.

§ *a*. The *east* and *west* are the points in which the equator and the horizon intersect each other.

§ *b*. The *north* and *south* are the points in which the meridian of the place cuts the horizon.

§ 273. Every observer has two horizons, one *rational*, the other *sensible*.

§ *a*. The eye is the centre of the latter, and is on the axis of the former.

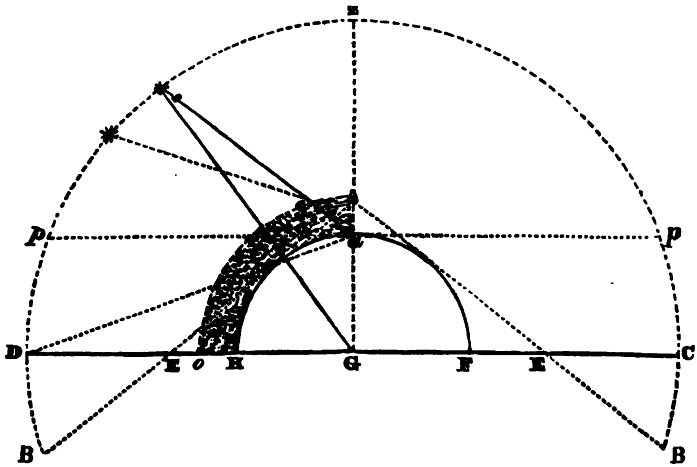
§ 274. The *sensible horizon* is that circle which terminates t'e view upon an uninterrupted plane.

§ *a*. It is formed by the apparent meeting of the plane upon which we stand, with the concave expanse above.

§ *b*. It is a small circle, and is parallel to the rational horizon.

§ *c*. The circle which terminates our view at sea, is the sensible horizon.

§ 275. The *rational horizon* is a great circle; its plane passes through the centre of the earth, and its axis through the eye of the observer. Suppose H *a* F to be half of the earth, D Z C the concave blue which bounds the vision, and D H C the plane of the rational horizon. If an observer were placed at the centre (G) of the earth, the angle D G Z would show the altitude of an object in the zenith, at Z, from the rational horizon. If the observer were placed at the circumference (at *a*) of the earth, *p a p* would be the plane of his visible horizon, and the angle *p a* Z (=D G Z § 30.) would show the altitude of a body at Z, from the sensible horizon. But if the observer were placed at A above the surface of the earth, the angle B A Z (>D G Z) would show the altitude of Z from his sensible horizon.



§ *a*. When the eye is elevated above the level of the sea, (as at A,) the line of vision A B to a point B in the sensible horizon, cuts the plane C D of the rational horizon at an angle, D E B, which angle is called the *dip*. Consequently, when the eye is above the surface of the plane on which we stand, the sensible horizon is *below* the rational horizon.

§ *b*. The poles of the rational horizon are the zenith and nadir.

§ 276. The *zenith* is the point in the heavens which is directly over head.

§ *a*. Being a pole of the horizon, the zenith is 90° from the horizon.

§ 277. The *nadir* is the other pole of the horizon; it is in the lower part of the heavens, directly under our feet, and diametrically opposite to the zenith.

§ 278. *Azimuth* circles are secondaries (§ 127.) to the horizon; cutting it perpendicularly, they intersect each other in the zenith and nadir.

§ *a*. They are also called *vertical* circles.

§ 279. The azimuth circle which cuts the horizon in the east and west points, is called the *prime vertical*.

§ *a*. The prime vertical of every observer, is secondary to his meridian.

§ 280. The altitude, and zenith distance of a heavenly body, are measured on its azimuth circle.

§ 281. The *zenith distance* of a heavenly body is its distance from the zenith of the observer; thus, Z *s* (§ 275.) is the zenith distance of the star at *s*.

§ *a*. It is measured on the arc of the azimuth circle, which lies between the centre of that body and the zenith.

§ *b*. The *zenith distance* is *north* when the body is south of the observer.

§ *c*. And south, when the body is north of the observer.

§ 282. The *altitude* of a heavenly body, is its distance above the horizon.

§ *a*. The arc of the azimuth circle which is contained between the centre of a body and the horizon, measures the altitude of that body; thus, D *s* (§ 275.) is the altitude of the star at *s*.

§ *b*. The complement of the altitude of a body, gives its zenith distance.

§ 283. The altitude which is taken of the sun or moon, with a quadrant or sextant, is the observed *altitude* of one of the edges, called a *limb*.

§ *a*. The apparent altitude of the *centre* is found by applying the corrections, (which are laid down in the Nautical Almanac,) for the semidiameter of the body, to the apparent altitude of its limb.

§ *b*. And the *true*, is obtained from the *apparent* altitude of the centre, by applying to the latter, corrections for the parallax and refraction, which are also known by previous calculations.

§ *c*. The apparent and the true altitude of a body, are always measured on the same azimuth circle.

§ 284. The rays of light coming from the heavenly bodies strike the atmosphere obliquely, and entering from a rarer into a denser medium, are refracted, or *bent downwards;* this causes the body whence they emanate to appear higher up in its azimuth circle than it really is. Suppose * *e* (§ 275.) be a ray of light from *, and A *o* to represent the atmosphere; when this ray strikes the atmosphere, it will be refracted so as to reach the eye of the observer at *a*, in the direction *a e*, which makes * appear at *s*, above its true place.

§ *a*. Hence the apparent altitude of the sun or a star is always greater than the true altitude, unless the body be in the zenith.

§ 285. Parallax has a contrary effect; it acts in a direction opposite to that of refraction, and causes a body to appear *lower* down in its azimuth circle than it really is.

§ *a*. But the effects of parallax and refraction, though acting in contrary and opposite directions, seldom counterbalance each other, so as to make an object appear in its true place.

§ 286. The parallax of the moon is always greater than the refraction; and the moon always appears below its true place.

§ *a*. Hence the apparent, is always *less* than the true altitude of the moon.

§ 287. The *horizontal parallax* of a body, is the difference between the *true* and *apparent* place of that body, (supposing there be no refraction), when it is in the horizon.

§ *a*. The horizontal parallax is equal to the angle at the body, which is subtended by the distance of the observer, from the centre of the earth.

§ *b*. The angle which this distance, or semidiameter, subtends, is greatest when the body is in the plane of the rational horizon; thus, the parallax of a body at D, (§ 275.) is the angle G D *a*; and the parallax of the same body, when at *s*, is G *s a*.

§ *c*. As the object rises above the horizon, the angle which this semidiameter subtends, is called *parallax* in *altitude;* it gradually decreases until the object reaches the zenith, when it vanishes.

§ *d*. The nearer the object is to the earth, the greater will this angle be at the centre. Hence the moon's parallax is greater than the sun's, and this greater than that of the fixed stars.

§ 288. The parallax of a body decreases from the horizon to the zenith, in the proportion of sine of the zenith distance (§ 281.) to radius.

§ 289. Owing to the effects of parallax and refraction upon the heavenly bodies(§ 285. § *a*.), they are never seen in their *true* places, except when in the zenith.

§ *a*. The places in which the heavenly bodies are seen, are called their *apparent places*.

§ 290. The *true place* of a heavenly body, is that place in which it would appear, if seen from the centre of the earth.

§ 291. The *azimuth* of a celestial body is the angle which is contained at the zenith, between the meridian of the place, and an arc of the azimuth circle, which passes through the centre of that body.

§ *a*. In north latitudes, the angle on the *north* side, and in south latitudes, the angle on the *south* side, of the arc of this azimuth circle, is called the azimuth.

§ *b*. Before a body crosses the meridian of the observer, its azimuth is east, and west afterwards.

§ *c*. Thus, in north latitude, an azimuth is said to be *north*, so many degrees east, if the body be east of the meridian; or *N*, so many degrees west, if it have passed the meridian.

§ *d*. And in south latitude, the azimuth is reckoned in the same manner from the south point, to the east or west.

§ 292. The *amplitude* of a celestial object, is the arc of the horizon that lies between the east or west point, and the centre of that object when it is rising or setting.

VARIATION OF THE COMPASS.

§ 293. The variation of the needle, is determined by means of azimuths, or amplitudes.

§ 294. The needle does not always point to the north and south poles. At some places it points to the east, and at others to the west, of the true north and south points.

§ *a*. Even at the same place, the polarity of the needle does not remain constant.

§ *b*. As to the direction in which the needle points, it is subject to certain periodical changes, which do not follow any known laws.

At some places, after having pointed, for several years, to the eastward of the true north, it has gradually pointed nearer to the north point, until its position lay due north and south; then crossing the direction of the meridian, the needle has continued to turn more and more to the westward of the true north, until it has attained the maximum of its deviation for that place, when, after having remained stationary for a time, it commenced its return towards its former position.

§ 295. *Variation* of the compass is the deviation of the needle, from pointing to the north and south poles.

§ 296. The points to which the needle tends, are called the *magnetic* north and south points.

§ 297. When the northern point of the needle, or the N point on the compass card, points to the eastward, or to the *right*, of the true north, the variation is *easterly*.

§ *a.* And *westerly* when the same point points to the *left*, or to the westward of the true north.

§ 298. The true direction of the magnetic north point, is found by applying the variation, when it is easterly, to the *right* of the true north; and to the *left* of the *true* north, when the variation is westerly.

§ *a.* Thus, when the variation is one point easterly, the north point of the needle, or the N point on the compass card, points N. by E. And it points N.N.W. when the variation is two points westerly.

§ *b.* Wherefore, knowing the magnetic bearing of any object, its true bearing may be determined, by applying the variation, when easterly, to the *right* of its compass bearing; and to the *left*, when the variation is westerly.

§ *c.* The true bearing of an object, that bears east per compass, is E. by S. if the variation be one point easterly; but E. by N. if the variation be one point westerly.

§ 299. The cause of variation, as well as of the attraction of the needle, towards the poles, is unknown.

§ 300. The needle is subject to the influence of another power equally mysterious in its nature; it is called *local attraction.*

§ *a.* This attraction operates on ship-board, and with different effects in different latitudes, as well as in the different directions in which the vessel may be heading,

§ *b.* Its effects upon the needle become obvious by taking the bearing of a fixed point on shore, then swinging the ship entirely around, and observing at several different points of her heading, the bearing of said fixed point.

§ *c.* The effect of local attraction upon the compass, is not often taken into consideration by navigators, although on board of vessels in some latitudes, (as in the English channel), it is said to cause the needle to deviate several degrees. The loss of fleets has been ascribed to the neglect of this attraction, on the part of navigators. N.B.

§ *d.* In conducting surveys particular attention should be paid to the effect of local attraction upon the needle.

§ 301. A *magnetic* meridian is a great circle that passes through the magnetic north and south points, and through the zenith of the observer.

§ *a*. The needle always lies in the direction of this meridian.

§ *b*. Magnetic meridians cross each other in the magnetic poles.

§ 302. The *magnetic* equator is a secondary to all magnetic meridians.

§ 303. The *magnetic* prime vertical is a secondary to the magnetic meridian of the observer.

§ *a*. It passes through the zenith and the magnetic east and west points of the horizon.

§ 304. The *magnetic* azimuth of a celestial body, is an angle at the zenith, that is contained between the magnetic meridian of the observer and the zenith distance of the object, when its bearing is taken.

§ *a*. The magnetic azimuth should always be reckoned from the nearest pole, around towards the east, when the object is on the east side of the meridian of the observer; and to the west, after the object has crossed the meridian.

§ *b*. The advantage of reckoning the magnetic azimuth in this way, consists in having the true and magnetic azimuth always of the same name; i. e. either both east, or both west.

§ 305. The *magnetic* amplitude of a celestial body, is that arc of the horizon, which lies between the centre of the body, when the body is in the horizon, and the magnetic east or west point, according as the body is rising or setting.

§ 306. Upon the magnetic equator, the needle assumes a horizon tal position.

§ *a*. To the north or south of this equator, it points *downwards*, inclining towards the nearest magnetic pole.

§ 307. The angle of this inclination of the needle, below the plane of the horizon, is called the *dip* of the needle.

§ *a*. The maximum of the dip is at the magnetic poles, and the minimum at the equator.

§ *b*. The ratio of the increment in dip, from the equator, towards the poles, has never been satisfactorily established.

§ 308. The variation of the compass is found by ascertaining the true and magnetic azimuths, or amplitudes, of any celestial object at the same moment.

§ *a*. The difference between them is the variation.

§ 309. The magnetic azimuth, or amplitude of a celestial object, is found by taking its bearing with an azimuth compass.

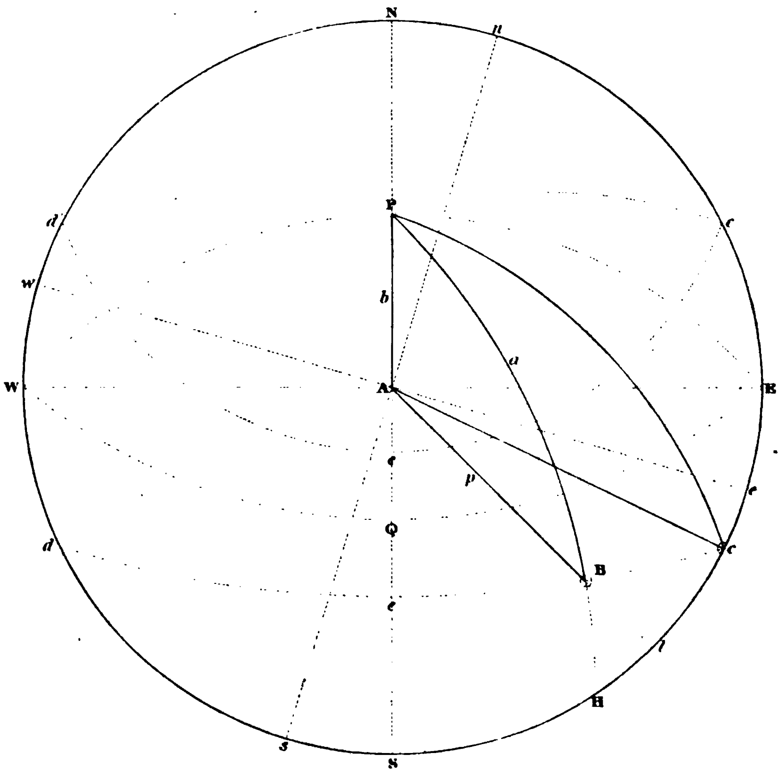
§ 310. The true azimuth or amplitude of a celestial object is determined by trigonometrical calculations.

§ *a*. The usual data for this operation, are the co-latitude of the observer, and the zenith, and polar, distances of the object.

§ 311. In North Latitude; the variation is easterly, if the magnetic, be less than the true, azimuth, when the object is on the east side of the meridian; or the variation is easterly, if the magnetic be the greater azimuth, when the object is west of the meridian.

§ *a*. And in South Latitude; the variation is easterly, when the magnetic is the greater azimuth in the former, and the less in the latter case.

Plate 2.



§ 312. In each case, *mutatis mutandis*, the variation is westerly.

§ 313. *Stereographic projection* is the most useful, and being the most natural, is the most simple mode of representing a sphere, or circles of a sphere, upon a plaue.

§ 314. In stereographic projection the eye is supposed to be at some point on the surface of the sphere, and to see one half of the sphere.

§ *a*. The circle which terminates the vision is called, in projection, the *primitive circle*.

§ *b*. The eye is the centre of this circle, and is the *projecting point*.

§ 315. The diagrams for the purposes of nautical astronomy, in this treatise, are projected upon the plane of the horizon.

§ 317. This Fig. is a stereographic projection upon the plane of the horizon, in lat. 40° north. } Plate 2.

§ *a*. A, the projecting point, represents the centre of the horizon W N E S, as well as the zenith and the eye of the observer; P, the pole of the observer; P N (§ 251.) the elevation of the pole; W Q E (§ 232.) the equator; A Q (§ 248. § *b*.) the latitude of the observer; and A P the complement of his latitude; W A E (§ 279.) his prime vertical; N P S (§ 248. § *c*.) his meridian; A B *l* (§ 278.) the azimuth circle of the body whose altitude is taken; B *l* and A B (§ 280.) its altitude and zenith distance; *d e c* (§257.) the parallel of its declination; P B (§ 258. § *a*.) its polar distance, and P B H (§ 256. § *a*.) is an arc of its circle of declination; A P B (§ 263.) is the horary angle at which the body is; B A P (§ 291.) is its azimuth; N, E, S, and W, (§ 272.) are the cardinal points of the horizon; and W P E (§ 263. § *a*.) is the six o'clock hour circle.

§ *b*. It is easily conceived how it is, that, of all circles which cut the primitive circle of a projection, only that part of their circumference which is above the primitive, can be seen from the projecting point; and that 180° of every arc of these circles, that are great circles, is above (§ 125. § *a*.) the horizon or plane of projection.

§ *c*. And consequently that all of these arcs will appear in the projection to be more straightened out, or of less curvature than the primitive circle; and this curvature will be in proportion inverse to the obliquity with which their planes cut the plane of the primitive.

§ *d*. The less obliquely these planes cut the plane of the horizon, the more obliquely the observer at A looks upon them, and consequently the less their arcs appear to be curved, until, looking upon the edge of the planes of those which pass through his zenith, they appear as straight lines.

§ 318. In these projections, every great circle (N P S, W A E,) which passes through the zenith, is represented as a straight line.

§ *a*. And the length of every line (A N, A *l*, etc.) included between the projecting point (A) and the circumference of the primitive, measures 90°, and is considered as the quadrant of a circle.

§ 319. All of those circles which cut the plane of the primitive obliquely, and whose arcs (W Q E, P B, etc.) appear in the projection, to be of less curvature than the primitive, are called *oblique circles.*

Plate 2. § 320. And those circles, whose arcs (N P S, W A E,) pass through the zenith (§ 318.) are called *right circles.*

§ *a.* With the horizon as the primitive circle; the meridian, (§ 248. § *c.*), prime vertical, (§ 279. § *a.*), and azimuth circles (§ 278.), pass through the zenith, and appear upon the plane of projection (§ 318.) as right circles.

§ 321. In lat. 40 N., the sun's declination being 20° S.; its magnetic azimuth was N. 119° 25′ E. in the morning, when its true altitude was 16° 48′ 25″; required the sun's true azimuth, and the variation of the compass.

§ 322. W N E S, (§ 316. § *a.*) represents the horizon of the observer; A, the centre of it, his zenith, and the place at which he stood to take the observation; *n* A *s*, the magnetic (§ 301.) meridian; and (§ 308. § *a.*) N A *n* is the variation.

§ *a.* The co-lat. (A P), the zenith, and the polar distance, (A B, P B) (§ 317. § *a.*), are the sides of the triangle A P B, and (§ 321.) are the given parts; and the azimuth P A B, is the required part; the value of it is determined according to Case V, (§ 201. § *d.*)

§ *b.* In the formulæ for calculation,
P D, stands for polar distance.
Z D, " zenith distance.
Co-lat. " complement of the latitude of the place of observation.

§ *c.* The complements of what is given (§ 321.) constitute the data of the proposed triangle.

§ *d.* b = 50° - = Co-lat.
p = 73° 11′ 35″ = Z D
a = 110° - = P D

To find the azimuth P A B, (§ 201. § *f.*)

§ *e.* a, or P D	= 110°		
p, or Z D	= 73° 11′ 35″	co-sec. =	0.018959
b, or Co-lat.	= 50° -	co-sec. =	0.115746
Sum	2)233° 11′ 35″		
½ Sum	= 116° 35′ 47″	sin. =	9.951426
½ Sum ∽ P D	= 6° 35′ 47″	sin. =	9.060224
			2)19.146355
Cos. ½ P A B	=		9.573177 = 68° 1′ 16″
			2

P A B (the true azimuth, § 291. § *c.*) = N 136° 2′ 32″ E
B A *n* (the magnetic do. (§ 304. § *a.*) = N 119° 25′ E

N A *n* = Variation (§ 311.) = 16° 37′ 32″ E.

§ *f*. The difference between the true and magnetic azimuths (§ 308. § *a*.) (N A B—*n* A B=N A *n*) is the variation. Plate 2.

§ *g*. The true, being greater than the magnetic azimuth, the variation (§ 311.) is easterly.

§ 323. Bearing in mind, that the co-sec. sine, etc., of an arc (§ 99.), is the sec., cos., etc., of the complement of that arc, the process by which the subjoined formula is deduced from (§ 322. § *e*.) the one above, becomes manifest.

§ *a*. Calculation by this formula operates more directly upon the data, and is, perhaps, preferable in practice on account of its greater readiness.

§ *b*. P.D.=110°

Alt.=	16° 48′ 25″	sec.=	0.018959
Lat.=	40°	sec.=	0.115746
	2)166° 48′ 25″		
½ Sum=	83° 24′ 12″	cos.=	9.060242
(½ S. ∾ P.D.)=	26° 35′ 48″	cos.=	9.951425
			2)19.146372
Cos. ½ tr. azim.=			9.573186= 68° 1′ 15″
			2
		Tr. azimuth=	N 136° 2′ 30″ E.

§ *c*. This difference of 2″ in the result of the two methods, arises from the fraction of a second in ½ *sum*; which, in either case, is not taken into computation.

§ *d*. Whence (§ 323.) the rule for calculating an azimuth. Take the difference between the P.D., and ½ sum of the lat. alt. and P.D.; then the *product* of the cos. of this ½ sum and of this difference, *multiplied* by the *product* of the sec. of the lat. and of the alt., is *double* the cos. of ½ of the true azimuth.

AMPLITUDES.

§ 324. When the magnetic, and true amplitudes of a body, are both north, or both south, the difference between them is the variation.

§ *a*. But when one of the amplitudes is north and the other south, they are of different names; and their sum is the variation.

§ 325. If the amplitudes be of the same name (§ 324.), and the *true* be the less northern, or the greater southern amplitude, the variation is easterly when the object is rising; and,

§ *a*. The variation is also easterly, when the object is setting, and the *true* is north and the greater, or south and the less, of the two amplitudes.

§ 326. If "*magnetic*" be read for "*true*" in the conditions above, the variation becomes westerly.

§ 327. If the amplitudes be of different names (§ 324. § *a.*), and the *true* be the northern amplitude, when the object is rising, or the southern amplitude when the object is setting, the variation is westerly.

§ *a.* The converse of these conditions makes the variation easterly.

§ 328. The true amplitude and declination of a body, are always of the same name.

§ *a.* Therefore it is known by inspecting the declination, whether the true amplitude be north or south.

§ 329. Every object in the heavens, always rises and sets to the north, or to the south of the east and west points, according as its declination is north or south;

§ *a.* The equator (§ 272. § *a.*) cuts the horizon in the east and west points; and a parallel of north or south declination, being (§ 257.) parallel to the equator, must therefore cut the horizon, (if at all), to the north or south of the east or west points.

§ 330. A body (say the sun), rises and sets in the points, in which the parallel of its declination cuts the horizon.

Plate 2. } § *a.* Thus the sun's declination being 20° S., it rises and sets in the points (*c* & *d*) in which the parallel (*d e c*) of that declination cuts the horizon.

§ 331. To an observer who is on the equator, the sun's declination at the time of its rising or setting, is its amplitude; for,

§ *a.* The equator is then the prime vertical, and that arc of the horizon which (§ 292.) measures the amplitude, coincides with the arc of the circle of right ascension, which (§ 255. § *b.*) measures the declination.

§ 332. The sun rises in the east, and sets in the west, point, only twice in the year.

§ *a.* This happens at the moments in which the sun enters the first point of Aries, and the first point of Libra, for (§ 226. and § 226. § *c.*) the sun is then crossing the equator.

§ 333. To an observer at either pole, the horizon and equator coincide, and the sun does not set, while it is on that side of the equator, which is next to the observer. And,

§ 334. If the observer approach any point of the equator, that point will rise *above*, and the one diametrically opposite, will sink *below*, the horizon as many degrees as the observer advances from the pole. And,

§ *a.* The observer will not see the sun go below the horizon, until his distance from the pole is greater than the sun's declination.

§ 335. When the latitude and the sun's declination are of the same name, the sun is not seen to set as long as its declination is greater than the co-latitude.

§ 336. To find the sun's true amplitude, and thence the variation.

§ 337. At sun-rise in lat. 40° N., the sun's declination being 20° S., its magnetic amplitude was E. 9° 53′ 32″ South; required the true amplitude, and the variation.

§ 338. The place of the sun at the time of its rising (§ 330. § *a*.) is at the point (*c*) in which the parallel of its declination intersects the horizon; *w* A *e* (§ 303.) is the magnetic prime vertical; the arc E *c* (§ 292.) is the true, and *e c* (§ 305.) the magnetic, amplitude of the sun; and P A *c* is the triangle of the proposed problem, of which the sides are given, and P A *c* is the part required. The triangle (§ 142.) is quadrantal, of which the quadrantal side is A *c*, the zenith distance. } Plate 2.

§ *a*. Now (§ 150. § *a*.), calling the quadrantal side (A *c*) radius, and the legs (P A, P *c*) angles, and the angle P A *c* a leg, the problem is an example under Case IV. (§ 173. § *b*.).

§ *b*. P A or co-lat.= 50° cosec.=0.115746
P *c* or Z.D. =110° cos.=9.534052

Cos. P A *c*=9.649798=116° 31′ 4″

§ *c*. Now (§ 133. § *a*.) the arc N E *c* is the measure of the angle P A *c*; and the arc E *c* (§ 52. § *a*.) is the complement of N E *c*, and (§ 292.) the sun's true amplitude.

§ *d*. E *c*, the sun's true amplitude=E 26° 31′ 4″ S
e c, the sun's magnetic do. =E 9° 53′ 32″ S

The variation=16° 37′ 32″ E (§ 324.)

§ *e*. The amplitudes are both south, and the true is the greater; wherefore (§ 325.) the variation is easterly.

§ 339. By recurring to § 323. it is evident that the process of calculation (§ 338. § *b*.) for determining the amplitude, may be simplified, and rendered more convenient in practice, by a similar artifice.

§ *a*. Lat. =40° sec.=0.115746
Dec.=20° sin.=9.534052

Sin. ampl.=9.649798=26° 31′ 4″

Magnetic ampl.= 9° 53′ 32″

Variation=16° 37′ 32″ E

§ *b*. Whence the general rule in practice, for finding an amplitude.

The sine of the amplitude is the *product* of sec. of the lat. and sine of the dec. See Table VII.

SUNRISE.

§ 340. When the latitude of an observer, and the sun's declination, are either both north, or both south, the sun always rises before, and sets after, six o'clock.

§ 341. When the latitude and declination are of different names, the sun rises after, and sets before, six o'clock.

§ 342. When the sun rises in the east, or sets in the west, point of the horizon, the sun is (§ 272. § *a.*) on the equator, and (§ 263. § *a.*) in its six o'clock hour circle (W P E); and therefore rises and sets at six o'clock. Plate 2.

§ 343. The time of sunrise subtracted from 12 o'clock, gives the time of sunset, when the points in which the sun rises and sets, are equidistant from the point at which it crossed the meridian.

§ *a.* This happens when the declination at sunrise, and at sunset, is the same.

§ 344. When the sun (§ 342.) rises and sets at six o'clock, it is also in the first point of Aries, or of Libra;

§ *a.* As the sun's declination increases, its right ascension (§ 259.) becomes greater, and the first point of Aries farther from the east point of the horizon, when the sun is rising; and,

§ *b.* The interval between sunrise and 6 o'clock, also increases.

TIME.

§ 345. The time between sunrise and 12 o'clock, in any latitude, may be determined by knowing the sun's declination.

§ *a.* This operation consists in finding the value of the horary angle A P *c*, which the circle (P *c*) of declination, in which the sun rises, makes (§ 263.) with the meridian (N P S) of the place.

§ 346. The value of this angle, (A P *c*), like that of every other, is expressed in degrees; but may be converted into time, in the proportion of 360° to 24*h*, which (§ 218. § *a.*) is the mean time in which the earth performs a diurnal revolution.

§ *a.* $\frac{360°}{24}=15°$; therefore the sun describes an horary angle of 15° in 1*h*; $\frac{1h}{15}$ or $\frac{60m}{15}=4m$; wherefore the sun describes an horary angle of 1° in 4*m*, of 15′ in 1*m*, and of 15″ in 1*s*.

§ *b.* Whence the rule for converting longitude, degrees, etc., into time, and the reverse.

§ 347. Divide the degrees by 15, for *hours*, the product of 4 and the remainder, is *minutes*, (*m*); the quotient of the minutes (′) by 15 is also *minutes*, (*m*); and the product of 4 and the remainder to this quotient, is seconds (*s*); also the quotient of the seconds (″) by 15 is seconds (*s*) of time.

§ 348. The product of hours by 15, and the quotient of the minutes (*m*) by 4, are *degrees;* the product of the remainder of the minutes (*m*) by 15, and the quotient of the seconds (*s*) by 4, are *minutes* (′); and the product of the remaining seconds (*s*) by 15, is *seconds* (″).

§ *a.* The two first and two last columns of Tables II., show (with the hours at the bottom or top,) the value in time of the degrees and minutes which stand nearest to them.

§ *b.* And these columns may be used for finding the logarithmic value of hours, minutes, and seconds, as well as for converting degrees, etc., into hours, etc., and vice versa. Therefore in the solution of problems, in which a given or required part consists of hours, etc., these need not be commuted in the process of solution, into degrees, etc.; but may be operated with in calculations, under the denomination of *time*, and thus save the trouble of substituting their value in degrees, etc.

§ *c*. Substituting hours, etc., for degrees, etc., the logarithmic value of a horary angle may be taken from Tables II., according to the directions given under § 102. for degrees, etc. Thus, to take from the tables the log. of 4*h*, 20*m*, 40*s*; 4*h* is found at the right hand *bottom* corner of the tables; 20*m* is found in the right hand (*m*) column; and above 20*m*, 40*s* is found in the (*s*) column on the same side; opposite to 40*s*, and in the column which has the required precept at the *bottom*, is the required log.; thus, log. sine 4*h* 20*m* 40*s*=9.957863.

§ *d*. The time corresponding to any log. is taken from the tables according to the directions under § 103. given for taking out the degrees, etc., for a log. sine, etc. Thus, the value in time of log. sin. 9.618004=1*h* 38*m* 4*s*. The log. 9.618004 is found in the column marked (sin.) at the *top*. In the left hand column (*s*) of the page, and opposite to 9.618004, is 4*s*; above 4*s* in the (*m*) column is 38*m*, and at the top of the page on the same side is 1*h*.

§ *e*. The small columns marked (diff.) show the difference which 1*s*. or 15″ make in the log. sine, etc. of an arc or angle.

§ *f*. To convert 33° 10′ into hours, etc.; in juxta-position with 33° is 2*h*; and in the left hand columns, 10′ is opposite to 40*s*; and above 40*s*, is 12*m*; then 33° 10′=2*h* 12*m* 40*s*.

§ *g*. To convert 5*h* 20*m* 28*s* into degrees, etc.; 5*h* is found at the bottom, and 20*m* 28*s* in the right hand columns. In juxta-position with 5*h* is 80°, and above 20*m*, but opposite to 28*s*, stands 7′ in the (′) column; then 5*h* 20*m* 28*s*=80° 7′.

§ 349. To find the time of sunrise in lat. 40° N., the declination being 20° south.

§ *a*. The triangle of the problem proposed, is the quadrantal triangle A P *c* with the same data, and a similar process, which were used (§ 338. § *b*.) for finding the amplitude; } Plate 2.

§ *b*. P *c*, or P. D.=110° cot.=9.561066
P A, or Co-lat.= 50° cot.=9.923813

Cos. A P *c* (§ 348. § *d*.)=9.484879=4*h* 48*m* 52*s*.

§ *c*. 4*h* 48*m* 52*s* ∽ 12*h* (§ 341.)=7*h* 11*m* 8*s*, the apparent time of day at sunrise.

§ *d*. If the declination were 20° N., 4*h* 48*m* 52*s* (§ 340.) would be the apparent time of day at sunrise, and 7*h* 11*m* 8*s* at sunset.

§ *e*. The angle *c* P E, (§ 263. § *b*.) is the complement of the horary angle A P *c*.

§ *f*. And being the difference between sunrise and 6 o'clock, (§ 262.) it is the ascensional difference.

§ 350. To find the ascensional difference, we have only to take

Plate 2. { the *sine*, where cos. was taken above, in the operation (§ 349. § *b.*) for finding the time between sunrise and noon.

§ *a.* P. Dist.=110° co-tang.=9.561066
Co-lat. = 50° co-tang.=9.923813

Sin. *c* P E=9.484879=1*h* 11*m* 8*s*.

§ *b.* 1*h* 11*m* 8*s* (§ 349. § *c.*) is the complement of 4*h* 48*m* 52*s*, and (§ 349. § *f.*) is the ascensional difference.

§ 351. By using the trigonometric functions of the complements, the calculation (§ 350. § *a.*) is rendered more convenient for practice.

§ *a.* Dec. 20° tang.=9.561066
Lat. 40° tang.=9.923813

Sin. *c* P E=9.484879=1*h* 11*m* 8*s*.

Whence the rule for finding ascensional diff.

§ *b.* The *product* of the tang. of the lat. and dec., is the sine of the ascensional difference.

§ 352. When the latitude and declination are of the *same* name, the ascensional difference *subtracted* from 6 o'clock, gives the apparent time of day at sunrise; and,

§ 353. *Added* to 6 o'clock, when they are of *different* names, it gives the apparent time of sunrise.

§ *a.* Hence Table VIII. also shows the apparent time at *sunrise*, when the lat. and dec. are of the *same* name; and the apparent time of *sunset* when the lat. and dec. are of *different* names; for (§ 343.) the time at sunrise subtracted from 12*h* shows nearly the time at sunset. In the Table, the time from sunrise to 12 o'clock is supposed to be always equal to the time from noon till sunset.

§ 354. The length of the days and nights may be determined by means of the problem (§ 351.); for doubling the time from sunrise till noon, gives the time that the sun remains above the horizon; and,

§ *a.* Subtracting this time from 24, gives the length of the night, or the time that the sun is below the horizon.

THE PLANETS, MOON, ETC.

§ 355. A satellite is a body that revolves around a planet, as the centre of one of its motions, and also revolves with that planet around the sun.

§ *a.* The moon is the earth's satellite.

§ 356. Mercury and Venus, (§ 230.) are called *inferior* planets, because their orbits are between the earth's and the sun.

§ 357. Mars, Jupiter, Saturn, Herschel, etc., (§ 230. § *a.*) are *superior* planets.

§ *a.* Their orbits are further than the earth's is, from the sun.

§ 358. Jupiter has four satellites, which, revolving with different radii around its centre, accompany it in its revolutions around the sun.

§ *a.* As they revolve in their orbits from west to east, they pass behind Jupiter; and as they pass in front of it, they cross its disc. From the frequency of these passages, (called eclipses,) and the celerity of the motion of the satellites, their eclipses with Jupiter furnish excellent opportunities for ascertaining longitude, when the observer is on shore. The satellites cannot be seen with the naked eye, and are of no use for ascertaining longitude at sea, because telescopes for observing their immersions and emersions, cannot be used on ship-board on account of the motion of the vessel.

§ *b.* When Jupiter is nearly in conjunction with the sun, the satellites cannot be seen at all.

§ 359. The moon moves from west to east in its orbit, around the earth.

§ *a.* The average, or mean time in which the moon performs one revolution in its orbit, is 27*d* 7*h* 43*m* 5*s*; this is called a *periodical month.*

§ *b.* The moon performs, in nearly the same time, one revolution on its axis, by which means the same side of the moon is always presented towards the earth.

§ 360. At the same time every day, the moon is seen about 13° 10′ 30″ further to the east than it was the day preceding.

§ *a.* This gives the moon an hourly motion with regard to the sun, or fixed stars, of about 32′ 56″; and makes the lunar, about 49*m* longer than the solar day.

§ 361. When the moon presents a round, illuminated disc towards the earth, the latter is between the sun and the moon.

§ *a.* The moon is then about the point in its orbit at which it attains its greatest distance from the sun; and is said to be in *opposition* with the sun.

§ 362. At new moon, the moon is nearest to the sun, being between it and the earth.

§ *a.* The moon is then in *conjunction* with the sun.

§ *b.* The interval between two consecutive new or full moons is about 29*d* 12¾ *h.*

§ *c.* This interval of time is called a synodical month, to distinguish it from a periodical month (§ 359. § *a.*).

§ *d.* The difference between the periodical and synodical months is caused by the motion of the earth in its orbit around the sun; for by the time the moon returns in its orbit to the same place in the heavens, and is again in the position with regard to the fixed stars, which it had occupied 27*d* 7*h* 43*m* 5*s* (§ 359. § *a.*) before, the earth will have advanced in its own orbit, and the moon will have to continue on in its orbit, about 2*d* and 5*h*, before it overtakes the earth, and occupies the position, with regard to the earth and the sun, and presents the same appearance, which it did when the two months commenced together.

§ 363. The light of the moon is reflected from the sun.

§ *a*. And the different appearances of the moon's figure, called *phases*, are caused by the enlightened part of the moon being turned more or less towards the earth.

§ 364. When the moon, passing between the earth and the sun, crosses the straight line which joins their centres, the whole of its unenlightened side is turned towards the earth; then it eclipses the sun, and is seen, like an opake circular plane, passing over the disc of the sun.

§ 365. If the plane of the moon's orbit coincided with the plane of the ecliptic, the sun would be eclipsed at every new moon.

§ *a*. But as these planes are inclined at an angle of several degrees towards each other, the new moon passes sometimes below, and sometimes above, the line of vision from the earth to the sun.

§ 366. At full moon, when the earth intercepts the line of vision from the sun to the moon, the latter passes into the shadow of the earth caused by the sun, and is eclipsed.

§ *a*. The moon is not eclipsed at every opposition, on account (§ 365. § *a*.) of the inclination of the plane of its orbit to that of the ecliptic.

§ 367. *Syzygies* are the points in which the moon is, (§ 361. § *a*. & § 362. § *a*.), at apposition and conjunction. Consequently, the moon is in syzygy at every new or full moon.

§ 368. An eclipse of the sun or moon takes place only when the moon is in syzygy, and at, or near, one of its nodes (§ 231.).

§ 369. When the moon is half way between the syzygies, it appears as a semicircular plane, with the round part turned towards the sun.

§ *a*. Only half of the enlightened surface of the moon being seen from the earth, produces the appearance of a *half moon*.

§ *b*. In this position, the moon's angular distance from the sun is about 90°, and the moon is said to be in quadrature.

§ 370. A quadrature is marked (□), opposition (☍), and conjunction (☌).

§ *a*. There are two quadratures; one between new and full moon, the other between full and new moon.

§ 371. *Disc* is the face of the sun, of a planet, or of a satellite.

§ 372. *Digit* is the twelfth part of the breadth of a disc.

§ 373. *Apogee* is that point in the orbit of a body which is furthest from the earth.

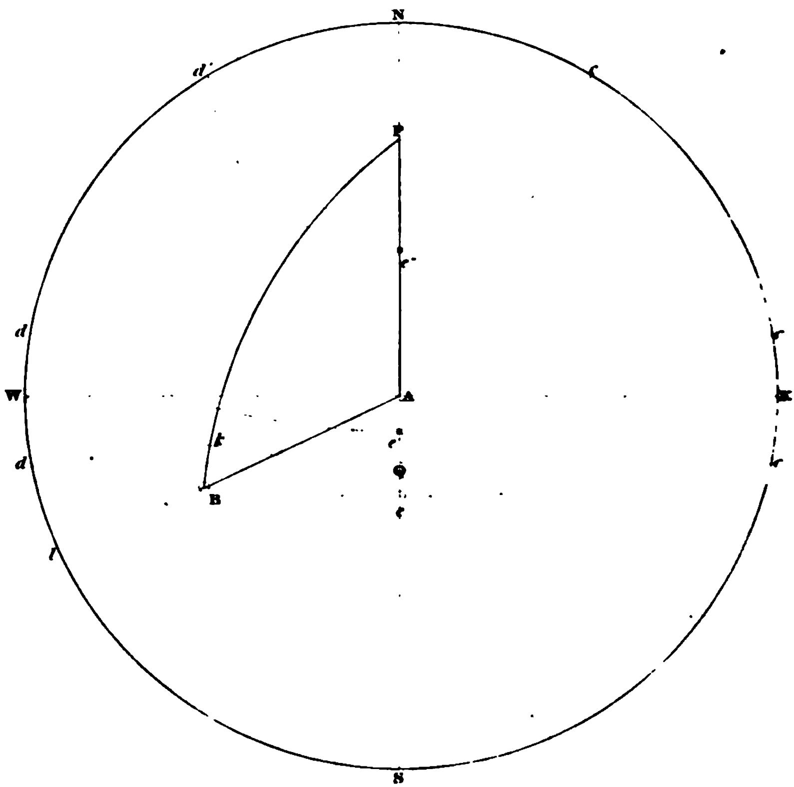
§ 374. *Perigee* is that point in which, when a body is, it is nearest to the earth.

§ 375. *Aphelion* and *perihelion* are positions of a body with regard to the sun, similar to those of apogee and perigee with regard to the earth.

§ 376. The motion of light is progressive.

§ *a*. During the time which a ray of light requires to come from the sun to the earth, the latter advances in its orbit nearly 21″; this

Plate 3.



causes the sun to be seen about that much always in the rear of its actual position in longitude.

§ 377. The sun's *aberration*, is the difference between the sun's longitude, at the time of the emanation of a ray of light from it, and its longitude, at the time when this ray reaches the earth.

§ *a*. The amount of aberration must always be added to the sun's *apparent* longitude, in order to obtain the *true* longitude of the sun.

§ *b*. The longitude of the sun, given in the ephemeris, is *apparent*.

§ 378. *Radius vector* is a line supposed to join the centres of a planet and the sun.

§ *a*. The logarithm of " the radius vector of the earth" is the logarithmic value of the earth's radius vector; the semi-axis major of the earth's orbit being taken as the base, or unity, in the logarithmic scale.

TIME OF DAY.

§ 379. In the triangle P A B, are comprised the elements necessary to the operation of finding, by trigonometrical calculation, the apparent time of day. Plate 3.

§ *a*. B P A, (§ 263.), is an horary angle, and if any three parts of the triangle in which it is, be given, the value of B P A is at once determinable.

§ 381. The primitive data, in the problem for finding the time of day by an observation, are usually the latitude of the observer, and the altitude and declination of the body under observation.

§ *a*. The complements of which form the triangle (B A P) of the problem.

§ 382. By inspecting the triangle of the problem proposed, it appears evident, that the horary angle (A P B) expresses the interval of time that elapses between the taking of the observation, and the transit of the body, (say the sun), across the meridian of the observer.

§ *a*. The time thus deduced is *apparent* time.

§ 383. If the observation be made in the forenoon, the value of the horary angle must be subtracted from 12*h*, in order to find the apparent time of day.

§ *a*. But if the time be P. M. the value of the horary angle expresses the apparent time of day when the altitude was measured.

§ 384. This problem, coming under Case V., (§ 201.), may be solved by either of the methods of solution there shown.

§ *a*. But as it is a rule, in the application of theory to practice, (and one too, which is highly important in navigation,) to combine facility of design with readiness of execution, a solution of the problem after the formula, § *f*. (§ 201.), will be given, in order to show thereby a process of solution less circuitous; by which process the problem under consideration may be solved.

§ 385. In lat. 20° N.; the observed altitude of the sun's lower limb, was 29° 29′ 50″; and its declination was 10° 20′ south. To find the time of day, the observation being made P. M.

Plate 3. § *a*. First to find the true altitude of the sun's centre.

§ *b*. Obs. alt. Sun's L. L. = 29° 29′ 50″
Sun's semi-diam. = 15′ 47″

Sun's app. alt. = 29° 45′ 37″ (§ 283. § *a*.)
Refraction (§ 284.) = 1′ 37″ (Table IX.)
Dip = 4′ (§ 275. § *a*.)

Sun's true alt. = 29° 40′ (§ 283. § *b*.)

§ *c*. To find the time of day.
B A, or Z, Dist. = 60° 20′
P A, or Co-lat. = 70° 00′ co-sec. = 0.027014 (§ 201. § *f*.)
P B, or P. Dist. = 100° 20′ co-sec. = 0.007102

2)230° 40′

$\frac{1}{2}$ sum = 115° 20′ sin. = 9.956089
($\frac{1}{2}$ sum ∽ Z. Dist.) = 55° 00′ sin. = 9.913364

2)19.903569

Cos. $\frac{1}{2}$ A P B = 9.951784 = 1*h* 46*m* $\frac{1}{2}$*s*

2

Horary angle A P B = 3*h* 32*m* 1*s*

This time (§ 383. § *a*.) is P. M.

§ 386. The data of the problem may be operated upon, more directly, by using the lat. and alt., instead of their complements.

§ *a*. Alt. = 29° 40′
Lat. = 20° 00′ sec. = 0.027014
P. D. = 100° 20′ co-sec. = 0.007102

2)150° 00′

$\frac{1}{2}$ sum = 75° 00′ cos. = 9.412996
($\frac{1}{2}$ sum ∽ Alt.) = 45° 20′ sin. = 9.851997

2)19.299109

Sin. $\frac{1}{2}$ A P B = 9.649554 = 1*h* 46*m* $\frac{1}{2}$*s*

2

Horary angle A P B = 3*h* 32*m* 1*s*

§ 387. Whence the general rule for practice.

Take the difference between the true alt., and half the sum of the lat., P. dist., and alt.; then the *product* of the sine of this difference, and cos. of said half sum, *multiplied* by the *product* of sec. of lat., and co-sec. of P. dist., is the sine of half the horary angle.

§ 388. The time thus found being apparent time, may be converted into mean time (§ 217.), by applying to it the equation of time, according to the precept given with the equation of time in the Nautical Almanac.

§ *a*. App. time (§ 385. § *c*.) 3*h* 32*m* 1*s* P. M.
Equation of time — 13*m* 50*s*

Mean time=3*h* 18*m* 11*s*

§ 389. By comparing the mean time thus found, with the time shown by a chronometer, or other time-piece, when the altitude was measured, the error of the time-piece is obtained.

§ *a*. If this time-piece be regulated for a prime meridian, which is the case with chronometers; the difference between the true chronometrical, and the mean, time found by observation, expresses in *time* the difference in longitude between said prime meridian and the place of observation.

§ *b*. This difference of time being converted (§ 348. § *g*.) into degrees (°), minutes (′), etc., expresses the longitude of the observer.

LONGITUDE BY CHRONOMETER.

§ 390. The whole doctrine of determining longitude, consists in knowing the time of day at any two places at the same instant.

§ *a*. This is what is determined by every practicable method of finding longitude; whether it be by means of rockets, eclipses, occultations, lunar observations, or chronometers.

§ 391. The time of day at the prime meridian when an eclipse, occultation, or distance, occurs, is set down in the ephemeris; and the time of day at any other place when the same eclipse, etc., occurs, is known, either by well-regulated time-pieces, or by observations.

§ *a*. And the difference between these times, (§ 389. § *b*.), gives the longitude of the observer.

§ *b*. The longitude is west, when the *prime meridian* (Greenwich, § 252. § *c*.) time is in advance of the time of day at the observer.

§ *c*. But if the observer's time of day be in advance of the Greenwich time, his longitude is east; for it is evident that the sun must cross his meridian, before it does that of Greenwich, and consequently, that Greenwich must be to the westward.

§ 392. Chronometers are generally regulated so as to show the mean time of day at Greenwich.

§ *a*. But they are subject to variations from change of temperature, etc., and from other causes, and cannot be regulated so as to show at all times, the true time of day at Greenwich, or at any other prime meridian.

§ 393. The difference between the time shown by the face of a chronometer, and the mean time of day at Greenwich, is called "the error of chronometer."

§ *a.* The daily variation of this error is "the rate of chronometer."

§ 394. The rate of chronometer is found by noting the difference between mean time, and the time shown by the face of the chronometer, and after several days, noting again the difference between the mean and the chronometer time.

§ *a.* The difference between these two *differences*, (called "comparisons"), shows the time which the chronometer has gained, or lost, from the first to the last comparison.

§ *b.* And the quotient of this gain or loss, by the number of days that elapsed between the two comparisons, is the daily gain or loss, or rate, of the chronometer.

§ 395. The error (§ 393.) being applied to the chronometer time, with the precept of *plus* or *minus*, according as the chronometer be slow or fast, of Greenwich time, gives the mean time of day at Greenwich.

§ *a.* And the *rate* of the chronometer being applied to the chronometer's error yesterday, with the precept +, or —, according as the *rate* is *increasing* or *decreasing*, gives the chronometer's error for to-day.

§ 396. Before the chronometer is rated, the mean time of day at Greenwich for rating it, is found by turning the longitude of the observer, (§ 347.) into time; and,

§ *a.* Adding this time to the observer's mean time of day, if he be in west long.

§ *b.* And subtracting it from his mean time of day, if he be in east longitude.

§ 397. Ten or twelve days previous to the sailing of the vessel, will generally serve for keeping her chronometer under comparison, in order to find its error, and ascertain its rate.

§ *a.* But after sailing, the rate should be compared, (and corrected if necessary), as often as opportunities for making comparisons occur.

§ 398. To find the error and ascertain the rate of a chronometer, the observer being in lat. 40° 42′ N. and long. 74° 00′ W.

§ *a.* Aug. 4th, A. M., 1834.

Chro. 12*h* 58*m*.	App. alt. Sun's L. L.		30° 17′ 20″
	Sun's semi-diam.	=	15′ 47″
	App. alt. Sun's centr.	=	30° 33′ 7″
	Refraction -	=	1′ 37″
	Sun's Tr. alt.	=	30° 31′ 30″

§ *b*.

Sun's tr. alt. =	30° 31′ 30″		(§ 387.)
Lat. =	40° 42′ 00″	sec. =0.120254	
Sun's P. dist. =	72° 40′ 30″	co-sec. =0.020164	
	2)143° 54′ 00″		
½ sum =	71° 57′ 00″	cos. =9.491147	
(Alt. ∾ ½ sum) =	41° 25′ 30″	sin. =9.820621	
		2)19.452186	
	Sin. ½ Horary angle =	9.726093 =	2*h* 8*m* 37*s*+
			2
	12*h* 00*m* 00*s* (§ 383.)		
Horary angle =	4*h* 17*m* 14*s*	-	=4*h* 17*m* 14*s*
	7*h* 42*m* 46*s*	App. time	
Equation	+ 5*m* 47*s*	(§ 388.)	
	7*h* 48*m* 33*s*	Mean time, A. M.	
Chron.	12*h* 58*m* 00*s*	(§ 398. § *a*.)	
	5*h* 9*m* 27*s*	1st comparison, (§ 394.)	

§ *c*. Aug. 15, A. M. Chron. 12*h* 34*m* 25*s*.

App. alt. Sun's L. L.	24° 2′ 10″	
Sun's semi-diam.	15′ 49″	
App. alt. Sun's centr.	24° 17′ 59″	
Refraction -	2′ 9″	(Table IX.)

§ *d*.

Sun's tr. alt.	24° 15′ 50″	
Lat. -	40° 42′ 0″	sec. =0.120254
Sun's P. dist.	75° 51′ 10″	cosec. =0.013376
	2)140° 49′ 00″	
½ Sum -	70° 24′ 30″	cos. =9.525452
(½ sum ∾ Alt.)	46° 8′ 40″	sin. =9.857989
		2)19.517071

Sin. ½ Horary angle = 9.758535 = 2*h* 19*m* 58½*s*

2

Horary angle = 4*h* 39*m* 57*s*

	12h 0m 0s	
Horary angle	4h 39m 57s	
	7h 20m 3s	App. time
Equation	+4m 15s	
	7h 24m 18s	Mean time, A. M.
Chro.	12h 34m 25s	
	5h 10m 7s	2d comparison.

§ e. 2d Compr. 5h 10m 7s
1st do. 5h 9m 27s (§ 394. § a.)

Chro. gains 40s in 11 days.

§ f. 40s÷11=$3\frac{7}{11}$s (§ 394. § b.) the daily gain, or rate.

§ g. Long. of the observer 74° W. = 4h 56m
Time of (§ d.) last. obs. - = 7h 24m 18s

(§ 396. § a.) Greenwich time do. =12h 20m 18s
Chro. (§ c.) - - =12h 34m 25s

Error (§ 393.) of chro. Aug. 15th, =14m 7s (*fast.*)

§ h. To find long. by chronometer;
Time per watch 3h P. M.=15h 0m 0s
do. chron. - =11h 15m 22s

Diff.= 3h 44m 38s Chr. slow.

Time of obs. per W. 15h 2m 30s
Chro. slow of W. 3h 44m 38s

Chro. time of obs.=11h 17m 52s

Formula for calculation.

Sun's Alt.	31° 18′ (corrected)			
Lat.	36° 19′	sec.	=0.093796	
P. D.	104° 9′	co-sec.	=0.013381	
Sum=2)171° 46′				
½ sum=	85° 53′	cos.	=8.856049	
Rem'r.=	54° 35′	sin.	=9.911136	(Alt. ∽ ½ Sum.)
			2)18.874362	

Sin. ½ App. time=9.437181=1*h* 3*m* 31½*s*

2

App. time of obs.	=2*h* 7*m* 3*s* P. M.
Equation -	+ 4*m* 16*s*
Mean time of obs.	2*h* 11*m* 19*s* P. M.

Time of obs. per chro.	11*h* 17*m* 52*s*
Chro. slow of Gr. time	1*h* 3*m* 8*s*
Greenwich time	12*h* 21*m* 0*s*
Time of obs. -	14*h* 11*m* 19*s*

Long. in time (§ 391. § *c.*) 1*h* 50*m* 19*s*=27° 34′ 45″ E.

§ 399. By inspecting the triangle (P B A) of the problem for finding the apparent time of day, it becomes evident, that if, of the lat., time of day, dec., alt., and azimuth, of the sun, or any other body, any three be known, the two others are determinable. Plate 3.

§ *a.* The azimuth gives the angle P A B; and the apparent time of day gives the angle A P B; the altitude (B *l*) determines the zenith distance A B; the latitude A Q, determines P A, the co-lat., and the declination k B, determines the polar distance P B.

LATITUDE BY MERIDIAN ALTITUDES.

§ 400. The most common method of determining latitude at sea, is by means of an altitude of a celestial body, measured when the body is on the meridian.

§ *a.* Then the circle of the body's declination, coincides with the meridian (N A S) of the observer.

§ 401. Suppose the body be a star; the zenith distance (A *e′*) (§ 282. § *b.*) expresses the number of degrees, etc., from (A) the zenith to the star.

§ *a.* And the declination Q *e′* (§ 255. § *b.*) gives in the same measure, the distance of the body from the equator.

Plate 3. { § *b*. Wherefore the difference between the declination (Q e') and the zenith distance (A e') gives A Q the latitude.

§ 402. The sun being south of the observer, and its declination 10° 20′ south, its meridian altitude (corrected) was 59° 40′.

To find the latitude of the observer,

§ *a*. The sun's altitude (§ 282. § *a*.) is *e* S; 90°—*e* S=A *e* (§ 282. § *b*.) the zenith distance.

§ *b*. The observer being at A, north of the sun, makes (§ 281. § *b*.) the zenith dist., A *e*, ***north***.

§ *c*. The dec. Q *e*, being taken from the zenith dist. A *e*, leaves A Q, the required latitude.

§ *d*. Sun's Z. D. (§ *a*.)=30° 20′ N. (§ *b*.)
Sun's dec. =10° 20′ S.

Lat. =20° 00′ N.

§ 403. Suppose the object to bear south, but its dec. to be 9° 3′ N. and its meridian alt. 79° 3′.

To find the latitude,

§ *a*. The stars alt. is e' S; A S—e' S=A e' the *'s zenith dist.

§ *b*. The dec. Q e' being added to e' A the zenith dist., makes A Q, which is the latitude.

§ *c*. *'s Z. D.=10° 57′ N.
*'s dec. = 9° 3′ N.

Lat. =20° 00′ N.

§ 404. Suppose the star to be north of the observer, its declination 60° 5′ N., and its meridian alt. = 49° 55′.

To find the lat. of the observer,

§ *a*. N e'' is the *'s alt. The zenith dist. (§ 281. § *c*.) is south; N A—N e''=A e'', the *'s zenith dist.

§ *b*. The dec. Q e''—A e'' (the zenith dist.), gives A Q, the lat.

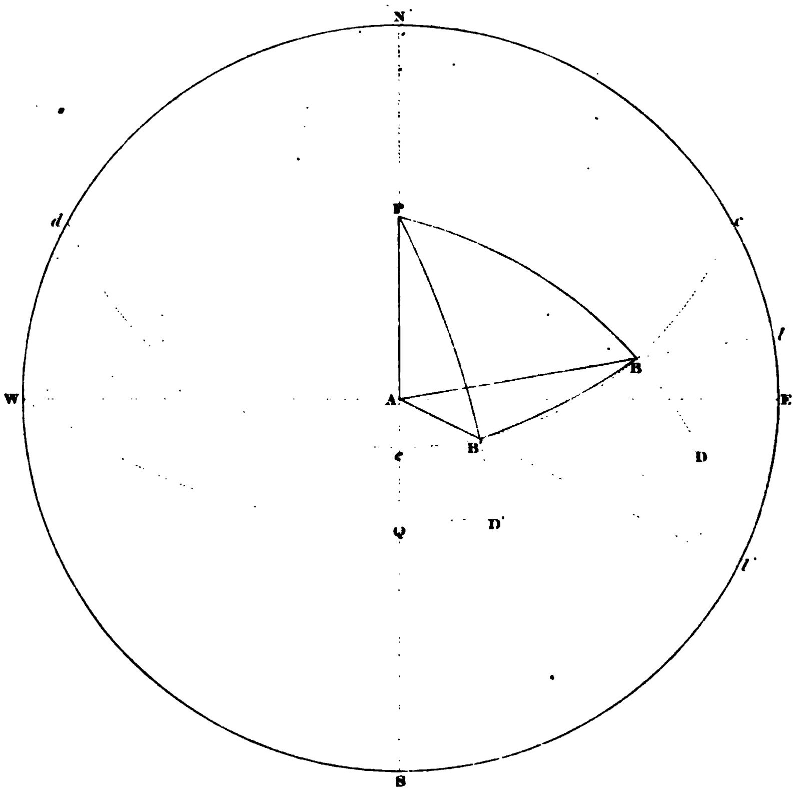
§ *c*. *'s dec. =60° 5′ N.
*'s Z. D. =40° 5′ S.

Lat. =20° 0′ N.

§ 405. Wherefore, when the dec., and the meridian zenith dist. are both north, or both south, their *sum* is the latitude.

§ 406. And, when one is north, and the other south, their *difference* is the latitude.

§ 407. When the body is in the zenith, there is no zenith dist., and the dec. is the lat.


N
P
d
c
l
W
A
B
E
B'
D
c
D'
Q
l'
S

LATITUDE BY DOUBLE ALTITUDES.

§ 408. The sun, (and every other celestial object), is frequently obscured by clouds, so that a meridian alt. cannot be measured.

§ *a*. Under such circumstances, data sufficient for determining the lat. may be obtained by taking at two different hours of the day the sun's alt., and noting the time that elapses between the two observations.

§ 409. The time, expressed in degrees, or hours, etc. (§ 348. § *b*.) constitutes, with the zenith and polar distances, the required data.

§ 410. This method of finding the lat. is called "by *Double Altitudes*."

§ *a*. The process of calculation is tedious, but the result will give the latitude as correctly as it can be obtained through any other process of observation and calculation.

§ 412. For determining the lat. by "double altitudes," B D represents the declination, and B *l* the alt. of the sun, at the first observation; and B′ D′, and B′ *l*′ the dec. and alt., at the second observation. } Plate 4.

§ *a*. A P B is the sun's horary angle at the first, and A P B′, its horary angle at the second, observation.

§ *b*. The difference (B′ P B) between these two angles, is the angular value of the time that elapses between the observations.

§ *c*. B B′ is the arc of the great circle, which passes through the points, in which the centre of the sun was at each observation.

§ *d*. The other circles, arcs and angles, of the Fig., are explained under § 317. (§ *a*.).

§ 413. The problem of "double altitudes" involves three triangles (B′ P B, A B B′, & A P B′) in the process of solution.

§ *a*. The side B′ B is common to the first and second triangles; P B′ to the first and third; and A B′ to the second and third.

§ 414. The parts that are given in the first triangle (B′ P B), are the two sides, P B and P B′ (§ 412.), which are the P. dist. (§ 256.) at the first, and the second observation; and (§ 412. § *b*.) their contained angle B′ P B=Elapsed Time.

§ *a*. And the parts required are, the third side B′ B, and the angle P B′ B.

§ 415. The value of P B′ B and B′ B being determined by calculation, the parts that are then known in the second triangle A B B′, are B A and B′ A (§ 412.); which are the zenith dist. (§ 281.) of the sun at the first and the second observation; and the common side B′ B.

§ *a*. The part here required, is the angle A B′ B.

§ 416. The difference between the angles A B′ B, and P B′ B (§ 414. § *a*.) gives the value of the angle A B′ P, in the third triangle A P B′.

§ 417. Then in the third triangle, the two sides A B′, P B′ and their contained angle A B′ P, are the given parts; and P A is the part required, and the co-lat.

§ 418. In north latitude, at 7 A. M. by a watch.
Sun's true alt. 24° 58′ 12″
Sun's dec. 22° 25′ 00″ N.

Plate 4. § *a*. And at the 10*h* 15*m* by the same watch,
Sun's true alt. 62° 49′ 20″
Sun's dec. 22° 24′ 00 N.

§ *b*. The elapsed time is 3*h* 15*m*.

§ 419. P B (1st P. D.)=67° 35′
P B′ (2d P. D.)=67° 36′
A B (1st Z. D.)=65° 1′ 48″
A B′ (2d Z. D.)=27° 10′ 40″
B′ P B (E. time) = 3*h* 15*m*. (§ 409.)

§ 420. To find the side B′ B and angle P B′ B (§ 414. § *a*.) in the first triangle B′ P B.

§ *a*. 1st. To find the value of B′ B (§ 200. § *s*. & § *t*.).

B′ P B (E. T.)=3*h* 15*m* cos. =9.819113 (§ 348. § *c*.)
P B′ (2d P. D.)=67° 36′ tang.=0.384923

Tang. aux. *a*=0.204036=57° 59′ 23″
P B=67° 35′
(*a* ∾ P B)= 9° 35′ 37″

P B′ (2d P. D.)= 67° 36′ cos.=9.581005
Auxl. *a*=57° 59′ 23″ sec.=0.275666
(*a* ∾ 1st P. D.)=9° 35′ 37″ cos.=9.993884

Cos. B′B=9.850555=44° 51′ 30″

§ *b*. To find the value of P B′ B (§ 144.).

B′ B =44° 51′ 30″ co-sec.=0.151591
B′ P B (E. T.) =3*h* 15*m* sin. =9.876125
P B (1st P. D.)=67° 35′ sin. =9.965876

Sin P B′ B=9.993592=80° 10′ 53″

§ *c.* In the second triangle, to find the value of the angle A B′ B (§ 201. § *d.*). } Plate 4.

A B (1st Z. D.) =65° 1′ 48″
A B′ (2d Z. D.) =27° 10′ 40″ co-sec.=0.340319
B′ B (§ *a.*) =44° 51′ 30″ co-sec.=0.151591

2)137° 3′ 58″

½ Sum=68° 31′ 59″ sin. =9.968776
(½ S. ∾ 1st Z. D.)= 3° 30′ 11″ sin. =8.786053

2)19.246739

Cos. $\frac{A\,B'\,B}{2}$=9.623369= 65° 9′ 29″

2

A B′ B =130° 18′ 58″
P B′ B (§ *b.*) = 80° 10′ 53″

A B′ P = 50° 8′ 5″

§ *d.* In the third triangle, to find the value of the third side A P; or to find the latitude (§ 200. § *s.* & § *t.*)

A B′ P=50° 8′ 5″ cos. =9.806848
P B (2d P. D.)=67° 36′ tang.=0.384923

Tang. auxl. *a*=0.191771=57° 15′ 29″

A B′=27° 10′ 40″

(*a*∾A B′)=30° 4′ 49″

P B′ (2d P. D.)=67° 36′ cos.=9.581005
Auxl. *a*=57° 15′ 29″ sec.=0.266918
(*a*∾2d Z. D.) =30° 4′ 49″ cos.=9.937178

Cos. A P=9.785101 sin.=lat. 37°33′59″N

§ 421. In the example last quoted, the two observations are taken at the same place; but in practice, this cannot always be done, especially at sea, when the vessel is changing her place during the time that elapses between the taking of the observations.

§ *a.* Therefore the 1st altitude must be corrected, in order to know what it would have been, had it been taken at the same time per watch, but at the place where the 2d obs. was made.

§ 422. When the first observation is being made, note the bearing of the sun and the course of the ship; and after the second observation has been taken, find in a traverse table (Table IV.), the course and distance from the place where the first, to that where the second, observation was taken.

§ *a.* The angle, which this distance makes with the bearing of the sun, being used in the traverse table, as a course, the correction which is to be applied to the first alt., is found under this course, and opposite to said distance, and in the column marked "*d. lat.*"

§ 423. If this angle be less than 90°, the correction thus found is addative.

§ 424. If it be greater than 90°, its supplement is the course; and,

§ *a.* The correction is subtractive.

§ 425. If the ship sail on the line of the sun's bearing, the distance sailed in miles, is the correction in minutes (′) of a degree.

§ *a.* It is addative when the ship sails towards the sun; and,

§ *b.* Subtractive when she sails from the sun.

§ 426. The corrections are found as geographical miles, but are to be applied to the altitude as minutes (′) of a degree.

§ 427. When the angle between the bearing of the sun, and the course which the ship makes, is 90°, there is no correction.

§ 428. The corrections thus obtained and applied, do not show *exactly* what the 1st altitude would have been at the place of the second observation; but the approximation is sufficiently close to answer the purposes of common navigation.

§ 429. The time that elapses between the taking of the observations, should not be less than 30*m*, or more than 6*h*, if avoidable, especially if the observer be at sea.

§ *a.* If the body under observation do not change much in declination during the "elapsed time," the *mean* of its declination at the two observations may be used as the body's declination at each observation.

§ *b.* This "*mean*" declination is found by taking out the declination for half of the "elapsed time," *plus* the time of the first observation.

Plate 4. } § *c.* When the *mean* declination is used, P B=P B′; and the first triangle B′ P B (§ 140.) is isosceles.

§ 430. The latitude at the time and place of the first observation, may be found, if required, by making A P B the third triangle, and using the angles P B B′, A B B′ and A B P, instead of P B′ B, A B′ B and A B′ P (§ 420. § *b.* & § *c.*).

§ *a.* But generally, in navigation, the latitude of the time present, is most desirable to be known; and usually, when the problem is solved, the vessel is nearer to the place of the second, than she is to the place of the first observation.

§ *b.* A formula for practice in finding the latitude at sea by "double altitudes;" the mean declination being used. Under the example § 418.

Sun's mean dec.=22° 24′ 30″, P. D. =67° 35′ 30″
Sun's 1st alt. =24° 58′ 12″, 1st Z. D.=65° 1′ 48″
Sun's 2d alt. =62° 49′ 20″, 2d Z. D.=27° 10′ 40″
E. time - 3*h* 15*m*

§ *c.* The first triangle (§ 429. § *c.*) is isosceles; wherefore (§ 200. § *z a.*, § *z c.* & § *z f.*)

P. D. =67° 35′ 30″ sin.=9.965903 sec.=0.418842
(½ E. time)=1*h* 37*m* 30*s* sin.=9.615642 cot.=0.343812

Arc $\frac{B'B}{2}$ 22°25′46″ Sin.=9.581545

2 1st Ang. 80° 12′ 2″ Tang.=0.762654

ArcB′B=44°51′32″ co-sec.=0.151587 (§ 420. § *c.*)
2d Z.D.=27°10′40″ co-sec.=0.340319
1st " =65° 1′48″

2)137° 4′ 0″

½ S.=68°32′ 0″ sin. =9.968777
(½S.∽Z.D.)3°30′12″ sin. =8.786087

2)19.246770

Cos. ½ 2d Angle=9.623385= 65° 9′25″

2

2d Angle=130° 18′ 50″
1st " = 80° 12′ 2″

3d " = 50° 6′ 48″

½ (3d Angle) =25° 3′ 24″ sin.×2=19.253736 (§ 200. § *z f.*)
P. D. - =67° 35′ 30″ sin. = 9.965903
2d Z. D. =27° 10′ 40″ sin. = 9.659681

2)38.879320

(P.D. ∽2dZ.D.)=40° 24′ 50″ 19.439660

$\frac{\text{P. D.} \backsim \text{2d Z. D.}}{2}$=20° 12′ 25″ co-sec.=0.461662

Tang. *a*=9.901322=38° 32′ 46″

a. co-sec.=0.205412

Sin. ½ co-lat.=9.645072=26° 12′ 32″

2

Lat.=37° 34′ 56″ or co-lat.=52° 25′ 4″

§ *d.* The result by this method differs 57″ from the truth. Like every other trigonometrical calculation, in which *true* data are not operated upon, it brings an error into the result; but the result is an approximation, which oscillates about the truth, and within limits that depend upon the correctness of the assumed data.

§ *e.* Some navigators solve the problem of "double altitudes" by the method proposed by a Mr. Douwes; but the correctness of the result by his method, depends upon repeated calculations, or the proximity of a *supposed*, to the correct, latitude.*

§ 431. Latitude by "double altitudes" may also be determined by taking, at the same instant, the altitudes of any two bodies, whose right ascension and declination are given.

§ 432. The method of solving this problem consists in a process of operation, precisely similar to that (§ 420.) for finding the latitude by means of two altitudes of the same body, taken at different times.

Plate 4. { § 433. The difference in right ascension of the two bodies gives an angle, which corresponds to the angular value (B′ P B) of the "elapsed time," between the two observations.

§ 434. When the difference in right ascension of the two bodies, exceeds 180° or 12*h*, the greater right ascension, subtracted from the less *plus* 24*h*, gives the angle corresponding to B′ P B.

§ 435. In this method of finding latitude, the altitude of the moon, unless the Greenwich time be known, cannot be used with certainty of success. For the moon's variation in declination and right ascension, is so rapid, that unless the Greenwich time of day, when the observations are made, be known, the proper value of the angle corresponding to B′ P B, cannot be obtained.

§ 436. The stars afford the greatest facilities for the application of this problem to practice.

§ *a.* Their variation in declination and right ascension, being for the most part, not very rapid; consequently when the horizon is well defined, the data requisite to the solution of the problem, can be obtained by means of the stars, with sufficient accuracy.

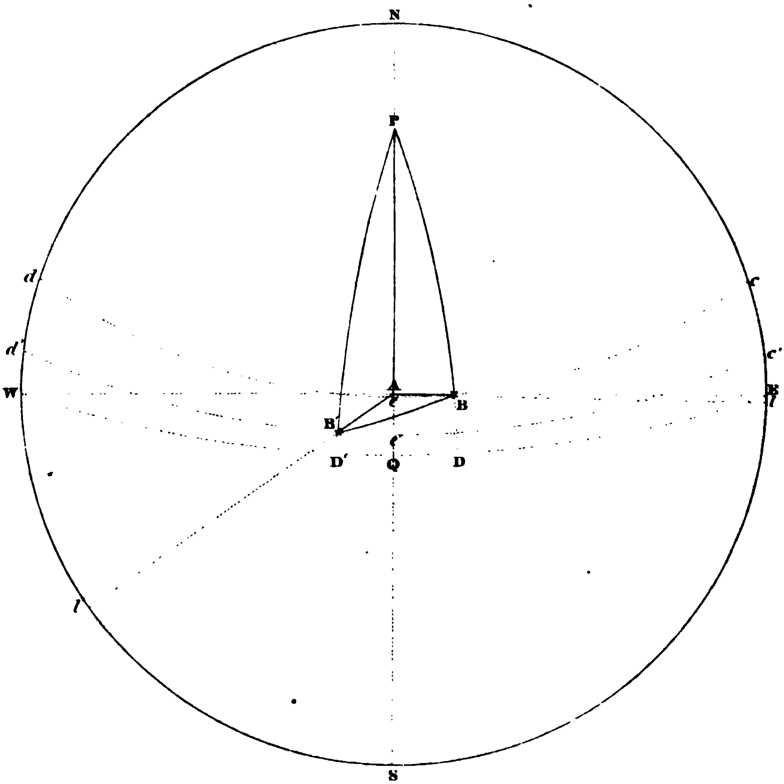
§ 437. In north lat. June 2, 1834, Jupiter being east, and Mars west, of the meridian; their altitudes were taken at the same instant;

J.'s alt.	71°	49′			To find the latitude.
" dec.	18°	0′	40″	N	
" rt. asn.	3*h*	27*m*	36*s*		
M.'s "	1*h*	9*m*	20*s*		
" dec.	5°	54′	20″	N	
" alt.	70°	29′	12″		

Plate 5. { § *a.* Difference in right ascension is 2*h* 18*m* 16*s*.
§ 438. B *l* and B D are Jupiter's altitude and declina-

* Mr. Douwes' method is both supported and questioned by high authority. Bowditch has adopted it in his Practical Navigator. And there is a paper from M. Delambre, showing that the result by this method is not always an approximation, but that, in some cases, if repetitions be made, the result will recede from the true latitude.

Plate 5.



tion; and B′ *l*, and B′ D′ are Mars' alt. and dec.; and B′ P B is the angular value of their difference in right ascension. } Plate 5.

§ 440. B P B′ is the first triangle in the problem, that is brought under calculation; B′ B and B′ B P, are the required parts.

§ *a*. B′ A B is the second triangle, and A B B′ is the part in it, that is required;

§ *b*. A B B′ ∾ B′ B P=A B P.

§ *c*. A P B is the third triangle, and A P is the part required to complete the problem.

§ 441. P B (J.'s P. D.) =71° 59′ 20″
P B′ (M.'s P. D.) =84° 5′ 40″
B′ P B (diff. R. A.) = 2*h* 18*m* 16*s*
A B (J.'s Z. D,) =18° 11′ 0″
A B′ (M.'s Z. D.) =19° 30′ 48″

§ *a*. To find the value of B′ B (§ 200. § *s*. & § *t*.)
B′ P B (diff. R. A.) 2*h* 18*m* 16*s* cos.=9.915646
P B (J.'s P. D.)=71° 59′ 20″ tang.=0.487937

Tang. auxl. *a*=0.403583=68° 27′ 15″
M.'s P. D.=84° 5′ 40″
M.'s P. D.∾ *a*= 15° 38′ 25″

P B (J.'s P. D.)=71° 59′ 20″ cos.=9.490243
Auxl. *a*=68° 27′ 15″ sec.=0.435044
(*a*∾ P B′ (M.'s P. D.)=15° 38′ 25″ cos.=9.983614

Cos. B′ B=9.908901=35° 49′ 42″

§ *b*. To find the value of the angle P B B′ (§ 420. § *b*.)
B B′ 30° 49′ 42″ co-sec.=0.232578
B P B′ (diff. R. A.)=7*h* 18*m* 16*s* sin.=9.753862
P B′ (M.'s P. D.)=84° 5′ 40″ sin.=9.997689

Sin. P B B′=9.984129=105° 23′ 52″

Plate 5. | § c. To find the value of A B B′ (§ 201. § f.)

A B′ (M.'s Z.D.) =19° 30′ 48″
A B (J.'s Z. D.) =18° 11′ 00″ cosec.=0.505764
B′ B . . . =35° 49′ 42″ " =0.232578

2)73° 31′ 30″

½ Sum =36° 45′ 45″ sin. =9.777063
(½ S ∽ A B′, M.'s Z.D.)=17° 14′ 57″ " =9.472066

2)19.987471

$\text{Cos.}\ \frac{ABB'}{2}$ =9.993735=9° 42′ 30″

2

A B B′ = 19° 25′ 00″
P B B′ =105° 23′ 52″

A B P = 85° 58′ 52″

§ *d*. To find the value of A P or co-lat. (§ 200. § *u*.)

A B P=85° 58′ 52″ cos.=8.845627
P B=71° 59′ 20″ tang.=0.487937

Tang. Auxl. *a*= 9.333564=12° 9′ 52″
A B (J.'s Z. D.)=18° 11′ 00″

(*a* ∽ J.'s Z. D.)= 6° 01′ 8″

P B (J.'s P. D.) =71° 59′ 20″ cos.=9.490243
Auxl. *a*=12° 9′ 52″ sec.=0.009864
(*a* ∽ A B, J.'s Z.D.)=6° 1″ 8″ cos.=9.997599

Cos. A P (co-lat.)=9.497706 S.=lat. 18°20′4″N.

§ 442. The data for determining latitude by "double altitudes" may be obtained also by taking the altitude of two objects, each at a different time of the day.

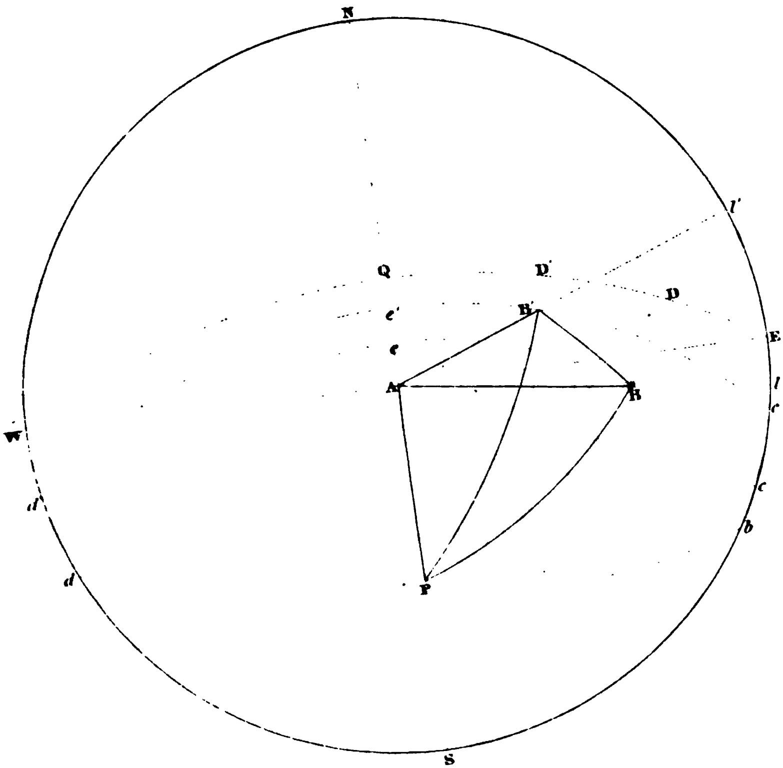
§ *a*. This method may sometimes be found useful in cloudy weather, when the two objects cannot be seen at the same time, and when it is highly important to know the latitude.

§ 443. When the first object (say a star) is seen, let its altitude be taken, and the time, per watch, when the observation is made, noted down.

§ *a*. The bearing of the star at the same time, must also be observed, in order that the angle may be known, which is contained between this bearing, and the rhumb line, upon which the ship sails until the second observation may be made.

§ *b*. This angle, and the distance sailed during the interval that elapses between the taking of the two observations, are to be used

Plate 6.



in finding the correction (§ 422. § *a.*) which must be applied to the first altitude, to make it what it would have been, had it been taken at the place where the second observation was taken.

§ 444. The right ascension and declination of this star must be taken out of the Nautical Almanac, also for the time at which its altitude was measured.

§ 445. When the second object (say the sun) is seen, its altitude also must be taken, and the time of its being done noted down, in order to know the time which has elapsed since the first observation.

§ 446. The right ascension and declination of the sun, when its altitude is measured, must also be found, in order to obtain the difference in right ascension of the two bodies when their altitudes were taken.

§ *u.* This difference is an angle formed at the pole, by the intersection of the circle of right ascension, in which the star was, when its altitude was taken, with the circle of right ascension which passed through the centre of the sun, when the alt. of it was measured.

§ 447. This angle corresponds to B′ P B; and with the portion of *apparent time* that elapses from the taking of the first, till the taking of the last, observation, it constitutes the angle which is contained between the P. distances of the two bodies; and with the polar and zenith distances of these bodies, it also constitutes the required data of the problem. } Plate 5,

§ 448. The sum or difference of the *difference* of the two bodies in right ascension, and the portion of *mean time* from one observation to the other, give the required contained angle.

§ *a.* If the sun be the second object, the *apparent* instead of the *mean* time, from one observation to the other, must be taken.

§ 449. The sum of said two quantities is the value of this angle, when the first object is to the eastward of the second.

§ 450. But when the second is the more eastwardly object, the difference of the two in right ascension, *minus* the *elapsed* time, gives the value of the required polar angle.

§ 451. If, when the second is the eastern object, the elapsed time exceed the difference in right ascension of the two bodies, the second will have crossed the hour circle (§ 263. § *c.*) which coincides with the circle of declination, in which the first object was, when its altitude was measured.

§ 452. The excess of the elapsed time above this difference in ascension, is the value of the required polar angle (B′ P B). } Plate 6.

§ 453. B represents the place of Venus (the first object), when its altitude was taken.

§ *a.* Venus was then the morning star, and consequently to the westward of the sun, (which is the second object).

§ *b.* Venus' altitude was taken in the morning, when the sun was below the horizon.

§ *c.* P *b* is an arc of the circle of right ascension in which the sun was, when Venus' altitude was taken.

Plate 6. § *d*. B P *b*, is the angular value of the difference in right ascension of the sun and Venus, when the altitude (B *l*) of the latter was taken; it is about 2*h* 36*m* 54*s*.

§ 454. The sun's altitude, B′ *l*′, was taken 4*h* 29*m* 45*s* after Venus' was measured.

§ 455. The sun had then crossed over the hour circle P B (§ 263. § *c*.) in which Venus was, when its altitude was taken.

§ *a*. The sun was at B′, to the westward of this circle, when its altitude was taken.

§ 456. B′ P *b*, is the horary angle, in *apparent* time, which the sun described during the interval between the taking of the altitudes.

§ *a*. Consequently the difference (B P *b*) of the sun and Venus in right ascension, when their altitudes were measured, subtracted from (B′ P *b*) the angular value of the *apparent* time between the observations, gives the value of the angle B′ P B.

§ 457. If the portion of time that elapses, between the observations, be given in mean time, it may be converted into apparent time, by applying to it the fraction which during the elapsed time, the second object's equation of time gains or loses, on mean time.

§ 458. In surveying expeditions the elapsed time should be corrected and changed into *apparent* time, in order to determine the latitude with exactness.

§ 459. But upon the open sea, this nicety in operation may be omitted, for it only advances, by a very small fraction, the accuracy of the result.

§ 460. If the altitude of the more easterly object, be taken last, and the elapsed time be equal to their difference in right ascension, the same hour circle (§ 263. § *c*.) will pass through each object when its altitude is taken; and the process of deducing the latitude will be confined to the simple operation of finding an angle with the three sides of a triangle as data; and thence in deducing, from the two sides and their contained angle, as data in a second triangle, its third side, which is the co-lat.

§ *a*. The three sides of the former of these two triangles, would be the zenith dist. of each body, and the difference between their polar distances.

§ 461. Feb. 25, 1832. Venus being the morning star, and the observer being in south latitude when he made his observations.

§ *a*. Venus' Alt. 24° 50′ (*True*.)
" Dec. 20° 5′ S.
" Rt. Ascen. 19*h* 59*m*
" bearing E. ¾ S. (§ 443. § *a*.)
Time per watch 3*h* 16*m* 19*s*

§ *b*. The ship then sailed N. E. ¼ N. 18 miles, when the sun was seen, and its altitude taken.

Sun's Alt. 43° 44′ (*Correct*. § 385. § *b*.)
Sun's Dec. 9° 16′ S.
Sun's Rt. A. 22*h* 30*m* 59*s*
Time per watch 7*h* 46*m* 8*s*

§ 462. The angle between the bearing of Venus (§ 461. § *a.*), and the ship's course, is five points, which (§ 422. § *a.*) with the distance sailed, (18 miles), gives 10′ (§ 426.) in the column (*d. lat.*) of the traverse tables; which 10′ (§ 423.) being added to Venus' altitude, makes it 25°, (what it was at the time of its being taken, but at the place where the sun's alt. was observed.)

§ 463. The watch kept *mean* time. The elapsed time (§ 457.) must therefore be corrected, in order to obtain the portion of *apparent* time, that elapsed from the first, until the second observation was taken.

§ *a.* During this interval there were 2*s* *less* of apparent, than of mean time, which being subtracted from the mean time elapsed, gives the elapsed apparent time.

§ 464. This correction is obtained from the ephemeris. It is the quantity which the equation of time gains or loses from the first to the second observation; and it must be applied accordingly.

§ 465. The triangulation, through which the process of finding the latitude by means of the data in this problem is conducted, is represented in the triangles B′ P B, A B′ B and A B′ P. Plate 6.

§ 466. A B (star's Z. D.)=65° 0′
P B (star's P. D.)=69° 55′
A B′ (sun's Z. D.)=46° 16′
P B′ (sun's P. D.)=80° 44′
Elapsed mean time = 4*h* 29*m* 49*s*
Correction (§ 463. § *a.*) 2*s*

Elapsed app. time - =4*h* 29*m* 47*s*
Diff. in R. A. of sun and star=2*h* 31*m* 59*s*

B′ P B=1*h* 57*m* 48*s* (§ 456. § *a.*)

To find the latitude.

§ *a.* In the triangle B′ B P, to find the value of B′ B. (§ 200. § *n.*)

B′ P B=1*h* 57*m* 48*s* cos. = 9.939911
P B′ (Sun's P.D.)=80° 44′ tang.= 0.787389

Tang. auxl. *a*= 0.727300=79° 23′ 15″

P B=69° 55′ 0″

(*a* ∾ star's P. D.)= 9° 28′ 15″

P B′ (sun's P. D.)= 80° 44′ cos.=9.206906
Auxl. *a*=79° 23′ 15″ sec.=0.734791
(*a* ∾ P B) - =9° 28′ 15″ cos.=9.994040

Cos. B′ B=9.935737=30° 24′ 24″

Plate 6. § *b*. To find the value of P B′ B.

B′ B = 30° 24′ 24″ co-sec. = 0.295734
B′ P B - = 1*h* 57*m* 48*s* sin. = 9.691668
P B (star's P. D.) = 69° 55′ 0″ sin. = 9.972755

Sine P B′ B = 9.960157 = 65° 49′ 50″

§ *c*. To find A B′ B (§ 201. § *f*.)

A B (star's Z. D.) = 65°
A B′ (sun's Z. D.) = 46° 16′ co-sec. = 0.141123
B′ B - = 30° 24′ 24″ co-sec. = 0.295734

2)141° 40′ 24″

½ sum = 70° 50′ 12″ sin. = 9.975241
(½ S. ∽ star's Z.D.) = 5° 50′ 12″ sin. = 9.007291

2)19.419389

Cos. $\frac{AB'B}{2}$ = 9.709694 = 59° 10′ 10″

2

A B′ B = 118° 20′ 20″
P B′ B = 65° 49′ 50″

A B′ P = 52° 30′ 30″

§ *d*. To find A P, the co-lat.

A B′ P = 52° 30′ 30″ cos. = 9.784365
P B′ (Sun's P.D.) = 80° 44′ tang. = 0.787389

Tang. auxl. *a* = 0.571754 = 74° 59′ 37″

A B′ = 46° 16′ 0″

(*a* ∽ A B′) = 28° 43′ 37″

P B′ (sun's P. D.) = 80° 44′ cos. = 9.206906
Auxl. *a* = 74° 59′ 37″ sec. = 0.586823
(*a* ∽ sun's Z. D.) = 28° 43′ 37″ cos. = 9.942959

Sin. Complement A P, or lat. = 9.736688 = 33° 2′ 59″ South.*

* This differs 1″ from the truth.

LUNARS.

§ 467. The problem of finding the *true* distance between the sun, or a star, and the moon, for the purpose of thence determining the longitude, is one of great importance in navigation.

§ 468. The necessity for the circuity of calculalion in finding the longitude by lunar observations, arises from the circumstance that the two observed bodies are not seen (§ 289.) in their true places.

§ *a*. They always appear, each in its proper azimuth circle, but higher up, or lower down in it (§ 283. § *c*.), than its true place,

§ *b*. And consequently (§ 283.) they appear either nearer to, or farther from, each other, than they really are, which makes the difference between the true, and apparent lunar distance.

§ 469. Only two triangles are involved in the process of finding, by trigonometrical calculation, the *true* from the *observed* lunar distance.

§ *a*. Of the first triangle, the three sides are given; and the angle required is that which is contained at the zenith, between the zenith distance of the moon, and of the other body.

§ *b*. Of the second triangle, this angle and its adjacent sides, are the given parts; and the third side, or true lunar distance, is the part required.

§ *c*. The three sides of the first triangle are the apparent lunar, and the app. zenith distances of the two bodies.

§ *d*. And the three sides of the second triangle, are the *true* lunar and zenith distances.

§ 470. The *lunar*, or the *true lunar distance* of the sun, or a star, is an arc of a great circle, contained between the centres of either of those objects, and the moon.

§ 471. The distance between the perfect limb (§ 283.), or the round edge, of the moon and the near limb of the sun, is the distance usually measured with a sextant.

§ 472. The *apparent* is obtained from the observed distance, by applying, with proper signs, the corrections for the error of the sextant, for the semidiameters of the two bodies, and for the augmentation of the moon's semidiameter.

§ *a*. The sun and moon's semidiameter is given in the ephemeris; the sun's for every 24*h*, and the moon's for every noon and midnight.

§ *b*. The correction for augmentation is found in Table X.

§ 473. *Augmentation* of the moon's semidiameter, is the difference between the visual angle of the moon's semidiameter at the centre, and its visual angle at the circumference, of the earth.

§ 474. The difference between these two angles, is proportional to the ratio between the length of the semidiameter of the earth, and its distance from the moon.

§ 475. On account of its great distance from the earth, the sun's semidiameter has no augmentation.

§ *a*. As the earth's semidiameter measures more in proportion to the moon's geocentric distance, than to that distance of the sun, or of any other heavenly body, the difference of the moon's semidiameter, when seen from the circumference and from the centre of the earth, is greater than that of any other body, when seen from the same positions.

§ 476. The semidiameter of the moon when it is in the horizon, appears under nearly the same visual angle (barring refraction) that it does from the centre of the earth.

§ 477. The moon appears larger when it is in the horizon, than it does when in the zenith. This though is an optical delusion, for the moon actually subtends the largest visual angle when in the zenith; as it is then nearer to the observer than it is when in the horizon, by a little more than the semidiameter of the earth.

Plate 7. § 478. B′ A B represents a diagram of the lunar problem. b' b is the apparent, (§ 472.), and B′ B the true (§ 470.) lunar distance.

§ 479. The three apparent distances, (b' b, b' A, A b), are the given parts (§ 469. § *a*.) of the first triangle b' A b, and the angle b' A b is the part required in it.

§ 480. The angle b' A b is common to the second triangle B′ A B, of which the true zenith distances A B, and A B′ are the given, and the true lunar distance B′ B is the required part.

§ 481. The apparent Z. D. of the sun, or of a star, (§ 284. § *a*.) being less, and the app. Z. D. of the moon (§ 286. § *a*) being greater, than the true Z. D.; it appears from the diagram, that, when the moon's is the greater of the two Z. D., the *true* is always less than the apparent lunar distance.

§ *a*. And when the moon's is the less Z. D., the true is sometimes greater, and sometimes less, than the app. distance.

§ *b*. The *true* is the less, when the lunar distance exceeds 90°.

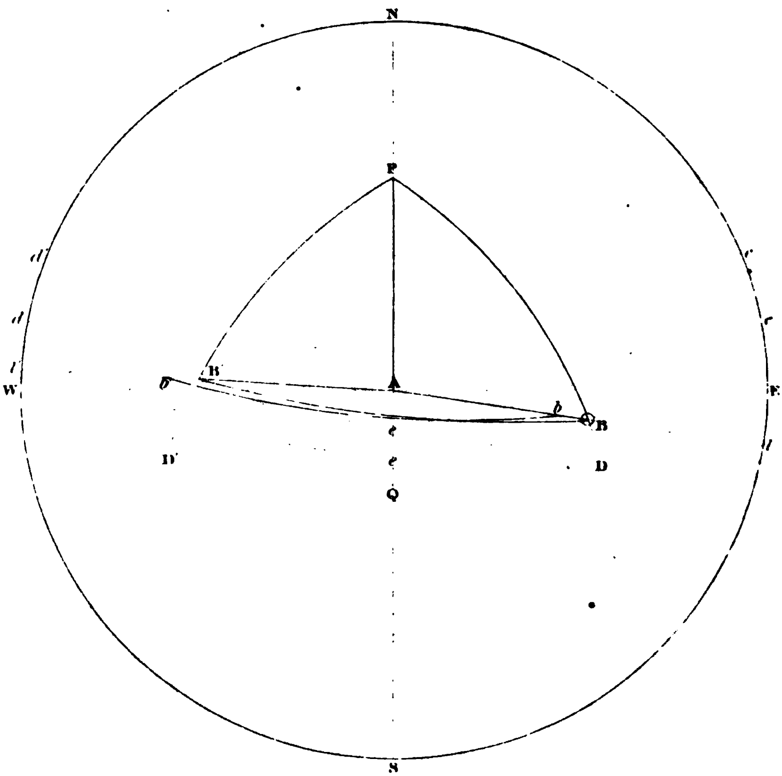
§ *c*. And it is generally the greater, when the distance is less than a quadrant, and the ratio of cos. moon's Z. D. to cos. sun or star's Z. D., is greater than the ratio of rad. to cos. of the lunar distance.

§ 482. The reason why the difference between the app. and the true L. dist., appears to be governed by the moon more than by the other body, is, that the moon being nearer to the earth, has the greater parallax, and is generally seen further from its true place in the heavens, than any other body, from which lunar distances are measured, appears from its true place.

§ 483. In N. lat., Aug. 27th, 1834.

Obs. Dist. sun and moon		=89° 51′ 40″
Obs. Alt. sun	-	=34° 4′ 50″
Obs. Alt. moon's upper limb		=54° 27′ 50″

§ *a*. Obs. dist. sun & moon		=89° 51′ 40″	
Sun's semidiameter	-	15′ 51″	
Moon's " -	-	15′ 1″	
Moon's augmentation	-	13″	(§ 472. § *b*.)
Error of sextant -	-	+ 6″	
App. lunar dist.		=90° 22′ 51″	


N
P
W
E
S
Q
B
B'
b
b'
D
D'
d
d'
c
c'
e
e'

§ *b*. Sun's obs. alt. -	34° 4′ 50″	
Sun's semidiameter -	15′ 51″	
*Dip (§ 275. § *a*.) -	— 3′ 21″	
Sun's app. alt. - -	34° 17′ 20″	
§ *c*. Refraction for sun's alt.	— 1′ 20″	(Table IX.)
Sun's plx. in alt.	8″	(Table XI.)
Sun's true alt. - -	34° 16′ 8″	
§ *d*. Obs. alt. moon's U. L.	54° 27′ 50″	
Moon's semidiameter -	—15′ 1″	
Moon's augmentation -	—13″	(Table X.)
Dip (§ 275. § *a*.) -	— 3′ 21″	
§ *e*. Moon's app. alt.	54° 9′ 15″	cos.=9.767605 (§ 288.)
Moon's hor. plx. (§ 287.)	55′ 7″	sin. =8.204991
Moon's plx. in alt. (§ 287. § *c*.)=	32′ 16″	sin. =7.972596
§ *f*. Refraction for moon's alt.=	—43″	
Correction for moon's app. alt.=	31′ 33″†	

§ *g*. To find the value of b' A b (§ 201. § *f*.) in the first triangle. } Plate 7.

b' b (app. lunar dist.)	=90° 22′ 51″		
b' A (moon's app. Z. D.)	=35° 50′ 45″	co-sec.	=0.232394
A b (sun's app. Z. D.)	=55° 42′ 40″	co-sec.	=0.082911
	2)181° 56′ 16″		
½ sum - - - - -	90° 58′ 8″	sin.	=9.999938
(½ S. ∽ app. lunar dist.)	= 0° 35′ 17″	sin.	=8.011288
			2)18.326531

$$\text{Cos. } 81°\ 37'\ 34''\ \left(=\frac{b'\,\text{A}\,b}{2}\right) \qquad 9.163265$$

$$b'\,\text{A}\,b = 163°\ 15'\ 8''$$

* The *dip*, when the eye is 9 feet above the water, is about 3′; and 4′, when the height of the eye is 17 feet. On board ship 4′ is generally allowed for *dip*.

† When the nicest accuracy is required, corrections may be applied for the difference in the effects of refraction on the upper and the lower limb of the sun and moon; for the moon's parallax in different latitudes, supposing the equatorial to be greater than the polar diameter; and also a correction for the actual barometrical, and thermometrical state of the atmosphere; but at sea, greater errors are unavoidable, hence these corrections are of minor importance.

§ *h*. To find B′ B (§ 200. § *v*.) the tr. lunar dist. (§ 480.)

b' A b=163° 15′ 8″ cos. = 9.981176

A B (Sun's tr. Z. D.)=55° 43′ 52″ tang.= 0.166625

Tang. auxl. a= 0.147801=125° 26′

Moon's tr. Z. D.= 35° 19′ 12″

90° 6′ 48″

A B (Sun's tr. Z. D.)=55° 43′ 52″ cos.=9.750567
Auxl. a=125° 26′ - - sec.=0.236755
(∞ Moon's tr. Z. D.)=90° 6′ 48″ cos.=7.296235

Tr. lunar dist.=89° 53′ 24″ Cos. B′ B=7.283557

§ 484. By referring to the Nautical Almanac, page xvii., of the ephemeris for Aug. 1834, it will be observed, that it was near noon of the 27th at the Greenwich observatory, when the moon was 89° 53′ 24″ from the sun.

§ *a*. If the latitude of the place at which the observation (§ 483.) was made, be known, the time of day at that place, and when the observation was taken, may be found according to the rule § 387.

§ *b*. And the difference (§ 391. § *a*.) between the time of day thus found, and the time in the ephemeris, which corresponds to the calculated lunar distance, is the longitude in time.

§ 485. Distances for determining longitude are always measured from the moon, because the change of the moon's position in the heavens is more obvious than that of any other heavenly body that is visible to the naked eye.

§ 486. The moon (§ 360.) has a daily motion of about 13° 10′ in the heavens; owing to which the moon rises, culminates, and sets, later and later every day, until, having passed through all its phases, it crosses the circle of the sun's altitude, gets to the eastward of the sun, and presents the appearance of a new moon.

§ 487. At a mean, an error of 2′ 12″ in the lunar distance, will produce an error of 1° in the longitude.

§ 488. The moon changes its distance from those bodies, which lie directly in its path, more rapidly than it does from those towards or from which it moves more obliquely.

§ *a*. Therefore the stars from which the change of the lunar distance for the time being is the most obvious, should be preferred in taking lunar observations; for the more rapidly the distance changes, the less will the longitude be affected by a small error in the observation.

§ 489. In the Nautical Almanac; pages xiii. to xviii., of the ephemeris for each month, contain at intervals of three hours, the distance of the moon from the sun, from four of the planets, and eight of the principal fixed stars.

§ *a*. The small column, marked P. L. contains the proportional logarithm of the quantity, which the distance preceding it in the left hand column, varies during the three hours between which the P. log. stands.

§ *b.* Table III. of this volume, contains the proportional log. for every second from 1″ to 3° ; or for every second of time from 1*s* to 3*h*.

§ *c.* Proportional logarithms are nothing more than the *difference* between the log. of 3, and the log. of the given number less than 3.

Thus, the log. of 3 - - -	=0.4771+
Log. of 12′; (12′ reduced to the decimal of a degree is 0.20.) Log. 0.20 - -	9.3010+
P. log. of 12′, or 12*m*	=1.1761

§ *d.* This Table (III.) is always used for finding the Greenwich time when a given lunar distance occurred.

Thus, to find the time at Greenwich when the sun was distant from the moon	84° 17′ 10″	Diff. - 20′ 51″	P. L.=9362
L. Dist. at 6.	83° 56′ 19″	Diff. for 3*h*=1° 20′ 9″	P. L.=3514
" at 9.	85° 16′ 28″		
		46*m* 49*s*	=5848

And 46*m* 49*s* added to 6*h*, shows the time (6*h* 46*m* 49*s*) at Greenwich, when the sun was distant from the moon 84° 17′ 10″.

§ *e.* This is a much shorter way than that of arriving at the same result by common logs.; thus,

As 1° 20′ 9″=1.336 (decm'ls of a deg.)	Ar. co.	=9.874193
Is to 3*h* - - -	Log.	=0.477121
So is 20′ 51″=0.3475 (do. of a deg.)	Log.	=9.540955 (§ 90.)
To 46*m* 49*s*=0.7803 " "	Log.	=9.892269 (§ 93. § *g*.)

§ 490. In selecting a star to measure a lunar distance from, that one should be fixed upon, whose lunar distance at the time has the *least* p. log. after it in the ephemeris; for, as the greatest variations in the dist. are represented by the smallest p. logs., the lunar dist. of those bodies, which has the smallest p. log. after it, is increasing or decreasing, in a greater ratio, than that is which has after it a greater p. log.; consequently, (§ 488. § *a.*) those bodies are the most favourably situated for determining longitude.

§ 491. When practicable, the distance of the moon should be measured from two stars; one to the east, the other to the west of it; and the *mean* of the longitude resulting from the observations should be taken as the long. of the place.

§ *a.* If the sextant have an unknown error, the error will partially correct itself by its own counteracting effects in distances measured to the east and west of the moon.

§ 492. Latitude by "double altitudes" may also be determined by means of the data in the lunar problem.

Plate 7. { § 493. By inspecting the lunar diagram, it is seen that the arcs (P B, P B′) of the circles of declination of the sun and moon, join the extremities of the true lunar distance (B′ B), forming thereby the triangle B′ P B, of which the three sides are known.

§ *a*. Then the value of the angles P B B′, and A B B′ being found, their difference gives the value of A B P, which, with B A, and B P in the triangle P A B, constitutes data requisite for determining A P, the co-latitude.

§ 494. The lunar problem is one of the most useful and most beautiful problems in navigation; for besides his longitude and latitude, the navigator may deduce, from the principles involved in it, data for the solution of almost any problem in nautical astronomy.

§ 495. The three parts A P, P A B, A P B, in the fourth triangle, are determinable from the data obtained by a lunar observation.

§ *a*. A P is the co-lat. of the place of observation.

§ *b*. A P B is the horary angle, which (§ 382. § *a*.) shows the app. time of day at the place of observation when the latter was made. And,

§ *c*. The difference between this time converted into *mean* time, and the Greenwich time in the N. A. that corresponds to the lunar dist., expresses, in time, the longitude of the place of observation.

§ *d*. P A B is the sun's true azimuth at the time and place of observation; the difference between it, and the sun's magnetic azimuth, (§ 308. § *a*.) is the variation of the compass.

§ 496. By increasing the triangulation, and extending the operations, other quæsita may be added to the problem; and the length of the day and night; the time of the sun and moon's rising and setting; the hour of the moon's passing the meridian; the hour when each object bears east or west; the duration of twilight; and the amplitudes of the two objects on the day, and at the place of observation, may all be determined by means of the parts involved in the common lunar problem.

§ 497. Therefore when, on account of unknown drifts, and of gales during several days in succession of thick or cloudy weather, a ship has lost her reckoning, it may be successfully restored by a single lunar observation.

§ *a*. If the variation of the compass be required also at the same time in addition to the lat., time of day, and longitude, the calculation, after being conducted into the fourth triangle B A P, should be conducted by a process different from that for evolving the value of A P, the co-lat., alone.

§ *b*. In the latter case, the value of A P would be determined by the rule § *s*. and § *t*., under Case IV. (§ 200.)

§ *c*. And in the former case, the proportion between the sines of opposite sides and angles, would evolve it; for, when the three un-

Plate 7. known parts of this triangle (B A P) are required, the most direct method of arriving at the required results, consists in applying the rules § *z*. and § *z a*., Case IV., (§ 200.) to calculation, in order to determine first the value of the horary and azimuth angles (A P B, & P A B.)

§ *d*. In trigonometrical operations, that method of calculation should ever be adopted, which, being less elaborate, arrives more directly at the required result.

§ 498. When the latitude, etc., is required by means of a lunar observation, the operation of correcting altitudes and of finding the true lunar distance, is conducted as it is under § 483.; and then the value of A B B′ is found, before the operation passes from the second triangle B′ A B.

§ *a*. The true lunar distance B′ B being determined, the Greenwich time corresponding thereto, is found (§ 489. § *d*.) in the lunar tables of the Ephemeris; and then the declination and the right ascension of the sun and moon, at this time, are found in the appropriate tables of the Nautical Almanac.

§ 499. The declination of the two bodies thus found, gives (§ 258. § *b*.) the sides B′ P and B P.

§ *a*. And the difference of their right ascensions (§ 433.), expresses in time the value of the angle B′ PB.

§ *b*. The angle P B B′ is the only part in this triangle, which is required, and it may be found without the trouble of taking from the Ephemeris, the right ascension of the two bodies.

§ 500. The true lunar distance (§ 483.) 89° 53′ 24″ of the problem occurred (§ 484.) at Greenwich, August 27, 1834, near mean noon, when the sun's declination (page ii. of the Monthly Ephemeris) was 10° 10′ 2″ N.; and the moon's (page v. to xii. do.) was 19° 12′ 39″ N. Their difference in right ascension then was 6*h* 13*m* 52*s*.

§ *a*. And the sun's magnetic azimuth (§ 304. § *a*.) at the time of observation, was N. 109° 4′ 30″ East.

§ 501. The apparent and true zenith distances are found, and the calculation for determining the true lunar distance (B′ B) is conducted precisely in the same manner, as it is (§ 483.) when the true distance is the only object of the problem.

§ 502. In the second triangle B′ A B, to find the value of A B B′.

B′ B (Tr. lunar D.)	=89°53′24″	cosec.=0.000001
B′ A B	=163°15′ 8″	sin.=9.459632
B′ A (Moon's Z. D.)	=35°19′12″	sin.=9.762035

Sin. A B B′=9.221668=9° 35′24″

Plate 7. § *a.* In the third triangle B′ P B, to find the value of P B B′.

B′ B (Tr. L. D.) =89° 53′ 24″ cosec.=0.000001
B′ P B (Diff. R. A.)=6*h* 13*m* 52*s* sin.=9.999205
B′ P (Moon's P.D.) 70° 47′ 21″ sin.=9.975116

Sin. P B B′=9.974322=70° 29′ 27″

A B B′= 9° 35′ 24″

A B P=60° 54′ 3″

§ *b.* To find, in the fourth triangle, the sun's azimuth P A B, and the horary angle A P B (§ 200. § *z b.*)

$\frac{AB+BP}{2}$ =67° 46′ 55″	sec.=0.422357	cosec.=0.033505
$\frac{AB \backsim BP}{2}$ =12° 3′ 3″	cos.=9.990322	sin. =9.319687
$\frac{ABP}{2}$ =30° 27′ 1″	cot.=0.230713	cot. =0.230713

Tang. $\frac{PAB+APB}{2}$ =77° 11′ 38″=0.643392

Tang. $\frac{PAB \backsim APB}{2}$ =20° 59′ 17″ - - - =9.583905

A P B (H. Ang.) =56° 12′ 21″ (§ 77. § *h.*)

P A B (Azm.) =N. 98° 10′ 55″ E.

§ *c.* APB (H. Ang.)=56° 12′ 21″=3*h* 44*m* 49*s*=(§ 348. § *g.*) 8*h* 15*m* 11*s* A.M.

1*m* 25*s* =Equation of time, (Naut. Al., p. ii. Mon. Eph.)

8*h* 16*m* 36*s* A.M.=Mean time of day at the place of observation.

§ *d.* To find A P, the co-lat.

A P B (Hry. Ang.) =56° 12′ 21″ cosec.=0.080377
A B (Sun's Z. D.) =55° 43′ 52″ sin.=9.917192
A B P =60° 54′ 3″ sin.=9.941402

Cos.=29° 40′ 8″N. Lat.=Sin. A P (co-lat.)=9.938971

§ *e.* Sun's Mag. Azm. (§ 500. § *a.*) N. 109° 4′ 30″ E.
Sun's Azm. (§ *b.*) N. 98° 10′ 55″ E.

Variation (§ 312.)= 10° 53′ 35″ Westerly.

§ *f*. Time at Greenwich (§ 484.) when the obs. was made, 12*h* 00*m* 17*s* P.M. } Plate 7.
Time (§ c.) at the place of observation, 8*h* 16*m* 36*s* A.M.

Long. of the obsr. (§ 391. § *b*.) W. 3*h* 43*m* 41*s*=55° 55′ 15″

§ 503. If the latitude and time of day, without the variation, be required from a lunar observation, the process of calculation may be varied from that above for finding the azimuth, time, and latitude; and may be made more direct.

§ *a*. But in either case, the order and method of calculation are the same, in the process of arriving at the value of A B P in the fourth triangle.

§ 504. The true lunar distance (B′ B) must always be determined, before the correct P. distances, (P B, P B′) and the difference (B′ P B) in right ascension (§ 498. § *a*.) of the two bodies, can be known.

§ *a*. These parts must always be taken from the Ephemeris, and for the time in it, which corresponds to the true lunar distance.

§ 505. Having found, in the second triangle, the required angle A B B′; then having taken (§ 498. § *a*.) from the Ephemeris, the proper P. D., etc., and calculated (§ 502. § *a*.) the value of the angle (P B B′) required in the third triangle; the value of A B P is obtained, and the lat. and time of day may thence be deduced by the following formula.

§ 506. Formula of calculation for finding the latitude and time of day by a lunar observation.

To find the lat. (§ 200. § *n*.)

		Contd. Angle (A B P)	cos.=*.******
Sun's Z. D. (A B)	cos.=*.******		tang.=*.******
Auxl. *a*	sec.=*.******	Tang. auxl.	*a*=*.******
(*a* ∽ Sun's P. D.)	cos.=*.******		
Cos. co-lat. (A P)	=*.******		

To find the time of day, (§ 144.)

Co-lat. (A P)	co-sec.=*.******
Contd. Angle (A B P)	sin.=*.******
Sun's Z. D. (A B)	sin.=*.******
Sin. Horary Angle (A P B)	=*.******

§ 507. If the second and third triangles fall on opposite sides of the lunar distance B′ B, then the sum of the angles (A B B′ & P B B′) of the second and third triangles, gives the value of the required angle (P B A) of the fourth triangle. } Plate 8.

§ 508. When the polar distance of each body is greater than the co-latitude of the observer, then the second and third triangles fall upon the same side of the lunar distance B′ B, } Plate 7.

Plate 7. and the difference between the angles (A B B′, P B B′) is the value of the angle (A B P) sought in the fourth triangle.

§ 509. It may always be known, whether the sum or difference of the angles of the second and third triangle, will give the angle required to be known in the fourth triangle, by observing the inclination of the plane in which the sextant is held to bring the sun and moon in contact.

§ *a*. If the sextant be inclined to the plane of the horizon, towards the pole of the observer, then his co-lat. is greater than the P. dist. of either body, and the second and third triangles fall upon different sides of the lunar distance, and the sum of the two angles is the required angle of the fourth triangle.

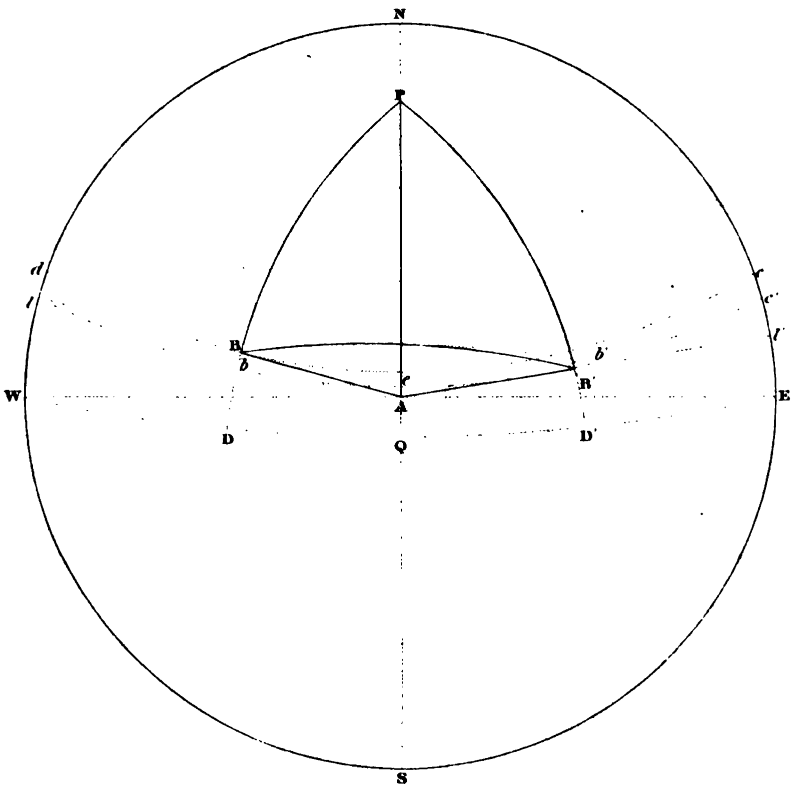
§ 510. May 16, (P. M.), 1834.

Obs. dist. sun & moon 97° 16′ 28″
Obs. alt. sun's L. L. =41° 3′ 59″
Obs. alt. moon's U. L.=37° 58′ 24″

Required the latitude and longitude of the place of observation?

§ *a*. To apply the preliminary corrections.

1st. Obs. lunar dist.	97° 16′ 28″	
Sun's semidiam. - -	15′ 50″	(N. A., p. ii., M. E.)
Moon's " - -	16′ 6″	(" iii. ")
Moon's augmentation -	10″	
App. lunar dist.	=97° 48′ 34″	
2d. Obs. alt. sun's L. L.	41° 3′ 59″	
Sun's semidiameter -	15′ 50″	
Sun's app. alt. - -	41° 19′ 49″	App. Z. D. 48° 40′ 11″
3d. Sun's refraction -	—1′ 11″	
Sun's plx. in alt. -	7″	
Sun's true alt.	41° 18′ 45″	Z. D. 48° 41′ 15″
4th. Obs. alt. moon's U. L.	37° 58′ 24″	
Moon's semidiameter -	—16′ 6″	
Moon's augmentation -	—10″	
Moon's app. alt. - -	37° 42′ 8″	cos.=9.898286
Moon's hor. plx. - -	- -	59′ 4″ sin. =8.235047
Moon's plx. in alt. -	46′ 44″	Sine=8.133333
Moon's refraction -	—1′ 14″	
Moon's true alt.	38° 27′ 38″	Z. D. 51° 32′ 22″


N
P
d
l
B
b
b′
B′
c′
l′
W
e
A
E
D
Q
D′
S

§ *b*. To find the tr. lunar dist.

1st. To find *b* A *b′* in the first triangle, (§ 201. § *f*.) } **Plate 8.**

b b′ **(Ap. lunar dist.)**	**=97° 48′ 34″**	
A *b* **(sun's ap. Z. D.)**	**=48° 40′ 11″**	**co-sec.=0.124410**
A *b′* **(moon's ap. Z. D.)**	**=52° 17′ 52″**	**co-sec.=0.101714**
	2)198° 46′ 37″	

$\frac{1}{2}$ sum=99° 23′ 18″ sin. =9.994144
($\frac{1}{2}$ S.∾*b b′*)= 1° 34′ 44″ sin. =8.440173

2)18.660441

Cos. $\frac{b\ A\ b'}{2}$=77° 38′ 55″= 9.330220

2

2d. To find B B′ (§ 200. § *u*.)

b A *b′*=155°17′50″ cos.=9.958319

A B= 48°41′15″ cos.=9.819653 - - tang.=0.056056

Auxl. *a* - sec.=0.157822 Tang.*a* 134° 3′ 7″ =0.014375

51°32′22″ (M.'s Z. D.)

(*a*∾M.'s Z.D.) cos.=9.114977 - 82°30′45″ (A B′ ∾*a*)

Cos. B B′=9.092452 = 97° 6′25″ (Tr. l'r dist.)

When this distance (97° 6′ 25″) occurred, it was 9 P. M. at Greenwich of the given day (N. A. p. xv., Monthly Ephemeris.)

§ *c*. To take (§ 498. § *a*.) the other requisite data from the ephemeris.

Moon's dec.	14° 59′ 6″	N. P. D. 75° 0′ 54″	(N. A., p. viii. M. E.)
Sun's dec.	19° 8′ 28″	N. P. D. 70° 51′ 32″	(" ii. ")
Moon's Rt. A.	10*h* 25*m* 15*s*	-	(" viii. ")
Sun's "	3*h* 52*m* 25*s*	-	(" ii. ")

Polar angle =6*h* 52*m* 50*s*=B P B′.

§ *d*. To find the required angle B′ B A of the second triangle.

B B′ (lunar dist.)	=97° 6′25″	cosec.=0.003350
B A B′ -	155°17′50″	sine =9.621084
A B′ (moon's Z. D.)	=51°32′22″	sine =9.893782

Sin. B′ B A=9.518216=19°15′18″

Plate 8. § *e*. To find the required angle B′ B P of the third triangle

B B′ (lunar dist.)	= 97° 6′ 25″	co-sec.	=0.003350
B′ P B (pl'r. angl.)	= 6*h* 52*m* 50″	sin.	=9.988356
P B′ (moon's P. D.)	= 75° 0′ 54″	sin.	=9.984975
	Sin. B′ B P=71°23′30″		=9.976681

§ *f*. 4th triangle B A P; to find the co-lat. B′ B A=19°15′18″ (§ 506.)

P B A=90°38′48″ cos.=8.052549

A B=48°41′15″ cos.=9.819653 - tang.=0.056056

Auxl. *a* - sec.=0.000036 Tang. *a* 179°15′51″=8.108605

70°51′32″ (S.'s P.D.)

(*a* ∽ sun's P.D.) cos.=9.499325 108°24′19″ (A B ∽ *a*)

Cos. A P, or sin. lat.=9.319014=12°1′55″N. sec.=0.009647

To find the Hr. angle A P B.
P B A=90°38′49″ sin.=9.999973
A B (sun's Z. D.)=48°41′15″ sin.=9.875710

Sin. A P B 3*h* 20*m* 41*s*=9.885330

Equation= 3*m* 56*s*

Mean time=3*h* 16*m* 45*s* P. M.
Gr. time (§ *b*.)=9*h* P. M.

W. Long. (§ 391. § *b*.) 5*h* 43*m* 15*s*=85°48′45″

§ 511. Examples under § 483. and § 510. are drawn out in the solution, in order to familiarize the problem to the student. But such a process of calculation as is there shown, is not desirable in practice; especially that part of it which has been made to come under Case IV., (§ 200. § *n*.) on account of the perplexity in determining whether the value of the auxl. *a* be greater or less than 90°.

§ *a*. Therefore, in practice, those methods of calculation are generally preferred, which give the trigonometric function of *half* the value of the required part; such as § *a*. (§ 386.), for *half* the value of a required arc or angle should never exceed 90°.

§ 512. The learner has now become familiar with the triangulation, which is brought under calculation in the process of finding longitude, etc., from a lunar observation; he will therefore readily comprehend the manner by which such an operation is simplified, and reduced to the following methods and formulæ for practice.

§ 513. The process of correcting the obs. distance and altitudes is fully shown under § 483. and § 510. This part of the operation is the same in every method for calculating the true from an obs. lunar distance..

§ 514. An improved method for finding the true from an observed lunar dist.*

§ *a*. Aug. 27th, 1834.

App. dist. sun & moon = 88° 26′ 52″

Sun's app. alt. -	= 47° 52′ 12″	
Sun's refraction -	— 53″	
Sun's pl'x. in alt.	7″	
Sun's tr. alt. -	47° 51′ 26″	
Moon's app. alt. -	40° 52′ 58″	cos. = 9.878550
Moon's hor. pl'x. - -	55′ 0″	sin. = 8.204070
Moon's pl'x. in alt. -	41′ 35″	sine = 8.082620
Moon's refraction -	—1′ 7″	
Moon's true alt.	= 41° 33′ 26″	

§ *b*. App. lunar D.	88° 26′ 52″	
Sun's app. alt. -	47° 52′ 12″	sec. = 0.173397
Moon's " -	40° 52′ 58″	sec. = 0.121449
	2)177° 12′ 2″	
½ sum	= 88° 36′ 1″	cos. = 8.387876
(½S. ∾ app. lunar D.)	= 0° 9′ 9″	cos. = 9.999998
Sun's tr. alt. -	47° 51′ 26″	cos. = 9.826710
Moon's " -	41° 33′ 26″	cos. = 9.874073
		2)38.383503
Sun's + Mon's alt.	2)89° 24′ 52″	
		19.191751
$\frac{\text{Sun's + Moon's Alt.}}{2}$	= 44° 42′ 26″	cos. = 9.851693†

Sin. auxl. *a* = 9.340058 = 12°38′20″

Auxl. *a* cos. = 9.989347†

Sin. $\frac{\text{Tr. lunar dist.}}{2}$ = 9.841040 = 43°54′25″

2

True lunar dist. = 87°48′50″

* Vide Kelly's Spherics, p. 195.

§ c. (N. A., p. xvii., M. E.) 3h P. M.
Sun's lunar dist. 88° 29′ 8″ P. L.=3277
True lunar dist. =87° 48′ 50″

40° 18″ P. L.=6500 3h P. M.

3223=1h 25m 42s

Greenwich time=4h 25m 42s P.M.

LATITUDE BY THE NORTH STAR.

§ 515. In northern latitudes, the latitude may be found at any time of the night, by an altitude of the north star.

§ 516. If the north star were situated in the pole of the world, its altitude would always show the elevation of the north pole; and (§ 251. § *a.*) consequently to the observer, his latitude.

§ 517. But as this star revolves in a very small circle around the pole, the elevation of the pole may always be determined by applying to the star's altitude at any time, the corrections opposite to that time in the subjoined tables (A & B).

§ 518. The corrections in Table A, and those after (✶'s alt. +) in the hour columns of Table B, are *always* to be added to the star's alt. They are expressed in seconds (″).

§ 519. And the other corrections in Table B, must be applied to the star's altitude, according to the precept, which is at the head of the hour column in which the *sidereal* time is found.

§ 520. To find the lat. by an alt. of the north star; the altitude being corrected for dip, refraction, etc.

§ *a* Subtract 1′ from the star's alt.

§ *b*. For the supposed time of night when the observation is made, take the corresponding sidereal time; the correction found in Table B and opposite to this time, being applied, according to the precept (§ 519.) at the head of its column, to the star's alt., gives the approximate latitude.

§ *c*. And the corrections under the hour in Table B, and opposite the hour, but under the "approximate latitude," in Table A, being added to the approximate latitude, give the lat. of the observer.

§ 521. May 4, 1834, long. 85° W. the altitude of the north star, at 7*h* P. M., was 35° 29′ 43″. To find the lat.

§ *a*. Supposed time - -	7*h* 0*m* 0*s* P. M.	
Longitude in time - -	5*h* 40*m* 0*s*	
Time at Greenwich - -	12*h* 40*m* 0*s*	(§ 396. § *a.*)
Sidereal time, May 4 - -	2*h* 47*m* 34*s*	(N. A., p. ii., M. E.)
Supposed time - - - -	7*h*	
Acceleration of S. T. for 12*h* 40*m*	2*m* 5*s*	(§ 213. § *b.*)
Sidereal time of obs. - -	=9*h* 49*m* 39*s*	

§ *b*. Star's alt. 35° 29′ 43″
1′ (§ 520. § *a*.)

35° 28′ 43″
Oppos. 9*h* 49*m* 39*s* (Table B) correction + 1° 3′ 38″

Apprx. lat. 36° 32′ 21″
Under 9*h*, *'s alt. + (Table B) - 66″
Oppos. 9*h* 49*m* 39*s* and under 40° (Table A) 32″

Latitude 36° 33′ 59″ N.

§ 522. Jan. 14, 1834. Long. 45° East 9*h* P. M.; the altitude of the north star was 41° 11′. To find the lat.

§ *a*. Supposed time - -	9*h*	
Longitude in time - -	3*h*	
Time at Greenwich - -	6*h*	(§ 396. § *b*.)
Sidereal time, Jan. 14 -	19*h* 33*m* 53*s*	(N. A., p. ii., M.E.)
Supposed time of obs. -	9*h*	
Acceleration of S. T. for 6*h*	59*s*	(§ 213. § *b*.)
Sidereal time of obs. - -	28*h* 34*m* 52*s*—24*h*=4*h* 34*m* 52*s*	

§ *b*. Star's altitude - - - -		41° 11′
		1′
		41° 10′
Opposit. 4*h* 34*m* 52*s* (Table B)	Cor.	—56′ 15″
Approx. lat. - - - - - - -		40° 13′ 45″
Under 4*h*, *'s alt. + (Table B)	Cor.	56″
Oppos. 4*h* 34*m* 52*s*, and under 41° (Table A)		41″
Latitude		40° 15′ 22″ N.

§ 523. Aug. 8, 1834, longitude 150° East. The alt. of the north star at 4 A. M. was 49° 33′. To find the latitude.

§ *a*. Supposed time 4*h* A. M.	=16*h*	(§ 221. § *b*.)
Longitude in time - -	=10*h*	
Time at Greenwich - -	= 6*h*	
Sidereal time, Aug. 8 - -	9*h* 6*m* 3*s*	
Supposed time of obs. - -	16*h*	
Acceleration of S. time for 6*h*	59*s*	
Sidereal time of observation -	25*h* 7*m* 2*s*=1*h* 7*m* 2*s*.	

§ *b*. Star's altitude - - - - -		51° 34′
		1′
		51° 33′
Oppos. 1*h* 7*m* 2*s* (Table B)	Cor.	—1° 41′ 54″
Approx. latitude - - - - - -		50° 1′ 6″
Under 1*h*, *'s alt.+(Table B)	Cor. -	58″
Oppos. 1*h* and under 50° (T. A)	" -	0″
	Latitude	50° 2′ 4″

§ 524. An error of several degrees in the longitude, and of several minutes in the time of taking the star's altitude, brings only a small error into the latitude, therefore the ship's time, and longitude by dead reckoning, may always be used for finding the latitude at sea by the polar star.

*Tables for finding the Latitude by the alt. of the North Star.**

Table A.

Sidereal Time.	APPROXIMATE LATITUDE.							Sidereal Time.
	15°	30°	40°	50°	60°	65°	70°	
h m	″	″	″	″	″	″	″	*h m*
0.	1	3	4	6	9	12	15	12
30	0	1	1	2	2	3	4	30
1.	0	0	0	0	0	0	0	13.
30	0	1	1	2	2	2	3	30
2.	1	3	4	6	9	11	14	14.
30	3	7	9	13	13	24	31	30
3.	5	11	16	23	34	42	53	15.
30	7	17	24	34	50	62	79	30
4.	10	22	33	46	67	83	106	16.
30	13	28	41	58	85	108	134	30
5.	15	34	49	70	101	128	160	17.
30	18	38	56	79	115	145	182	30
6.	19	42	61	87	126	159	199	18.
30	20	44	65	91	133	168	210	30
7.	21	45	64	93	135	170	214	19.
30	21	44	64	91	133	168	211	30
8.	20	42	60	87	127	159	200	20.
30	18	38	50	79	116	146	183	30
9.	15	44	43	70	102	129	161	21.
30	13	28	32	59	86	109	136	30
10.	10	23	29	47	69	84	108	22.
30	8	17	27	35	50	62	80	30
11.	5	11	17	23	34	42	54	23.
30	3	7	10	13	20	35	32	30
12.	1″	3″	4″	6″	9″	12″	15″	24.
Sidereal Time.	15°	30°	40°	50°	60°	65°	70°	Sidereal Time.
	APPROXIMATE LATITUDE.							

* Vide N. A. for 1834, p. 483.

Table B.

Sidereal Time.			Corrections.	Sidereal Time.			Corrections.
H	M	H		H	M	H	
− 0	0	+ 12	1° 31′ 12″	− 6	0	+ 18	0° 24′ 43″
*'s Alt. + 58″	10	*'s Alt. + 60″	32 12	*'s Alt. + 64″	10	*'s Alt. + 58″	20 44
	20		33 1		20		16 41
	30		33 39		30		12 36
	40		34 7		40		8 31
	50		34 24		50		4 24
1	0	13	1° 34′ 30″	7 19	0	19 7	0° 01′ 6″
*'s Alt. + 58″	10	*'s Alt. + 62″	34 25	*'s A. + 57″	10	*'s A. + 64″	3 51
	20		34 10		20		7 58
	30		33 44		30		12 4
	40		33 7		40		16 8
	50		32 19		50		20 11
2	0	14	1° 31′ 21″	20	0	8	0° 24′ 12″
*'s Alt. + 58″	10	*'s Alt. + 59″	30 13	*'s Alt. + 55″	10	*'s Alt. + 63″	28 9
	20		28 54		20		32 4
	30		27 25		30		35 55
	40		25 46		40		39 41
	50		23 57		50		43 23
3	0	15	1° 21′ 59″	21	0	9	0° 47′ 1″
*'s Alt. + 57″	10	*'s Alt. + 61″	19 51	*'s Alt. + 54″	10	*'s Alt. + 66″	50 33
	20		17 34		20		53 59
	30		15 8		30		57 19
	40		12 34		40		1° 0 32
	50		9 52		50		3 38
4	0	16	1° 7′ 1″	22	0	10	1° 6′ 38″
*'s Alt. + 56″	10	*'s Alt. + 60″	4 3	*'s Alt. + 57″	10	*'s Alt. + 71″	9 29
	20		0 57		20		12 13
	30		0° 57 45		30		14 48
	40		54 26		40		17 15
	50		51 0		50		19 33
5	0	17	0° 47′ 29″	23	0	11	1° 21′ 42″
*'s Alt. + 59″	10	*'s Alt. + 59″	43 53	*'s Alt. + 59″	10	*'s Alt. + 65″	23 42
	20		40 11		20		25 32
	30		36 25		30		27 12
	40		32 35		40		28 42
	50		28 41		50		30 3
6	0	18	1° 24′ 43″	24	0	12	1° 31′ 12″
H	M	H	Corrections.	H	M	H	Corrections.

TIDES.

§ 525. The flux and reflux of the waters, known under the name of TIDES, are caused by the attractive forces of the sun and moon exerted upon the ocean.

§ 526. The moon being nearer to the earth than the sun is, has a greater effect than the sun upon the tides.

§ *a.* The action of the moon upon the tides, is about three times greater than that of the sun.

§ 527. When the attractive forces of the sun and moon act in conjunction, they produce the highest tides.

§ *a.* When this is the case, the moon (§ 367.) is in syzygy.

§ *b.* And the tides caused about this time are called *spring* tides.

§ 528. The tides have the least rise and fall, when the attractive forces act perpendicularly to each other.

§ *a.* And this is the case, when the moon (§ 369. § *b.*) is in quadrature. Then the tides are called *neap* tides.

§ 529. That portion of the ocean which is immediately under, and nearest to, the sun or moon, is more attracted by either than the centre of the earth is. This portion then, has a tendency to approach the attracting body, and rises up, until its tendency is counteracted by the attraction of gravitation towards the centre of the earth.

§ *a.* About twelve hours afterwards, this portion of the ocean, owing to the earth's diurnal motion (§ 206. § *a.*), is at the furthest point from the sun or moon; and the waters about it, owing to their tendency to restore the equilibrium, which is disturbed by the effects of the attraction of the sun or moon on the opposite side of the earth, rise up and make high tide again.

§ *b.* Hence, during the time in which the moon is performing one revolution around the earth (§ 362. § *d.*),the tide rises twice, and falls twice, at the same place.

§ 530. The attractive forces of the sun and moon upon equal portions of the surface of the sea, being (§ 526. § *a.*) about 3 to 1 in favour of the latter; if the solar tide at any place be 2 feet and the lunar 6, and the moon be in syzygy, the two tides will happen at the same time, and (§ 527. § *b.*) make a spring tide of 8 feet.

§ *a.* Then, as the lunar (§ 360. § *a.*) is longer than a solar day, the following solar will happen earlier than the succeeding lunar tide, by the difference between half a solar and half a lunar day.

§ *b.* Thus, the lunar tide continues to retard upon the solar tide, until the moon quadrates; when the high lunar and low solar tides coincide in time, and (§ 528. § *a.*) we have a neap tide of four feet rise.

§ *c.* After this, the lunar still continues to retard upon the solar tide, until the moon arrives in the other syzygy; when the two high tides again happen at the same time, and bring about other spring tides.

§ *d*. At this second spring tide, the moon has completed half of a revolution in its orbit, and has lost one tide upon the sun; therefore, while the moon is completing one entire revolution through its phases, there are two more solar, than lunar, tides.

§ 531. The attraction of the moon being more partial, and its effect upon small portions of the earth's surface being more obvious than that of the sun, the combined tides are governed more by the moon than by the sun.

§ 532. The effects of the moon's attraction upon the earth, tend (§ 529.) to create high tide, both in that part of the ocean immediately under, and nearest to, the moon, and in that part diametrically opposite; and were not the motion of the waters resisted and obstructed, there would be high tide at the moment when the moon crosses either the superior or the inferior meridian.

§ *a*. But, at some places, the passage of the moon across the meridian, precedes, by several hours, the time of high water.

§ *b*. This retardation of the tides might be explained, by attributing the retarding power to the effects of the resistance, which the shores, unequal depths of ocean, etc., offer to the mass of moving waters, were it not, that the waters do not rise up into spring tides, when the moon is in syzygy, and when the attractive forces of the sun and moon are combined in their action upon the waters; but the highest tides in every synodical month (§ 362. § *c*.), is generally about the third tide after the passage of the moon through either syzygy.

§ *c*. And the least neap tide, is generally the third tide after the moon quadrates.

§ 533. Observations show, that the tides require a little longer time to ebb, than they do to flow.

§ *a*. This difference observable at sea, becomes more obvious in rivers of strong currents.

§ 534. Upon the smaller seas, and sheets of water, such as the Lakes, the Mediterranean, etc., the effect of the lunar and solar attractions, are partially counteracted by the circumscribed limits to their action; and hence but little, or no tide is produced there.

§ 335. There are a variety of causes, (and some of a local nature), which, acting together, tend, some to retard at one place, and others to hasten at another place, the hour of high tide on the full and change days of the moon; so that, there are no general rules for determining beyond certain limits of approximation, the time of high or low water at any place.

§ 536. The greaiest interval between two consecutive tides, generally happens about a day and a half after the moon has quadrated; when the tides, (§ 532. § *c*.) being at the minimum of their rise and fall, are the weakest.

§ *a*. And the least retardation of one tide after another, is the 2d upon the 3d, or the 3d upon the 4th tide, after the moon's latest passage through a syzygy; the tides, having then (§ 532. § *b*.) the greatest rise and fall, are strongest.

§ 537. On an average, the tides rise and fall once, in about 12*h* 48*m*.

§ *a*. Consequently every tide retards, at a mean, about 24*m*, upon the one which it succeeds; and each tide happens about 48*m* later than it did the day before.

§ 538. Were there not so wide a difference in the tides, between the minimum and maximum of their retardation, the hour of high or low water, at any place and on any day, might be found by adding to the time of high water on full or change days, the product of 48*m*, and the number of days from the latest full or new moon, to the day proposed.

§ *a*. About the time of neap tides, there is sometimes a difference of more than an hour and three quarters in the time of high water, on two successive days.

§ *b*. And a similar difference about the time of spring tides, is frequently less than half an hour.

§ 539. The annexed table (C) shows the retardation of the *mean* tides, upon the hour of high tide on full and change days, for every day between the full and change of the moon.

§ *a*. Therefore, to find the time of mean high water on any day, we have only to look in the Nautical Almanac (page xii. M. Ephemeris), for the day of the latest new, or full moon, in order to find its age (in days) since the last change in syzygy; the time, in the annexed table (C), found opposite to this age, and added to the time of high water at the place proposed, on full and change days, gives the time of mean high tide for the day when it is so required.

§ *b*. The hour of high tide at any port, on full and change days, is called the *establishment* of the port.[a]

§ *c*. And the *establishment of the port* for any one place is always the same; for on every full and change day throughout the year, high tides are considered to take place there at the same hour of the day.

§ 540. A table for finding the time of high or low water, at any place, the *establishment* of the *port* (§ 539. § *b*.) being known.

TABLE C.

From ● to ○ * Corrections. H	M	Days.	From ○ to ● Corrections. H	M
	21	½		20
	41	1		41
1	0	1½	1	5
1	19	2	1	28
1	38	2½	1	47
1	58	3	2	6
2	18	3½	2	26
2	38	4	2	46
2	58	4½	3	5
3	19	5	3	24
3	40	5½	3	45
4	3	6	4	6
4	26	6½	4	28
4	51	7	4	50
5	15	7½	5	15
5	41	8	5	44
6	14	8½	6	14
6	53	9	6	48
7	30	9½	7	28
8	5	10	8	10
8	38	10½	8	47
9	7	11	9	20
9	29	11½	9	48
9	51	12	10	14
10	18	12½	10	35
10	48	13	10	35
11	10	13½	11	16
11	30	14	11	38
11	51	14½	11	59
12	12	15	12	20

§ *a*. To find the time of high water at Charleston, Aug. 29, 1834. The establishment of the port being 7*h* 5*m*.

§ *b*. The last change in syzygy (§ 367.) was full moon, Aug. 18th, 20*h* (N. A., p. 12, M. E.); consequently the moon's age is 10 days.

§ *c*. Opposite to 10*d*, and in the column, from ○ to ●, is 8*h* 10*m*, which, added to the establishment of the port, gives 15*h* 25*m*, the hour of high water on the day proposed.

§ *d*. To find the time of high water at Portland, Feb. 14, 1834; the establishment of the port being 10*h* 45*m*

§ *e*. The last change in syzygy was new moon February 3; consequently the age of the moon is six days.

§ *f*. Opposite to 6*d*, and in the column, from ● to ○, is 4*h* 3*m*, which, added to 10*h* 45*m*, gives 14*h* 48*m*, the time of high water.

§ 541. This method does not show the precise hour of high water; but it approximates the true time of high water, within limits which will serve on all ordinary occasions.

§ *a*. The time of low water may be found by adding 6*h* 15*m* to the time of high water on the day proposed.

* The arguments ● to ○, mean from *New* to *Full* moon; and ○ to ●, from *Full* to *New* moon.

NAVIGATION.

NAVIGATION.

§ 542. The geographical situation of places, is designated by their distance, north or south, from the equator; and by their distance, east or west, from a prime meridian (§ 252. § *c*.).

§ *a*. These distances (§ 248. § *b*. & § 252.) are known by the name of Latitude and Longitude of the places.

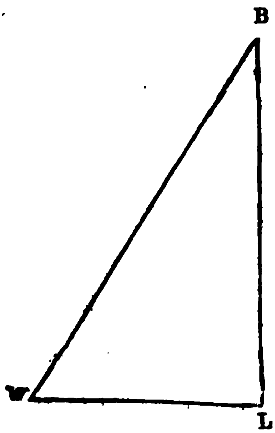
§ 543. It has been shown in Nautical Astronomy, how the latitude and longitude of places may be determined by means of observations made upon the sun, moon, or stars; but in practice these means are not always at hand.

§ *a*. It remains then to be shown, how the geographical position of places may be determined, by knowing in certain respects, their relative situation with regard to each other.

§ 544. Washington city is to the southward and westward of Baltimore. The difference of latitude between them (§ 254. § *c*.) is the meridianal arc, which is contained between Baltimore and the parallel of the latitude of Washington.

§ *a*. And the arc of this parallel which is between Washington and the meridian of Baltimore, (§ 254. § *b*.), is the difference in longitude between the two places.

§ *b*. These two arcs are perpendicular to each other; for the meridian of Baltimore (§ 248. § *a*.) cuts the equator at right angles, and the parallel of Washington (§ 249.) is parallel to the equator.



§ *c*. Now, if a line (W B) be drawn direct from Washington to Baltimore, it will connect their difference of longitude (W L) and of latitude (B L), and form a right angled triangle (W L B), of which the hypothenuse (W B) is the distance, and the legs, the difference of latitude and of longitude, between Washington and Baltimore.

§ *d*. The two acute angles (W & B) show the bearings of each place from the other. The angle W is the course from Washington to Baltimore, and the angle B is the course from Baltimore to Washington.

§ *e*. Hence if, of the Dist., Diff. Lat., Diff. Long., and Course, between two places, any two be given, the others are determinable.

§ 545. Now, the section of a loxodromic curve, which a ship traces while she is sailing upon a given course, is the hypothenuse of a right angled triangle, and corresponds to W B.

§ *a*. Then if the course and distance, which a ship sails in any given time, be known, we have the hypothenuse and an acute angle of a right angled triangle, given; and the other parts are determinable.

§ *b*. Therefore, knowing the latitude and longitude of the place from which a ship takes her departure, and knowing the course and distance which she sails from that place, in a specified time, we may determine by right angled trigonometrical calculations, the latitude and longitude of the ship, at the end of that time.

§ 546. The sides of all such triangles are curved lines; for the earth (§ 204.) is a spheroid, therefore all triangles upon its surface are spherical triangles, and are properly subject to the rules of spherical trigonometry, for investigation.

§ *a*. But the laborious operations of obtaining results from these triangles, when brought under calculation, as spherical triangles, would be inconvenient in practice; and they are not necessary in the ordinary purposes of navigation.

§ *b*. Therefore all such triangles are considered in navigation as right angled plane triangles, and are brought under calculation according to the rules of plane trigonometry.

§ 547. A degree (°) of all great circles, such as the equator, meridians of longitude, etc., whose radii and the earth's semidiameter are the same, consists of 60 *nautical miles*, or of about 69½ statute miles; so that, calling the number of minutes ('), miles, which is contained in an arc of one of these great circles, we have the value of this arc considered as a straight line.

§ *a*. Wherefore, knowing the distance and the difference of latitude between any two places, the difference of longitude between them, may be determined also in *nautical* miles, by right angled, plane trigonometrical calculations founded upon § 75.

§ *b*. The difference of longitude thus found, is called departure.

§ 548. *Departure* is the difference in longitude between any two places, expressed in *miles*.

§ *a*. And the departure in any latitude, may be converted into its corresponding minutes (') of longitude by means of the principles established under § 76.

§ 549. It is evident, that, if in mathematical calculations, curved lines be treated as right lines, there must be an error in the result; and this error increases with the number of degrees contained in such curved lines.

§ 550. The result then, obtained by calculating the sides of a spherical triangle, as though they were the straight lines of a plane triangle, is only an approximation; and the smaller the sides, the closer is the approximation.

§ *a*. This method therefore is particularly applicable in small distances, and short runs; it is used for working up "dead reckoning", and for calculating the distance, the difference of latitude and of longitude, and the course, from one place to another; any two of which four quantities being known, (§ 544. § *e*.), the others are determinable.

§ 551. The diagram shows by a mere inspection, the solution of every problem which can occur in right angled plane trigonometry, provided the hypothenuse of the triangle involved, do not exceed 300 miles, or 300 units of any measure. Plate 1.

§ *a*. This diagram may answer the purpose of Tables IV. & V.; and it also shows the principles upon which they are constructed; for the number in the Dist. column of these tables, is the length of the hypothenuse of a right angled triangle, whose acute angles contain, one the number of degrees at the top, and the other those at the bottom of the page, and the value of whose legs is set down opposite to that of the hypothenuse, and in the columns marked Dep. and D. Lat.

§ 552. This diagram, then, shows the solution of every case, or problem in loxodromic sailing; for it shows the dimensions of the triangle involved in every problem, provided the distance or hypothenuse do not exceed 300 miles.

§ *a*. If it exceed 300 miles, the solution may be obtained by dividing the given side or sides, by 2 or 3, or by any other divisor, which will reduce the triangle of the problem within the limits of the diagram; then the value of the side or sides, obtained, by using said quotient in the diagram, being multiplied by the same divisor (§ 70.), gives the value of the required side or sides.

§ 553. The angle B A D is 45°.

§ *a*. The acute angles of a right angled triangle (§ 32. § *d*.) being complementary to each other, the less must always be located at A.

§ *b*. And the leg adjacent to it, must be called the *base*, and be a part of A D.

§ *c*. And the leg opposite to it, must be called the *perpendicular*.

§ *d*. All the straight lines standing upon A D, are alluded to as *perpendiculars*.

§ *e*. B C is the greatest *perpendicular* in the diagram. Equal portions of it are transferred by means of the parallels *b d*, to the graduated arc B D, for admeasurement.

§ *f*. The graduated arc B D is thus made to answer the purpose of a graduated *perpendicular*, for the arc contains the same divisions which the *perpendicular* B C would have shown, had it been graduated to the scale of A B and A D.

§ *g*. The height of every *perpendicular* is therefore shown on that portion of the graduated arc, which is between the *base* (§ *b*.) and that parallel, under which the *perpendicular* stands. Thus the height of the *perpendicular* *b* C, transferred by the parallel *b d*, to the graduated arc, is D *d*=11.3.

§ 554. The arcs in the diagram show the angular value of any course, provided it be not more than 4 Points, or 45°.

§ *a*. If the course be greater than this, they show the angular value of its complement.

§ *b*. The arcs, 3, 4, 5, etc., also show the length of the *base* and

Plate 1. hypothenuse of the triangle proposed; while the scale on the graduated arc (§ 553. § *g*.) shows the value of the *perpendicular* (*b c*) in the several triangles.

§ *c*. The section of any arc, which is contained between the *base*, and the lines A *e*, shows the angular value of the courses which are marked *upon* these lines; and the angular value of the complements (§ 553. § *a*.) of the courses, marked *under* these lines.

§ *d*. The marks on the arcs show the value of these arcs in degrees.

§ *e*. The even numbers (2°, 4°, 6°, etc.) of degrees are marked on the concave side of the arcs; and the odd numbers (1°, 3° 5°, etc.) are marked on the convex side.

§ *f*. The degrees (46°, 47°, 48°, etc.) that stand on the outside of the graduated arc, are the complements of those (42°, 43°, 44°, etc.) on the inside of the arc.

§ *g*. The entire length of every arc (§ 553.) is 45°.

§ 555. The dotted lines, A *e'*, represent quarters of Points; the broken lines A *e*, represent halves of Points; and the continuous lines A *e* whole Points.

§ *a*. The distance on a given course is shown on the lines A *e*, at the end of which lines that course is found; then the portion of that line (A *e*) which is contained between A, and the arc 3, 4, etc., which is marked with the distance proposed, is hypothenuse to the triangle required.

§ *b*. Thus 24 miles on a 2½ Point course, is the distance A *b* on the broken line A *e*, at the end of which 2½ is marked; and A C *b* is the right angled triangle, of which the course and the distance proposed constitute an angle and the hypothenuse.

§ *c*. The two legs of this triangle are the *base* A C, and the *perpendicular* *b* C which stands under the parallel *b d*.

§ *d*. The graduated scale on A D shows the value of A C=21.1, the D. lat.; and the portion (D *d*) of the scale on the graduated arc, between the *base* and the parallel *b d* (§ 553. § *g*.), shows the height of the *perpendicular* *b* C=11.3, the Dep.

§ 556. Now as the distance which a ship may sail upon any loxodromic course, is considered (§ 546. § *b*.) as the hypothenuse of a right angled plane triangle, if the distance sailed upon such course can be found in the diagram, the departure and difference of latitude, which correspond to that course and distance, may be found by means of the graduated *base* and arc, A D and B D.

§ *a*. Or; if any two of these quantities; viz., Course, Dist., Dep., and Diff. Lat., be known, the other two are determinable by means of the diagram.

§ 557. A ship sails N.W.¼N. 19 miles, What departure and difference of latitude does she make?

§ *a*. The given course is found *upon* the dotted line A *e'*, and that portion (A *b*) of this line, which is between A and the 19th arc, is the hypothenuse of the triangle (A *c b*) involved.

§ *b*. The *perpendiculcr* (*b c*) intersects the *base* at 14.1, which is the difference of latitude.

§ c. And the parallel, from the top of the *perpendicular*, intersects the graduated arc at 12.7, which is the departure. } Plate 1.

§ 558. A ship sails N.W. by N. and makes 12.7 miles of departure, What distance and diff. lat. does she make?

§ *a*. The parallel from 12.7 on the graduated arc, intersects the N. W. by N. line, in the point, (nearly), where the 23d arc crosses it; then nearly 23 (22.9) miles in the distance sailed.

§ *b*. And the *perpendicular* from this point of intersection, falls upon the *base*, and shows the difference of latitude required, to be 19.1 miles.

§ 559. A ship sails N. by W.¾W. and makes 19.8 miles diff. lat., What departure and distance does she make?

§ *a*. The *perpendicular* at 19.8 on the *base*, being traced up, is found to intersect the N. by W.¾W. line on the 21st arc; then 21 miles is the distance sailed.

§ *b*. And the parallel from this point of intersection, being traced to the graduated arc, shows the height of the perpendicular 7 miles, which is the departure required.

§ 560. A ship, after sailing 18 miles, finds that she has made 16.2 miles diff. lat., What course did she sail, and what departure has she made?

§ *a*. The *perpendicular* from 16.2 on the *base*, intersects the 18th arc on the dotted line marked 2¼ Points, which is the course required.

§ *b*. And the parallel from this point of intersection, shows, on the graduated arc, the height of the perpendicular to be 7.8 miles, which is the departure required.

§ 561. A ship sails 28 miles, and finds that she has made 15.6 miles departure, What course and diff. lat. has she made?

§ *a*. The parallel from 15.6 on the graduated arc, cuts the 28th arc, on the line marked 3 Points, which is the course sailed.

§ *b*. And the *perpendicular* from this point of intersection, falls upon the *base* at 23.3 miles, which is the diff. lat. required.

§ 562. The departure between two places is 8.7 miles, and the diff. lat. between them is 28.6 miles, What is the course, and the distance from one place to the other?

§ *a*. The *perpendicular* from 28.6 on the *base*, intersects the 30th arc on the broken line, 1½, which shows the required course and distance to be 1½ Points, and 30 miles.

§ 563. If the distance sailed be not more than a mile, or if the hypothenuse of the triangle proposed, be not greater than 3, the divisions on the scales must be decimated; then the figures 1, 2, 3, 4, 5, etc., stand for $\frac{1}{10}$, $\frac{2}{10}$, $\frac{3}{10}$, $\frac{4}{10}$, $\frac{5}{10}$, etc., and the subdivisions stand for 100ths.

§ *a*. Wherefore, when the distance is not more than 3 miles, the distance from A, to the 10th arc, is 1 mile; to the 20th, 2 miles; and to the 30th, 3 miles; and all the numbers in the diagram stand for 10ths.

§ 564. What departure and difference of the lat. would a ship make by sailing 2 miles N.W.½N.?

Plate 1. § *a*. The parallel and *perpendicular* which would pass through the point in which the 20th arc intersects the N. W.¼N. line, measured by the eye, would cut the graduated arc and base in 12.7 and 15.4.

§ *b*. And using only one decimal place (§ 563.), the nearest would be 1.5 diff. lat. and 1.3 departure; but the exact is 1.54 and 1.27 diff. lat. and dep.

§ 565. When the lines in the diagram do not pass through the point required by the conditions of the triangle involved, the imaginary lines required, may be traced by the eye with all the precision which is necessary; and after a little practice, with the utmost accuracy and facility.

§ *a*. Thus, the distance of one place from another, is N. by W. 27½ miles; the triangle involved in this problem, being filled up by the eye, the imaginary parallel and *perpendicular*, cut the graduated arc and *base* in 5.3 and 27; which shows the departure between the two places to be 5.3 miles, and the diff. lat. 27 miles.

§ 566. If the distance sailed on a single course exceed 30 miles, or the hypothenuse of the triangle involved, be greater than 30, all the numbers in the diagram must be increased tenfold.

§ *a*. Then the arcs must be reckoned as being 10 miles a part; the numbers 1, 2, 3, 4, 5, etc., will stand for 10, 20, 30, 40, 50, etc.; and the distance between these numbers being divided, every one in 10 equal parts, every one of these subdivisions must be counted as 1 mile.

§ 567. A ship sails N. W. 240 miles; what departure and diff. lat. does she make?

§ *a*. The parallel and *perpendicular* from the intersection of the 24th arc (now counted (§ 566.) 240), with the N. W. line, cuts the graduated arc and *base* (§ 41.) at equal distances, and the departure and diff. lat. (§ 14.) are the same.

§ *b*. Departure=169.5. diff. lat.=169.5. This is $\frac{2}{10}$ of a mile less than the result by logarithmic calculation. This difference is owing to the smallness of the scale upon which the diagram is projected, and not to any defect in the principles involved in the projection of the diagram.

§ 568. In the examples quoted above, the courses are *on* the lines, and the diff. lat., except (§ 567.) when the course consists of 4 Points, is always greater than the departure.

§ 569. The courses and figures *under* the lines, (§ 554. § *e*.) are the complements of those *on* the line above them; and when the course is found *under* the line, the departure is the longest leg of the triangle involved, and must be read off upon the *base* A D; and the diff. lat. is taken from the graduated arc B D.

§ *a*. A ship sails E. ¼ N. 28 miles. What departure and diff. lat. does she make?

§ *b*. The parallel and *perpendicular* which pass through the point where the 28th arc cuts the dotted line, *under* which the given course is marked, meet the graduated arc and base in 1.3 and 27.9+.

§ *c*. Then (§ 569.) the departure=27.9. and the diff. lat.=1.3.

§ 570. The four cardinal points of the horizon (§ 272.) divide it into four quadrants, each containing 8 Points. } Plate 1.

§ *a*. Wherefore a Point=11° 15′, the quotient of 90° by 8.

§ 571. The Points, when expressed by numbers, begin at the north and south, and are reckoned in numerical order, to the east and west points.

§ *a*. Hence, it is easy to conceive that a vessel that sails N. 3 Points W., or N. W. by N., would make more *northing* than *westing*, and that her diff. lat. would be greater than her departure.

§ *b*. And conversely, that if a vessel sail on any course between 4 and 8 Points, e. g., N. 5 Points W., or N. W. by W., she would make more *westing* than *northing*, and that consequently her departure would be greater than her diff. lat.

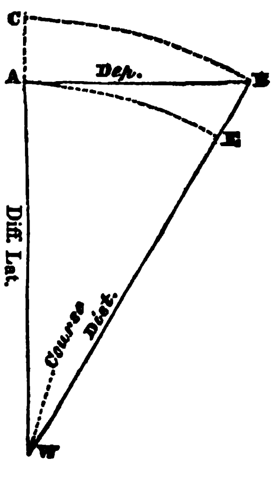
§ 572. From what has already been advanced in explanation of the diagram, it appears that the triangle involved in the trigonometrical solution of any problem in *loxodromic* sailing, is a right angled plane triangle.

§ *a*. *Loxodromic* sailing,* is so called from the sort of curve which the track of a ship forms, when she is sailing upon any course not exactly due east or west, north or south.

§ *b*. *Loxodromic* curves are spirals, which continually approach the poles, but can never reach them.

§ *c*. And any course, not due east or west, north or south, is called a loxodromic course.†

§ 573. A number of formulæ, varied in the trigonometric functions to be used, may be drawn up for the solutions of the several cases in loxodromic sailing.



§ *a*. The terms in these formulæ depend upon the side of the triangle, whether it be the distance, the departure, or diff. lat., which is made radius.

§ 574. Baltimore is 35 miles N. N. E. ¾ E. from Washington. The formula for finding by calculation the departure and diff. lat. between the two places, depends upon the trigonometrical construction which is given to the triangle involved.

§ *a*. If the hypothenuse be made radius, to an arc B C, the dep. becomes (§ 54.) sine to the course, and the diff. lat. its co-sine.

§ *b*. Then, (§ 75.), rad. : dist. : : sin. of course : dep. : : cos. course : diff. lat.

* The subdivisions of the *sailings*, viz., Plane, Traverse, Parallel, and Middle Latitude Sailing, are not here preserved. These distinctions are by no means necessary for the purpose of facilitating the navigator's calculations; they have therefore been generalized under the term of *loxodromic sailing*.

† E. by N. is a loxodromic course. Suppose a vessel could sail E. by N.

§ *c*. Hence (§ 74.) are deduced the following formulæ; the three first being the given terms, and the fourth, the unknown and required term, of the proportion.

§ *d*. Sin. course : dep. : : rad. : dist. (§ 75. § *b*.).

§ *e*. Dist. : rad. : : dep. : sin. course.

§ *f*. Cos. course : diff. lat. : : rad. : dist.

§ *g*. Dist. : rad. : : diff. lat. : : cos. course.

§ *h*. Cos. course : diff. lat. : : sin. course : dep.

§ *i*. Dist.=35. log.= - - - 1.544068
Course=2¾ pts. (§ 571.) sin. (Table D)=9.711049

Log. dep.=1.255117=18 miles.

§ *j*. Dist. 35. log.= - - 1.544068
Course, 2¾ pts. cos.= - - 9.933350

Log. diff. lat.=1.477418=30 miles.

§ 575. If the triangle be constructed upon the diff. lat. as radius of the arc A E, then the dist. becomes (§ 57.) secant, and the dep. (§ 56.) tangent, to the course.

§ *a*. And (§ 75.) sec. course : dist. : : rad. : diff. lat. : : tang. course : dep.

§ *b*. Wherefore, the diff. lat. being taken as radius, the following formulæ are derived either (§ 75. § *c*.) immediately from the construction of the triangle, or (§ 67. § *e*.) from the relation of the terms, as they are expressed in the proportion § *a*.

§ *c*. Diff. lat. : rad. : : dist. : sec. course.

§ *d*. Rad. : diff. lat. : : sec. course : dist.

§ *e*. Diff. lat. : rad. : : dep. : tang. course.

§ *f*. Tang. course : dep. : : rad. : diff. lat.

§ *g*. Tang. course : dep. : : sec. course : dist.

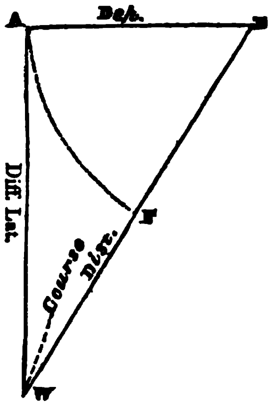
§ *h*. Course 2¾ pts. cos.=9.933350 (§ 101. § *b*.)
Dist. 35 miles, log.=1.544068

Log. diff. lat.=1.477418=30 miles.

§ *i*. Course 2¾ pts. cos.=9.933350
Dist. 35 miles, log.=1.544068
Course 2¾ pts. tang.=9.777700

Log. dep.=1.255118=18 miles.

without any obstruction, or without ever deviating from that course; the N. pole would then be always *one Point* forward of her beam. It is difficult to imagine how a vessel could ever arrive at such a point.



§ 576. Or if the triangle be constructed upon the dep., as radius of the arc A F, the dist. becomes secant, and the diff. lat. the tangent, of B, the complement (§ 32. § *d.*) of the course.

§ *a.* Wherefore (§ 75. § *c.*) co-sec. course : dist. : : rad. : dep. : : co-tang. course : diff. lat.

§ *b.* Other formulæ of proportion, similar to those under § 575., might be drawn out here, but these for the most part would be a repetition of those, as the expression 4×6 is a repetition of the form 6×4 of multiplication. Indeed several sets of the proportions under § 574. & § 575., are similar repetitions of each other.

§ *c.* Course 2¾ pts. sin.=9.711049 (§ 101. § *b.*)
Dist. 35 miles, log.=1.544068

Log. dep.=1.255117=18 miles.

§ *d.* Course 2¾ pts. sin.=9.711049
Dist. 35 miles, log.=1.544068
Course 2¼ pts. co-tang.=0.222300

Log. diff. lat.=1.477417=30 miles.

§ 577. The principles of the above trigonometrical construction are also developed in the solution of problems by the diagram. } Plate 1.

§ *a.* Thus, to find the course and dist. which correspond to 12 miles diff. lat., and 5 miles dep.

§ *b.* The *perpendicular* which cuts the *base* in 12, is tangent to the 12th arc, and A 12 is its radius.

§ *c.* The parallel from 5, on the graduated arc, cuts this *perpendicular* on the 13th arc, at its intersection with the 2 Point line, and A 13 is secant to the course (2 Points) and the dist. required.

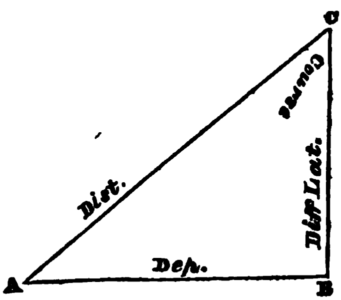
§ *d.* If the dist. A 13, on the 2 Point line be called radius of the 13th arc, then the portion of the *perpendicular*, between the point of this intersection, is sine of the course, and A 12 on the *base*, is its co-sine.

§ 578. **Table of log. sines, etc., of the Points of the Compass.**

TABLE D.

Points.	Sine.	Co-sec.	Co-sin.	Sec.	Tang.	Co-Tang.	
¼	8.690795	1.309205	9.999477	0.000523	8.691319	1.308681	7¾
½	.991302	.008698	.997904	.002096	.993398	.006602	7½
¾	9.166520	0.833480	.995274	.004726	9.171246	0.828754	7¼
1	.290236	.709764	.991574	.008426	.298662	.701338	7
1¼	.385572	.614428	.986787	.013213	.398784	.601216	6¾
1½	.462824	.537176	.980885	.019115	.481939	.518061	6½
1¾	.527488	.472512	.973840	.026160	.553647	.446353	6¼
2	.582840	.417160	.965615	.034385	.617224	.382776	6
2¼	.630992	.369008	.956163	.043837	.674829	.325171	5¾
2½	.673387	.326613	.945430	.054570	.727957	.272043	5½
2¾	.711049	.288951	.933350	.066650	.777700	.222300	5¼
3	.744739	.255261	.919846	.080154	.824893	.175107	5
3¼	.775037	.224963	.904828	.095172	.870199	.129801	4¾
3½	.802359	.197641	.888185	.111815	.914173	.085827	4½
3¾	.827083	.172917	.869790	.130210	.957294	.042706	4¼
4	.849485	.150515	.849485	.150515	0.000000	0.000000	4
	Co-sine.	Sec.	Sine.	Co-sec.	Co-tang.	Tang.	Points.

§ 579. In every case, except when the dep. and diff. lat. constitute the two given parts, the solution of the problem proposed, may be obtained by means of the proportion (§ 74.) between the sides of a triangle and sines of their opposite angles.



§ *a.* In the triangle A B C (§ 74.) right angled at B, (§ 74.) dist. : sin. B=90° : : dep. : sin. course; but the sine of 90 (§ 62.) is radius, wherefore we have again the formula § *e.*, (§ 574.), viz., dist. : rad. : : dep. : sin. course, and a repetition of others under § 574.

§ 580. Some one of the following formulæ (*rejecting or borrowing* 10 for rad., (§ 197. § *f.*), *in the index of the second member of the equation*), may be used in every case where two of the four quantities, dist., course, dep. and diff. lat., are given.

§ *a.* Dep. (§ 574. § *b.*)=dist.×sin. course.

§ *b.* Dep. (§ 575. § *e.*)=diff. lat.×tang. course.

§ *c.* Diff. lat. (§ 574. § *j.*)=dist.×cos. course.

§ *d.* Diff. lat. (§ 575. § *f.*)$=\frac{\text{Dep.}}{\text{tang. course}}$ (§ 101. § *b.*)=dep.×cot. course.

§ *e*. Dist. (§ 575. § *d*.)=diff. lat.×sec. course.
§ *f*. Dist. (§ 576. § *a*.)=dep.×co-sec. course.
§ *g*. Sin. course (§ 574. § *e*.)=$\frac{\text{Dep.}}{\text{dist.}}$
§ *h*. Cos. course (§ 574. § *g*.)=$\frac{\text{Diff. lat.}}{\text{dist.}}$
§ *i*. Tang. course (§ 575. § *e*.)=$\frac{\text{Dep.}}{\text{diff. lat.}}$
§ *j*. These formulæ will always be found convenient in practice.

OF TURNING DEPARTURE INTO DIFF. LONG.

§ 581. If the difference of longitude between two places (§ 548.) be expressed in miles, it is called departure.

§ *a*. A minute of longitude is no where, except at the equator, equal to a mile of departure; for the distance between any two meridians of longitude (§ 248. § *a*.) is greatest at the equator, and the least about the poles.

§ *b*. Therefore the dep. between any two meridians is greater at the equator than in any latitude.

§ *c*. Furthermore, as all meridians (§ 248. § *a*.) intersect at the poles, the dep. between any two becomes less and less, as you approach the poles, where there can be no dep.; whereas the difference of longitude, between these meridians in any latitude, (§ 254. § *a*.) is the same, being expressed by the same number of degrees (°), minutes (′), etc.

§ 582. Suppose two places to be situated in the same latitude, the arc of this parallel of latitude, contained between them, (§ 254. § *b*.) is their difference in longitude.

§ *a*. And parallels of latitude (§ 249.) are small circles.

§ *b*. Suppose also an arc of a great circle (§ 122.) to be drawn from one of these places to the other, this arc (§ 122. § *a*.) would be the shortest distance between the two places, and the minutes (′) contained in it, would show (§ 547.) the departure between them.*

§ 583. These two arcs are contained between the same two points, and (§ 76.) the arcs are to each other, as the radius of the great circle is to the radius of the small circle.

§ *a*. The rad. of such a great circle, as well as of the equator, etc., (§ 122.) is semidiameter to the earth.

§ *b*. And the radius of the small circle, or the parallel, (§ 130. § *a*.) is the cos. of its latitude.

§ 584. Then, calling the semidiameter of the earth, unity, or rad., we have (§ 76.) for any latitude, diff. long. : dep. : : rad. : cos. lat.

§ *a*. Also cos. lat. : dep. : : rad. : diff. long.

b. And rad. : diff. long. : : cos. lat. : dep.

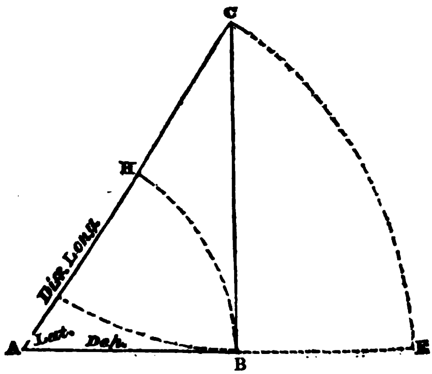
* Hence it appears that the *course* between two places, is never the shortest distance between them, unless they be either upon the equator, or upon the same meridian.

§ *c.* Wherefore, if any two of these three quantities, (rad. is always known), be given, the other and remaining one is determinable.

§ 585. The terms of these proportions represent quantities, comprised in the elements of a right angled plane triangle.

§ *a.* Wherefore, if the figure which furnishes such proportions, be considered a plane triangle; it will be right angled, the latitude will be one of its acute angles; the diff. long., the hypothenuse; and the dep. will be one of the legs of such triangle.

§ *b.* The result obtained from calculations conducted upon such principles, (§ 549.) must be only an approximation.



§ 586. Suppose a ship sailed E. 15½ miles on the parallel of 56° 15′ south latitude, her departure would be 15½ miles, the distance sailed.

§ *a.* And in the right angled triangle A B C, the angle A=56° 15′, the lat.; the leg A B= 15½, the dep.; and the hypothenuse (§ 585. § *a.*) is the diff. long.

§ *b.* Now, if the diff. long. be made radius, of the arc C E; C B becomes its sine, and A B its co-sine, whence (§ 75.) arise the proportions, under § 584.

§ *c.* Rad. : diff. long. : : cos. lat. : dep.

§ *d.* Diff. long. : rad. : : dep. : cos. lat.

§ *e.* Cos. lat. : dep. : : rad. : diff. long.

§ *f.* To find the corresponding diff. long. by calculation (§ *e.*).

Lat. 56° 15′ sec. =0.255261 (§ 101. § *b.*)
Dep. 15.5 log. =1.190332

Log. diff. long.=1.445593=27.9 minutes (′)

§ 587. If the dep. (A B) be made radius, to the arc B H, then the diff. long. becomes secant to the lat., and we have (§ 75. § *c.*)

§ *a.* Rad. : dep. : : sec. lat. : diff. long.

§ *b.* Sec. lat. : diff. long. : : rad. : dep.

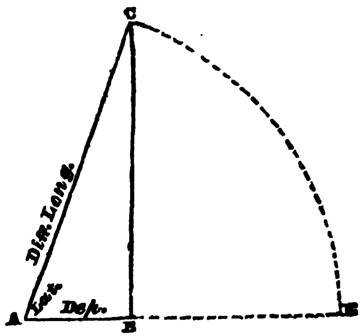
§ *c.* Dep. : rad. : : diff. long. : sec. lat.

§ 588. Now, if the other leg (C B) be made radius, the dep. becomes co-tang. (§ 57. § *b.*), and the diff. long. the co-sec., of the latitude, whence (§ 75.) arise the following sets of proportions.

§ *a.* Co-tang. lat. : dep. : : co-sec. lat. : diff. long.

§ *b.* Co-sec. lat. : diff. long. : co-tang. lat. : dep.

§ 589. To find the number of miles, or the dep., which correspond to 1° or 60′ on the parallel of 67° 30′.



§ *a*. The diff. long. being made radius, we have, (§ 586. § *c*.),
Rad. : diff. long. : : cos. lat. : dep.

Diff. long. 60 log.=1.778151
Lat. 67° 30′ cos.=9.582840

Log. dep.=1.360991=22.9

§ 590. C (§ 32. § *d*.) is the complement of A, and is equal to 22° 30′. C B is the cos. of C, and shows the number of miles contained in 1° of long. on the parallel of lat. 22° 30′.

§ *a*. Diff. long. 60 log.=1.778151 (§ 589. § *a*.)
Lat. 22° 30′ cos.=9.965615

Log. dep.=1.743766=55.4 miles,

which is equal to 1° of long. in lat. 22° 30′.

§ *b*. Now (§ 75. § *b*.) C B : cos. C : : A B : cos. A. A B shows the number of miles equal to 1° of long. in lat. 67° 30′, and C B shows the number of miles, that make 1° of long. in lat. 22° 30′, the complement of 67° 30′.

§ *c*. Wherefore, in any lat., the miles in a degree of long. are to the cos. of that lat., as the miles contained by a deg. of long. in any other lat., are to the cos. of this lat. And alternately.

§ 591. As a right angled plane triangle (§ 585,) is involved in the solution of the several problems under § 586. § 587. § 588., etc.; the solution of every one of such problems may be obtained by means of the diagram. Plate 1.

§ *a*. The diff. long. (§ 585. § *a*.) is the hypothenuse; and the leg adjacent to the angle which in degrees (°), is equal to the latitude in which the dep. or diff. long. is made, is the dep.

§ 592. Of dep., diff. long. and lat., either is determined on the diagram, by means of the two others, in the same manner, that any

Plate 1. one of the three quantities, viz., diff. lat., dist. and course, is determined (§ 556. § *a.*) by means of any two of these.

§ 593. When the latitude in which the diff. long. or dep. is made, is less than 45°, the degrees of lat. are to be found on the *inside* of the graduated arc; and the dep. on the *base*.

§ *a.* But when the latitude is *greater* than 45°, the degrees of it are to be found on the *outside*, and the dep. on, the graduated *arc*.

§ *b.* Thus, 26′ of long. is equal to 24.5 miles, in lat. 19°; and in lat. 71°, it is equal to 8.4 miles.

§ *c.* The *perpendicular* from the mark for the 19°th on the 26th arc, cuts the *base* at 24.5, which shows the dep. for 26′ of long. in lat. 19°.

§ *d.* The parallel from 71° on the 26th arc, cuts the graduated arc at 8.4, which is the dep. (§ 593. § *a.*) for 26′ of long. in lat. 71°.

§ 594. A ship in lat. 27°, makes 20.5 miles dep. To find the diff. long.

§ *a.* The diff. lat. is found on the *inside* (§ 593.) of the graduated arc, and the dep. on the *base*.

§ *b.* The *perpendicular* from 20.5 on the *base*, intersects 27° on the 23d arc, then 23′ is the required diff. long.

§ 595. A ship in lat. 60°, makes 12 miles dep. To find the diff. long.

§ *a.* The degrees of the lat. (§ 593. § *a.*) are found on the *outside*, and the dep. on the graduated arc.

§ *b.* The parallel from 12, intersects 60° on the 24th arc; 24′ is the diff. long.

§ 596. The diff. long. between two places in lat. 33° is 27′. To find the dist. between them.

§ *a.* The lat. is found on the *inside* (§ 593.) of the graduated arc, and the dep. on the *base*.

§ *b.* The *perpendicular* from 33° on the 27th arc, falls upon the *base* at 22.6, the dist. in miles between the two places.

§ 597. The diff. long. between two places in lat. 54°, is 24′. To find the dist. between them.

§ *a.* The degrees of lat. are on the *outside*, and the dist. (§ 593. § *a.*) is to be found on the graduated arc.

§ *b.* The parallel from 54° on the 24th arc, cuts the graduated arc at 14.1, the dist. required.

§ 598. The dep. between two places on the same parallel, is 18.4 miles, and the diff. long. is 20′. To find their lat.

§ *a.* The *perpendicular* from 18.4 cuts the 20th arc at 23°, the lat. required.

§ *b.* The dep. being found on the *base*, the degrees (§ 593. § *a.*) are taken from the *inside* of the arc.

§ *c.* But if the dep. were found on the graduated arc, then the degrees on the *outside* of the arc, would show the lat.

§ 599. The diff. long. being 20′, and the dep. between two places in the same latitude being 6.8 miles; to find their lat.

§ *a*. The parallel from 7.8, cuts the 20th arc at 67°, which (§ 598. § *c*.) is the lat. } Plate 1.

b. When the minutes (′) of long. exceed 30′, every division on the several graduated scales, (§ 566.) must be counted as a mile, or as a minute (′).

§ *c*. And when the minutes (′) of long. do not exceed 3′, the divisions on the graduated scales (§ 563.) must be decimated.

§ 600. Of the diff. long., dep. and lat., either one may be found, the others being given, by means of Table V.

§ *a*. The degrees at the top of the table, are those which are *inside* of the arc; and those at the bottom of the table, and on the *outside* of the arc, are the same.

§ *b*. The numbers in the column marked (dist.) stand for minutes (′) of longitude; they show the value of the hypothenuse of a triangle, whose legs are equal to the quantities in the next two columns; and whose acute angles contain, one the degrees at the *top*, and the other those at the *bottom* of the page.

§ *c*. When the lat. is found at the top of the page, the miles which are equal to any number of minutes of longitude, are opposite to them in the column marked, at the top, (d. lat.)

§ *d*. Thus, in lat. 41°, 60′ of long.=45.3 miles.

§ *e*. If the degrees of lat. be found at the bottom of the page, then the miles which are equal to any number of minutes (′) of long., are found opposite to them in the column marked (d. lat.), at the bottom.

§ *f*. Thus, in lat. 71°, 60′ of long.=19.5 miles.

§ 601. When a ship sails due east, or west, she sails either upon a parallel of lat., or upon the equator, and the whole distance sailed is dep.; which may be converted into diff. long. by the formula § *f*. (§ 586.), or by means of the diagram (Plate I.), or Table V.; either of the two latter means is most convenient in practice.

§ 602. When a ship sails due North or South, she sails upon the arc of a meridian, and the whole distance sailed is diff. lat.

§ 603. It is frequently the case, that a ship sails during the day, on more courses than one, making a zig-zag track.

§ *a*. In such cases, it would be a very tedious operation, after finding the diff. lat. and dep. for every course and distance, to convert the dep. for every such course and dist. into diff. long. by a separate operation.

§ *b*. Such circuity is avoided by taking the whole amount of dep., and converting it into diff. long. by a single inspection of the diagram, or of Table V.

§ 604. Suppose a ship sails from lat. 64° N., 216 miles N.E. by N.; she makes 120 miles of dep. and 179.6, say 180 or 3° diff. lat.

§ *a*. Now this dep., or the diff. long. is not all made upon the parallel of 64°, ’5°, ’6°, or ’7°; or upon any one of the intermediate parallels, but upon all of them together.

§ *b*. And in order to convert, by a single operation, this dep. into long., and to find the diff. long. which the ship has made by sailing this course and distance, the whole dep. is supposed to be made upon that parallel (65° 30′) which is midway between the lat. left (64°), and that (67°) arrived at.

§ *c.* This lat. (65° 30′) is called the ***middle latitude;*** it is ***half the diff. lat. added to lat.*** left; or to that arrived at, if the latter be the less lat.

§ 605. If the number of miles in a degree of long. on the different parallels, as you approach the poles, decreased, as the miles from the equator to those parallels increase, this method would show the true diff. long.

§ *a.* But the number of miles in a degree of long. at different parallels, is (§ 590. § *c.*) as the cosines of the lat. of such parallels.

§ *b.* Wherefore, the result given by this method is only an approximate one.

§ *c.* But in working up "dead reckoning," "days' works," etc., this method is generally used; it is used in all cases, except in the computation of great distances.

§ 606. On ship-board at the expiration of every hour, sometimes of every two hours, the course and distance sailed during that time are marked opposite each other, on the *log slate.*

§ *a.* And at the end of every sea day, or at every noon, the courses and distances sailed in the last 24 hours, are "taken off," for the purpose of "working up;" and the whole distance sailed on every separate course is set down, opposite to that course, in a *traverse table.*

Plate 1. § *b.* The diff. lat. and the dep. for every course and dist., are taken, either from the diagram, or from Table IV., and set down opposite to their proper course and dist. in the "traverse table."

§ *c.* The dep. and diff. lat. for every course and dist., are then added up; the sums show the whole dep. and diff. lat.

§ *d.* And by means of the whole dep. and diff. lat., the course and dist. "made good," are found on the diagram (§ 577. § *a.*), or are taken from Table IV. or V.

§ *e.* The "middle lat." (604. § *c.*) is then found; and by means of it and the dep., the diff. long. is found (§ 594.) on the diagram, or in Table V.

Fig. A.

Course.	Dist.	Diff. Lat.		Depart.	
		N.	S.	E.	W.
N. by E.	20	19.6	- -	3.9	- -
S. W.	12	- -	8.5	- -	8.5

§ 607. Fig. A is the formula of a "traverse table."

§ *a.* The diff. lat. is written in the column marked N. or S. according as the course has *northing*, or *southing* in it. Thus, the diff. lat. for 20 miles N. by E. is put in the N. column, and the diff. lat. for 12 miles S. W. is written in the S. column.

§ *b.* The dep. must be placed in the column E. or W., according as the course has *easting*, or *westing* in it. Thus the dep. for the dist. 20 N. by E., is written in the E. column, and the dep. for the dist. 12, S.W. is written in the W. column.

§ 608. The dep. and diff. lat. for any dist. less than 300 miles, and for any course, are found in Table IV., in a manner similar to that by which they are found on the diagram.

§ *a.* If the course be less than 4 Points, it is to be found at the top of the page, and the diff. lat. must be taken from the column marked at the top (d. lat.), and over which the course is found.

§ *b.* Thus, to take from Table IV. the dep. and diff. lat. for 120 miles S.½E.; find S.½E. at the top of the page, and 120 in the dist. column; then in the two columns, at the head of which S. ½ E. is found, and opposite to 120, are the diff. lat. 119.4, and the dep. 11.8.

§ *c.* But if the course be more than 4 Points, it is to be found at the bottom of the page, and the precept at the foot of the column must be the guide for taking out dep. and diff. lat.

§ *d.* Thus to take from Table IV. the dep. and diff. lat. for 30 miles E.N.E.; find E.N.E. at the bottom of the page, and 30 in the dist. column, then in the two columns, at the foot of which E.N.E. is found, are 27.7 (dep.) and 11.5 (diff. lat.) opposite to 30.

§ *e.* If the dist. exceed 300 miles, some aliquot part of it is taken as the 2d, 3d, etc., and the dep. and diff. lat. opposite to this quotient being increased by 2, 3, etc., as much as the dist. was reduced, give the required dep. and diff. lat. Thus to find the dep. and diff. lat. for 400 miles N.N.W.; take 200, the half of it; then, under N.N.W. and opposite 200, stands 184.8 in the d. lat. column, and 76.5 in the dep. do.; each of which being multiplied by 2, gives the required diff. lat. 369.6 or 6° 9′ 36″, and the dep. 153 miles.

§ *f.* Table V. is used in the same way for finding dep., diff. lat., etc., when the course is given in degrees. Thus the dep. for 18 miles N. 30° E. is 9 miles; and the diff. lat. for 40 miles S. 74° E. is 11 miles.

Traverse Table.

Compass Courses.	Courses Corrected.	Dist.	Diff. Lat. N.	Diff. Lat. S.	Dep. E.	Dep. W.
N.N.E.	N.E. by N.	14	11.6	—	7.8	—
S.S.E.	S. by E.	18	—	17.7	3.5	—
South	S. by W.	40	—	39.2	—	7.8
S.½E.	S.½W.	19	—	18.9	—	1.9
N.W.½N.	N.N.W.½W.	9	7.9	—	—	4.2
N. by W.	North	6	6	—	—	—
W. by S.	West	3	—	—	—	3
East	E. by S.	2	—	.4	2	—
N.E.	N.E. by E.	60	33.3	—	49.9	—
S.W. by S.	S.W.	16	—	11.3	—	11.3
W.¾S.	W.¼N.	7	.3	—	—	7.
W.¾N.	W. by N.¾N.	4	1	—	—	3.9
			60.1	87.5	68.2	39.1
				60.1	39.1	
				27.4	24.1	

Lat. sailed from 41° 13′ N.
Diff. Lat. - - 27′ 24″ S.
Lat. in - - 40° 45′ 36″ N.
Mid. Lat. (§ 604. § *c.*) 41°
Long. sailed from 70° 15′ W.
Diff. Long. 32′ E.
Long. in 69° 43′ W.

Variation 1 Point E.

§ 609. The courses in the 1st column of the "traverse table" are the courses sailed per compass.

§ *a.* Those in the 2d column are those corrected (§ 298. § *b.*) for variation, which is 1 Point E.

§ *b.* The diff. lat. and dep. in their columns, answer to the dist. and *corrected courses* to which they are opposite.

§ *d.* The diff. lat. 27′.4 S. and the dep. 24.1 E. show that the ship, by sailing the several courses and distances in the table, went to the Southward and Eastward.

§ *d.* The dep. 24.1 and diff. lat. 27.4 are found opposite 36 (Table V.) and *under* 42°, which shows the course and dist. "made good," (§ 606. § *d.*) to be S. 42° E., 36 miles.

§ *e.* Under 41° (Table V.) 24.1 in the d. lat. column, stands opposite to 32 in the dist. column; the diff. long. then is 32′ East.

§ 610. The manner in which "dead reckoning," "days' works," etc., are worked up, and kept at sea, whether by means of the Tables IV. and V., or the diagram, may be learned from the subjoined formulæ. Plate 1.

§ *a*. Aug. 23, lat. and long., 62° N. and 47° W.

§ *b*. Variation W. 1½ Pt., which (§ 298. § *b*.) is to be allowed towards the *left*.

AUG. 24.

Compass Courses.	Courses Corrected.	Dist.	Diff. Lat. N.	Diff. Lat. S.	Dep. E.	Dep. W.
S. E.	S. E. by E. ½ E.	16		7.5	14.1	
E. ½ N.	E. N. E.	12	4.6		11.1	
E. by N.	N. E. by E. ½ E.	14	6.6		12.3	
N. E.	N. N. E. ½ E.	20	17.6		9.4	
N. N. E.	N. ½ E.	18	17.9		1.8	
N. by E. ½ E.	North	66	66			
North.	N. by W. ½ W.	40	38.3			11.6
S. W.	S. S. W. ½ W.	26		22.9		12.3
			151.	30.4	48.7	23.9
			30.4		23.9	
			120.6		24.8	

Yesterday's lat. (§ *a*.) 62° N.
Diff. lat. - - 2° 0′ 36″ N.
Lat. in - - 64° 0′ 36″ N.
Mid. lat. - - 63° 0′
Yesterday's long. 47° 0′ W.
Diff. long. - 55′ E.
Long. in - - 46° 5′ W.
Course and dist. "made good" N. 12° E. 123 miles.

§ *c*. Above 63°, the mid. lat. (Table V.) 24.8* in the d. lat. column, stands opposite to 55 in the dist. column; the diff. long. then is 55′ E.

§ *d*. And the dep. 24.8 and diff. lat. 120.6 are found opposite to each other under 12°, (Table V.), and opposite to 123, which shows the course and distance made good.

* In this and all similar cases, the tabular number which is nearest to the given number is always used, when the given number cannot be found. Thus, in the present example, the given number 24.8 cannot be found in the d. lat. column over 63°; 25 is the tabular number nearest to 24.8; and 55′ is opposite 25.

Aug. 25.

Compass Courses.	Courses Corrected.	Dist.	Diff. Lat. N.	Diff. Lat. S.	Dep. E.	Dep. W.
East	E.¾S.	30		4.4	29.7	
E.S.E.	S.E. by E.¼E.	18		9.3	15.4	
S.¾E.	South	16		16		
S.S.W.	S.S.W.¾W.	19		16.3		9.8
S.W. by S.	S.W.¼S.	25		18.5		16.8
W.S.W.	W. by S.¼S.	22		5.3		21.3
W.¾S.	West	17				17
West	W.¾N.	30	4.4			29.7
W.N.W.	N. W. by W.¼W.	29	14.9			24.9
			19.3	69.8	45.1	119.5
				19.3		45.1
				50.5		74.4

Yesterday's lat. 64° 0′ 36″ N.
Diff. lat. - 50′ 30″ S.

Lat. in - 63° 10′ 6″

Mid. lat. - 64°
Yesterday's long. 46° 5′ W.
Diff. long. - 2° 50′ W.

Long. in - 48° 55′ W.

Variation ¾ Point E.

Course and dist. sailed S. 56° W. 90 miles.

§ *f*. To find the bearing and dist. of a place in Lat. 63° 20′ N., and long. 49° 10′ W.

§ *g*.

Lat. of place 63° 20′
Lat. in 63° 10′

Diff. lat. 10 miles.

Long. of place 49.10
Long. in 48 49

Diff. long.=21′

§ *h*. 21 being found in the dist. column (Table V.) *over* 63° the lat., shows opposite to it 9.5 in the d. lat. column; 9.5 then is the dep. between the ship and the place.

§ *i*. The diff. lat. 10, and dep. 9.5 are found together under 43° (Table V.) and opposite 14; the course and dist. then from the ship to the place, is N. 43° W. 14 miles.

§ *j*. April 9, lat. 39° 50′ N., long. 70° 10′ W.; bound to New York.

APRIL 10.

Compass Courses.	Courses Corrected.	Dist.	Diff. Lat. N.	Dep. W.
W.N.W.	W. by N.½N.	30	8.7	28.7
W. by N.¼N.	W. by N.¼N.	25	6.1	24.3
W. by N.½N.	W. by N.	18	3.5	17.7
W. by N.	W.½N.	29	2.8	28.9
W. by N.¼N.	W.¾N.	26	3.8	25.7
W.¼N.	W.¼N.	9	.4	9
W.½N.	West	5	.0	5
			25.3	139.3

Yesterday's lat. 39° 50′ N.
Diff. lat. - 25′ 18″ N.

Lat. in - 40° 15′ 18″

Mid. lat. 40°
Yesterday's long. 70° 10′ W.
Diff. long. - 3° 2′ W.

Variation ½ Point W.

Long. in - 73° 12′ W.

Course and dist. sailed N. 80° W. 142 miles.

§ *k*. To find the bearing and dist. of Sandy Hook Light House.

S. L. House, lat. 40° 28′ N.
Lat. ship - 40° 15′ N.

Diff. long. 13′

Long. S. L. House, 74° 1′ W.
Long. ship - 73° 12′ W.

Diff. long. 49′

49′ of long. in lat. 40° is equal to 37.5 miles. (Table V.)

§ *l*. 13 and 37.5 are found together over 71° (Table V.), and opposite 40. The dist. then of the Light House from the ship, is N. 71° W. 40 miles.

MERCATOR'S SAILING.

§ 611. Dep. : rad. : : diff. long. : sec. lat. (§ 587. § *c.*). Upon the principles involved in this proportion, the charts, called Mercator's, are constructed.

§ *a.* In these charts, the meridians of longitude, after they cross the equator, instead of approaching each other, till they reach the parallel of any latitude, in the ratio (§ 486. § *b.*) of rad. to the cos. of that lat., are drawn parallel to each other.

§ *b.* And the parallels of lat., say at 1° a part, instead of being at equal distances from each other, are drawn in the ratio of rad. to the sec. of their latitude. By which means, places on a sphere, are represented on a plane with their proper relative positions.

§ 612. In this manner of representing portions of the surface of a sphere upon planes, the parallels of latitude are lengthened out, and the meridians of longitude are expanded.

§ *a.* So that, if the 1st degree of lat., from the equator, be divided on the chart into 60 equal parts, every degree as they succeed each other in numerical order will contain a greater number of these parts, than the 1st, or than that which precedes it; thus, the 61°st of lat. contains 126 of these parts, and the 31°st, 70 of the same parts.

§ 613. These parts are called *meridional* parts.

§ *a.* Table VI. shows the number of meridional parts from the equator to any degree and minute within the parallel of the 84°th of lat.

§ *b.* The number of meridional parts between any two parallels, is called the *meridional* diff. lat. of those parallels.

§ *c.* Thus, the mer. diff. lat. between 13° 10′ and 18° 10′, is 312.

$$\left.\begin{array}{ll}\text{The mer. parts of } 18° \ 10' = & 1109 \\ \text{do.} \quad 13° \ 10' = & 797\end{array}\right\} \text{Table VI.}$$

$$\text{Mer. diff. lat} = 312$$

§ 614. Now, if any section of the earth's surface be represented on a plane projected according to Mercator's plan, the *true* (nearly), instead (§ 550.) of the *approximate*, distance, etc., between any two places, may be determined by *plane* trigonometrical operations.

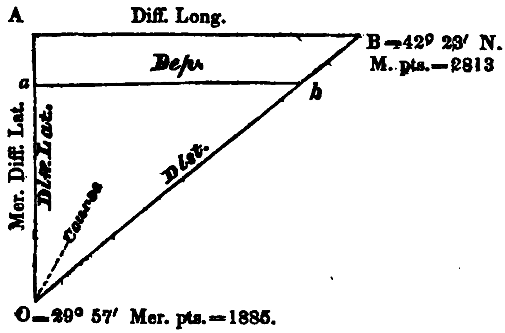
§ *a.* To do this, the Mer. diff. lat., as well as the actual diff. lat. between places, must be used.

§ 615. Mercator's sailing is useful to the navigator, chiefly in enabling him to find, by plane trigonometrical calculations, the number of miles between places that are at a great distance from each other.

§ *a.* The several cases in loxodromic sailing, may also be accurately solved, according to the principles of Mercator's sailing; but the Mer. diff. lat. must be used, as well as the actual diff. lat.

§ *b.* Methods of applying the principles of Mercator's sailing to the solution of cases in loxodromic sailing, will be shown; but the application of them to practice, will be left for the amusement of the learner.

§ 616. A B O represents the relative position of Boston and New Orleans in lat. and long., according to the principles of Mercator's sailing.



§ *a*. And the triangle *a b* O shows the bearing, dist., etc., according to loxodromic sailing.

§ *b*. The *meridional* lat. of Boston is 2813, and that of New Orleans, is 1885 (Table VI.); and the difference between these (§ 613. § *b*.) is (O A) the Mer. diff. lat.; and A B is the diff. long.; A O B is the course from New Orleans to Boston.

§ *c*. According to the loxodromic plan of constructing the triangle, *a* O is the actual diff. lat. between the two places, and *a b* is the dep.

§ *d*. Whether the problem proposed be solved according to the loxodromic or Mercator plan, the actual diff. lat. between the two places is the same.

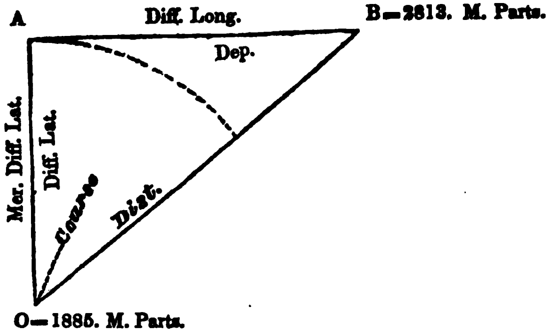
§ *e*. But the dep. and dist. determined by the former method (§ 550.) are not the true dep. and dist. between the two places.

§ 617. As the angles *a b* O and A B O (§ 616. § *d*.) are equal, *a b* (§ 30. § *d*.) is parallel to A B; whence (§ 73. § *d*.) arise the relation between the sides of a triangle in loxodromic sailing when compared with the sides of a similar triangle in Mercator's sailing.

§ *a*. Diff. lat. : dep. : : Mer. diff. lat. : diff. long.; also inversely and alternately.

§ *b*. The relations between the other parts of the two triangles may be established according to the principles derived from § 72. & § 73. The learner may arrange them.

§ 618. If the Mer. diff. of lat. (O A) between New Orleans and Boston be made radius, several sets of proportions (§ 75.) will appear among the different parts of the triangle involved.



§ *a.* But the most useful proportion (and in fact almost the only one which occurs in practice), in Mercator's sailing, is that by which the *true* course and dist. between any two places are evolved. I shall give the terms of this proportion, and leave the others to be arranged by the learner.

§ 619. The Mer. diff. lat. (§ 618.) being radius; Mer. diff. lat. : rad. : : diff. long. : tang. course.

§ *a.* The diff. long. thus used, must in all cases be converted into minutes, which must be used in the log. Table of Numbers, as miles.

§ *b.* To find the course from New Orleans to Boston.

Boston	lat.	42° 23′	M. pts.=	2813
N. Orleans	"	29° 57′	"	1885
		12° 26′	"	
		60	"	928=Mer. diff. lat.

Diff. lat.=746 miles.

N. Orleans,	long.	90° 9′ W.
Boston	"	71° 4′ W.
		19° 5′
		60

Diff. long.=1145 minutes (′).

Now, (§ 619.) 928 : rad. : : 1145 : tang. course.

928 log. (Ar. co.)=7.032452

1145 log. (§ *b.*) =3.058806

Tang. course=0.091258 N. 50° 58′ 34″ E.

§ *c.* Then calling O A, the actual diff. lat., A B becomes dep., and retaining O A, as rad., we have (§ 574. § *d.*) rad. : diff. lat. : : sec. course : dist.

Diff. lat. 746 miles log.=2.872739
Course N. 50° 58′ 34″ E. sec.=0.200906

Log. dist.=3.073645=1184.8 miles.

§ *d.* Problems in Mercator's sailing may also be solved either by Tables IV. & V., or by the diagram (Plate 1). Thus the mer. diff. lat., and the diff. long., being used on the diagram, or in the tables as diff. lat. and dep., show the course. Then with this course the dist. is found opposite to the actual diff. lat.

§ *e.* Philadelphia lat. 39° 57′ N. M. parts - 2619
Washington city lat. 38° 53′ N. " - 2536

1° 4′ M. diff. lat.= 83
60

Diff. lat.=64 miles.

Washington long. 77° 2′ W.
Philadelphia " 75° 9′ W.

1° 53′
60

Diff. long.=113 minutes (′).

113 in the dep. column stands opposite to 83 in the d. lat. column; (Table V.) 54° is at the bottom of the page. The course then from Philadelphia to Washington is S. 54° W. On the same page 64 in the d. lat. column stands opposite to 109 miles, which is the dist. between the two places.

SURVEYING.

§ 620. In conducting the survey of a coast, harbour, etc., the first object should be to ascertain the geographical position of some point connected with the survey, and the next to establish a *base* line.

§ 621. The most advantageous location for the base line, must be determined by the surveyor himself; and in this, he should be governed by circumstances, such as the nature of the ground about the place to be surveyed, and the place itself.

§ *a.* A level piece of ground should be selected for the base line, and the line should terminate at points, whence some of the prominent points, headlands, etc., of the place (say a harbour) under survey can be seen.

§ 622. The length of the base line must be ascertained by actual measurement, and the direction in which it lies must be established by observations, and noted down.

§ *a.* Then, knowing the length of the base line, it serves as a given side of a triangle, either for determining the length of other lines, or for finding the distance between either end of it, and any point visible from each end of the base.

§ *b.* For if the bearing of such point be taken from each end of the base, a triangle may be formed, in which the angles and the base are known, wherefore (§ 106. § *a.*) the two sides are determinable.

Plate 9. } § 623. The figure in the annexed plate is the *profile* of a harbour, that is being surveyed. A B is the base line, A C B, A D B, etc., are triangles constructed upon it; the angles at A, B, C, D, etc., are measured with a sextant or a theodolite, and the length of the lines B D, B C, A C, etc., is determined by trigonometrical calculation. The principal triangles used, are represented by the broken lines A X, A D, etc.

§ *a.* So that triangles may be constructed from one line to another, until sufficient data are obtained for determining, by trigonometrical calculation, the position of every point of the survey.

§ *b.* The line (X Y) of verification is determined, as to its length, both by trigonometrical calculation, and by measurement, in order to establish the accuracy of the survey.

§ 624. The position of the prominent points C, D, E, F, etc., is determined to a greater degree of nicety in this way, than it can be by taking cross bearings, etc., and the intersection of lines.

§ 625. After the *triangulation* of the survey is completed, and the points C, D, E, F, etc., are laid down upon the chart to the requisite scale; the intermediate spaces, G L, L H, etc., of the shore, may be filled up by the eye. A little practice will enable one to sketch these intermediate spaces with all necessary accuracy.

§ *a.* The position though, of every prominent point, such as light houses, rocks, hills, castles, etc., should be established by actual calculation.

§ *b.* In taking the angles, all the angles of every triangle should be measured whenever it can be done. This affords one means of detecting errors during the work of triangulating; for if the sum (§ 32.) of the three angles of a triangle be not 180° according to the measurement, an error is known to exist.

§ *c.* Also the sum of all the angles around the same point (§ 26.) should be 360; and, the sum of all the angles which lie within any measured angle, should be equal (§ 24. § *d.*) to the whole angle.

§ 626. After the work of triangulation is completed, or when it is temporarily suspended, the trigonometrical calculations for the part already triangulated, may be made.

§ 627. The soundings of the harbour should be accurately taken, and correctly laid down upon the chart.

§ *b.* The most practicable way of doing this, is to take a row boat, which will pull equal distances in equal times; establish the position of the point from which she sets out, and let her pull directly for a given point, sounding and noting the soundings at every interval of one, two, three, or more, minutes, as she goes along. When she arrives at the end of this line, establish the position of this end also, draw the line on the chart, divide it into as many equal parts as there were soundings taken, and write along the line every one at its proper point.

§ *b*. The surest way of making a straight course in the boat, is to bring two points on shore in the same line of bearing, and then pull for them, keeping them in that line. For instance; a boat at *a*, would pull in a straight line to E, if she kept a tree, or a steeple, or any object at *b*, in a line with E; then the soundings taken would all be on the line *a* E; and the position at *a* being determined; taking the angles B *a* E & E B *a*, the length of *a* E may be known, and the soundings laid down.

§ 628. The soundings should be given for low water; wherefore the time of the tide when the soundings are being taken, should be noted, in order to correct them for low water.

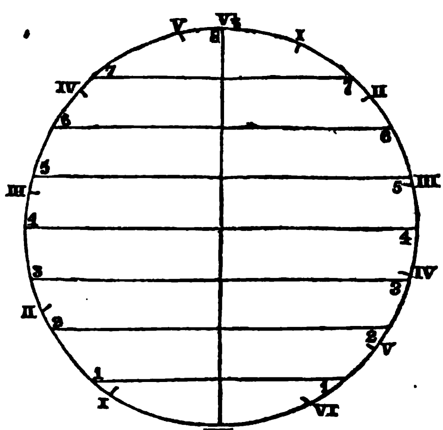
§ *a*. The corrections to be applied may be obtained, either according to the rate of the rise and fall of the tide, as established by previous observation, or by means of a figure (§ *e*.), thus;

§ *b*. Say that the rise and fall of the tide is 8 feet, and that the flood tide lasts 5½ hours, and the ebb, 7.

§ *c*. Let the diameter of a circle be divided into 8 equal parts, by the chords 1, 2, 3, etc. Also let one semicircumference of this circle be divided into V.½ equal parts or hours, to represent the time of flooding; and let the other semicircumference be divided into VII. equal arcs to represent the hours during ebb.

§ *d*. The point in which each of these chords cuts the circle, shows the correction in feet which is to be applied, when the tide is that number of hours, flood or ebb. Thus, when the tide is III.½ flood, the correction to be applied is 4½ feet; and when the tide is III. hours ebb, the correction is 5 feet.*

§ *e*.



* These corrections are always subtractive.

§ 629. The sort of bottom should also be noted down, i. e. mud, rock, sand, etc.

§ 630. The position, extent, etc., of all the hidden dangers, such as rocks, reefs, shoals, banks, and of every other object of importance to the navigator, should be ascertained and laid down.

§ 631. Surveys of harbours are frequently taken by measuring first, a base line, then drawing this line upon the paper at the proportional length to the scale upon which the chart is to be constructed, and then establishing the position of the principal points in the survey, by the intersection of the lines of their bearing from different points.

§ *a.* But the difficulty of measuring with accuracy the proper angles upon paper, makes this method of taking a survey more liable to inaccuracies, than the triangulating plan.

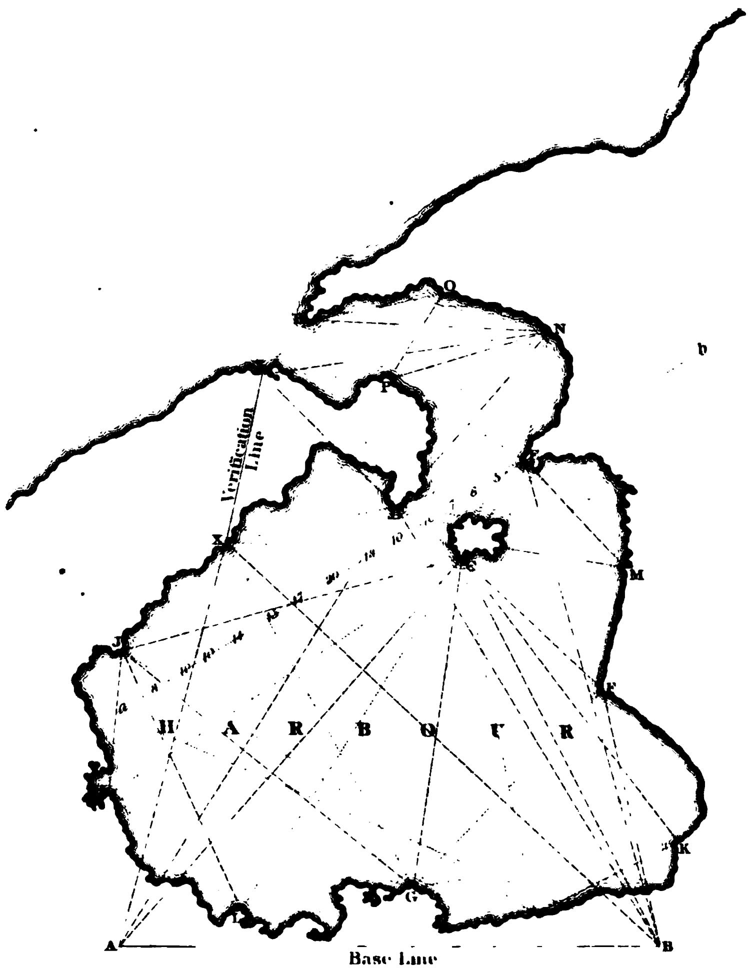

O
N
P
Verification Line
X
J
M
F
K
G
L
A
B
H A R B O U R
Base Line

TABLE I.

LOGARITHMS OF NUMBERS

TABLE I.

LOGARITHMS OF NUMBERS.

N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0.000000	25	1.397940	50	1.698970	75	1.875061
2	0.301030	26	1.414973	51	1.707570	76	1.880814
3	0.477121	27	1.431363	52	1.716003	77	1.886491
4	0.602060	28	1.447158	53	1.724276	78	1.892094
		29	1.462398	54	1.732393	79	1.897627
5	0.698970						
6	0.778151	30	1.477121	55	1.740363	80	1.903090
7	0.845098	31	1.491362	56	1.748188	81	1.908484
8	0.903090	32	1.505150	57	1.755875	82	1.913814
9	0.954242	33	1.518514	58	1.763428	83	1.919078
		34	1.531479	59	1.770852	84	1.924279
10	1.000000						
11	1.041393	35	1.544068	60	1.778151	85	1.929419
12	1.079181	36	1.556302	61	1.785330	86	1.934499
13	1.113943	37	1.568202	62	1.792392	87	1.939519
14	1.146128	38	1.579784	63	1.799340	88	1.944483
		39	1.591064	64	1.806180	89	1.949390
15	1.176091						
16	1.204120	40	1.602060	65	1.812913	90	1.954243
17	1.230449	41	1.612784	66	1.819544	91	1.959041
18	1.255272	42	1.623249	67	1.826075	92	1.963788
19	1.278754	43	1.633469	68	1.832509	93	1.968483
		44	1.643453	69	1.838849	94	1.973128
20	1.301030						
21	1.322219	45	1.653212	70	1.845098	95	1.977724
22	1.342423	46	1.662758	71	1.851258	96	1.982271
23	1.361728	47	1.672098	72	1.857332	97	1.986772
24	1.380211	48	1.681241	73	1.863323	98	1.991226
		49	1.690196	74	1.869232	99	1.995635

N.	0		1	2	3	4	5	6	7	8	9
100	00	0000	0434	0868	1301	1734	2166	2598	3030	3460	3891
01		4321	4751	5181	5609	6038	6466	6894	7321	7748	8174
02		8600	9026	9451	9876						
	01					0300	0724	1147	1570	1993	2415
03		2837	3259	3680	4100	4521	4940	5360	5779	6197	6616
04		7033	7451	7868	8284	8700	9116	9532	9947		
	02									0361	0776
105		1189	1603	2016	2428	2841	3253	3664	4075	4486	4896
06		5306	5715	6124	6533	6942	7350	7757	8164	8571	8978
07		9384	9789								
	03			0195	0600	1004	1409	1812	2216	2619	3021
08		3424	3826	4227	4628	5028	5430	5830	6230	6629	7028
09		7427	7825	8223	8620	9017	9414	9811			
	04								0207	0602	0998
110		1393	1787	2182	2576	2969	3362	3755	4148	4540	4932
11		5323	5714	6105	6495	6885	7275	7664	8053	8442	8830
12		9218	9606	9993							
	05				0380	0766	1152	1538	1924	2309	2694
13		3078	3463	3846	4230	4613	4996	5378	5761	6142	6524
14		6905	7286	7666	8046	8426	8806	9185	9563	9942	
	06										0320
115		0698	1075	1453	1829	2206	2582	2958	3333	3709	4083
16		4458	4832	5206	5580	5953	6326	6699	7071	7443	7815
17		8186	8557	8928	9298	9668					
	07						0038	0407	0777	1145	1514
18		1882	2250	2617	2985	3352	3718	4085	4451	4816	5182
19		5547	5912	6276	6640	7004	7368	7731	8094	8457	8819
120		9181	9543	9905							
	08				0266	0626	0987	1347	1707	2067	2426
21		2785	3144	3503	3861	4219	4576	4934	5291	5647	6004
22		6360	6716	7071	7427	7781	8136	8491	8845	9198	9552
23		9905									
	09		0258	0611	0963	1315	1667	2018	2370	2721	3071
24		3422	3772	4122	4471	4820	5169	5518	5867	6215	6562
125		6910	7257	7604	7951	8297	8644	8990	9335	9681	
	10										0026
26		0370	0715	1059	1403	1747	2091	2434	2777	3119	3462
27		3804	4146	4487	4828	5160	5510	5851	6191	6531	6871
28		7210	7549	7888	8227	8565	8903	9241	9578	9916	
	11										0253
29		0590	0926	1263	1598	1934	2270	2605	2940	3275	3609
130		3943	4277	4611	4944	5278	5610	5943	6276	6608	6940
31		7271	7603	7934	8265	8595	8926	9256	9586	9915	
	12										0245
32		0574	0903	1232	1560	1888	2216	2543	2871	3198	3525
33		3852	4178	4504	4830	5156	5481	5807	6131	6456	6781
34		7105	7429	7753	8076	8399	8722	9045	9368	9690	
	13										0012
135		0334	0655	0977	1298	1619	1939	2260	2580	2900	3219
36		3539	3858	4177	4496	4814	5133	5451	5769	6086	6403
37		6721	7037	7354	7671	7987	8303	8618	8934	9249	9564
38		9879									
	14		0194	0508	0822	1136	1450	1763	2077	2390	2702
39		3015	3327	3639	3951	4263	4574	4885	5196	5507	5818
140		6128	6438	6748	7058	7367	7676	7985	8294	8603	8911
41		9219	9527	9835							
	15				0142	0449	0756	1063	1370	1676	1982
42		2288	2594	2900	3205	3510	3815	4120	4424	4728	5032
43		5336	5640	5943	6246	6549	6852	7154	7457	7759	8061
44		8362	8664	8965	9266	9567	9868				
	16							0168	0469	0769	1068
145		1368	1667	1967	2266	2564	2863	3161	3460	3757	4055
46		4353	4650	4947	5244	5541	5838	6134	6430	6726	7022
47		7317	7613	7908	8203	8496	8792	9086	9381	9674	9968
48	17	0262	0555	0848	1141	1434	1726	2019	2311	2603	2895
N.	0		1	2	3	4	5	6	7	8	9

N.		0	1	2	3	4	5	6	7	8	9
149	17	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802
150		6091	6381	6670	6959	7248	7536	7825	8113	8401	8689
51	18	8977	9265	9552	9839	0126	0413	0699	0986	1272	1558
52		1844	2129	2415	2700	2985	3270	3555	3839	4123	4407
53		4691	4975	5259	5542	5825	6108	6391	6674	6956	7239
54	19	7521	7803	8084	8366	8647	8928	9210	9490	9771	0051
155		0332	0612	0892	1172	1451	1730	2010	2289	2568	2846
56		3125	3403	3681	3959	4237	4514	4792	5069	5346	5623
57		5900	6176	6453	6729	7005	7281	7556	7832	8107	8382
58	20	8657	8932	9206	9481	9755	0029	0303	0577	0851	1124
59		1397	1670	1943	2216	2488	2761	3033	3305	3577	3848
160		4120	4391	4663	4934	5204	5475	5746	6016	6286	6556
61		6826	7096	7365	7634	7904	8173	8441	8710	8979	9247
62	21	9515	9783	0051	0319	0586	0853	1120	1388	1654	1921
63		2188	2454	2720	2986	3252	3518	3783	4049	4314	4579
64		4844	5109	5373	5638	5902	6166	6430	6694	6957	7221
165		7484	7747	8010	8273	8536	8798	9060	9323	9585	9846
66	22	0108	0370	0631	0892	1153	1414	1675	1936	2196	2456
67		2717	2976	3236	3496	3755	4015	4274	4533	4792	5051
68		5309	5568	5826	6084	6342	6600	6858	7115	7372	7630
69	23	7887	8144	8400	8657	8913	9170	9426	9682	9938	0193
170		0449	0704	0960	1215	1470	1724	1979	2233	2488	2742
71		2996	3250	3504	3757	4011	4264	4517	4770	5023	5276
72		5528	5781	6033	6285	6537	6789	7041	7292	7544	7795
73	24	8046	8297	8548	8799	9049	9300	9550	9800	0050	0300
74		0549	0799	1048	1297	1547	1795	2044	2293	2541	2790
175		3038	3286	3534	3782	4030	4277	4525	4772	5019	5266
76		5513	5759	6006	6252	6499	6745	6991	7236	7482	7728
77	25	7973	8219	8464	8709	8954	9198	9443	9687	9932	0176
78		0420	0664	0908	1151	1395	1638	1882	2125	2368	2610
79		2853	3096	3338	3580	3822	4064	4306	4548	4790	5031
180		5273	5514	5755	5996	6237	6477	6718	6958	7198	7439
81		7679	7919	8158	8398	8637	8877	9116	9355	9594	9833
82	26	0071	0310	0548	0787	1025	1263	1501	1738	1976	2214
83		2451	2688	2925	3162	3399	3636	3873	4109	4346	4582
84		4818	5054	5290	5525	5761	5996	6232	6467	6702	6937
185		7172	7406	7641	7875	8110	8344	8578	8812	9046	9279
86	27	9513	9746	9980	0213	0446	0679	0912	1144	1377	1609
87		1842	2074	2306	2538	2770	3001	3233	3464	3696	3927
88		4158	4389	4620	4850	5081	5311	5542	5772	6002	6232
89		6462	6692	6921	7151	7380	7609	7838	8067	8296	8525
190	28	8754	8982	9210	9439	9667	9895	0123	0351	0578	0806
91		1033	1261	1488	1715	1942	2169	2396	2622	2849	3075
92		3301	3527	3753	3979	4205	4431	4656	4882	5107	5332
93		5557	5782	6007	6232	6457	6681	6905	7130	7354	7578
94		7802	8025	8249	8473	8696	8920	9143	9366	9589	9812
195	29	0035	0257	0480	0702	0925	1147	1369	1591	1813	2034
96		2256	2478	2699	2920	3142	3363	3584	3804	4025	4246
97		4466	4687	4907	5127	5347	5567	5787	6007	6226	6446
98		6665	6884	7104	7323	7542	7761	7979	8198	8416	8635
99	30	8853	9071	9289	9507	9725	9943	0161	0378	0595	0813
200		1030	1247	1464	1681	1898	2114	2331	2547	2764	2980
01		3196	3412	3628	3844	4060	4275	4490	4706	4921	5136
N.		0	1	2	3	4	5	6	7	8	9

N.	0		1	2	3	4	5	6	7	8	9
202	30	5351	5566	5781	5996	6211	6425	6639	6854	7068	7282
03		7496	7710	7924	8137	8351	8564	8778	8991	9204	9417
04		9630	9843								
	31			0056	0268	0481	0693	0906	1118	1330	1542
205		1754	1966	2177	2389	2600	2812	3023	3234	3445	3656
06		3867	4078	4289	4499	4710	4920	5130	5340	5551	5761
07		5970	6180	6390	6599	6809	7018	7227	7437	7646	7854
08		8063	8272	8481	8689	8898	9106	9314	9522	9730	9938
09	32	0146	0354	0562	0769	0977	1184	1391	1598	1805	2012
210		2219	2426	2633	2839	3046	3252	3458	3665	3871	4077
11		4283	4488	4694	4900	5105	5310	5516	5721	5926	6131
12		6336	6541	6745	6950	7154	7359	7563	7767	7972	8176
13		8380	8583	8787	8991	9194	9398	9601	9805		
	33									0008	0211
14		0414	0617	0819	1022	1225	1427	1630	1832	2034	2236
215		2439	2640	2842	3044	3246	3447	3649	3850	4051	4253
16		4454	4655	4856	5056	5257	5458	5657	5859	6059	6260
17		6460	6660	6860	7060	7260	7459	7659	7858	8058	8257
18		8457	8656	8855	9054	9253	9451	9650	9849		
	34									0047	0246
19		0444	0642	0841	1039	1237	1435	1632	1830	2028	2225
220		2423	2620	2817	3014	3212	3409	3606	3802	3999	4196
21		4392	4589	4785	4981	5178	5374	5570	5766	5962	6157
22		6353	6549	6744	6939	7135	7330	7525	7720	7915	8110
23		8305	8500	8694	8889	9083	9277	9472	9666	9860	
	35										0054
24		0248	0442	0636	0829	1023	1216	1410	1603	1796	1989
225		2182	2376	2568	2761	2954	3147	3339	3532	3724	3916
26		4108	4301	4493	4685	4876	5068	5260	5452	5643	5835
27		6026	6217	6408	6599	6791	6981	7172	7363	7554	7744
28		7935	8125	8316	8506	8696	8886	9076	9266	9456	9646
29		9836									
	36		0025	0215	0404	0593	0783	0972	1161	1350	1539
230		1728	1917	2105	2294	2483	2671	2859	3048	3236	3424
31		3612	3800	3988	4176	4363	4551	4739	4926	5113	5301
32		5488	5675	5862	6049	6236	6423	6610	6796	6983	7170
33		7356	7542	7729	7915	8101	8287	8473	8659	8845	9030
34		9216	9401	9587	9772	9958					
	37						0143	0328	0513	0698	0883
235		1068	1253	1437	1622	1807	1991	2175	2360	2544	2728
36		2912	3096	3280	3464	3647	3831	4015	4198	4382	4565
37		4748	4932	5115	5298	5481	5664	5846	6029	6212	6394
38		6577	6759	6942	7124	7306	7488	7670	7852	8034	8216
39		8398	8580	8761	8943	9124	9306	9487	9668	9849	
	38										0030
240		0211	0392	0573	0754	0935	1115	1296	1476	1656	1837
41		2017	2197	2377	2557	2737	2917	3097	3277	3456	3636
42		3815	3995	4174	4353	4533	4712	4891	5070	5249	5428
43		5606	5785	5964	6142	6321	6499	6677	6856	7034	7212
44		7390	7568	7746	7923	8101	8279	8457	8634	8811	8989
245		9166	9343	9521	9698	9875					
	39						0052	0228	0405	0582	0759
46		0935	1112	1288	1464	1641	1817	1993	2169	2345	2521
47		2697	2873	3048	3224	3400	3575	3751	3926	4101	4277
48		4452	4627	4802	4977	5152	5326	5501	5676	5850	6025
49		6199	6374	6548	6722	6896	7071	7245	7419	7592	7766
250		7940	8114	8287	8461	8634	8808	8981	9154	9327	9501
51		9674	9847								
	40			0020	0192	0365	0538	0711	0883	1056	1228
52		1400	1573	1745	1917	2089	2261	2433	2605	2777	2949
53		3121	3292	3464	3635	3807	3978	4149	4321	4492	4663
54		4834	5005	5176	5346	5517	5688	5858	6029	6199	6370
255		6540	6711	6881	7051	7221	7391	7561	7731	7901	8070
N.	0		1	2	3	4	5	6	7	8	9

N.		0	1	2	3	4	5	6	7	8	9
256	40	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764
57		9933									
	41		0102	0271	0440	0608	0777	0946	1114	1283	1451
58		1620	1788	1956	2124	2293	2461	2629	2796	2964	3132
59		3300	3467	3635	3803	3970	4137	4305	4472	4639	4806
260		4973	5140	5307	5474	5641	5808	5974	6141	6308	6474
61		6640	6807	6973	7139	7306	7472	7638	7804	7970	8135
62		8301	8467	8633	8798	8964	9129	9295	9460	9625	9791
63		9956									
	42		0121	0286	0451	0616	0781	0945	1110	1275	1439
64		1604	1768	1933	2097	2262	2426	2590	2754	2918	3082
265		3246	3410	3573	3737	3901	4064	4228	4392	4555	4718
66		4882	5045	5208	5371	5534	5697	5860	6023	6186	6349
67		6511	6674	6837	6999	7161	7324	7486	7648	7811	7973
68		8135	8297	8459	8621	8783	8944	9106	9268	9429	9591
69		9752	9914								
	43			0075	0236	0398	0559	0720	0881	1042	1203
270		1364	1525	1685	1846	2007	2167	2328	2488	2649	2809
71		2969	3130	3290	3450	3610	3770	3930	4090	4249	4409
72		4569	4728	4888	5048	5207	5367	5526	5685	5844	6004
73		6163	6322	6481	6640	6799	6957	7116	7275	7433	7592
74		7751	7909	8067	8226	8384	8542	8701	8859	9017	9175
275		9333	9491	9648	9806	9964					
	44						0122	0279	0437	0594	0752
76		0909	1066	1224	1381	1538	1695	1852	2009	2166	2323
77		2480	2637	2793	2950	3107	3263	3420	3576	3732	3889
78		4045	4201	4357	4513	4669	4825	4981	5137	5293	5449
79		5604	5760	5915	6071	6226	6382	6537	6693	6848	7003
280		7158	7313	7468	7623	7778	7933	8088	8242	8397	8552
81		8706	8861	9015	9170	9324	9478	9633	9787	9941	
	45										0095
82		0249	0403	0557	0711	0865	1018	1172	1326	1479	1633
83		1786	1940	2093	2247	2400	2553	2706	2859	3012	3165
84		3318	3471	3624	3777	3930	4082	4235	4387	4540	4692
285		4845	4997	5150	5302	5454	5606	5758	5910	6062	6214
86		6366	6518	6670	6821	6973	7125	7276	7428	7579	7731
87		7882	8033	8184	8336	8487	8638	8789	8940	9091	9242
88		9392	9543	9694	9845	9995					
	46						0146	0296	0447	0597	0747
89		0898	1048	1198	1348	1499	1649	1799	1949	2098	2248
290		2398	2548	2697	2847	2997	3146	3296	3445	3594	3744
91		3893	4042	4191	4341	4490	4639	4787	4936	5085	5234
92		5383	5532	5680	5829	5977	6126	6274	6423	6571	6719
93		6868	7016	7164	7312	7460	7608	7756	7904	8052	8200
94		8347	8495	8643	8790	8938	9085	9233	9380	9528	9675
295		9822	9969								
	47			0116	0263	0411	0557	0704	0851	0998	1145
96		1292	1438	1585	1732	1878	2025	2171	2317	2464	2610
97		2756	2903	3049	3195	3341	3487	3633	3779	3925	4070
98		4216	4362	4508	4653	4799	4944	5090	5235	5381	5526
99		5671	5816	5962	6107	6252	6397	6542	6687	6832	6977
300		7121	7266	7411	7555	7700	7845	7989	8133	8278	8422
01		8567	8711	8855	8999	9143	9287	9431	9575	9719	9863
02	48	0007	0151	0295	0438	0582	0725	0869	1012	1156	1299
03		1443	1586	1729	1872	2016	2159	2302	2445	2588	2731
04		2874	3016	3159	3302	3445	3587	3730	3873	4015	4157
305		4300	4442	4585	4727	4869	5011	5153	5295	5438	5579
06		5721	5863	6005	6147	6289	6431	6572	6714	6855	6997
07		7138	7280	7421	7563	7704	7845	7986	8128	8269	8410
08		8551	8692	8833	8974	9114	9255	9396	9537	9677	9818
09		9958									
	49		0099	0240	0380	0520	0661	0801	0941	1081	1222
310		1362	1502	1642	1782	1922	2062	2202	2341	2481	2621
N.		0	1	2	3	4	5	6	7	8	9

N.		0	1	2	3	4	5	6	7	8	9
311	49	2760	2900	3040	3179	3319	3458	3597	3737	3876	4015
12		4155	4294	4433	4572	4711	4850	4989	5128	5267	5406
13		5544	5683	5822	5960	6099	6237	6376	6515	6653	6791
14		6930	7068	7206	7344	7483	7621	7759	7897	8035	8173
315		8311	8448	8586	8724	8862	8999	9137	9275	9412	9550
16		9687	9825	9962							
	50				0099	0236	0374	0511	0648	0785	0922
17		1059	1196	1333	1470	1607	1744	1881	2017	2154	2291
18		2427	2564	2700	2837	2973	3109	3246	3382	3518	3654
19		3791	3927	4063	4199	4335	4471	4607	4743	4878	5014
320		5150	5286	5421	5557	5693	5828	5964	6099	6234	6370
21		6505	6640	6776	6911	7046	7181	7316	7451	7586	7721
22		7856	7991	8126	8260	8395	8530	8664	8799	8934	9068
23		9203	9337	9471	9606	9740	9874				
	51							0009	0143	0277	0411
24		0545	0679	0813	0947	1081	1215	1349	1482	1616	1750
325		1883	2017	2150	2284	2418	2551	2684	2818	2951	3084
26		3218	3351	3484	3617	3750	3883	4016	4149	4282	4415
27		4548	4681	4813	4946	5079	5211	5344	5476	5609	5741
28		5874	6006	6139	6271	6403	6535	6668	6800	6932	7064
29		7196	7328	7460	7592	7724	7855	7987	8119	8251	8382
330		8514	8646	8777	8909	9040	9172	9303	9434	9566	9697
31		9828	9959								
	52			0090	0221	0353	0483	0615	0746	0876	1007
32		1138	1269	1400	1530	1661	1792	1922	2053	2183	2314
33		2444	2575	2705	2835	2966	3096	3226	3356	3486	3616
34		3747	3877	4006	4136	4266	4396	4526	4656	4785	4915
335		5045	5174	5304	5434	5563	5693	5822	5951	6081	6210
36		6339	6469	6598	6727	6856	6985	7114	7243	7372	7501
37		7630	7759	7888	8016	8145	8274	8402	8531	8660	8788
38		8917	9045	9174	9302	9430	9559	9687	9815	9943	
	53										0072
39		0200	0328	0456	0584	0712	0840	0968	1096	1223	1351
340		1479	1607	1734	1862	1990	2117	2245	2372	2500	2627
41		2754	2882	3009	3136	3263	3391	3518	3645	3772	3899
42		4026	4153	4280	4407	4534	4661	4787	4914	5041	5168
43		5294	5421	5547	5674	5800	5927	6053	6180	6306	6432
44		6558	6685	6811	6937	7063	7189	7315	7441	7567	7693
345		7819	7945	8071	8197	8322	8448	8574	8699	8825	8951
46		9076	9202	9327	9453	9578	9703	9829	9954		
	54									0079	0204
47		0330	0455	0580	0705	0830	0955	1080	1205	1330	1454
48		1579	1704	1829	1953	2078	2203	2327	2452	2577	2701
49		2825	2950	3074	3199	3323	3447	3571	3696	3820	3944
350		4068	4192	4316	4440	4564	4688	4812	4936	5060	5183
51		5307	5431	5555	5678	5802	5925	6049	6172	6296	6419
52		6543	6666	6789	6913	7036	7159	7282	7406	7529	7652
53		7775	7898	8021	8144	8266	8389	8512	8635	8758	8881
54		9003	9126	9249	9371	9494	9616	9739	9861	9984	
	55										0106
355		0228	0351	0473	0595	0717	0840	0962	1084	1206	1328
56		1450	1572	1694	1816	1938	2060	2181	2303	2425	2547
57		2668	2790	2912	3033	3155	3276	3398	3519	3640	3762
58		3883	4004	4126	4247	4368	4489	4610	4731	4852	4974
59		5094	5215	5336	5457	5578	5699	5820	5940	6061	6182
360		6303	6423	6544	6664	6785	6905	7026	7146	7267	7387
61		7507	7627	7748	7868	7988	8108	8228	8349	8469	8589
62		8709	8829	8948	9068	9188	9308	9428	9548	9667	9787
63		9907									
	56		0026	0146	0265	0385	0504	0624	0743	0863	0982
64		1101	1221	1340	1459	1578	1697	1817	1936	2055	2174
365		2293	2412	2531	2650	2769	2887	3006	3125	3244	3362
N.		0	1	2	3	4	5	6	7	8	9

N.		0	1	2	3	4	5	6	7	8	9
366	56	3481	3600	3718	3837	3956	4074	4192	4311	4429	4548
67		4666	4784	4903	5021	5139	5257	5376	5494	5612	5730
68		5848	5966	6084	6202	6320	6438	6555	6673	6791	6909
69		7026	7144	7262	7379	7497	7614	7732	7850	7967	8084
370		8202	8319	8436	8554	8671	8788	8905	9023	9140	9257
71		9374	9491	9608	9725	9842	9959				
	57							0076	0193	0309	0426
72		0543	0660	0776	0893	1010	1126	1243	1359	1476	1592
73		1709	1825	1942	2058	2174	2291	2407	2523	2639	2756
74		2872	2988	3104	3220	3336	3452	3568	3684	3800	3915
375		4031	4147	4263	4379	4494	4610	4726	4841	4957	5072
76		5188	5303	5419	5534	5650	5765	5880	5996	6111	6226
77		6341	6456	6572	6687	6802	6917	7032	7147	7262	7377
78		7492	7607	7722	7836	7951	8066	8181	8295	8410	8525
79		8639	8754	8868	8983	9097	9212	9326	9441	9555	9669
380		9784	9898								
	58			0012	0126	0240	0355	0469	0583	0697	0811
81		0925	1039	1153	1267	1381	1495	1608	1722	1836	1950
82		2063	2177	2291	2404	2518	2631	2745	2858	2972	3085
83		3199	3312	3426	3539	3652	3765	3879	3992	4105	4218
84		4331	4444	4557	4670	4783	4896	5009	5122	5235	5348
385		5461	5574	5686	5799	5912	6024	6137	6250	6362	6475
86		6587	6700	6812	6925	7037	7150	7262	7374	7487	7599
87		7711	7823	7935	8047	8160	8272	8384	8496	8608	8720
88		8832	8944	9055	9167	9279	9391	9503	9615	9726	9838
89		9950									
	59		0061	0173	0284	0396	0508	0619	0730	0842	0953
390		1065	1176	1287	1399	1510	1621	1732	1843	1955	2066
91		2177	2288	2399	2510	2621	2732	2843	2954	3064	3175
92		3286	3397	3508	3618	3729	3840	3950	4061	4172	4282
93		4393	4503	4614	4724	4834	4945	5055	5165	5276	5386
94		5496	5606	5717	5827	5937	6047	6157	6267	6377	6487
395		6597	6707	6817	6927	7037	7146	7256	7366	7476	7586
96		7695	7805	7914	8024	8134	8243	8353	8462	8572	8681
97		8791	8900	9009	9119	9228	9337	9446	9556	9665	9774
98		9883	9992								
	60			0101	0210	0319	0428	0537	0646	0755	0864
99		0973	1082	1191	1299	1408	1517	1625	1734	1843	1951
400		2060	2169	2277	2386	2494	2602	2711	2819	2928	3036
01		3144	3253	3361	3469	3577	3686	3794	3902	4010	4118
02		4226	4334	4442	4550	4658	4766	4874	4982	5090	5197
03		5305	5413	5520	5628	5736	5843	5951	6059	6166	6274
04		6381	6489	6596	6704	6811	6919	7026	7133	7241	7348
405		7455	7562	7670	7777	7884	7991	8098	8205	8312	8419
06		8526	8633	8740	8847	8954	9060	9167	9274	9381	9488
07		9594	9701	9808	9914						
	61					0021	0128	0234	0341	0447	0554
08		0660	0767	0873	0979	1086	1192	1298	1405	1511	1617
09		1723	1830	1936	2042	2148	2254	2360	2466	2572	2678
410		2784	2890	2996	3102	3207	3313	3419	3525	3630	3736
11		3842	3948	4053	4159	4264	4370	4475	4581	4686	4792
12		4897	5003	5108	5213	5319	5424	5529	5635	5740	5845
13		5950	6055	6160	6265	6370	6476	6581	6686	6791	6895
14		7000	7105	7210	7315	7420	7525	7629	7734	7839	7943
415		8048	8153	8257	8362	8467	8571	8676	8780	8884	8989
16		9093	9198	9302	9406	9511	9615	9719	9823	9928	
	62										0032
17		0136	0240	0344	0448	0552	0657	0760	0864	0968	1072
18		1176	1280	1384	1488	1592	1695	1799	1903	2007	2110
19		2214	2318	2421	2525	2628	2732	2836	2939	3042	3146
420		3249	3353	3456	3559	3663	3766	3869	3973	4076	4179
21		4282	4385	4488	4591	4695	4798	4901	5004	5107	5210
22		5313	5415	5518	5621	5724	5827	5930	6032	6135	6238
N.		0	1	2	3	4	5	6	7	8	9

N.		0	1	2	3	4	5	6	7	8	9
423	62	6340	6443	6546	6648	6751	6853	6956	7059	7161	7263
24		7366	7468	7571	7673	7775	7878	7980	8082	8184	8287
425		8389	8491	8593	8695	8797	8900	9002	9104	9206	9308
26		9410	9512	9613	9715	9817	9919				
	63							0021	0123	0224	0326
27		0428	0530	0631	0733	0835	0936	1038	1139	1241	1342
28		1444	1545	1647	1748	1849	1951	2052	2153	2255	2356
29		2457	2559	2660	2761	2862	2963	3064	3165	3266	3367
430		3469	3569	3670	3771	3872	3973	4074	4175	4276	4377
31		4477	4578	4679	4780	4880	4981	5081	5182	5283	5383
32		5484	5584	5685	5785	5886	5986	6086	6187	6287	6388
33		6488	6588	6688	6789	6889	6989	7089	7189	7290	7390
34		7490	7590	7690	7790	7890	7990	8090	8190	8290	8389
435		8489	8589	8689	8789	8888	8988	9088	9188	9287	9387
36		9487	9586	9686	9785	9885	9984				
	64							0084	0183	0283	0382
37		0481	0581	0680	0780	0879	0978	1077	1176	1276	1375
38		1474	1573	1672	1771	1871	1970	2069	2168	2267	2366
39		2465	2563	2662	2761	2860	2959	3058	3157	3255	3354
440		3453	3551	3650	3749	3847	3946	4044	4143	4242	4340
41		4439	4537	4636	4734	4832	4931	5029	5127	5226	5324
42		5422	5521	5619	5717	5815	5913	6011	6110	6208	6306
43		6404	6502	6600	6698	6796	6894	6992	7089	7187	7285
44		7383	7481	7579	7676	7774	7872	7969	8067	8165	8262
445		8360	8458	8555	8653	8750	8848	8945	9043	9140	9237
46		9335	9432	9530	9627	9724	9821	9919			
	65								0016	0113	0210
47		0307	0405	0502	0599	0696	0793	0890	0987	1084	1181
48		1278	1375	1472	1569	1666	1762	1859	1956	2053	2150
49		2246	2343	2440	2536	2633	2730	2826	2923	3019	3116
450		3212	3309	3406	3502	3598	3695	3791	3888	3984	4080
51		4177	4273	4369	4465	4562	4658	4754	4850	4946	5042
52		5138	5234	5331	5427	5523	5619	5715	5811	5906	6002
53		6098	6194	6290	6386	6482	6577	6673	6769	6865	6960
54		7056	7152	7247	7343	7438	7534	7629	7725	7821	7916
455		8011	8107	8202	8298	8393	8488	8584	8679	8774	8870
56		8965	9060	9155	9250	9346	9441	9536	9631	9726	9821
57		9916									
	66		0011	0106	0201	0296	0391	0486	0581	0676	0771
58		0866	0960	1055	1150	1245	1339	1434	1529	1623	1718
59		1813	1907	2002	2096	2191	2286	2380	2475	2569	2663
460		2758	2852	2947	3041	3135	3230	3324	3418	3513	3607
61		3701	3795	3889	3983	4078	4172	4266	4360	4454	4548
62		4642	4736	4830	4924	5018	5112	5206	5299	5393	5487
63		5581	5675	5769	5862	5956	6050	6143	6237	6331	6424
64		6518	6612	6705	6799	6892	6986	7079	7173	7266	7360
465		7453	7546	7640	7733	7826	7920	8013	8106	8200	8293
66		8386	8479	8572	8665	8759	8852	8945	9038	9131	9224
67		9317	9410	9503	9596	9689	9782	9875	9967		
	67									0060	0153
68		0246	0339	0431	0524	0617	0710	0802	0895	0988	1080
69		1173	1265	1358	1451	1543	1636	1728	1821	1913	2005
470		2098	2190	2283	2375	2467	2560	2652	2744	2837	2929
71		3021	3113	3205	3297	3390	3482	3574	3666	3758	3850
72		3942	4034	4126	4218	4310	4402	4494	4586	4677	4769
73		4861	4953	5045	5137	5228	5320	5412	5503	5595	5687
74		5778	5870	5962	6053	6145	6236	6328	6419	6511	6602
475		6694	6785	6876	6968	7059	7150	7242	7333	7424	7516
76		7607	7698	7789	7881	7972	8063	8154	8245	8336	8427
77		8518	8609	8700	8791	8882	8973	9064	9155	9246	9337
78		9428	9519	9610	9700	9791	9882	9973			
	68								0063	0154	0245
79		0336	0426	0517	0607	0698	0789	0879	0970	1060	1151
N.		0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
480	68 1241	1332	1422	1513	1603	1693	1784	1874	1965	2055
81	2145	2235	2326	2416	2506	2596	2686	2777	2867	2957
82	3047	3137	3227	3317	3407	3497	3587	3677	3767	3857
83	3947	4037	4127	4217	4307	4396	4486	4576	4666	4756
84	4845	4935	5025	5115	5205	5294	5383	5473	5563	5652
485	5742	5831	5921	6010	6100	6189	6279	6368	6458	6547
86	6636	6726	6815	6904	6994	7083	7172	7261	7351	7440
87	7529	7618	7707	7796	7886	7975	8064	8153	8242	8331
88	8420	8509	8598	8687	8776	8865	8953	9042	9131	9220
89	9309	9398	9486	9575	9664	9753	9841	9930		
	69								0019	0107
490	0196	0285	0373	0462	0551	0639	0728	0816	0905	0993
91	1082	1170	1258	1347	1435	1524	1612	1700	1789	1877
92	1965	2053	2142	2230	2318	2406	2494	2583	2671	2759
93	2847	2935	3023	3111	3199	3287	3375	3463	3551	3639
94	3727	3815	3903	3991	4078	4166	4254	4342	4430	4517
495	4605	4693	4781	4868	4956	5044	5131	5219	5307	5394
96	5482	5569	5657	5744	5832	5919	6007	6094	6182	6269
97	6356	6444	6531	6619	6706	6793	6880	6968	7055	7142
98	7229	7317	7404	7491	7578	7665	7752	7839	7926	8013
99	8101	8188	8275	8362	8449	8535	8622	8709	8796	8883
500	8970	9057	9144	9231	9317	9404	9491	9578	9664	9751
01	9838	9924								
	70		0011	0098	0184	0271	0357	0444	0531	0617
02	0704	0790	0877	0963	1050	1136	1222	1309	1395	1482
03	1568	1654	1741	1827	1913	2000	2086	2172	2258	2344
04	2430	2517	2603	2689	2775	2861	2947	3033	3119	3205
505	3291	3377	3463	3549	3635	3721	3807	3893	3979	4065
06	4151	4236	4322	4408	4494	4579	4665	4751	4837	4922
07	5008	5094	5179	5265	5351	5436	5522	5607	5693	5778
08	5864	5949	6035	6120	6206	6291	6376	6462	6547	6632
09	6718	6803	6888	6974	7059	7144	7229	7315	7400	7485
510	7570	7655	7741	7826	7911	7996	8081	8166	8251	8336
11	8421	8506	8591	8676	8761	8846	8931	9015	9100	9185
12	9270	9355	9440	9524	9609	9694	9779	9863	9948	
	71									0033
13	0117	0202	0287	0371	0456	0540	0625	0710	0794	0879
14	0963	1048	1132	1217	1301	1385	1470	1554	1636	1723
515	1807	1891	1976	2060	2144	2229	2313	2397	2481	2566
16	2650	2734	2818	2902	2986	3070	3154	3239	3323	3407
17	3491	3575	3658	3742	3826	3910	3994	4078	4162	4246
18	4330	4414	4497	4581	4665	4749	4833	4916	5000	5084
19	5167	5251	5335	5418	5502	5586	5669	5753	5836	5920
520	6003	6087	6170	6254	6337	6421	6504	6588	6671	6754
21	6838	6921	7004	7088	7171	7254	7338	7421	7504	7587
22	7670	7754	7837	7920	8003	8086	8169	8253	8336	8419
23	8502	8585	8668	8751	8834	8917	9000	9083	9165	9248
24	9331	9414	9497	9580	9663	9746	9828	9911	9994	
	72									0077
525	0159	0242	0325	0407	0490	0573	0655	0738	0821	0903
26	0986	1068	1151	1233	1316	1398	1481	1563	1646	1728
27	1811	1893	1975	2058	2140	2222	2305	2387	2469	2552
28	2634	2716	2798	2881	2963	3045	3127	3209	3291	3374
29	3456	3538	3620	3702	3784	3866	3948	4030	4112	4194
530	4276	4358	4440	4522	4603	4685	4767	4849	4931	5013
31	5094	5176	5258	5340	5422	5503	5585	5667	5748	5830
32	5912	5993	6075	6157	6238	6320	6401	6483	6564	6646
33	6727	6809	6890	6972	7053	7134	7216	7297	7379	7460
34	7541	7623	7704	7785	7866	7948	8029	8110	8191	8273
535	8354	8435	8516	8597	8678	8759	8841	8922	9003	9084
36	9165	9246	9327	9408	9489	9570	9651	9732	9813	9893
37	9974									
	73	0055	0136	0217	0298	0379	0459	0540	0621	0701
N.	0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
538	73 0782	0863	0944	1024	1105	1186	1266	1347	1428	1508
39	1589	1669	1750	1830	1911	1991	2072	2152	2233	2313
540	2394	2474	2555	2635	2715	2796	2876	2956	3037	3117
41	3197	3278	3358	3438	3518	3598	3679	3759	3839	3919
42	3999	4079	4160	4240	4320	4400	4480	4560	4640	4720
43	4800	4880	4960	5040	5120	5200	5280	5360	5440	5520
44	5599	5679	5758	5838	5918	5998	6078	6157	6237	6317
545	6397	6476	6556	6636	6715	6795	6874	6954	7034	7113
46	7193	7272	7352	7431	7511	7590	7670	7749	7829	7908
47	7987	8067	8146	8225	8305	8384	8463	8543	8622	8701
48	8781	8860	8939	9018	9097	9177	9256	9335	9414	9493
49	9572	9651	9731	9810	9889	9968				
	74						0047	0126	0205	0284
550	0363	0442	0521	0600	0678	0757	0836	0915	0994	1073
51	1152	1230	1309	1388	1467	1546	1624	1703	1782	1860
52	1939	2018	2096	2175	2254	2332	2411	2490	2568	2647
53	2725	2804	2882	2961	3039	3118	3196	3274	3353	3431
54	3510	3588	3667	3745	3823	3902	3980	4058	4137	4215
555	4293	4371	4450	4528	4606	4684	4762	4840	4919	4997
56	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777
57	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556
58	6634	6712	6790	6868	6945	7023	7101	7179	7256	7334
59	7412	7490	7567	7645	7723	7800	7878	7955	8033	8111
560	8188	8266	8343	8421	8498	8576	8653	8731	8808	8885
61	8963	9040	9118	9195	9272	9350	9427	9504	9582	9659
62	9736	9814	9891	9968						
	75				0045	0122	0200	0277	0354	0431
63	0508	0585	0663	0740	0817	0894	0971	1048	1125	1202
64	1279	1356	1433	1510	1587	1664	1741	1818	1895	1972
565	2048	2125	2202	2279	2356	2433	2509	2586	2663	2740
66	2816	2893	2970	3047	3123	3200	3277	3353	3430	3507
67	3583	3660	3736	3813	3889	3966	4042	4119	4195	4272
68	4348	4425	4501	4578	4654	4731	4807	4883	4960	5036
69	5112	5189	5265	5341	5417	5494	5570	5646	5722	5799
570	5875	5951	6027	6103	6180	6256	6332	6408	6484	6560
71	6636	6712	6788	6864	6940	7016	7092	7168	7244	7320
72	7396	7472	7548	7624	7700	7776	7851	7927	8003	8079
73	8155	8230	8306	8382	8458	8533	8609	8685	8761	8836
74	8912	8988	9063	9139	9214	9290	9366	9441	9517	9592
575	9668	9743	9819	9894	9970					
	76					0045	0121	0196	0272	0347
76	0422	0498	0573	0649	0724	0799	0875	0950	1025	1100
77	1176	1251	1326	1402	1477	1552	1627	1702	1777	1853
78	1928	2003	2078	2153	2228	2303	2378	2453	2529	2604
79	2679	2754	2829	2903	2979	3053	3128	3203	3278	3353
580	3428	3503	3578	3653	3727	3802	3877	3952	4027	4101
81	4176	4251	4326	4400	4475	4550	4624	4699	4774	4848
82	4923	4998	5072	5147	5221	5296	5371	5445	5520	5594
83	5669	5743	5817	5892	5966	6041	6115	6190	6264	6339
84	6413	6487	6562	6636	6710	6785	6859	6933	7007	7082
585	7156	7230	7304	7378	7453	7527	7601	7675	7749	7823
86	7898	7972	8046	8120	8194	8268	8342	8416	8490	8564
87	8638	8712	8786	8860	8934	9008	9082	9156	9230	9304
88	9377	9451	9525	9599	9673	9747	9820	9894	9968	
	77									0042
89	0115	0189	0263	0336	0410	0484	0558	0631	0705	0778
590	0852	0926	0999	1073	1146	1220	1293	1367	1441	1514
91	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248
92	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981
93	3055	3128	3201	3274	3347	3421	3494	3567	3640	3713
94	3786	3860	3933	4006	4079	4152	4225	4298	4371	4444
595	4517	4590	4663	4736	4809	4882	4955	5028	5100	5173
N.	0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
596	77 5246	5319	5392	5465	5538	5610	5683	5756	5829	5902
97	5974	6047	6120	6193	6265	6338	6411	6483	6556	6629
98	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354
99	7427	7499	7572	7644	7717	7789	7862	7934	8007	8079
600	8151	8224	8296	8368	8441	8513	8585	8658	8730	8802
01	8875	8947	9019	9091	9163	9236	9308	9380	9452	9524
02	9597	9669	9741	9813	9885	9957	0029	0101	0173	0245
03	78 0317	0389	0461	0533	0605	0677	0749	0821	0893	0965
04	1037	1109	1181	1253	1325	1396	1468	1540	1612	1684
605	1755	1827	1899	1971	2042	2114	2186	2258	2329	2401
06	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117
07	3189	3260	3332	3403	3475	3546	3618	3689	3761	3832
08	3904	3975	4046	4118	4189	4261	4332	4403	4475	4546
09	4617	4689	4760	4831	4902	4974	5045	5116	5187	5259
610	5330	5401	5472	5543	5615	5686	5757	5828	5899	5970
11	6041	6112	6183	6254	6325	6396	6468	6538	6609	6680
12	6751	6822	6893	6964	7035	7106	7177	7248	7319	7390
13	7461	7531	7602	7673	7744	7815	7885	7956	8027	8098
14	8168	8239	8310	8381	8451	8522	8593	8663	8734	8805
615	8875	8946	9016	9087	9158	9228	9299	9369	9440	9510
16	9581	9651	9722	9792	9863	9933	0004	0074	0144	0215
17	79 0285	0356	0426	0496	0567	0637	0707	0778	0848	0918
18	0988	1059	1129	1199	1270	1340	1410	1480	1550	1620
19	1691	1761	1831	1901	1971	2041	2111	2181	2252	2322
620	2392	2462	2532	2602	2672	2742	2812	2882	2952	3022
21	3092	3162	3231	3301	3371	3441	3511	3581	3651	3721
22	3790	3860	3930	4000	4070	4139	4209	4279	4349	4418
23	4488	4558	4627	4697	4767	4837	4906	4976	5045	5115
24	5185	5254	5324	5393	5463	5532	5602	5672	5741	5810
625	5880	5950	6019	6088	6158	6227	6297	6366	6436	6505
26	6574	6644	6713	6782	6852	6921	6990	7060	7129	7198
27	7267	7337	7406	7475	7545	7614	7683	7752	7821	7890
28	7960	8029	8098	8167	8236	8305	8374	8443	8512	8582
29	8651	8720	8789	8858	8927	8996	9065	9134	9203	9272
630	9341	9410	9478	9547	9616	9685	9754	9823	9892	9960
31	80 0029	0098	0167	0236	0305	0373	0442	0511	0580	0648
32	0717	0786	0855	0923	0992	1061	1129	1198	1266	1335
33	1404	1472	1541	1609	1678	1747	1815	1884	1952	2021
34	2089	2158	2226	2295	2363	2432	2500	2569	2637	2705
635	2774	2842	2911	2979	3047	3116	3184	3252	3321	3389
36	3457	3525	3594	3662	3730	3798	3867	3935	4003	4071
37	4139	4208	4276	4344	4412	4480	4548	4616	4684	4753
38	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433
39	5501	5569	5637	5705	5773	5841	5908	5976	6044	6112
640	6180	6248	6316	6384	6451	6519	6587	6655	6722	6790
41	6858	6926	6994	7061	7129	7197	7264	7332	7400	7467
42	7535	7603	7670	7738	7806	7873	7941	8008	8076	8143
43	8211	8279	8346	8414	8481	8549	8616	8684	8751	8818
44	8886	8953	9021	9088	9156	9223	9290	9358	9425	9492
645	9560	9627	9694	9762	9829	9896	9964	0031	0098	0165
46	81 0233	0300	0367	0434	0501	0568	0636	0703	0770	0837
47	0904	0971	1039	1106	1173	1240	1307	1374	1441	1508
48	1575	1642	1709	1776	1843	1910	1977	2044	2111	2178
49	2245	2312	2379	2445	2512	2579	2646	2713	2780	2847
650	2913	2980	3047	3114	3180	3247	3314	3381	3448	3514
51	3581	3648	3714	3781	3848	3914	3981	4048	4114	4181
52	4248	4314	4381	4447	4514	4580	4647	4714	4780	4847
N.	0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
653	81 4913	4980	5046	5113	5179	5246	5312	5378	5445	5511
54	5578	5644	5711	5777	5843	5910	5976	6042	6109	6175
655	6241	6308	6374	6440	6506	6573	6639	6705	6771	6838
56	6904	6970	7036	7102	7169	7235	7301	7367	7433	7499
57	7565	7632	7698	7764	7830	7896	7962	8028	8094	8160
58	8226	8292	8358	8424	8490	8556	8622	8688	8754	8820
59	8885	8951	9017	9083	9149	9215	9281	9346	9412	9478
660	9544	9610	9676	9741	9807	9873	9939			
	82							0004	0070	0136
61	0202	0267	0333	0399	0464	0530	0596	0661	0727	0792
62	0858	0924	0989	1055	1120	1186	1251	1317	1383	1448
63	1513	1579	1645	1710	1776	1841	1906	1972	2037	2103
64	2168	2234	2299	2364	2430	2495	2560	2626	2691	2756
665	2822	2887	2952	3018	3083	3148	3213	3279	3344	3409
66	3474	3539	3605	3670	3735	3800	3865	3931	3996	4061
67	4126	4191	4256	4321	4386	4451	4516	4581	4646	4711
68	4777	4841	4907	4972	5036	5101	5166	5231	5296	5361
69	5426	5491	5556	5621	5686	5751	5815	5880	5945	6010
670	6075	6140	6204	6269	6334	6399	6464	6528	6593	6658
71	6723	6787	6852	6917	6981	7046	7111	7175	7240	7305
72	7369	7434	7499	7563	7628	7692	7757	7821	7886	7950
73	8015	8080	8144	8209	8273	8338	8402	8467	8531	8596
74	8660	8724	8789	8853	8918	8982	9046	9111	9175	9239
675	9304	9368	9432	9497	9561	9625	9690	9754	9818	9882
76	9947									
	83	0011	0075	0139	0204	0268	0332	0396	0460	0525
77	0589	0653	0717	0781	0845	0909	0973	1037	1102	1166
78	1230	1294	1358	1422	1486	1550	1614	1678	1742	1806
79	1870	1934	1998	2062	2126	2189	2253	2317	2381	2445
680	2509	2573	2637	2701	2764	2828	2892	2956	3020	3083
81	3147	3211	3275	3338	3402	3466	3530	3593	3657	3721
82	3784	3848	3912	3975	4039	4103	4166	4230	4293	4357
83	4421	4484	4548	4611	4675	4739	4802	4866	4929	4993
84	5056	5120	5183	5246	5310	5373	5437	5500	5564	5627
685	5691	5754	5817	5881	5944	6007	6071	6134	6198	6261
86	6324	6387	6451	6514	6577	6641	6704	6767	6830	6894
87	6957	7020	7083	7146	7210	7273	7336	7399	7462	7525
88	7588	7652	7715	7778	7841	7904	7967	8030	8093	8156
89	8219	8282	8345	8408	8471	8534	8597	8660	8723	8786
690	8849	8912	8975	9038	9101	9164	9227	9290	9352	9415
91	9478	9541	9604	9667	9729	9792	9855	9918	9981	
	84									0043
92	0106	0169	0232	0294	0357	0420	0485	0545	0608	0671
93	0733	0796	0859	0921	0984	1047	1109	1172	1234	1297
94	1359	1422	1485	1547	1610	1672	1735	1797	1860	1922
695	1985	2047	2110	2172	2235	2297	2360	2422	2484	2547
96	2609	2672	2734	2796	2859	2921	2983	3046	3108	3170
97	3233	3295	3357	3420	3482	3544	3607	3669	3731	3793
98	3855	3918	3980	4042	4104	4166	4229	4291	4353	4415
99	4477	4539	4601	4663	4725	4788	4850	4912	4974	5036
700	5098	5160	5222	5284	5346	5408	5470	5532	5594	5656
01	5718	5780	5842	5904	5966	6028	6090	6151	6213	6275
02	6337	6399	6461	6523	6585	6646	6708	6770	6832	6894
03	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511
04	7573	7634	7696	7758	7819	7881	7943	8004	8066	8128
705	8189	8251	8312	8374	8436	8497	8559	8620	8682	8743
06	8805	8866	8928	8989	9051	9112	9174	9235	9297	9358
07	9419	9481	9542	9604	9665	9726	9788	9849	9911	9972
08	85 0033	0095	0156	0217	0279	0340	0401	0462	0524	0585
09	0646	0707	0769	0830	0891	0952	1014	1075	1136	1197
N.	0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
710	85 1258	1319	1381	1442	1503	1564	1625	1686	1747	1809
11	1870	1931	1992	2053	2114	2175	2236	2297	2358	2419
12	2480	2541	2602	2663	2724	2785	2846	2907	2968	3029
13	3090	3150	3211	3272	3333	3394	3455	3516	3577	3637
14	3698	3759	3820	3881	3941	4002	4063	4124	4185	4245
715	4306	4367	4428	4488	4549	4610	4670	4731	4792	4852
16	4913	4974	5034	5095	5156	5216	5277	5337	5398	5459
17	5519	5580	5640	5701	5761	5822	5882	5943	6004	6064
18	6124	6185	6245	6306	6366	6427	6487	6548	6608	6668
19	6729	6789	6850	6910	6970	7031	7091	7151	7212	7272
720	7332	7393	7453	7513	7574	7634	7694	7755	7815	7875
21	7935	7996	8056	8116	8176	8236	8297	8357	8417	8477
22	8537	8597	8658	8718	8778	8838	8898	8958	9018	9078
23	9138	9198	9258	9318	9379	9439	9499	9559	9619	9679
24	9739	9799	9858	9918	9978					
	86					0038	0098	0158	0218	0278
725	0338	0398	0458	0518	0578	0637	0697	0757	0817	0877
26	0937	0996	1056	1116	1176	1236	1295	1355	1415	1475
27	1534	1594	1654	1714	1773	1833	1893	1952	2012	2072
28	2131	2191	2251	2310	2370	2430	2489	2549	2608	2668
29	2727	2787	2847	2906	2966	3025	3085	3144	3204	3263
730	3323	3382	3442	3501	3561	3620	3680	3739	3798	3858
31	3917	3977	4036	4096	4155	4214	4274	4333	4392	4452
32	4511	4570	4630	4689	4748	4808	4867	4926	4986	5045
33	5104	5163	5222	5282	5341	5400	5459	5519	5578	5637
34	5696	5755	5814	5874	5933	5992	6051	6110	6169	6228
735	6287	6346	6406	6465	6524	6583	6642	6701	6760	6819
36	6878	6937	6996	7055	7114	7173	7232	7291	7350	7409
37	7468	7526	7585	7644	7703	7762	7821	7880	7939	7998
38	8056	8115	8174	8233	8292	8351	8409	8468	8527	8586
39	8644	8703	8762	8821	8879	8938	8997	9056	9114	9173
740	9232	9290	9349	9408	9466	9525	9584	9642	9701	9760
41	9818	9877	9935	9994						
	87				0053	0111	0170	0228	0287	0345
42	0404	0462	0521	0580	0638	0696	0755	0813	0872	0930
43	0989	1047	1106	1164	1223	1281	1339	1398	1456	1515
44	1573	1631	1690	1748	1806	1865	1923	1981	2040	2098
745	2156	2215	2273	2331	2389	2448	2506	2564	2622	2681
46	2739	2797	2855	2913	2972	3030	3088	3146	3204	3262
47	3321	3379	3437	3495	3553	3611	3669	3727	3786	3844
48	3902	3960	4018	4076	4134	4192	4250	4308	4366	4424
49	4482	4540	4598	4656	4714	4772	4830	4888	4945	5003
750	5061	5119	5177	5235	5293	5351	5409	5466	5524	5582
51	5640	5698	5756	5813	5871	5929	5987	6045	6102	6160
52	6218	6276	6333	6391	6449	6507	6564	6622	6680	6737
53	6795	6853	6910	6968	7026	7083	7141	7199	7256	7314
54	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889
755	7947	8004	8062	8119	8177	8235	8292	8349	8407	8464
56	8522	8579	8637	8694	8752	8809	8866	8924	8981	9038
57	9096	9153	9211	9268	9325	9383	9440	9497	9555	9612
58	9669	9726	9784	9841	9898	9956				
	88						0013	0070	0127	0185
59	0242	0299	0356	0413	0471	0528	0585	0642	0699	0756
760	0814	0871	0928	0985	1042	1099	1156	1213	1270	1328
61	1385	1442	1499	1556	1613	1670	1727	1784	1841	1898
62	1955	2012	2069	2126	2183	2240	2297	2354	2411	2468
63	2525	2582	2638	2695	2752	2809	2866	2923	2980	3037
64	3093	3150	3207	3264	3321	3378	3434	3491	3548	3605
765	3661	3718	3775	3832	3889	3945	4002	4059	4115	4172
66	4229	4286	4342	4399	4456	4512	4569	4626	4682	4739
67	4795	4852	4909	4965	5022	5078	5135	5191	5248	5305
N.	0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
768	88 5361	5418	5474	5531	5587	5644	5700	5757	5813	5870
69	5926	5983	6039	6096	6152	6209	6265	6322	6378	6434
770	6491	6547	6604	6660	6716	6773	6829	6885	6942	6998
71	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561
72	7617	7674	7730	7786	7842	7899	7955	8011	8067	8123
73	8180	8236	8292	8348	8404	8460	8517	8573	8629	8685
74	8741	8797	8853	8909	8965	9021	9077	9134	9190	9246
775	9302	9358	9414	9470	9526	9582	9638	9694	9750	9806
76	9862	9918	9974	89 0030	0085	0142	0197	0253	0309	0365
77	89 0421	0477	0533	0589	0645	0700	0756	0812	0868	0924
78	0980	1035	1091	1147	1203	1259	1314	1370	1426	1482
79	1538	1593	1649	1705	1760	1816	1872	1927	1983	2039
780	2095	2150	2206	2262	2317	2373	2429	2484	2540	2595
81	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151
82	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706
83	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261
84	4316	4372	4427	4482	4538	4593	4648	4704	4759	4814
785	4870	4925	4980	5036	5091	5146	5202	5257	5312	5367
86	5423	5478	5533	5588	5644	5699	5754	5809	5864	5919
87	5975	6030	6085	6140	6195	6251	6306	6361	6416	6471
88	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022
89	7076	7132	7187	7242	7297	7352	7407	7462	7517	7572
790	7627	7682	7737	7792	7847	7902	7957	8012	8067	8122
91	8176	8231	8286	8341	8396	8451	8506	8561	8616	8670
92	8725	8780	8835	8890	8944	8999	9054	9109	9164	9218
93	9273	9328	9383	9438	9492	9547	9602	9656	9711	9766
94	9821	9875	9930	9985	90 0039	0094	0149	0203	0258	0313
795	90 0367	0422	0476	0531	0586	0640	0695	0749	0804	0858
96	0913	0968	1022	1077	1131	1186	1240	1295	1349	1404
97	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948
98	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492
99	2547	2601	2655	2710	2764	2818	2873	2927	2981	3035
800	3090	3144	3199	3253	3307	3361	3416	3470	3524	3578
01	3632	3687	3741	3795	3849	3904	3958	4012	4066	4120
02	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661
03	4716	4770	4824	4878	4932	4986	5040	5094	5148	5202
04	5256	5310	5364	5418	5472	5526	5580	5634	5688	5742
805	5796	5850	5904	5958	6012	6066	6120	6173	6227	6281
06	6335	6389	6443	6497	6550	6604	6658	6712	6766	6820
07	6873	6927	6981	7035	7089	7143	7196	7250	7304	7358
08	7411	7465	7519	7573	7626	7680	7734	7787	7841	7895
09	7949	8002	8056	8110	8163	8217	8271	8324	8378	8431
810	8485	8539	8592	8646	8699	8753	8807	8860	8914	8967
11	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503
12	9556	9610	9663	9717	9770	9823	9877	9930	9984	91 0037
13	91 0090	0144	0197	0251	0304	0358	0411	0464	0518	0571
14	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104
815	1158	1211	1264	1317	1371	1424	1477	1530	1584	1637
16	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169
17	2222	2275	2328	2382	2435	2488	2541	2594	2647	2700
18	2753	2806	2860	2913	2966	3019	3072	3125	3178	3231
19	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761
820	3814	3867	3920	3973	4026	4079	4132	4184	4237	4290
21	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819
22	4872	4925	4978	5030	5083	5136	5189	5242	5294	5347
23	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875
24	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401
N.	0	1	2	3	4	5	6	7	8	9

N.		0	1	2	3	4	5	6	7	8	9
825	91	6454	6507	6559	6612	6665	6717	6770	6822	6875	6927
26		6980	7033	7085	7138	7190	7243	7295	7348	7400	7453
27		7506	7558	7611	7663	7716	7768	7821	7873	7925	7978
28		8030	8083	8135	8188	8240	8293	8345	8397	8450	8502
29		8555	8607	8659	8712	8764	8816	8869	8921	8973	9026
830		9078	9130	9183	9235	9287	9340	9392	9444	9497	9549
31		9601	9653	9706	9758	9810	9862	9914	9967		
	92									0019	0071
32		0123	0176	0228	0280	0332	0384	0436	0489	0541	0593
33		0645	0697	0749	0801	0853	0906	0958	1010	1062	1114
34		1166	1218	1270	1322	1374	1426	1478	1530	1582	1634
835		1687	1739	1790	1842	1894	1946	1998	2050	2102	2154
36		2206	2258	2310	2362	2414	2466	2518	2570	2622	2674
37		2725	2777	2829	2881	2933	2985	3037	3089	3140	3192
38		3244	3296	3348	3400	3451	3503	3555	3607	3658	3710
39		3762	3814	3866	3917	3969	4021	4072	4124	4176	4228
840		4279	4331	4383	4434	4486	4538	4589	4641	4603	4744
41		4796	4848	4899	4951	5003	5054	5106	5157	5209	5261
42		5312	5364	5415	5467	5518	5570	5621	5673	5725	5776
43		5828	5879	5931	5982	6034	6085	6137	6188	6240	6291
44		6342	6394	6445	6497	6548	6600	6651	6703	6754	6805
845		6857	6908	6960	7011	7062	7114	7165	7216	7268	7319
46		7370	7422	7473	7524	7576	7627	7678	7730	7781	7832
47		7883	7935	7986	8037	8088	8140	8191	8242	8293	8345
48		8396	8447	8498	8550	8601	8652	8703	8754	8805	8857
49		8908	8959	9010	9061	9112	9163	9214	9266	9317	9368
850		9419	9470	9521	9572	9623	9674	9725	9776	9827	9879
51		9930	9981								
	93			0032	0083	0134	0185	0236	0287	0338	0389
52		0440	0491	0542	0593	0643	0694	0745	0796	0847	0898
53		0949	1000	1051	1102	1153	1203	1254	1305	1356	1407
54		1458	1509	1560	1610	1661	1712	1763	1814	1865	1915
855		1966	2017	2068	2118	2169	2220	2271	2322	2372	2423
56		2474	2525	2575	2626	2677	2727	2778	2829	2879	2930
57		2981	3031	3082	3133	3183	3234	3285	3335	3386	3437
58		3487	3538	3589	3639	3690	3740	3791	3842	3892	3943
59		3993	4044	4094	4145	4195	4246	4296	4347	4397	4448
860		4499	4549	4599	4650	4700	4751	4801	4852	4902	4953
61		5003	5054	5104	5154	5205	5255	5306	5356	5407	5457
62		5507	5558	5608	5658	5709	5759	5810	5860	5910	5961
63		6011	6061	6111	6162	6212	6262	6313	6363	6413	6464
64		6514	6564	6614	6665	6715	6765	6815	6866	6916	6966
865		7016	7066	7116	7167	7217	7267	7317	7367	7418	7468
66		7518	7568	7618	7668	7718	7769	7819	7869	7919	7969
67		8019	8069	8119	8169	8219	8270	8320	8370	8420	8470
68		8520	8570	8620	8670	8720	8770	8820	8870	8920	8970
69		9020	9070	9120	9170	9220	9270	9320	9370	9419	9469
870		9519	9569	9619	9669	9719	9769	9819	9869	9918	9968
71	94	0018	0068	0118	0168	0218	0267	0317	0367	0417	0467
72		0517	0566	0616	0666	0716	0765	0815	0865	0915	0964
73		1014	1064	1114	1163	1213	1263	1313	1362	1412	1462
74		1511	1561	1611	1661	1710	1760	1810	1859	1909	1958
875		2008	2058	2107	2157	2206	2256	2306	2355	2405	2455
76		2504	2554	2603	2653	2702	2752	2801	2851	2901	2950
77		3000	3049	3099	3148	3198	3247	3297	3346	3396	3445
78		3495	3544	3593	3643	3692	3742	3791	3841	3890	3940
79		3989	4038	4088	4137	4187	4236	4285	4335	4384	4433
880		4483	4532	4581	4631	4680	4729	4779	4828	4877	4927
81		4976	5025	5074	5124	5173	5222	5272	5321	5370	5419
82		5469	5518	5567	5616	5666	5715	5764	5813	5862	5911
83		5961	6010	6059	6108	6157	6207	6256	6305	6354	6403
N.		0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
884	94 6452	6501	6551	6600	6649	6698	6747	6796	6845	6894
885	6943	6992	7041	7091	7140	7189	7238	7287	7336	7385
86	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875
87	7924	7973	8022	8071	8119	8168	8217	8266	8315	8364
88	8413	8462	8511	8560	8609	8657	8706	8755	8804	8853
89	8902	8951	8999	9048	9097	9146	9195	9244	9292	9341
890	9390	9439	9488	9536	9585	9634	9683	9732	9780	9829
91	9878	9926	9975							
	95			0024	0073	0121	0170	0219	0267	0316
92	0365	0414	0462	0511	0560	0608	0657	0706	0754	0803
93	0852	0900	0949	0997	1046	1095	1143	1192	1240	1289
94	1337	1386	1435	1483	1532	1580	1629	1677	1726	1775
895	1823	1872	1920	1969	2017	2066	2114	2163	2211	2260
96	2308	2356	2405	2453	2502	2550	2599	2647	2696	2744
97	2792	2841	2889	2938	2986	3034	3083	3131	3180	3228
98	3276	3325	3373	3421	3470	3518	3566	3615	3663	3711
99	3760	3808	3856	3905	3953	4001	4049	4098	4146	4194
900	4242	4291	4339	4387	4436	4484	4532	4580	4628	4677
01	4725	4773	4821	4869	4918	4966	5014	5062	5110	5158
02	5207	5255	5303	5351	5399	5447	5495	5543	5592	5640
03	5688	5736	5784	5832	5880	5928	5976	6024	6072	6120
04	6168	6216	6264	6313	6361	6409	6457	6505	6553	6601
905	6649	6697	6745	6793	6841	6889	6936	6984	7032	7080
06	7128	7176	7224	7272	7320	7368	7416	7464	7512	7559
07	7607	7655	7703	7751	7799	7847	7895	7942	7990	8038
08	8086	8134	8182	8229	8277	8325	8373	8420	8468	8516
09	8564	8612	8659	8707	8755	8803	8851	8898	8946	8994
910	9041	9089	9137	9185	9232	9280	9328	9375	9423	9471
11	9518	9566	9614	9661	9709	9758	9804	9852	9900	9947
12	9995									
	96	0042	0090	0138	0185	0233	0280	0328	0376	0423
13	0471	0518	0566	0614	0661	0709	0756	0804	0851	0899
14	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374
915	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848
16	1896	1943	1990	2038	2085	2132	2180	2227	2275	2322
17	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795
18	2843	2890	2937	2985	3032	3079	3126	3174	3221	3268
19	3316	3363	3410	3457	3505	3552	3599	3646	3693	3741
920	3788	3835	3882	3929	3977	4024	4071	4118	4165	4213
21	4260	4307	4354	4401	4448	4495	4543	4590	4637	4684
22	4731	4778	4825	4872	4919	4966	5013	5061	5108	5155
23	5202	5249	5296	5343	5390	5437	5484	5531	5578	5625
24	5672	5719	5766	5813	5860	5907	5954	6001	6048	6095
925	6142	6189	6236	6283	6329	6376	6423	6470	6517	6564
26	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033
27	7080	7127	7173	7220	7267	7314	7361	7408	7454	7501
38	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969
29	8016	8062	8109	8156	8203	8249	8296	8343	8390	8436
930	8483	8530	8576	8623	8670	8716	8763	8810	8856	8903
31	8950	8996	9043	9090	9136	9183	9230	9276	9323	9369
32	9416	9462	9509	9556	9602	9649	9695	9742	9789	9635
33	9882	9928	9975							
	97			0021	0068	0114	0161	0207	0254	0300
34	0347	0393	0440	0486	0533	0579	0626	0672	0719	0765
935	0812	0858	0905	0951	0997	1044	1090	1137	1183	1229
36	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693
47	1740	1786	1832	1879	1925	1971	2018	2064	2110	2157
38	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619
39	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082
940	3128	3174	3220	3266	3313	3359	3405	3451	3497	3544
N.	0	1	2	3	4	5	6	7	8	9

N.	0	1	2	3	4	5	6	7	8	9
941	97 3590	3636	3682	3728	3774	3820	3866	3913	3959	4005
42	4051	4097	4143	4189	4235	4281	4327	4374	4420	4466
43	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926
44	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386
945	5432	5478	5524	5570	5616	5662	5707	5753	5799	5845
46	5891	5937	5983	6029	6075	6121	6167	6212	6258	6304
47	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763
48	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220
49	7266	7312	7358	7404	7449	7495	7541	7586	7632	7678
950	7724	7769	7815	7861	7906	7952	7998	8043	8089	8135
51	8180	8226	8272	8317	8363	8409	8454	8500	8546	8591
52	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047
53	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503
54	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958
955	98 0003	0049	0094	0140	0185	0231	0276	0322	0367	0413
56	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867
57	0912	0957	1003	1048	1093	1139	1184	1230	1275	1320
58	1366	1411	1456	1501	1547	1592	1637	1683	1728	1773
59	1819	1864	1909	1954	2000	2045	2090	2135	2181	2226
960	2271	2317	2362	2407	2452	2497	2543	2588	2633	2678
61	2723	2769	2814	2859	2904	2949	2995	3040	3085	3130
62	3175	3220	3265	3311	3356	3401	3446	3491	3536	3581
63	3626	3671	3716	3762	3807	3852	3897	3942	3987	4032
64	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482
965	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932
66	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382
67	5426	5471	5516	5561	5606	5651	5696	5741	5786	5831
68	5875	5920	5965	6010	6055	6100	6145	6189	6234	6279
69	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727
970	6772	6817	6861	6906	6951	6995	7040	7085	7130	7175
71	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622
72	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068
73	8113	8158	8202	8247	8291	8336	8381	8425	8470	8514
74	8559	8603	8648	8693	8737	8782	8826	8871	8916	8960
975	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405
76	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850
77	9895	9939	9984	99 0028	0072	0117	0161	0206	0250	0294
78	0339	0383	0428	0472	0516	0561	0605	0650	0694	0738
79	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182
980	1226	1270	1315	1359	1403	1448	1492	1536	1581	1625
81	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067
82	2112	2156	2200	2244	2288	2333	2377	2421	2465	2509
83	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951
84	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392
985	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833
86	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273
87	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713
88	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152
89	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591
990	5635	5679	5723	5767	5811	5854	5898	5942	5986	6030
91	6074	6118	6161	6205	6249	6293	6337	6380	6424	6468
92	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906
93	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343
94	7386	7430	7474	7517	7561	7605	7649	7692	7736	7779
995	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216
96	8259	8303	8347	8390	8434	8477	8521	8565	8608	8652
97	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087
98	9131	9174	9218	9261	9305	9348	9392	9435	9479	9522
99	9565	9609	9652	9696	9730	9783	9826	9870	9913	9957
1000	00 0000	0043	0087	0130	0174	0217	0261	0304	0347	0391
N.	0	1	2	3	4	5	6	7	8	9

TABLE II.

LOGARITHMS OF SINES, COSEC'S, TANGENTS, &c.

0h 0° $1^s = 15''$ $1^m = 15'$ $1^h = 15°$ 179° 11h

Hours. m	Hours. s	Deg. '	Deg. ''	L. Sin.	Diff. for 5''	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 5''	L. Cot.	Deg. '	Deg. ''	Hours. m	Hours. s
0	1	0	15	5.861666	100343	4.138334	0.000000	0.000000	5.861666	100343	4.138334		45	59	59
	2		30	6.162696	58697	3.837304	00	00	6.162696	58697	3.837304		30		58
	3		45	.338787	41646	.661213	00	00	.338787	41646	.661213		15		57
	4	1		.463726	32303	.536274	00	00	.463726	32303	.536274	59			56
	5		15	.560636	26394	.439364	00	00	.560636	26394	.439364		45		55
	6		30	.639817	22316	.360183	00	00	.639817	22316	.360183		30		54
	7		45	.706764	19331	.293236	00	00	.706764	19331	.293236		15		53
	8	2		.764756	17051	.235244	00	00	.764756	17051	.235244	58			52
	9		15	.815909	15252	.184091	00	00	.815909	15252	.184091		45		51
	10		30	.861666	13798	.138334	00	00	.861666	13798	.138334		30		50
	11		45	.903059	12596	.096941	00	00	.903059	12596	.096941		15		49
	12	3		.940847	11587	.059153	00	00	.940847	11587	.059153	57			48
	13		15	.975609	10728	.024391	00	00	.975610	10728	.024390		45		47
	14		30	7.007794	9988	2.992206	00	00	7.007794	9988	2.992206		30		46
	15		45	.037757	9343	.962243	00	00	.037758	9343	.962242		15		45
	16	4		.065786	8776	.934214	00	00	.065786	8776	.934214	56			44
	17		15	.092115	8275	.907885	00	00	.092115	8275	.907885		45		43
	18		30	.116939	7827	.883061	00	00	.116939	7827	.883061		30		42
	19		45	.140420	7425	.859580	00	00	.140420	7425	.859580		15		41
	20	5		.162696	7063	.837304	00	00	.162696	7063	.837304	55			40
	21		15	.183885	6735	.816115	9.999999	01	.183886	6735	.816114		45		39
	22		30	.204089	6435	.795911	99	01	.204089	6435	.795911		30		38
	23		45	.223304	6161	.776696	99	01	.223304	6161	.776696		15		37
	24	6		.241877	5910	.758123	99	01	.241878	5910	.758122	54			36
	25		15	.259606	5678	.740394	99	01	.259607	5678	.740393		45		35
	26		30	.276639	5464	.723361	99	01	.276640	5464	.723360		30		34
	27		45	.293030	5265	.706970	99	01	.293030	5265	.706970		15		33
	28	7		.308824	5080	.691176	99	01	.308825	5080	.691175	53			32
	29		15	.324064	4908	.675936	99	01	.324065	4908	.675935		45		31
	30		30	.338787	4747	.661213	99	01	.338788	4747	.661212		30		30
	31		45	.353028	4596	.646972	99	01	.353029	4596	.646971		15		29
	32	8		.366816	4455	.633184	99	01	.366817	4455	.633183	52			28
	33		15	.380180	4322	.619820	99	01	.380181	4322	.619819		45		27
	34		30	.393145	4196	.606855	99	01	.393146	4196	.606854		30		26
	35		45	.405734	4078	.594266	99	01	.405735	4078	.594265		15		25
	36	9		.417968	3966	.582032	99	01	.417970	3966	.582030	51			24
	37		15	.429867	3861	.570133	98	02	.429869	3861	.570131		45		23
	38		30	.441449	3760	.558551	98	02	.441451	3760	.558549		30		22
	39		45	.452730	3665	.547270	98	02	.452732	3665	.547268		15		21
	40	10		.463725	3575	.536275	98	02	.463727	3575	.536273	50			20
	41		15	.474449	3489	.525551	98	02	.474451	3489	.525549		45		19
	42		30	.484915	3406	.515085	98	02	.484917	3406	.515083		30		18
	43		45	.495134	3328	.504866	98	02	.495136	3328	.504864		15		17
	44	11		.505118	3253	.494882	98	02	.505120	3253	.494880	49			16
	45		15	.514878	3182	.485122	98	02	.514880	3182	.485120		45		15
	46		30	.524423	3113	.475577	98	02	.524425	3113	.475575		30		14
	47		45	.533763	3048	.466237	97	03	.533766	3048	.466234		15		13
	48	12		.542906	2985	.457094	97	03	.542909	2985	.457091	48			12
	49		15	.551861	2925	.448139	97	03	.551864	2925	.448136		45		11
	50		30	.560635	2867	.439365	97	03	.560638	2867	.439362		30		10
	51		45	.569235	2811	.430765	97	03	.569238	2811	.430762		15		9
	52	13		.577668	2758	.422332	97	03	.577671	2758	.422329	47			8
	53		15	.585941	2706	.414059	97	03	.585944	2706	.414056		45		7
	54		30	.594059	2656	.405941	97	03	.594062	2656	.405938		30		6
	55		45	.602028	2608	.397972	97	03	.602031	2608	.397969		15		5
	56	14		.609853	2562	.390147	96	04	.609857	2562	.390143	46			4
	57		15	.617540	2518	.382460	96	04	.617544	2518	.382456		45		3
	58		30	.625093	2475	.374907	96	04	.625097	2475	.374903		30		2
	59		45	.632517	2433	.367483	96	04	.632521	2433	.367479		15		1
0	60	15		7.639816		2.360184	9.999996	0.000004	7.639820		2.360180	45		59	0
m	s	'	''	L. Cos.	Diff. for 5''	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 5''	L. Tang.	'	''	m	s
Hours.		Deg.										Deg.		Hours.	

6h = 90° $1' = 4^s$ $1° = 4^m$ 89° 5h

0h 0° 1s = 15'' 1m = 15' 1h = 15° 179° 11h

Hours. m	Hours. s	Deg. '	Deg. ''	L. Sin.	Diff. for 5''	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 5''	L. Cot.	Deg. '	Deg. ''	Hours. m	Hours. s
1	0	15		7.639816	2393	2.360184	9.999996	0.000004	7.639820	2393	2.360180	45		58	60
	1		15	.646995	2354	.353005	. 96	. 04	.646999	2354	.353001		45		59
	2		30	.654056	2316	.345944	. 96	. 04	.654061	2316	.345939		30		58
	3		45	.661005	2280	.338995	. 96	. 04	.661010	2280	.338990		15		57
	4	16		.667845	2244	.332155	. 95	. 05	.667849	2244	.332151	44			56
	5		15	.674578	2210	.325422	. 95	. 05	.674583	2210	.325417		45		55
	6		30	.681208	2177	.318792	. 95	. 05	.681213	2177	.318787		30		54
	7		45	.687739	2145	.312261	. 95	. 05	.687744	2145	.312256		15		53
	8	17		.694173	2113	.305827	. 95	. 05	.694178	2113	.305822	43			52
	9		15	.700513	2083	.299487	. 95	. 05	.700519	2083	.299481		45		51
	10		30	.706762	2054	.293238	. 94	. 06	.706768	2054	.293232		30		50
	11		45	.712922	2025	.287078	. 94	. 06	.712928	2025	.287072		15		49
	12	18		.718997	1997	.281003	. 94	. 06	.719003	1997	.280997	42			48
	13		15	.724987	1970	.275013	. 94	. 06	.724993	1970	.275007		45		47
	14		30	.730896	1943	.269104	. 94	. 06	.730902	1943	.269098		30		46
	15		45	.736725	1917	.263275	. 94	. 06	.736732	1917	.263268		15		45
	16	19		.742477	1892	.257523	. 93	. 07	.742484	1892	.257516	41			44
	17		15	.748155	1868	.251845	. 93	. 07	.748161	1868	.251839		45		43
	18		30	.753758	1844	.246242	. 93	. 07	.753765	1844	.246235		30		42
	19		45	.759291	1821	.240709	. 93	. 07	.759298	1821	.240702		15		41
	20	20		.764754	1798	.235246	. 93	. 07	.764761	1798	.235239	40			40
	21		15	.770149	1776	.229851	. 93	. 07	.770156	1776	.229844		45		39
	22		30	.775477	1755	.224523	. 92	. 08	.775485	1755	.224515		30		38
	23		45	.780742	1734	.219258	. 92	. 08	.780750	1734	.219250		15		37
	24	21		.785943	1713	.214057	. 92	. 08	.785951	1713	.214049	39			36
	25		15	.791082	1693	.208918	. 92	. 08	.791090	1693	.208910		45		35
	26		30	.796162	1674	.203838	. 92	. 08	.796170	1674	.203830		30		34
	27		45	.801183	1654	.198817	. 92	. 08	.801191	1654	.198809		15		33
	28	22		.806146	1636	.193854	. 91	. 09	.806155	1636	.193845	38			32
	29		15	.811053	1618	.188947	. 91	. 09	.811062	1618	.188938		45		31
	30		30	.815906	1599	.184094	. 91	. 09	.815915	1599	.184085		30		30
	31		45	.820704	1582	.179296	. 91	. 09	.820714	1582	.179286		15		29
	32	23		.825451	1565	.174549	. 90	. 10	.825460	1565	.174540	37			28
	33		15	.830146	1548	.169854	. 90	. 10	.830156	1548	.169844		45		27
	34		30	.834791	1532	.165209	. 90	. 10	.834801	1532	.165199		30		26
	35		45	.839386	1516	.160614	. 89	. 11	.839397	1516	.160603		15		25
	36	24		.843934	1500	.156066	. 89	. 11	.843944	1500	.156056	36			24
	37		15	.848434	1485	.151566	. 89	. 11	.848445	1485	.151555		45		23
	38		30	.852889	1470	.147111	. 89	. 11	.852900	1470	.147100		30		22
	39		45	.857298	1455	.142702	. 89	. 11	.857309	1455	.142691		15		21
	40	25		.861662	1441	.138338	. 89	. 11	.861674	1441	.138326	35			20
	41		15	.865984	1426	.134016	. 89	. 11	.865995	1426	.134005		45		19
	42		30	.870262	1412	.129738	. 88	. 12	.870274	1412	.129726		30		18
	43		45	.874499	1399	.125501	. 88	. 12	.874511	1399	.125489		15		17
	44	26		.878695	1385	.121305	. 88	. 12	.878706	1385	.121294	34			16
	45		15	.882851	1372	.117149	. 87	. 13	.882864	1372	.117136		45		15
	46		30	.886968	1359	.113032	. 87	. 13	.886981	1359	.113019		30		14
	47		45	.891046	1346	.108954	. 87	. 13	.891059	1346	.108941		15		13
	48	27		.895085	1334	.104915	. 87	. 13	.895099	1334	.104901	33			12
	49		15	.899088	1322	.100912	. 87	. 13	.899102	1322	.100898		45		11
	50		30	.903054	1310	.096946	. 86	. 14	.903068	1310	.096932		30		10
	51		45	.906984	1298	.093016	. 86	. 14	.906998	1298	.093002		15		9
	52	28		.910879	1287	.089121	. 86	. 14	.910894	1287	.089106	32			8
	53		15	.914740	1275	.085260	. 86	. 14	.914754	1275	.085246		45		7
	54		30	.918566	1264	.081434	. 85	. 15	.918581	1264	.081419		30		6
	55		45	.922359	1253	.077641	. 85	. 15	.922374	1253	.077626		15		5
	56	29		.926119	1242	.073881	. 85	. 15	.926134	1242	.073866	31			4
	57		15	.929847	1232	.070153	. 85	. 15	.929863	1232	.070137		45		3
	58		30	.933543	1222	.066457	. 84	. 16	.933559	1222	.066441		30		2
	59		45	.937208	1211	.062792	. 84	. 16	.937224	1211	.062776		15		1
1	60	30		7.940842		2.059158	9.999984	0.000016	7.940858		2.059142	30		58	0
m	s	'	''	L. Cos.	Diff. for 5''	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 5''	L. Tang.	'	''	m	s
Hours.		Deg.										Deg.		Hours.	

6h = 90° 1' = 4s 1° = 4m 89° 5h

0h 0° $1^s = 15''$ $1^m = 15'$ $1^h = 15°$ 179° 11h

Hours m	Hours s	Deg. '	Deg. "	L. Sin.	Diff. for 5''	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 5''	L. Cot.	Deg. '	Deg. "	Hours m	Hours s
2	0	30		7.940842	1201	2.059158	9.999984	0.000016	7.940858	1202	2.059142	30		57	60
	1		15	.944446	1191	.055554	. 84	. 16	.944463	1191	.055537		45		59
	2		30	.948020	1182	.051980	. 83	. 17	.948037	1182	.051963		30		58
	3		45	.951565	1172	.048435	. 83	. 17	.951583	1172	.048417		15		57
	4	31		.955082	1163	.044918	. 82	. 18	.955100	1163	.044900	29			56
	5		15	.958570	1154	.041430	. 82	. 18	.958588	1154	.041412		45		55
	6		30	.962031	1144	.037969	. 82	. 18	.962049	1144	.037951		30		54
	7		45	.965464	1135	.034536	. 81	. 19	.965482	1136	.034518		15		53
	8	32		.968870	1127	.031130	. 81	. 19	.968889	1127	.031111	28			52
	9		15	.972250	1118	.027750	. 81	. 19	.972269	1118	.027731		45		51
	10		30	.975603	1109	.024397	. 81	. 19	.975622	1110	.024378		30		50
	11		45	.978931	1101	.021069	. 80	. 20	.978951	1101	.021049		15		49
	12	33		.982233	1093	.017767	. 80	. 20	.982253	1093	.017747	27			48
	13		15	.985511	1084	.014489	. 80	. 20	.985531	1085	.014469		45		47
	14		30	.988764	1076	.011236	. 79	. 21	.988785	1076	.011215		30		46
	15		45	.991993	1068	.008007	. 79	. 21	.992014	1068	.007986		15		45
	16	34		.995198	1060	.004802	. 79	. 21	.995219	1061	.004781	26			44
	17		15	.998379	1053	.001621	. 78	. 22	.998401	1053	.001599		45		43
	18		30	8.001538	1045	1.998462	. 78	. 22	8.001560	1045	1.998440		30		42
	19		45	.004674	1038	.995326	. 78	. 22	.004696	1038	.995304		15		41
	20	35		.007787	1030	.992213	. 78	. 22	.007809	1031	.992191	25			40
	21		15	.010878	1023	.989122	. 77	. 23	.010901	1023	.989099		45		39
	22		30	.013947	1016	.986053	. 77	. 23	.013970	1016	.986030		30		38
	23		45	.016994	1009	.983006	. 77	. 23	.017018	1009	.982982		15		37
	24	36		.020021	1002	.979979	. 76	. 24	.020045	1002	.979955	24			36
	25		15	.023026	995	.976974	. 76	. 24	.023050	995	.976950		45		35
	26		30	.026011	988	.973989	. 76	. 24	.026035	988	.973965		30		34
	27		45	.028975	982	.971025	. 75	. 25	.029000	982	.971000		15		33
	28	37		.031920	975	.968080	. 75	. 25	.031945	975	.968055	23			32
	29		15	.034844	968	.965156	. 75	. 25	.034869	969	.965131		45		31
	30		30	.037749	962	.962251	. 74	. 26	.037775	962	.962225		30		30
	31		45	.040634	956	.959366	. 74	. 26	.040660	956	.959340		15		29
	32	38		.043501	949	.956499	. 74	. 26	.043527	950	.956473	22			28
	33		15	.046349	943	.953651	. 73	. 27	.046376	943	.953624		45		27
	34		30	.049178	937	.950822	. 73	. 27	.049205	937	.950795		30		26
	35		45	.051989	931	.948011	. 72	. 28	.052016	931	.947984		15		25
	36	39		.054781	925	.945219	. 72	. 28	.054809	925	.945191	21			24
	37		15	.057556	919	.942444	. 72	. 28	.057584	919	.942416		45		23
	38		30	.060314	913	.939686	. 71	. 29	.060342	914	.939658		30		22
	39		45	.063054	907	.936946	. 71	. 29	.063083	908	.936917		15		21
	40	40		.065776	902	.934224	. 71	. 29	.065806	902	.934194	20			20
	41		15	.068482	896	.931518	. 70	. 30	.068512	896	.931488		45		19
	42		30	.071171	891	.928829	. 70	. 30	.071201	891	.928799		30		18
	43		45	.073844	885	.926156	. 70	. 30	.073874	886	.926126		15		17
	44	41		.076500	880	.923500	. 69	. 31	.076531	880	.923469	19			16
	45		15	.079140	875	.920860	. 69	. 31	.079171	875	.920829		45		15
	46		30	.081764	869	.918236	. 68	. 32	.081795	870	.918205		30		14
	47		45	.084372	864	.915628	. 68	. 32	.084404	864	.915596		15		13
	48	42		.086965	859	.913035	. 68	. 32	.086997	859	.913003	18			12
	49		15	.089542	854	.910458	. 67	. 33	.089575	854	.910425		45		11
	50		30	.092104	849	.907896	. 67	. 33	.092137	849	.907863		30		10
	51		45	.094651	844	.905349	. 66	. 34	.094685	844	.905315		15		9
	52	43		.097183	839	.902817	. 66	. 34	.097217	839	.902783	17			8
	53		15	.099701	834	.900299	. 66	. 34	.099735	835	.900265		45		7
	54		30	.102204	829	.897796	. 65	. 35	.102239	830	.897761		30		6
	55		45	.104693	825	.895307	. 65	. 35	.104728	825	.895272		15		5
	56	44		.107167	820	.892833	. 64	. 36	.107203	820	.892797	16			4
	57		15	.109627	816	.890373	. 64	. 36	.109663	816	.890337		45		3
	58		30	.112074	811	.887926	. 64	. 36	.112110	811	.887890		30		2
	59		45	.114507	806	.885493	. 63	. 37	.114544	806	.885456		15		1
2	60	45		8.116926		1.883074	9.999963	0.000037	8.116963		1.883037	15		57	0
m	s	'	"	L. Cos.	Diff. for 5''	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 5''	L. Tang.	'	"	m	s
Hours.		Deg.										Deg.		Hours.	

6h = 90 $1' = 4^s$ $1° = 4^m$ 89° 5h

0° $1^s = 15''$ $1^m = 15'$ $1^h = 15°$ 179° 11^h

Deg. ′	Deg. ″	L. Sin.	Diff. for 5″	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 5″	L. Cot.	Deg. ′	Deg. ″	Hours m	Hours s
45		8.116926	802	1.883074	9.999963	0.000037	8.116963	802	1.883037	15		56	60
	15	.119332	798	.880668	. 62	. 38	.119370	798	.880630		45		59
	30	.121725	793	.878275	. 62	. 38	.121763	793	.878237		30		58
	45	.124104	789	.875896	. 62	. 38	.124143	789	.875857		15		57
46		.126471	785	.873529	. 61	. 39	.126510	785	.873490	14			56
	15	.128825	780	.871175	. 61	. 39	.128864	781	.871136		45		55
	30	.131166	776	.868834	. 60	. 40	.131206	776	.868794		30		54
	45	.133494	772	.866506	. 60	. 40	.133534	772	.866466		15		53
47		.135810	768	.864190	. 59	. 41	.135851	768	.864149	13			52
	15	.138114	764	.861886	. 59	. 41	.138155	764	.861845		45		51
	30	.140406	760	.859594	. 59	. 41	.140447	760	.859553		30		50
	45	.142685	756	.857315	. 58	. 42	.142727	756	.857273		15		49
48		.144953	752	.855047	. 57	. 43	.144996	752	.855004	12			48
	15	.147209	748	.852791	. 57	. 43	.147252	748	.852748		45		47
	30	.149453	744	.850547	. 56	. 44	.149497	744	.850503		30		46
	45	.151686	741	.848314	. 56	. 44	.151730	741	.848270		15		45
49		.153908	737	.846092	. 56	. 44	.153952	737	.846048	11			44
	15	.156118	733	.843882	. 55	. 45	.156162	733	.843838		45		43
	30	.158316	729	.841684	. 55	. 45	.158361	730	.841639		30		42
	45	.160504	726	.839496	. 54	. 46	.160550	726	.839450		15		41
50		.162681	722	.837319	. 54	. 46	.162727	722	.837273	10			40
	15	.164847	719	.835153	. 54	. 46	.164893	719	.835107		45		39
	30	.167002	715	.832998	. 53	. 47	.167049	715	.832951		30		38
	45	.169146	711	.830854	. 52	. 48	.169194	711	.830806		15		37
51		.171280	708	.828720	. 52	. 48	.171328	708	.828672	9			36
	15	.173404	705	.826596	. 52	. 48	.173452	705	.826548		45		35
	30	.175517	701	.824483	. 51	. 49	.175566	701	.824434		30		34
	45	.177620	698	.822380	. 51	. 49	.177669	698	.822331		15		33
52		.179713	694	.820287	. 50	. 50	.179763	694	.820237	8			32
	15	.181796	691	.818204	. 50	. 50	.181846	691	.818154		45		31
	30	.183868	688	.816132	. 49	. 51	.183919	688	.816081		30		30
	45	.185931	684	.814069	. 48	. 52	.185983	684	.814017		15		29
53		.187984	682	.812016	. 48	. 52	.188036	682	.811964	7			28
	15	.190028	678	.809972	. 48	. 52	.190081	678	.809919		45		27
	30	.192062	675	.807938	. 47	. 53	.192115	675	.807885		30		26
	45	.194087	672	.805913	. 47	. 53	.194140	672	.805860		15		25
54		.196102	669	.803898	. 46	. 54	.196156	669	.803844	6			24
	15	.198108	665	.801892	. 46	. 54	.198162	666	.801838		45		23
	30	.200104	663	.799896	. 45	. 55	.200159	663	.799841		30		22
	45	.202092	659	.797908	. 45	. 55	.202147	660	.797853		15		21
55		.204070	657	.795930	. 44	. 56	.204126	657	.795874	5			20
	15	.206040	653	.793960	. 44	. 56	.206096	654	.793904		45		19
	30	.208000	651	.792000	. 43	. 57	.208057	651	.791943		30		18
	45	.209952	648	.790048	. 43	. 57	.210009	648	.789991		15		17
56		.211895	645	.788105	. 42	. 58	.211953	645	.788047	4			16
	15	.213829	642	.786171	. 42	. 58	.213887	642	.786113		45		15
	30	.215755	639	.784245	. 41	. 59	.215814	639	.784186		30		14
	45	.217672	636	.782328	. 41	. 59	.217731	637	.782269		15		13
57		.219581	634	.780419	. 40	. 60	.219641	634	.780359	3			12
	15	.221482	631	.778518	. 40	. 60	.221542	631	.778458		45		11
	30	.223374	628	.776626	. 39	. 61	.223435	628	.776565		30		10
	45	.225258	625	.774742	. 39	. 61	.225319	625	.774681		15		9
58		.227133	623	.772867	. 38	. 62	.227195	623	.772805	2			8
	15	.229001	620	.770999	. 37	. 63	.229064	620	.770936		45		7
	30	.230861	617	.769139	. 37	. 63	.230924	617	.769076		30		6
	45	.232713	615	.767287	. 37	. 63	.232776	615	.767224		15		5
59		.234557	612	.765443	. 36	. 64	.234621	612	.765379	1			4
	15	.236393	609	.763607	. 35	. 65	.236458	609	.763542		45		3
	30	.238221	607	.761779	. 35	. 65	.238286	607	.761714		30		2
	45	.240042	604	.759958	. 34	. 66	.240108	605	.759892		15		1
60		8.241855		1.758145	9.999933	0.000067	8.241922		1.758078	0		56	0
′	″									′	″	m	s
Deg.		L. Cos.	Diff. for 5″	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 5″	L. Tang.	Deg.		Hours.	

90° $1' = 4^s$ $1° = 4^m$ 89° 5^h

0h 1° 1s = 15″ 1m = 15′ 1h = 15° 178° 11h

Hours m	Hours s	Deg. ′	Deg. ″	L. Sin.	Diff for 15″ or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15″ or 1s	L. Cot.	Deg. ′	Deg. ″	Hours m	Hours s
4	0	0		8.241855	1802	1.758145	9.999933	0.000067	8.241922	1802	1.758078	60		55	60
	2		30	.245459	1787	.754541	. 33	. 67	.245526	1787	.754474		30		58
	4	1		.249033	1772	.750967	. 32	. 68	.249101	1772	.750899	59			56
	6		30	.252578	1758	.742422	. 30	. 70	.252648	1758	.747352		30		54
	8	2		.256004	1744	.743906	. 29	. 71	.256165	1744	.743835	58			52
	10		30	.259582	1730	.740418	. 28	. 72	.259654	1730	.740346		30		50
	12	3		.263042	1716	.736958	. 27	. 73	.263115	1717	.736885	57			48
	14		30	.266475	1703	.733525	. 26	. 74	.266549	1703	.733451		30		46
	16	4		.269881	1689	.730119	. 25	. 75	.269956	1690	.730044	56			44
	18		30	.273260	1677	.726740	. 24	. 76	.273337	1677	.726663		30		42
	20	5		.276614	1663	.723386	. 23	. 77	.276691	1664	.723309	55			40
	22		30	.279941	1651	.720059	. 21	. 79	.280020	1651	.719980		30		38
	24	6		.283243	1639	.716757	. 20	. 80	.283323	1639	.716677	54			36
	26		30	.286521	1626	.713479	. 19	. 81	.286602	1627	.713398		30		34
	28	7		.289773	1614	.710227	. 17	. 83	.289856	1615	.710144	53			32
	30		30	.293002	1602	.706998	. 16	. 84	.293086	1603	.706914		30		30
	32	8		.296207	1590	.703793	. 15	. 85	.296292	1591	.703708	52			28
	34		30	.299388	1579	.700612	. 14	. 86	.299474	1580	.700526		30		26
	36	9		.302546	1567	.697454	. 13	. 87	.302633	1568	.697367	51			24
	38		30	.305681	1556	.694319	. 11	. 89	.305770	1557	.694230		30		22
	40	10		.308794	1545	.691206	. 10	. 90	.308884	1546	.691116	50			20
	42		30	.311885	1534	.688115	. 09	. 91	.311976	1535	.688024		30		18
	44	11		.314954	1523	.685046	. 07	. 93	.315046	1524	.684954	49			16
	46		30	.318001	1513	.681999	. 06	. 94	.318095	1514	.681905		30		14
	48	12		.321027	1502	.678973	. 05	. 95	.321122	1503	.678878	48			12
	50		30	.324032	1492	.675968	. 03	. 97	.324129	1492	.675871		30		10
	52	13		.327016	1482	.672984	. 02	. 98	.327114	1483	.672886	47			8
	54		30	.329981	1472	.670019	. 01	. 99	.330080	1473	.669920		30		6
	56	14		.332924	1462	.667076	.999899	.000101	.333025	1463	.666975	46			4
	58		30	.335848	1452	.664152	. 98	. 02	.335950	1453	.664050		30		2
5	0	15		.338753	1442	.661247	. 97	. 03	.338856	1443	.661144	45		55	0
	2		30	.341638	1433	.658362	. 95	. 05	.341743	1434	.658257		30		58
	4	16		.344504	1424	.655496	. 94	. 06	.344610	1425	.655390	44			56
	6		30	.347352	1414	.652648	. 93	. 07	.347459	1415	.652541		30		54
	8	17		.350181	1405	.649819	. 91	. 09	.350290	1406	.649710	43			52
	10		30	.352991	1396	.647009	. 90	. 10	.353101	1397	.646899		30		50
	12	18		.355783	1387	.644217	. 88	. 12	.355895	1388	.644105	42			48
	14		30	.358558	1378	.641442	. 87	. 13	.358671	1379	.641329		30		46
	16	19		.361315	1370	.638685	. 85	. 15	.361430	1371	.638570	41			44
	18		30	.364055	1361	.635945	. 84	. 16	.364171	1362	.635829		30		42
	20	20		.366777	1352	.633223	. 82	. 18	.366895	1353	.633105	40			40
	22		30	.369482	1344	.630518	. 81	. 19	.369601	1345	.630399		30		38
	24	21		.372171	1336	.627829	. 79	. 21	.372292	1337	.627708	39			36
	26		30	.374843	1328	.625157	. 78	. 22	.374965	1329	.625035		30		34
	28	22		.377499	1319	.622501	. 77	. 23	.377622	1320	.622378	38			32
	30		30	.380138	1312	.619862	. 75	. 25	.380263	1313	.619737		30		30
	32	23		.382762	1304	.617238	. 73	. 27	.382889	1305	.617111	37			28
	34		30	.385370	1296	.614630	. 72	. 28	.385498	1297	.614502		30		26
	36	24		.387962	1288	.612038	. 70	. 30	.388092	1289	.611908	36			24
	38		30	.390539	1281	.609461	. 69	. 31	.390670	1282	.609330		30		22
	40	25		.393101	1273	.606899	. 67	. 33	.393234	1274	.606766	35			20
	42		30	.395648	1265	.604352	. 66	. 34	.395782	1266	.604218		30		18
	44	26		.398179	1258	.601821	. 64	. 36	.398315	1259	.601685	34			16
	46		30	.400696	1251	.599304	. 62	. 38	.400834	1252	.599166		30		14
	48	27		.403199	1244	.596801	. 61	. 39	.403338	1245	.596662	33			12
	50		30	.405687	1237	.594313	. 59	. 41	.405828	1238	.594172		30		10
	52	28		.408162	1230	.591838	. 58	. 42	.408304	1231	.591696	32			8
	54		30	.410621	1223	.589379	. 56	. 44	.410765	1224	.589235		30		6
	56	29		.413068	1216	.586932	. 55	. 45	.413213	1217	.586787	31			4
	58		30	.415500	1209	.584500	. 53	. 47	.415647	1210	.584353		30		2
5	60	30		8.417919		1.582081	9.999851	0.000149	8.418068		1.581932	30		54	0
Hours m	Hours s	Deg. ′	Deg. ″	L. Cos.	Diff. for 15″ or 1s	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15″ or 1s	L. Tang.	Deg. ′	Deg. ″	Hours m	Hours s

6h 91° 1′ = 4s 1° = 4m 88° 5h

Deg. '	Deg. ''	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Deg. ''	Hours m	Hours s
30		8.417919	1203	1.582081	9.999851	0.000149	8.418068	1204	1.581932	30		53	0
	30	.420325	1196	.579675	. 50	. 50	.420475	1197	.579525		30		58
31		.422717	1189	.577283	. 48	. 52	.422869	1190	.577131	29			56
	30	.425096	1183	.574904	. 46	. 54	.425250	1184	.574750		30		54
32		.427462	1176	.572538	. 44	. 56	.427618	1177	.572382	28			52
	30	.429816	1170	.570184	. 43	. 57	.429973	1171	.570027		30		50
33		.432158	1164	.567844	. 41	. 59	.432315	1165	.567685	27			48
	30	.434484	1158	.565516	. 39	. 61	.434645	1159	.565355		30		46
34		.436800	1151	.563200	. 38	. 62	.436962	1152	.563038	26			44
	30	.439103	1145	.560897	. 36	. 64	.439267	1146	.560733		30		42
35		.441394	1140	.558606	. 34	. 66	.441560	1141	.558440	25			40
	30	.443674	1133	.556326	. 33	. 67	.443841	1134	.556159		30		38
36		.445941	1127	.554059	. 31	. 69	.446110	1128	.553890	24			36
	30	.448196	1122	.551804	. 29	. 71	.448367	1123	.551633		30		34
37		.450440	1116	.549560	. 27	. 73	.450613	1117	.549387	23			32
	30	.452672	1110	.547328	. 25	. 75	.452847	1111	.547153		30		30
38		.454893	1105	.545107	. 23	. 77	.455070	1106	.544930	22			28
	30	.457103	1099	.542897	. 22	. 78	.457281	1100	.542719		30		26
39		.459301	1094	.540699	. 20	. 80	.459481	1095	.540519	21			24
	30	.461489	1088	.538511	. 18	. 82	.461671	1089	.538329		30		22
40		.463665	1082	.536335	16	. 84	.463849	1083	.536151	20			20
	30	.465830	1077	.534170	. 14	. 86	.466016	1078	.533984		30		18
41		.467985	1072	.532015	. 13	. 87	.468172	1073	.531828	19			16
	30	.470129	1067	.529871	. 11	. 89	.470318	1068	.529682		30		14
42		.472263	1062	.527737	. 09	. 91	.472454	1063	.527546	18			12
	30	.474386	1056	.525614	. 07	. 93	.474579	1057	.525421		30		10
43		.476498	1051	.523502	. 05	. 95	.476693	1052	.523307	17			8
	30	.478601	1046	.521399	. 03	. 97	.478798	1047	.521202		30		6
44		.480693	1041	.519307	. 01	. 99	.480892	1042	.519108	16			4
	30	.482775	1036	.517225	.999799	.000201	.482976	1037	.517024		30		2
45		.484848	1031	.515152	. 97	. 03	.485051	1032	.514949	15		53	0
	30	.486910	1026	.513090	. 95	. 05	.487115	1027	.512885		30		58
46		.488963	1021	.511037	. 93	. 07	.489170	1022	.510830	14			56
	30	.491006	1017	.508994	. 92	. 08	.491214	1018	.508786		30		54
47		.493040	1012	.506960	. 90	. 10	.493250	1013	.506750	13			52
	30	.495064	1007	.504936	. 88	. 12	.495276	1008	.504724		30		50
48		.497079	1003	.502921	. 86	. 14	.497293	1004	.502707	12			48
	30	.499084	998	.500916	. 84	. 16	.499300	999	.500700		30		46
49		.501080	993	.498920	. 82	. 18	.501298	994	.498702	11			44
	30	.503067	989	.496933	. 80	. 20	.503287	990	.496713		30		42
50		.505045	984	.494955	. 78	. 22	.505267	985	.494733	10			40
	30	.507014	980	.492986	. 76	. 24	.507238	981	.492762		30		38
51		.508974	975	.491026	. 74	. 26	.509200	976	.490800	9			36
	30	.510925	971	.489075	. 72	. 28	.511153	972	.488847		30		34
52		.512867	967	.487133	. 69	. 31	.513098	968	.486902	8			32
	30	.514801	962	.485199	. 67	. 33	.515034	963	.484966		30		30
53		.516726	958	.483274	. 65	. 35	.516961	959	.483039	7			28
	30	.518643	954	.481357	. 63	. 37	.518880	955	.481120		30		26
54		.520551	950	.479449	. 61	. 39	.520790	951	.479210	6			24
	30	.522451	946	.477549	. 59	. 41	.522692	947	.477308		30		22
55		.524343	941	.475657	. 57	. 43	.524586	942	.475414	5			20
	30	.526226	938	.473774	. 55	. 45	.526471	939	.473529		30		18
56		.528102	933	.471898	. 53	. 47	.528349	934	.471651	4			16
	30	.529969	929	.470031	. 51	. 49	.530218	930	.469782		30		14
57		.531828	925	.468172	. 48	. 52	.532080	926	.467920	3			12
	30	.533679	922	.466321	. 46	. 54	.533933	923	.466067		30		10
58		.535523	918	.464477	. 44	. 56	.535779	919	.464221	2			8
	30	.537359	913	.462641	. 42	. 58	.537616	914	.462384		30		6
59		.539186	910	.460814	. 40	. 60	.539447	911	.460554	1			4
	30	.541007	906	.458993	. 38	. 62	.541269	907	.458731		30		2
60		8.542819		1.457181	9.999735	0.000265	8.543084		1.456916	0		52	0
'	''	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15'' or 1	L. Tang.	'	''	m	s
Deg.										Deg.		Hours.	

0h 2° | 1s = 15'' 1m = 15' 1h = 15° | 177°

Hours. m	Hours. s	Deg. '	Deg. ''	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Deg. ''
8	0	0		8.542819	902	1.457181	9.999735	0.000265	8.543084	903	1.456916	60	
	2		30	.544624	899	.455376	. 33	. 67	.544891	900	.455109		30
	4	1		.546422	895	.453578	. 31	. 69	.546691	896	.453309	59	
	6		30	.548212	891	.451788	. 29	. 71	.548483	892	.451517		30
	8	2		.549995	887	.450005	. 27	. 73	.550268	889	.449732	58	
	10		30	.551770	884	.448230	. 24	. 76	.552046	885	.447954		30
	12	3		.553539	880	.446461	. 22	. 78	.553817	881	.446183	57	
	14		30	.555300	877	.444700	. 20	. 80	.555580	878	.444420		30
	16	4		.557054	873	.442946	. 18	. 82	.557336	874	.442664	56	
	18		30	.558800	870	.441200	. 15	. 85	.559085	871	.440915		30
	20	5		.560541	866	.439459	. 13	. 87	.560828	867	.439172	55	
	22		30	.562273	863	.437727	. 10	. 99	.562563	864	.437437		30
	24	6		.563999	860	.436001	. 08	. 92	.564291	861	.435709	54	
	26		30	.565719	856	.434281	. 06	. 94	.566013	857	.433987		30
	28	7		.567431	853	.432569	. 04	. 96	.567727	854	.432273	53	
	30		30	.569137	849	.430863	. 01	. 99	.569436	850	.430564		30
	32	8		.570836	846	.429164	.999599	.000301	.571137	847	.428863	52	
	34		30	.572528	843	.427472	. 96	. 04	.572832	844	.427168		30
	36	9		.574214	839	.425786	. 94	. 06	.574520	840	.425480	51	
	38		30	.575893	836	.424107	. 92	. 08	.576201	838	.423799		30
	40	10		.577566	833	.422434	. 89	. 11	.577877	834	.422123	50	
	42		30	.579232	830	.420768	. 87	. 13	.579545	831	.420455		30
	44	11		.580892	827	.419108	. 84	. 16	.581208	828	.418792	49	
	46		30	.582546	823	.417454	. 82	. 18	.582864	825	.417136		30
	48	12		.584193	820	.415807	. 80	. 20	.584513	822	.415487	48	
	50		30	.585834	817	.414166	. 77	. 23	.586157	819	.413843		30
	52	13		.587469	814	.412531	. 75	. 25	.587794	816	.412206	47	
	54		30	.589098	811	.410902	. 72	. 28	.589426	812	.410574		30
	56	14		.590721	808	.409279	. 70	. 30	.591051	809	.408949	46	
	58		30	.592338	805	.407662	. 68	. 32	.592670	806	.407330		30
9	0	15		.593948	802	.406052	. 65	. 35	.594283	803	.405717	45	
	2		30	.595553	799	.404447	. 63	. 37	.595890	801	.404110		30
	4	16		.597152	796	.402848	. 60	. 40	.597492	797	.402508	44	
	6		30	.598745	793	.401255	. 58	. 42	.599087	795	.400913		30
	8	17		.600332	790	.399668	. 55	. 45	.600677	792	.399323	43	
	10		30	.601913	788	.398087	. 52	. 48	.602261	789	.397739		30
	12	18		.603489	785	.396511	. 50	. 50	.603839	786	.396161	42	
	14		30	.605058	782	.394942	. 47	. 53	.605411	783	.394589		30
	16	19		.606623	779	.393377	. 45	. 55	.606978	780	.393022	41	
	18		30	.608181	776	.391819	. 42	. 58	.608539	777	.391461		30
	20	20		.609734	774	.390266	. 40	. 60	.610094	775	.389906	40	
	22		30	.611281	771	.388719	. 37	. 63	.611644	772	.388356		30
	24	21		.612824	768	.387176	. 35	. 65	.613189	769	.386811	39	
	26		30	.614360	765	.385640	. 32	. 68	.614728	767	.385272		30
	28	22		.615891	763	.384109	. 29	. 71	.616262	764	.383738	38	
	30		30	.617417	760	.382583	. 27	. 73	.617790	761	.382210		30
	32	23		.618937	757	.381063	. 24	. 76	.619313	758	.380687	37	
	34		30	.620452	755	.379548	. 22	. 78	.620830	756	.379170		30
	36	24		.621962	752	.378038	. 19	. 81	.622343	753	.377657	36	
	38		30	.623466	749	.376534	. 16	. 84	.623850	751	.376150		30
	40	25		.624965	747	.375035	. 13	. 87	.625352	748	.374648	35	
	42		30	.626459	744	.373541	. 11	. 89	.626848	746	.373152		30
	44	26		.627948	742	.372052	. 08	. 92	.628340	743	.371660	34	
	46		30	.629432	739	.370568	. 05	. 95	.629827	740	.370173		30
	48	27		.630911	737	.369089	. 03	. 97	.631308	738	.368692	33	
	50		30	.632385	734	.367615	. 00	.000400	.632785	735	.367215		30
	52	28		.633854	732	.366146	.999598	. 02	.634256	733	.365744	32	
	54		30	.635318	729	.364682	. 95	. 05	.635723	731	.364277		30
	56	29		.636776	727	.363224	. 92	. 08	.637184	728	.362816	31	
	58		30	.638230	725	.361770	. 89	. 11	.638641	726	.361359		30
9	60	30		8.639680		1.360320	9.999587	0.000413	8.640093		1.359907	30	
m	s	'	''	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	''
Hours.		Deg.										Deg.	

6h 92° | 1' = 4s 1° = 4m | 87°

0h 2° 1s = 15'' 1m = 15' 1h = 15° 177° 11h

Hours. m	Hours. s	Deg. '	Deg. ''	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Deg. ''	Hours. m	Hours. s
10	0	30		8.639680	722	1.360320	9.999587	0.000413	8.640093	723	1.359907	30		49	60
	2		30	.641124	719	.358876	. 84	. 16	.641540	721	.358460		30		58
	4	31		.642563	717	.357437	. 81	. 19	.642982	719	.357018	29			56
	6		30	.643998	715	.356002	. 78	. 22	.644420	716	.355580		30		54
	8	32		.645428	713	.354572	. 75	. 25	.645853	714	.354147	28			52
	10		30	.646853	710	.353147	. 72	. 28	.647281	711	.352719		30		50
	12	33		.648274	708	.351726	. 70	. 30	.648704	709	.351296	27			48
	14		30	.649690	706	.350310	. 67	. 33	.650123	707	.349877		30		46
	16	34		.651102	703	.348898	. 64	. 36	.651538	704	.348462	26			44
	18		30	.652508	701	.347492	. 61	. 39	.652947	702	.347053		30		42
	20	35		.653911	698	.346089	. 59	. 41	.654352	700	.345648	25			40
	22		30	.655308	697	.344692	. 55	. 45	.655753	698	.344247		30		38
	24	36		.656702	694	.343298	. 53	. 47	.657149	696	.342851	24			36
	26		30	.658091	692	.341909	. 50	. 50	.658541	693	.341459		30		34
	28	37		.659475	690	.340525	. 47	. 53	.659928	691	.340072	23			32
	30		30	.660855	687	.339145	. 44	. 56	.661311	689	.338689		30		30
	32	38		.662230	685	.337770	. 41	. 59	.662689	687	.337311	22			28
	34		30	.663601	684	.336399	. 38	. 62	.664063	685	.335937		30		26
	36	39		.664969	681	.335031	. 35	. 64	.665433	683	.334567	21			24
	38		30	.666331	679	.333669	. 32	. 68	.666799	680	.333201		30		22
	40	40		.667689	677	.332311	. 29	. 71	.668160	678	.331840	20			20
	42		30	.669043	675	.330957	. 26	. 74	.669517	676	.330483		30		18
	44	41		.670393	673	.329607	. 23	. 77	.670870	674	.329130	19			16
	46		30	.671739	671	.328261	. 21	. 79	.672218	672	.327782		30		14
	48	42		.673081	669	.326919	. 18	. 82	.673563	670	.326437	18			12
	50		30	.674418	666	.325582	. 15	. 85	.674903	668	.325097		30		10
	52	43		.675751	664	.324249	. 12	. 88	.676239	666	.323761	17			8
	54		30	.677080	662	.322920	. 09	. 91	.677571	664	.322429		30		6
	56	44		.678405	661	.321595	. 06	. 94	.678899	662	.321101	16			4
	58		30	.679727	658	.320273	. 03	. 97	.680224	660	.319776		30		2
11	0	45		.681044	656	.318956	. 00	.000500	.681544	658	.318456	15		49	0
	2		30	.682356	654	.317644	.999496	. 04	.682860	656	.317140		30		58
	4	46		.683665	653	.316335	. 93	. 07	.684172	654	.315828	14			56
	6		30	.684971	650	.315029	. 91	. 09	.685480	652	.314520		30		54
	8	47		.686272	648	.313728	. 88	. 12	.686784	650	.313216	13			52
	10		30	.687569	647	.312431	. 84	. 16	.688085	648	.311915		30		50
	12	48		.688862	645	.311138	. 81	. 19	.689381	646	.310619	12			48
	14		30	.690152	643	.309848	. 78	. 22	.690674	644	.309326		30		46
	16	49		.691438	641	.308562	. 75	. 25	.691963	642	.308037	11			44
	18		30	.692720	639	.307280	. 72	. 28	.693248	640	.306752		30		42
	20	50		.693998	637	.306002	. 69	. 31	.694529	639	.305471	10			40
	22		30	.695273	635	.304727	. 66	. 34	.695807	637	.304193		30		38
	24	51		.696543	633	.303457	. 62	. 38	.697081	635	.302919	9			36
	26		30	.697810	631	.302190	. 59	. 41	.698351	633	.301649		30		34
	28	52		.699073	630	.300927	. 56	. 44	.699617	631	.300383	8			32
	30		30	.700333	628	.299667	. 53	. 47	.700880	629	.299120		30		30
	32	53		.701589	626	.298411	. 50	. 50	.702139	628	.297861	7			28
	34		30	.702841	624	.297159	. 47	. 53	.703394	626	.296606		30		26
	36	54		.704090	622	.295910	. 44	. 56	.704646	624	.295354	6			24
	38		30	.705335	621	.294665	. 40	. 60	.705895	622	.294105		30		22
	40	55		.706577	619	.293423	. 37	. 63	.707140	620	.292860	5			20
	42		30	.707815	617	.292185	. 34	. 66	.708381	619	.291619		30		18
	44	56		.709049	615	.290951	. 31	. 69	.709618	617	.290382	4			16
	46		30	.710280	614	.289720	. 27	. 73	.710853	615	.289147		30		14
	48	57		.711507	612	.288493	. 24	. 76	.712083	614	.287917	3			12
	50		30	.712732	610	.287268	. 21	79	.713311	612	.286689		30		10
	52	58		.713952	608	.286048	. 18	. 82	.714534	610	.285466	2			8
	54		30	.715169	607	.284831	. 14	. 86	.715755	609	.284246		30		6
	56	59		.716383	605	.283617	. 11	. 89	.716972	607	.283028	1			4
	58		30	.717593	603	.282407	. 08	. 92	.718185	605	.281815		30		2
11	60	60		8.718800		1.281200	9.999404	0.000596	8.719396		1.280604	0		48	0
m	s	'	''	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	''	m	s
Hours.		Deg.										Deg.		Hours.	

6h 92° 1' = 4s 1° = 4m 87° 5h

0h 3° 1s = 15'' 1m = 15' 1h = 15° 176° 11h

Hours. m	Hours. s	Deg. '	Deg. ''	L. Sin.	Diff for 15'' or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff for 15'' or 1s	L. Cot.	Deg. '	Deg. ''	Hours. m	Hours. s
12	0	0		8.718800	602	1.281200	9.999404	0.000596	8.719396	603	1.280604	60		47	60
	2		30	.720004	600	.279996	. 01	. 99	.720603	601	.279397		30		58
	4	1		.721204	598	.278796	.999398	.000602	.721806	600	.278194	59			56
	6		30	.722401	597	.277599	. 94	. 06	.723007	598	.276993		30		54
	8	2		.723595	595	.276405	. 91	. 09	.724204	596	.275796	58			52
	10		30	.724785	593	.275215	. 88	. 12	.725397	595	.274603		30		50
	12	3		.725972	592	.274028	. 84	. 16	.726588	593	.273412	57			48
	14		30	.727156	590	.272844	. 81	. 19	.727775	592	.272225		30		46
	16	4		.728337	588	.271663	. 78	. 22	.728959	590	.271041	56			44
	18		30	.729514	587	.270486	. 74	. 26	.730140	588	.269860		30		42
	20	5		.730688	585	.269312	. 71	. 29	.731317	587	.268683	55			40
	22		30	.731859	584	.268141	. 67	. 33	.732492	585	.267508		30		38
	24	6		.733027	582	.266973	. 64	. 36	.733663	584	.266337	54			36
	26		30	.734192	581	.265808	. 61	. 39	.734831	582	.265169		30		34
	28	7		.735353	579	.264647	. 57	. 43	.735996	581	.264004	53			32
	30		30	.736512	577	.263488	. 54	. 46	.737158	579	.262842		30		30
	32	8		.737667	576	.262333	. 50	. 50	.738317	578	.261683	52			28
	34		30	.738820	575	.261180	. 47	. 53	.739473	576	.260527		30		26
	36	9		.739969	573	.260031	. 43	. 57	.740626	575	.259374	51			24
	38		30	.741115	572	.258885	. 40	. 60	.741775	573	.258225		30		22
	40	10		.742259	570	.257741	. 37	. 63	.742922	572	.257078	50			20
	42		30	.743399	568	.256601	. 33	. 67	.744066	570	.255934		30		18
	44	11		.744536	567	.255464	. 29	. 71	.745207	568	.254793	49			16
	46		30	.745670	566	.254330	. 26	. 74	.746344	567	.253656		30		14
	48	12		.746801	564	.253199	. 22	. 78	.747479	566	.252521	48			12
	50		30	.747930	562	.252070	. 19	. 81	.748611	564	.251389		30		10
	52	13		.749055	561	.250945	. 15	. 85	.749740	563	.250260	47			8
	54		30	.750178	559	.249822	. 12	. 88	.750866	561	.249134		30		6
	56	14		.751297	558	.248703	. 08	. 92	.751989	560	.248011	46			4
	58		30	.752414	557	.247586	. 04	. 96	.753110	558	.246890		30		2
13	0	15		.753528	555	.246472	. 01	. 99	.754227	557	.245773	45		47	0
	2		30	.754639	554	.245361	.999297	.000703	.755342	556	.244658		30		58
	4	16		.755747	552	.244253	. 94	. 06	.756453	554	.243547	44			56
	6		30	.756852	551	.243148	. 90	. 10	.757562	553	.242438		30		54
	8	17		.757955	549	.242045	. 87	. 13	.758668	551	.241332	43			52
	10		30	.759054	548	.240946	. 83	. 17	.759771	550	.240229		30		50
	12	18		.760151	547	.239849	. 79	. 21	.760872	549	.239128	42			48
	14		30	.761245	546	.238755	. 75	. 25	.761970	547	.238030		30		46
	16	19		.762337	544	.237663	. 72	. 28	.763065	546	.236935	41			44
	18		30	.763425	543	.236575	. 68	. 32	.764157	544	.235843		30		42
	20	20		.764511	541	.235489	. 65	. 35	.765246	543	.234754	40			40
	22		30	.765594	540	.234406	. 61	. 39	.766333	542	.233667		30		38
	24	21		.766675	539	.233325	. 57	. 43	.767418	541	.232582	39			36
	26		30	.767753	537	.232247	. 54	. 46	.768499	539	.231501		30		34
	28	22		.768828	536	.231172	. 50	. 50	.769578	538	.230422	38			32
	30		30	.769900	535	.230100	. 46	. 54	.770654	536	.229346		30		30
	32	23		.770970	533	.229030	. 43	. 57	.771727	535	.228273	37			28
	34		30	.772037	532	.227963	. 39	. 61	.772798	534	.227202		30		26
	36	24		.773101	531	.226899	. 35	. 65	.773866	533	.226134	36			24
	38		30	.774163	530	.225837	. 31	. 69	.774932	531	.225068		30		22
	40	25		.775223	528	.224777	. 28	. 72	.775995	530	.224005	35			20
	42		30	.776279	527	.223721	. 23	. 77	.777056	529	.222944		30		18
	44	26		.777334	526	.222666	. 20	. 80	.778114	527	.221886	34			16
	46		30	.778385	524	.221615	. 16	. 84	.779169	526	.220831		30		14
	48	27		.779434	523	.220566	. 12	. 88	.780222	525	.219778	33			12
	50		30	.780480	522	.219520	. 08	. 92	.781272	524	.218728		30		10
	52	28		.781525	520	.218475	. 05	. 95	.782320	522	.217680	32			8
	54		30	.782566	519	.217434	. 01	. 99	.783365	521	.216635		30		6
	56	29		.783605	518	.216395	.999197	.000803	.784408	520	.215592	31			4
	58		30	.784641	517	.215359	. 93	. 07	.785448	519	.214552		30		2
13	60	30		8.785675		1.214325	9.999189	0.000811	8.786486		1.213514	30		46	0
m	s	'	''	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff for 15'' or 1s	L. Tang.	'	''	m	s
Hours.		Deg.										Deg.		Hours.	

6h 93° 1' = 4s 1° = 4m 86° 5h

Deg. ′	Deg. ″	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15″ or 1ˢ	L. Cot.	Deg. ′	Deg. ″	Hours ᵐ	Hours ˢ
30		8.785675	516	1.214325	9.999189	0.000811	8.786486	518	1.213514	30		45	60
	30	.786707	514	.213293	. 85	. 15	.787522	516	.212478		30		58
31		.787736	513	.212264	. 82	. 18	.788554	515	.211446	29			56
	30	.788763	512	.211237	. 78	. 22	.789585	514	.210415		30		54
32		.789787	511	.210213	. 74	. 26	.790613	513	.209387	28			52
	30	.790809	509	.209191	. 70	. 30	.791639	512	.208361		30		50
33		.791828	508	.208172	. 66	. 34	.792662	510	.207338	27			48
	30	.792845	507	.207155	. 62	. 38	.793683	509	.206317		30		46
34		.793859	506	.206141	. 58	. 42	.794701	508	.205299	26			44
	30	.794872	505	.205128	. 54	. 46	.795718	507	.204282		30		42
35		.795881	504	.204119	. 50	. 50	.796731	506	.203269	25			40
	30	.796889	502	.203111	. 46	. 54	.797743	504	.202257		30		38
36		.797894	501	.202106	. 42	. 58	.798752	503	.201248	24			36
	30	.798897	500	.201103	. 38	. 62	.799759	502	.200241		30		34
37		.799897	499	.200103	. 34	. 66	.800762	501	.199237	23			32
	30	.800896	498	.199104	. 30	. 70	.801766	500	.198234		30		30
38		.801891	497	.198109	. 26	. 74	.802765	499	.197235	22			28
	30	.802885	495	.197115	. 22	. 78	.803763	497	.196237		30		26
39		.803876	494	.196124	. 18	. 82	.804758	496	.195242	21			24
	30	.804865	493	.195135	. 14	. 86	.805751	495	.194249		30		22
40		.805852	492	.194148	. 10	. 90	.806742	494	.193258	20			20
	30	.806837	491	.193163	. 06	. 94	.807731	493	.192269		30		18
41		.807819	490	.192181	. 02	. 98	.808717	492	.191283	19			16
	30	.808799	489	.191201	999098	.000902	.809701	491	.190299		30		14
42		.809777	488	.190223	. 94	. 06	.810683	490	.189317	18			12
	30	.810753	487	.189247	. 90	. 10	.811663	489	.188337		30		10
43		.811727	485	.188273	. 86	. 14	.812641	487	.187359	17			8
	30	.812698	484	.187302	. 82	. 18	.813616	486	.186384		30		6
44		.813667	483	.186333	. 78	. 22	.814589	486	.185411	16			4
	30	.814634	482	.185366	. 73	. 27	.815561	484	.184439		30		2
45		.815598	481	.184402	. 69	. 31	.816529	483	.183471	15		45	0
	30	.816561	480	.183439	. 65	. 35	.817496	482	.182504		30		58
46		.817522	479	.182478	. 61	. 39	.818461	481	.181539	14			56
	30	.818480	478	.181520	. 57	. 43	.819423	480	.180577		30		54
47		.819436	477	.180564	. 52	. 48	.820384	479	.179616	13			52
	30	.820390	476	.179610	. 48	. 52	.821342	478	.178658		30		50
48		.821342	475	.178658	. 44	. 56	.822298	477	.177702	12			48
	30	.822293	474	.177707	. 40	. 60	.823253	476	.176747		30		46
49		.823241	473	.176759	. 36	. 64	.824205	475	.175795	11			44
	30	.824186	472	.175814	. 31	. 69	.825155	474	.174845		30		42
50		.825130	471	.174870	. 27	. 73	.826103	473	.173897	10			40
	30	.826072	470	.173928	. 23	. 77	.827049	471	.172951		30		38
51		.827011	469	.172989	. 19	. 81	.827992	471	.172008	9			36
	30	.827949	467	.172051	. 15	. 85	.828934	470	.171066		30		34
52		.828884	467	.171116	. 10	. 90	.829874	469	.170126	8			32
	30	.829818	466	.170182	. 06	. 94	.830812	468	.169188		30		30
53		.830750	464	.169250	. 02	. 98	.831748	467	.168252	7			28
	30	.831679	464	.168321	.998997	.001003	.832682	466	.167318		30		26
54		.832607	463	.167393	. 93	. 07	.833614	465	.166386	6			24
	30	.833532	462	.166468	. 89	. 11	.834543	464	.165457		30		22
55		.834456	460	.165544	. 85	. 15	.835471	463	.164529	5			20
	30	.835377	460	.164623	. 80	. 20	.836397	462	.163603		30		18
56		.836297	459	.163703	. 76	. 24	.837321	461	.162679	4			16
	30	.837215	457	.162785	. 72	. 28	.838243	460	.161757		30		14
57		.838130	457	.161870	. 67	. 33	.839163	459	.160837	3			12
	30	.839044	456	.160956	. 63	. 37	.840081	458	.159919		30		10
58		.839956	455	.160044	. 58	. 42	.840998	457	.159002	2			8
	30	.840866	454	.159134	. 54	. 46	.841912	456	.158088		30		6
59		.841774	453	.158226	. 50	. 50	.842824	455	.157176	1			4
	30	.842680	452	.157320	. 45	. 55	.843735	454	.156265		30		2
60		8.843585		1.156415	9.998941	0.001059	8.844644		1.155356	0		44	0
′	″	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15″ or 1ˢ	L. Tang.	′	″	ᵐ	ˢ
Deg.										Deg.		Hours	

0h 4° 1s = 15″ 1m = 15′ 1h = 15° 175° 11h

Hours. m	Hours. s	Deg. ′	Deg. ″	L. Sin.	Diff. for 15″ or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15″ or 1s	L. Cot.	Deg. ′	Deg. ″	Hours. m	Hours. s
16	0	0		8.843585	451	1.156415	9.998941	0.001059	8.844644	453	1.155356	60		43	60
	2		30	.844487	450	.155513	. 36	. 64	.845551	452	.154449		30		58
	4	1		.845387	449	.154613	. 32	. 68	.846455	451	.153545	59			56
	6		30	.846286	448	.153714	. 27	. 73	.847359	450	.152641		30		54
	8	2		.847183	447	.152817	. 23	. 77	.848260	449	.151740	58			52
	10		30	.848078	446	.151922	. 19	. 81	.849159	449	.150841		30		50
	12	3		.848971	445	.151029	. 14	. 86	.850057	447	.149943	57			48
	14		30	.849862	444	.150138	. 10	. 90	.850952	447	.149048		30		46
	16	4		.850751	444	.149249	. 05	. 95	.851846	446	.148154	56			44
	18		30	.851639	443	.148361	. 01	. 99	.852738	445	.147262		30		42
	20	5		.852524	442	.147476	.998896	.001104	.853628	444	.146372	55			40
	22		30	.853409	440	.146591	. 92	. 08	.854517	443	.145483		30		38
	24	6		.854290	440	.145710	. 87	. 13	.855403	442	.144597	54			36
	26		30	.855171	439	.144829	. 83	. 17	.856288	441	.143712		30		34
	28	7		.856049	438	.143951	. 78	. 22	.857171	441	.142829	53			32
	30		30	.856926	437	.143074	. 73	. 27	.858053	439	.141947		30		30
	32	8		.857801	436	.142199	. 69	. 31	.858932	439	.141068	52			28
	34		30	.858674	436	.141326	. 64	. 36	.859810	438	.140190		30		26
	36	9		.859546	434	140454	. 60	. 40	.860686	437	.139314	51			24
	38		30	.860415	434	.139585	. 55	. 45	.861560	436	.138440		30		22
	40	10		.861283	433	.138717	. 50	. 50	.862433	435	.137567	50			20
	42		30	.862150	432	.137850	. 46	. 54	.863304	434	.136696		30		18
	44	11		.863014	431	.136986	. 41	. 59	.864173	433	.135827	49			16
	46		30	.863877	430	.136123	. 37	. 63	.865040	433	.134960		30		14
	48	12		.864738	429	.135262	. 32	. 68	.865906	432	.134094	48			12
	50		30	.865597	429	.134403	. 27	. 73	.866770	431	.133230		30		10
	52	13		.866455	428	.133545	. 23	. 77	.867632	430	.132368	47			8
	54		30	.867310	427	.132690	. 18	. 82	.868492	429	.131508		30		6
	56	14		.868165	426	.131835	. 14	. 86	.869351	428	.130649	46			4
	58		30	.869017	425	.130983	. 09	. 91	.870208	428	.129792		30		2
17	0	15		.869868	424	.130132	. 04	. 96	.871064	427	.128936	45		43	0
	2		30	.870717	424	.129283	.998799	.001201	.871918	426	.128082		30		58
	4	16		.871565	423	.128435	. 95	. 05	.872770	425	.127230	44			56
	6		30	.872411	422	.127589	. 90	. 10	.873621	424	.126379		30		54
	8	17		.873255	421	.126745	. 85	. 15	.874470	423	.125530	43			52
	10		30	.874097	420	.125903	. 80	. 20	.875317	422	.124683		30		50
	12	18		.874938	419	.125062	. 76	. 24	.876162	422	.123838	42			48
	14		30	.875777	419	.124223	. 71	. 29	.877006	421	.122994		30		46
	16	19		.876615	418	.123385	. 66	. 34	.877849	420	.122151	41			44
	18		30	.877451	417	.122549	. 61	. 39	.878690	419	.121310		30		42
	20	20		.878286	416	.121714	. 57	. 43	.879529	418	.120471	40			40
	22		30	.879118	415	.120882	. 52	. 48	.880366	418	.119634		30		38
	24	21		.879949	415	.120051	. 47	. 53	.881202	417	.118798	39			36
	26		30	.880779	414	.119221	. 42	. 58	.882037	416	.117963		30		34
	28	22		.881607	413	.118393	. 37	. 63	.882870	415	.117130	38			32
	30		30	.882433	412	.117567	. 32	. 68	.883701	414	.116299		30		30
	32	23		.883258	411	.116742	. 28	. 72	.884530	414	.115470	37			28
	34		30	.884081	411	.115919	. 23	. 77	.885358	413	.114642		30		26
	36	24		.884903	410	.115097	. 18	. 82	.886185	412	.113815	36			24
	38		30	.885723	409	.114277	. 13	. 87	.887010	411	.112990		30		22
	40	25		.886542	408	.113458	. 09	. 91	.887833	411	.112167	35			20
	42		30	.887359	407	.112641	. 04	. 96	.888655	410	.111345		30		18
	44	26		.888174	407	.111826	.998698	.001302	.889476	409	.110524	34			16
	46		30	.888988	406	.111012	. 94	. 06	.890294	409	.109706		30		14
	48	27		.889801	405	.110199	. 89	. 11	.891112	408	.108888	33			12
	50		30	.890612	404	.109388	. 84	. 16	.891928	407	.108072		30		10
	52	28		.891421	404	.108579	. 79	. 21	.892742	406	.107258	32			8
	54		30	.892229	403	.107771	. 74	. 26	.893555	405	.106445		30		6
	56	29		.893035	402	.106965	. 69	. 31	.894366	405	.105634	31			4
	58		30	.893840	401	.106160	. 64	. 36	.895176	404	.104824		30		2
17	60	30		8.894643		1.105357	9.998659	0.001341	8.895984		1.104016	30		42	0
m	s	′	″	L. Cos.	Diff. for 15″ or 1s	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15″ or 1s	L. Tang.	′	″	m	s
Hours.		Deg.										Deg.		Hours.	

6h 94° 1′ = 4s 1° = 4m 85° 5h

0h 4° 1s = 15'' 1m = 15' 1h = 15° 175° 11h

Hours m	Hours s	Deg. '	Deg. ''	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Deg. ''	Hours m	Hours s
18	0	30		8.894643	401	1.105357	9.998659	0.001341	8.895984	403	1.104016	30		41	0
	2		30	.895445	400	.104555	. 54	. 46	.896791	402	.103209		30		58
	4	31		.896245	399	.103755	. 49	. 51	.897596	402	.102404	29			56
	6		30	.897044	398	.102956	. 44	. 56	.898400	401	.101600		30		54
	8	32		.897842	398	.102158	. 39	. 61	.899203	400	.100797	28			52
	10		30	.898638	397	.101362	. 34	. 66	.900004	399	.099996		30		50
	12	33		.899432	396	.100568	. 29	. 71	.900803	398	.099197	27			48
	14		30	.900225	396	.099775	. 24	. 76	.901601	398	.098399		30		46
	16	34		.901017	395	.098983	. 19	. 81	.902398	397	.097602	26			44
	18		30	.901807	394	.098193	. 14	. 86	.903193	397	.096807		30		42
	20	35		.902596	393	.097404	. 09	. 91	.903987	396	.096013	25			40
	22		30	.903383	393	.096617	. 04	. 96	.904779	395	.095221		30		38
	24	36		.904169	392	.095831	.998599	.001401	.905570	394	.094430	24			36
	26		30	.904953	391	.095047	. 94	. 06	.906359	394	.093641		30		34
	28	37		.905736	390	.094264	. 89	. 11	.907147	393	.092853	23			32
	30		30	.906517	390	.093483	. 83	. 17	.907934	392	.092066		30		30
	32	38		.907297	389	.092703	. 78	. 22	.908719	392	.091281	22			28
	34		30	.908076	388	.091924	. 73	. 27	.909503	391	.090497		30		26
	36	39		.908853	388	.091147	. 68	. 32	.910285	390	.089715	21			24
	38		30	.909629	387	.090371	. 63	. 37	.911066	390	.088934		30		22
	40	40		.910404	386	.089596	. 58	. 42	.911846	389	.088154	20			20
	42		30	.911177	386	.088823	. 53	. 47	.912624	388	.087376		30		18
	44	41		.911949	385	.088051	. 48	. 52	.913401	388	.086599	19			16
	46		30	.912719	384	.087281	. 42	. 58	.914177	387	.085823		30		14
	48	42		.913488	384	.086512	. 37	. 63	.914951	386	.085049	18			12
	50		30	.914256	383	.085744	. 32	. 68	.915724	385	.084276		30		10
	52	43		.915022	382	.084978	. 27	. 73	.916495	385	.083505	17			8
	54		30	.915786	382	.084214	. 21	. 79	.917265	384	.082735		30		6
	56	44		.916550	381	.083450	. 16	. 84	.918034	383	.081966	16			4
	58		30	.917312	380	.082688	. 11	. 89	.918801	383	.081199		30		2
19	0	45		.918073	380	.081927	. 06	. 94	.919567	382	.080433	15		41	0
	2		30	.918833	379	.081167	. 01	. 99	.920332	382	.079668		30		58
	4	46		.919591	378	.080409	.998495	.001505	.921096	381	.078904	14			56
	6		30	.920348	378	.079652	. 90	. 10	.921858	380	.078142		30		54
	8	47		.921104	377	.078896	. 85	. 15	.922619	379	.077381	13			52
	10		30	.921858	376	.078142	. 80	. 20	.923378	379	.076622		30		50
	12	48		.922610	376	.077390	. 74	. 26	.924136	378	.075864	12			48
	14		30	.923362	375	.076638	. 69	. 31	.924893	378	.075107		30		46
	16	49		.924112	374	.075888	. 63	. 37	.925649	377	.074351	11			44
	18		30	.924861	374	.075139	. 58	. 42	.926403	376	.073597		30		42
	20	50		.925609	373	.074391	. 53	. 47	.927156	376	.072844	10			40
	22		30	.926355	372	.073645	. 47	. 53	.927908	375	.072092		30		38
	24	51		.927100	372	.072900	. 42	. 58	.928658	374	.071342	9			36
	26		30	.927844	371	.072156	. 37	. 63	.929407	374	.070593		30		34
	28	52		.928587	370	.071413	. 32	. 68	.930155	373	.069845	8			32
	30		30	.929328	370	.070672	. 26	. 74	.930902	372	.069098		30		30
	32	53		.930068	369	.069932	. 21	. 79	.931647	372	.068353	7			28
	34		30	.930806	369	.069194	. 15	. 85	.932391	571	.067609		30		26
	36	54		.931544	368	.068456	. 10	. 90	.933134	371	.066866	6			24
	38		30	.932280	367	.067720	. 04	. 96	.933876	370	.066124		30		22
	40	55		.933015	367	.066985	.998399	.001601	.934616	369	.065384	5			20
	42		30	.933749	366	.066251	. 94	. 06	.935355	369	.064645		30		18
	44	56		.934481	365	.065519	. 88	. 12	.936093	368	.063907	4			16
	46		30	.935212	365	.064788	. 83	. 17	.936829	368	.063171		30		14
	48	57		.935942	364	.064058	. 77	. 23	.937565	367	.062435	3			12
	50		30	.936671	363	.063329	. 72	. 28	.938299	366	.061701		30		10
	52	58		.937398	363	.062602	. 66	. 34	.939032	366	.060968	2			8
	54		30	.938125	362	.061875	. 61	. 39	.939764	365	.060236		30		6
	56	59		.938850	362	.061150	. 55	. 45	.940495	365	.059505	1			4
	58		30	.939574	361	.060426	. 50	. 50	.941224	364	.058776		30		2
19	0	0		8.940296		1.059704	9.998344	0.001656	8.941952		1.058048	0		40	0
m	s	'	''	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	''	m	s
Hours.		Deg.										Deg.		Hours.	

0ʰ 5° 1ˢ = 15″ 1ᵐ = 15′ 1ʰ = 15° 174° 11ʰ

Hours. m	Hours. s	Deg. ′	Deg. ″	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15″ or 1ˢ	L. Cot.	Deg. ′	Deg. ″	Hours. m	Hours. s
20	0	0		8.940296	361	1.059704	9.998344	0.001656	8.941952	363	1.058048	60		39	60
	2		30	.941018	360	.058982	. 39	. 61	.942679	363	.057321		30		58
	4	1		.941738	359	.058262	. 33	. 67	.943405	362	.056595	59			56
	6		30	.942457	358	.057543	. 28	. 72	.944129	361	.055871		30		54
	8	2		.943174	358	.056826	. 22	. 78	.944852	361	.055148	58			52
	10		30	.943891	357	.056109	. 17	. 83	.945574	360	.054426		30		50
	12	3		.944606	357	.055394	. 11	. 89	.946295	360	.053705	57			48
	14		30	.945320	357	.054680	. 05	. 95	.947015	359	.052985		30		46
	16	4		.946031	355	.053969	. 00	.001700	.947734	358	.052266	56			44
	18		30	.946745	355	.053255	.998294	. 06	.948451	358	.051549		30		42
	20	5		.947456	355	.052544	. 88	. 12	.949168	357	.050832	55			40
	22		30	.948166	354	.051834	. 83	. 17	.949883	357	.050117		30		38
	24	6		.948874	353	.051126	. 77	. 23	.950597	356	.049403	54			36
	26		30	.949581	353	.050419	. 72	. 28	.951309	356	.048691		30		34
	28	7		.950287	352	.049713	. 66	. 34	.952021	355	.047979	53			32
	30		30	.950992	352	.049008	. 60	. 40	.952732	354	.047268		30		30
	32	8		.951696	351	.048304	. 55	. 45	.953441	354	.046559	52			28
	34		30	.952398	351	.047602	. 49	. 51	.954149	354	.045851		30		26
	36	9		.953100	350	.046900	. 43	. 57	.954857	353	.045143	51			24
	38		30	.953800	349	.046200	. 38	. 62	.955562	352	.044438		30		22
	40	10		.954499	349	.045501	. 32	. 68	.956267	352	.043733	50			20
	42		30	.955197	348	.044803	. 26	. 74	.956971	351	.043029		30		18
	44	11		.955894	348	.044106	. 20	. 80	.957674	350	.042326	49			16
	46		30	.956590	347	.043410	. 15	. 85	.958375	350	.041625		30		14
	48	12		.957284	347	.042716	. 09	. 91	.959075	350	.040925	48			12
	50		30	.957978	346	.042022	. 03	. 97	.959775	349	.040225		30		10
	52	13		.958670	346	.041330	.998197	.001803	.960473	348	.039527	47			8
	54		30	.959362	345	.040638	. 92	. 08	.961170	348	.038830		30		6
	56	14		.960052	344	.039948	. 86	. 14	.961866	347	.038134	46			4
	58		30	.960741	344	.039259	. 80	. 20	.962561	347	.037439		30		2
21	0	15		.961429	343	.038571	. 74	. 26	.963255	346	.036745	45		39	0
	2		30	.962116	343	.037884	. 69	. 31	.963947	346	.036053		30		58
	4	16		.962802	342	.037198	. 63	. 37	.964639	345	.035361	44			56
	6		30	.963486	342	.036514	. 57	. 43	.965329	345	.034671		30		54
	8	17		.964170	341	.035830	. 51	. 49	.966019	344	.033981	43			52
	10		30	.964852	341	.035148	. 45	. 55	.966707	344	.033293		30		50
	12	18		.965534	340	.034466	. 39	. 61	.967395	343	.032605	42			48
	14		30	.966214	339	.033786	. 33	. 67	.968081	342	.031919		30		46
	16	19		.966893	339	.033107	. 27	. 73	.968766	342	.031234	41			44
	18		30	.967572	338	.032428	. 22	. 78	.969450	341	.030550		30		42
	20	20		.968249	338	.031751	. 16	. 84	.970133	341	.029867	40			40
	22		30	.968925	337	.031075	. 10	. 90	.970815	340	.029185		30		38
	24	21		.969600	337	.030400	. 04	. 96	.971496	340	.028504	39			36
	26		30	.970274	336	.029726	.998098	.001902	.972176	339	.027824		30		34
	28	22		.970947	336	.029053	. 92	. 08	.972855	339	.027145	38			32
	30		30	.971619	335	.028381	. 86	. 14	.973533	338	.026467		30		30
	32	23		.972289	335	.027711	. 80	. 20	.974209	338	.025791	37			28
	34		30	.972959	334	.027041	. 74	. 26	.974885	337	.025115		30		26
	36	24		.973628	334	.026372	. 68	. 32	.975560	337	.024440	36			24
	38		30	.974296	333	.025704	. 62	. 38	.976234	336	.023766		30		22
	40	25		.974962	333	.025038	. 56	. 44	.976906	336	.023094	35			20
	42		30	.975628	332	.024372	. 50	. 50	.977578	335	.022422		30		18
	44	26		.976292	332	.023708	. 44	. 56	.978248	335	.021752	34			16
	46		30	.976956	331	.023044	. 38	. 62	.978918	334	.021082		30		14
	48	27		.977619	330	.022381	. 32	. 68	.979587	333	.020413	33			12
	50		30	.978280	330	.021720	. 26	. 74	.980254	333	.019746		30		10
	52	28		.978941	329	.021059	. 20	. 80	.980921	332	.019079	32			8
	54		30	.979600	329	.020400	. 14	. 86	.981586	332	.018414		30		6
	56	29		.980259	328	.019741	. 08	. 92	.982251	331	.017749	31			4
	58		30	.980916	328	.019084	. 02	. 98	.982914	331	.017086		30		2
21	60	30		8.981573		1.018427	9.997996	0.002004	8.983577		1.016423	30		38	0
m	s	′	″	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Sin.	L. Cosec.	L. Cot.	Diff. for 15″ or 1ˢ	L. Tang.	′	″	m	s
Hours.		Deg.										Deg.		Hours.	

6ʰ 95° 1′ = 4ˢ 1° = 4ᵐ 84° 5ʰ

Deg. ''	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Deg. ''	Hours m	Hours s
	8.981573	327	1.018427	9.997936	0.002004	8.983577	331	1.016423	30		37	60
30	.982228	327	.017772	. 90	. 10	.984238	330	.015762		30		58
	.982883	327	.017117	. 84	. 16	.984899	330	.015101	29			56
30	.983537	326	.016463	. 78	. 22	.985559	329	.014441		30		54
	.984189	325	.015811	. 72	. 28	.986217	329	.013783	28			52
30	.984840	325	.015160	. 65	. 35	.986875	328	.013125		30		50
	.985491	325	.014509	. 59	. 41	.987532	327	.012468	27			48
30	.986140	324	.013860	. 53	. 47	.988187	327	.011813		30		46
	.986789	324	.013211	. 47	. 53	.988842	327	.011158	26			44
30	.987437	323	.012563	. 41	. 59	.989496	326	.010504		30		42
	.988084	323	.011916	. 35	. 65	.990149	326	.009851	25			40
30	.988729	322	.011271	. 28	. 72	.990801	325	.009199		30		38
	.989374	321	.010626	. 22	. 78	.991452	325	.008548	24			36
30	.990017	321	.009983	. 16	. 84	.992101	324	.007899		30		34
	.990660	321	.009340	. 10	. 90	.992750	324	.007250	23			32
30	.991302	320	.008698	. 04	. 96	.993398	323	.006602		30		30
	.991943	320	.008057	.997898	.002102	.994045	323	.005955	22			28
30	.992583	319	.007417	. 91	. 09	.994692	322	.005308		30		26
	.993222	319	.006778	. 85	. 15	.995337	322	.004663	21			24
30	.993860	318	.006140	. 79	. 21	.995981	321	.004019		30		22
	.994497	318	.005503	. 73	. 27	.996624	321	.003376	20			20
30	.995133	317	.004867	. 66	. 34	.997267	320	.002733		30		18
	.995768	317	.004232	. 60	. 40	.997908	320	.002092	19			16
30	.996402	317	.003598	. 53	. 47	.998549	319	.001451		30		14
	.997035	316	.002965	. 47	. 53	.999188	319	.000812	18			12
30	.997668	316	.002332	. 41	. 59	.999827	319	.000173		30		10
	.998300	315	.001700	. 35	. 65	9.000465	318	0.999535	17			8
30	.998930	315	.001070	. 28	. 72	.001102	318	.998898		30		6
	.999560	314	.000440	. 22	. 78	.001738	317	.998262	16			4
30	9.000188	314	0.999812	. 16	. 84	.002372	317	.997628		30		2
	.000816	313	.999184	. 09	. 91	.003007	316	.996993	15		37	0
30	.001443	313	.998557	. 03	. 97	.003640	316	.996360		30		58
	.002069	312	.997931	.997797	.002203	.004272	316	.995728	14			56
30	.002694	312	.997306	. 90	. 10	.004904	315	.995096		30		54
	.003318	311	.996682	. 84	. 16	.005534	315	.994466	13			52
30	.003941	311	.996059	. 77	. 23	.006164	314	.993836		30		50
	.004563	311	.995437	. 71	. 29	.006792	314	.993208	12			48
30	.005185	310	.994815	. 65	. 35	.007420	313	.992580		30		46
	.005805	310	.994195	. 58	. 42	.008047	313	.991953	11			44
30	.006425	309	.993575	. 52	. 48	.008673	313	.991327		30		42
	.007044	309	.992956	. 45	. 55	.009299	312	.990701	10			40
30	.007662	308	.992338	. 39	. 61	.009923	311	.990077		30		38
	.008278	308	.991722	. 32	. 68	.010546	311	.989454	9			36
30	.008895	307	.991105	. 26	. 74	.011169	310	.988831		30		34
	.009510	307	.990490	. 20	. 80	.011790	310	.988210	8			32
30	.010124	306	.989876	. 13	. 87	.012411	310	.987589		30		30
	.010737	306	.989263	. 06	. 94	.013031	309	.986969	7			28
30	.011350	305	.988650	. 00	.002300	.013650	309	.986350		30		26
	.011961	305	.988039	.997693	. 07	.014268	308	.985732	6			24
30	.012572	305	.987428	. 87	. 13	.014885	308	.985115		30		22
	.013182	305	.986818	. 80	. 20	.015502	308	.984498	5			20
30	.013792	304	.986208	. 74	. 26	.016118	307	.983882		30		18
	.014400	303	.985600	. 67	. 33	.016733	306	.983267	4			16
30	.015007	303	.984993	. 61	. 39	.017346	306	.982654		30		14
	.015613	303	.984387	. 54	. 46	.017959	306	.982041	3			12
30	.016219	302	.983781	. 47	. 53	.018572	305	.981428		30		10
	.016824	302	.983176	. 41	. 59	.019183	305	.980817	2			8
30	.017428	301	.982572	. 34	. 66	.019794	304	.980206		30		6
	.018031	301	.981969	. 28	. 72	.020403	304	.979597	1			4
30	.018633	301	.981367	. 21	. 79	.021012	304	.978988		30		2
	9.019234		0.980766	9.997614	0.002386	9.021620		0.978380	0		36	0
'' Deg.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	L. Cosec	L. Cot.	Diff. for 15'' or 1s	L. Tang.	Deg. '	Deg. ''	Hours m	Hours s

0h 6° 1s = 15'' 1m = 15' 1h = 15° 173° 11h

Hours m	Hours s	Deg '	L. Sin.	Diff for 15'' or 1s	L. Cosec.	L. Cos.	Diff for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours m	Hours s
24	0	0	9.019234	300	9.980766	9.997614	3	0.002386	9.021620	303	0.978380	60	35	60
	4	1	.020435	299	.979565	. 7601	3	. 2399	. 2834	302	. 7166	59		56
	8	2	. 1632	298	. 8368	. 7588	3	. 2412	. 4044	302	. 5956	58		52
	12	3	. 2825	298	. 7175	. 7574	3	. 2426	. 5251	301	. 4749	57		48
	16	4	. 4016	297	. 5984	. 7561	3	. 2439	. 6455	300	. 3545	56		44
	20	5	. 5203	296	. 4797	. 7548	3	. 2452	. 7655	299	. 2345	55		40
	24	6	. 6386	295	. 3614	. 7534	3	. 2466	. 8852	298	. 1148	54		36
	28	7	. 7567	294	. 2433	. 7521	3	. 2479	.030046	298	.969954	53		32
	32	8	. 8744	293	. 1256	. 7507	3	. 2493	. 1237	297	. 8763	52		28
	36	9	. 9918	293	. 0082	. 7493	3	. 2507	. 2425	296	. 7575	51		24
	40	10	.031089	292	.968911	. 7480	3	. 2520	. 3609	295	. 6391	50		20
	44	11	. 2257	291	. 7743	. 7466	3	. 2534	. 4791	294	. 5209	49		16
	48	12	. 3421	290	. 6579	. 7452	3	. 2548	. 5969	294	. 4031	48		12
	52	13	. 4583	289	. 5417	. 7439	3	. 2561	. 7144	293	. 2856	47		8
	56	14	. 5741	289	. 4259	. 7425	3	. 2575	. 8316	292	. 1684	46		4
25	0	15	. 6896	288	. 3104	. 7411	3	. 2589	. 9485	291	. 0515	45	35	0
	4	16	. 8048	287	. 1952	. 7397	3	. 2603	.040651	291	.959349	44		56
	8	17	. 9197	286	. 0803	. 7383	3	. 2617	. 1814	290	. 8186	43		52
	12	18	.040342	286	.959658	. 7369	3	. 2631	. 2973	289	. 7027	42		48
	16	19	. 1485	285	. 8515	. 7355	3	. 2645	. 4130	288	. 5870	41		44
	20	20	. 2625	284	. 7375	. 7341	3	. 2659	. 5284	288	. 4716	40		40
	24	21	. 3762	283	. 6238	. 7327	3	. 2673	. 6435	287	. 3565	39		36
	28	22	. 4895	283	. 5105	. 7313	3	. 2687	. 7582	286	. 2418	38		32
	32	23	. 6026	282	. 3974	. 7299	3	. 2701	. 8727	285	. 1273	37		28
	36	24	. 7154	281	. 2846	. 7285	3	. 2715	. 9869	285	. 0131	36		24
	40	25	. 8279	280	. 1721	. 7271	3	. 2729	.051008	284	.948992	35		20
	44	26	. 9401	279	. 0599	. 7257	4	. 2743	. 2144	283	. 7856	34		16
	48	27	.050519	279	.949481	. 7242	3	. 2758	. 3277	282	. 6723	33		12
	52	28	. 1635	278	. 8365	. 7228	3	. 2772	. 4407	282	. 5593	32		8
	56	29	. 2749	277	. 7251	. 7214	4	. 2786	. 5535	281	. 4465	31		4
26	0	30	. 3859	277	. 6141	. 7199	3	. 2801	. 6660	280	. 3340	30	34	0
	4	31	. 4966	276	. 5034	. 7185	3	. 2815	. 7781	280	. 2219	29		56
	8	32	. 6071	275	. 3929	. 7171	4	. 2829	. 8900	279	. 1100	28		52
	12	33	. 7172	275	. 2828	. 7156	4	. 2844	.060016	278	.939984	27		48
	16	34	. 8271	274	. 1729	. 7141	3	. 2859	. 1130	277	. 8870	26		44
	20	35	. 9367	273	. 0633	. 7127	4	. 2873	. 2240	277	. 7760	25		40
	24	36	.060460	273	.939540	. 7112	3	. 2888	. 3348	276	. 6652	24		36
	28	37	. 1551	272	. 8449	. 7098	4	. 2902	. 4453	276	. 5547	23		32
	32	38	. 2639	271	. 7361	. 7083	4	. 2917	. 5556	275	. 4444	22		28
	36	39	. 3723	271	. 6277	. 7068	3	. 2932	. 6655	274	. 3345	21		24
	40	40	. 4806	270	. 5194	. 7054	4	. 2946	. 7752	273	. 2248	20		20
	44	41	. 5885	269	. 4115	. 7039	4	. 2961	. 8846	273	. 1154	19		16
	48	42	. 6962	268	. 3038	. 7024	4	. 2976	. 9938	272	. 0062	18		12
	52	43	. 8036	268	. 1964	. 7009	4	. 2991	.071027	271	.928973	17		8
	56	44	. 9107	267	. 0893	. 6994	4	. 3006	. 2113	271	. 7887	16		4
27	0	45	.070176	266	.929824	. 6979	4	. 3021	. 3197	270	. 6803	15	33	0
	4	46	. 1242	266	. 8758	. 6964	4	. 3036	. 4278	269	. 5722	14		56
	8	47	. 2305	265	. 7695	. 6949	4	. 3051	. 5356	269	. 4644	13		52
	12	48	. 3366	264	. 6634	. 6934	4	. 3066	. 6432	268	. 3568	12		48
	16	49	. 4424	264	. 5576	. 6919	4	. 3081	. 7505	268	. 2495	11		44
	20	50	. 5480	263	. 4520	. 6904	4	. 3096	. 8576	267	. 1424	10		40
	24	51	. 6533	262	. 3467	. 6889	4	. 3111	. 9644	266	. 0356	9		36
	28	52	. 7583	262	. 2417	. 6873	4	. 3127	.080710	266	.919290	8		32
	32	53	. 8631	261	. 1369	. 6858	4	. 3142	. 1773	265	. 8227	7		28
	36	54	. 9676	261	. 0324	. 6843	4	. 3157	. 2833	264	. 7167	6		24
	40	55	.080719	260	.919281	. 6828	4	. 3172	. 3891	264	. 6109	5		20
	44	56	. 1759	259	. 8241	. 6812	4	. 3188	. 4947	263	. 5053	4		16
	48	57	. 2797	259	. 7203	. 6797	4	. 3203	. 6000	262	. 4000	3		12
	52	58	. 3832	258	. 6168	. 6782	4	. 3218	. 7050	262	. 2950	2		8
	56	59	. 4864	258	. 5136	. 6766	4	. 3234	. 8098	261	. 1902	1		4
27	0	60	9.085895		0.914105	9.996751		0.003249	9.089144		0.910856	0	32	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg	Hours.	

6h 96° 1' = 4s 1° = 4m 83° 5h

7°   1' = 15''   1m = 15'   1h = 15°   172°   11h

Deg. ′	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot	Deg ′	Hours m	s
0	9.085895	257	0.914105	9.996751	4	0.003249	9.089144	261	0.910856	60	31	60
1	. 6922	256	. 3078	. 6735	4	. 3265	.090187	260	.909813	59		56
2	. 7947	256	. 2053	. 6719	4	. 3281	. 1228	259	. 8772	58		52
3	. 8970	255	. 1030	. 6704	4	. 3296	. 2266	259	. 7734	57		48
4	. 9990	254	. 0010	. 6688	4	. 3312	. 3302	258	. 6698	56		44
5	.091008	254	.908992	. 6673	4	. 3327	. 4335	258	. 5665	55		40
6	. 2024	253	. 7976	. 6657	4	. 3343	. 5367	257	. 4633	54		36
7	. 3037	252	. 6963	. 6641	4	. 3359	. 6396	256	. 3604	53		32
8	. 4047	252	. 5953	. 6625	4	. 3375	. 7422	256	. 2578	52		28
9	. 5056	251	. 4944	. 6610	4	. 3390	. 8446	255	. 1554	51		24
10	. 6062	251	. 3938	. 6594	4	. 3406	. 9468	255	. 0532	50		20
11	. 7065	250	. 2935	. 6578	4	. 3422	.100487	254	.899513	49		16
12	. 8066	250	. 1934	. 6562	4	. 3438	. 1504	254	. 8496	48		12
13	. 9065	249	. 0935	. 6546	4	. 3454	. 2519	253	. 7481	47		8
14	.100062	248	.899938	. 6530	4	. 3470	. 3532	252	. 6468	46		4
15	. 1056	248	. 8944	. 6514	4	. 3486	. 4542	252	. 5458	45	31	0
16	. 2048	247	. 7952	. 6498	4	. 3502	. 5550	251	. 4450	44		56
17	. 3037	247	. 6963	. 6481	4	. 3519	. 6556	251	. 3444	43		52
18	. 4025	246	. 5975	. 6466	4	. 3534	. 7559	250	. 2441	42		48
19	. 5010	245	. 4990	. 6449	4	. 3551	. 8561	250	. 1439	41		44
20	. 5992	245	. 4008	. 6433	4	. 3567	. 9559	249	. 0441	40		40
21	. 6973	244	. 3027	. 6417	4	. 3583	.110556	249	.889444	39		36
22	. 7951	244	. 2049	. 6400	4	. 3600	. 1551	248	. 8449	38		32
23	. 8927	243	. 1073	. 6384	4	. 3616	. 2543	247	. 7457	37		28
24	. 9901	243	. 0099	. 6368	4	. 3632	. 3533	247	. 6467	36		24
25	.110872	242	.889128	. 6351	4	. 3649	. 4521	246	. 5479	35		20
26	. 1842	242	. 8158	. 6335	4	. 3665	. 5507	246	. 4493	34		16
27	. 2809	241	. 7191	. 6318	4	. 3682	. 6491	245	. 3509	33		12
28	. 3774	241	. 6226	. 6302	4	. 3698	. 7472	245	. 2528	32		8
29	. 4737	240	. 5263	. 6285	4	. 3715	. 8452	244	. 1548	31		4
30	. 5698	239	. 4302	. 6269	4	. 3731	. 9429	244	. 0571	30	30	0
31	. 6656	239	. 3344	. 6252	4	. 3748	.120404	243	.879596	29		56
32	. 7612	239	. 2388	. 6235	4	. 3765	. 1377	243	. 8623	28		52
33	. 8567	238	. 1433	. 6219	4	. 3781	. 2348	242	. 7652	27		48
34	. 9519	237	. 0481	. 6202	4	. 3798	. 3317	242	. 6683	26		44
35	.120469	237	.879531	. 6185	4	. 3815	. 4284	241	. 5716	25		40
36	. 1417	236	. 8583	. 6168	4	. 3832	. 5249	240	. 4751	24		36
37	. 2362	236	. 7638	. 6151	4	. 3849	. 6211	240	. 3789	23		32
38	. 3306	235	. 6694	. 6134	4	. 3866	. 7172	239	. 2828	22		28
39	. 4248	235	. 5752	. 6118	4	. 3882	. 8130	239	. 1870	21		24
40	. 5187	234	. 4813	. 6100	4	. 3900	. 9087	238	. 0913	20		20
41	. 6125	234	. 3875	. 6084	4	. 3916	.130041	238	.869959	19		16
42	. 7060	233	. 2940	. 6066	4	. 3934	. 0994	237	. 9006	18		12
43	. 7993	233	. 2007	. 6049	4	. 3951	. 1944	237	. 8056	17		8
44	. 8925	232	. 1075	. 6032	4	. 3968	. 2893	236	. 7107	16		4
45	. 9854	232	. 0146	. 6015	4	. 3985	. 3839	236	. 6161	15	29	0
46	.130781	231	.869219	. 5998	4	. 4002	. 4783	236	. 5217	14		56
47	. 1703	231	. 8297	. 5980	4	. 4020	. 5726	235	. 4274	13		52
48	. 2630	230	. 7370	. 5963	4	. 4037	. 6667	234	. 3333	12		48
49	. 3551	230	. 6449	. 5946	4	. 4054	. 7605	234	. 2395	11		44
50	. 4470	229	. 5530	. 5928	4	. 4072	. 8542	233	. 1458	10		40
51	. 5387	229	. 4613	. 5911	4	. 4089	. 9476	233	. 0524	9		36
52	. 6303	228	. 3697	. 5894	4	. 4106	.140409	233	.859591	8		32
53	. 7216	228	. 2784	. 5876	4	. 4194	. 1340	232	. 8660	7		28
54	. 8128	227	. 1872	. 5859	4	. 4141	. 2269	232	. 7731	6		24
55	. 9037	227	. 0963	. 5841	4	. 4159	. 3196	231	. 6804	5		20
56	. 9945	226	. 0055	. 5824	4	. 4176	. 4121	231	. 5879	4		16
57	.140850	226	.859150	. 5806	4	. 4194	. 5044	230	. 4956	3		12
58	. 1754	225	. 8246	. 5788	4	. 4212	. 5966	230	. 4034	2		8
59	. 2656	225	. 7344	. 5771	4	. 4229	. 6885	229	. 3115	1		4
60	9.143555		0.856445	9.995753		0.004247	9.147803		0.852197	0	28	0
′ Deg.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	′ Deg.	m Hours	s

97°   1' = 4s   1° = 4m   82°   5h

0h 8° 1s = 15'' 1m = 15' 1h = 15° 171°

Hours. m	Hours. s	Deg. °	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '
32	0		0	9.143555	224	0.856445	9.995753	4	0.004247	9.147802	229	0.852198	60
	4		1	. 4453	224	. 5547	. 5735	4	. 4265	. 8718	228	. 1282	59
	8		2	. 5349	223	. 4651	. 5717	4	. 4283	. 9632	228	. 0368	58
	12		3	. 6243	223	. 3757	. 5699	4	. 4301	.150544	227	.849456	57
	16		4	. 7136	222	. 2864	. 5682	4	. 4318	. 1454	227	. 8546	56
	20		5	. 8026	222	. 1974	. 5663	4	. 4337	. 2363	226	. 7637	55
	24		6	. 8915	222	. 1085	. 5646	4	. 4354	. 3269	226	. 6731	54
	28		7	. 9802	221	. 0198	. 5628	4	. 4372	. 4174	226	. 5826	53
	32		8	.150686	221	.849314	. 5609	4	. 4391	. 5077	225	. 4923	52
	36		9	. 1569	220	. 8431	. 5591	5	. 4409	. 5978	225	. 4022	51
	40		10	. 2451	220	. 7549	. 5574	4	. 4426	. 6877	224	. 3123	50
	44		11	. 3330	219	. 6670	. 5555	4	. 4445	. 7775	224	. 2225	49
	48		12	. 4208	219	. 5792	. 5537	4	. 4463	. 8671	223	. 1329	48
	52		13	. 5084	218	. 4916	. 5519	4	. 4481	. 9565	223	. 0435	47
	56		14	. 5957	218	. 4043	. 5500	5	. 4500	.160457	222	.839543	46
33	0		15	. 6829	218	. 3171	. 5482	4	. 4518	. 1347	222	. 8653	45
	4		16	. 7700	217	. 2300	. 5464	4	. 4536	. 2236	222	. 7764	44
	8		17	. 8569	216	. 1431	. 5446	5	. 4554	. 3123	221	. 6877	43
	12		18	. 9435	216	. 0565	. 5427	4	. 4573	. 4008	221	. 5992	42
	16		19	.160301	216	.839699	. 5409	5	. 4591	. 4892	220	. 5108	41
	20		20	. 1164	215	. 8836	. 5390	4	. 4610	. 5774	220	. 4226	40
	24		21	. 2026	215	. 7974	. 5372	5	. 4628	. 6654	219	. 3346	39
	28		22	. 2885	214	. 7115	. 5353	4	. 4647	. 7532	219	. 2468	38
	32		23	. 3743	214	. 6257	. 5334	5	. 4666	. 8409	219	. 1591	37
	36		24	. 4600	213	. 5400	. 5316	5	. 4684	. 9284	218	. 0716	36
	40		25	. 5454	213	. 4546	. 5297	4	. 4703	.170157	218	.829843	35
	44		26	. 6307	213	. 3693	. 5278	5	. 4722	. 1029	217	. 8971	34
	48		27	. 7159	212	. 2841	. 5260	5	. 4740	. 1899	217	. 8101	33
	52		28	. 8008	212	. 1992	. 5241	5	. 4759	. 2767	217	. 7233	32
	56		29	. 8856	211	. 1144	. 5222	5	. 4778	. 3634	216	. 6366	31
34	0		30	. 9702	211	. 0298	. 5203	5	. 4797	. 4499	216	. 5501	30
	4		31	.170546	211	.829454	. 5184	5	. 4816	. 5362	215	. 4638	29
	8		32	. 1389	210	. 8611	. 5165	5	. 4835	. 6224	215	. 3776	28
	12		33	. 2230	210	. 7770	. 5146	5	. 4854	. 7084	215	. 2916	27
	16		34	. 3070	209	. 6930	. 5127	5	. 4873	. 7943	214	. 2057	26
	20		35	. 3908	209	. 6092	. 5108	5	. 4892	. 8800	214	. 1200	25
	24		36	. 4744	208	. 5256	. 5089	5	. 4911	. 9655	213	. 0345	24
	28		37	. 5578	208	. 4422	. 5070	5	. 4930	.180508	213	.819492	23
	32		38	. 6411	208	. 3589	. 5051	5	. 4949	. 1360	213	. 8640	22
	36		39	. 7243	207	. 2757	. 5032	5	. 4968	. 2211	212	. 7789	21
	40		40	. 8072	207	. 1928	. 5013	5	. 4987	. 3059	212	. 6941	20
	44		41	. 8900	207	. 1100	. 4993	5	. 5007	. 3907	211	. 6093	19
	48		42	. 9727	206	. 0273	. 4974	5	. 5026	. 4753	211	. 5247	18
	52		43	.180551	206	.819449	. 4954	5	. 5046	. 5597	210	. 4403	17
	56		44	. 1374	205	. 8626	. 4935	5	. 5065	. 6439	210	. 3561	16
35	0		45	. 2196	205	. 7804	. 4916	5	. 5084	. 7280	210	. 2720	15
	4		46	. 3016	204	. 6984	. 4896	5	. 5104	. 8120	209	. 1880	14
	8		47	. 3834	204	. 6166	. 4877	5	. 5123	. 8957	209	. 1043	13
	12		48	. 4651	204	. 5349	. 4857	5	. 5143	. 9794	209	. 0206	12
	16		49	. 5467	203	. 4533	. 4838	5	. 5162	.190629	208	.809371	11
	20		50	. 6280	203	. 3720	. 4818	5	. 5182	. 1462	208	. 8538	10
	24		51	. 7092	203	. 2908	. 4798	5	. 5202	. 2294	207	. 7706	9
	28		52	. 7903	202	. 2097	. 4779	5	. 5221	. 3124	207	. 6876	8
	32		53	. 8712	202	. 1288	. 4759	5	. 5241	. 3953	207	. 6047	7
	36		54	. 9519	201	. 0481	. 4739	5	. 5261	. 4780	206	. 5220	6
	40		55	.190325	201	.809675	. 4719	5	. 5281	. 5606	206	. 4394	5
	44		56	. 1130	201	. 8870	. 4700	5	. 5300	. 6430	206	. 3570	4
	48		57	. 1933	200	. 8067	. 4680	5	. 5320	. 7253	205	. 2747	3
	52		58	. 2734	200	. 7266	. 4660	5	. 5340	. 8074	205	. 1926	2
	56		59	. 3534	199	. 6466	. 4640	5	. 5360	. 8894	204	. 1106	1
36	60		60	9.194332		0.805668	9.994620		0.005380	9.199712		0.800288	0
m	s	°	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'
Hours.		Deg.											Deg.

TABLE II.—LOG. SINES, TANG'S, &c.

9° 1ˢ = 15″ 1ᵐ = 15′ 1ʰ = 15° 170° 11ʰ

Deg. ′	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Tang.	Diff. for 15″ or 1ˢ	L. Cot.	Deg. ′	Hours ᵐ	Hours ˢ
0	9.194332	199	0.805668	9.994620	5	0.005380	9.199712	204	0.800288	60	23	60
1	. 5129	199	. 4871	. 4600	5	. 5400	.200529	204	.799471	59		56
2	. 5925	198	. 4075	. 4580	5	. 5420	. 1345	203	. 8655	58		52
3	. 6719	198	. 3281	. 4560	5	. 5440	. 2159	203	. 7841	57		48
4	. 7511	198	. 2489	. 4540	5	. 5460	. 2971	203	. 7029	56		44
5	. 8302	197	. 1698	. 4519	5	. 5481	. 3783	202	. 6217	55		40
6	. 9091	197	. 0909	. 4499	5	. 5501	. 4592	202	. 5408	54		36
7	. 9879	197	. 0121	. 4479	5	. 5521	. 5400	202	. 4600	53		32
8	.200666	196	.799334	. 4459	5	. 5541	. 6207	201	. 3793	52		28
9	. 1451	196	. 8549	. 4438	5	. 5562	. 7013	201	. 2987	51		24
10	. 2235	195	. 7765	. 4418	5	. 5582	. 7817	200	. 2183	50		20
11	. 3017	195	. 6983	. 4398	5	. 5602	. 8619	200	. 1381	49		16
12	. 3797	195	. 6203	. 4377	5	. 5623	. 9420	200	. 0580	48		12
13	. 4577	194	. 5423	. 4357	5	. 5643	.210220	199	.789780	47		8
14	. 5354	194	. 4646	. 4336	5	. 5664	. 1018	199	. 8982	46		4
15	. 6131	194	. 3869	. 4316	5	. 5684	. 1815	199	. 8185	45	23	0
16	. 6906	193	. 3094	. 4295	5	. 5705	. 2611	198	. 7389	44		56
17	. 7679	193	. 2321	. 4274	5	. 5726	. 3405	198	. 6595	43		52
18	. 8452	192	. 1548	. 4254	5	. 5746	. 4198	198	. 5802	42		48
19	. 9222	192	. 0778	. 4233	5	. 5767	. 4989	197	. 5011	41		44
20	. 9991	192	. 0009	. 4212	5	. 5788	. 5779	197	. 4221	40		40
21	.210760	191	.789240	. 4192	5	. 5808	. 6568	197	. 3432	39		36
22	. 1526	191	. 8474	. 4170	5	. 5830	. 7356	196	. 2644	38		32
23	. 2292	191	. 7708	. 4150	5	. 5850	. 8142	196	. 1858	37		28
24	. 3055	191	. 6945	. 4129	5	. 5871	. 8926	196	. 1074	36		24
25	. 3818	190	. 6182	. 4108	5	. 5892	. 9710	195	. 0290	35		20
26	. 4579	190	. 5421	. 4087	5	. 5913	.220492	195	.779508	34		16
27	. 5338	190	. 4662	. 4066	5	. 5934	. 1272	195	. 8728	33		12
28	. 6097	189	. 3903	. 4045	5	. 5955	. 2052	194	. 7948	32		8
29	. 6854	189	. 3146	. 4024	5	. 5976	. 2830	194	7170	31		4
30	. 7609	189	. 2391	. 4003	5	. 5997	. 3606	194	. 6394	30	22	0
31	. 8364	188	. 1636	. 3982	5	. 6018	. 4382	193	. 5618	29		56
32	. 9116	188	. 0884	. 3960	5	. 6040	. 5156	193	. 4844	28		52
33	. 9868	187	. 0132	. 3939	5	. 6061	. 5929	193	. 4071	27		48
34	.220618	187	.779382	. 3918	5	. 6082	. 6700	193	. 3300	26		44
35	. 1367	187	. 8633	. 3896	5	. 6104	. 7471	192	. 2529	25		40
36	. 2115	186	. 7885	. 3875	5	. 6125	. 8240	192	. 1760	24		36
37	. 2861	186	. 7139	. 3854	5	. 6146	. 9007	192	. 0993	23		32
38	. 3606	186	. 6394	. 3832	5	. 6168	. 9774	191	. 0226	22		28
39	. 4350	185	. 5650	. 3811	5	. 6189	.230539	191	.769461	21		24
40	. 5092	185	. 4908	. 3789	5	. 6211	. 1303	190	. 8697	20		20
41	. 5833	185	. 4167	. 3768	5	. 6232	. 2065	190	. 7935	19		16
42	. 6572	185	. 3428	. 3746	5	. 6254	. 2826	190	. 7174	18		12
43	. 7311	184	. 2689	. 3725	5	. 6275	. 3586	190	. 6414	17		8
44	. 8048	184	. 1952	. 3703	5	. 6297	. 4345	189	. 5655	16		4
45	. 8784	184	. 1216	. 3681	5	. 6319	. 5103	189	. 4897	15	21	0
46	. 9519	183	. 0481	. 3660	5	. 6340	. 5859	189	. 4141	14		56
47	.230252	183	.769748	. 3638	5	. 6362	. 6614	188	. 3386	13		52
48	. 0984	182	. 9016	. 3616	5	. 6384	. 7368	188	. 2632	12		48
49	. 1714	182	. 8286	. 3594	5	. 6406	. 8120	188	. 1880	11		44
50	. 2444	182	. 7556	. 3572	5	. 6428	. 8872	187	. 1128	10		40
51	. 3172	182	. 6828	. 3550	5	. 6450	. 9622	187	. 0378	9		36
52	. 3899	181	. 6101	. 3528	5	. 6472	.240371	187	.759629	8		32
53	. 4625	181	. 5375	. 3506	6	. 6494	. 1119	186	. 8881	7		28
54	. 5349	181	. 4651	. 3484	5	. 6516	. 1865	186	. 8135	6		24
55	. 6072	180	. 3928	. 3462	5	. 6538	. 2610	186	. 7390	5		20
56	. 6794	180	. 3206	. 3440	5	. 6560	. 3354	186	. 6646	4		16
57	. 7515	180	. 2485	. 3418	5	. 6582	. 4097	185	. 5903	3		12
58	. 8235	179	. 1765	. 3396	5	. 6604	. 4839	185	. 5161	2		8
59	. 8953	179	. 1047	. 3374	6	. 6626	. 5579	185	. 4421	1		4
60	9.239670		0.760330	9.993351		0.006649	9.246319		0.753681	0	20	0
′ Deg.	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cot.	Diff. for 15″ or 1ˢ	L. Tang.	′ Deg.	ᵐ Hours.	ˢ

99° 1′ = 4ˢ 1° = 4ᵐ 80° 5ʰ

0h 10° 1° = 15'' 1m = 15' 1h = 15° 169° 11h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Tang.	Diff. for 15'' or 1'	L. Cot.	Deg. '	Hours. m	Hours. s
40	0	0	9.239670	179	0.760330	9.993351	6	0.006649	9.246319	184	0.753681	60	19	60
	4	1	.240386	179	.759614	. 3329	5	. 6671	. 7057	184	. 2943	59		56
	8	2	. 1101	178	. 8899	. 3307	6	. 6693	. 7794	184	. 2206	58		52
	12	3	. 1814	178	. 8186	. 3284	5	. 6716	. 8530	183	. 1470	57		48
	16	4	. 2526	178	. 7474	. 3262	5	. 6738	. 9264	183	. 0736	56		44
	20	5	. 3238	177	. 6762	. 3240	6	. 6760	. 9998	183	. 0002	55		40
	24	6	. 3947	177	. 6053	. 3217	5	. 6783	.250730	183	.749270	54		36
	28	7	. 4656	177	. 5344	. 3195	6	. 6805	. 1461	182	. 8539	53		32
	32	8	. 5363	176	. 4637	. 3172	6	. 6828	. 2191	182	. 7809	52		28
	36	9	. 6069	176	. 3931	. 3149	5	. 6851	. 2920	182	. 7080	51		24
	40	10	. 6775	176	. 3225	. 3127	6	. 6873	. 3648	181	. 6352	50		20
	44	11	. 7479	176	. 2522	. 3104	6	. 6896	. 4374	181	. 5626	49		16
	48	12	. 8181	175	. 1819	. 3081	5	. 6919	. 5100	181	. 4900	48		12
	52	13	. 8883	175	. 1117	. 3059	6	. 6941	. 5824	181	. 4176	47		8
	56	14	. 9583	175	. 0417	. 3036	6	. 6964	. 6547	180	. 3453	46		4
41	0	15	.250282	174	.749718	. 3013	6	. 6987	. 7269	180	. 2731	45	19	0
	4	16	. 0980	174	. 9020	. 2990	6	. 7010	. 7990	180	. 2010	44		56
	8	17	. 1677	174	. 8323	. 2967	6	. 7033	. 8710	180	. 1290	43		52
	12	18	. 2373	173	. 7627	. 2944	6	. 7056	. 9429	179	. 0571	42		48
	16	19	. 3067	173	. 6933	. 2921	6	. 7079	.260146	179	.739854	41		44
	20	20	. 3761	173	. 6239	. 2898	6	. 7102	. 0863	179	. 9137	40		40
	24	21	. 4453	173	. 5547	. 2875	6	. 7125	. 1578	178	. 8422	39		36
	28	22	. 5144	172	. 4856	. 2852	6	. 7148	. 2292	178	. 7708	38		32
	32	23	. 5834	172	. 4166	. 2829	6	. 7171	. 3005	178	. 6995	37		28
	36	24	. 6523	172	. 3477	. 2806	6	. 7194	. 3717	178	. 6283	36		24
	40	25	. 7211	172	. 2789	. 2783	6	. 7217	. 4428	177	. 5572	35		20
	44	26	. 7898	171	. 2102	. 2760	6	. 7240	. 5138	177	. 4862	34		16
	48	27	. 8583	171	. 1417	. 2736	6	. 7264	. 5847	177	. 4153	33		12
	52	28	. 9268	171	. 0732	. 2713	6	. 7287	. 6555	176	. 3445	32		8
	56	29	. 9951	170	. 0049	. 2690	6	. 7310	. 7261	176	. 2739	31		4
42	0	30	.260633	170	.739367	. 2666	6	. 7334	. 7967	176	. 2033	30	18	0
	4	31	. 1314	170	. 8686	. 2643	6	. 7357	. 8671	176	. 1329	29		56
	8	32	. 1994	170	. 8006	. 2619	6	. 7381	. 9375	175	. 0625	28		52
	12	33	. 2673	169	. 7327	. 2596	6	. 7404	.270077	175	.729923	27		48
	16	34	. 3351	169	. 6649	. 2572	6	. 7428	. 0779	175	. 9221	26		44
	20	35	. 4027	169	. 5973	. 2548	6	. 7452	. 1479	175	. 8521	25		40
	24	36	. 4703	168	. 5297	. 2525	6	. 7475	. 2178	174	. 7822	24		36
	28	37	. 5377	168	. 4623	. 2501	6	. 7499	. 2876	174	. 7124	23		32
	32	38	. 6051	168	. 3949	. 2477	6	. 7523	. 3573	174	. 6427	22		28
	36	39	. 6723	168	. 3277	. 2454	6	. 7546	. 4269	174	. 5731	21		24
	40	40	. 7394	168	. 2606	. 2430	6	. 7570	. 4964	174	. 5036	20		20
	44	41	. 8065	167	. 1935	. 2406	6	. 7594	. 5659	173	. 4341	19		16
	48	42	. 8734	167	. 1266	. 2382	6	. 7618	. 6352	173	. 3648	18		12
	52	43	. 9402	167	. 0598	. 2359	6	. 7641	. 7043	173	. 2957	17		8
	56	44	.270069	166	.729931	. 2335	6	. 7665	. 7734	172	. 2266	16		4
43	0	45	. 0735	166	. 9265	. 2311	6	. 7689	. 8424	172	. 1576	15	17	0
	4	46	. 1400	166	. 8600	. 2287	6	. 7713	. 9113	172	. 0887	14		56
	8	47	. 2064	165	. 7936	. 2263	6	. 7737	. 9801	172	. 0199	13		52
	12	48	. 2726	165	. 7274	. 2238	6	. 7762	.280488	171	.719512	12		48
	16	49	. 3388	165	. 6612	. 2214	6	. 7786	. 1174	171	. 8826	11		44
	20	50	. 4049	165	. 5951	. 2190	6	. 7810	. 1859	171	. 8141	10		40
	24	51	. 4708	165	. 5292	. 2166	6	. 7834	. 2542	171	. 7458	9		36
	28	52	. 5367	164	. 4633	. 2142	6	. 7858	. 3225	170	. 6775	8		32
	32	53	. 6025	164	. 3975	. 2118	6	. 7882	. 3907	170	. 6093	7		28
	36	54	. 6681	164	. 3319	. 2093	6	. 7907	. 4588	170	. 5412	6		24
	40	55	. 7337	163	. 2663	. 2069	6	. 7931	. 5268	170	. 4732	5		20
	44	56	. 7991	163	. 2009	. 2044	6	. 7956	. 5947	169	. 4053	4		16
	48	57	. 8645	163	. 1355	. 2020	6	. 7980	. 6625	169	. 3375	3		12
	52	58	. 9297	163	. 0703	. 1996	6	. 8004	. 7301	169	. 2699	2		8
	56	59	. 9948	163	. 0052	. 1971	6	. 8029	. 7977	169	. 2023	1		4
43	60	60	9.280599		0.719401	9.991947		0.008053	9.288652		0.711348	0	16	0
m	s	'	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cot.	Diff. for 15'' or 1'	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

6h 100° 1' — 4s 10 — 4m 79° 5h

0ʰ 11° 1ˢ — 15'' 1ᵐ — 15' 1ʰ — 15° 168° 11ʰ

Hours. m	Hours. s	Deg. '	L. Sin.	Diff for 15'' or 1ˢ	L. Cosec.	L. Cos.	Diff for 15'' or 1ˢ	L. Sec.	L. Tang.	Diff for 15'' or 1ˢ	L. Cot.	Deg. '	Hours. m	Hours. s
44	0	0	9.280599	162	0.719401	9.991947	6	0.008053	9.288652	168	0.711348	60	15	60
	4	1	. 1248	162	. 8752	. 1922	6	. 8078	. 9326	168	. 0674	59		56
	8	2	. 1897	162	. 8103	. 1898	6	. 8102	. 9999	168	. 0001	58		52
	12	3	. 2544	162	. 7456	. 1873	6	. 8127	.290671	168	.709329	57		48
	16	4	. 3191	161	. 6809	. 1848	6	. 8151	. 1342	168	. 8658	56		44
	20	5	. 3836	161	. 6164	. 1823	6	. 8177	. 2012	167	. 7987	55		40
	24	6	. 4480	161	. 5520	. 1798	6	. 8202	. 2682	167	. 7318	54		36
	28	7	. 5124	160	. 4876	. 1774	6	. 8226	. 3350	167	. 6650	53		32
	32	8	. 5766	160	. 4234	. 1749	6	. 8251	. 4017	167	. 5983	52		28
	36	9	. 6408	160	. 3592	. 1724	6	. 8276	. 4684	166	. 5316	51		24
	40	10	. 7048	160	. 2952	. 1699	6	. 8301	. 5349	166	. 4651	50		20
	44	11	. 7687	160	. 2313	. 1674	6	. 8326	. 6013	166	. 3987	49		16
	48	12	. 8326	159	. 1674	. 1649	6	. 8351	. 6677	166	. 3323	48		12
	52	13	. 8964	159	. 1036	. 1624	6	. 8376	. 7340	165	. 2660	47		8
	56	14	. 9600	159	. 0400	. 1599	6	. 8401	. 8001	165	. 1999	46		4
45	0	15	.290236	159	.709764	. 1574	6	. 8426	. 8662	165	. 1338	45	15	0
	4	16	. 0871	158	. 9129	. 1549	6	. 8451	. 9322	164	. 0678	44		56
	8	17	. 1504	158	. 8496	. 1524	6	. 8476	. 9980	164	. 0020	43		52
	12	18	. 2137	158	. 7863	. 1499	6	. 8501	.300638	164	.699362	42		48
	16	19	. 2768	158	. 7232	. 1473	6	. 8527	. 1295	164	. 8705	41		44
	20	20	. 3399	157	. 6601	. 1448	6	. 8552	. 1951	164	. 8049	40		40
	24	21	. 4029	157	. 5971	. 1422	6	. 8578	. 2607	163	. 7393	39		36
	28	22	. 4658	157	. 5342	. 1397	6	. 8603	. 3261	163	. 6739	38		32
	32	23	. 5286	157	. 4714	. 1372	6	. 8628	. 3914	163	. 6086	37		28
	36	24	. 5913	156	. 4087	. 1346	6	. 8654	. 4567	163	. 5433	36		24
	40	25	. 6539	156	. 3461	. 1321	6	. 8679	. 5218	163	. 4782	35		20
	44	26	. 7164	156	. 2836	. 1295	6	. 8705	. 5869	162	. 4131	34		16
	48	27	. 7788	156	. 2212	. 1269	6	. 8731	. 6519	162	. 3481	33		12
	52	28	. 8412	155	. 1588	. 1244	6	. 8756	. 7168	162	. 2832	32		8
	56	29	. 9034	155	. 0966	. 1218	6	. 8782	. 7816	162	. 2184	31		4
46	0	30	. 9655	155	. 0345	. 1193	6	. 8807	. 8463	162	. 1537	30	14	0
	4	31	.300276	155	.699724	. 1167	6	. 8833	. 9109	161	. 0891	29		56
	8	32	. 0895	155	. 9105	. 1141	6	. 8859	. 9754	161	. 0246	28		52
	12	33	. 1514	154	. 8486	. 1115	6	. 8885	.310399	161	.689601	27		48
	16	34	. 2132	154	. 7868	. 1090	6	. 8910	. 1042	161	. 8958	26		44
	20	35	. 2749	154	. 7251	. 1064	6	. 8936	. 1685	160	. 8315	25		40
	24	36	. 3365	153	. 6635	. 1038	6	. 8962	. 2327	160	. 7673	24		36
	28	37	. 3979	153	. 6021	. 1012	6	. 8988	. 2967	160	. 7033	23		32
	32	38	. 4593	153	. 5407	. 0986	6	. 9014	. 3607	160	. 6393	22		28
	36	39	. 5207	153	. 4793	. 0960	6	. 9040	. 4247	159	. 5753	21		24
	40	40	. 5819	153	. 4181	. 0934	6	. 9066	. 4885	159	. 5115	20		20
	44	41	. 6430	153	. 3570	. 0908	6	. 9092	. 5522	159	. 4478	19		16
	48	42	. 7041	152	. 2959	. 0882	7	. 9118	. 6159	159	. 3841	18		12
	52	43	. 7650	152	. 2350	. 0855	6	. 9145	. 6795	159	. 3205	17		8
	56	44	. 8259	152	. 1741	. 0829	6	. 9171	. 7430	158	. 2570	16		4
47	0	45	. 8867	152	. 1133	. 0803	6	. 9197	. 8064	158	. 1936	15	13	0
	4	46	. 9474	151	. 0526	. 0777	7	. 9223	. 8697	158	. 1303	14		56
	8	47	.310080	151	.689920	. 0750	6	. 9250	. 9330	158	. 0670	13		52
	12	48	. 0685	151	. 9315	. 0724	7	. 9276	. 9961	158	. 0039	12		48
	16	49	. 1289	151	. 8711	. 0697	6	. 9303	.320592	157	.679408	11		44
	20	50	. 1893	150	. 8107	. 0671	7	. 9329	. 1222	157	. 8778	10		40
	24	51	. 2495	150	. 7505	. 0644	6	. 9356	. 1851	157	. 8149	9		36
	28	52	. 3097	150	. 6903	. 0618	6	. 9382	. 2479	157	. 7521	8		32
	32	53	. 3698	150	. 6302	. 0592	7	. 9408	. 3106	157	. 6894	7		28
	36	54	. 4298	150	. 5702	. 0565	7	. 9435	. 3733	156	. 6267	6		24
	40	55	. 4896	149	. 5104	. 0538	6	. 9462	. 4358	156	. 5642	5		20
	44	56	. 5495	149	. 4505	. 0512	7	. 9488	. 4983	156	. 5017	4		16
	48	57	. 6092	149	. 3908	. 0485	7	. 9515	. 5607	156	. 4393	3		12
	52	58	. 6689	149	. 3311	. 0458	7	. 9542	. 6231	155	. 3769	2		8
	56	59	. 7284	149	. 2716	. 0431	7	. 9569	. 6853	155	. 3147	1		4
47	60	60	9.317879		0.682121	9.990404		0.009596	9.327475		0.672525	0	12	0
m	s	'	L. Cos.	Diff. for 15'' or 1ˢ	L. Sec.	L. Sin.	Diff. for 15'' or 1ˢ	L. Cosec.	L. Cot.	Diff. for 15'' or 1ˢ	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

6ʰ 101° 1' — 4ˢ 1° — 4ᵐ 78° 5ʰ

0h 12° 1s = 15'' 1m = 15' 1h = 15° 167° 11h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
48	0	0	9.317879	148	0.682121	9.990404	6	0.009596	9.327475	155	0.672525	60	11	60
	4	1	. 8473	148	. 1527	. 0378	7	. 9622	. 8095	155	. 1905	59		[illegible]
	8	2	. 9066	148	. 0934	. 0351	7	. 9649	. 8715	155	. 1285	58		[illegible]
	12	3	. 9658	148	. 0342	. 0324	7	. 9676	. 9334	155	. 0666	57		48
	16	4	.320250	147	.679750	. 0297	7	. 9703	. 9953	154	. 0047	56		44
	20	5	. 0840	147	. 9160	. 0270	7	. 9730	.330570	154	.669430	55		40
	24	6	. 1430	147	. 8570	. 0243	7	. 9757	. 1187	154	. 8813	54		36
	28	7	. 2019	147	. 7981	. 0216	7	. 9784	. 1803	154	. 8197	53		32
	32	8	. 2606	147	. 7394	. 0188	7	. 9812	. 2418	154	. 7582	52		28
	36	9	. 3194	146	. 6806	. 0161	7	. 9839	. 3033	153	. 6967	51		24
	40	10	. 3780	146	. 6220	. 0134	7	. 9866	. 3646	153	. 6354	50		20
	44	11	. 4366	146	. 5634	. 0107	7	. 9893	. 4259	153	. 5741	49		16
	48	12	. 4950	146	. 5050	. 0079	7	. 9921	. 4871	153	. 5129	48		12
	52	13	. 5534	146	. 4466	. 0052	7	. 9948	. 5482	153	. 4518	47		8
	56	14	. 6118	145	. 3882	. 0025	7	. 9975	. 6093	152	. 3907	46		4
49	0	15	. 6700	145	. 3300	.989997	7	.010003	. 6703	152	. 3297	45	11	0
	4	16	. 7281	145	. 2719	. 9970	7	. 0030	. 7311	152	. 2689	44		56
	8	17	. 7862	145	. 2138	. 9942	7	. 0058	. 7920	152	. 2080	43		52
	12	18	. 8442	144	. 1558	. 9915	7	. 0085	. 8527	151	. 1473	42		48
	16	19	. 9020	144	. 0980	. 9887	7	. 0113	. 9133	151	. 0867	41		44
	20	20	. 9599	144	. 0401	. 9860	7	. 0140	. 9739	151	. 0261	40		40
	24	21	.330176	144	.669824	. 9832	7	. 0168	.340344	151	.659656	39		36
	28	22	. 0753	144	. 9247	. 9804	7	. 0196	. 0949	151	. 9051	38		32
	32	23	. 1329	144	. 8671	. 9777	7	. 0223	. 1552	151	. 8448	37		28
	36	24	. 1904	143	. 8096	. 9749	7	. 0251	. 2155	150	. 7845	36		24
	40	25	. 2478	143	. 7522	. 9721	7	. 0279	. 2757	150	. 7243	35		20
	44	26	. 3051	143	. 6949	. 9693	7	. 0307	. 3358	150	. 6642	34		16
	48	27	. 3624	143	. 6376	. 9666	7	. 0334	. 3958	150	. 6042	33		12
	52	28	. 4195	143	. 5805	. 9637	7	. 0363	. 4558	150	. 5442	32		8
	56	29	. 4767	142	. 5233	. 9610	7	. 0390	. 5157	149	. 4843	31		4
50	0	30	. 5337	142	. 4663	. 9582	7	. 0418	. 5755	149	. 4245	30	10	0
	4	31	. 5906	142	. 4094	. 9553	7	. 0447	. 6353	149	. 3647	29		56
	8	32	. 6475	142	. 3525	. 9525	7	. 0475	. 6950	149	. 3050	28		52
	12	33	. 7043	142	. 2957	. 9497	7	. 0503	. 7546	149	. 2454	27		48
	16	34	. 7610	141	. 2390	. 9469	7	. 0531	. 8141	148	. 1859	26		44
	20	35	. 8176	141	. 1824	. 9441	7	. 0559	. 8735	148	. 1265	25		40
	24	36	. 8742	141	. 1258	. 9413	7	. 0587	. 9329	148	. 0671	24		36
	28	37	. 9307	141	. 0693	. 9385	7	. 0615	. 9922	148	. 0078	23		32
	32	38	. 9870	141	. 0130	. 9356	7	. 0644	.350514	148	.649486	22		28
	36	39	.340434	140	.659566	. 9328	7	. 0672	. 1106	148	. 8894	21		24
	40	40	. 0996	140	. 9004	. 9299	7	. 0701	. 1697	147	. 8303	20		20
	44	41	. 1558	140	. 8442	. 9271	7	. 0729	. 2287	147	. 7713	19		16
	48	42	. 2119	140	. 7881	. 9243	7	. 0757	. 2876	147	. 7124	18		12
	52	43	. 2679	140	. 7321	. 9214	7	. 0786	. 3465	147	. 6535	17		8
	56	44	. 3239	139	. 6761	. 9186	7	. 0814	. 4053	147	. 5947	16		4
51	0	45	. 3797	139	. 6203	. 9157	7	. 0843	. 4640	147	. 5360	15	9	0
	4	46	. 4355	139	. 5645	. 9128	7	. 0872	. 5227	146	. 4773	14		56
	8	47	. 4913	139	. 5087	. 9100	7	. 0900	. 5813	146	. 4187	13		52
	12	48	. 5469	139	. 4531	. 9071	7	. 0929	. 6398	146	. 3602	12		48
	16	49	. 6024	139	. 3976	. 9042	7	. 0958	. 6982	146	. 3018	11		44
	20	50	. 6580	138	. 3420	. 9014	7	. 0986	. 7566	146	. 2434	10		40
	24	51	. 7134	138	. 2866	. 8985	7	. 1015	. 8149	145	. 1851	9		36
	28	52	. 7687	138	. 2313	. 8956	7	. 1044	. 8731	145	. 1269	8		32
	32	53	. 8240	138	. 1760	. 8927	7	. 1073	. 9313	145	. 0687	7		28
	36	54	. 8792	138	. 1208	. 8898	7	. 1102	. 9894	145	. 0106	6		24
	40	55	. 9343	137	. 0657	. 8869	7	. 1131	.360474	145	.639526	5		20
	44	56	. 9893	137	. 0107	. 8840	7	. 1160	. 1053	145	. 8947	4		16
	48	57	.350443	137	.649557	. 8811	7	. 1189	. 1632	144	. 8368	3		12
	52	58	. 0992	137	. 9008	. 8782	7	. 1218	. 2210	144	. 7790	2		8
	56	59	. 1540	137	. 8460	. 8753	7	. 1247	. 2787	144	. 7213	1		4
51	60	60	9.352088		0.647912	9.988724		0.011276	9.363364		0.636636	0	8	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours	

6h 102° 1' = 4s 1° = 4m 77° 5h

0h 13° $1^s = 15''$ $1^m = 15'$ $1^h = 15°$ 166° 11h

Hours. m	s	Deg. ′	L. Sin.	Diff. for 15″ or 1s	L. Cosec.	L. Cos.	Diff. for 15″ or 1s	L. Sec.	L. Tang.	Diff. for 15″ or 1s	L. Cot.	Deg. ′	Hours. m	s
52	0	0	9.352088	137	0.647912	9.988724	7	0.011276	9.363364	144	0.636636	60	7	60
	4	1	2635	136	7365	8695	7	1305	3940	144	6060	59		56
	8	2	3181	136	6819	8665	7	1335	4516	143	5484	58		52
	12	3	3726	136	6274	8636	7	1364	5090	143	4910	57		48
	16	4	4271	136	5729	8607	7	1393	5664	143	4336	56		44
	20	5	4815	136	5185	8578	7	1422	6237	143	3763	55		40
	24	6	5358	136	4642	8548	7	1452	6810	143	3190	54		36
	28	7	5901	135	4099	8519	7	1481	7382	143	2618	53		32
	32	8	6442	135	3558	8489	7	1511	7953	143	2047	52		28
	36	9	6984	135	3016	8460	7	1540	8524	142	1476	51		24
	40	10	7524	135	2476	8430	7	1570	9094	142	0906	50		20
	44	11	8064	135	1936	8401	7	1599	9663	142	0337	49		16
	48	12	8603	135	1397	8371	7	1629	.370232	142	.629768	48		12
	52	13	9141	134	0859	8342	7	1658	0799	142	9201	47		8
	56	14	9679	134	0321	8312	7	1688	1367	141	8633	46		4
53	0	15	.360215	134	.639785	8282	7	1718	1933	141	8067	45	7	0
	4	16	0751	134	9249	8252	7	1748	2499	141	7501	44		56
	8	17	1287	134	8713	8222	7	1778	3065	141	6935	43		52
	12	18	1822	133	8178	8193	7	1807	3629	141	6371	42		48
	16	19	2356	133	7644	8163	7	1837	4193	141	5807	41		44
	20	20	2889	133	7111	8133	7	1867	4756	141	5244	40		40
	24	21	3422	133	6578	8103	7	1897	5319	140	4681	39		36
	28	22	3954	133	6046	8073	7	1927	5881	140	4119	38		32
	32	23	4485	133	5515	8043	7	1957	6442	140	3558	37		28
	36	24	5016	132	4984	8013	7	1987	7003	140	2997	36		24
	40	25	5546	132	4454	7983	7	2017	7563	140	2437	35		20
	44	26	6075	132	3925	7953	8	2047	8122	140	1878	34		16
	48	27	6603	132	3397	7922	7	2078	8681	139	1319	33		12
	52	28	7131	132	2869	7892	7	2108	9239	139	0761	32		8
	56	29	7659	131	2341	7862	7	2138	9797	139	0203	31		4
54	0	30	8185	131	1815	7832	8	2168	.380354	139	.619646	30	6	0
	4	31	8711	131	1289	7801	7	2199	0910	139	9090	29		56
	8	32	9236	131	0764	7771	8	2229	1465	139	8535	28		52
	12	33	9761	131	0239	7740	7	2260	2021	138	7979	27		48
	16	34	.370285	131	.629715	7710	8	2290	2575	138	7425	26		44
	20	35	0808	130	9192	7679	7	2321	3129	138	6871	25		40
	24	36	1330	130	8670	7649	8	2351	3681	138	6319	24		36
	28	37	1852	130	8148	7618	7	2382	4234	138	5766	23		32
	32	38	2374	130	7626	7588	8	2412	4786	138	5214	22		28
	36	39	2894	130	7106	7557	8	2443	5337	138	4663	21		24
	40	40	3414	130	6586	7526	8	2474	5888	137	4112	20		20
	44	41	3933	130	6067	7495	7	2505	6438	137	3562	19		16
	48	42	4452	129	5548	7465	8	2535	6987	137	3013	18		12
	52	43	4970	129	5030	7434	8	2566	7536	137	2464	17		8
	56	44	5487	129	4513	7403	8	2597	8084	137	1916	16		4
55	0	45	6003	129	3997	7372	8	2628	8631	137	1369	15	5	0
	4	46	6519	129	3481	7341	8	2659	9178	137	0822	14		56
	8	47	7035	128	2965	7310	8	2690	9725	136	0275	13		52
	12	48	7549	128	2451	7279	8	2721	.390270	136	.609730	12		48
	16	49	8063	128	1937	7248	8	2752	0815	136	9185	11		44
	20	50	8577	128	1423	7217	8	2783	1360	136	8640	10		40
	24	51	9089	128	0911	7186	8	2814	1903	136	8097	9		36
	28	52	9602	128	0398	7155	8	2845	2447	135	7553	8		32
	32	53	.380113	128	.619887	7124	8	2876	2989	135	7011	7		28
	36	54	0624	127	9376	7093	8	2907	3531	135	6469	6		24
	40	55	1134	127	8866	7061	8	2939	4073	135	5927	5		20
	44	56	1644	127	8356	7030	8	2970	4614	135	5386	4		16
	48	57	2152	127	7848	6998	8	3002	5154	135	4846	3		12
	52	58	2661	127	7339	6967	8	3033	5694	135	4306	2		8
	56	59	3168	127	6832	6935	8	3065	6233	134	3767	1		4
55	60	60	9.383675		0.616325	9.986904		0.013096	9.396771		0.603229	0	4	0
m	s	′	L. Cos.	Diff. for 15″ or 1s	L. Sec.	L. Sin.	Diff. for 15″ or 1s	L. Cosec.	L. Cot.	Diff. for 15″ or 1s	L. Tang.	′	m	s
Hours.		Deg.										Deg.	Hours.	

6h 103° $1' = 4^s$ $1° = 4^m$ 76° 5h

0ʰ 14° 1ˢ = 15″ 1ᵐ = 15′ 1ʰ = 15° 165° = 11ʰ

Hours. m	Hours. s	Deg. ′	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Tang.	Diff. for 15″ or 1ˢ	L. Cot.	Deg. ′	Hours. m	Hours. s
56	0	0	9.383675	127	0.616325	9.986904	8	0.013096	9.396771	134	0.603229	60	3	60
	4	1	. 4183	126	. 5818	. 6873	8	. 3127	. 7309	134	. 2691	59		56
	8	2	. 4687	126	. 5313	. 6841	8	. 3159	. 7846	134	. 2154	58		52
	12	3	. 5192	126	. 4808	. 6809	8	. 3191	. 8383	134	. 1617	57		48
	16	4	. 5697	126	. 4303	. 6778	8	. 3222	. 8919	134	. 1081	56		44
	20	5	. 6201	126	. 3799	. 6746	8	. 3254	. 9455	134	. 0545	55		40
	24	6	. 6704	126	. 3296	. 6714	8	. 3286	. 9990	133	. 0010	54		36
	28	7	. 7207	125	. 2793	. 6683	8	. 3317	.400524	133	.599476	53		32
	32	8	. 7709	125	. 2291	. 6651	8	. 3349	. 1058	133	. 8942	52		28
	36	9	. 8210	125	. 1790	. 6619	8	. 3381	. 1591	133	. 8409	51		24
	40	10	. 8711	125	. 1289	. 6587	8	. 3413	. 2124	133	. 7876	50		20
	44	11	. 9211	125	. 0789	. 6555	8	. 3445	. 2656	133	. 7344	49		16
	48	12	. 9710	125	. 0290	. 6523	8	. 3477	. 3187	133	. 6813	48		12
	52	13	.390209	125	.609791	. 6491	8	. 3509	. 3718	133	. 6282	47		8
	56	14	. 0708	124	. 9292	. 6459	8	. 3541	. 4249	132	. 5751	46		4
57	0	15	. 1206	124	. 8794	. 6427	8	. 3573	. 4779	132	. 5221	45	3	0
	4	16	. 1703	124	. 8297	. 6395	8	. 3605	. 5308	132	. 4692	44		56
	8	17	. 2199	124	. 7801	. 6363	8	. 3637	. 5836	132	. 4164	43		52
	12	18	. 2695	124	. 7305	. 6331	8	. 3669	. 6364	132	. 3636	42		48
	16	19	. 3191	123	. 6809	. 6299	8	. 3701	. 6892	132	. 3108	41		44
	20	20	. 3685	123	. 6315	. 6266	8	. 3734	. 7419	131	. 2581	40		40
	24	21	. 4179	123	. 5821	. 6234	8	. 3766	. 7945	131	. 2055	39		36
	28	22	. 4673	123	. 5327	. 6202	8	. 3798	. 8471	131	. 1529	38		32
	32	23	. 5166	123	. 4834	. 6169	8	. 3831	. 8997	131	. 1003	37		28
	36	24	. 5658	123	. 4342	. 6137	8	. 3863	. 9521	131	. 0479	36		24
	40	25	. 6150	123	. 3850	. 6105	8	. 3895	.410045	131	.589955	35		20
	44	26	. 6641	123	. 3359	. 6072	8	. 3928	. 0569	131	. 9431	34		16
	48	27	. 7131	123	. 2869	. 6039	8	. 3961	. 1092	131	. 8908	33		12
	52	28	. 7622	122	. 2378	. 6007	8	. 3993	. 1615	130	. 8385	32		8
	56	29	. 8111	122	. 1889	. 5974	8	. 4026	. 2137	130	. 7863	31		4
58	0	30	. 8600	122	. 1400	. 5942	8	. 4058	. 2658	130	. 7342	30	2	0
	4	31	. 9088	122	. 0912	. 5909	8	. 4091	. 3179	130	. 6821	29		56
	8	32	. 9575	122	. 0425	. 5876	8	. 4124	. 3699	130	. 6301	28		52
	12	33	.400062	122	.599938	. 5843	8	. 4157	. 4219	130	. 5781	27		48
	16	34	. 0549	121	. 9451	. 5811	8	. 4189	. 4738	130	. 5262	26		44
	20	35	. 1035	121	. 8965	. 5778	8	. 4222	. 5257	129	. 4743	25		40
	24	36	. 1520	121	. 8480	. 5745	8	. 4255	. 5775	129	. 4225	24		36
	28	37	. 2005	121	. 7995	. 5712	8	. 4288	. 6293	129	. 3707	23		32
	32	38	. 2489	121	. 7511	. 5679	8	. 4321	. 6810	129	. 3190	22		28
	36	39	. 2972	121	. 7028	. 5646	8	. 4354	. 7326	129	. 2674	21		24
	40	40	. 3455	121	. 6545	. 5613	8	. 4387	. 7842	129	. 2158	20		20
	44	41	. 3938	120	. 6062	. 5580	8	. 4420	. 8358	129	. 1642	19		16
	48	42	. 4420	120	. 5580	. 5547	8	. 4453	. 8873	128	. 1127	18		12
	52	43	. 4901	120	. 5099	. 5514	8	. 4486	. 9387	128	. 0613	17		8
	56	44	. 5381	120	. 4619	. 5480	8	. 4520	. 9901	128	. 0099	16		4
59	0	45	. 5862	120	. 4138	. 5447	8	. 4553	.420415	128	.579585	15	1	0
	4	46	. 6341	120	. 3659	. 5414	8	. 4586	. 0927	128	. 9073	14		56
	8	47	. 6820	120	. 3180	. 5380	8	. 4620	. 1440	128	. 8560	13		52
	12	48	. 7299	119	. 2701	. 5347	8	. 4653	. 1952	128	. 8048	12		48
	16	49	. 7777	119	. 2223	. 5314	8	. 4686	. 2463	128	. 7537	11		44
	20	50	. 8254	119	. 1746	. 5280	8	. 4720	. 2974	127	. 7026	10		40
	24	51	. 8731	119	. 1269	. 5247	8	. 4753	. 3484	127	. 6516	9		36
	28	52	. 9207	119	. 0793	. 5213	8	. 4787	. 3994	127	. 6006	8		32
	32	53	. 9682	119	. 0318	. 5180	8	. 4820	. 4502	127	. 5498	7		28
	36	54	.410157	119	.589843	. 5146	8	. 4854	. 5011	127	. 4989	6		24
	40	55	. 0632	118	. 9368	. 5113	8	. 4887	. 5519	127	. 4481	5		20
	44	56	. 1106	118	. 8894	. 5079	8	. 4921	. 6027	127	. 3973	4		16
	48	57	. 1579	118	. 8421	. 5045	8	. 4955	. 6534	127	. 3466	3		12
	52	58	. 2052	118	. 7948	. 5011	8	. 4989	. 7041	126	. 2959	2		8
	56	59	. 2525	118	. 7475	. 4978	8	. 5022	. 7547	126	. 2453	1		4
59	60	60	9.412996		0.587004	9.984944		0.015056	9.428052		0.571948	0	0	0
m	s	′	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cot.	Diff. for 15″ or 1ˢ	L. Tang.	′	m	s
Hours.		Deg.										Deg.	Hours.	

6ʰ 104° 1′ = 4ˢ 1° = 4ᵐ 75° = 5ʰ

1h — 15° 1' — 15'' 1m — 15' 1h — 15° 164° 10h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Tang.	Diff. for 15'' or 1'	L. Cot.	Deg. '	Hours. m	Hours. s
0	0	0	9.412396	118	0.587004	9.984944	8	0.015056	9.428052	126	0.571948	60	59	60
	4	1	. 3467	118	. 6533	. 4910	8	. 5090	. 8557	126	. 1443	59		56
	8	2	. 3938	117	. 6062	. 4876	8	. 5124	. 9062	126	. 0938	58		52
	12	3	. 4408	117	. 5592	. 4842	8	. 5158	. 9566	126	. 0434	57		48
	16	4	. 4878	117	. 5122	. 4808	8	. 5192	.430070	126	.569930	56		44
	20	5	. 5347	117	. 4653	. 4774	8	. 5226	. 0573	125	. 9427	55		40
	24	6	. 5815	117	. 4185	. 4740	8	. 5260	. 1075	125	. 8925	54		36
	28	7	. 6283	117	. 3717	. 4706	8	. 5294	. 1577	125	. 8423	53		32
	32	8	. 6751	117	. 3249	. 4672	8	. 5328	. 2079	125	. 7921	52		28
	36	9	. 7218	116	. 2782	. 4638	9	. 5362	. 2580	125	. 7420	51		24
	40	10	. 7684	116	. 2316	. 4601	8	. 5397	. 3081	125	. 6919	50		20
	44	11	. 8150	116	. 1850	. 4569	8	. 5431	. 3581	125	. 6419	49		16
	48	12	. 8615	116	. 1385	. 4535	9	. 5465	. 4080	125	. 5920	48		12
	52	13	. 9079	116	. 0921	. 4500	8	. 5500	. 4579	125	. 5421	47		8
	56	14	. 9544	116	. 0456	. 4466	9	. 5534	. 5078	124	. 4922	46		4
1	0	15	.420007	116	.579993	. 4431	8	. 5569	. 5576	124	. 4424	45	59	0
	4	16	. 0470	116	. 9530	. 4397	8	. 5603	. 6073	124	. 3927	44		56
	8	17	. 0933	115	. 9067	. 4363	9	. 5637	. 6570	124	. 3430	43		52
	12	18	. 1395	115	. 8605	. 4328	8	. 5672	. 7067	124	. 2933	42		48
	16	19	. 1857	115	. 8143	. 4294	9	. 5706	. 7563	124	. 2437	41		44
	20	20	. 2318	115	. 7682	. 4259	9	. 5741	. 8059	124	. 1941	40		40
	24	21	. 2778	115	. 7222	. 4224	9	. 5776	. 8554	124	. 1446	39		36
	28	22	. 3238	115	. 6762	. 4189	8	. 5811	. 9049	123	. 0951	38		32
	32	23	. 3697	115	. 6303	. 4155	9	. 5845	. 9542	123	. 0458	37		28
	36	24	. 4156	115	. 5844	. 4120	9	. 5880	.440036	123	.559964	36		24
	40	25	. 4615	114	. 5385	. 4085	9	. 5915	. 0530	123	. 9470	35		20
	44	26	. 5072	114	. 4928	. 4050	9	. 5950	. 1022	123	. 8978	34		16
	48	27	. 5530	114	. 4470	. 4015	8	. 5985	. 1515	123	. 8485	33		12
	52	28	. 5987	114	. 4013	. 3981	9	. 6019	. 2006	123	. 7994	32		8
	56	29	. 6443	114	. 3557	. 3946	9	. 6054	. 2497	123	. 7503	31		4
2	0	30	. 6899	114	. 3101	. 3911	9	. 6089	. 2988	123	. 7012	30	58	0
	4	31	. 7354	114	. 2646	. 3875	9	. 6125	. 3479	122	. 6521	29		56
	8	32	. 7809	113	. 2191	. 3840	9	. 6160	. 3969	122	. 6031	28		52
	12	33	. 8263	113	. 1737	. 3805	9	. 6195	. 4458	122	. 5542	27		48
	16	34	. 8717	113	. 1283	. 3770	9	. 6230	. 4947	122	. 5053	26		44
	20	35	. 9170	113	. 0830	. 3735	9	. 6265	. 5435	122	. 4565	25		40
	24	36	. 9623	113	. 0377	. 3700	9	. 6300	. 5923	122	. 4077	24		36
	28	37	.430075	113	.569925	. 3664	9	. 6336	. 6411	122	. 3589	23		32
	32	38	. 0527	113	. 9473	. 3629	9	. 6371	. 6898	121	. 3102	22		28
	36	39	. 0978	113	. 9022	. 3594	9	. 6406	. 7384	121	. 2616	21		24
	40	40	. 1428	113	. 8572	. 3559	9	. 6442	. 7870	121	. 2130	20		20
	44	41	. 1879	112	. 8121	. 3523	9	. 6477	. 8356	121	. 1644	19		16
	48	42	. 2328	112	. 7672	. 3487	9	. 6513	. 8841	121	. 1159	18		12
	52	43	. 2778	112	. 7222	. 3452	9	. 6548	. 9326	121	. 0674	17		8
	56	44	. 3226	112	. 6774	. 3416	9	. 6584	. 9810	121	. 0190	16		4
3	0	45	. 3675	112	. 6325	. 3381	9	. 6619	.450294	121	.549706	15	57	0
	4	46	. 4122	112	. 5878	. 3345	9	. 6655	. 0777	121	. 9223	14		56
	8	47	. 4569	112	. 5431	. 3309	9	. 6691	. 1260	121	. 8740	13		52
	12	48	. 5016	111	. 4984	. 3273	9	. 6727	. 1743	120	. 8257	12		48
	16	49	. 5462	111	. 4538	. 3238	9	. 6762	. 2224	120	. 7776	11		44
	20	50	. 5908	111	. 4092	. 3202	9	. 6798	. 2706	120	. 7294	10		40
	24	51	. 6353	111	. 3647	. 3166	9	. 6834	. 3187	120	. 6813	9		36
	28	52	. 6798	111	. 3202	. 3130	9	. 6870	. 3668	120	. 6332	8		32
	32	53	. 7242	111	. 2758	. 3094	9	. 6906	. 4148	120	. 5852	7		28
	36	54	. 7686	111	. 2314	. 3058	9	. 6942	. 4628	120	. 5372	6		24
	40	55	. 8129	111	. 1871	. 3022	9	. 6978	. 5107	120	. 4893	5		20
	44	56	. 8572	110	. 1428	. 2986	9	. 7014	. 5586	119	. 4414	4		16
	48	57	. 9014	110	. 0986	. 2950	9	. 7050	. 6064	119	. 3936	3		12
	52	58	. 9456	110	. 0544	. 2914	9	. 7086	. 6542	119	. 3458	2		8
	56	59	. 9897	110	. 0103	. 2878	9	. 7122	. 7019	119	. 2981	1		4
3	60	60	9.440338		0.559662	9.982842		0.017158	9.457496		0.542504	0	56	0
m	s	'	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cot.	Diff. for 15'' or 1'	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

7h — 105° 1' — 4s 1° — 4m 74° 4h

1ʰ 16° 1' — 15'' 1ᵐ — 15' 1ʰ — 15° 163° 10ʰ

Hours. m	Hours. s	Deg. '	L. Sin.	Diff for 15'' or 1ˢ	L. Cosec.	L. Cos.	Diff for 15'' or 1ˢ	L. Sec.	L. Tang.	Diff. for 15'' or 1ˢ	L. Cot.	Deg. '	Hours m	Hours s
4	0	0	9.440338	110	0.559662	9.982842	9	0.017158	9.457496	119	0.542504	60	55	60
	4	1	. 0778	110	. 9222	. 2805	9	. 7195	. 7973	119	. 2027	59		56
	8	2	. 1218	110	. 8782	. 2769	9	. 7231	. 8449	119	. 1551	58		52
	12	3	. 1658	110	. 8342	. 2733	9	. 7267	. 8925	119	. 1075	57		48
	16	4	. 2096	109	. 7904	. 2696	9	. 7304	. 9400	119	. 0600	56		44
	20	5	. 2535	109	. 7465	. 2660	9	. 7340	. 9875	118	. 0125	55		40
	24	6	. 2973	109	. 7027	. 2624	9	. 7376	.460349	118	.539651	54		36
	28	7	. 3410	109	. 6590	. 2587	9	. 7413	. 0823	118	. 9177	53		32
	32	8	. 3847	109	. 6153	. 2550	9	. 7450	. 1297	118	. 8703	52		28
	36	9	. 4284	109	. 5716	. 2514	9	. 7486	. 1770	118	. 8230	51		24
	40	10	. 4720	109	. 5280	. 2477	9	. 7523	. 2243	118	. 7757	50		20
	44	11	. 5155	109	. 4845	. 2441	9	. 7559	. 2714	118	. 7286	49		16
	48	12	. 5590	109	. 4410	. 2404	9	. 7596	. 3186	118	. 6814	48		12
	52	13	. 6025	108	. 3975	. 2367	9	. 7633	. 3657	118	. 6342	47		8
	56	14	. 6459	108	. 3541	. 2331	9	. 7669	. 4128	118	. 5872	46		4
5	0	15	. 6893	108	. 3107	. 2294	9	. 7706	. 4599	117	. 5401	45	55	0
	4	16	. 7326	108	. 2674	. 2257	9	. 7743	. 5069	117	. 4931	44		56
	8	17	. 7759	108	. 2241	. 2220	9	. 7780	. 5538	117	. 4461	43		52
	12	18	. 8191	108	. 1809	. 2183	9	. 7817	. 6008	117	. 3992	42		48
	16	19	. 8623	108	. 1377	. 2146	9	. 7854	. 6477	117	. 3523	41		44
	20	20	. 9054	108	. 0946	. 2109	9	. 7891	. 6945	117	. 3055	40		40
	24	21	. 9485	107	. 0515	. 2072	9	. 7928	. 7413	117	. 2587	39		36
	28	22	. 9915	107	. 0085	. 2035	9	. 7965	. 7880	117	. 2120	38		32
	32	23	.450345	107	.549655	. 1998	9	. 8002	. 8347	117	. 1653	37		28
	36	24	. 0775	107	. 9225	. 1961	9	. 8039	. 8814	116	. 1186	36		24
	40	25	. 1204	107	. 8796	. 1924	9	. 8076	. 9280	116	. 0720	35		20
	44	26	. 1632	107	. 8368	. 1886	9	. 8114	. 9746	116	. 0254	34		16
	48	27	. 2060	107	. 7940	. 1849	9	. 8151	.470211	116	.529789	33		12
	52	28	. 2488	107	. 7512	. 1812	9	. 8188	. 0676	116	. 9324	32		8
	56	29	. 2915	107	. 7085	. 1774	9	. 8226	. 1141	116	. 8859	31		4
6	0	30	. 3342	106	. 6658	. 1737	9	. 8263	. 1605	116	. 8395	30	54	0
	4	31	. 3768	106	. 6232	. 1699	9	. 8301	. 2069	116	. 7931	29		56
	8	32	. 4194	106	. 5806	. 1662	9	. 8338	. 2532	116	. 7468	28		52
	12	33	. 4619	106	. 5381	. 1624	9	. 8376	. 2995	115	. 7005	27		48
	16	34	. 5044	106	. 4956	. 1587	9	. 8413	. 3457	115	. 6543	26		44
	20	35	. 5469	106	. 4531	. 1550	9	. 8450	. 3919	115	. 6081	25		40
	24	36	. 5893	106	. 4107	. 1512	9	. 8488	. 4381	115	. 5619	24		36
	28	37	. 6316	106	. 3684	. 1474	9	. 8526	. 4842	115	. 5158	23		32
	32	38	. 6739	106	. 3261	. 1436	9	. 8564	. 5303	115	. 4697	22		28
	36	39	. 7162	105	. 2838	. 1399	9	. 8601	. 5763	115	. 4237	21		24
	40	40	. 7584	105	. 2416	. 1361	9	. 8639	. 6223	115	. 3777	20		20
	44	41	. 8006	105	. 1994	. 1323	9	. 8677	. 6683	115	. 3317	19		16
	48	42	. 8427	105	. 1573	. 1285	9	. 8715	. 7142	115	. 2858	18		12
	52	43	. 8848	105	. 1152	. 1247	9	. 8753	. 7601	114	. 2399	17		8
	56	44	. 9268	105	. 0732	. 1209	9	. 8791	. 8059	114	. 1941	16		4
7	0	45	. 9688	105	. 0312	. 1171	9	. 8829	. 8517	114	. 1483	15	53	0
	4	46	.460108	105	.539892	. 1133	9	. 8867	. 8975	114	. 1025	14		56
	8	47	. 0527	105	. 9473	. 1095	9	. 8905	. 9432	114	. 0568	13		52
	12	48	. 0946	104	. 9054	. 1057	9	. 8943	. 9889	114	. 0111	12		48
	16	49	. 1364	104	. 8636	. 1019	9	. 8981	.480345	114	.519655	11		44
	20	50	. 1782	104	. 8218	. 0981	9	. 9019	. 0801	114	. 9199	10		40
	24	51	. 2199	104	. 7801	. 0942	10	. 9058	. 1257	114	. 8743	9		36
	28	52	. 2616	104	. 7384	. 0904	9	. 9096	. 1712	114	. 8288	8		32
	32	53	. 3032	104	. 6968	. 0866	10	. 9134	. 2166	114	. 7834	7		28
	36	54	. 3448	104	. 6552	. 0827	9	. 9173	. 2621	114	. 7379	6		24
	40	55	. 3864	104	. 6136	. 0789	9	. 9211	. 3075	113	. 6925	5		20
	44	56	. 4279	104	. 5721	. 0751	10	. 9249	. 3529	113	. 6471	4		16
	48	57	. 4694	103	. 5306	. 0712	9	. 9288	. 3982	113	. 6018	3		12
	52	58	. 5108	103	. 4892	. 0674	10	. 9326	. 4434	113	. 5566	2		8
	56	59	. 5522	103	. 4478	. 0635	10	. 9365	. 4887	113	. 5113	1		4
7	60	60	9.465935		0.534065	9.980596		0.019404	9.485339		0.514661	0	52	0
Hours. m	Hours. s	Deg. '	L. Cos.	Diff. for 15'' or 1ˢ	L. Sec.	L. Sin.	Diff. for 15'' or 1ˢ	L. Cosec.	L. Cot.	Diff for 15'' or 1ˢ	L. Tang.	Deg. '	Hours. m	Hours. s

7ʰ 106° 1' — 4ˢ 1° — 4ᵐ 73° 4ʰ

1h 17° 1' = 15'' 1m = 15' 1h = 15° 162° 10h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
8	0	0	9.465935	103	0.534065	9.980536	9	0.019404	9.485339	113	0.514661	60	51	60
	4	1	. 6348	103	. 3652	. 0558	10	. 9442	. 5791	113	. 4209	59		56
	8	2	. 6761	103	. 3239	. 0519	10	. 9481	. 6242	113	. 3758	58		52
	12	3	. 7173	103	. 2827	. 0480	9	. 9520	. 6693	112	. 3307	57		48
	16	4	. 7585	103	. 2415	. 0442	10	. 9558	. 7143	112	. 2857	56		44
	20	5	. 7996	103	. 2004	. 0403	10	. 9597	. 7593	112	. 2407	55		40
	24	6	. 8407	102	. 1593	. 0364	10	. 9636	. 8043	112	. 1957	54		36
	28	7	. 8817	102	. 1183	. 0325	10	. 9675	. 8492	112	. 1508	53		32
	32	8	. 9227	102	. 0773	. 0286	10	. 9714	. 8941	112	. 1059	52		28
	36	9	. 9637	102	. 0363	. 0247	10	. 9753	. 9390	112	. 0610	51		24
	40	10	.470046	102	.529954	. 0208	10	. 9792	. 9838	112	. 0162	50		20
	44	11	. 0455	102	. 9545	. 0169	10	. 9831	.490286	112	.509714	49		16
	48	12	. 0863	102	. 9137	. 0130	10	. 9870	. 0733	112	. 9267	48		12
	52	13	. 1271	102	. 8729	. 0091	10	. 9909	. 1180	112	. 8820	47		8
	56	14	. 1679	102	. 8321	. 0052	10	. 9948	. 1627	111	. 8373	46		4
9	0	15	. 2085	102	. 7915	. 0012	10	. 9988	. 2073	111	. 7927	45	51	0
	4	16	. 2492	102	. 7508	.979973	10	.020027	. 2519	111	. 7481	44		56
	8	17	. 2899	101	. 7101	. 9934	10	. 0066	. 2965	111	. 7035	43		52
	12	18	. 3304	101	. 6696	. 9894	10	. 0106	. 3410	111	. 6590	42		48
	16	19	. 3710	101	. 6290	. 9855	10	. 0145	. 3855	111	. 6145	41		44
	20	20	. 4115	101	. 5885	. 9816	10	. 0184	. 4299	111	. 5701	40		40
	24	21	. 4519	101	. 5481	. 9776	10	. 0224	. 4743	111	. 5257	39		36
	28	22	. 4923	101	. 5077	. 9737	10	. 0263	. 5186	111	. 4814	38		32
	32	23	. 5327	101	. 4673	. 9697	10	. 0303	. 5630	111	. 4370	37		28
	36	24	. 5731	101	. 4269	. 9658	10	. 0342	. 6073	110	. 3927	36		24
	40	25	. 6133	101	. 3867	. 9618	10	. 0382	. 6515	110	. 3485	35		20
	44	26	. 6536	100	. 3464	. 9579	10	. 0421	. 6957	110	. 3043	34		16
	48	27	. 6938	100	. 3062	. 9539	10	. 0461	. 7399	110	. 2601	33		12
	52	28	. 7340	100	. 2660	. 9499	10	. 0501	. 7841	110	. 2159	32		8
	56	29	. 7741	100	. 2259	. 9459	10	. 0541	. 8282	110	. 1718	31		4
10	0	30	. 8142	100	. 1858	. 9420	10	. 0580	. 8722	110	. 1278	30	50	0
	4	31	. 8542	100	. 1458	. 9380	10	. 0620	. 9162	110	. 0838	29		56
	8	32	. 8942	100	. 1058	. 9340	10	. 0660	. 9602	110	. 0398	28		52
	12	33	. 9342	100	. 0658	. 9300	10	. 0700	.500042	110	.499958	27		48
	16	34	. 9741	100	. 0259	. 9260	10	. 0740	. 0481	110	. 9519	26		44
	20	35	.480140	100	.519860	. 9220	10	. 0780	. 0920	110	. 9080	25		40
	24	36	. 0539	99	. 9461	. 9180	10	. 0820	. 1359	109	. 8641	24		36
	28	37	. 0937	99	. 9063	. 9140	10	. 0860	. 1797	109	. 8203	23		32
	32	38	. 1334	99	. 8666	. 9099	10	. 0901	. 2235	109	. 7765	22		28
	36	39	. 1731	99	. 8269	. 9059	10	. 0941	. 2672	109	. 7328	21		24
	40	40	. 2128	99	. 7872	. 9019	10	. 0981	. 3109	109	. 6891	20		20
	44	41	. 2525	99	. 7475	. 8979	10	. 1021	. 3546	109	. 6454	19		16
	48	42	. 2921	99	. 7079	. 8939	10	. 1061	. 3982	109	. 6018	18		12
	52	43	. 3316	99	. 6684	. 8898	10	. 1102	. 4418	109	. 5582	17		8
	56	44	. 3712	99	. 6288	. 8858	10	. 1142	. 4854	109	. 5146	16		4
11	0	45	. 4107	98	. 5893	. 8818	10	. 1182	. 5289	109	. 4711	15	49	0
	4	46	. 4501	98	. 5499	. 8777	10	. 1223	. 5724	108	. 4276	14		56
	8	47	. 4895	98	. 5105	. 8736	10	. 1264	. 6159	108	. 3841	13		52
	12	48	. 5289	98	. 4711	. 8696	10	. 1304	. 6593	108	. 3407	12		48
	16	49	. 5682	98	. 4318	. 8655	10	. 1345	. 7027	108	. 2973	11		44
	20	50	. 6075	98	. 3925	. 8615	10	. 1385	. 7460	108	. 2540	10		40
	24	51	. 6467	98	. 3533	. 8574	10	. 1426	. 7893	108	. 2107	9		36
	28	52	. 6859	98	. 3141	. 8533	10	. 1467	. 8326	108	. 1674	8		32
	32	53	. 7251	98	. 2749	. 8493	10	. 1507	. 8758	108	. 1242	7		28
	36	54	. 7643	98	. 2357	. 8452	10	. 1548	. 9191	108	. 0809	6		24
	40	55	. 8033	98	. 1967	. 8411	10	. 1589	. 9622	108	. 0378	5		20
	44	56	. 8424	97	. 1576	. 8370	10	. 1630	.510054	108	.489946	4		16
	48	57	. 8814	97	. 1186	. 8329	10	. 1671	. 0485	108	. 9515	3		12
	52	58	. 9204	97	. 0796	. 8288	10	. 1712	. 0916	107	. 9084	2		8
	56	59	. 9593	97	. 0407	. 8247	10	. 1753	. 1346	107	. 8654	1		4
11	60	60	9.489982		0.510018	9.978206		0.021794	9.511776		0.488224	0	48	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang	'	m	s
Hours.		Deg.										Deg.	Hours	

7h 107° 1' = 4s 1° = 4m 72° 4h

1h 18° — 1' = 15'' 1m = 15' 1h = 15° — 161° 10h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Tang.	Diff. for 15'' or 1'	L. Cot.	Deg. '	Hours. m	Hours. s
12	0	0	9.489982	97	0.510018	9.978206	10	0.021794	9.511776	107	0.488224	60	47	60
	4	1	.490371	97	.509629	. 8165	10	. 1835	. 2206	107	. 7794	59		56
	8	2	. 0759	97	. 9241	. 8124	10	. 1876	. 2635	107	. 7365	58		52
	12	3	. 1147	97	. 8853	. 8083	10	. 1917	. 3064	107	. 6936	57		48
	16	4	. 1535	97	. 8465	. 8042	10	. 1958	. 3493	107	. 6507	56		44
	20	5	. 1922	97	. 8078	. 8001	10	. 1999	. 3921	107	. 6079	55		40
	24	6	. 2308	97	. 7692	. 7959	10	. 2041	. 4349	107	. 5651	54		36
	28	7	. 2695	96	. 7305	. 7918	10	. 2082	. 4777	107	. 5223	53		32
	32	8	. 3081	96	. 6919	. 7877	10	. 2123	. 5204	107	. 4796	52		28
	36	9	. 3466	96	. 6534	. 7835	10	. 2165	. 5631	107	. 4369	51		24
	40	10	. 3851	96	. 6149	. 7794	10	. 2206	. 6057	107	. 3943	50		20
	44	11	. 4236	96	. 5764	. 7752	10	. 2248	. 6484	106	. 3516	49		16
	48	12	. 4621	96	. 5379	. 7711	10	. 2289	. 6910	106	. 3090	48		12
	52	13	. 5004	96	. 4996	. 7669	10	. 2331	. 7335	106	. 2665	47		8
	56	14	. 5388	96	. 4612	. 7628	10	. 2372	. 7760	106	. 2240	46		4
13	0	15	. 5772	96	. 4228	. 7586	10	. 2414	. 8186	106	. 1814	45	47	0
	4	16	. 6154	96	. 3846	. 7544	10	. 2456	. 8610	106	. 1390	44		56
	8	17	. 6537	95	. 3463	. 7503	10	. 2497	. 9034	106	. 0966	43		52
	12	18	. 6919	95	. 3081	. 7461	10	. 2539	. 9458	106	. 0542	42		48
	16	19	. 7301	95	. 2699	. 7419	10	. 2581	. 9882	106	. 0118	41		44
	20	20	. 7682	95	. 2318	. 7377	10	. 2623	.520305	106	.479695	40		40
	24	21	. 8063	95	. 1937	. 7335	10	. 2665	. 0728	106	. 9272	39		36
	28	22	. 8444	95	. 1556	. 7293	10	. 2707	. 1151	105	. 8849	38		32
	32	23	. 8825	95	. 1175	. 7252	10	. 2748	. 1573	105	. 8427	37		28
	36	24	. 9205	95	. 0795	. 7210	11	. 2790	. 1995	105	. 8005	36		24
	40	25	. 9584	95	. 0416	. 7167	10	. 2833	. 2417	105	. 7583	35		20
	44	26	. 9963	95	. 0037	. 7125	10	. 2875	. 2838	105	. 7162	34		16
	48	27	.500342	95	.499658	. 7083	10	. 2917	. 3259	105	. 6741	33		12
	52	28	. 0721	94	. 9279	. 7041	10	. 2959	. 3680	105	. 6320	32		8
	56	29	. 1099	94	. 8901	. 6999	10	. 3001	. 4100	105	. 5900	31		4
14	0	30	. 1477	94	. 8523	. 6957	11	. 3043	. 4520	105	. 5480	30	46	0
	4	31	. 1854	94	. 8146	. 6914	10	. 3086	. 4940	105	. 5060	29		56
	8	32	. 2231	94	. 7769	. 6872	10	. 3128	. 5359	105	. 4641	28		52
	12	33	. 2608	94	. 7392	. 6830	11	. 3170	. 5778	105	. 4222	27		48
	16	34	. 2984	94	. 7016	. 6787	10	. 3213	. 6197	104	. 3803	26		44
	20	35	. 3360	94	. 6640	. 6745	11	. 3255	. 6615	104	. 3385	25		40
	24	36	. 3735	94	. 6265	. 6702	10	. 3298	. 7033	104	. 2967	24		36
	28	37	. 4111	94	. 5889	. 6660	11	. 3340	. 7451	104	. 2549	23		32
	32	38	. 4485	94	. 5515	. 6617	10	. 3383	. 7868	104	. 2132	22		28
	36	39	. 4860	93	. 5140	. 6575	11	. 3425	. 8285	104	. 1715	21		24
	40	40	. 5234	93	. 4766	. 6532	11	. 3468	. 8702	104	. 1298	20		20
	44	41	. 5608	93	. 4392	. 6489	11	. 3511	. 9119	104	. 0881	19		16
	48	42	. 5981	93	. 4019	. 6446	10	. 3554	. 9535	104	. 0465	18		12
	52	43	. 6354	93	. 3646	. 6404	11	. 3596	. 9950	104	. 0050	17		8
	56	44	. 6727	93	. 3273	. 6361	11	. 3639	.530366	104	.469634	16		4
15	0	45	. 7099	93	. 2901	. 6318	11	. 3682	. 0781	104	. 9219	15	45	0
	4	46	. 7471	93	. 2529	. 6275	11	. 3725	. 1196	104	. 8804	14		56
	8	47	. 7843	93	. 2157	. 6232	11	. 3768	. 1611	103	. 8389	13		52
	12	48	. 8214	93	. 1786	. 6189	11	. 3811	. 2025	103	. 7975	12		48
	16	49	. 8585	93	. 1415	. 6146	11	. 3854	. 2439	103	. 7561	11		44
	20	50	. 8956	92	. 1044	. 6103	11	. 3897	. 2853	103	. 7147	10		40
	24	51	. 9326	92	. 0674	. 6060	11	. 3940	. 3266	103	. 6734	9		36
	28	52	. 9696	92	. 0304	. 6017	11	. 3983	. 3679	103	. 6321	8		32
	32	53	.510065	92	.489935	. 5974	11	. 4026	. 4091	103	. 5909	7		28
	36	54	. 0434	92	. 9566	. 5930	11	. 4070	. 4504	103	. 5496	6		24
	40	55	. 0803	92	. 9197	. 5887	11	. 4113	. 4916	103	. 5084	5		20
	44	56	. 1172	92	. 8828	. 5844	11	. 4156	. 5328	103	. 4672	4		16
	48	57	. 1540	92	. 8460	. 5801	11	. 4199	. 5739	103	. 4261	3		12
	52	58	. 1907	92	. 8093	. 5757	11	. 4243	. 6150	103	. 3850	2		8
	56	59	. 2275	92	. 7725	. 5714	11	. 4286	. 6561	103	. 3439	1		4
15	60	60	9.512642		0.487358	9.975670		0.024330	9.536972		0.463028	0	44	0
m	s	'	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cot.	Diff. for 15'' or 1'	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

7h 108° — 1' = 4s 1° = 4m — 71° 4h

19° 1' — 15'' 1m — 15' 1h — 15° 160° 10h

Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours m	s
0	9.512642	92	0.487358	9.975670	11	0.024330	9.536972	102	0.463028	60	43	60
1	. 3009	91	. 6991	. 5627	11	. 4373	. 7382	102	. 2618	59		56
2	. 3375	91	. 6625	. 5583	11	. 4417	. 7792	102	. 2208	58		52
3	. 3741	91	. 6259	. 5539	11	. 4461	. 8202	102	. 1798	57		48
4	. 4107	91	. 5893	. 5496	11	. 4504	. 8611	102	. 1389	56		44
5	. 4472	91	. 5528	. 5452	11	. 4548	. 9020	102	. 0980	55		40
6	. 4837	91	. 5163	. 5408	11	. 4592	. 9429	102	. 0571	54		36
7	. 5202	91	. 4798	. 5365	11	. 4635	. 9837	102	. 0163	53		32
8	. 5566	91	. 4434	. 5321	11	. 4679	.540245	102	.459755	52		28
9	. 5930	91	. 4070	. 5277	11	. 4723	. 0653	102	. 9347	51		24
10	. 6294	91	. 3706	. 5233	11	. 4767	. 1061	102	. 8939	50		20
11	. 6657	91	. 3343	. 5189	11	. 4811	. 1468	102	. 8532	49		16
12	. 7020	91	. 2980	. 5145	11	. 4855	. 1875	102	. 8125	48		12
13	. 7382	91	. 2618	. 5101	11	. 4899	. 2281	102	. 7719	47		8
14	. 7745	90	. 2255	. 5057	11	. 4943	. 2688	101	. 7312	46		4
15	. 8107	90	. 1893	. 5013	11	. 4987	. 3094	101	. 6906	45	43	0
16	. 8468	90	. 1532	. 4969	11	. 5031	. 3499	101	. 6501	44		56
17	. 8830	90	. 1170	. 4925	11	. 5075	. 3905	101	. 6095	43		52
18	. 9190	90	. 0810	. 4880	11	. 5120	. 4310	101	. 5690	42		48
19	. 9551	90	. 0449	. 4836	11	. 5164	. 4715	101	. 5285	41		44
20	. 9911	90	. 0089	. 4792	11	. 5208	. 5119	101	. 4881	40		40
21	.520271	90	.479729	. 4747	11	. 5253	. 5524	101	. 4476	39		36
22	. 0631	90	. 9369	. 4703	11	. 5297	. 5928	101	. 4072	38		32
23	. 0990	90	. 9010	. 4659	11	. 5341	. 6331	101	. 3669	37		28
24	. 1349	90	. 8651	. 4614	11	. 5386	. 6735	101	. 3265	36		24
25	. 1708	89	. 8292	. 4570	11	. 5430	. 7138	101	. 2862	35		20
26	. 2066	89	. 7934	. 4525	11	. 5475	. 7541	100	. 2459	34		16
27	. 2424	89	. 7576	. 4481	11	. 5519	. 7943	100	. 2057	33		12
28	. 2781	89	. 7219	. 4436	11	. 5564	. 8345	100	. 1655	32		8
29	. 3138	89	. 6862	. 4391	11	. 5609	. 8747	100	. 1253	31		4
30	. 3495	89	. 6505	. 4346	11	. 5654	. 9149	100	. 0851	30	42	0
31	. 3852	89	. 6148	. 4302	11	. 5698	. 9550	100	. 0450	29		56
32	. 4208	89	. 5792	. 4257	11	. 5743	. 9951	100	. 0049	28		52
33	. 4564	89	. 5436	. 4212	11	. 5788	.550352	100	.449648	27		48
34	. 4919	89	. 5081	. 4167	11	. 5833	. 0752	100	. 9248	26		44
35	. 5275	89	. 4725	. 4122	11	. 5878	. 1153	100	. 8847	25		40
36	. 5630	89	. 4370	. 4077	11	. 5923	. 1553	100	. 8447	24		36
37	. 5984	89	. 4016	. 4032	11	. 5968	. 1952	100	. 8048	23		32
38	. 6339	88	. 3661	. 3987	11	. 6013	. 2352	100	. 7648	22		28
39	. 6693	88	. 3307	. 3942	11	. 6058	. 2751	100	. 7249	21		24
40	. 7046	88	. 2954	. 3897	11	. 6103	. 3149	100	. 6851	20		20
41	. 7400	88	. 2600	. 3852	11	. 6148	. 3548	99	. 6452	19		16
42	. 7753	88	. 2247	. 3807	11	. 6193	. 3946	99	. 6054	18		12
43	. 8105	88	. 1895	. 3761	11	. 6239	. 4344	99	. 5656	17		8
44	. 8458	88	. 1542	. 3716	11	. 6284	. 4742	99	. 5258	16		4
45	. 8810	88	. 1190	. 3671	11	. 6329	. 5139	99	. 4861	15	41	0
46	. 9161	88	. 0839	. 3625	11	. 6375	. 5536	99	. 4464	14		56
47	. 9513	88	. 0487	. 3580	11	. 6420	. 5933	99	. 4067	13		52
48	. 9864	88	. 0136	. 3535	11	. 6465	. 6329	99	. 3671	12		48
49	.530215	87	.469785	. 3489	11	. 6511	. 6726	99	. 3274	11		44
50	. 0565	87	. 9435	. 3444	11	. 6556	. 7121	99	. 2879	10		40
51	. 0915	87	. 9085	. 3398	11	. 6602	. 7517	99	. 2483	9		36
52	. 1265	87	. 8735	. 3352	11	. 6648	. 7913	99	. 2087	8		32
53	. 1615	87	. 8385	. 3307	11	. 6693	. 8308	99	. 1692	7		28
54	. 1964	87	. 8036	. 3261	11	. 6739	. 8703	99	. 1297	6		24
55	. 2312	87	. 7688	. 3215	11	. 6785	. 9097	99	. 0903	5		20
56	. 2661	87	. 7339	. 3169	11	. 6831	. 9492	98	. 0508	4		16
57	. 3009	87	. 6991	. 3124	11	. 6876	. 9885	98	. 0115	3		12
58	. 3357	87	. 6643	. 3078	11	. 6922	.560279	98	.439721	2		8
59	. 3705	87	. 6295	. 3032	11	. 6968	. 0673	98	. 9327	1		4
60	9.534052		0.465948	9.972986		0.027014	9.561066		0.438934	0	40	0
' Deg.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	' Deg.	m Hours	s

109° 1' — 4s 1° — 4m 70° 4h

1h 20° 1s = 15'' 1m = 15' 1h = 15° 159° 10h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
20	0	0	9.534052	87	0.465948	9.972986	11	0.027014	9.561066	98	0.438934	60	39	60
	4	1	. 4399	87	. 5601	. 2940	11	. 7060	. 1459	98	. 8541	59		56
	8	2	. 4745	87	. 5255	. 2894	11	. 7106	. 1851	98	. 8149	58		52
	12	3	. 5092	86	. 4908	. 2848	11	. 7152	. 2244	98	. 7756	57		48
	16	4	. 5438	86	. 4562	. 2802	12	. 7198	. 2636	98	. 7364	56		44
	20	5	. 5783	86	. 4217	. 2755	11	. 7245	. 3028	98	. 6972	55		40
	24	6	. 6128	86	. 3872	. 2709	11	. 7291	. 3419	98	. 6581	54		36
	28	7	. 6474	86	. 3526	. 2663	11	. 7337	. 3811	98	. 6189	53		32
	32	8	. 6819	86	. 3181	. 2617	12	. 7383	. 4202	98	. 5798	52		28
	36	9	. 7163	86	. 2837	. 2570	11	. 7430	. 4593	97	. 5407	51		24
	40	10	. 7507	86	. 2493	. 2524	11	. 7476	. 4983	97	. 5017	50		20
	44	11	. 7851	86	. 2149	. 2478	12	. 7522	. 5373	97	. 4627	49		16
	48	12	. 8194	86	. 1806	. 2431	11	. 7569	. 5763	97	. 4237	48		12
	52	13	. 8538	86	. 1462	. 2385	12	. 7615	. 6153	97	. 3847	47		8
	56	14	. 8880	86	. 1120	. 2338	12	. 7662	. 6542	97	. 3458	46		4
21	0	15	. 9223	85	. 0777	. 2291	11	. 7709	. 6932	97	. 3068	45	39	0
	4	16	. 9565	85	. 0435	. 2245	12	. 7755	. 7320	97	. 2680	44		56
	8	17	. 9907	85	. 0093	. 2198	12	. 7802	. 7709	97	. 2291	43		52
	12	18	.540249	85	.459751	. 2151	11	. 7849	. 8098	97	. 1902	42		48
	16	19	. 0590	85	. 9410	. 2105	12	. 7895	. 8485	97	. 1515	41		44
	20	20	. 0931	85	. 9069	. 2058	12	. 7942	. 8873	97	. 1127	40		40
	24	21	. 1272	85	. 8728	. 2011	12	. 7989	. 9261	97	. 0739	39		36
	28	22	. 1613	85	. 8387	. 1964	12	. 8036	. 9649	97	. 0351	38		32
	32	23	. 1953	85	. 8047	. 1917	12	. 8083	.570036	97	.429964	37		28
	36	24	. 2292	85	. 7708	. 1870	12	. 8130	. 0422	97	. 9578	36		24
	40	25	. 2632	85	. 7368	. 1823	12	. 8177	. 0809	96	. 9191	35		20
	44	26	. 2971	85	. 7029	. 1776	12	. 8224	. 1195	96	. 8805	34		16
	48	27	. 3310	85	. 6690	. 1729	12	. 8271	. 1581	96	. 8419	33		12
	52	28	. 3649	84	. 6351	. 1682	12	. 8318	. 1967	96	. 8033	32		8
	56	29	. 3987	84	. 6013	. 1635	12	. 8365	. 2352	96	. 7648	31		4
22	0	30	. 4325	84	. 5675	. 1587	12	. 8413	. 2738	96	. 7262	30	38	0
	4	31	. 4663	84	. 5337	. 1540	12	. 8460	. 3123	96	. 6877	29		56
	8	32	. 5000	84	. 5000	. 1493	12	. 8507	. 3507	96	. 6493	28		52
	12	33	. 5338	84	. 4662	. 1445	12	. 8554	. 3892	96	. 6108	27		48
	16	34	. 5674	84	. 4326	. 1398	12	. 8602	. 4276	96	. 5724	26		44
	20	35	. 6011	84	. 3989	. 1351	12	. 8649	. 4660	96	. 5340	25		40
	24	36	. 6347	84	. 3653	. 1303	12	. 8697	. 5044	96	. 4956	24		36
	28	37	. 6683	84	. 3317	. 1256	12	. 8744	. 5427	96	. 4573	23		32
	32	38	. 7019	84	. 2981	. 1209	12	. 8791	. 5810	96	. 4190	22		28
	36	39	. 7354	84	. 2646	. 1161	12	. 8839	. 6193	96	. 3807	21		24
	40	40	. 7689	84	. 2311	. 1113	12	. 8887	. 6576	96	. 3424	20		20
	44	41	. 8024	84	. 1976	. 1066	12	. 8934	. 6958	96	. 3042	19		16
	48	42	. 8359	83	. 1641	. 1018	12	. 8982	. 7341	95	. 2659	18		12
	52	43	. 8693	83	. 1307	. 0970	12	. 9030	. 7723	95	. 2277	17		8
	56	44	. 9026	83	. 0974	. 0922	12	. 9078	. 8104	95	. 1896	16		4
23	0	45	. 9360	83	. 0640	. 0874	12	. 9126	. 8486	95	. 1514	15	37	0
	4	46	. 9694	83	. 0306	. 0827	12	. 9173	. 8867	95	. 1133	14		56
	8	47	.550027	83	.449973	. 0779	12	. 9221	. 9248	95	. 0752	13		52
	12	48	. 0359	83	. 9641	. 0731	12	. 9269	. 9628	95	. 0372	12		48
	16	49	. 0692	83	. 9308	. 0683	12	. 9317	.580009	95	.419991	11		44
	20	50	. 1024	83	. 8976	. 0635	12	. 9365	. 0389	95	. 9611	10		40
	24	51	. 1356	83	. 8644	. 0587	12	. 9413	. 0769	95	. 9231	9		36
	28	52	. 1687	83	. 8313	. 0538	12	. 9462	. 1149	95	. 8851	8		32
	32	53	. 2018	83	. 7982	. 0490	12	. 9510	. 1528	95	. 8472	7		28
	36	54	. 2349	83	. 7651	. 0442	12	. 9558	. 1907	95	. 8093	6		24
	40	55	. 2680	83	. 7320	. 0394	12	. 9606	. 2286	95	. 7714	5		20
	44	56	. 3010	83	. 6990	. 0345	12	. 9655	. 2665	95	. 7335	4		16
	48	57	. 3341	82	. 6659	. 0297	12	. 9703	. 3044	94	. 6956	3		12
	52	58	. 3671	82	. 6329	. 0249	12	. 9751	. 3422	94	. 6578	2		8
	56	59	. 4000	82	. 6000	. 0200	12	. 9800	. 3800	94	. 6200	1		4
23	60	60	9.554329		0.445671	9.970152		0.029848	9.584177		0.415823	0	36	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

7h 110° 1' = 4s 1° = 4m 69° 4h

1h 21° 1s = 15'' 1m = 15' 1h = 15° 158° 10h

Hours m	Hours s	Deg. '	L. Sin.	Diff for 15'' or 1s	L. Cosec.	L. Cos.	Diff for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours m	Hours s
24	0	0	9.554329	82	0.445671	9.970152	12	0.029848	9.584177	94	0.415823	60	35	60
	4	1	. 4658	82	. 5342	. 0103	12	. 9897	. 4555	94	. 5445	59		56
	8	2	. 4987	82	. 5013	. 0055	12	. 9945	. 4932	94	. 5068	58		52
	12	3	. 5315	82	. 4685	. 0006	12	. 9994	. 5309	94	. 4691	57		48
	16	4	. 5643	82	. 4357	.969957	12	.030043	. 5686	94	. 4314	56		44
	20	5	. 5971	82	. 4029	. 9909	12	. 0091	. 6062	94	. 3938	55		40
	24	6	. 6299	82	. 3701	. 9860	12	. 0140	. 6439	94	. 3561	54		36
	28	7	. 6626	82	. 3374	. 9811	12	. 0189	. 6815	94	. 3185	53		32
	32	8	. 6953	82	. 3047	. 9763	12	. 0237	. 7190	94	. 2810	52		28
	36	9	. 7280	81	. 2720	. 9714	12	. 0286	. 7566	94	. 2434	51		24
	40	10	. 7606	81	. 2394	. 9665	12	. 0335	. 7941	94	. 2059	50		20
	44	11	. 7932	81	. 2068	. 9616	12	. 0384	. 8316	94	. 1684	49		16
	48	12	. 8258	81	. 1742	. 9567	12	. 0433	. 8691	94	. 1309	48		12
	52	13	. 8584	81	. 1416	. 9518	12	. 0482	. 9066	93	. 0934	47		8
	56	14	. 8909	81	. 1091	. 9469	12	. 0531	. 9440	93	. 0560	46		4
25	0	15	. 9234	81	. 0766	. 9420	12	. 0580	. 9814	93	. 0186	45	35	0
	4	16	. 9558	81	. 0442	. 9370	12	. 0630	.590188	93	.409812	44		56
	8	17	. 9883	81	. 0117	. 9321	12	. 0679	. 0562	93	. 9438	43		52
	12	18	.560207	81	.439793	. 9272	12	. 0728	. 0935	93	. 9065	42		48
	16	19	. 0531	81	. 9469	. 9223	12	. 0777	. 1308	93	. 8692	41		44
	20	20	. 0854	81	. 9146	. 9173	12	. 0827	. 1681	93	. 8319	40		40
	24	21	. 1178	81	. 8822	. 9124	12	. 0876	. 2054	93	. 7946	39		36
	28	22	. 1501	81	. 8499	. 9075	12	. 0925	. 2426	93	. 7574	38		32
	32	23	. 1824	80	. 8176	. 9025	12	. 0975	. 2799	93	. 7201	37		28
	36	24	. 2146	80	. 7854	. 8976	12	. 1024	. 3170	93	. 6830	36		24
	40	25	. 2468	80	. 7532	. 8926	12	. 1074	. 3542	93	. 6458	35		20
	44	26	. 2790	80	. 7210	. 8876	12	. 1124	. 3914	93	. 6086	34		16
	48	27	. 3112	80	. 6888	. 8827	12	. 1173	. 4285	93	. 5715	33		12
	52	28	. 3433	80	. 6567	. 8777	12	. 1223	. 4656	93	. 5344	32		8
	56	29	. 3755	80	. 6245	. 8728	12	. 1272	. 5027	93	. 4973	31		4
26	0	30	. 4075	80	. 5925	. 8678	12	. 1322	. 5397	93	. 4603	30	34	0
	4	31	. 4396	80	. 5604	. 8628	12	. 1372	. 5768	92	. 4232	29		56
	8	32	. 4716	80	. 5284	. 8578	12	. 1422	. 6138	92	. 3862	28		52
	12	33	. 5036	80	. 4964	. 8528	12	. 1472	. 6508	92	. 3492	27		48
	16	34	. 5356	80	. 4644	. 8478	12	. 1522	. 6878	92	. 3122	26		44
	20	35	. 5676	80	. 4324	. 8429	12	. 1571	. 7247	92	. 2753	25		40
	24	36	. 5995	80	. 4005	. 8379	12	. 1621	. 7616	92	. 2384	24		36
	28	37	. 6314	80	. 3686	. 8329	13	. 1671	. 7985	92	. 2015	23		32
	32	38	. 6632	80	. 3368	. 8278	12	. 1722	. 8354	92	. 1646	22		28
	36	39	. 6951	79	. 3049	. 8228	12	. 1772	. 8723	92	. 1277	21		24
	40	40	. 7269	79	. 2731	. 8178	12	. 1822	. 9091	92	. 0909	20		20
	44	41	. 7587	79	. 2413	. 8128	12	. 1872	. 9459	92	. 0541	19		16
	48	42	. 7905	79	. 2095	. 8078	12	. 1922	. 9827	92	. 0173	18		12
	52	43	. 8222	79	. 1778	. 8028	13	. 1972	.600194	92	.399806	17		8
	56	44	. 8539	79	. 1461	. 7977	12	. 2023	. 0562	92	. 9438	16		4
27	0	45	. 8856	79	. 1144	. 7927	13	. 2073	. 0929	92	. 9071	15	33	0
	4	46	. 9172	79	. 0828	. 7876	12	. 2124	. 1296	92	. 8704	14		56
	8	47	. 9488	79	. 0512	. 7826	13	. 2174	. 1662	92	. 8338	13		52
	12	48	. 9804	79	. 0196	. 7775	12	. 2225	. 2029	91	. 7971	12		48
	16	49	.570120	79	.429880	. 7725	13	. 2275	. 2395	91	. 7605	11		44
	20	50	. 0435	79	. 9565	. 7674	12	. 2326	. 2761	91	. 7239	10		40
	24	51	. 0751	79	. 9249	. 7624	13	. 2376	. 3127	91	. 6873	9		36
	28	52	. 1066	79	. 8934	. 7573	13	. 2427	. 3493	91	. 6507	8		32
	32	53	. 1380	79	. 8620	. 7522	13	. 2478	. 3858	91	. 6142	7		28
	36	54	. 1694	79	. 8306	. 7471	12	. 2529	. 4223	91	. 5777	6		24
	40	55	. 2009	78	. 7991	. 7421	13	. 2579	. 4588	91	. 5412	5		20
	44	56	. 2323	78	. 7677	. 7370	13	. 2630	. 4953	91	. 5047	4		16
	48	57	. 2636	78	. 7364	. 7319	13	. 2681	. 5317	91	. 4683	3		12
	52	58	. 2950	78	. 7050	. 7268	13	. 2732	. 5682	91	. 4318	2		8
	56	59	. 3263	78	. 6737	. 7217	13	. 2783	. 6046	91	. 3954	1		4
27	60	60	9.573576		0.426424	9.967166		0.032834	9.606410		0.393590	0	32	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg	Hours.	

7h 111° 1' = 4s 1° = 4m 68° 4h

1h 22° 1s = 15'' 1m = 15' 1h = 15° 157° 10h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
28	0	0	9.573576	78	0.426424	9.967166	13	0.032834	9.606410	91	0.393590	60	31	60
	4	1	. 3888	78	. 6112	. 7115	13	. 2885	. 6773	91	. 3227	59		56
	8	2	. 4200	78	. 5800	. 7064	13	. 2936	. 7136	91	. 2864	58		52
	12	3	. 4512	78	. 5488	. 7012	13	. 2988	. 7500	91	. 2500	57		48
	16	4	. 4824	78	. 5176	. 6961	13	. 3039	. 7863	91	. 2137	56		44
	20	5	. 5135	78	. 4865	. 6910	13	. 3090	. 8225	91	. 1775	55		40
	24	6	. 5447	78	. 4553	. 6859	13	. 3141	. 8588	90	. 1412	54		36
	28	7	. 5758	78	. 4242	. 6808	13	. 3192	. 8950	90	. 1050	53		32
	32	8	. 6069	78	. 3932	. 6756	13	. 3244	. 9312	90	. 0688	52		28
	36	9	. 6379	77	. 3621	. 6705	13	. 3295	. 9674	90	. 0326	51		24
	40	10	. 6689	77	. 3311	. 6653	13	. 3347	.610036	90	.389964	50		20
	44	11	. 6999	77	. 3001	. 6602	13	. 3398	. 0397	90	. 9603	49		16
	48	12	. 7309	77	. 2691	. 6550	13	. 3450	. 0759	90	. 9241	48		12
	52	13	. 7618	77	. 2382	. 6499	13	. 3501	. 1119	90	. 8881	47		8
	56	14	. 7927	77	. 2073	. 6447	13	. 3553	. 1480	90	. 8520	46		4
29	0	15	. 8236	77	. 1764	. 6395	13	. 3605	. 1841	90	. 8159	45	31	0
	4	16	. 8545	77	. 1455	. 6344	13	. 3656	. 2201	90	. 7799	44		56
	8	17	. 8854	77	. 1146	. 6292	13	. 3708	. 2562	90	. 7438	43		52
	12	18	. 9162	77	. 0838	. 6240	13	. 3760	. 2922	90	. 7078	42		48
	16	19	. 9469	77	. 0531	. 6188	13	. 3812	. 3281	90	. 6719	41		44
	20	20	. 9777	77	. 0223	. 6136	13	. 3864	. 3641	90	. 6359	40		40
	24	21	.580085	77	.419915	. 6085	13	. 3915	. 4000	90	. 6000	39		36
	28	22	. 0392	77	. 9608	. 6033	13	. 3967	. 4359	90	. 5641	38		32
	32	23	. 0699	76	. 9301	. 5981	13	. 4019	. 4718	90	. 5282	37		28
	36	24	. 1005	76	. 8995	. 5928	13	. 4072	. 5077	89	. 4923	36		24
	40	25	. 1311	76	. 8689	. 5876	13	. 4124	. 5435	90	. 4565	35		20
	44	26	. 1618	76	. 8382	. 5824	13	. 4176	. 5794	89	. 4206	34		16
	48	27	. 1924	76	. 8076	. 5772	13	. 4228	. 6152	89	. 3848	33		12
	52	28	. 2229	76	. 7771	. 5720	13	. 4280	. 6509	89	. 3491	32		8
	56	29	. 2535	76	. 7465	. 5668	13	. 4332	. 6867	89	. 3133	31		4
30	0	30	. 2840	76	. 7160	. 5616	13	. 4384	. 7224	89	. 2776	30	30	0
	4	31	. 3145	76	. 6855	. 5563	13	. 4437	. 7582	89	. 2418	29		56
	8	32	. 3449	76	. 6551	. 5511	13	. 4489	. 7938	89	. 2062	28		52
	12	33	. 3753	76	. 6247	. 5458	13	. 4542	. 8295	89	. 1705	27		48
	16	34	. 4058	76	. 5942	. 5406	13	. 4594	. 8652	89	. 1348	26		44
	20	35	. 4361	76	. 5639	. 5353	13	. 4647	. 9008	89	. 0992	25		40
	24	36	. 4665	76	. 5335	. 5301	13	. 4699	. 9364	89	. 0636	24		36
	28	37	. 4969	76	. 5031	. 5248	13	. 4752	. 9721	89	. 0279	23		32
	32	38	. 5272	76	. 4728	. 5196	13	. 4804	.620076	89	.379924	22		28
	36	39	. 5575	75	. 4425	. 5143	13	. 4857	. 0432	89	. 9568	21		24
	40	40	. 5877	75	. 4123	. 5090	13	. 4910	. 0787	89	. 9213	20		20
	44	41	. 6179	75	. 3821	. 5037	13	. 4963	. 1142	89	. 8858	19		16
	48	42	. 6481	75	. 3519	. 4984	13	. 5016	. 1497	89	. 8503	18		12
	52	43	. 6783	75	. 3217	. 4931	13	. 5069	. 1852	89	. 8148	17		8
	56	44	. 7085	75	. 2915	. 4878	13	. 5122	. 2207	88	. 7793	16		4
31	0	45	. 7387	75	. 2613	. 4825	13	. 5174	. 2561	88	. 7439	15	29	0
	4	46	. 7688	75	. 2312	. 4773	13	. 5227	. 2915	88	. 7085	14		56
	8	47	. 7989	75	. 2011	. 4720	13	. 5280	. 3269	88	. 6731	13		52
	12	48	. 8289	75	. 1711	. 4666	13	. 5334	. 3623	88	. 6377	12		48
	16	49	. 8589	75	. 1411	. 4613	13	. 5387	. 3976	88	. 6024	11		44
	20	50	. 8890	75	. 1110	. 4560	13	. 5440	. 4330	88	. 5670	10		40
	24	51	. 9190	75	. 0810	. 4507	13	. 5493	. 4683	88	. 5317	9		36
	28	52	. 9489	75	. 0511	. 4454	13	. 5546	. 5035	88	. 4965	8		32
	32	53	. 9789	75	. 0211	. 4401	13	. 5599	. 5388	88	. 4612	7		28
	36	54	.590088	75	.409912	. 4347	13	. 5653	. 5741	88	. 4259	6		24
	40	55	. 0387	75	. 9613	. 4294	13	. 5706	. 6093	88	. 3907	5		20
	44	56	. 0686	74	. 9314	. 4240	13	. 5760	. 6446	88	. 3554	4		16
	48	57	. 0984	74	. 9016	. 4187	13	. 5813	. 6797	88	. 3203	3		12
	52	58	. 1282	74	. 8718	. 4133	13	. 5867	. 7149	88	. 2851	2		8
	56	59	. 1580	74	. 8420	. 4080	13	. 5920	. 7500	88	. 2500	1		4
31	60	60	9.591878		0.408122	9.964026		0.035974	9.627852		0.372148	0	28	0
Hours. m	Hours. s	Deg. '	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	Deg. '	Hours. m	Hours. s

7h 112° 1' = 4s 1° = 4m 67° 4h

1h 23° 1s = 15'' 1m = 15' 1h = 15° 156° 10h

Hours m	Hours s	Deg. '	L. Sin	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours m	Hours s
32	0	0	9.591878	74	0.408122	9.964026	13	0.035974	9.637852	88	0.372148	60	27	60
	4	1	. 2175	74	. 7825	. 3972	13	. 6028	. 8203	88	. 1797	59		56
	8	2	. 2473	74	. 7527	. 3919	13	. 6081	. 8554	88	. 1446	58		52
	12	3	. 2770	74	. 7230	. 3865	13	. 6135	. 8905	88	. 1095	57		48
	16	4	. 3066	74	. 6934	. 3811	13	. 6189	. 9255	88	. 0745	56		44
	20	5	. 3363	74	. 6637	. 3757	13	. 6243	. 9606	87	. 0394	55		40
	24	6	. 3659	74	. 6341	. 3703	13	. 6297	. 9956	87	. 0044	54		36
	28	7	. 3956	74	. 6044	. 3650	13	. 6350	.630306	87	.369694	53		32
	32	8	. 4251	74	. 5749	. 3596	13	. 6404	. 0655	87	. 9345	52		28
	36	9	. 4547	74	. 5453	. 3542	13	. 6458	. 1005	87	. 8995	51		24
	40	10	. 4842	74	. 5158	. 3488	14	. 6512	. 1354	87	. 8646	50		20
	44	11	. 5137	74	. 4863	. 3433	13	. 6567	. 1704	87	. 8296	49		16
	48	12	. 5432	74	. 4568	. 3379	14	. 6621	. 2053	87	. 7947	48		12
	52	13	. 5727	73	. 4273	. 3325	13	. 6675	. 2402	87	. 7598	47		8
	56	14	. 6021	73	. 3979	. 3271	13	. 6729	. 2750	87	. 7250	46		4
33	0	15	. 6315	73	. 3685	. 3217	14	. 6783	. 3098	87	. 6902	45	27	0
	4	16	. 6609	73	. 3391	. 3162	14	. 6838	. 3447	87	. 6553	44		56
	8	17	. 6903	73	. 3097	. 3108	13	. 6892	. 3795	87	. 6205	43		52
	12	18	. 7197	73	. 2803	. 3054	14	. 6946	. 4143	87	. 5857	42		48
	16	19	. 7490	73	. 2510	. 3000	14	. 7000	. 4490	87	. 5510	41		44
	20	20	. 7783	73	. 2217	. 2945	14	. 7055	. 4838	87	. 5162	40		40
	24	21	. 8075	73	. 1925	. 2890	13	. 7110	. 5185	87	. 4815	39		36
	28	22	. 8368	73	. 1632	. 2836	14	. 7164	. 5532	87	. 4468	38		32
	32	23	. 8660	73	. 1340	. 2781	14	. 7219	. 5879	87	. 4121	37		28
	36	24	. 8952	73	. 1048	. 2726	14	. 7274	. 6226	87	. 3774	36		24
	40	25	. 9244	73	. 0756	. 2672	14	. 7328	. 6572	87	. 3428	35		20
	44	26	. 9536	73	. 0464	. 2617	14	. 7383	. 6919	86	. 3081	34		16
	48	27	. 9827	73	. 0173	. 2562	14	. 7438	. 7265	86	. 2735	33		12
	52	28	.600118	73	.399882	. 2507	14	. 7493	. 7611	86	. 2389	32		8
	56	29	. 0409	73	. 9591	. 2453	14	. 7547	. 7956	86	. 2044	31		4
34	0	30	. 0700	72	. 9300	. 2398	14	. 7602	. 8302	86	. 1698	30	26	0
	4	31	. 0990	72	. 9010	. 2343	14	. 7657	. 8647	86	. 1353	29		56
	8	32	. 1280	72	. 8720	. 2288	14	. 7712	. 8992	86	. 1008	28		52
	12	33	. 1570	72	. 8430	. 2233	14	. 7767	. 9337	86	. 0663	27		48
	16	34	. 1860	72	. 8140	. 2178	14	. 7822	. 9682	86	. 0318	26		44
	20	35	. 2150	72	. 7850	. 2123	14	. 7877	.640027	86	.359973	25		40
	24	36	. 2439	72	. 7561	. 2067	14	. 7933	. 0372	86	. 9628	24		36
	28	37	. 2728	72	. 7272	. 2012	14	. 7988	. 0716	86	. 9284	23		32
	32	38	. 3017	72	. 6983	. 1957	14	. 8043	. 1060	86	. 8940	22		28
	36	39	. 3305	72	. 6695	. 1902	14	. 8098	. 1403	86	. 8597	21		24
	40	40	. 3593	72	. 6407	. 1846	14	. 8154	. 1747	86	. 8253	20		20
	44	41	. 3882	72	. 6118	. 1791	14	. 8209	. 2091	86	. 7909	19		16
	48	42	. 4170	72	. 5830	. 1736	14	. 8264	. 2434	86	. 7566	18		12
	52	43	. 4457	72	. 5543	. 1680	14	. 8320	. 2777	86	. 7223	17		8
	56	44	. 4745	72	. 5255	. 1625	14	. 8375	. 3120	86	. 6880	16		4
35	0	45	. 5032	72	. 4968	. 1569	14	. 8431	. 3463	86	. 6537	15	25	0
	4	46	. 5319	72	. 4681	. 1513	14	. 8487	. 3806	85	. 6194	14		56
	8	47	. 5606	72	. 4394	. 1458	14	. 8542	. 4148	85	. 5852	13		52
	12	48	. 5892	71	. 4108	. 1402	14	. 8598	. 4490	85	. 5510	12		48
	16	49	. 6179	71	. 3821	. 1347	14	. 8653	. 4832	85	. 5168	11		44
	20	50	. 6465	71	. 3535	. 1291	14	. 8709	. 5174	85	. 4826	10		40
	24	51	. 6751	71	. 3249	. 1235	14	. 8765	. 5516	85	. 4484	9		36
	28	52	. 7036	71	. 2964	. 1179	14	. 8821	. 5857	85	. 4143	8		32
	32	53	. 7322	71	. 2678	. 1123	14	. 8877	. 6199	85	. 3801	7		28
	36	54	. 7607	71	. 2393	. 1067	14	. 8933	. 6540	85	. 3460	6		24
	40	55	. 7892	71	. 2108	. 1011	14	. 8989	. 6881	85	. 3119	5		20
	44	56	. 8177	71	. 1823	. 0955	14	. 9045	. 7222	85	. 2778	4		16
	48	57	. 8461	71	. 1539	. 0899	14	. 9101	. 7562	85	. 2438	3		12
	52	58	. 8745	71	. 1255	. 0842	14	. 9158	. 7903	85	. 2097	2		8
	56	59	. 9029	71	. 0971	. 0786	14	. 9214	. 8243	85	. 1757	1		4
35	60	60	9.609313		0.390687	9.960730		0.039270	9.648583		0.351417	0	24	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

7h 113° 1' = 4s 1° = 4m 66° 4h

1h 24° 1s = 15'' 1m = 15' 1h = 15° 155° 10h

Hours m	Hours s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours m	Hours s
36	0	0	9.609313	71	0.390687	9.960730	14	0.039270	9.648583	85	0.351417	60	23	60
	4	1	. 9597	71	. 0403	. 0674	14	. 9326	. 8923	85	. 1077	59		56
	8	2	. 9880	71	. 0120	. 0617	14	. 9383	. 9263	85	. 0737	58		52
	12	3	.610163	71	.389837	. 0561	14	. 9439	. 9602	85	. 0398	57		48
	16	4	. 0447	71	. 9553	. 0505	14	. 9495	. 9942	85	. 0058	56		44
	20	5	. 0729	71	. 9271	. 0448	14	. 9552	.650281	85	.349719	55		40
	24	6	. 1012	70	. 8988	. 0392	14	. 9608	. 0620	85	. 9380	54		36
	28	7	. 1294	70	. 8706	. 0335	14	. 9665	. 0959	85	. 9041	53		32
	32	8	. 1576	70	. 8424	. 0279	14	. 9721	. 1297	85	. 8703	52		28
	36	9	. 1858	70	. 8142	. 0222	14	. 9778	. 1636	84	. 8364	51		24
	40	10	. 2140	70	. 7860	. 0166	14	. 9834	. 1974	84	. 8026	50		20
	44	11	. 2421	70	. 7579	. 0109	14	. 9891	. 2312	84	. 7688	49		16
	48	12	. 2702	70	. 7298	. 0052	14	. 9948	. 2650	84	. 7350	48		12
	52	13	. 2983	70	. 7017	.959995	14	.040005	. 2988	84	. 7012	47		8
	56	14	. 3264	70	. 6736	. 9938	14	. 0062	. 3326	84	. 6674	46		4
37	0	15	. 3545	70	. 6455	. 9882	14	. 0118	. 3663	84	. 6337	45	23	0
	4	16	. 3825	70	. 6175	. 9825	14	. 0175	. 4000	84	. 6000	44		56
	8	17	. 4105	70	. 5895	. 9768	14	. 0232	. 4337	84	. 5663	43		52
	12	18	. 4385	70	. 5615	. 9711	14	. 0289	. 4674	84	. 5326	42		48
	16	19	. 4665	70	. 5335	. 9654	14	. 0346	. 5011	84	. 4989	41		44
	20	20	. 4944	70	. 5056	. 9596	14	. 0404	. 5348	84	. 4652	40		40
	24	21	. 5223	70	. 4777	. 9539	14	. 0461	. 5684	84	. 4316	39		36
	28	22	. 5502	70	. 4498	. 9482	14	. 0518	. 6020	84	. 3980	38		32
	32	23	. 5781	70	. 4219	. 9425	14	. 0575	. 6356	84	. 3644	37		28
	36	24	. 6060	69	. 3940	. 9368	14	. 0632	. 6692	84	. 3308	36		24
	40	25	. 6338	69	. 3662	. 9310	14	. 0690	. 7028	84	. 2972	35		20
	44	26	. 6616	69	. 3384	. 9253	14	. 0747	. 7363	84	. 2637	34		16
	48	27	. 6894	69	. 3106	. 9195	14	. 0805	. 7699	84	. 2301	33		12
	52	28	. 7172	69	. 2828	. 9138	14	. 0862	. 8034	84	. 1966	32		8
	56	29	. 7450	69	. 2550	. 9081	14	. 0919	. 8369	84	. 1631	31		4
38	0	30	. 7727	69	. 2273	. 9023	14	. 0977	. 8704	84	. 1296	30	22	0
	4	31	. 8004	69	. 1996	. 8965	14	. 1035	. 9039	84	. 0961	29		56
	8	32	. 8281	69	. 1719	. 8908	14	. 1092	. 9373	84	. 0627	28		52
	12	33	. 8558	69	. 1442	. 8850	14	. 1150	. 9708	83	. 0292	27		48
	16	34	. 8834	69	. 1166	. 8792	14	. 1208	.660042	83	.339958	26		44
	20	35	. 9110	69	. 0890	. 8734	14	. 1266	. 0376	83	. 9624	25		40
	24	36	. 9386	69	. 0614	. 8677	14	. 1323	. 0709	83	. 9291	24		36
	28	37	. 9662	69	. 0338	. 8619	14	. 1381	. 1043	83	. 8957	23		32
	32	38	. 9938	69	. 0062	. 8561	14	. 1439	. 1377	83	. 8623	22		28
	36	39	.620213	69	.379787	. 8503	14	. 1497	. 1710	83	. 8290	21		24
	40	40	. 0488	69	. 9512	. 8445	14	. 1555	. 2043	83	. 7957	20		20
	44	41	. 0763	69	. 9237	. 8386	14	. 1614	. 2377	83	. 7623	19		16
	48	42	. 1038	69	. 8962	. 8329	14	. 1671	. 2709	83	. 7291	18		12
	52	43	. 1313	68	. 8687	. 8271	15	. 1729	. 3042	83	. 6958	17		8
	56	44	. 1587	68	. 8413	. 8212	15	. 1788	. 3375	83	. 6625	16		4
39	0	45	. 1861	68	. 8139	. 8154	14	. 1846	. 3707	83	. 6293	15	21	0
	4	46	. 2135	68	. 7865	. 8096	14	. 1904	. 4039	83	. 5961	14		56
	8	47	. 2409	68	. 7591	. 8038	15	. 1962	. 4371	83	. 5629	13		52
	12	48	. 2682	68	. 7318	. 7979	14	. 2021	. 4703	83	. 5297	12		48
	16	49	. 2956	68	. 7044	. 7921	14	. 2079	. 5035	83	. 4965	11		44
	20	50	. 3229	68	. 6771	. 7863	15	. 2137	. 5366	83	. 4634	10		40
	24	51	. 3502	68	. 6498	. 7804	15	. 2196	. 5698	83	. 4302	9		36
	28	52	. 3774	68	. 6226	. 7745	15	. 2255	. 6029	83	. 3971	8		32
	32	53	. 4047	68	. 5953	. 7687	15	. 2313	. 6360	83	. 3640	7		28
	36	54	. 4319	68	. 5681	. 7628	14	. 2372	. 6691	83	. 3309	6		24
	40	55	. 4591	68	. 5409	. 7570	15	. 2430	. 7021	83	. 2979	5		20
	44	56	. 4863	68	. 5137	. 7511	15	. 2489	. 7352	83	. 2648	4		16
	48	57	. 5134	68	. 4866	. 7452	15	. 2548	. 7682	83	. 2318	3		12
	52	58	. 5406	68	. 4594	. 7393	15	. 2607	. 8013	82	. 1987	2		8
	56	59	. 5677	68	. 4323	. 7334	15	. 2666	. 8343	82	. 1657	1		4
39	60	60	9.625948		0.374052	9.957276		0.042724	9.668672		0.331328	0	20	0
m	s	'										'	m	s
Hours.		Deg.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	Deg.	Hours.	

7h 114° 1' = 4s 1° = 4m 65° 4h

1h 25° 1s = 15'' 1m = 15' 1h = 15° 154° 10h

Hours.		Deg.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg.	Hours.	
m	s	'										'	m	s
40	0	0	9.625948	68	0.374052	9.957276	15	0.042724	9.668672	82	0.331328	60	19	60
	4	1	. 6219	68	. 3781	. 7217	15	. 2783	. 9002	82	. 0998	59		56
	8	2	. 6490	67	. 3510	. 7158	15	. 2842	. 9332	82	. 0668	58		52
	12	3	. 6760	67	. 3240	. 7099	15	. 2901	. 9661	82	. 0339	57		48
	16	4	. 7030	67	. 2970	. 7040	15	. 2960	. 9990	82	. 0010	56		44
	20	5	. 7300	67	. 2700	. 6980	15	. 3020	.670320	82	.329680	55		40
	24	6	. 7570	67	. 2430	. 6921	15	. 3079	. 0649	82	. 9351	54		36
	28	7	. 7840	67	. 2160	. 6863	15	. 3137	. 0977	82	. 9023	53		32
	32	8	. 8109	67	. 1891	. 6803	15	. 3197	. 1306	82	. 8694	52		28
	36	9	. 8378	67	. 1622	. 6744	15	. 3256	. 1634	82	. 8366	51		24
	40	10	. 8647	67	. 1353	. 6684	15	. 3316	. 1963	82	. 8037	50		20
	44	11	. 8916	67	. 1084	. 6625	15	. 3372	. 2291	82	. 7709	49		16
	48	12	. 9185	67	. 0815	. 6566	15	. 3434	. 2619	82	. 7381	48		12
	52	13	. 9453	67	. 0547	. 6506	15	. 3494	. 2947	82	. 7053	47		8
	56	14	. 9721	67	. 0279	. 6447	15	. 3553	. 3274	82	. 6726	46		4
41	0	15	. 9989	67	. 0011	. 6387	15	. 3613	. 3602	82	. 6398	45	19	0
	4	16	.630257	67	.369743	. 6328	15	. 3672	. 3929	82	. 6071	44		56
	8	17	. 0524	67	. 9476	. 6268	15	. 3732	. 4256	82	. 5744	43		52
	12	18	. 0792	67	. 9208	. 6208	15	. 3792	. 4584	82	. 5416	42		48
	16	19	. 1059	67	. 8941	. 6148	15	. 3852	. 4911	82	. 5089	41		44
	20	20	. 1326	67	. 8674	. 6089	15	. 3911	. 5237	82	. 4763	40		40
	24	21	. 1593	67	. 8407	. 6029	15	. 3971	. 5564	81	. 4436	39		36
	28	22	. 1859	67	. 8141	. 5969	15	. 4031	. 5890	81	. 4110	38		32
	32	23	. 2126	66	. 7874	. 5909	15	. 4091	. 6217	81	. 3783	37		28
	36	24	. 2392	66	. 7608	. 5849	15	. 4151	. 6543	81	. 3457	36		24
	40	25	. 2658	66	. 7342	. 5789	15	. 4211	. 6869	81	. 3131	35		20
	44	26	. 2923	66	. 7077	. 5729	15	. 4271	. 7194	81	. 2806	34		16
	48	27	. 3189	66	. 6811	. 5669	15	. 4331	. 7520	81	. 2480	33		12
	52	28	. 3454	66	. 6546	. 5609	15	. 4391	. 7845	81	. 2155	32		8
	56	29	. 3719	66	. 6281	. 5548	15	. 4452	. 8171	81	. 1829	31		4
42	0	30	. 3984	66	. 6016	. 5488	15	. 4512	. 8496	81	. 1504	30	18	0
	4	31	. 4249	66	. 5751	. 5428	15	. 4572	. 8821	81	. 1179	29		56
	8	32	. 4514	66	. 5486	. 5368	15	. 4632	. 9146	81	. 0854	28		52
	12	33	. 4778	66	. 5222	. 5307	15	. 4693	. 9471	81	. 0529	27		48
	16	34	. 5042	66	. 4958	. 5247	15	. 4753	. 9795	81	. 0205	26		44
	20	35	. 5306	66	. 4694	. 5186	15	. 4814	.680120	81	.319880	25		40
	24	36	. 5570	66	. 4430	. 5126	15	. 4874	. 0444	81	. 9556	24		36
	28	37	. 5833	66	. 4167	. 5065	15	. 4935	. 0768	81	. 9232	23		32
	32	38	. 6097	66	. 3903	. 5005	15	. 4995	. 1092	81	. 8908	22		28
	36	39	. 6360	66	. 3640	. 4944	15	. 5056	. 1416	81	. 8584	21		24
	40	40	. 6623	66	. 3377	. 4883	15	. 5117	. 1740	81	. 8260	20		20
	44	41	. 6886	66	. 3114	. 4823	15	. 5177	. 2063	81	. 7937	19		16
	48	42	. 7148	66	. 2852	. 4762	15	. 5238	. 2386	81	. 7614	18		12
	52	43	. 7411	65	. 2589	. 4701	15	. 5299	. 2710	81	. 7290	17		8
	56	44	. 7673	65	. 2327	. 4640	15	. 5360	. 3033	81	. 6967	16		4
43	0	45	. 7935	65	. 2065	. 4579	15	. 5421	. 3356	81	. 6644	15	17	0
	4	46	. 8197	65	. 1803	. 4519	15	. 5482	. 3679	80	. 6321	14		56
	8	47	. 8459	65	. 1542	. 4457	15	. 5543	. 4001	80	. 5999	13		52
	12	48	. 8720	65	. 1280	. 4396	15	. 5604	. 4324	80	. 5676	12		48
	16	49	. 8981	65	. 1019	. 4335	15	. 5665	. 4646	80	. 5354	11		44
	20	50	. 9242	65	. 0758	. 4274	15	. 5726	. 4968	80	. 5032	10		40
	24	51	. 9503	65	. 0497	. 4213	15	. 5787	. 5290	80	. 4710	9		36
	28	52	. 9764	65	. 0236	. 4152	15	. 5848	. 5612	80	. 4388	8		32
	32	53	.640021	65	.359979	. 4090	15	. 5910	. 5934	80	. 4066	7		28
	36	54	. 0284	65	. 9716	. 4029	15	. 5971	. 6255	80	. 3745	6		24
	40	55	. 0545	65	. 9455	. 3968	15	. 6032	. 6577	80	. 3423	5		20
	44	56	. 0804	65	. 9196	. 3906	15	. 6094	. 6898	80	. 3102	4		16
	48	57	. 1064	65	. 8936	. 3845	15	. 6155	. 7219	80	. 2781	3		12
	52	58	. 1323	65	. 8677	. 3783	15	. 6217	. 7540	80	. 2460	2		8
	56	59	. 1583	65	. 8417	. 3722	15	. 6278	. 7861	80	. 2139	1		4
43	60	60	9.641842		0.358158	9.953660		0.046340	9.688182		0.311818	0	16	0
m	s	'										'	m	s
Hours.		Deg	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	Deg.	Hours.	

7h 115° 1' = 4s 1° = 4m 64° 4h

1ʰ	26°		1' = 15'' 1ᵐ = 15' 1ʰ = 15°									153°	10ʰ	
Hours m	s	Deg '	L. Sin.	Diff for 15'' or 1ˢ	L. Cosec.	L. Cos.	Diff for 15'' or 1ˢ	L. Sec.	L. Tang.	Diff for 15'' or 1ˢ	L. Cot.	Deg '	Hours m	s
44	0	0	9.641842	65	0.358158	9.953660	15	0.046340	9.688182	80	0.311818	60	15	0
	4	1	2101	65	7899	3599	15	6401	8502	80	1498	59		56
	8	2	2360	65	7640	3537	15	6463	8823	80	1177	58		52
	12	3	2618	65	7382	3475	15	6525	9143	80	0857	57		48
	16	4	2876	64	7124	3413	15	6587	9463	80	0537	56		44
	20	5	3135	64	6865	3352	15	6648	9783	80	0217	55		40
	24	6	3393	64	6607	3290	15	6710	.690103	80	.309897	54		36
	28	7	3651	64	6349	3228	15	6772	0423	80	9577	53		32
	32	8	3908	64	6092	3166	15	6834	0742	80	9258	52		28
	36	9	4166	64	5834	3104	15	6896	1062	80	8938	51		24
	40	10	4423	64	5577	3042	15	6958	1381	80	8619	50		20
	44	11	4680	64	5320	2980	15	7020	1700	80	8300	49		16
	48	12	4937	64	5063	2918	16	7082	2019	80	7981	48		12
	52	13	5193	64	4807	2855	15	7145	2338	80	7662	47		8
	56	14	5450	64	4550	2793	15	7207	2657	79	7343	46		4
45	0	15	5706	64	4294	2731	15	7269	2975	79	7025	45	15	0
	4	16	5962	64	4038	2669	16	7331	3293	79	6707	44		56
	8	17	6218	64	3782	2606	15	7394	3612	79	6388	43		52
	12	18	6474	64	3526	2544	16	7456	3930	79	6070	42		48
	16	19	6729	64	3271	2481	15	7519	4248	79	5752	41		44
	20	20	6985	64	3015	2419	16	7581	4566	79	5434	40		40
	24	21	7239	64	2761	2356	15	7644	4883	79	5117	39		36
	28	22	7495	64	2505	2294	16	7706	5201	79	4799	38		32
	32	23	7749	64	2251	2231	16	7769	5518	79	4482	37		28
	36	24	8004	63	1996	2168	15	7832	5836	79	4164	36		24
	40	25	8258	63	1742	2105	16	7895	6153	79	3847	35		20
	44	26	8512	63	1488	2043	16	7957	6470	79	3530	34		16
	48	27	8766	63	1234	1980	16	8020	6786	79	3214	33		12
	52	28	9020	63	0980	1917	16	8083	7103	79	2897	32		8
	56	29	9274	63	0726	1854	16	8146	7420	79	2580	31		4
46	0	30	9527	63	0473	1791	16	8209	7736	79	2264	30	14	0
	4	31	9781	63	0219	1728	16	8272	8053	79	1947	29		56
	8	32	.650034	63	.349966	1665	16	8335	8369	79	1631	28		52
	12	33	0287	63	9713	1602	16	8398	8685	79	1315	27		48
	16	34	0540	63	9460	1539	16	8461	9001	79	0999	26		44
	20	35	0792	63	9208	1476	16	8524	9316	79	0684	25		40
	24	36	1044	63	8956	1412	16	8588	9632	79	0368	24		36
	28	37	1297	63	8703	1349	16	8651	9948	79	0052	23		32
	32	38	1549	63	8451	1286	16	8714	.700263	79	.299737	22		28
	36	39	1800	63	8200	1222	16	8778	0578	79	9422	21		24
	40	40	2052	63	7948	1159	16	8841	0893	79	9107	20		20
	44	41	2303	63	7697	1096	16	8904	1208	79	8792	19		16
	48	42	2555	63	7445	1032	16	8968	1523	78	8477	18		12
	52	43	2806	63	7194	0969	16	9031	1837	78	8163	17		8
	56	44	3057	63	6943	0905	16	9095	2152	78	7848	16		4
47	0	45	3307	62	6693	0841	16	9159	2466	78	7534	15	13	0
	4	46	3558	62	6442	0778	16	9222	2780	78	7220	14		56
	8	47	3809	62	6191	0714	16	9286	3095	78	6905	13		52
	12	48	4059	62	5941	0650	16	9350	3409	78	6591	12		48
	16	49	4309	62	5691	0586	16	9414	3723	78	6277	11		44
	20	50	4557	62	5443	0522	16	9478	4036	78	5964	10		40
	24	51	4808	62	5192	0458	16	9542	4350	78	5650	9		36
	28	52	5057	62	4943	0394	16	9606	4663	78	5337	8		32
	32	53	5307	62	4693	0330	16	9670	4977	78	5023	7		28
	36	54	5556	62	4444	0266	16	9734	5290	78	4710	6		24
	40	55	5805	62	4195	0202	16	9798	5603	78	4397	5		20
	44	56	6054	62	3946	0138	16	9862	5916	78	4084	4		16
	48	57	6302	62	3698	0074	16	9926	6228	78	3772	3		12
	52	58	6551	62	3449	0010	16	9990	6541	78	3459	2		8
	56	59	6799	62	3201	.949945	16	.050055	6854	78	3146	1		4
47	0	60	9.657047		0.342953	9.949881		0.050119	9.707166		0.292834	0	12	0
m	s	'	L. Cos.	Diff. for 15'' or 1ˢ	L. Sec.	L. Sin.	Diff. for 15'' or 1ˢ	L. Cosec.	L. Cot.	Diff for 15'' or 1ˢ	L. Tang.	'	m	s
Hours.		Deg.										Deg	Hours	
7ʰ	116°		1' = 4ˢ 1° = 4ᵐ									63°	4ʰ	

1h 27° 1s — 15'' 1m — 15' 1h — 15° 152° 10h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
48	0	0	9.657047	62	0.342953	9.949881	16	0.050119	9.707166	78	0.292834	60	11	60
	4	1	. 7295	62	. 2705	. 9817	16	. 0183	. 7478	78	. 2522	59		56
	8	2	. 7542	62	. 2458	. 9752	16	. 0248	. 7790	78	. 2210	58		52
	12	3	. 7790	62	. 2210	. 9688	16	. 0312	. 8102	78	. 1898	57		48
	16	4	. 8037	62	. 1963	. 9623	16	. 0377	. 8414	78	. 1586	56		44
	20	5	. 8284	62	. 1716	. 9558	16	. 0442	. 8726	78	. 1274	55		40
	24	6	. 8531	62	. 1469	. 9494	16	. 0506	. 9037	78	. 0963	54		36
	28	7	. 8778	62	. 1222	. 9429	16	. 0571	. 9349	78	. 0651	53		32
	32	8	. 9025	61	. 0975	. 9365	16	. 0635	. 9660	78	. 0340	52		28
	36	9	. 9271	61	. 0729	. 9300	16	. 0700	. 9971	78	. 0029	51		24
	40	10	. 9517	61	. 0483	. 9235	16	. 0765	.710282	78	.289718	50		20
	44	11	. 9763	61	. 0237	. 9170	16	. 0830	. 0593	78	. 9407	49		16
	48	12	.660009	61	.339991	. 9105	16	. 0895	. 0904	78	. 9096	48		12
	52	13	. 0255	61	. 9745	. 9040	16	. 0960	. 1215	78	. 8785	47		8
	56	14	. 0500	61	. 9500	. 8975	16	. 1025	. 1525	78	. 8475	46		4
49	0	15	. 0746	61	. 9254	. 8910	16	. 1090	. 1836	77	. 8164	45	11	0
	4	16	. 0991	61	. 9009	. 8845	16	. 1155	. 2146	77	. 7854	44		56
	8	17	. 1236	61	. 8764	. 8780	16	. 1220	. 2456	77	. 7544	43		52
	12	18	. 1481	61	. 8519	. 8715	16	. 1285	. 2766	77	. 7234	42		48
	16	19	. 1726	61	. 8274	. 8650	16	. 1350	. 3076	77	. 6924	41		44
	20	20	. 1970	61	. 8030	. 8584	16	. 1416	. 3386	77	. 6614	40		40
	24	21	. 2215	61	. 7785	. 8519	16	. 1481	. 3696	77	. 6304	39		36
	28	22	. 2459	61	. 7541	. 8454	16	. 1546	. 4005	77	. 5995	38		32
	32	23	. 2703	61	. 7297	. 8388	16	. 1612	. 4315	77	. 5685	37		28
	36	24	. 2947	61	. 7053	. 8323	16	. 1677	. 4624	77	. 5376	36		24
	40	25	. 3190	61	. 6810	. 8257	16	. 1743	. 4933	77	. 5067	35		20
	44	26	. 3431	61	. 6566	. 8192	16	. 1808	. 5242	77	. 4758	34		16
	48	27	. 3677	61	. 6323	. 8126	16	. 1874	. 5551	77	. 4449	33		12
	52	28	. 3920	61	. 6080	. 8060	16	. 1940	. 5860	77	. 4140	32		8
	56	29	. 4163	61	. 5837	. 7995	16	. 2005	. 6168	77	. 3832	31		4
50	0	30	. 4406	60	. 5594	. 7929	16	. 2071	. 6477	77	. 3523	30	10	0
	4	31	. 4648	60	. 5352	. 7863	16	. 2137	. 6785	77	. 3215	29		56
	8	32	. 4890	61	. 5110	. 7797	16	. 2203	. 7093	77	. 2907	28		52
	12	33	. 5132	60	. 4867	. 7732	16	. 2268	. 7401	77	. 2599	27		48
	16	34	. 5375	60	. 4625	. 7666	16	. 2334	. 7709	77	. 2291	26		44
	20	35	. 5617	60	. 4383	. 7600	16	. 2400	. 8017	[illegible]	. 1983	25		40
	24	36	. 5859	60	. 4141	. 7534	17	. 2466	. 8325	77	. 1675	24		36
	28	37	. 6100	60	. 3900	. 7467	17	. 2533	. 8633	77	. 1367	23		32
	32	38	. 6341	60	. 3659	. 7401	16	. 2599	. 8940	77	. 1060	22		28
	36	39	. 6583	60	. 3417	. 7335	16	. 2665	. 9248	77	. 0752	21		24
	40	40	. 6824	60	. 3176	. 7269	16	. 2731	. 9555	77	. 0445	20		20
	44	41	. 7065	60	. 2935	. 7203	17	. 2797	. 9862	77	. 0138	19		16
	48	42	. 7305	60	. 2695	. 7136	17	. 2864	.720169	77	.279831	18		12
	52	43	. 7546	60	. 2454	. 7070	17	. 2930	. 0476	77	. 9524	17		8
	56	44	. 7786	60	. 2214	. 7003	17	. 2997	. 0783	77	. 9217	16		4
51	0	45	. 8026	60	. 1974	. 6937	17	. 3063	. 1089	77	. 8911	15	9	0
	4	46	. 8266	60	. 1733	. 6871	17	. 3129	. 1396	77	. 8604	14		56
	8	47	. 8506	60	. 1494	. 6804	17	. 3196	. 1702	77	. 8298	13		52
	12	48	. 8746	60	. 1254	. 6738	17	. 3262	. 2008	77	. 7992	12		48
	16	49	. 8986	60	. 1014	. 6671	17	. 3329	. 2315	76	. 7685	11		44
	20	50	. 9225	60	. 0775	. 6604	16	. 3396	. 2621	76	. 7379	10		40
	24	51	. 9464	60	. 0536	. 6537	17	. 3463	. 2927	76	. 7073	9		36
	28	52	. 9703	60	. 0297	. 6471	17	. 3529	. 3232	76	. 6768	8		32
	32	53	. 9942	60	. 0058	. 6404	17	. 3596	. 3538	76	. 6462	7		28
	36	54	.670181	59	.329819	. 6337	17	. 3663	. 3844	76	. 6156	6		24
	40	55	. 0419	59	. 9581	. 6270	17	. 3730	. 4149	76	. 5851	5		20
	44	56	. 0657	59	. 9343	. 6203	17	. 3797	. 4454	76	. 5546	4		16
	48	57	. 0896	59	. 9104	. 6136	17	. 3864	. 4760	76	. 5240	3		12
	52	58	. 1134	59	. 8866	. 6069	17	. 3931	. 5065	76	. 4935	2		8
	56	59	. 1372	59	. 8628	. 6002	17	. 3998	. 5370	76	. 4630	1		4
51	60	60	9.671609		0.328391	9.945935		0.054065	9.725674		0.274326	0	8	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

7h 117° 1' — 4s 1° — 4m 62° 4h

Hours. h	m	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m
52	0	0	9.671610	59	0.328391	9.945935	17	0.054065	9.725674	76	0.274326	60	7
	4	1	. 1847	59	. 8153	. 5868	17	. 4132	. 5979	76	. 4021	59	
	8	2	. 2084	59	. 7916	. 5800	17	. 4200	. 6284	76	. 3716	58	
	12	3	. 2321	59	. 7679	. 5733	17	. 4267	. 6588	76	. 3412	57	
	16	4	. 2558	59	. 7442	. 5666	17	. 4334	. 6892	76	. 3108	56	
	20	5	. 2795	59	. 7205	. 5598	17	. 4402	. 7197	76	. 2803	55	
	24	6	. 3032	59	. 6968	. 5531	17	. 4469	. 7501	76	. 2499	54	
	28	7	. 3269	59	. 6731	. 5464	17	. 4536	. 7805	76	. 2195	53	
	32	8	. 3505	59	. 6495	. 5396	17	. 4604	. 8109	76	. 1891	52	
	36	9	. 3741	59	. 6259	. 5329	17	. 4671	. 8412	76	. 1588	51	
	40	10	. 3977	59	. 6023	. 5261	17	. 4739	. 8716	76	. 1284	50	
	44	11	. 4213	59	. 5787	. 5193	17	. 4807	. 9020	76	. 0980	49	
	48	12	. 4449	59	. 5551	. 5126	17	. 4874	. 9323	76	. 0677	48	
	52	13	. 4684	59	. 5316	. 5058	17	. 4942	. 9626	76	. 0374	47	
	56	14	. 4919	59	. 5081	. 4990	17	. 5010	. 9929	76	. 0071	46	
53	0	15	. 5155	59	. 4845	. 4922	17	. 5078	.730233	76	.269767	45	7
	4	16	. 5390	59	. 4610	. 4854	17	. 5146	. 0536	76	. 9464	44	
	8	17	. 5624	59	. 4376	. 4786	17	. 5214	. 0838	76	. 9162	43	
	12	18	. 5859	59	. 4141	. 4718	17	. 5282	. 1141	76	. 8859	42	
	16	19	. 6094	58	. 3906	. 4650	17	. 5350	. 1444	75	. 8556	41	
	20	20	. 6328	58	. 3672	. 4582	17	. 5418	. 1746	75	. 8254	40	
	24	21	. 6562	58	. 3438	. 4514	17	. 5486	. 2048	75	. 7952	39	
	28	22	. 6796	58	. 3204	. 4446	17	. 5554	. 2350	76	. 7650	38	
	32	23	. 7030	58	. 2970	. 4377	17	. 5623	. 2653	75	. 7347	37	
	36	24	. 7264	58	. 2736	. 4309	17	. 5691	. 2955	75	. 7045	36	
	40	25	. 7498	58	. 2502	. 4241	17	. 5759	. 3257	75	. 6743	35	
	44	26	. 7731	58	. 2269	. 4173	17	. 5827	. 3558	75	. 6442	34	
	48	27	. 7964	58	. 2036	. 4104	17	. 5896	. 3860	75	. 6140	33	
	52	28	. 8197	58	. 1803	. 4036	17	. 5964	. 4161	75	. 5838	32	
	56	29	. 8430	58	. 1570	. 3967	17	. 6033	. 4463	75	. 5537	31	
54	0	30	. 8663	58	. 1337	. 3899	17	. 6101	. 4764	75	. 5236	30	6
	4	31	. 8896	58	. 1104	. 3830	17	. 6170	. 5066	75	. 4934	29	
	8	32	. 9128	58	. 0872	. 3761	17	. 6239	. 5367	75	. 4633	28	
	12	33	. 9360	58	. 0640	. 3692	17	. 6308	. 5668	75	. 4332	27	
	16	34	. 9592	58	. 0408	. 3624	17	. 6376	. 5968	75	. 4032	26	
	20	35	. 9824	58	. 0176	. 3555	17	. 6445	. 6269	75	. 3731	25	
	24	36	.680056	58	.319944	. 3486	17	. 6514	. 6570	75	. 3430	24	
	28	37	. 0288	58	. 9712	. 3417	17	. 6583	. 6871	75	. 3129	23	
	32	38	. 0519	58	. 9481	. 3348	17	. 6652	. 7171	75	. 2829	22	
	36	39	. 0750	58	. 9250	. 3279	17	. 6721	. 7471	75	. 2529	21	
	40	40	. 0982	58	. 9018	. 3210	17	. 6790	. 7772	75	. 2228	20	
	44	41	. 1213	58	. 8787	. 3141	17	. 6859	. 8072	75	. 1928	19	
	48	42	. 1443	58	. 8557	. 3072	17	. 6928	. 8371	75	. 1629	18	
	52	43	. 1674	58	. 8326	. 3003	17	. 6997	. 8671	75	. 1329	17	
	56	44	. 1905	57	. 8095	. 2934	17	. 7066	. 8971	75	. 1029	16	
55	0	45	. 2135	57	. 7865	. 2864	17	. 7136	. 9271	75	. 0729	15	5
	4	46	. 2365	57	. 7635	. 2795	17	. 7205	. 9570	75	. 0430	14	
	8	47	. 2595	57	. 7405	. 2725	17	. 7275	. 9870	75	. 0130	13	
	12	48	. 2825	57	. 7175	. 2656	17	. 7344	.740169	75	.259831	12	
	16	49	. 3055	57	. 6945	. 2587	17	. 7413	. 0468	75	. 9532	11	
	20	50	. 3284	57	. 6716	. 2517	17	. 7483	. 0767	75	. 9233	10	
	24	51	. 3514	57	. 6486	. 2448	17	. 7552	. 1066	75	. 8934	9	
	28	52	. 3743	57	. 6257	. 2378	17	. 7622	. 1365	75	. 8635	8	
	32	53	. 3972	57	. 6028	. 2308	17	. 7692	. 1664	75	. 8336	7	
	36	54	. 4201	57	. 5799	. 2239	17	. 7761	. 1962	75	. 8038	6	
	40	55	. 4430	57	. 5570	. 2169	17	. 7831	. 2261	75	. 7739	5	
	44	56	. 4658	57	. 5342	. 2099	17	. 7901	. 2559	75	. 7441	4	
	48	57	. 4887	57	. 5113	. 2029	17	. 7971	. 2858	74	. 7142	3	
	52	58	. 5115	57	. 4885	. 1959	17	. 8041	. 3156	74	. 6844	2	
	56	59	. 5343	57	. 4657	. 1889	17	. 8111	. 3454	74	. 6546	1	
56	0	60	9.685571		0.314429	9.941819	17	0.058181	9.743752		0.256248	0	4
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	' Deg.	m Hours.

29° 1′ — 15″ 1m — 15′ 1h — 15° 150° — 10h

Deg. ′	L. Sin.	Diff. for 15″ or 1s	L. Cosec.	L. Cos.	Diff. for 15″ or 1s	L. Sec.	L. Tang.	Diff. for 15″ or 1s	L. Cot.	Deg. ′	Hours m	Hours s
0	9.685571		0.31442	9.941819		0.058181	9.743752		0.256248	60	3	60
1	. 5799	57	. 4201	. 1749	17	. 8251	. 4050	74	. 5950	59		56
2	. 6027	57	. 3973	. 1679	17	. 8321	. 4348	74	. 5652	58		52
3	. 6254	57	. 3746	. 1609	17	. 8391	. 4645	74	. 5355	57		48
4	. 6482	57	. 3518	. 1539	17	. 8461	. 4943	74	. 5057	56		44
5	. 6709	57	. 3291	. 1469	17	. 8531	. 5240	74	. 4760	55		40
6	. 6936	57	. 3064	. 1398	18	. 8602	. 5538	74	. 4462	54		36
7	. 7163	57	. 2837	. 1328	17	. 8672	. 5835	74	. 4165	53		32
8	. 7390	57	. 2610	. 1258	17	. 8742	. 6132	74	. 3868	52		28
9	. 7616	57	. 2384	. 1187	18	. 8813	. 6429	74	. 3571	51		24
10	. 7843	57	. 2157	. 1117	17	. 8883	. 6726	74	. 3274	50		20
11	. 8069	56	. 1931	. 1046	18	. 8954	. 7023	74	. 2977	49		16
12	. 8295	56	. 1705	. 0976	17	. 9024	. 7319	74	. 2681	48		12
13	. 8521	56	. 1479	. 0905	18	. 9095	. 7616	74	. 2384	47		8
14	. 8747	56	. 1253	. 0834	18	. 9166	. 7913	74	. 2087	46		4
15	. 8972	56	. 1028	. 0763	18	. 9237	. 8209	74	. 1791	45	3	0
16	. 9198	56	. 0802	. 0693	17	. 9307	. 8505	74	. 1495	44		56
17	. 9423	56	. 0577	. 0622	18	. 9378	. 8801	74	. 1199	43		52
18	. 9648	56	. 0352	. 0551	18	. 9449	. 9097	74	. 0903	42		48
19	. 9873	56	. 0127	. 0480	18	. 9520	. 9393	74	. 0607	41		44
20	.690098	56	.309902	. 0409	18	. 9591	. 9689	74	. 0311	40		40
21	. 0323	56	. 9677	. 0338	18	. 9662	. 9985	74	. 0015	39		36
22	. 0548	56	. 9452	. 0267	18	. 9733	.750281	74	.249719	38		32
23	. 0772	56	. 9228	. 0196	18	. 9804	. 0576	74	. 9424	37		28
24	. 0997	56	. 9003	. 0125	18	. 9875	. 0872	74	. 9128	36		24
25	. 1221	56	. 8779	. 0054	18	. 9946	. 1167	74	. 8833	35		20
26	. 1444	56	. 8556	.939982	18	.060018	. 1462	74	. 8538	34		16
27	. 1668	56	. 8332	. 9911	18	. 0089	. 1757	74	. 8243	33		12
28	. 1892	56	. 8108	. 9840	18	. 0160	. 2052	74	. 7948	32		8
29	. 2115	56	. 7885	. 9768	18	. 0232	. 2347	74	. 7653	31		4
30	. 2338	56	. 7661	. 9697	18	. 0303	. 2642	74	. 7358	30	2	0
31	. 2562	56	. 7438	. 9625	18	. 0375	. 2937	74	. 7063	29		56
32	. 2785	56	. 7215	. 9554	18	. 0446	. 3231	74	. 6769	28		52
33	. 3008	56	. 6992	. 9482	18	. 0518	. 3526	74	. 6474	27		48
34	. 3231	56	. 6769	. 9411	18	. 0589	. 3820	73	. 6180	26		44
35	. 3454	56	. 6546	. 9339	18	. 0661	. 4115	73	. 5885	25		40
36	. 3676	55	. 6324	. 9267	18	. 0733	. 4409	73	. 5591	24		36
37	. 3898	55	. 6102	. 9195	18	. 0805	. 4703	73	. 5297	23		32
38	. 4120	55	. 5880	. 9123	18	. 0877	. 4997	73	. 5003	22		28
39	. 4342	55	. 5658	. 9051	18	. 0949	. 5291	73	. 4709	21		24
40	. 4564	55	. 5436	. 8980	18	. 1020	. 5584	73	. 4416	20		20
41	. 4786	55	. 5214	. 8908	18	. 1092	. 5878	73	. 4122	19		16
42	. 5008	55	. 4992	. 8836	18	. 1164	. 6172	73	. 3828	18		12
43	. 5229	55	. 4771	. 8764	18	. 1236	. 6465	73	. 3535	17		8
44	. 5450	55	. 4550	. 8691	18	. 1309	. 6758	73	. 3241	16		4
45	. 5671	55	. 4329	. 8619	18	. 1381	. 7052	73	. 2948	15	1	0
46	. 5892	55	. 4108	. 8547	18	. 1453	. 7345	73	. 2655	14		56
47	. 6113	55	. 3887	. 8475	18	. 1525	. 7638	73	. 2362	13		52
48	. 6334	55	. 3666	. 8403	18	. 1597	. 7931	73	. 2069	12		48
49	. 6554	55	. 3446	. 8330	18	. 1670	. 8224	73	. 1776	11		44
50	. 6775	55	. 3225	. 8258	18	. 1742	. 8517	73	. 1483	10		40
51	. 6995	55	. 3005	. 8185	18	. 1815	. 8810	73	. 1190	9		36
52	. 7215	55	. 2785	. 8113	18	. 1887	. 9102	73	. 0898	8		32
53	. 7435	55	. 2565	. 8040	18	. 1960	. 9395	73	. 0605	7		28
54	. 7654	55	. 2346	. 7967	18	. 2033	. 9687	73	. 0313	6		24
55	. 7874	55	. 2126	. 7895	18	. 2105	. 9979	73	. 0021	5		20
56	. 8094	55	. 1906	. 7822	18	. 2178	.760272	73	.239728	4		16
57	. 8313	55	. 1687	. 7749	18	. 2251	. 0564	73	. 9436	3		12
58	. 8532	55	. 1468	. 7676	18	. 2324	. 0856	73	. 9144	2		8
59	. 8751	55	. 1249	. 7603	18	. 2397	. 1148	73	. 8852	1		4
60	9.698970	55	0.301030	9.937531	18	0.062469	9.761439	73	0.238561	0	0	0
′ Deg.	L. Cos.	Diff. for 15″ or 1s	L. Sec.	L. Sin.	Diff. for 15″ or 1s	L. Cosec.	L. Cot.	Diff. for 15″ or 1s	L. Tang.	′ Deg.	Hours m	Hours s

119° 1′ — 4s 1° — 4m 60° — 4h

2h — 30°				1s = 15'' 1m = 15' 1h = 15°								149°	9h	
Hours. h	s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	s
0	0	0	9.698970	55	0.301030	9.937531	18	0.062469	9.761439	73	0.238561	60	59	60
	4	1	. 9187	55	. 0811	. 7458	18	. 2542	. 1731	73	. 8269	59		56
	8	2	. 9407	55	. 0593	. 7385	18	. 2615	. 2022	73	. 7978	58		52
	12	3	. 9626	54	. 0374	. 7312	18	. 2688	. 2314	73	. 7686	57		48
	16	4	. 9844	54	. 0156	. 7238	18	. 2762	. 2606	73	. 7394	56		44
	20	5	.700062	54	.299938	. 7165	18	. 2835	. 2897	73	. 7103	55		40
	24	6	. 0280	54	. 9720	. 7092	18	. 2908	. 3188	73	. 6812	54		36
	28	7	. 0498	54	. 9502	. 7019	18	. 2981	. 3479	73	. 6521	53		32
	32	8	. 0716	54	. 9284	. 6946	18	. 3054	. 3770	73	. 6230	52		28
	36	9	. 0933	54	. 9067	. 6872	18	. 3128	. 4061	73	. 5939	51		24
	40	10	. 1151	54	. 8849	. 6799	18	. 3201	. 4352	73	. 5648	50		20
	44	11	. 1368	54	. 8632	. 6725	18	. 3275	. 4643	72	. 5357	49		16
	48	12	. 1585	54	. 8415	. 6652	18	. 3348	. 4933	73	. 5067	48		12
	52	13	. 1802	54	. 8198	. 6578	18	. 3422	. 5224	72	. 4776	47		8
	56	14	. 2019	54	. 7981	. 6505	18	. 3495	. 5514	73	. 4486	46		4
1	0	15	. 2236	54	. 7764	. 6431	18	. 3569	. 5805	72	. 4195	45	59	0
	4	16	. 2452	54	. 7548	. 6357	18	. 3643	. 6095	72	. 3905	44		56
	8	17	. 2669	54	. 7331	. 6284	18	. 3716	. 6385	72	. 3615	43		52
	12	18	. 2885	54	. 7115	. 6210	18	. 3790	. 6675	72	. 3325	42		48
	16	19	. 3101	54	. 6899	. 6136	18	. 3864	. 6965	72	. 3035	41		44
	20	20	. 3317	54	. 6683	. 6062	18	. 3938	. 7255	72	. 2745	40		40
	24	21	. 3533	54	. 6467	. 5988	18	. 4012	. 7545	72	. 2455	39		36
	28	22	. 3748	54	. 6252	. 5914	18	. 4086	. 7834	72	. 2166	38		32
	32	23	. 3964	54	. 6036	. 5840	18	. 4160	. 8124	72	. 1876	37		28
	36	24	. 4180	54	. 5820	. 5766	18	. 4234	. 8414	72	. 1586	36		24
	40	25	. 4395	54	. 5605	. 5692	18	. 4308	. 8703	72	. 1297	35		20
	44	26	. 4610	54	. 5390	. 5618	18	. 4382	. 8992	72	. 1008	34		16
	48	27	. 4825	54	. 5175	. 5543	18	. 4457	. 9282	72	. 0718	33		12
	52	28	. 5040	54	. 4960	. 5469	18	. 4531	. 9571	72	. 0429	32		8
	56	29	. 5254	54	. 4746	. 5395	19	. 4605	. 9859	72	. 0141	31		4
2	0	30	. 5469	53	. 4531	. 5320	18	. 4680	.770149	72	.229851	30	58	0
	4	31	. 5683	53	. 4317	. 5246	18	. 4754	. 0437	72	. 9563	29		56
	8	32	. 5898	53	. 4102	. 5172	19	. 4828	. 0726	72	. 9274	28		52
	12	33	. 6112	53	. 3888	. 5097	19	. 4903	. 1015	72	. 8985	27		48
	16	34	. 6326	53	. 3674	. 5023	19	. 4977	. 1303	72	. 8697	26		44
	20	35	. 6540	53	. 3460	. 4948	19	. 5052	. 1592	72	. 8408	25		40
	24	36	. 6753	53	. 3247	. 4873	19	. 5127	. 1880	72	. 8120	24		36
	28	37	. 6967	53	. 3033	. 4798	19	. 5202	. 2169	72	. 7831	23		32
	32	38	. 7180	53	. 2820	. 4723	19	. 5277	. 2457	72	. 7541	22		28
	36	39	. 7393	53	. 2607	. 4648	19	. 5352	. 2745	72	. 7255	21		24
	40	40	. 7606	53	. 2394	. 4573	19	. 5427	. 3033	72	. 6967	20		20
	44	41	. 7819	53	. 2181	. 4498	19	. 5502	. 3321	72	. 6679	19		16
	48	42	. 8032	53	. 1968	. 4424	19	. 5576	. 3608	72	. 6392	18		12
	52	43	. 8245	53	. 1755	. 4349	19	. 5651	. 3896	72	. 6104	17		8
	56	44	. 8458	53	. 1542	. 4274	19	. 5726	. 4184	72	. 5816	16		4
3	0	45	. 8670	53	. 1330	. 4199	19	. 5801	. 4471	72	. 5529	15	57	0
	4	46	. 8882	53	. 1118	. 4123	19	. 5877	. 4759	72	. 5241	14		56
	8	47	. 9094	53	. 0906	. 4048	19	. 5952	. 5046	72	. 4954	13		52
	12	48	. 9306	53	. 0694	. 3973	19	. 6027	. 5333	72	. 4667	12		48
	16	49	. 9518	53	. 0482	. 3898	19	. 6102	. 5620	72	. 4380	11		44
	20	50	. 9730	53	. 0270	. 3822	19	. 6178	. 5908	72	. 4092	10		40
	24	51	. 9942	53	. 0058	. 3747	19	. 6253	. 6195	72	. 3805	9		36
	28	52	.710153	53	.289847	. 3671	19	. 6329	. 6482	72	. 3518	8		32
	32	53	. 0364	53	. 9636	. 3596	19	. 6404	. 6768	72	. 3232	7		28
	36	54	. 0575	53	. 9425	. 3520	19	. 6480	. 7055	72	. 2945	6		24
	40	55	. 0786	53	. 9214	. 3444	19	. 6556	. 7342	71	. 2658	5		20
	44	56	. 0997	53	. 9003	. 3369	19	. 6631	. 7628	71	. 2372	4		16
	48	57	. 1208	53	. 8792	. 3293	19	. 6707	. 7915	71	. 2085	3		12
	52	58	. 1419	53	. 8582	. 3217	19	. 6783	. 8201	71	. 1799	2		8
	56	59	. 1629	52	. 8371	. 3141	19	. 6859	. 8488	71	. 1512	1		4
3	60	60	9.711839		0.288161	9.933065		0.066935	9.778774		0.221226	0	56	0
Hours. h	s	Deg. '	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	Deg. '	Hours. m	s
8h — 120°				1' = 4s 1° = 4m								59°	3h	

2h 31° 1s = 15'' 1m = 15' 1h = 15° 148° 9h

Hours. m	Hours. s	Deg. ′	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. ′	Hours. m	Hours. s
4	0	0	9.711839	53	0.288161	9.933065	19	0.066935	9.778774	71	0.221226	60	55	60
	4	1	. 2050	52	. 7950	. 2990	19	. 7010	. 9058	71	. 0940	59		56
	8	2	. 2260	52	. 7740	. 2914	19	. 7086	. 9340	71	. 0654	58		52
	12	3	. 2470	52	. 7530	. 2838	19	. 7162	. 9632	71	. 0368	57		48
	16	4	. 2679	52	. 7321	. 2761	19	. 7239	. 9918	71	. 0082	56		44
	20	5	. 2889	52	. 7111	. 2685	19	. 7315	.780204	71	.219796	55		40
	24	6	. 3098	52	. 6902	. 2609	19	. 7391	. 0489	71	. 9511	54		36
	28	7	. 3308	52	. 6692	. 2533	19	. 7467	. 0775	71	. 9225	53		32
	32	8	. 3517	52	. 6483	. 2457	19	. 7543	. 1060	71	. 8940	52		28
	36	9	. 3726	52	. 6274	. 2380	19	. 7620	. 1346	71	. 8654	51		24
	40	10	. 3935	52	. 6065	. 2304	19	. 7696	. 1631	71	. 8369	50		20
	44	11	. 4144	52	. 5856	. 2228	19	. 7772	. 1916	71	. 8084	49		16
	48	12	. 4352	52	. 5648	. 2151	19	. 7849	. 2201	71	. 7799	48		12
	52	13	. 4561	52	. 5439	. 2075	19	. 7925	. 2486	71	. 7514	47		8
	56	14	. 4769	52	. 5231	. 1998	19	. 8002	. 2771	71	. 7229	46		4
5	0	15	. 4977	52	. 5023	. 1921	19	. 8079	. 3056	71	. 6944	45	55	0
	4	16	. 5186	52	. 4814	. 1845	19	. 8155	. 3341	71	. 6659	44		56
	8	17	. 5394	52	. 4606	. 1768	19	. 8232	. 3626	71	. 6374	43		52
	12	18	. 5601	52	. 4399	. 1691	19	. 8309	. 3910	71	. 6090	42		48
	16	19	. 5809	52	. 4191	. 1614	19	. 8386	. 4195	71	. 5805	41		44
	20	20	. 6017	52	. 3983	. 1538	19	. 8462	. 4479	71	. 5521	40		40
	24	21	. 6224	52	. 3776	. 1460	19	. 8540	. 4764	71	. 5236	39		36
	28	22	. 6432	52	. 3568	. 1384	19	. 8616	. 5048	71	. 4952	38		32
	32	23	. 6639	52	. 3361	. 1307	19	. 8693	. 5332	71	. 4668	37		28
	36	24	. 6846	52	. 3154	. 1230	19	. 8770	. 5616	71	. 4384	36		24
	40	25	. 7052	52	. 2948	. 1152	19	. 8848	. 5900	71	. 4100	35		20
	44	26	. 7259	52	. 2741	. 1075	19	. 8925	. 6184	71	. 3816	34		16
	48	27	. 7466	52	. 2534	. 0998	19	. 9002	. 6468	71	. 3532	33		12
	52	28	. 7673	51	. 2327	. 0921	19	. 9079	. 6752	71	. 3248	32		8
	56	29	. 7879	51	. 2121	. 0843	19	. 9157	. 7036	71	. 2964	31		4
6	0	30	. 8085	51	. 1915	. 0766	19	. 9234	. 7319	71	. 2681	30	54	0
	4	31	. 8291	51	. 1709	. 0688	19	. 9312	. 7603	71	. 2397	29		56
	8	32	. 8497	51	. 1503	. 0611	19	. 9389	. 7886	71	. 2114	28		52
	12	33	. 8703	51	. 1297	. 0533	19	. 9467	. 8170	71	. 1830	27		48
	16	34	. 8909	51	. 1091	. 0456	19	. 9544	. 8453	71	. 1547	26		44
	20	35	. 9114	51	. 0886	. 0378	19	. 9622	. 8736	71	. 1264	25		40
	24	36	. 9319	51	. 0681	. 0300	19	. 9700	. 9019	71	. 0981	24		36
	28	37	. 9525	51	. 0475	. 0223	19	. 9777	. 9302	71	. 0698	23		32
	32	38	. 9730	51	. 0270	. 0145	19	. 9855	. 9585	71	. 0415	22		28
	36	39	. 9935	51	. 0065	. 0067	19	. 9933	. 9868	71	. 0132	21		24
	40	40	.720140	51	.279860	.929989	19	.070011	.790151	71	.209849	20		20
	44	41	. 0345	51	. 9655	. 9911	19	. 0089	. 0434	71	. 9566	19		16
	48	42	. 0549	51	. 9451	. 9833	19	. 0167	. 0716	71	. 9284	18		12
	52	43	. 0754	51	. 9246	. 9755	19	. 0245	. 0999	71	. 9001	17		8
	56	44	. 0958	51	. 9042	. 9677	19	. 0323	. 1281	71	. 8719	16		4
7	0	45	. 1162	51	. 8838	. 9599	19	. 0401	. 1563	70	. 8437	15	53	0
	4	46	. 1366	51	. 8634	. 9521	20	. 0479	. 1846	70	. 8154	14		56
	8	47	. 1570	51	. 8430	. 9442	19	. 0558	. 2128	70	. 7872	13		52
	12	48	. 1774	51	. 8226	. 9364	19	. 0636	. 2410	70	. 7590	12		48
	16	49	. 1978	51	. 8022	. 9286	20	. 0714	. 2692	70	. 7308	11		44
	20	50	. 2181	51	. 7819	. 9207	19	. 0793	. 2974	70	. 7026	10		40
	24	51	. 2385	51	. 7615	. 9129	20	. 0871	. 3256	70	. 6744	9		36
	28	52	. 2588	51	. 7412	. 9050	19	. 0950	. 3538	70	. 6462	8		32
	32	53	. 2791	51	. 7209	. 8972	20	. 1028	. 3819	70	. 6181	7		28
	36	54	. 2994	51	. 7006	. 8893	19	. 1107	. 4101	70	. 5899	6		24
	40	55	. 3197	51	. 6803	. 8814	20	. 1186	. 4383	70	. 5617	5		20
	44	56	. 3400	51	. 6600	. 8736	20	. 1264	. 4664	70	. 5336	4		16
	48	57	. 3603	50	. 6397	. 8657	20	. 1343	. 4946	70	. 5054	3		12
	52	58	. 3805	50	. 6195	. 8578	20	. 1422	. 5227	70	. 4773	2		8
	56	59	. 4007	50	. 5993	. 8499	20	. 1501	. 5508	70	. 4492	1		4
7	60	60	9.724210		0.275790	9.928421		0.071579	9.795789		0.204211	0	52	0
m	s	′										′	m	s
Hours.		Deg.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	Deg.	Hours.	

8h 121° 1' = 4s 1° = 4m 58° 3h

2ʰ 32° 1ˢ = 15″ 1ᵐ = 15′ 1ʰ = 15° 147° 9ʰ

Hours. m	Hours. s	Deg. ′	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Tang.	Diff. for 15″ or 1ˢ	L. Cot.	Deg. ′	Hours. m	Hours. s
8	0	0	9.724210	50	0.275790	9.928421	20	0.071579	9.795789	70	0.204211	60	51	0
	4	1	. 4412	50	. 5588	. 8342	20	. 1658	. 6070	70	. 3930	59		56
	8	2	. 4614	50	. 5386	. 8263	20	. 1737	. 6351	70	. 3649	58		52
	12	3	. 4816	50	. 5184	. 8184	20	. 1816	. 6632	70	. 3368	57		48
	16	4	. 5017	50	. 4983	. 8104	20	. 1896	. 6913	70	. 3087	56		44
	20	5	. 5219	50	. 4781	. 8025	20	. 1975	. 7194	70	. 2806	55		40
	24	6	. 5420	50	. 4580	. 7946	20	. 2054	. 7474	70	. 2526	54		36
	28	7	. 5622	50	. 4378	. 7867	20	. 2133	. 7755	70	. 2245	53		32
	32	8	. 5823	50	. 4177	. 7787	20	. 2213	. 8036	70	. 1964	52		28
	36	9	. 6024	50	. 3976	. 7708	20	. 2292	. 8316	70	. 1684	51		24
	40	10	. 6225	50	. 3775	. 7629	20	. 2371	. 8596	70	. 1404	50		20
	44	11	. 6425	50	. 3574	. 7549	20	. 2451	. 8877	70	. 1123	49		16
	48	12	. 6625	50	. 3374	. 7469	20	. 2531	. 9157	70	. 0843	48		12
	52	13	. 6827	50	. 3173	. 7390	20	. 2610	. 9437	70	. 0563	47		8
	56	14	. 7027	50	. 2973	. 7310	20	. 2690	. 9717	70	. 0283	46		4
9	0	15	. 7228	50	. 2772	. 7231	20	. 2769	. 9997	70	. 0003	45	51	0
	4	16	. 7428	50	. 2572	. 7151	20	. 2849	.800277	70	.199723	44		56
	8	17	. 7628	50	. 2372	. 7071	20	. 2929	. 0557	70	. 9443	43		52
	12	18	. 7828	50	. 2172	. 6991	20	. 3009	. 0837	70	. 9163	42		48
	16	19	. 8027	50	. 1973	. 6911	20	. 3089	. 1116	70	. 8884	41		44
	20	20	. 8227	50	. 1773	. 6831	20	. 3169	. 1396	70	. 8604	40		40
	24	21	. 8427	50	. 1573	. 6751	20	. 3248	. 1675	70	. 8325	39		36
	28	22	. 8625	50	. 1374	. 6671	20	. 3329	. 1955	70	. 8045	38		32
	32	23	. 8825	50	. 1175	. 6591	20	. 3409	. 2234	70	. 7766	37		28
	36	24	. 9024	50	. 0976	. 6511	20	. 3489	. 2513	70	. 7487	36		24
	40	25	. 9223	50	. 0777	. 6431	20	. 3569	. 2792	70	. 7208	35		20
	44	26	. 9422	50	. 0578	. 6351	20	. 3649	. 3071	70	. 6929	34		16
	48	27	. 9621	50	. 0379	. 6270	20	. 3730	. 3351	70	. 6649	33		12
	52	28	. 9820	50	. 0180	. 6190	20	. 3810	. 3630	70	. 6370	32		8
	56	29	.730018	49	.269982	. 6110	20	. 3890	. 3908	70	. 6092	31		4
10	0	30	. 0216	49	. 9784	. 6029	20	. 3971	. 4187	70	. 5813	30	50	0
	4	31	. 0415	49	. 9585	. 5949	20	. 4051	. 4466	70	. 5534	29		56
	8	32	. 0613	49	. 9387	. 5868	20	. 4132	. 4745	70	. 5255	28		52
	12	33	. 0811	49	. 9189	. 5788	20	. 4212	. 5023	70	. 4977	27		48
	16	34	. 1009	49	. 8991	. 5707	20	. 4293	. 5302	70	. 4698	26		44
	20	35	. 1206	49	. 8794	. 5626	20	. 4374	. 5580	70	. 4420	25		40
	24	36	. 1404	49	. 8596	. 5545	20	. 4455	. 5859	69	. 4141	24		36
	28	37	. 1602	49	. 8398	. 5465	20	. 4535	. 6137	69	. 3863	23		32
	32	38	. 1799	49	. 8201	. 5384	20	. 4616	. 6415	69	. 3585	22		28
	36	39	. 1996	49	. 8004	. 5303	20	. 4697	. 6693	69	. 3307	21		24
	40	40	. 2193	49	. 7807	. 5222	20	. 4778	. 6971	69	. 3029	20		20
	44	41	. 2390	49	. 7610	. 5141	20	. 4859	. 7249	69	. 2751	19		16
	48	42	. 2587	49	. 7413	. 5060	20	. 4940	. 7527	69	. 2473	18		12
	52	43	. 2784	49	. 7216	. 4979	20	. 5021	. 7805	69	. 2195	17		8
	56	44	. 2980	49	. 7020	. 4897	20	. 5103	. 8083	69	. 1917	16		4
11	0	45	. 3177	49	. 6823	. 4816	20	. 5184	. 8361	69	. 1639	15	49	0
	4	46	. 3373	49	. 6627	. 4735	20	. 5265	. 8638	69	. 1362	14		56
	8	47	. 3569	49	. 6431	. 4653	20	. 5347	. 8916	69	. 1084	13		52
	12	48	. 3765	49	. 6235	. 4572	20	. 5428	. 9193	69	. 0807	12		48
	16	49	. 3961	49	. 6039	. 4490	20	. 5510	. 9471	69	. 0529	11		44
	20	50	. 4157	49	. 5843	. 4409	20	. 5591	. 9748	69	. 0252	10		40
	24	51	. 4353	49	. 5647	. 4328	20	. 5672	.810025	69	.189975	9		36
	28	52	. 4549	49	. 5451	. 4246	20	. 5754	. 0303	69	. 9697	8		32
	32	53	. 4744	49	. 5256	. 4164	20	. 5836	. 0580	69	. 9420	7		28
	36	54	. 4939	49	. 5061	. 4082	20	. 5918	. 0857	69	. 9143	6		24
	40	55	. 5135	49	. 4865	. 4001	20	. 5999	. 1134	69	. 8866	5		20
	44	56	. 5330	49	. 4671	. 3919	20	. 6081	. 1410	69	. 8590	4		16
	48	57	. 5524	49	. 4476	. 3837	20	. 6163	. 1687	69	. 8313	3		12
	52	58	. 5719	49	. 4281	. 3755	20	. 6245	. 1964	69	. 8036	2		8
	56	59	. 5914	49	. 4086	. 3673	20	. 6327	. 2241	69	. 7759	1		4
11	60	60	9.736109		0.263891	9.923591		0.076409	9.812518		0.187482	0	48	0
m	s	′	L. Cos.	Diff. for 15″ or 1ˢ	L. Sec.	L. Sin.	Diff. for 15″ or 1ˢ	L. Cosec.	L. Cot.	Diff. for 15″ or 1ˢ	L. Tang.	′	m	s
Hours.		Deg.										Deg.	Hours.	

8ʰ 122° 1′ = 4ˢ 1° = 4ᵐ 57° 3ʰ

2h 33° 1s = 15'' 1m = 15' 1h = 15° 146° 9h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m
12	0	0	9.736109	48	0.263891	9.923591	20	0.076409	9.812517	69	0.187483	60	48
	4	1	. 6303	48	. 3697	. 3508	20	. 6491	. 2794	69	. 7206	59	
	8	2	. 6498	48	. 3502	. 3427	20	. 6573	. 3071	69	. 6929	58	
	12	3	. 6692	48	. 3308	. 3345	20	. 6655	. 3347	69	. 6653	57	
	16	4	. 6886	48	. 3114	. 3263	20	. 6737	. 3623	69	. 6377	56	
	20	5	. 7080	48	. 2920	. 3181	21	. 6819	. 3899	69	. 6101	55	
	24	6	. 7274	48	. 2726	. 3098	20	. 6902	. 4176	69	. 5824	54	
	28	7	. 7468	48	. 2532	. 3016	21	. 6984	. 4452	69	. 5548	53	
	32	8	. 7661	48	. 2339	. 2933	20	. 7067	. 4728	69	. 5272	52	
	36	9	. 7855	48	. 2145	. 2851	21	. 7149	. 5004	69	. 4996	51	
	40	10	. 8048	48	. 1952	. 2768	20	. 7232	. 5280	69	. 4720	50	
	44	11	. 8241	48	. 1759	. 2686	21	. 7314	. 5555	69	. 4445	49	
	48	12	. 8434	48	. 1566	. 2603	20	. 7397	. 5831	69	. 4169	48	
	52	13	. 8627	48	. 1373	. 2520	21	. 7480	. 6107	69	. 3893	47	
	56	14	. 8820	48	. 1180	. 2438	21	. 7562	. 6382	69	. 3618	46	
13	0	15	. 9013	48	. 0987	. 2355	21	. 7645	. 6658	69	. 3342	45	47
	4	16	. 9206	48	. 0794	. 2272	21	. 7728	. 6934	69	. 3066	44	
	8	17	. 9398	48	. 0602	. 2189	21	. 7811	. 7209	69	. 2791	43	
	12	18	. 9590	48	. 0410	. 2106	21	. 7894	. 7484	69	. 2516	42	
	16	19	. 9783	48	. 0217	. 2023	21	. 7977	. 7760	69	. 2240	41	
	20	20	. 9975	48	. 0025	. 1940	21	. 8060	. 8035	69	. 1965	40	
	24	21	.740167	48	.259833	. 1857	21	. 8143	. 8310	69	. 1690	39	
	28	22	. 0359	48	. 9641	. 1774	21	. 8226	. 8585	69	. 1415	38	
	32	23	. 0551	48	. 9449	. 1691	21	. 8309	. 8860	69	. 1140	37	
	36	24	. 0742	48	. 9258	. 1607	21	. 8393	. 9135	69	. 0865	36	
	40	25	. 0934	48	. 9066	. 1524	21	. 8476	. 9410	69	. 0590	35	
	44	26	. 1125	48	. 8875	. 1441	21	. 8559	. 9684	69	. 0316	34	
	48	27	. 1316	48	. 8684	. 1357	21	. 8643	. 9959	69	. 0041	33	
	52	28	. 1508	48	. 8492	. 1274	21	. 8726	.820234	69	.179766	32	
	56	29	. 1698	48	. 8302	. 1190	21	. 8810	. 0508	69	. 9492	31	
14	0	30	. 1890	48	. 8110	. 1107	21	. 8893	. 0783	69	. 9217	30	46
	4	31	. 2080	48	. 7920	. 1023	21	. 8977	. 1057	69	. 8943	29	
	8	32	. 2271	48	. 7729	. 0939	21	. 9061	. 1332	68	. 8668	28	
	12	33	. 2462	47	. 7538	. 0856	21	. 9144	. 1606	68	. 8394	27	
	16	34	. 2652	47	. 7348	. 0772	21	. 9228	. 1880	68	. 8120	26	
	20	35	. 2842	47	. 7158	. 0688	21	. 9312	. 2154	68	. 7846	25	
	24	36	. 3033	47	. 6967	. 0604	21	. 9396	. 2429	68	. 7571	24	
	28	37	. 3223	47	. 6777	. 0520	21	. 9480	. 2703	68	. 7297	23	
	32	38	. 3413	47	. 6587	. 0436	21	. 9564	. 2977	68	. 7023	22	
	36	39	. 3602	47	. 6398	. 0352	21	. 9648	. 3250	68	. 6750	21	
	40	40	. 3792	47	. 6208	. 0268	21	. 9732	. 3524	68	. 6476	20	
	44	41	. 3982	47	. 6018	. 0184	21	. 9816	. 3798	68	. 6202	19	
	48	42	. 4171	47	. 5829	. 0099	21	. 9901	. 4072	68	. 5928	18	
	52	43	. 4361	47	. 5639	. 0015	21	. 9985	. 4346	68	. 5654	17	
	56	44	. 4550	47	. 5450	.919931	21	.080069	. 4619	68	. 5381	16	
15	0	45	. 4739	47	. 5261	. 9846	21	. 0154	. 4893	68	. 5107	15	45
	4	46	. 4928	47	. 5072	. 9762	21	. 0238	. 5166	68	. 4834	14	
	8	47	. 5117	47	. 4883	. 9678	21	. 0322	. 5439	68	. 4561	13	
	12	48	. 5306	47	. 4694	. 9593	21	. 0407	. 5713	68	. 4287	12	
	16	49	. 5494	47	. 4506	. 9508	21	. 0492	. 5986	68	. 4014	11	
	20	50	. 5683	47	. 4317	. 9424	21	. 0576	. 6259	68	. 3741	10	
	24	51	. 5871	47	. 4129	. 9339	21	. 0661	. 6532	68	. 3468	9	
	28	52	. 6059	47	. 3941	. 9254	21	. 0746	. 6805	68	. 3195	8	
	32	53	. 6248	47	. 3752	. 9170	21	. 0830	. 7078	68	. 2922	7	
	36	54	. 6436	47	. 3564	. 9085	21	. 0915	. 7351	68	. 2649	6	
	40	55	. 6624	47	. 3376	. 9000	21	. 1000	. 7624	68	. 2376	5	
	44	56	. 6812	47	. 3188	. 8915	21	. 1085	. 7897	68	. 2103	4	
	48	57	. 6999	47	. 3001	. 8830	21	. 1170	. 8169	68	. 1831	3	
	52	58	. 7187	47	. 2813	. 8745	21	. 1255	. 8442	68	. 1558	2	
	56	59	. 7374	47	. 2626	. 8659	21	. 1341	. 8715	68	. 1285	1	
15	60	60	9.747562		0.252438	9.918574		0.081426	9.828988		0.171012	0	44
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	s
Hours.		Deg.										Deg.	Hours.

8h 123° 1' = 4s 1° = 4m 56° 3h

2h 34° 1′ = 15″ 1m = 15′ 1h = 15° 145° 9h

Hours m	Hours s	Deg. ′	L. Sin.	Diff. for 15″ or 1′	L. Cosec.	L. Cos.	Diff. for 15″ or 1′	L. Sec.	L. Tang.	Diff. for 15″ or 1′	L. Cot.	Deg. ′	Hours m	Hours s
16	0	0	9.747562	47	0.252438	9.918574	21	0.081426	9.828988	68	0.171012	60	43	60
	4	1	7749	47	2251	8489	21	1511	9260	68	0740	59		56
	8	2	7936	47	2064	8404	21	1596	9532	68	0468	58		52
	12	3	8123	47	1877	8318	21	1682	9805	68	0195	57		48
	16	4	8310	47	1690	8233	21	1767	.830077	68	.169923	56		44
	20	5	8497	46	1503	8148	21	1852	0349	68	9651	55		40
	24	6	8683	46	1317	8062	21	1938	0621	68	9379	54		36
	28	7	8870	46	1130	7977	21	2023	0893	68	9107	53		32
	32	8	9056	46	0944	7891	21	2109	1165	68	8835	52		28
	36	9	9242	46	0758	7805	21	2195	1437	68	8563	51		24
	40	10	9429	46	0571	7720	21	2280	1709	68	8291	50		20
	44	11	9615	46	0385	7634	21	2366	1981	68	8019	49		16
	48	12	9801	46	0199	7548	21	2452	2253	68	7747	48		12
	52	13	9987	46	0013	7462	21	2538	2525	68	7475	47		8
	56	14	.750172	46	.249828	7376	21	2624	2796	68	7204	46		4
17	0	15	0358	46	9642	7290	21	2710	3068	68	6932	45	43	0
	4	16	0543	46	9457	7204	21	2796	3339	68	6661	44		56
	8	17	0729	46	9271	7118	21	2882	3611	68	6389	43		52
	12	18	0914	46	9086	7032	21	2968	3882	68	6118	42		48
	16	19	1099	46	8901	6945	21	3055	4154	68	5846	41		44
	20	20	1284	46	8716	6859	21	3141	4425	68	5575	40		40
	24	21	1469	46	8531	6773	21	3227	4696	68	5304	39		36
	28	22	1654	46	8346	6687	22	3313	4967	68	5033	38		32
	32	23	1838	46	8162	6600	21	3400	5238	68	4762	37		28
	36	24	2023	46	7977	6514	22	3486	5509	68	4491	36		24
	40	25	2209	46	7791	6427	21	3573	5780	68	4220	35		20
	44	26	2392	46	7608	6341	22	3659	6051	68	3949	34		16
	48	27	2576	46	7424	6254	22	3746	6322	68	3678	33		12
	52	28	2760	46	7240	6167	22	3833	6593	68	3407	32		8
	56	29	2944	46	7056	6080	22	3920	6864	68	3136	31		4
18	0	30	3128	46	6872	5994	22	4006	7134	68	2866	30	42	0
	4	31	3312	46	6688	5907	22	4093	7405	68	2595	29		56
	8	32	3495	46	6505	5820	22	4180	7675	68	2325	28		52
	12	33	3679	46	6321	5733	22	4267	7946	67	2054	27		48
	16	34	3862	46	6138	5646	22	4354	8216	67	1784	26		44
	20	35	4046	46	5954	5559	22	4441	8487	67	1513	25		40
	24	36	4229	46	5771	5472	22	4528	8757	67	1243	24		36
	28	37	4412	46	5588	5385	22	4615	9027	67	0973	23		32
	32	38	4595	46	5405	5297	22	4703	9298	67	0702	22		28
	36	39	4778	46	5222	5210	22	4790	9568	67	0432	21		24
	40	40	4961	46	5039	5123	22	4877	9838	67	0162	20		20
	44	41	5143	46	4857	5035	22	4965	.840108	67	.159892	19		16
	48	42	5326	45	4674	4948	22	5052	0378	67	9622	18		12
	52	43	5508	45	4492	4860	22	5140	0648	67	9352	17		8
	56	44	5690	45	4310	4773	22	5227	0917	67	9083	16		4
19	0	45	5872	45	4128	4685	22	5315	1187	67	8813	15	41	0
	4	46	6054	45	3946	4597	22	5403	1457	67	8543	14		56
	8	47	6236	45	3764	4510	22	5490	1726	67	8274	13		52
	12	48	6418	45	3582	4422	22	5578	1996	67	8004	12		48
	16	49	6600	45	3400	4334	22	5666	2266	67	7734	11		44
	20	50	6781	45	3219	4246	22	5754	2535	67	7465	10		40
	24	51	6963	45	3037	4158	22	5842	2805	67	7195	9		36
	28	52	7144	45	2856	4070	22	5930	3074	67	6926	8		32
	32	53	7325	45	2675	3982	22	6018	3343	67	6657	7		28
	36	54	7507	45	2493	3894	22	6106	3613	67	6387	6		24
	40	55	7688	45	2312	3806	22	6194	3882	67	6118	5		20
	44	56	7869	45	2131	3718	22	6282	4151	67	5849	4		16
	48	57	8050	45	1950	3630	22	6370	4420	67	5580	3		12
	52	58	8230	45	1770	3541	22	6459	4689	67	5311	2		8
	56	59	8411	45	1589	3453	22	6547	4958	67	5042	1		4
19	60	60	9.758591		0.241409	9.913364		0.086636	9.845227		0.154773	0	40	0
Hours m	Hours s	Deg. ′	L. Cos.	Diff. for 15″ or 1′	L. Sec.	L. Sin.	Diff. for 15″ or 1′	L. Cosec.	L. Cot.	Diff. for 15″ or 1′	L. Tang.	Deg. ′	Hours m	Hours s

9h 124° 1′ = 4s 1° = 4m 55° 2h

9h 35° 1' = 15'' 1m = 15' 1h = 15° 144° 9h

Hours. m	s	Deg. ′	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. ′	Hours. m	s
20	0	0	9.758591	45	0.241409	9.913364	22	0.086636	9.845227	67	0.154773	60	39	60
	4	1	. 8772	45	. 1228	. 3276	22	. 6724	. 5496	67	. 4504	59		56
	8	2	. 8952	45	. 1048	. 3188	22	. 6812	. 5764	67	. 4236	58		52
	12	3	. 9132	45	. 0868	. 3099	22	. 6901	. 6033	67	. 3967	57		48
	16	4	. 9312	45	. 0688	. 3010	22	. 6990	. 6302	67	. 3698	56		44
	20	5	. 9492	45	. 0508	. 2921	22	. 7079	. 6571	67	. 3429	55		40
	24	6	. 9672	45	. 0328	. 2833	22	. 7167	. 6839	67	. 3161	54		36
	28	7	. 9852	45	. 0148	. 2744	22	. 7256	. 7108	67	. 2892	53		32
	32	8	.760031	45	.239969	. 2655	22	. 7345	. 7376	67	. 2624	52		28
	36	9	. 0211	45	. 9789	. 2566	22	. 7434	. 7645	67	. 2355	51		24
	40	10	. 0390	45	. 9610	. 2477	22	. 7523	. 7913	67	. 2087	50		20
	44	11	. 0569	45	. 9431	. 2388	22	. 7612	. 8181	67	. 1819	49		16
	48	12	. 0748	45	. 9252	. 2299	22	. 7701	. 8449	67	. 1551	48		12
	52	13	. 0927	45	. 9073	. 2210	22	. 7790	. 8717	67	. 1283	47		8
	56	14	. 1106	45	. 8894	. 2121	22	. 7879	. 8985	67	. 1015	46		4
21	0	15	. 1285	45	. 8715	2031	22	. 7969	. 9254	67	. 0746	45	39	0
	4	16	. 1464	45	. 8536	. 1942	22	. 8058	. 9522	67	. 0478	44		56
	8	17	. 1643	44	. 8357	. 1853	22	. 8147	. 9790	67	. 0210	43		52
	12	18	. 1821	44	. 8179	. 1763	22	. 8237	.850058	67	.149942	42		48
	16	19	. 1999	44	. 8001	. 1674	22	. 8326	. 0325	67	. 9675	41		44
	20	20	. 2177	44	. 7823	. 1584	22	. 8416	. 0593	67	. 9407	40		40
	24	21	. 2356	44	. 7644	. 1495	22	. 8505	. 0861	67	. 9139	39		36
	28	22	. 2534	44	. 7466	. 1405	22	. 8595	. 1129	67	. 8871	38		32
	32	23	. 2712	44	. 7288	. 1316	22	. 8684	. 1396	67	. 8604	37		28
	36	24	. 2890	44	. 7111	. 1226	22	. 8774	. 1664	67	. 8336	36		24
	40	25	. 3067	44	. 6933	. 1136	22	. 8864	. 1931	67	. 8069	35		20
	44	26	. 3245	44	. 6755	. 1046	22	. 8954	. 2199	67	. 7801	34		16
	48	27	. 3422	44	. 6578	. 0956	22	. 9044	. 2466	67	. 7534	33		12
	52	28	. 3600	44	. 6400	. 0866	22	. 9134	. 2734	67	. 7266	32		8
	56	29	. 3777	44	. 6223	. 0776	22	. 9224	. 3001	67	. 6999	31		4
22	0	30	. 3954	44	6046	. 0686	22	. 9314	. 3268	67	. 6732	30	38	0
	4	31	. 4131	44	. 5869	. 0596	22	. 9404	. 3535	67	. 6465	29		56
	8	32	. 4308	44	. 5692	. 0506	22	. 9494	. 3802	67	. 6198	28		52
	12	33	. 4485	44	. 5515	. 0416	23	. 9584	. 4069	67	. 5931	27		48
	16	34	. 4662	44	. 5338	. 0325	22	. 9675	. 4337	67	. 5663	26		44
	20	35	. 4838	44	. 5162	. 0235	22	. 9765	. 4603	67	. 5397	25		40
	24	36	. 5015	44	. 4985	. 0145	23	. 9855	. 4870	67	. 5130	24		36
	28	37	. 5191	44	. 4809	. 0054	23	. 9946	. 5137	67	. 4863	23		32
	32	38	. 5367	44	. 4633	.909963	22	.090037	. 5404	67	. 4596	22		28
	36	39	. 5544	44	. 4456	. 9873	23	. 0127	. 5671	67	. 4329	21		24
	40	40	. 5720	44	. 4280	. 9782	22	. 0218	. 5938	67	. 4062	20		20
	44	41	. 5896	44	. 4104	. 9692	23	. 0308	. 6204	67	. 3796	19		16
	48	42	. 6072	44	. 3928	. 9601	23	. 0399	. 6471	67	. 3529	18		12
	52	43	. 6247	44	. 3753	. 9510	23	. 0490	. 6737	67	. 3263	17		8
	56	44	. 6423	44	. 3577	. 9419	23	. 0581	. 7004	67	. 2996	16		4
23	0	45	. 6598	44	. 3402	. 9328	23	. 0672	. 7270	66	. 2730	15	37	0
	4	46	. 6774	44	. 3226	. 9237	23	. 0763	. 7537	66	. 2463	14		56
	8	47	. 6949	44	. 3051	. 9146	23	. 0854	. 7803	66	. 2197	13		52
	12	48	. 7124	44	. 2876	. 9055	23	. 0945	. 8069	66	. 1931	12		48
	16	49	. 7300	44	. 2700	. 8964	23	. 1036	. 8336	66	. 1664	11		44
	20	50	. 7475	44	. 2525	. 8873	23	. 1127	. 8602	66	. 1398	10		40
	24	51	. 7649	44	. 2351	. 8781	24	. 1219	. 8868	66	. 1132	9		36
	28	52	. 7824	44	. 2176	. 8690	23	. 1310	. 9134	66	. 0866	8		32
	32	53	. 7999	44	. 2001	. 8599	23	. 1401	. 9400	66	. 0600	7		28
	36	54	. 8173	44	. 1827	. 8507	23	. 1493	. 9666	66	. 0334	6		24
	40	55	. 8348	44	. 1652	. 8416	23	. 1584	. 9932	66	. 0068	5		20
	44	56	. 8522	43	. 1478	. 8324	23	. 1676	.860198	66	.139802	4		16
	48	57	. 8697	43	. 1303	. 8233	23	. 1767	. 0464	66	. 9536	3		12
	52	58	. 8871	43	. 1129	. 8141	23	. 1859	. 0730	66	. 9270	2		8
	56	59	. 9045	43	. 0955	. 8049	23	. 1951	. 0996	66	. 9004	1		4
23	60	60	9.769219		0.230781	9.907958		0.092042	9.861261		0.138739	0	36	0
m	s	′	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	′	m	s
Hours.		Deg.										Deg.	Hours.	

8h 125° 1' = 4s 1° = 4m 54° 3h

2ʰ 36° $1^s = 15''$ $1^m = 15'$ $1^h = 15°$ 143° 9ʰ

Hours m	Hours s	Deg. '	L. Sin.	Diff. for 15'' or 1ˢ	L. Cosec.	L. Cos.	Diff. for 15'' or 1ˢ	L. Sec.	L. Tang.	Diff. for 15'' or 1ˢ	L. Cot.	Deg. '	Hours m	Hours s
24	0	0	9.769219	43	0.230781	9.907958	23	0.092042	9.861261	66	0.138739	60	35	60
	4	1	. 9393	43	. 0607	. 7866	23	. 2134	. 1527	66	. 8473	59		56
	8	2	. 9566	43	. 0434	. 7774	23	. 2226	. 1792	66	. 8208	58		52
	12	3	. 9740	43	. 0260	. 7682	23	. 2318	. 2058	66	. 7942	57		48
	16	4	. 9913	43	. 0087	. 7590	23	. 2410	. 2323	66	. 7677	56		44
	20	5	.770087	43	.229913	. 7498	23	. 2502	. 2589	66	. 7411	55		40
	24	6	. 0260	43	. 9740	. 7406	23	. 2594	. 2854	66	. 7146	54		36
	28	7	. 0433	43	. 9567	. 7314	23	. 2686	. 3119	66	. 6881	53		32
	32	8	. 0606	43	. 9394	. 7221	23	. 2779	. 3385	66	. 6615	52		28
	36	9	. 0779	43	. 9221	. 7129	23	. 2871	. 3650	66	. 6350	51		24
	40	10	. 0952	43	. 9048	. 7037	23	. 2963	. 3915	66	. 6085	50		20
	44	11	. 1125	43	. 8875	. 6945	23	. 3055	. 4180	66	. 5820	49		16
	48	12	. 1297	43	. 8703	. 6852	23	. 3148	. 4445	66	. 5555	48		12
	52	13	. 1470	43	. 8530	. 6760	23	. 3240	. 4710	66	. 5290	47		8
	56	14	. 1643	43	. 8357	. 6667	23	. 3333	. 4976	66	. 5024	46		4
25	0	15	. 1815	43	. 8185	. 6575	23	. 3425	. 5240	66	. 4760	45	35	0
	4	16	. 1987	43	. 8013	. 6482	23	. 3518	. 5505	66	. 4495	44		56
	8	17	. 2159	43	. 7841	. 6389	23	. 3611	. 5770	66	. 4230	43		52
	12	18	. 2331	43	. 7669	. 6296	23	. 3704	. 6035	66	. 3965	42		48
	16	19	. 2503	43	. 7497	. 6203	23	. 3797	. 6300	66	. 3700	41		44
	20	20	. 2675	43	. 7325	. 6111	23	. 3889	. 6564	66	. 3436	40		40
	24	21	. 2847	43	. 7153	. 6018	23	. 3982	. 6829	66	. 3171	39		36
	28	22	. 3019	43	. 6981	. 5925	28	. 4075	. 7094	66	. 2906	38		32
	32	23	. 3190	43	. 6810	. 5832	23	. 4168	. 7358	66	. 2642	37		28
	36	24	. 3362	43	. 6638	. 5739	23	. 4261	. 7623	66	. 2377	36		24
	40	25	. 3533	43	. 6467	. 5646	23	. 4354	. 7887	66	. 2113	35		20
	44	26	. 3704	43	. 6296	. 5552	23	. 4448	. 8152	66	. 1848	34		16
	48	27	. 3875	43	. 6125	. 5459	23	. 4541	. 8416	66	. 1584	33		12
	52	28	. 4046	43	. 5954	. 5366	23	. 4634	. 8680	66	. 1320	32		8
	56	29	. 4217	43	. 5783	. 5272	23	. 4728	. 8945	66	. 1055	31		4
26	0	30	. 4388	43	. 5612	. 5179	23	. 4821	. 9209	66	. 0791	30	34	0
	4	31	. 4558	43	. 5442	. 5085	23	. 4915	. 9473	66	. 0527	29		56
	8	32	. 4729	43	. 5271	. 4992	23	. 5008	. 9737	66	. 0263	28		52
	12	33	. 4899	43	. 5101	. 4898	23	. 5102	.870001	66	.129999	27		48
	16	34	. 5070	42	. 4930	. 4805	23	. 5195	. 0265	66	. 9735	26		44
	20	35	. 5240	42	. 4760	. 4711	23	. 5289	. 0529	66	. 9471	25		40
	24	36	. 5410	42	. 4590	. 4617	23	. 5383	. 0793	66	. 9207	24		36
	28	37	. 5580	42	. 4420	. 4523	23	. 5477	. 1057	66	. 8943	23		32
	32	38	. 5750	42	. 4250	. 4429	23	. 5571	. 1321	66	. 8679	22		28
	36	39	. 5920	42	. 4080	. 4335	23	. 5665	. 1585	66	. 8415	21		24
	40	40	. 6090	42	. 3910	. 4241	23	. 5759	. 1849	66	. 8151	20		20
	44	41	. 6259	42	. 3741	. 4147	23	. 5853	. 2112	66	. 7888	19		16
	48	42	. 6429	42	. 3571	. 4053	23	. 5947	. 2376	66	. 7624	18		12
	52	43	. 6598	42	. 3402	. 3959	24	. 6041	. 2639	66	. 7361	17		8
	56	44	. 6767	42	. 3233	. 3864	23	. 6136	. 2903	66	. 7097	16		4
27	0	45	. 6937	42	. 3063	. 3770	23	. 6230	. 3167	66	. 6833	15	33	0
	4	46	. 7106	42	. 2894	. 3676	24	. 6324	. 3430	66	. 6570	14		56
	8	47	. 7275	42	. 2725	. 3581	23	. 6419	. 3694	66	. 6306	13		52
	12	48	. 7444	42	. 2556	. 3487	24	. 6513	. 3957	66	. 6043	12		48
	16	49	. 7613	42	. 2387	. 3392	23	. 6608	. 4221	66	. 5779	11		44
	20	50	. 7782	42	. 2218	. 3298	24	. 6702	. 4484	66	. 5516	10		40
	24	51	. 7950	42	. 2050	. 3203	24	. 6797	. 4747	66	. 5253	9		36
	28	52	. 8119	42	. 1881	. 3109	24	. 6891	. 5010	66	. 4990	8		32
	32	53	. 8287	42	. 1713	. 3014	24	. 6986	. 5273	66	. 4727	7		28
	36	54	. 8455	42	. 1545	. 2919	24	. 7081	. 5536	66	. 4464	6		24
	40	55	. 8624	42	. 1376	. 2824	24	. 7176	. 5800	66	. 4200	5		20
	44	56	. 8792	42	. 1208	. 2729	24	. 7271	. 6063	66	. 3937	4		16
	48	57	. 8960	42	. 1040	. 2634	24	. 7366	. 6326	66	. 3674	3		12
	52	58	. 9128	42	. 0872	. 2539	24	. 7461	. 6589	66	. 3411	2		8
	56	59	. 9295	42	. 0705	. 2444	24	. 7556	. 6851	66	. 3149	1		4
27	60	60	9.779463		0.220537	9.902349		0.097651	9.877114		0.122886	0	32	0
m	s	'	L. Cos.	Diff. for 15'' or 1ˢ	L. Sec.	L. Sin.	Diff. for 15'' or 1ˢ	L. Cosec.	L. Cot.	Diff. for 15'' or 1ˢ	L. Tang.	'	m	s
Hours		Deg.										Deg.	Hours	

8ʰ 126° $1' = 4^s$ $1° = 4^m$ 53° 3ʰ

2h 37° 1s = 15'' 1m = 15' 1h = 15° 142° 9h

Hours. h	Hours. m	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot	Deg. '	Hours. h	Hours. m
28	0	0	9.773463	42	0.220537	9.902349	24	0.097651	9.877114	66	0.122886	60	31	0
	4	1	. 9630	42	. 0370	. 2253	24	. 7747	. 7377	66	. 2623	59		56
	8	2	. 9798	42	. 0202	. 2158	24	. 7842	. 7640	66	. 2360	58		52
	12	3	. 9966	42	. 0034	. 2063	24	. 7937	. 7903	66	. 2097	57		48
	16	4	.780133	42	.219867	. 1967	24	. 8033	. 8166	66	. 1834	56		44
	20	5	. 0300	42	. 9700	. 1872	24	. 8128	. 8428	66	. 1572	55		40
	24	6	. 0467	42	. 9533	. 1776	24	. 8224	. 8691	66	. 1309	54		36
	28	7	. 0634	42	. 9366	. 1681	24	. 8319	. 8953	66	. 1047	53		32
	32	8	. 0801	42	. 9199	. 1585	24	. 8415	. 9216	66	. 0784	52		28
	36	9	. 0968	42	. 9032	. 1490	24	. 8510	. 9478	66	. 0522	51		24
	40	10	. 1135	42	. 8865	. 1394	24	. 8606	. 9741	65	. 0259	50		20
	44	11	. 1301	42	. 8699	. 1298	24	. 8702	.880003	65	.119997	49		16
	48	12	. 1467	42	. 8533	. 1202	24	. 8798	. 0265	66	. 9735	48		12
	52	13	. 1634	42	. 8366	. 1106	24	. 8894	. 0528	65	. 9472	47		8
	56	14	. 1800	41	. 8200	. 1010	24	. 8990	. 0790	65	. 9210	46		4
29	0	15	. 1966	41	. 8034	. 0914	24	. 9086	. 1052	65	. 8948	45	31	0
	4	16	. 2132	41	. 7868	. 0818	24	. 9182	. 1314	66	. 8686	44		56
	8	17	. 2298	41	. 7702	. 0722	24	. 9278	. 1576	66	. 8424	43		52
	12	18	. 2464	41	. 7536	. 0626	24	. 9374	. 1838	65	. 8162	42		48
	16	19	. 2630	41	. 7370	. 0529	24	. 9471	. 2101	65	. 7899	41		44
	20	20	. 2796	41	. 7204	. 0433	24	. 9567	. 2363	65	. 7637	40		40
	24	21	. 2962	41	. 7038	. 0337	24	. 9663	. 2625	65	. 7375	39		36
	28	22	. 3127	41	. 6873	. 0240	24	. 9760	. 2887	65	. 7113	38		32
	32	23	. 3292	41	. 6708	. 0144	24	. 9856	. 3148	65	. 6852	37		28
	36	24	. 3457	41	. 6543	. 0047	24	. 9953	. 3410	65	. 6590	36		24
	40	25	. 3623	41	. 6377	.899951	24	.100049	. 3672	65	. 6328	35		20
	44	26	. 3788	41	. 6212	. 9854	24	. 0146	. 3934	65	. 6066	34		16
	48	27	. 3953	41	. 6047	. 9757	24	. 0243	. 4196	65	. 5804	33		12
	52	28	. 4118	41	. 5882	. 9661	24	. 0339	. 4457	65	. 5543	32		8
	56	29	. 4283	41	. 5717	. 9564	24	. 0436	. 4719	65	. 5281	31		4
30	0	30	. 4447	41	. 5553	. 9467	24	. 0533	. 4980	65	. 5020	30	30	0
	4	31	. 4612	41	. 5388	. 9370	24	. 0630	. 5242	65	. 4758	29		56
	8	32	. 4776	41	. 5224	. 9273	24	. 0727	. 5503	65	. 4497	28		52
	12	33	. 4941	41	. 5059	. 9176	24	. 0824	. 5765	65	. 4235	27		48
	16	34	. 5105	41	. 4895	. 9079	24	. 0921	. 6026	65	. 3974	26		44
	20	35	. 5269	41	. 4731	. 8981	24	. 1019	. 6288	65	. 3712	25		40
	24	36	. 5433	41	. 4567	. 8884	24	. 1116	. 6549	65	. 3451	24		36
	28	37	. 5597	41	. 4403	. 8787	24	. 1213	. 6810	65	. 3190	23		32
	32	38	. 5761	41	. 4239	. 8689	24	. 1311	. 7072	65	. 2928	22		28
	36	39	. 5925	41	. 4075	. 8592	24	. 1408	. 7333	65	. 2667	21		24
	40	40	. 6089	41	. 3911	. 8495	24	. 1505	. 7594	65	. 2406	20		20
	44	41	. 6252	41	. 3748	. 8397	24	. 1603	. 7855	65	. 2145	19		16
	48	42	. 6416	41	. 3584	. 8299	24	. 1701	. 8117	65	. 1883	18		12
	52	43	. 6579	41	. 3421	. 8201	24	. 1799	. 8378	65	. 1622	17		8
	56	44	. 6743	41	. 3257	. 8104	24	. 1896	. 8639	65	. 1361	16		4
31	0	45	. 6906	41	. 3094	. 8006	24	. 1994	. 8900	65	. 1100	15	29	0
	4	46	. 7069	41	. 2931	. 7908	24	. 2092	. 9161	65	. 0839	14		56
	8	47	. 7232	41	. 2768	. 7810	24	. 2190	. 9422	65	. 0578	13		52
	12	48	. 7394	41	. 2606	. 7712	25	. 2288	. 9682	65	. 0318	12		48
	16	49	. 7557	41	. 2443	. 7614	24	. 2386	. 9943	65	. 0057	11		44
	20	50	. 7720	41	. 2280	. 7516	24	. 2484	.890204	65	.109796	10		40
	24	51	. 7883	41	. 2117	. 7418	25	. 2582	. 0465	65	. 9535	9		36
	28	52	. 8045	41	. 1955	. 7320	25	. 2680	. 0725	65	. 9275	8		32
	32	53	. 8208	40	. 1792	. 7222	24	. 2778	. 0986	65	. 9014	7		28
	36	54	. 8370	40	. 1630	. 7123	25	. 2877	. 1247	65	. 8753	6		24
	40	55	. 8532	40	. 1468	. 7025	24	. 2975	. 1507	65	. 8493	5		20
	44	56	. 8694	40	. 1306	. 6926	25	. 3074	. 1768	65	. 8232	4		16
	48	57	. 8857	40	. 1143	. 6828	25	. 3172	. 2029	65	. 7971	3		12
	52	58	. 9018	40	. 0982	. 6729	24	. 3271	. 2289	65	. 7711	2		8
	56	59	. 9180	40	. 0820	. 6631	25	. 3369	. 2549	65	. 7451	1		4
31	60	60	9.789342		0.210658	9.896532		0.103468	9.892810		0.107190	0	28	0
h	m	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	h	m
Hours.		Deg.										Deg.	Hours.	

8h 127° 1' = 4s 1° = 4m 52° 3h

2h 38° 1s = 15'' 1m = 15' 1h = 15° 141° 9h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
32	0	0	9.789342	40	0.210658	9.896532	25	0.103468	9.892810	65	0.107190	60	27	60
	4	1	. 9503	40	. 0497	. 6433	25	. 3567	. 3070	65	. 6930	59		56
	8	2	. 9665	40	. 0335	. 6334	25	. 3666	. 3331	65	. 6669	58		52
	12	3	. 9827	40	. 0173	. 6236	25	. 3764	. 3591	65	. 6409	57		48
	16	4	. 9988	40	. 0012	. 6137	25	. 3863	. 3851	65	. 6149	56		44
	20	5	.790149	40	.209851	. 6038	25	. 3962	. 4111	65	. 5889	55		40
	24	6	. 0310	40	. 9690	. 5939	25	. 4061	. 4371	65	. 5629	54		36
	28	7	. 0472	40	. 9528	. 5840	25	. 4160	. 4632	65	. 5368	53		32
	32	8	. 0633	40	. 9367	. 5741	25	. 4259	. 4892	65	. 5108	52		28
	36	9	. 0793	40	. 9207	. 5641	25	. 4359	. 5152	65	. 4848	51		24
	40	10	. 0954	40	. 9046	. 5542	25	. 4458	. 5412	65	. 4588	50		20
	44	11	. 1115	40	. 8885	. 5443	25	. 4557	. 5672	65	. 4328	49		16
	48	12	. 1275	40	. 8725	. 5343	25	. 4657	. 5932	65	. 4068	48		12
	52	13	. 1436	40	. 8564	. 5244	25	. 4756	. 6192	65	. 3808	47		8
	56	14	. 1596	40	. 8404	. 5144	25	. 4856	. 6452	65	. 3548	46		4
33	0	15	. 1757	40	. 8243	. 5045	25	. 4955	. 6712	65	. 3288	45	27	0
	4	16	. 1917	40	. 8083	. 4945	25	. 5055	. 6972	65	. 3028	44		56
	8	17	. 2077	40	. 7923	. 4846	25	. 5154	. 7231	65	. 2769	43		52
	12	18	. 2237	40	. 7763	. 4746	25	. 5254	. 7491	65	. 2509	42		48
	16	19	. 2397	40	. 7603	. 4646	25	. 5354	. 7751	65	. 2249	41		44
	20	20	. 2557	40	. 7443	. 4546	25	. 5454	. 8011	65	. 1989	40		40
	24	21	. 2716	40	. 7284	. 4446	25	. 5554	. 8270	65	. 1730	39		36
	28	22	. 2876	40	. 7124	. 4346	25	. 5654	. 8530	65	. 1470	38		32
	32	23	. 3035	40	. 6965	. 4246	25	. 5754	. 8789	65	. 1211	37		28
	36	24	. 3195	40	. 6805	. 4146	25	. 5854	. 9049	65	. 0951	36		24
	40	25	. 3354	40	. 6646	. 4046	25	. 5954	. 9308	65	. 0692	35		20
	44	26	. 3514	40	. 6486	. 3946	25	. 6054	. 9568	65	. 0432	34		16
	48	27	. 3673	40	. 6327	. 3846	25	. 6154	. 9827	65	. 0173	33		12
	52	28	. 3832	40	. 6168	. 3745	25	. 6255	.900087	65	.099913	32		8
	56	29	. 3991	40	. 6009	. 3645	25	. 6355	. 0346	65	. 9654	31		4
34	0	30	. 4150	40	. 5850	. 3544	25	. 6456	. 0605	65	. 9395	30	26	0
	4	31	. 4308	40	. 5692	. 3444	25	. 6556	. 0864	65	. 9136	29		56
	8	32	. 4467	40	. 5533	. 3343	25	. 6657	. 1124	65	. 8876	28		52
	12	33	. 4626	40	. 5374	. 3243	25	. 6757	. 1383	65	. 8617	27		48
	16	34	. 4784	40	. 5216	. 3142	25	. 6858	. 1642	65	. 8358	26		44
	20	35	. 4942	39	. 5058	. 3041	25	. 6959	. 1901	65	. 8099	25		40
	24	36	. 5101	39	. 4899	. 2940	25	. 7060	. 2161	65	. 7839	24		36
	28	37	. 5259	39	. 4741	. 2839	25	. 7161	. 2420	65	. 7580	23		32
	32	38	. 5417	39	. 4583	. 2738	25	. 7262	. 2679	65	. 7321	22		28
	36	39	. 5575	39	. 4425	. 2637	25	. 7363	. 2938	65	. 7062	21		24
	40	40	. 5733	39	. 4267	. 2536	25	. 7464	. 3197	65	. 6803	20		20
	44	41	. 5891	39	. 4109	. 2435	25	. 7565	. 3456	65	. 6544	19		16
	48	42	. 6049	39	. 3951	. 2334	25	. 7666	. 3715	65	. 6285	18		12
	52	43	. 6206	39	. 3794	. 2233	25	. 7767	. 3973	65	. 6027	17		8
	56	44	. 6364	39	. 3636	. 2132	25	. 7868	. 4232	65	. 5768	16		4
35	0	45	. 6521	39	. 3479	. 2030	25	. 7970	. 4491	65	. 5509	15	25	0
	4	46	. 6679	39	. 3321	. 1929	25	. 8071	. 4750	65	. 5250	14		56
	8	47	. 6836	39	. 3164	. 1827	25	. 8173	. 5009	65	. 4991	13		52
	12	48	. 6993	39	. 3007	. 1726	25	. 8274	. 5267	65	. 4733	12		48
	16	49	. 7150	39	. 2850	. 1624	25	. 8376	. 5526	65	. 4474	11		44
	20	50	. 7307	39	. 2693	. 1523	25	. 8477	. 5784	64	. 4216	10		40
	24	51	. 7464	39	. 2536	. 1421	25	. 8579	. 6043	65	. 3957	9		36
	28	52	. 7621	39	. 2379	. 1319	25	. 8681	. 6302	65	. 3698	8		32
	32	53	. 7777	39	. 2223	. 1217	25	. 8783	. 6560	65	. 3440	7		28
	36	54	. 7934	39	. 2066	. 1115	25	. 8885	. 6819	65	. 3181	6		24
	40	55	. 8090	39	. 1910	. 1013	25	. 8987	. 7077	65	. 2923	5		20
	44	56	. 8247	39	. 1753	. 0911	25	. 9089	. 7336	65	. 2664	4		16
	48	57	. 8403	39	. 1597	. 0809	25	. 9191	. 7594	65	. 2406	3		12
	52	58	. 8560	39	. 1440	. 0707	25	. 9293	. 7853	64	. 2147	2		8
	56	59	. 8716	39	. 1284	. 0605	25	. 9395	. 8111	64	. 1889	1		4
36	60	60	9.798872		0.201129	9.890503		0.109497	9.908369		0.091631	0	24	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

8h 128° 1' = 4s 1° = 4m 51° 3h

9h 39° 1s = 15'' 1m = 15' 1h = 15° 140° 9h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
36	0	0	9.798872	39	0.201128	9.890503	26	0.109497	9.909369	65	0.091631	60	23	60
	4	1	. 9028	39	. 0972	. 0400	25	. 9600	. 8628	64	. 1372	59		56
	8	2	. 9184	39	. 0816	. 0298	26	. 9702	. 8886	64	. 1114	58		52
	12	3	. 9339	39	. 0661	. 0195	25	. 9805	. 9144	64	. 0856	57		48
	16	4	. 9495	39	. 0505	. 0093	26	. 9907	. 9402	64	. 0598	56		44
	20	5	. 9651	39	. 0349	.889991	25	.110009	. 9660	64	. 0340	55		40
	24	6	. 9806	39	. 0194	. 9888	26	. 0112	. 9918	64	. 0082	54		36
	28	7	. 9962	39	. 0038	. 9785	26	. 0215	.910177	64	.089824	53		32
	32	8	.800117	39	.199883	. 9682	26	. 0318	. 0435	64	. 9565	52		28
	36	9	. 0272	39	. 9728	. 9579	26	. 0421	. 0693	64	. 9307	51		24
	40	10	. 0427	39	. 9573	. 9476	26	. 0524	. 0951	64	. 9049	50		20
	44	11	. 0582	39	. 9418	. 9373	26	. 0627	. 1209	64	. 8791	49		16
	48	12	. 0737	39	. 9263	. 9270	26	. 0730	. 1467	64	. 8533	48		12
	52	13	. 0892	39	. 9108	. 9167	26	. 0833	. 1725	64	. 8275	47		8
	56	14	. 1047	39	. 8953	. 9064	26	. 0936	. 1983	64	. 8017	46		4
37	0	15	. 1201	39	. 8799	. 8961	26	. 1039	. 2240	64	. 7760	45	23	0
	4	16	. 1356	39	. 8644	. 8858	26	. 1142	. 2498	64	. 7502	44		56
	8	17	. 1511	38	. 8489	. 8755	26	. 1245	. 2756	64	. 7244	43		52
	12	18	. 1665	38	. 8335	. 8651	26	. 1349	. 3014	64	. 6986	42		48
	16	19	. 1819	38	. 8181	. 8548	26	. 1452	. 3271	64	. 6729	41		44
	20	20	. 1973	38	. 8027	. 8444	26	. 1556	. 3529	64	. 6471	40		40
	24	21	. 2128	38	. 7872	. 8341	26	. 1659	. 3787	64	. 6213	39		36
	28	22	. 2282	38	. 7718	. 8237	26	. 1763	. 4045	64	. 5955	38		32
	32	23	. 2436	38	. 7564	. 8134	26	. 1866	. 4302	64	. 5698	37		28
	36	24	. 2590	38	. 7410	. 8030	26	. 1970	. 4560	64	. 5440	36		24
	40	25	. 2743	38	. 7257	. 7926	26	. 2074	. 4817	64	. 5183	35		20
	44	26	. 2897	38	. 7103	. 7822	26	. 2178	. 5075	64	. 4925	34		16
	48	27	. 3050	38	. 6950	. 7718	26	. 2282	. 5332	64	. 4668	33		12
	52	28	. 3204	38	. 6796	. 7614	26	. 2386	. 5590	64	. 4410	32		8
	56	29	. 3357	38	. 6643	. 7510	26	. 2490	. 5847	64	. 4153	31		4
38	0	30	. 3511	38	. 6489	. 7406	26	. 2594	. 6105	64	. 3895	30	22	0
	4	31	. 3664	38	. 6336	. 7302	26	. 2698	. 6362	64	. 3638	29		56
	8	32	. 3817	38	. 6183	. 7198	26	. 2802	. 6619	64	. 3381	28		52
	12	33	. 3970	38	. 6030	. 7093	26	. 2907	. 6877	64	. 3123	27		48
	16	34	. 4123	38	. 5877	. 6989	26	. 3011	. 7134	64	. 2866	26		44
	20	35	. 4276	38	. 5724	. 6885	26	. 3115	. 7391	64	. 2609	25		40
	24	36	. 4428	38	. 5572	. 6780	26	. 3220	. 7648	64	. 2352	24		36
	28	37	. 4581	38	. 5419	. 6676	26	. 3324	. 7905	64	. 2095	23		32
	32	38	. 4734	38	. 5266	. 6571	26	. 3429	. 8163	64	. 1837	22		28
	36	39	. 4886	38	. 5114	. 6466	26	. 3534	. 8420	64	. 1580	21		24
	40	40	. 5039	38	. 4961	. 6362	26	. 3638	. 8677	64	. 1323	20		20
	44	41	. 5191	38	. 4809	. 6257	26	. 3743	. 8934	64	. 1066	19		16
	48	42	. 5343	38	. 4657	. 6152	26	. 3848	. 9191	64	. 0809	18		12
	52	43	. 5495	38	. 4505	. 6047	26	. 3953	. 9448	64	. 0552	17		8
	56	44	. 5647	38	. 4353	. 5942	26	. 4058	. 9705	64	. 0295	16		4
39	0	45	. 5799	38	. 4201	. 5837	26	. 4163	. 9962	64	. 0038	15	21	0
	4	46	. 5951	38	. 4049	. 5732	26	. 4268	.920219	64	.079781	14		56
	8	47	. 6103	38	. 3897	. 5627	26	. 4373	. 0476	64	. 9524	13		52
	12	48	. 6254	38	. 3746	. 5521	26	. 4479	. 0733	64	. 9267	12		48
	16	49	. 6406	38	. 3594	. 5416	26	. 4584	. 0990	64	. 9010	11		44
	20	50	. 6558	38	. 3442	. 5311	26	. 4689	. 1247	64	. 8753	10		40
	24	51	. 6709	38	. 3291	. 5206	26	. 4794	. 1503	64	. 8497	9		36
	28	52	. 6860	38	. 3140	. 5100	26	. 4900	. 1760	64	. 8240	8		32
	32	53	. 7011	38	. 2988	. 4994	26	. 5006	. 2017	64	. 7983	7		28
	36	54	. 7163	38	. 2837	. 4889	26	. 5111	. 2274	64	. 7726	6		24
	40	55	. 7314	38	. 2686	. 4783	26	. 5217	. 2531	64	. 7469	5		20
	44	56	. 7465	38	. 2535	. 4678	26	. 5322	. 2787	64	. 7213	4		16
	48	57	. 7616	38	. 2384	. 4572	26	. 5428	. 3044	64	. 6956	3		12
	52	58	. 7766	38	. 2234	. 4466	26	. 5534	. 3300	64	. 6700	2		8
	56	59	. 7917	38	. 2083	. 4360	26	. 5640	. 3557	64	. 6443	1		4
39	60	60	9.808068		0.191932	9.884254		0.115746	9.923814		0.076186	0	20	0
m	s	'										'	m	s
Hours.		Deg.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec	L. Cot.	Diff. for 15'' or 1s	L. Tang.	Deg	Hours.	

5h 129° 1' = 4s 1° = 4m 50° 2h

2h 40°						1' = 15'' 1m = 15' 1h = 15°						139°	9h	
Hours. m	s	Deg. '	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Tang.	Diff. for 15'' or 1'	L. Cot.	Deg. '	Hours. m	s
40	0	0	9.808068	37	0.191932	9.884254	26	0.115746	9.923814	64	0.076186	60	19	0
	4	1	. 8218	37	. 1782	. 4148	26	. 5852	. 4070	64	. 5930	59		56
	8	2	. 8368	37	. 1631	. 4042	26	. 5958	. 4327	64	. 5673	58		52
	12	3	. 8519	37	. 1481	. 3936	27	. 6064	. 4583	64	. 5417	57		48
	16	4	. 8669	37	. 1331	. 3829	26	. 6171	. 4840	64	. 5160	56		44
	20	5	. 8819	37	. 1181	. 3723	26	. 6277	. 5096	64	. 4904	55		40
	24	6	. 8969	37	. 1031	. 3617	27	. 6383	. 5352	64	. 4648	54		36
	28	7	. 9119	37	. 0881	. 3510	27	. 6490	. 5609	64	. 4391	53		32
	32	8	. 9269	37	. 0731	. 3404	27	. 6596	. 5865	64	. 4135	52		28
	36	9	. 9419	37	. 0581	. 3297	27	. 6703	. 6122	64	. 3878	51		24
	40	10	. 9569	37	. 0431	. 3191	27	. 6809	. 6378	64	. 3622	50		20
	44	11	. 9718	37	. 0282	. 3084	27	. 6916	. 6634	64	. 3366	49		16
	48	12	. 9868	37	. 0132	. 2978	27	. 7022	. 6890	64	. 3110	48		12
	52	13	.810017	37	.189983	. 2871	27	. 7129	. 7146	64	. 2854	47		8
	56	14	. 0167	37	. 9833	. 2764	27	. 7236	. 7403	64	. 2597	46		4
41	0	15	. 0316	37	. 9684	. 2657	27	. 7343	. 7659	64	. 2341	45	19	0
	4	16	. 0465	37	. 9535	. 2550	27	. 7450	. 7915	64	. 2085	44		56
	8	17	. 0614	37	. 9386	. 2443	27	. 7557	. 8171	64	. 1829	43		52
	12	18	. 0763	37	. 9237	. 2336	27	. 7664	. 8427	64	. 1573	42		48
	16	19	. 0912	37	. 9088	. 2229	27	. 7771	. 8683	64	. 1317	41		44
	20	20	. 1061	37	. 8939	. 2121	27	. 7879	. 8940	64	. 1060	40		40
	24	21	. 1210	37	. 8790	. 2014	27	. 7986	. 9196	64	. 0804	39		36
	28	22	. 1358	37	. 8642	. 1907	27	. 8093	. 9451	64	. 0549	38		32
	32	23	. 1507	37	. 8493	. 1799	27	. 8201	. 9708	64	. 0292	37		28
	36	24	. 1656	37	. 8344	. 1692	27	. 8309	. 9964	64	. 0036	36		24
	40	25	. 1804	37	. 8196	. 1584	27	. 8416	.930220	64	.069780	35		20
	44	26	. 1952	37	. 8048	. 1477	27	. 8523	. 0475	64	. 9525	34		16
	48	27	. 2100	37	. 7900	. 1369	27	. 8631	. 0731	64	. 9269	33		12
	52	28	. 2248	37	. 7752	. 1261	27	. 8739	. 0987	64	. 9013	32		8
	56	29	. 2396	37	. 7604	. 1153	27	. 8847	. 1243	64	. 8757	31		4
42	0	30	. 2544	37	. 7456	. 1045	27	. 8955	. 1499	64	. 8501	30	18	0
	4	31	. 2692	37	. 7308	. 0937	27	. 9063	. 1755	64	. 8245	29		56
	8	32	. 2840	37	. 7160	. 0830	27	. 9170	. 2010	64	. 7990	28		52
	12	33	. 2988	37	. 7012	. 0722	27	. 9278	. 2266	64	. 7734	27		48
	16	34	. 3135	37	. 6865	. 0613	27	. 9387	. 2522	64	. 7478	26		44
	20	35	. 3283	37	. 6717	. 0505	27	. 9495	. 2778	64	. 7222	25		40
	24	36	. 3430	37	. 6570	. 0397	27	. 9603	. 3033	64	. 6967	24		36
	28	37	. 3578	37	. 6422	. 0289	27	. 9711	. 3289	64	. 6711	23		32
	32	38	. 3725	37	. 6275	. 0180	27	. 9820	. 3545	64	. 6455	22		28
	36	39	. 3872	37	. 6128	. 0072	27	. 9928	. 3800	64	. 6200	21		24
	40	40	. 4019	37	. 5981	.873963	27	.120037	. 4056	64	. 5944	20		20
	44	41	. 4166	37	. 5834	. 9855	27	. 0145	. 4311	64	. 5689	19		16
	48	42	. 4313	37	. 5687	. 9746	27	. 0254	. 4567	64	. 5433	18		12
	52	43	. 4460	37	. 5540	. 9637	27	. 0363	. 4823	64	. 5177	17		8
	56	44	. 4607	37	. 5393	. 9529	27	. 0471	. 5078	64	. 4922	16		4
43	0	45	. 4753	37	. 5247	. 9420	27	. 0580	. 5333	64	. 4667	15	17	0
	4	46	. 4900	37	. 5100	. 9311	27	. 0689	. 5589	64	. 4411	14		56
	8	47	. 5046	37	. 4954	. 9202	27	. 0798	. 5844	64	. 4156	13		52
	12	48	. 5193	37	. 4807	. 9093	27	. 0907	. 6100	64	. 3900	12		48
	16	49	. 5339	37	. 4661	. 8984	27	. 1016	. 6355	64	. 3645	11		44
	20	50	. 5485	37	. 4515	. 8875	27	. 1125	. 6610	64	. 3390	10		40
	24	51	. 5632	36	. 4368	. 8766	27	. 1234	. 6866	64	. 3134	9		36
	28	52	. 5778	36	. 4222	. 8657	27	. 1343	. 7121	64	. 2879	8		32
	32	53	. 5924	36	. 4076	. 8547	27	. 1453	. 7377	64	. 2623	7		28
	36	54	. 6070	36	. 3930	. 8438	27	. 1562	. 7632	64	. 2368	6		24
	40	55	. 6215	36	. 3785	. 8328	27	. 1672	. 7887	64	. 2113	5		20
	44	56	. 6361	36	. 3639	. 8219	27	. 1781	. 8142	64	. 1858	4		16
	48	57	. 6507	36	. 3493	. 8109	27	. 1891	. 8398	64	. 1602	3		12
	52	58	. 6652	36	. 3348	. 7999	27	. 2001	. 8653	64	. 1347	2		8
	56	59	. 6798	36	. 3202	. 7890	27	. 2110	. 8908	64	. 1092	1		4
43	60	60	9.816943		0.183057	9.877780		0.122220	9.939163		0.060837	0	16	0
m	s	'										'	m	s
Hours.		Deg.	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cot.	Diff. for 15'' or 1'	L. Tang.	Deg.	Hours.	
8h 130°						1' = 4s 1° = 4m						49°	2h	

2ʰ 41° 1ˢ = 15'' 1ᵐ = 15' 1ʰ = 15° 138° 9ʰ

Hours. m	s	Deg. '	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Tang.	Diff. for 15'' or 1'	L. Cot.	Deg. '	Hours. s
44	0	0	9.816943	36	0.183057	9.877780	27	0.122220	9.939163	64	0.060837	60	15
	4	1	. 7088	36	. 2912	. 7670	27	. 2330	. 9418	64	. 0582	59	
	8	2	. 7233	36	. 2767	. 7560	27	. 2440	. 9673	64	. 0327	58	
	12	3	. 7378	36	. 2622	. 7450	27	. 2550	. 9928	64	. 0072	57	
	16	4	. 7524	36	. 2476	. 7340	27	. 2660	.940184	64	.059816	56	
	20	5	. 7669	36	. 2331	. 7230	27	. 2770	. 0439	64	. 9561	55	
	24	6	. 7813	36	. 2187	. 7120	27	. 2880	. 0693	64	. 9307	54	
	28	7	. 7958	36	. 2042	. 7010	28	. 2990	. 0948	64	. 9052	53	
	32	8	. 8103	36	. 1897	. 6899	28	. 3101	. 1204	64	. 8796	52	
	36	9	. 8247	36	. 1753	. 6789	28	. 3211	. 1458	64	. 8542	51	
	40	10	. 8392	36	. 1608	. 6678	28	. 3322	. 1714	64	. 8286	50	
	44	11	. 8536	36	. 1464	. 6568	28	. 3432	. 1968	64	. 8032	49	
	48	12	. 8681	36	. 1319	. 6458	28	. 3542	. 2223	64	. 7777	48	
	52	13	. 8825	36	. 1175	. 6347	28	. 3653	. 2478	64	. 7522	47	
	56	14	. 8969	36	. 1031	. 6236	28	. 3764	. 2733	64	. 7267	46	
45	0	15	. 9113	36	. 0887	. 6125	28	. 3875	. 2988	64	. 7012	45	15
	4	16	. 9257	36	. 0743	. 6014	28	. 3986	. 3243	64	. 6757	44	
	8	17	. 9401	36	. 0599	. 5904	28	. 4096	. 3497	64	. 6503	43	
	12	18	. 9545	36	. 0455	. 5793	28	. 4207	. 3752	64	. 6248	42	
	16	19	. 9689	36	. 0311	. 5682	28	. 4318	. 4007	64	. 5993	41	
	20	20	. 9833	36	. 0167	. 5571	28	. 4429	. 4262	64	. 5738	40	
	24	21	. 9976	36	. 0024	. 5459	28	. 4541	. 4517	64	. 5483	39	
	28	22	.820120	36	.179880	. 5348	28	. 4652	. 4772	64	. 5228	38	
	32	23	. 0263	36	. 9737	. 5237	28	. 4763	. 5026	64	. 4974	37	
	36	24	. 0406	36	. 9594	. 5125	28	. 4875	. 5281	64	. 4719	36	
	40	25	. 0550	36	. 9450	. 5014	28	. 4986	. 5536	64	. 4464	35	
	44	26	. 0693	36	. 9307	. 4903	28	. 5097	. 5790	64	. 4210	34	
	48	27	. 0836	36	. 9164	. 4791	28	. 5209	. 6045	64	. 3955	33	
	52	28	. 0979	36	. 9021	. 4680	28	. 5320	. 6299	64	. 3701	32	
	56	29	. 1122	36	. 8878	. 4568	28	. 5432	. 6554	64	. 3446	31	
46	0	30	. 1265	36	. 8735	. 4456	28	. 5544	. 6809	64	. 3191	30	14
	4	31	. 1407	36	. 8593	. 4344	28	. 5656	. 7063	64	. 2937	29	
	8	32	. 1550	36	. 8450	. 4232	28	. 5768	. 7318	64	. 2682	28	
	12	33	. 1693	36	. 8307	. 4121	28	. 5879	. 7572	64	. 2428	27	
	16	34	. 1835	36	. 8165	. 4009	28	. 5991	. 7826	64	. 2174	26	
	20	35	. 1978	35	. 8022	. 3897	28	. 6103	. 8081	64	. 1919	25	
	24	36	. 2120	35	. 7880	. 3784	28	. 6216	. 8336	64	. 1664	24	
	28	37	. 2262	35	. 7738	. 3672	28	. 6328	. 8590	64	. 1410	23	
	32	38	. 2404	35	. 7596	. 3560	28	. 6440	. 8844	64	. 1156	22	
	36	39	. 2546	35	. 7454	. 3447	28	. 6553	. 9099	64	. 0901	21	
	40	40	. 2688	35	. 7312	. 3335	28	. 6665	. 9353	64	. 0647	20	
	44	41	. 2830	35	. 7170	. 3223	28	. 6777	. 9607	63	. 0393	19	
	48	42	. 2972	35	. 7028	. 3110	28	. 6890	. 9862	63	. 0138	18	
	52	43	. 3114	35	. 6886	. 2998	28	. 7002	.950116	63	.049884	17	
	56	44	. 3256	35	. 6744	. 2885	28	. 7115	. 0371	63	. 9629	16	
47	0	45	. 3397	35	. 6603	. 2772	28	. 7228	. 0625	63	. 9375	15	13
	4	46	. 3539	35	. 6462	. 2659	28	. 7341	. 0879	63	. 9121	14	
	8	47	. 3680	35	. 6320	. 2547	28	. 7453	. 1133	63	. 8867	13	
	12	48	. 3821	35	. 6179	. 2434	28	. 7566	. 1387	63	. 8613	12	
	16	49	. 3963	35	. 6037	. 2321	28	. 7679	. 1642	63	. 8358	11	
	20	50	. 4104	35	. 5896	. 2208	28	. 7792	. 1896	63	. 8104	10	
	24	51	. 4245	35	. 5755	. 2095	28	. 7905	. 2150	63	. 7850	9	
	28	52	. 4386	35	. 5614	. 1981	28	. 8019	. 2405	63	. 7595	8	
	32	53	. 4527	35	. 5473	. 1868	28	. 8132	. 2659	63	. 7341	7	
	36	54	. 4668	35	. 5332	. 1755	28	. 8245	. 2913	63	. 7087	6	
	40	55	. 4808	35	. 5192	. 1641	28	. 8359	. 3167	63	. 6833	5	
	44	56	. 4949	35	. 5051	. 1528	28	. 8472	. 3421	63	. 6579	4	
	48	57	. 5090	35	. 4910	. 1415	28	. 8585	. 3675	63	. 6325	3	
	52	58	. 5230	35	. 4770	. 1301	29	. 8699	. 3929	63	. 6071	2	
	56	59	. 5370	35	. 4630	. 1187	28	. 8813	. 4183	63	. 5817	1	
47	60	60	9.825511		0.174489	9.871074		0.128926	9.954437		0.045563	0	12
m	s	'	L. Cos.	Diff. for 15'' or 1'	L. Sec.	L. Sin.	Diff. for 15'' or 1'	L. Cosec.	L. Cot.	Diff. for 15'' or 1'	L. Tang	'	s
Hours.		Deg.										Deg.	Hours.

8ʰ 131° 1' = 4ˢ 1° = 4ᵐ 48° 3ʰ

2ʰ 42° 1ˢ = 15'' 1ᵐ = 15' 1ʰ = 15° 137° 9ʰ

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1ˢ	L. Cosec.	L. Cos.	Diff. for 15'' or 1ˢ	L. Sec.	L. Tang.	Diff. for 15'' or 1ˢ	L. Cot.	Deg. '	Hours. m	Hours. s
48	0	0	9.825511	35	0.174489	9.871074	28	0.128926	9.954437	63	0.045563	60	11	60
	4	1	. 5651	35	. 4349	. 0960	28	. 9040	. 4691	63	. 5309	59		56
	8	2	. 5791	35	. 4209	. 0846	28	. 9154	. 4945	63	. 5055	58		52
	12	3	. 5931	35	. 4069	. 0732	28	. 9268	. 5199	63	. 4801	57		48
	16	4	. 6072	35	. 3928	. 0618	28	. 9382	. 5454	63	. 4546	56		44
	20	5	. 6211	35	. 3789	. 0504	28	. 9496	. 5707	63	. 4293	55		40
	24	6	. 6351	35	. 3649	. 0390	28	. 9610	. 5961	63	. 4039	54		36
	28	7	. 6491	35	. 3509	. 0276	29	. 9724	. 6215	63	. 3785	53		32
	32	8	. 6630	35	. 3370	. 0161	28	. 9839	. 6469	63	. 3531	52		28
	36	9	. 6770	35	. 3230	. 0047	28	. 9953	. 6723	63	. 3277	51		24
	40	10	. 6910	35	. 3090	.869933	29	.130067	. 6977	63	. 3023	50		20
	44	11	. 7049	35	. 2951	. 9818	28	. 0182	. 7231	63	. 2769	49		16
	48	12	. 7189	35	. 2811	. 9704	29	. 0296	. 7485	63	. 2515	48		12
	52	13	. 7328	35	. 2672	. 9589	29	. 0411	. 7739	63	. 2261	47		8
	56	14	. 7467	35	. 2533	. 9474	28	. 0526	. 7993	63	. 2007	46		4
49	0	15	. 7606	35	. 2394	. 9360	29	. 0640	. 8246	63	. 1754	45	11	0
	4	16	. 7745	35	. 2255	. 9245	29	. 0755	. 8500	63	. 1500	44		56
	8	17	. 7884	35	. 2116	. 9130	29	. 0870	. 8754	63	. 1246	43		52
	12	18	. 8023	35	. 1977	. 9015	29	. 0985	. 9008	63	. 0992	42		48
	16	19	. 8162	35	. 1838	. 8900	29	. 1100	. 9262	63	. 0738	41		44
	20	20	. 8301	35	. 1699	. 8785	29	. 1215	. 9516	63	. 0484	40		40
	24	21	. 8439	35	. 1561	. 8670	29	. 1330	. 9769	63	. 0231	39		36
	28	22	. 8578	35	. 1422	. 8555	29	. 1445	.960023	63	.039977	38		32
	32	23	. 8716	35	. 1284	. 8439	29	. 1561	. 0277	63	. 9723	37		28
	36	24	. 8855	34	. 1145	. 8324	29	. 1676	. 0531	63	. 9469	36		24
	40	25	. 8993	34	. 1007	. 8209	29	. 1791	. 0784	63	. 9216	35		20
	44	26	. 9131	34	. 0869	. 8093	29	. 1907	. 1038	63	. 8962	34		16
	48	27	. 9269	34	. 0731	. 7978	29	. 2022	. 1291	63	. 8709	33		12
	52	28	. 9407	34	. 0593	. 7862	29	. 2138	. 1545	63	. 8455	32		8
	56	29	. 9546	34	. 0454	. 7747	29	. 2253	. 1799	63	. 8201	31		4
50	0	30	. 9683	34	. 0317	. 7631	29	. 2369	. 2054	63	. 7948	30	10	0
	4	31	. 9821	34	. 0179	. 7515	29	. 2485	. 2306	63	. 7694	29		56
	8	32	. 9959	34	. 0041	. 7399	29	. 2601	. 2560	63	. 7440	28		52
	12	33	.830096	34	.169904	. 7283	29	. 2717	. 2813	63	. 7187	27		48
	16	34	. 0234	34	. 9766	. 7167	29	. 2833	. 3067	63	. 6933	26		44
	20	35	. 0372	34	. 9628	. 7051	29	. 2949	. 3321	63	. 6679	25		40
	24	36	. 0509	34	. 9491	. 6935	29	. 3065	. 3574	63	. 6426	24		36
	28	37	. 0646	34	. 9354	. 6819	29	. 3181	. 3827	63	. 6173	23		32
	32	38	. 0784	34	. 9216	. 6703	29	. 3297	. 4081	63	. 5919	22		28
	36	39	. 0921	34	. 9079	. 6586	29	. 3414	. 4335	63	. 5665	21		24
	40	40	. 1058	34	. 8942	. 6470	29	. 3530	. 4588	63	. 5412	20		20
	44	41	. 1195	34	. 8805	. 6353	29	. 3647	. 4842	63	. 5158	19		16
	48	42	. 1332	34	. 8668	. 6237	29	. 3763	. 5095	63	. 4905	18		12
	52	43	. 1469	34	. 8531	. 6120	29	. 3880	. 5349	63	. 4651	17		8
	56	44	. 1606	34	. 8394	. 6004	29	. 3996	. 5602	63	. 4398	16		4
51	0	45	. 1742	34	. 8258	. 5887	29	. 4113	. 5855	63	. 4145	15	9	0
	4	46	. 1879	34	. 8121	. 5770	29	. 4230	. 6109	63	. 3891	14		56
	8	47	. 2015	34	. 7985	. 5653	29	. 4347	. 6362	63	. 3638	13		52
	12	48	. 2152	34	. 7848	. 5536	29	. 4464	. 6616	63	. 3384	12		48
	16	49	. 2288	34	. 7712	. 5419	29	. 4581	. 6869	63	. 3131	11		44
	20	50	. 2425	34	. 7575	. 5302	29	. 4698	. 7123	63	. 2877	10		40
	24	51	. 2561	34	. 7439	. 5185	29	. 4815	. 7376	63	. 2624	9		36
	28	52	. 2697	34	. 7303	. 5068	29	. 4932	. 7629	63	. 2371	8		32
	32	53	. 2833	34	. 7167	. 4950	29	. 5050	. 7883	63	. 2117	7		28
	36	54	. 2969	34	. 7031	. 4833	29	. 5167	. 8136	63	. 1864	6		24
	40	55	. 3105	34	. 6895	. 4716	29	. 5284	. 8389	63	. 1611	5		20
	44	56	. 3241	34	. 6759	. 4598	29	. 5402	. 8643	63	. 1357	4		16
	48	57	. 3377	34	. 6623	. 4481	29	. 5519	. 8896	63	. 1104	3		12
	52	58	. 3512	34	. 6488	. 4363	29	. 5637	. 9149	63	. 0851	2		8
	56	59	. 3648	34	. 6352	. 4245	29	. 5755	. 9403	63	. 0597	1		4
51	60	60	9.833783		0.166217	9.864127		0.135873	9.969656		0.030344	0	8	0
m	s	'	L. Cos.	Diff. for 15'' or 1ˢ	L. Sec.	L. Sin.	Diff. for 15'' or 1ˢ	L. Cosec.	L. Cot.	Diff. for 15'' or 1ˢ	L. Tang.	' Deg.	m Hours	s

8ʰ 132° 1' = 4ˢ 1° = 4ᵐ 47° 3ʰ

2^h 43° 1^s — 15'' 1^m — 15' 1^h — 15° 136° 9^h

Hours. m	Hours. s	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours. m	Hours. s
52	0	0	9.833783	34	0.166217	9.864127	29	0.135873	9.969656	63	0.030344	60	7	
	4	1	. 3919	34	. 6081	. 4010	29	. 5990	. 9909	63	. 0091	59		
	8	2	. 4054	34	. 5946	. 3892	29	. 6108	.970162	63	.029838	58		
	12	3	. 4190	34	. 5810	. 3774	29	. 6226	. 0416	63	. 9584	57		
	16	4	. 4325	34	. 5675	. 3656	29	. 6344	. 0669	63	. 9331	56		
	20	5	. 4460	34	. 5540	. 3538	30	. 6462	. 0922	63	. 9078	55		
	24	6	. 4595	34	. 5405	. 3419	29	. 6581	. 1177	63	. 8824	54		
	28	7	. 4730	34	. 5270	. 3301	29	. 6699	. 1429	63	. 8571	53		
	32	8	. 4865	34	. 5135	. 3183	30	. 6817	. 1682	63	. 8318	52		
	36	9	. 4999	34	. 5001	. 3064	29	. 6936	. 1935	63	. 8065	51		
	40	10	. 5134	34	. 4866	. 2946	30	. 7054	. 2188	63	. 7812	50		
	44	11	. 5269	34	. 4731	. 2828	29	. 7172	. 2441	63	. 7559	49		
	48	12	. 5403	34	. 4597	. 2709	30	. 7291	. 2694	63	. 7306	48		
	52	13	. 5538	34	. 4462	. 2590	30	. 7410	. 2948	63	. 7052	47		
	56	14	. 5672	34	. 4328	. 2471	30	. 7529	. 3201	63	. 6799	46		
53	0	15	. 5807	33	. 4193	. 2353	30	. 7647	. 3454	63	. 6546	45	7	
	4	16	. 5941	33	. 4059	. 2234	30	. 7766	. 3707	63	. 6293	44		
	8	17	. 6075	33	. 3925	. 2115	30	. 7885	. 3960	63	. 6040	43		
	12	18	. 6209	33	. 3791	. 1996	30	. 8004	. 4213	63	. 5787	42		
	16	19	. 6343	33	. 3657	. 1877	30	. 8123	. 4466	63	. 5534	41		
	20	20	. 6477	33	. 3523	. 1758	30	. 8242	. 4719	63	. 5281	40		
	24	21	. 6611	33	. 3389	. 1638	30	. 8362	. 4973	63	. 5027	39		
	28	22	. 6745	33	. 3255	. 1519	30	. 8481	. 5226	63	. 4774	38		
	32	23	. 6879	33	. 3121	. 1400	30	. 8600	. 5479	63	. 4521	37		
	36	24	. 7012	33	. 2988	. 1280	30	. 8720	. 5732	63	. 4268	36		
	40	25	. 7146	33	. 2854	. 1161	30	. 8839	. 5985	63	. 4015	35		
	44	26	. 7279	33	. 2721	. 1041	30	. 8959	. 6238	63	. 3762	34		
	48	27	. 7413	33	. 2587	. 0922	30	. 9078	. 6491	63	. 3509	33		
	52	28	. 7546	33	. 2454	. 0802	30	. 9198	. 6744	63	. 3256	32		
	56	29	. 7679	33	. 2321	. 0682	30	. 9318	. 6997	63	. 3003	31		
54	0	30	. 7812	33	. 2188	. 0562	30	. 9438	. 7250	63	. 2750	30	6	
	4	31	. 7945	33	. 2055	. 0442	30	. 9558	. 7503	63	. 2497	29		
	8	32	. 8078	33	. 1922	. 0322	30	. 9678	. 7756	63	. 2244	28		
	12	33	. 8211	33	. 1789	. 0202	30	. 9798	. 8009	63	. 1991	27		
	16	34	. 8344	33	. 1656	. 0082	30	. 9918	. 8262	63	. 1738	26		
	20	35	. 8477	33	. 1523	.859962	30	.140038	. 8515	63	. 1485	25		
	24	36	. 8610	33	. 1390	. 9842	30	. 0158	. 8768	63	. 1232	24		
	28	37	. 8742	33	. 1258	. 9721	30	. 0279	. 9021	63	. 0979	23		
	32	38	. 8875	33	. 1125	. 9601	30	. 0399	. 9274	63	. 0726	22		
	36	39	. 9007	33	. 0993	. 9480	30	. 0520	. 9527	63	. 0473	21		
	40	40	. 9140	33	. 0860	. 9360	30	. 0640	. 9780	63	. 0220	20		
	44	41	. 9272	33	. 0728	. 9239	30	. 0761	.980033	63	.019967	19		
	48	42	. 9404	33	. 0596	. 9118	30	. 0882	. 0286	63	. 9714	18		
	52	43	. 9536	33	. 0464	. 8998	30	. 1002	. 0538	63	. 9462	17		
	56	44	. 9668	33	. 0332	. 8877	30	. 1123	. 0791	63	. 9209	16		
55	0	45	. 9800	33	. 0200	. 8756	30	. 1244	. 1044	63	. 8956	15	5	
	4	46	. 9932	33	. 0068	. 8635	30	. 1365	. 1297	63	. 8703	14		
	8	47	.840064	33	.159936	. 8514	30	. 1486	. 1550	63	. 8450	13		
	12	48	. 0196	33	. 9804	. 8393	30	. 1607	. 1803	63	. 8197	12		
	16	49	. 0328	33	. 9672	. 8272	30	. 1728	. 2056	63	. 7944	11		
	20	50	. 0459	33	. 9541	. 8150	30	. 1850	. 2309	63	. 7691	10		
	24	51	. 0591	33	. 9409	. 8029	30	. 1971	. 2562	63	. 7438	9		
	28	52	. 0722	33	. 9278	. 7908	30	. 2092	. 2814	63	. 7186	8		
	32	53	. 0853	33	. 9147	. 7786	30	. 2214	. 3067	63	. 6933	7		
	36	54	. 0985	33	. 9015	. 7665	30	. 2335	. 3320	63	. 6680	6		
	40	55	. 1116	33	. 8884	. 7543	30	. 2457	. 3573	63	. 6427	5		
	44	56	. 1247	33	. 8753	. 7421	30	. 2579	. 3826	63	. 6174	4		
	48	57	. 1379	33	. 8621	. 7300	30	. 2700	. 4079	63	. 5921	3		
	52	58	. 1510	33	. 8490	. 7178	30	. 2822	. 4332	63	. 5668	2		
	56	59	. 1640	33	. 8360	. 7056	30	. 2944	. 4584	63	. 5416	1		
55	60	60	9.841771		0.158229	9.856934		0.143066	9.984837		0.015163	0	4	
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m	s
Hours.		Deg.										Deg.	Hours.	

8^h 133° 1' — 4^s 1° — 4^m 46° 3^h

Hours h	m	Deg. '	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Tang.	Diff. for 15'' or 1s	L. Cot.	Deg. '	Hours m
56	0	0	9.841771	33	0.158229	9.856934	30	0.143066	9.984837	63	0.015163	60	3
	4	1	1902	33	8098	6812	30	3188	5090	63	4910	59	
	8	2	2033	33	7967	6690	30	3310	5343	63	4657	58	
	12	3	2164	33	7836	6568	30	3432	5596	63	4404	57	
	16	4	2294	33	7706	6446	31	3554	5848	63	4152	56	
	20	5	2424	33	7576	6323	31	3677	6101	63	3899	55	
	24	6	2555	32	7445	6201	31	3799	6354	63	3646	54	
	28	7	2685	32	7315	6078	31	3922	6607	63	3393	53	
	32	8	2816	32	7184	5956	31	4044	6860	63	3140	52	
	36	9	2946	32	7054	5834	31	4166	7112	63	2888	51	
	40	10	3076	32	6924	5711	31	4289	7365	63	2635	50	
	44	11	3206	32	6794	5588	31	4412	7618	63	2382	49	
	48	12	3336	32	6664	5465	31	4535	7871	63	2129	48	
	52	13	3465	32	6535	5342	31	4658	8123	63	1877	47	
	56	14	3595	32	6405	5219	31	4781	8376	63	1624	46	
57	0	15	3725	32	6275	5096	31	4904	8629	63	1371	45	3
	4	16	3855	32	6145	4973	31	5027	8882	63	1118	44	
	8	17	3984	32	6016	4850	31	5150	9134	63	0866	43	
	12	18	4114	32	5886	4727	31	5273	9387	63	0613	42	
	16	19	4243	32	5757	4603	31	5397	9640	63	0360	41	
	20	20	4373	32	5627	4480	31	5520	9893	63	0107	40	
	24	21	4502	32	5498	4357	31	5643	.990145	63	.009855	39	
	28	22	4631	32	5369	4233	31	5767	0398	63	9602	38	
	32	23	4760	32	5240	4109	31	5891	0651	63	9349	37	
	36	24	4889	32	5111	3986	31	6014	0903	63	9097	36	
	40	25	5018	32	4982	3862	31	6138	1156	63	8844	35	
	44	26	5147	32	4853	3738	31	6262	1409	63	8591	34	
	48	27	5276	32	4724	3614	31	6386	1662	63	8338	33	
	52	28	5404	32	4596	3490	31	6510	1914	63	8086	32	
	56	29	5533	32	4467	3366	31	6634	2167	63	7833	31	
58	0	30	5662	32	4338	3242	31	6758	2420	63	7580	30	2
	4	31	5790	32	4210	3118	31	6882	2672	63	7328	29	
	8	32	5919	32	4081	2994	31	7006	2925	63	7075	28	
	12	33	6047	32	3953	2869	31	7131	3178	63	6822	27	
	16	34	6175	32	3825	2745	31	7255	3430	63	6570	26	
	20	35	6303	32	3697	2620	31	7380	3683	63	6317	25	
	24	36	6432	32	3568	2496	31	7504	3936	63	6064	24	
	28	37	6560	32	3440	2371	31	7629	4189	63	5811	23	
	32	38	6688	32	3312	2247	31	7753	4441	63	5559	22	
	36	39	6816	32	3184	2122	31	7878	4694	63	5306	21	
	40	40	6944	32	3056	1997	31	8003	4947	63	5053	20	
	44	41	7071	32	2929	1872	31	8128	5199	63	4801	19	
	48	42	7199	32	2801	1747	31	8253	5452	63	4548	18	
	52	43	7327	32	2673	1622	31	8378	5705	63	4295	17	
	56	44	7454	32	2546	1497	31	8503	5957	63	4043	16	
59	0	45	7582	32	2418	1372	31	8628	6210	63	3790	15	1
	4	46	7709	32	2291	1246	31	8754	6463	63	3537	14	
	8	47	7836	32	2164	1121	31	8879	6715	63	3285	13	
	12	48	7964	32	2036	0996	31	9004	6968	63	3032	12	
	16	49	8091	32	1909	0870	31	9130	7221	63	2779	11	
	20	50	8218	32	1782	0745	31	9255	7473	63	2527	10	
	24	51	8345	32	1655	0619	31	9381	7726	63	2274	9	
	28	52	8472	32	1528	0493	31	9507	7979	63	2021	8	
	32	53	8599	32	1401	0368	31	9632	8231	63	1769	7	
	36	54	8726	32	1274	0242	31	9758	8484	63	1516	6	
	40	55	8853	32	1147	0116	31	9884	8737	63	1263	5	
	44	56	8979	32	1021	.849990	31	.150010	8989	63	1011	4	
	48	57	9106	32	0894	9864	31	0136	9242	63	0758	3	
	52	58	9232	32	0768	9737	31	0263	9495	63	0505	2	
	56	59	9358	32	0642	9611	31	0389	9747	63	0253	1	
59	60	60	9.849485		0.150515	9.849485		0.150515	0.000000		0.000000	0	0
m	s	'	L. Cos.	Diff. for 15'' or 1s	L. Sec.	L. Sin.	Diff. for 15'' or 1s	L. Cosec.	L. Cot.	Diff. for 15'' or 1s	L. Tang.	'	m
Hours.		Deg.										Deg.	Hours.

TABLE III.

PROPORTIONAL LOGARITHMS.

′ ″	h m 0° 0′	h m 0° 1′	h m 0° 2′	h m 0° 3′	h m 0° 4′	h m 0° 5′	h m 0° 6′	h m 0° 7′	h m 0° 8′	″ ′
0		2.2553	1.9542	1.7782	1.6532	1.5563	1.4771	1.4102	1.3522	0
1	4.0334	.2481	.9506	.7757	.6514	.5549	.4759	.4091	.3513	1
2	3.7324	.2410	.9471	.7734	.6496	.5534	.4747	.4081	.3504	2
3	.5563	.2341	.9435	.7710	.6478	.5520	.4735	.4071	.3495	3
4	.4314	.2272	.9400	.7686	.6460	.5506	.4723	.4061	.3486	4
5	.3345	.2205	.9365	.7663	.6443	.5491	.4711	.4050	.3477	5
6	.2553	.2139	.9331	.7639	.6425	.5477	.4699	.4040	.3468	6
7	.1883	.2073	.9296	.7616	.6407	.5463	.4688	.4030	.3459	7
8	.1303	.2009	.9262	.7593	.6390	.5449	.4676	.4020	.3450	8
9	.0792	.1946	.9228	.7570	.6372	.5435	.4664	.4010	.3441	9
10	.0334	.1883	.9195	.7547	.6355	.5421	.4652	.4000	.3432	10
11	2.9920	.1822	.9162	.7524	.6338	.5407	.4640	.3989	.3423	11
12	.9542	.1761	.9128	.7501	.6320	.5393	.4629	.3979	.3415	12
13	.9195	.1701	.9096	.7479	.6303	.5379	.4617	.3969	.3406	13
14	.8873	.1642	.9063	.7456	.6286	.5365	.4606	.3959	.3397	14
15	.8573	.1584	.9031	.7434	.6269	.5351	.4594	.3949	.3388	15
16	.8293	.1526	.8999	.7412	.6252	.5337	.4582	.3939	.3379	16
17	.8030	.1469	.8967	.7390	.6235	.5324	.4571	.3929	.3371	17
18	.7782	.1413	.8935	.7368	.6218	.5310	.4559	.3919	.3362	18
19	.7547	.1358	.8904	.7346	.6201	.5296	.4548	.3910	.3353	19
20	.7324	.1303	.8873	.7324	.6185	.5283	.4536	.3900	.3345	20
21	.7112	.1249	.8842	.7302	.6168	.5269	.4525	.3890	.3336	21
22	.6910	.1196	.8811	.7281	.6151	.5256	.4514	.3880	.3327	22
23	.6717	.1143	.8781	.7259	.6135	.5242	.4502	.3870	.3319	23
24	.6532	.1091	.8751	.7238	.6118	.5229	.4491	.3860	.3310	24
25	.6355	.1040	.8721	.7217	.6102	.5215	.4480	.3851	.3301	25
26	.6185	.0989	.8691	.7196	.6085	.5202	.4468	.3841	.3293	26
27	.6021	.0939	.8661	.7175	.6069	.5189	.4457	.3831	.3284	27
28	.5863	.0889	.8632	.7154	.6053	.5174	.4446	.3821	.3276	28
29	.5710	.0840	.8602	.7133	.6037	.5162	.4435	.3812	.3267	29
30	.5563	.0792	.8573	.7112	.6021	.5149	.4424	.3802	.3259	30
31	.5421	.0744	.8544	.7091	.6005	.5136	.4412	.3792	.3250	31
32	.5283	.0696	.8516	.7071	.5989	.5123	.4401	.3783	.3242	32
33	.5149	.0649	.8487	.7050	.5973	.5110	.4390	.3773	.3233	33
34	.5019	.0603	.8459	.7030	.5957	.5097	.4379	.3764	.3225	34
35	.4894	.0557	.8431	.7010	.5941	.5084	.4368	.3754	.3216	35
36	.4771	.0512	.8403	.6990	.5925	.5071	.4357	.3745	.3208	36
37	.4652	.0467	.8375	.6970	.5909	.5058	.4346	.3735	.3199	37
38	.4536	.0422	.8348	.6950	.5894	.5045	.4335	.3726	.3191	38
39	.4424	.0378	.8320	.6930	.5878	.5032	.4325	.3716	.3183	39
40	.4314	.0334	.8293	.6910	.5863	.5019	.4314	.3707	.3174	40
41	.4206	.0291	.8266	.6890	.5847	.5006	.4303	.3697	.3166	41
42	.4102	.0248	.8239	.6871	.5832	.4994	.4292	.3688	.3158	42
43	.4000	.0206	.8212	.6851	.5816	.4981	.4281	.3678	.3149	43
44	.3900	.0164	.8186	.6832	.5801	.4968	.4270	.3669	.3141	44
45	.3802	.0122	.8159	.6812	.5786	.4956	.4260	.3660	.3133	45
46	.3707	.0081	.8133	.6793	.5771	.4943	.4249	.3650	.3124	46
47	.3613	.0040	.8107	.6774	.5755	.4931	.4238	.3641	.3116	47
48	.3522	.0000	.8081	.6755	.5740	.4918	.4228	.3632	.3108	48
49	.3432	1.9960	.8055	.6736	.5725	.4906	.4217	.3622	.3100	49
50	.3345	.9920	.8030	.6717	.5710	.4894	.4206	.3613	.3091	50
51	.3259	.9881	.8004	.6698	.5695	.4881	.4196	.3604	.3083	51
52	.3174	.9842	.7979	.6679	.5680	.4869	.4185	.3595	.3075	52
53	.3091	.9803	.7954	.6661	.5666	.4856	.4175	.3586	.3067	53
54	.3010	.9765	.7929	.6642	.5651	.4844	.4164	.3576	.3059	54
55	.2931	.9727	.7904	.6624	.5636	.4832	.4154	.3567	.3051	55
56	.2852	.9690	.7879	.6605	.5621	.4820	.4143	.3558	.3043	56
57	.2775	.9652	.7855	.6587	.5607	.4808	.4133	.3549	.3034	57
58	.2700	.9615	.7830	.6568	.5592	.4795	.4122	.3540	.3026	58
59	2.2626	1.9579	.7806	.6550	.5578	.4783	.4112	.3531	.3018	59
′ ″	0° 0′ h m	0° 1′ h m	0° 2′ h m	0° 3′ h m	0° 4′ h m	0° 5′ h m	0° 6′ h m	0° 7′ h m	0° 8′ h m	″ ′

•	h m	h m	h m	h m	h m	h m	h m	h m	h m	•
″	0° 9′	0° 10′	0° 11′	0° 12′	0° 13′	0° 14′	0° 15′	0° 16′	0° 17′	″
0	1.3010	1.2353	1.2139	1.1761	1.1413	1.1091	1.0792	1.0512	1.0248	0
1	. 02	. 45	. 32	. 55	. 08	. 86	. 87	. 07	. 44	1
2	.2994	. 38	. 26	. 49	. 02	. 81	. 82	. 02	. 40	2
3	. 86	. 31	. 19	. 43	.1397	. 76	. 77	.0498	. 35	3
4	. 78	. 24	. 13	. 37	. 91	. 71	. 73	. 93	. 31	4
5	. 70	. 17	. 06	. 31	. 86	. 66	. 68	. 89	. 27	5
6	. 62	. 10	.2099	. 25	. 80	. 61	. 63	. 84	. 23	6
7	. 54	. 02	. 93	. 19	. 74	. 55	. 58	. 80	. 19	7
8	. 46	.2495	. 86	. 13	. 69	. 50	. 53	. 75	. 14	8
9	. 39	. 88	. 80	. 07	. 63	. 45	. 49	. 71	. 10	9
10	. 31	. 81	. 73	. 01	. 58	. 40	. 44	. 67	. 06	10
11	. 23	. 74	. 67	.1695	. 52	. 35	. 39	. 62	. 02	11
12	. 15	. 67	. 61	. 89	. 47	. 30	. 34	. 58	.0197	12
13	. 07	. 60	. 54	. 83	. 42	. 25	. 30	. 53	. 93	13
14	.2899	. 53	. 48	. 77	. 36	. 20	. 25	. 49	. 89	14
15	. 91	. 45	. 41	. 71	. 31	. 15	. 20	. 44	. 85	15
16	. 83	. 38	. 35	. 65	. 25	. 09	. 15	. 40	. 81	16
17	. 76	. 31	. 28	. 60	. 20	. 04	. 11	. 35	. 76	17
18	. 68	. 24	. 22	. 54	. 14	.0999	. 06	. 31	. 72	18
19	. 60	. 17	. 16	. 48	. 09	. 94	. 01	. 26	. 68	19
20	. 52	. 10	. 09	. 42	. 03	. 89	.0696	. 22	. 64	20
21	. 45	. 03	. 03	. 36	.1298	. 84	. 92	. 18	. 60	21
22	. 37	.2396	.1996	. 30	. 92	. 79	. 87	. 13	. 56	22
23	. 29	. 89	. 90	. 24	. 87	. 74	. 82	. 09	. 51	23
24	. 21	. 82	. 84	. 19	. 82	. 69	. 78	. 04	. 47	24
25	. 14	. 75	. 77	. 13	. 76	. 64	. 73	. 00	. 43	25
26	. 06	. 68	. 71	. 07	. 71	. 59	. 68	.0395	. 39	26
27	.2798	. 62	. 65	. 01	. 66	. 54	. 63	. 91	. 35	27
28	. 91	. 55	. 58	.1595	. 60	. 49	. 59	. 87	. 31	28
29	. 83	. 48	. 52	. 89	. 55	. 44	. 54	. 82	. 26	29
30	. 75	. 41	. 46	. 84	. 49	. 39	. 49	. 78	. 22	30
31	. 68	. 34	. 39	. 78	. 44	. 34	. 45	. 74	. 18	31
32	. 60	. 27	. 33	. 72	. 39	. 29	. 40	. 69	. 14	32
33	. 53	. 20	. 27	. 66	. 33	. 24	. 35	. 65	. 10	33
34	. 45	. 13	. 21	. 61	. 28	. 19	. 31	. 60	. 06	34
35	. 38	. 07	. 14	. 55	. 23	. 14	. 26	. 56	. 02	35
36	. 30	. 00	. 08	. 49	. 17	. 09	. 21	. 52	.0098	36
37	. 22	.2293	. 02	. 43	. 12	. 04	. 17	. 47	. 93	37
38	. 15	. 86	.1896	. 38	. 07	.0899	. 12	. 43	. 89	38
39	. 07	. 79	. 89	. 32	. 01	. 94	. 08	. 39	. 85	39
40	. 00	. 72	. 83	. 26	.1196	. 89	. 03	. 34	. 81	40
41	.2692	. 66	. 77	. 20	. 91	. 84	.0598	. 30	. 77	41
42	. 85	. 59	. 71	. 15	. 86	. 80	. 94	. 26	. 73	42
43	. 78	. 52	. 65	. 09	. 80	. 75	. 89	. 21	. 69	43
44	. 70	. 45	. 59	. 03	. 75	. 70	. 85	. 17	. 65	44
45	. 63	. 39	. 52	.1498	. 70	. 65	. 80	. 13	. 61	45
46	. 55	. 32	. 46	. 92	. 64	. 60	. 75	. 08	. 57	46
47	. 48	. 25	. 40	. 86	. 59	. 55	. 71	. 04	. 53	47
48	. 40	. 18	. 34	. 81	. 54	. 50	. 66	. 00	. 49	48
49	. 33	. 12	. 28	. 75	. 49	. 45	. 62	.0295	. 44	49
50	. 26	. 05	. 22	. 69	. 43	. 40	. 57	. 91	. 40	50
51	. 18	.2198	. 16	. 64	. 38	. 35	. 52	. 87	. 36	51
52	. 11	. 92	. 09	. 58	. 33	. 31	. 48	. 82	. 32	52
53	. 04	. 85	. 03	. 52	. 28	. 26	. 43	. 78	. 28	53
54	.2596	. 78	.1797	. 47	. 23	. 21	. 39	. 74	. 24	54
55	. 89	. 72	. 91	. 41	. 17	. 16	. 34	. 70	. 20	55
56	. 82	. 65	. 85	. 36	. 12	. 11	. 30	. 65	. 16	56
57	. 74	. 59	. 79	. 30	. 07	. 06	. 25	. 61	. 12	57
58	. 67	. 52	. 73	. 24	. 02	. 01	. 21	. 57	. 08	58
59	. 60	. 45	. 67	. 19	.1097	.0797	. 16	. 52	. 04	59
″	0° 9′	0° 10′	0° 11′	0° 12′	0° 13′	0° 14′	0° 15′	0° 16′	0° 17′	″
•	h m	h m	h m	h m	h m	h m	h m	h m	h m	•

″	h m 0° 18′	h m 0° 19′	h m 0° 20′	h m 0° 21′	h m 0° 22′	h m 0° 23′	h m 0° 24′	h m 0° 25′	h m 0° 26′	h m 0° 27′	h m 0° 28′	h m 0° 29′	″
0	10000	9765	9542	9331	9128	8935	8751	8573	8403	8239	8081	7929	0
1	9996	61	39	27	25	32	48	70	00	36	79	26	1
2	92	58	35	24	22	29	45	68	8397	34	76	24	2
3	88	54	32	20	19	26	42	65	95	31	73	21	3
4	84	50	28	17	15	23	39	62	92	28	71	19	4
5	80	46	24	13	12	20	36	59	89	26	68	16	5
6	76	42	21	10	09	17	33	56	86	23	66	14	6
7	72	39	17	06	06	13	30	53	84	20	63	11	7
8	68	35	14	03	02	10	27	50	81	18	61	09	8
9	64	31	10	00	9099	07	24	47	78	15	58	06	9
10	60	27	06	9296	96	04	21	44	75	12	55	04	10
11	56	23	03	93	92	01	18	42	72	10	53	01	11
12	52	20	9499	89	89	8898	15	39	70	07	50	7899	12
13	48	16	96	86	86	95	12	36	67	04	48	96	13
14	44	12	92	83	83	92	09	33	64	02	45	94	14
15	40	08	88	79	79	88	06	30	61	8199	43	91	15
16	36	05	85	76	76	85	03	27	59	96	40	89	16
17	32	01	81	72	73	82	00	24	56	94	37	87	17
18	28	9697	78	69	70	79	8697	22	53	91	35	84	18
19	24	93	74	66	66	76	94	19	50	88	32	82	19
20	20	90	71	62	63	73	91	16	48	86	30	79	20
21	16	86	67	59	60	70	88	13	45	83	27	77	21
22	12	82	64	55	57	67	85	10	42	81	25	74	22
23	08	78	60	52	53	64	82	07	39	78	22	72	23
24	05	75	56	49	50	61	79	04	37	75	20	69	24
25	01	71	53	45	47	57	76	02	34	73	17	67	25
26	9897	67	49	42	44	54	73	8499	31	70	14	64	26
27	93	64	46	39	41	51	70	96	28	67	12	62	27
28	89	60	42	35	37	48	67	93	26	65	09	59	28
29	85	56	39	32	34	45	64	90	23	62	07	57	29
30	81	52	35	28	31	42	61	87	20	59	04	55	30
31	77	49	32	25	28	39	58	84	18	57	02	52	31
32	73	45	28	22	24	36	55	82	15	54	7999	50	32
33	69	41	25	18	21	33	52	79	12	52	97	47	33
34	65	38	21	15	18	30	49	76	09	49	94	45	34
35	61	34	18	12	15	27	46	73	07	46	92	42	35
36	58	30	14	08	12	24	43	70	04	44	89	40	36
37	54	26	11	05	08	21	40	67	01	41	87	37	37
38	50	23	07	01	05	17	37	65	8298	38	84	35	38
39	46	19	04	9198	02	14	35	62	96	36	81	32	39
40	42	15	00	95	8999	11	32	59	93	33	79	30	40
41	38	12	9397	91	96	08	29	56	90	31	76	28	41
42	34	08	93	88	92	05	26	53	88	28	74	25	42
43	30	04	90	85	89	02	23	51	85	25	71	23	43
44	27	01	86	81	86	8799	20	48	82	23	69	20	44
45	23	9597	83	78	83	96	17	45	79	20	66	18	45
46	19	93	79	75	80	93	14	42	77	17	64	15	46
47	15	90	76	71	77	90	11	39	74	15	61	13	47
48	11	86	72	68	73	87	08	37	71	12	59	10	48
49	07	82	69	65	70	84	05	34	69	10	56	08	49
50	03	79	65	62	67	81	02	31	66	07	54	06	50
51	00	75	62	58	64	78	8599	28	63	04	51	03	51
52	9796	71	58	55	61	75	97	25	61	02	49	01	52
53	92	68	55	52	58	72	94	23	58	8099	46	7798	53
54	88	64	51	48	54	69	91	20	55	97	44	96	54
55	84	61	48	45	51	66	88	17	53	94	41	94	55
56	80	57	44	42	48	63	85	14	50	91	39	91	56
57	77	53	41	38	45	60	82	11	47	89	36	89	57
58	73	50	37	35	42	57	79	09	44	86	34	86	58
59	69	46	34	32	39	54	76	06	42	84	31	84	59
″ s	0° 18′ h m	0° 19′ h m	0° 20′ h m	0° 21′ h m	0° 22′ h m	0° 23′ h m	0° 24′ h m	0° 25′ h m	0° 26′ h m	0° 27′ h m	0° 28′ h m	0° 29′ h m	″ s

′	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	′
″	0° 30′	0° 31′	0° 32′	0° 33′	0° 34′	0° 35′	0° 36′	0° 37′	0° 38′	0° 39′	0° 40′	0° 41′	″
0	7782	7639	7501	7368	7238	7112	6990	6871	6755	6642	6532	6425	0
1	79	37	7499	65	36	10	88	69	53	40	30	23	1
2	77	34	97	63	34	08	86	67	51	38	29	21	2
3	74	32	94	61	32	06	84	65	49	37	27	20	3
4	72	30	92	59	29	04	82	63	47	35	25	18	4
5	69	27	90	57	27	02	80	61	45	33	23	16	5
6	67	25	88	54	25	00	78	59	43	31	21	14	6
7	65	23	85	52	23	7098	76	57	42	29	19	13	7
8	62	20	83	50	21	96	74	55	40	27	18	11	8
9	60	18	81	48	19	93	72	53	38	25	16	09	9
10	57	16	79	46	17	91	70	51	36	24	14	07	10
11	55	13	76	44	15	89	68	49	34	22	12	06	11
12	53	11	74	41	12	87	66	47	32	20	10	04	12
13	50	09	72	39	10	85	64	45	30	18	09	02	13
14	48	07	70	37	08	83	62	43	28	16	07	00	14
15	45	04	67	35	06	81	60	42	26	14	05	6398	15
16	43	02	65	33	04	79	58	40	25	12	03	97	16
17	41	00	63	30	02	77	56	38	23	11	01	95	17
18	38	7597	61	28	00	75	54	36	21	09	00	93	18
19	36	95	58	26	7198	73	52	34	19	07	6498	91	19
20	34	93	56	24	96	71	50	32	17	05	96	90	20
21	31	90	54	22	93	69	48	30	15	03	94	88	21
22	29	88	52	20	91	67	46	28	13	01	92	86	22
23	26	86	50	17	89	65	44	26	11	00	91	84	23
24	24	83	47	15	87	63	42	24	09	6598	89	83	24
25	22	81	45	13	85	61	40	22	08	96	87	81	25
26	19	79	43	11	83	59	38	20	06	94	85	79	26
27	17	77	41	09	81	57	36	18	04	92	84	77	27
28	14	74	38	07	79	55	34	16	02	90	82	76	28
29	12	72	36	04	77	53	32	14	00	89	80	74	29
30	10	70	34	02	75	50	30	12	6698	87	78	72	30
31	07	67	32	00	72	48	28	11	96	85	76	71	31
32	05	65	29	7298	70	46	26	09	94	83	75	69	32
33	03	63	27	96	68	44	24	07	92	81	73	67	33
34	00	60	25	94	66	42	22	05	91	79	71	65	34
35	7698	58	23	91	64	40	20	03	89	78	69	64	35
36	96	56	21	89	62	38	18	01	87	76	67	62	36
37	93	54	18	87	60	36	16	6799	85	74	66	60	37
38	91	51	16	85	58	34	14	97	83	72	64	58	38
39	88	49	14	83	56	32	12	95	81	70	62	57	39
40	86	47	12	81	54	30	10	93	79	68	60	55	40
41	84	44	09	79	52	28	08	91	77	67	59	53	41
42	81	42	07	76	49	26	06	89	76	65	57	51	42
43	79	40	05	74	47	24	04	87	74	63	55	50	43
44	77	38	03	72	45	22	02	85	72	61	53	48	44
45	74	35	01	70	43	20	00	84	70	59	51	46	45
46	72	33	7398	68	41	18	6898	82	68	58	50	44	46
47	70	31	96	66	39	16	96	80	66	56	48	43	47
48	67	28	94	64	37	14	94	78	64	54	46	41	48
49	65	26	92	61	35	12	92	76	63	52	44	39	49
50	63	24	90	59	33	10	90	74	61	50	43	38	50
51	60	22	87	57	31	08	88	72	59	48	41	36	51
52	58	19	85	55	29	06	86	70	57	47	39	34	52
53	55	17	83	53	27	04	84	68	55	45	37	32	53
54	53	15	81	51	24	02	83	66	53	43	35	31	54
55	51	13	79	49	22	00	81	64	51	41	34	29	55
56	48	10	76	46	20	6998	79	63	50	39	32	27	56
57	46	08	74	44	18	96	77	61	48	38	30	25	57
58	44	06	72	42	16	94	75	59	46	36	28	24	58
59	41	03	70	40	14	92	73	57	44	34	27	22	59
″	0° 30′	0° 31′	0° 32′	0° 33′	0° 34′	0° 35′	0° 36′	0° 37′	0° 38′	0° 39′	0° 40′	0° 41′	″
′	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	′

′	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	′
″	0° 42′	0° 43′	0° 44′	0° 45′	0° 46′	0° 47′	0° 48′	0° 49′	0° 50′	0° 51′	0° 52′	0° 53′	″
0	6320	6218	6118	6021	5925	5832	5740	5651	5563	5477	5393	5310	0
1	19	16	17	19	24	30	39	49	62	76	91	09	1
2	17	15	15	17	22	29	37	48	60	74	90	07	2
3	15	13	13	16	20	27	36	46	59	73	89	06	3
4	13	11	12	14	19	26	34	45	57	71	87	05	4
5	12	10	10	13	17	24	33	43	56	70	86	03	5
6	10	08	08	11	16	23	31	42	54	69	84	02	6
7	08	06	07	09	14	21	30	40	53	67	83	00	7
8	06	05	05	08	13	19	28	39	51	66	82	5299	8
9	05	03	03	06	11	18	27	37	50	64	80	98	9
10	03	01	02	05	09	16	25	36	49	63	79	96	10
11	01	00	00	03	08	15	24	35	47	61	77	95	11
12	00	6198	6099	01	06	13	22	33	46	60	76	94	12
13	6298	96	97	00	05	12	21	32	44	59	75	92	13
14	96	95	95	5998	03	10	19	30	43	57	73	91	14
15	94	93	94	97	02	09	18	29	41	56	72	90	15
16	93	91	92	95	00	07	16	27	40	54	70	88	16
17	91	90	90	93	5898	06	15	26	38	53	69	87	17
18	89	88	89	92	97	04	13	24	37	52	68	85	18
19	88	86	87	90	95	03	12	23	36	50	66	84	19
20	86	85	85	89	94	01	10	21	34	49	65	83	20
21	84	83	84	87	92	00	09	20	33	47	64	81	21
22	82	81	82	85	91	5798	07	18	31	46	62	80	22
23	81	79	81	84	89	96	06	17	30	45	61	79	23
24	79	78	79	82	88	95	04	15	28	43	59	77	24
25	78	76	77	81	86	93	03	14	27	42	58	76	25
26	76	74	76	79	84	92	01	13	26	40	57	75	26
27	74	73	74	77	83	90	00	11	24	39	55	73	27
28	72	71	72	76	81	89	5698	10	23	37	54	72	28
29	71	69	71	74	80	87	97	08	21	36	53	71	29
30	69	68	69	73	78	86	95	07	20	35	51	69	30
31	67	66	67	71	77	84	94	05	18	33	50	68	31
32	65	65	66	69	75	83	92	04	17	32	48	66	32
33	64	63	64	68	74	81	91	02	16	30	47	65	33
34	62	61	63	66	72	80	89	01	14	29	46	64	34
35	60	60	61	65	70	78	88	5599	13	28	44	62	35
36	59	58	59	63	69	77	86	98	11	26	43	61	36
37	57	56	58	61	67	75	85	96	10	25	41	60	37
38	55	55	56	60	66	74	83	95	08	23	40	58	38
39	54	53	55	58	64	72	82	94	07	22	39	57	39
40	52	51	53	57	63	71	80	92	06	21	37	56	40
41	50	50	51	55	61	69	79	91	04	19	36	54	41
42	48	48	50	54	60	68	77	89	03	18	35	53	42
43	47	46	48	52	58	66	76	88	01	16	33	52	43
44	45	45	46	50	56	65	74	86	00	15	32	50	44
45	43	43	45	49	55	63	73	85	5498	14	31	49	45
46	42	41	43	47	53	61	71	83	97	12	29	48	46
47	40	40	42	46	52	60	70	82	96	11	28	46	47
48	38	38	40	44	50	58	69	80	94	09	26	45	48
49	37	36	38	42	49	57	67	79	93	08	25	44	49
50	35	35	37	41	47	55	66	78	91	07	24	42	50
51	33	33	35	39	46	54	64	76	90	05	22	41	51
52	32	31	33	38	44	52	63	75	88	04	21	40	52
53	30	30	32	36	43	51	61	73	87	02	20	38	53
54	28	28	30	35	41	49	60	72	86	01	18	37	54
55	26	26	29	33	39	48	58	70	84	00	17	35	55
56	25	25	27	31	38	46	57	69	83	5398	15	34	56
57	23	23	25	30	36	45	55	67	81	97	14	33	57
58	21	21	24	28	35	43	54	66	80	95	13	31	58
59	20	20	22	27	33	42	52	64	78	94	11	30	59
″	0° 42′	0° 43′	0° 44′	0° 45′	0° 46′	0° 47′	0° 48′	0° 49′	0° 50′	0° 51′	0° 52′	0° 53′	″
′	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	′

° ″	h m 0° 30′	h m 0° 31′	h m 0° 32′	h m 0° 33′	h m 0° 34′	h m 0° 35′	h m 0° 36′	h m 0° 37′	h m 0° 38′	h m 0° 39′	h m 0° 40′	h m 0° 41′	° ″
0	7782	7639	7501	7368	7238	7112	6990	6871	6755	6642	6532	6425	0
1	79	37	7499	65	36	10	88	69	53	40	30	23	1
2	77	34	97	63	34	08	86	67	51	38	29	21	2
3	74	32	94	61	32	06	84	65	49	37	27	20	3
4	72	30	92	59	29	04	82	63	47	35	25	18	4
5	69	27	90	57	27	02	80	61	45	33	23	16	5
6	67	25	88	54	25	00	78	59	43	31	21	14	6
7	65	23	85	52	23	7098	76	57	42	29	19	13	7
8	62	20	83	50	21	96	74	55	40	27	18	11	8
9	60	18	81	48	19	93	72	53	38	25	16	09	9
10	57	16	79	46	17	91	70	51	36	24	14	07	10
11	55	13	76	44	15	89	68	49	34	22	12	06	11
12	53	11	74	41	12	87	66	47	32	20	10	04	12
13	50	09	72	39	10	85	64	45	30	18	09	02	13
14	48	07	70	37	08	83	62	43	28	16	07	00	14
15	45	04	67	35	06	81	60	42	26	14	05	6398	15
16	43	02	65	33	04	79	58	40	25	12	03	97	16
17	41	00	63	30	02	77	56	38	23	11	01	95	17
18	38	7597	61	28	00	75	54	36	21	09	00	93	18
19	36	95	58	26	7198	73	52	34	19	07	6498	91	19
20	34	93	56	24	96	71	50	32	17	05	96	90	20
21	31	90	54	22	93	69	48	30	15	03	94	88	21
22	29	88	52	20	91	67	46	28	13	01	92	86	22
23	26	86	50	17	89	65	44	26	11	00	91	84	23
24	24	83	47	15	87	63	42	24	09	6598	89	83	24
25	22	81	45	13	85	61	40	22	08	96	87	81	25
26	19	79	43	11	83	59	38	20	06	94	85	79	26
27	17	77	41	09	81	57	36	18	04	92	84	77	27
28	14	74	38	07	79	55	34	16	02	90	82	76	28
29	12	72	36	04	77	53	32	14	00	89	80	74	29
30	10	70	34	02	75	50	30	12	6698	87	78	72	30
31	07	67	32	00	72	48	28	11	96	85	76	71	31
32	05	65	29	7298	70	46	26	09	94	83	75	69	32
33	03	63	27	96	68	44	24	07	92	81	73	67	33
34	00	60	25	94	66	42	22	05	91	79	71	65	34
35	7698	58	23	91	64	40	20	03	89	78	69	64	35
36	96	56	21	89	62	38	18	01	87	76	67	62	36
37	93	54	18	87	60	36	16	6799	85	74	66	60	37
38	91	51	16	85	58	34	14	97	83	72	64	58	38
39	88	49	14	83	56	32	12	95	81	70	62	57	39
40	86	47	12	81	54	30	10	93	79	68	60	55	40
41	84	44	10	79	52	28	08	91	77	67	59	53	41
42	81	42	07	76	49	26	06	89	76	65	57	51	42
43	79	40	05	74	47	24	04	87	74	63	55	50	43
44	77	38	03	72	45	22	02	85	72	61	53	48	44
45	74	35	01	70	43	20	00	84	70	59	51	46	45
46	72	33	7398	68	41	18	6898	82	68	58	50	44	46
47	70	31	96	66	39	16	96	80	66	56	48	43	47
48	67	28	94	64	37	14	94	78	64	54	46	41	48
49	65	26	92	61	35	12	92	76	63	52	44	39	49
50	63	24	90	59	33	10	90	74	61	50	43	38	50
51	60	22	87	57	31	08	88	72	59	48	41	36	51
52	58	19	85	55	29	06	86	70	57	47	39	34	52
53	55	17	83	53	27	04	84	68	55	45	37	32	53
54	53	15	81	51	24	02	83	66	53	43	35	31	54
55	51	13	79	49	22	00	81	64	51	41	34	29	55
56	48	10	76	46	20	6998	79	63	50	39	32	27	56
57	46	08	74	44	18	96	77	61	48	38	30	25	57
58	44	06	72	42	16	94	75	59	46	36	28	24	58
59	41	03	70	40	14	92	73	57	44	34	27	22	59
″ °	0° 30′ h m	0° 31′ h m	0° 32′ h m	0° 33′ h m	0° 34′ h m	0° 35′ h m	0° 36′ h m	0° 37′ h m	0° 38′ h m	0° 39′ h m	0° 40′ h m	0° 41′ h m	″ °

s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s
"	0° 42'	0° 43'	0° 44'	0° 45'	0° 46'	0° 47'	0° 48'	0° 49'	0° 50'	0° 51'	0° 52'	0° 53'	"
0	6320	6218	6118	6021	5925	5832	5740	5651	5563	5477	5393	5310	0
1	19	16	17	19	24	30	39	49	62	76	91	09	1
2	17	15	15	17	22	29	37	48	60	74	90	07	2
3	15	13	13	16	20	27	36	46	59	73	89	06	3
4	13	11	12	14	19	26	34	45	57	71	87	05	4
5	12	10	10	13	17	24	33	43	56	70	86	03	5
6	10	08	08	11	16	23	31	42	54	69	84	02	6
7	08	06	07	09	14	21	30	40	53	67	83	00	7
8	06	05	05	08	13	19	28	39	51	66	82	5299	8
9	05	03	03	06	11	18	27	37	50	64	80	98	9
10	03	01	02	05	09	16	25	36	49	63	79	96	10
11	01	00	00	03	08	15	24	35	47	61	77	95	11
12	00	6198	6099	01	06	13	22	33	46	60	76	94	12
13	6298	96	97	00	05	12	21	32	44	59	75	92	13
14	96	95	95	5998	03	10	19	30	43	57	73	91	14
15	94	93	94	97	02	09	18	29	41	56	72	90	15
16	93	91	92	95	00	07	16	27	40	54	70	88	16
17	91	90	90	93	5898	06	15	26	38	53	69	87	17
18	89	88	89	92	97	04	13	24	37	52	68	85	18
19	88	86	87	90	95	03	12	23	36	50	66	84	19
20	86	85	85	89	94	01	10	21	34	49	65	83	20
21	84	83	84	87	92	00	09	20	33	47	64	81	21
22	82	81	82	85	91	5798	07	18	31	46	62	80	22
23	81	79	81	84	89	96	06	17	30	45	61	79	23
24	79	78	79	82	88	95	04	15	28	43	59	77	24
25	78	76	77	81	86	93	03	14	27	42	58	76	25
26	76	74	76	79	84	92	01	13	26	40	57	75	26
27	74	73	74	77	83	90	00	11	24	39	55	73	27
28	72	71	72	76	81	89	5698	10	23	37	54	72	28
29	71	69	71	74	80	87	97	08	21	36	53	71	29
30	69	68	69	73	78	86	95	07	20	35	51	69	30
31	67	66	67	71	77	84	94	05	18	33	50	68	31
32	65	65	66	69	75	83	92	04	17	32	48	66	32
33	64	63	64	68	74	81	91	02	16	30	47	65	33
34	62	61	63	66	72	80	89	01	14	29	46	64	34
35	60	60	61	65	70	78	88	5599	13	28	44	62	35
36	59	58	59	63	69	77	86	98	11	26	43	61	36
37	57	56	58	61	67	75	85	96	10	25	41	60	37
38	55	55	56	60	66	74	83	95	08	23	40	58	38
39	54	53	55	58	64	72	82	94	07	22	39	57	39
40	52	51	53	57	63	71	80	92	06	21	37	56	40
41	50	50	51	55	61	69	79	91	04	19	36	54	41
42	48	48	50	54	60	68	77	89	03	18	35	53	42
43	47	46	48	52	58	66	76	88	01	16	33	52	43
44	45	45	46	50	56	65	74	86	00	15	32	50	44
45	43	43	45	49	55	63	73	85	5498	14	31	49	45
46	42	41	43	47	53	61	71	83	97	12	29	48	46
47	40	40	42	46	52	60	70	82	96	11	28	46	47
48	38	38	40	44	50	58	69	80	94	09	26	45	48
49	37	36	38	42	49	57	67	79	93	08	25	44	49
50	35	35	37	41	47	55	66	78	91	07	24	42	50
51	33	33	35	39	46	54	64	76	90	05	22	41	51
52	32	31	33	38	44	52	63	75	88	04	21	40	52
53	30	30	32	36	43	51	61	73	87	02	20	38	53
54	28	28	30	35	41	49	60	72	86	01	18	37	54
55	26	26	29	33	39	48	58	70	84	00	17	35	55
56	25	25	27	31	38	46	57	69	83	5398	15	34	56
57	23	23	25	30	36	45	55	67	81	97	14	33	57
58	21	21	24	28	35	43	54	66	80	95	13	31	58
59	20	20	22	27	33	42	52	64	78	94	11	30	59
"	0° 42'	0° 43'	0° 44'	0° 45'	0° 46'	0° 47'	0° 48'	0° 49'	0° 50'	0° 51'	0° 52'	0° 53'	"
s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s

s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s
″	0° 54′	0° 55′	0° 56′	0° 57′	0° 58′	0° 59′	1° 0′	1° 1′	1° 2′	1° 3′	1° 4′	1° 5′	″
0	5229	5149	5071	4994	4918	4844	4771	4699	4628	4559	4491	4424	0
1	27	48	70	93	17	43	70	98	27	58	90	22	1
2	26	46	68	91	16	42	69	67	26	57	89	21	2
3	25	45	67	90	15	41	68	96	25	56	88	20	3
4	23	44	66	89	13	39	66	95	24	55	86	19	4
5	22	43	64	88	12	38	65	93	23	54	85	18	5
6	21	41	63	86	11	37	64	92	22	52	84	17	6
7	19	40	62	85	10	36	63	91	21	51	83	16	7
8	18	39	61	84	08	34	62	90	19	50	82	15	8
9	17	37	59	83	07	33	60	89	18	49	81	14	9
10	15	36	58	81	06	32	59	88	17	48	80	12	10
11	14	35	57	80	05	31	58	86	16	47	79	11	11
12	13	33	55	79	03	30	57	85	15	46	77	10	12
13	11	32	54	77	02	28	56	84	14	44	76	09	13
14	10	31	53	76	01	27	54	83	12	43	75	08	14
15	09	29	51	75	00	26	53	82	11	42	74	07	15
16	07	28	50	74	4899	25	52	80	10	41	73	06	16
17	06	27	49	72	97	23	51	79	09	40	72	05	17
18	05	25	48	71	96	22	50	78	08	39	71	04	18
19	03	24	46	70	95	21	48	77	07	38	69	02	19
20	02	23	45	69	94	20	47	76	06	36	68	01	20
21	01	22	44	67	92	19	46	75	04	35	67	00	21
22	5199	20	43	66	91	17	45	73	03	34	66	4399	22
23	98	19	41	65	90	16	44	72	02	33	65	98	23
24	97	18	40	64	89	15	42	71	01	32	64	97	24
25	95	16	39	62	87	14	41	70	00	31	63	96	25
26	94	15	37	61	86	12	40	69	4599	30	62	95	26
27	93	14	36	60	85	11	39	68	97	28	60	94	27
28	91	12	35	59	84	10	38	66	96	27	59	93	28
29	90	11	34	57	82	09	36	65	95	26	58	91	29
30	89	10	32	56	81	07	35	64	94	25	57	90	30
31	87	08	31	55	80	06	34	63	93	24	56	89	31
32	86	07	30	54	79	05	33	62	92	23	55	88	32
33	85	06	28	52	77	04	32	60	90	22	54	87	33
34	83	05	27	51	76	03	30	59	89	20	53	86	34
35	82	03	26	50	75	01	29	58	88	19	52	85	35
36	81	02	25	49	74	00	28	57	87	18	50	84	36
37	79	01	23	47	73	4799	27	56	86	17	49	83	37
38	78	5099	22	46	71	98	26	55	85	16	48	81	38
39	77	98	21	45	70	97	24	53	84	15	47	80	39
40	75	97	19	43	69	95	23	52	83	14	46	79	40
41	74	95	18	42	68	94	22	51	81	12	45	78	41
42	73	94	17	41	66	93	21	50	80	11	44	77	42
43	72	93	16	40	65	92	20	49	79	10	43	76	43
44	70	92	14	38	64	91	18	48	78	09	41	75	44
45	69	90	13	37	63	89	17	46	77	08	40	74	45
46	68	89	12	36	61	88	16	45	75	07	39	73	46
47	66	88	11	35	60	87	15	44	74	06	38	72	47
48	65	86	09	33	59	86	14	43	73	05	37	70	48
49	64	85	08	32	58	85	12	42	72	03	36	69	49
50	62	84	07	31	56	83	11	40	71	02	35	68	50
51	61	82	05	30	55	82	10	39	70	01	34	67	51
52	60	81	04	28	54	81	09	38	69	00	33	66	52
53	58	80	03	27	53	80	08	37	67	4499	31	65	53
54	57	79	02	26	52	78	06	36	66	98	30	64	54
55	56	77	00	25	50	77	05	35	65	97	29	63	55
56	54	76	4999	23	49	76	04	33	64	95	28	62	56
57	53	75	98	22	48	75	03	32	63	94	27	61	57
58	52	73	97	21	47	74	02	31	62	93	26	59	58
59	50	72	95	20	45	72	01	30	60	92	25	58	59
″	0° 54′	0° 55′	0° 56′	0° 57′	0° 58′	0° 59′	1° 0′	1° 1′	1° 2′	1° 3′	1° 4′	1° 5′	″
s	h m	h m	h m	m h	h m	h m	h m	h m	h m	h m	h m	h m	s

°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°
″	1° 6′	1° 7′	1° 8′	1° 9′	1° 10′	1° 11′	1° 12′	1° 13′	1° 14′	1° 15′	1° 16′	1° 17′	″
0	4357	4292	4228	4164	4102	4040	3979	3919	3860	3802	3745	3688	0
1	56	91	27	63	01	39	78	18	59	01	44	87	1
2	55	90	26	62	00	38	77	18	58	00	43	86	2
3	54	89	24	61	4099	37	76	17	57	3799	42	85	3
4	53	88	23	60	98	36	75	16	56	98	41	84	4
5	52	86	22	59	97	35	74	15	55	97	40	83	5
6	51	85	21	58	96	34	73	14	55	96	39	82	6
7	50	84	20	57	95	33	72	13	54	95	38	81	7
8	49	83	19	56	93	32	71	12	53	94	37	80	8
9	47	82	18	55	92	31	70	11	52	93	36	79	9
10	46	81	17	54	91	30	69	10	51	92	35	78	10
11	45	80	16	53	90	29	68	09	50	92	34	77	11
12	44	79	15	52	89	28	67	08	49	91	33	77	12
13	43	78	14	51	88	27	66	07	48	90	32	76	13
14	42	77	13	50	87	26	65	06	47	89	31	75	14
15	41	76	12	48	86	25	64	05	46	88	30	74	15
16	40	75	11	47	85	24	63	04	45	87	29	73	16
17	39	74	10	46	84	23	62	03	44	86	28	72	17
18	38	73	09	45	83	22	61	02	43	85	27	71	18
19	36	71	07	44	82	21	60	01	42	84	27	70	19
20	35	70	06	43	81	20	59	00	41	83	26	69	20
21	34	69	05	42	80	19	58	3899	40	82	25	68	21
22	33	68	04	41	79	18	57	98	39	81	24	67	22
23	32	67	03	40	78	17	56	97	38	80	23	66	23
24	31	66	02	39	77	16	55	96	37	79	22	65	24
25	30	65	01	38	76	15	54	95	36	78	21	64	25
26	29	64	00	37	75	14	53	94	35	77	20	63	26
27	28	63	4199	36	74	13	52	93	34	76	19	63	27
28	27	62	98	35	73	12	51	92	33	75	18	62	28
29	26	61	97	34	72	11	50	91	32	74	17	61	29
30	25	60	96	33	71	10	49	90	31	73	16	60	30
31	23	59	95	32	70	09	48	89	30	72	15	59	31
32	22	58	94	31	69	08	47	88	29	71	14	58	32
33	21	56	93	30	68	07	46	87	28	70	13	57	33
34	20	55	92	29	67	06	45	86	27	69	12	56	34
35	19	54	91	28	66	05	44	85	26	09	11	55	35
36	18	53	89	27	65	04	43	84	25	68	10	54	36
37	17	52	88	26	64	03	42	83	24	67	09	53	37
38	16	51	87	25	63	02	41	82	23	66	09	52	38
39	15	50	86	23	62	01	40	81	22	65	08	51	39
40	14	49	85	22	61	00	39	80	21	64	07	50	40
41	13	48	84	21	60	3999	38	79	21	63	06	49	41
42	11	47	83	20	59	98	37	78	20	62	05	49	42
43	10	46	82	19	58	97	56	77	19	61	04	48	43
44	09	45	81	18	57	96	35	76	18	60	03	47	44
45	08	44	80	17	55	94	34	75	17	59	02	46	45
46	07	43	79	16	54	93	33	74	16	58	01	45	46
47	06	41	78	15	53	92	32	73	15	57	00	44	47
48	05	40	77	14	52	91	31	72	14	56	3699	43	48
49	04	39	76	13	51	90	30	71	13	55	98	42	49
50	03	38	75	12	50	89	29	70	12	54	97	41	50
51	02	37	74	11	49	88	28	69	11	53	96	40	51
52	01	36	73	10	48	87	27	68	10	52	95	39	52
53	00	35	72	09	47	86	26	67	09	51	94	38	53
54	4299	34	71	08	46	85	25	66	08	50	93	37	54
55	98	33	69	07	45	84	24	65	07	49	93	36	55
56	96	32	68	06	44	83	23	64	06	48	92	35	56
57	95	31	67	05	43	82	22	63	05	47	91	35	57
58	94	30	66	04	42	81	21	62	04	46	90	34	58
59	93	29	65	03	41	80	20	61	03	46	89	33	59
″	1° 6′	1° 7′	1° 8′	1° 9′	1° 10′	1° 11′	1° 12′	1° 13′	1° 14′	1° 15′	1° 16′	1° 17′	″
°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°

°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°
″	1° 18′	1° 19′	1° 20′	1° 21′	1° 22′	1° 23′	1° 24′	1° 25′	1° 26′	1° 27′	1° 28′	1° 29′	″
0	3632	3576	3522	3468	3415	3362	3310	3259	3208	3158	3108	3059	0
1	31	76	21	67	14	61	09	58	07	57	07	58	1
2	30	75	20	66	13	60	08	57	06	56	06	57	2
3	29	74	19	65	12	59	07	56	05	55	05	56	3
4	28	73	18	64	11	58	06	55	04	54	05	56	4
5	27	72	17	63	10	58	06	54	04	53	04	55	5
6	26	71	16	63	09	57	05	53	03	53	03	54	6
7	25	70	15	62	08	56	04	53	02	52	02	53	7
8	24	69	15	61	08	55	03	52	01	51	01	52	8
9	23	68	14	60	07	54	02	51	00	50	01	52	9
10	23	67	13	59	06	53	01	50	3199	49	00	51	10
11	22	66	12	58	05	52	00	49	98	48	3099	50	11
12	21	65	11	57	04	51	00	48	98	48	98	49	12
13	20	65	10	56	03	51	3299	47	97	47	97	48	13
14	19	64	09	55	02	50	98	47	96	46	96	47	14
15	18	63	08	54	01	49	97	46	95	45	96	47	15
16	17	62	07	54	00	48	96	45	94	44	95	46	16
17	16	61	06	53	00	47	95	44	93	43	94	45	17
18	15	60	06	52	3399	46	94	43	93	43	93	44	18
19	14	59	05	51	98	45	94	42	92	42	92	43	19
20	13	58	04	50	97	45	93	42	91	41	91	43	20
21	12	57	03	49	96	44	92	41	90	40	91	42	21
22	11	56	02	48	95	43	91	40	89	39	90	41	22
23	10	55	01	47	94	42	90	39	88	38	89	40	23
24	10	55	00	46	93	41	89	38	88	38	88	39	24
25	09	54	3499	46	93	40	88	37	87	37	87	39	25
26	08	53	98	45	92	39	88	36	86	36	87	38	26
27	07	52	97	44	91	38	87	36	85	35	86	37	27
28	06	51	97	43	90	38	86	35	84	34	85	36	28
29	05	50	96	42	89	37	85	34	83	33	84	35	29
30	04	49	95	41	88	36	84	33	83	33	83	34	30
31	03	48	94	40	87	35	83	32	82	32	82	34	31
32	02	47	93	39	86	34	82	31	81	31	82	33	32
33	01	46	92	38	86	33	82	31	80	30	81	32	33
34	00	45	91	38	85	32	81	30	79	29	80	31	34
35	3599	45	90	37	84	32	80	29	78	29	79	30	35
36	98	44	89	36	83	31	79	28	78	28	78	30	36
37	98	43	88	35	82	30	78	27	77	27	78	29	37
38	97	42	88	34	81	29	77	26	76	26	77	28	38
39	96	41	87	33	80	28	76	25	75	25	76	27	39
40	95	40	86	32	79	27	76	25	74	24	75	26	40
41	94	39	85	31	79	26	75	24	73	24	74	26	41
42	93	38	84	31	78	25	74	23	73	23	73	25	42
43	92	37	83	30	77	25	73	22	72	22	73	24	43
44	91	36	82	29	76	24	72	21	71	21	72	23	44
45	90	35	81	28	75	23	71	20	70	20	71	22	45
46	89	35	80	27	74	22	70	20	69	19	70	22	46
47	88	34	80	26	73	21	70	19	68	19	69	21	47
48	87	33	79	25	72	20	69	18	68	18	69	20	48
49	87	32	78	24	72	19	68	17	67	17	68	19	49
50	86	31	77	23	71	19	67	16	66	16	67	18	50
51	85	30	76	23	70	18	06	15	65	15	66	18	51
52	84	29	75	22	69	17	65	14	04	14	65	17	52
53	83	28	74	21	68	16	65	14	63	14	65	16	53
54	82	27	73	20	67	15	64	13	63	13	64	15	54
55	81	26	72	19	66	14	63	12	62	12	63	14	55
56	80	25	71	18	65	13	62	11	61	11	62	14	56
57	79	25	71	17	65	13	61	10	60	10	61	13	57
58	78	24	70	16	64	12	60	09	59	10	00	12	58
59	77	23	69	15	63	11	59	00	58	09	60	11	59
″	1° 18′	1° 19′	1° 20′	1° 21′	1° 22′	1° 23′	1° 24′	1° 25′	1° 26′	1° 27′	1° 28′	1° 29′	″
°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°

″	h m 1° 30′	h m 1° 31′	h m 1° 32′	h m 1° 33′	h m 1° 34′	h m 1° 35′	h m 1° 36′	h m 1° 37′	h m 1° 38′	h m 1° 39′	h m 1° 40′	h m 1° 41′	″
0	3010	2962	2915	2868	2821	2775	2730	2685	2640	2596	2553	2510	0
1	09	62	14	67	21	75	29	84	40	96	52	09	1
2	09	61	13	66	20	74	29	84	39	95	51	08	2
3	08	60	12	66	19	73	28	83	38	94	51	07	3
4	07	59	12	65	18	72	27	82	38	93	50	07	4
5	06	58	11	64	18	72	26	81	37	93	49	06	5
6	05	58	10	63	17	71	25	81	36	92	48	05	6
7	05	57	09	62	16	70	25	80	35	91	48	04	7
8	04	56	09	62	15	69	24	79	35	91	47	04	8
9	03	55	08	61	15	69	23	78	34	90	46	03	9
10	02	54	07	60	14	68	22	78	33	89	45	02	10
11	01	54	06	59	13	67	22	77	32	88	45	02	11
12	01	53	05	59	12	66	21	76	32	88	44	01	12
13	00	52	05	58	11	66	20	75	31	87	43	00	13
14	2999	51	04	57	11	65	19	75	30	86	43	2499	14
15	98	50	03	56	10	64	19	74	29	85	42	99	15
16	97	50	02	55	09	63	18	73	29	85	41	98	16
17	97	49	01	55	08	63	17	72	28	84	40	97	17
18	96	48	01	54	08	62	16	72	27	83	40	97	18
19	95	47	00	53	07	61	16	71	26	83	39	96	19
20	94	46	2899	52	06	60	15	70	26	82	38	95	20
21	93	46	98	52	05	60	14	69	25	81	38	94	21
22	93	45	98	51	05	59	13	69	24	80	37	94	22
23	92	44	97	50	04	58	13	68	24	80	36	93	23
24	91	43	96	49	03	57	12	67	23	79	35	92	24
25	90	42	95	48	02	56	11	66	22	78	35	92	25
26	89	42	94	48	01	56	10	66	21	77	34	91	26
27	89	41	94	47	01	55	10	65	21	77	33	90	27
28	88	40	93	46	00	54	09	64	20	76	33	89	28
29	87	39	92	45	2799	53	08	63	19	75	32	89	29
30	86	39	91	45	98	53	07	63	18	74	31	88	30
31	85	38	91	44	98	52	07	62	18	74	30	87	31
32	85	37	90	43	97	51	06	61	17	73	30	87	32
33	84	36	89	42	96	50	05	60	16	72	29	86	33
34	83	35	88	42	95	50	04	60	15	72	28	85	34
35	82	35	87	41	95	49	04	59	15	71	27	85	35
36	81	34	87	40	94	48	03	58	14	70	27	84	36
37	81	33	86	39	93	47	02	57	13	69	26	83	37
38	80	32	85	38	92	47	01	57	12	69	25	82	38
39	79	31	84	38	92	46	01	56	12	68	25	82	39
40	78	31	83	37	91	45	00	55	11	67	24	81	40
41	77	30	83	36	90	44	2699	55	10	66	23	80	41
42	77	29	82	35	89	44	98	54	10	66	22	80	42
43	76	28	81	35	88	43	98	53	09	65	22	79	43
44	75	27	80	34	88	42	97	52	08	64	21	78	44
45	74	27	80	33	87	41	96	52	07	64	20	77	45
46	73	26	79	32	86	41	95	51	07	63	20	77	46
47	73	25	78	31	85	40	95	50	06	62	19	76	47
48	72	24	77	31	85	30	94	49	05	61	18	75	48
49	71	24	76	30	84	38	93	49	04	61	17	75	49
50	70	23	76	29	83	38	92	48	04	60	17	74	50
51	69	22	75	28	82	37	92	47	03	59	16	73	51
52	69	21	74	28	82	36	91	46	02	59	15	72	52
53	68	20	73	27	81	35	90	46	01	58	15	72	53
54	67	20	73	26	80	35	89	45	01	57	14	71	54
55	66	19	72	25	79	34	89	44	00	56	13	70	55
56	65	18	71	25	79	33	88	43	2599	56	12	70	56
57	65	17	70	24	78	32	87	43	99	55	12	69	57
58	64	16	69	23	77	32	87	42	98	54	11	68	58
59	63	16	69	22	76	31	86	41	97	53	10	67	59
″	1° 30′	1° 31′	1° 32′	1° 33′	1° 34′	1° 36′	1° 36′	1° 37′	1° 38′	1° 39′	1° 40′	1° 41′	″
′	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	′

s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s
″	1° 42′	1° 43′	1° 44′	1° 45′	1° 46′	1° 47′	1° 48′	1° 49′	1° 50′	1° 51′	1° 52′	1° 53′	″
0	2467	2424	2382	2341	2300	2259	2218	2178	2139	2099	2061	2022	0
1	66	24	82	40	2299	58	18	78	38	99	60	21	1
2	65	23	81	39	98	58	17	77	37	98	59	21	2
3	65	22	80	39	98	57	16	76	37	98	59	20	3
4	64	22	80	38	97	56	16	76	36	97	58	19	4
5	63	21	79	37	96	56	15	75	36	96	57	19	5
6	62	20	78	37	96	55	14	74	35	96	57	18	6
7	62	19	78	36	95	54	14	74	34	95	56	17	7
8	61	19	77	35	94	53	13	73	34	94	55	17	8
9	60	18	76	35	94	53	12	72	33	94	55	16	9
10	60	17	75	34	93	52	12	72	32	93	54	16	10
11	59	17	75	33	92	51	11	71	32	92	53	15	11
12	58	16	74	33	91	51	10	70	31	92	53	14	12
13	58	15	73	32	91	50	10	70	30	91	52	14	13
14	57	15	73	31	90	49	09	69	30	90	52	13	14
15	56	14	72	31	89	49	08	69	29	90	51	12	15
16	55	13	71	30	89	48	08	68	28	89	50	12	16
17	55	12	71	29	88	47	07	67	28	88	50	11	17
18	54	12	70	28	87	47	06	67	27	88	49	10	18
19	53	11	69	28	87	46	06	66	26	87	48	10	19
20	53	10	68	27	86	45	05	65	26	86	48	09	20
21	52	10	68	26	85	45	04	65	25	86	47	09	21
22	51	09	67	26	85	44	04	64	24	85	46	08	22
23	50	08	66	25	84	43	03	63	24	85	46	07	23
24	50	08	66	24	83	43	02	63	23	84	45	07	24
25	49	07	65	24	83	42	02	62	22	83	44	06	25
26	48	06	64	23	82	41	01	61	22	83	44	05	26
27	48	05	64	22	81	41	00	61	21	82	43	05	27
28	47	05	63	22	81	40	00	60	20	81	42	04	28
29	46	04	62	21	80	39	2199	59	20	81	42	03	29
30	45	03	62	20	79	39	98	59	19	80	41	03	30
31	45	03	61	20	79	38	98	58	18	79	41	02	31
32	44	02	60	19	78	37	97	57	18	79	40	01	32
33	43	01	59	18	77	37	96	57	17	78	39	01	33
34	43	01	59	17	77	36	96	56	16	77	39	00	34
35	42	00	58	17	76	35	95	55	16	77	38	00	35
36	41	2399	57	16	75	35	94	55	15	76	37	1999	36
37	41	98	57	15	74	34	94	54	15	75	37	98	37
38	40	98	56	15	74	33	93	53	14	75	36	98	38
39	39	97	55	14	73	33	92	53	13	74	35	97	39
40	39	96	55	13	72	32	92	52	13	73	35	96	40
41	38	96	54	13	72	31	91	51	12	73	34	96	41
42	37	95	53	12	71	31	90	51	11	72	33	95	42
43	36	94	53	11	70	30	90	50	11	72	33	94	43
44	36	94	52	11	70	29	89	49	10	71	32	94	44
45	35	93	51	10	69	29	88	49	09	70	32	93	45
46	34	92	50	09	68	28	88	48	09	70	31	93	46
47	33	91	50	09	68	27	87	47	08	69	30	92	47
48	33	91	49	08	67	27	86	47	07	68	30	91	48
49	32	90	48	07	66	26	86	46	07	68	29	91	49
50	31	89	48	07	66	25	85	45	06	67	28	90	50
51	31	89	47	06	65	25	84	45	05	66	28	89	51
52	30	88	46	05	64	24	84	44	05	66	27	89	52
53	29	87	46	04	64	23	83	43	04	65	26	88	53
54	29	87	45	04	63	23	82	43	03	64	26	87	54
55	28	86	44	03	62	22	82	42	03	64	25	87	55
56	27	85	44	02	62	21	81	41	02	63	25	86	56
57	26	84	43	02	61	20	80	41	01	62	24	86	57
58	26	84	42	01	60	20	80	40	01	62	23	85	58
59	25	83	42	00	60	19	79	39	00	61	23	84	59
″	1° 42′	1° 43′	1° 44′	1° 45′	1° 46′	1° 47′	1° 48′	1° 49′	1° 50′	1° 51′	1° 52′	1° 53′	″
s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s

′ ″	h m 1° 54′	h m 1° 55′	h m 1° 56′	h m 1° 57′	h m 1° 58′	h m 1° 59′	h m 2° 0′	h m 2° 1′	h m 2° 2′	h m 2° 3′	h m 2° 4′	′ ″
0	1984	1946	1908	1871	1834	1797	1761	1725	1689	1654	1619	0
1	83	45	08	70	33	97	60	24	89	53	18	1
2	82	44	07	70	33	96	60	24	88	52	17	2
3	82	44	06	69	32	95	59	23	87	52	17	3
4	81	43	06	68	31	95	59	22	87	51	16	4
5	81	43	05	68	31	94	58	22	86	51	16	5
6	80	42	04	67	30	94	57	21	86	50	15	6
7	79	41	04	67	30	93	57	21	85	50	14	7
8	79	41	03	66	29	92	56	20	84	49	14	8
9	78	40	03	65	28	92	55	19	84	48	13	9
10	77	39	02	65	28	91	55	19	83	48	13	10
11	77	39	01	64	27	91	54	18	83	47	12	11
12	76	38	01	63	27	90	54	18	82	47	12	12
13	75	38	00	63	26	89	53	17	81	46	11	13
14	75	37	1899	62	25	89	52	17	81	45	10	14
15	74	36	99	62	25	88	52	16	80	45	10	15
16	74	36	98	61	24	88	51	15	80	44	09	16
17	73	35	98	60	23	87	51	15	79	44	09	17
18	72	34	97	60	23	86	50	14	78	43	08	18
19	72	34	96	59	22	86	49	14	78	43	07	19
20	71	33	96	59	22	85	49	13	77	42	07	20
21	70	33	95	58	21	85	48	12	77	41	06	21
22	70	32	94	57	20	84	48	12	76	41	06	22
23	69	31	94	57	20	83	47	11	76	40	05	23
24	68	31	93	56	19	83	46	11	75	40	05	24
25	68	30	93	55	19	82	46	10	74	39	04	25
26	67	29	92	55	18	81	45	09	74	38	03	26
27	67	29	91	54	17	81	45	09	73	38	03	27
28	66	28	91	54	17	80	44	08	73	37	02	28
29	65	28	90	53	16	80	43	08	72	37	02	29
30	65	27	89	52	16	79	43	07	71	36	01	30
31	64	26	89	52	15	78	42	06	71	35	00	31
32	63	26	88	51	14	78	42	06	70	35	00	32
33	63	25	88	50	14	77	41	05	70	34	1599	33
34	62	24	87	50	13	77	40	05	69	34	99	34
35	62	24	86	49	12	76	40	04	68	33	98	35
36	61	23	86	49	12	75	39	03	68	33	98	36
37	60	23	85	48	11	75	39	03	67	32	97	37
38	60	22	84	47	11	74	38	02	67	31	96	38
39	59	21	84	47	10	74	37	02	66	31	96	39
40	58	21	83	46	09	73	37	01	65	30	95	40
41	58	20	83	46	09	72	36	00	65	30	95	41
42	57	19	82	45	08	72	36	00	64	29	94	42
43	56	19	81	44	08	71	35	1699	64	28	93	43
44	56	18	81	44	07	71	34	99	63	28	93	44
45	55	18	80	43	06	70	34	98	63	27	92	45
46	55	17	80	43	06	69	33	97	62	27	92	46
47	54	16	79	42	05	69	33	97	61	26	91	47
48	53	16	78	41	05	68	32	96	61	26	91	48
49	53	15	78	41	04	68	31	96	60	25	90	49
50	52	14	77	40	03	67	31	95	60	24	89	50
51	51	14	76	39	03	66	30	94	59	24	89	51
52	51	13	76	39	02	66	30	94	58	23	88	52
53	50	13	75	38	02	65	29	93	58	23	88	53
54	50	12	75	38	01	65	28	93	57	22	87	54
55	49	11	74	37	00	64	28	92	57	21	87	55
56	49	11	73	36	00	63	27	92	56	21	86	56
57	48	10	73	36	1799	63	27	91	55	20	85	57
58	47	09	72	35	98	62	26	90	55	20	85	58
59	46	09	71	35	98	62	25	90	54	19	84	59
″ ′	1° 54′ h m	1° 55′ h m	1° 56′ h m	1° 57′ h m	1° 58′ h m	1° 59′ h m	2° 0′ h m	2° 1′ h m	2° 2′ h m	2° 3′ h m	2° 4′ h m	″ ′

s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s
''	2° 5'	2° 6'	2° 7'	2° 8'	2° 9'	2° 10'	2° 11'	2° 12'	2° 13'	2° 14'	2° 15'	''
0	1584	1549	1515	1481	1447	1413	1380	1347	1314	1282	1249	0
1	83	48	14	80	46	13	79	46	14	81	49	1
2	82	48	14	79	46	12	79	46	13	81	48	2
3	82	47	13	79	45	12	78	45	13	80	48	3
4	81	47	12	78	45	11	78	45	12	80	47	4
5	81	46	12	78	44	11	77	44	11	79	47	5
6	80	46	11	77	43	10	77	44	11	78	46	6
7	80	45	11	77	43	09	76	43	10	78	46	7
8	79	44	10	76	42	09	76	43	10	77	45	8
9	78	44	10	76	42	08	75	42	09	77	45	9
10	78	43	09	75	41	08	74	42	09	76	44	10
11	77	43	08	74	41	07	74	41	08	76	43	11
12	77	42	08	74	40	07	73	40	08	75	43	12
13	76	42	07	73	40	06	73	40	07	75	42	13
14	76	41	07	73	39	06	72	39	07	74	42	14
15	75	40	06	72	38	05	72	39	06	74	41	15
16	74	40	06	72	38	04	71	38	06	73	41	16
17	74	39	05	71	37	04	71	38	05	73	40	17
18	73	39	04	70	37	03	70	37	04	72	40	18
19	73	38	04	70	36	03	70	37	04	71	39	19
20	72	38	03	69	36	02	69	36	03	71	39	20
21	71	37	03	69	35	02	68	35	03	70	38	21
22	71	36	02	68	35	01	68	35	02	70	38	22
23	70	36	02	68	34	01	67	34	02	69	37	23
24	70	35	01	67	33	00	67	34	01	69	37	24
25	69	35	00	67	33	1399	66	33	01	68	36	25
26	69	34	00	66	32	99	66	33	00	68	35	26
27	68	34	1499	65	32	98	65	32	00	67	35	27
28	67	33	99	65	31	98	65	32	1299	67	34	28
29	67	32	98	64	31	97	64	31	98	66	34	29
30	66	32	98	64	30	97	63	31	98	66	33	30
31	66	31	97	63	29	96	63	30	97	65	33	31
32	65	31	96	63	29	96	62	29	97	64	32	32
33	65	30	96	62	28	95	62	29	96	64	32	33
34	64	30	95	61	28	94	61	28	96	63	31	34
35	63	29	95	61	27	94	61	28	95	63	31	35
36	63	28	94	60	27	93	00	27	95	62	30	36
37	62	28	94	60	26	93	60	27	94	62	30	37
38	62	27	93	59	26	92	59	26	94	61	29	38
39	61	27	93	59	25	92	59	26	93	61	29	39
40	61	26	92	58	24	91	58	25	92	60	28	40
41	60	26	91	58	24	91	57	25	92	60	27	41
42	59	25	91	57	23	90	57	24	91	50	27	42
43	59	24	90	56	23	89	56	23	91	59	26	43
44	58	24	90	56	22	89	56	23	90	58	26	44
45	58	23	89	55	22	88	55	22	90	57	25	45
46	57	23	89	55	21	88	55	22	89	57	25	46
47	56	22	88	54	21	87	54	21	89	56	24	47
48	56	22	87	54	20	87	54	21	88	56	24	48
49	55	21	87	53	19	86	53	20	88	55	23	49
50	55	20	86	52	19	86	52	20	87	55	23	50
51	54	20	86	52	18	85	52	19	87	54	22	51
52	54	19	85	51	18	84	51	19	86	54	22	52
53	53	19	85	51	17	84	51	18	85	53	21	53
54	52	18	84	50	17	83	50	17	85	53	21	54
55	52	18	83	50	16	83	50	17	84	52	20	55
56	51	17	83	49	16	82	49	16	84	52	19	56
57	51	16	82	49	15	82	49	16	83	51	19	57
58	50	16	82	48	14	81	48	15	83	50	18	58
59	50	15	81	47	14	81	48	15	82	50	18	59
''	2° 5'	2° 6'	2° 7'	2° 8'	2° 9'	2° 10'	2° 11'	2° 12'	2° 13'	2° 14'	2° 15'	''
s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s

°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°
″	2° 16′	2° 17′	2° 18′	2° 19′	2° 20′	2° 21′	2° 22′	2° 23′	2° 24′	2° 25′	2° 26′	″
0	1217	1186	1154	1123	[illegible]	1061	1030	0999	0969	0939	[illegible]	0
1	17	85	53	22	91	60	29	99	69	39	[illegible]	1
2	16	84	53	22	90	60	29	98	68	38	08	2
3	16	84	52	21	90	59	28	98	68	38	[illegible]	3
4	15	83	52	20	89	58	28	97	67	37	07	4
5	15	83	51	20	89	58	27	97	67	37	07	5
6	14	82	51	19	88	57	27	96	66	36	06	6
7	14	82	50	19	88	57	26	96	66	36	06	7
8	13	81	50	18	87	56	26	95	65	35	05	8
9	13	81	49	18	87	56	25	95	65	35	05	9
10	12	80	49	17	86	55	25	94	64	34	04	10
11	11	80	48	17	86	55	24	94	64	34	04	11
12	11	79	48	16	85	54	24	93	63	33	03	12
13	10	79	47	16	85	54	23	93	63	33	03	13
14	10	78	47	15	84	53	23	92	62	32	02	14
15	09	78	46	15	84	53	22	92	62	32	02	15
16	09	77	46	14	83	52	22	91	61	31	01	16
17	08	77	45	14	83	52	21	91	61	31	01	17
18	08	76	45	13	82	51	21	90	60	30	00	18
19	07	75	44	13	82	51	20	90	60	30	00	19
20	07	75	43	12	81	50	20	89	59	29	0899	20
21	06	74	43	12	81	50	19	89	59	29	99	21
22	06	74	42	11	80	49	19	88	58	28	98	22
23	05	73	42	11	80	49	18	88	58	28	98	23
24	65	73	41	10	79	48	18	87	57	27	97	24
25	04	72	41	10	79	48	17	87	57	27	97	25
26	04	72	40	09	78	47	17	86	56	26	96	26
27	03	71	40	09	78	47	16	86	56	26	96	27
28	02	71	39	08	77	46	16	85	55	25	95	28
29	02	70	30	08	76	46	15	85	55	25	95	29
30	01	70	38	07	76	45	15	84	54	24	94	39
31	01	69	38	06	75	45	14	84	54	24	94	31
32	00	69	37	06	75	44	14	83	53	23	93	32
33	60	68	37	05	74	44	13	83	53	23	93	33
34	1199	68	36	05	74	43	13	82	52	22	92	34
35	99	67	36	04	73	43	12	82	52	22	92	35
36	98	67	35	04	73	42	12	81	51	21	91	36
37	98	66	35	03	72	42	11	81	51	21	91	37
38	97	65	34	03	72	41	11	80	50	20	90	38
39	97	65	34	02	71	41	10	80	50	20	90	39
40	96	64	33	02	71	40	09	79	49	19	89	40
41	96	64	32	01	70	40	09	79	49	19	89	41
42	95	63	32	01	70	39	08	78	48	18	88	42
43	95	63	31	00	60	39	08	78	48	18	88	43
44	94	62	31	00	69	38	07	77	47	17	87	44
45	93	62	30	1099	68	37	07	77	47	17	87	45
46	93	61	30	99	68	37	06	76	46	16	86	46
47	92	61	29	98	67	36	06	76	46	16	86	47
48	92	60	29	98	67	36	05	75	45	15	85	48
49	91	60	28	97	66	35	05	75	45	15	85	49
50	91	59	28	97	66	35	04	74	44	14	84	50
51	90	59	27	96	65	34	04	74	44	14	84	51
52	90	58	27	96	65	34	03	73	43	13	83	52
53	89	58	26	95	64	33	03	73	43	13	83	53
54	89	57	26	95	64	33	02	72	42	12	83	54
55	88	57	25	94	63	32	02	72	42	12	82	55
56	88	56	25	94	63	32	01	71	41	11	82	56
57	87	56	24	93	62	31	01	71	41	11	81	57
58	87	55	24	92	62	31	00	70	40	10	81	58
59	86	54	23	92	61	30	00	70	40	10	80	59
″	2° 16′	2° 17′	2° 18′	2° 19′	2° 20′	2° 21′	2° 22′	2° 23′	2° 24′	2° 25′	2° 26′	″
°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°

s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s
"	2° 27'	2° 28'	2° 29'	2° 30'	2° 31'	2° 32'	2° 33'	2° 34'	2° 35'	2° 36'	2° 37'	"
0	0880	0850	0821	0792	0763	0734	0706	0678	0649	0621	0594	0
1	79	50	20	91	62	34	05	77	49	21	93	1
2	79	49	20	91	62	33	05	77	48	21	93	2
3	78	49	19	90	62	33	04	76	48	20	92	3
4	78	48	19	90	61	32	04	76	48	20	92	4
5	77	48	18	89	61	32	03	75	47	19	91	5
6	77	47	18	89	60	31	03	75	47	19	91	6
7	76	47	17	88	60	31	03	74	46	18	91	7
8	76	46	17	88	59	30	02	74	46	18	90	8
9	75	46	16	87	59	30	02	73	45	17	90	9
10	75	45	16	87	58	30	01	73	45	17	89	10
11	74	45	16	87	58	29	01	72	44	16	89	11
12	74	44	15	86	57	29	00	72	44	16	88	12
13	73	44	15	86	57	28	00	71	43	15	88	13
14	73	43	14	85	56	28	0699	71	43	15	87	14
15	72	43	14	85	56	27	99	70	42	15	87	15
16	72	42	13	84	55	27	98	70	42	14	86	16
17	71	42	13	84	55	26	98	70	41	14	86	17
18	71	41	12	83	54	26	97	69	41	13	85	18
19	70	41	12	83	54	25	97	69	41	13	85	19
20	70	40	11	82	53	25	96	68	40	12	85	20
21	69	40	11	82	53	24	96	68	40	12	84	21
22	69	39	10	81	52	24	95	67	39	11	84	22
23	68	39	10	81	52	23	95	67	39	11	83	23
24	68	38	09	80	51	23	94	66	38	10	83	24
25	67	38	09	80	51	22	94	66	38	10	82	25
26	67	37	08	79	51	22	94	65	37	09	82	26
27	66	37	08	79	50	21	93	65	37	09	81	27
28	66	36	07	78	50	21	93	64	36	09	81	28
29	65	36	07	78	49	21	92	64	36	08	80	29
30	65	35	06	77	49	20	92	63	35	08	80	30
31	64	35	06	77	48	20	91	63	35	07	79	31
32	64	34	05	76	48	19	91	63	34	07	79	32
33	63	34	05	76	47	19	90	62	34	06	79	33
34	63	34	04	75	47	18	90	62	34	06	78	34
35	62	33	04	75	46	18	89	61	33	05	78	35
36	62	33	03	74	46	17	89	61	33	05	77	36
37	61	32	03	74	45	17	88	60	32	04	77	37
38	61	32	02	74	45	16	88	60	32	04	76	38
39	60	31	02	73	44	16	87	59	31	03	76	39
40	60	31	01	73	44	15	87	59	31	03	75	40
41	59	30	01	72	43	15	86	58	30	02	75	41
42	59	30	01	72	43	14	86	58	30	02	74	42
43	58	29	00	71	42	14	86	57	29	02	74	43
44	58	29	00	71	42	13	85	57	29	01	73	44
45	57	28	0799	70	41	13	85	56	28	01	73	45
46	57	28	99	70	41	12	84	56	28	00	73	46
47	56	27	98	69	40	12	84	55	28	00	72	47
48	56	27	98	69	40	11	83	55	27	0599	72	48
49	55	26	97	68	40	11	83	55	27	99	71	49
50	55	26	97	68	39	11	82	54	26	98	71	50
51	55	25	96	67	39	10	82	54	26	98	70	51
52	54	25	96	67	38	10	81	53	25	97	70	52
53	54	24	95	66	38	09	81	53	25	97	69	53
54	53	24	95	66	37	09	80	52	24	96	69	54
55	53	23	94	65	37	08	80	52	24	96	68	55
56	52	23	94	65	36	08	79	51	23	96	68	56
57	52	22	93	64	36	07	79	51	23	95	68	57
58	51	22	93	64	35	07	78	50	22	95	67	58
59	51	21	92	63	35	06	78	50	22	94	67	59
"	2° 27'	2° 28'	2° 29'	2° 30'	2° 31'	2° 32'	2° 33'	2° 34'	2° 35'	2° 36'	2° 37'	"
s	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	s

′ ″	h m 2° 38′	h m 2° 39′	h m 2° 40′	h m 2° 41′	h m 2° 42′	h m 2° 43′	h m 2° 44′	h m 2° 45′	h m 2° 46′	h m 2° 47′	h m 2° 48′	′ ″
0	0566	0539	0512	0484	0458	0431	0404	0378	0352	0326	0300	0
1	66	38	11	84	57	30	04	77	51	25	99	1
2	65	38	11	84	57	30	03	77	51	25	99	2
3	65	37	10	83	56	30	03	77	50	24	98	3
4	64	37	10	83	56	29	03	76	50	24	98	4
5	64	36	09	82	55	29	02	76	49	23	97	5
6	63	36	09	82	55	28	02	75	49	23	97	6
7	63	36	08	81	54	28	01	75	49	23	97	7
8	62	35	08	81	54	27	01	74	48	22	96	8
9	62	35	07	80	54	27	00	74	48	22	96	9
10	62	34	07	80	53	26	00	74	47	21	95	10
11	61	34	07	80	53	26	0399	73	47	21	95	11
12	61	33	06	79	52	26	99	73	46	20	94	12
13	60	33	06	79	52	25	99	72	46	20	94	13
14	60	32	05	78	51	25	98	72	46	19	94	14
15	59	32	05	78	51	24	98	71	45	19	93	15
16	59	31	04	77	50	24	97	71	45	19	93	16
17	58	31	04	77	50	23	97	70	44	18	92	17
18	58	31	03	76	50	23	96	70	44	18	92	18
19	57	30	03	76	49	22	96	70	43	17	91	19
20	57	30	02	75	49	22	95	69	43	17	91	20
21	57	29	02	75	48	22	95	69	42	16	91	21
22	56	29	02	75	48	21	95	68	42	16	90	22
23	56	28	01	74	47	21	94	68	42	16	90	23
24	55	28	01	74	47	20	94	67	41	15	89	24
25	55	27	00	73	46	20	93	67	41	15	89	25
26	54	27	00	73	46	19	93	66	40	14	88	26
27	54	26	0499	72	46	19	92	66	40	14	88	27
28	53	26	99	72	45	18	92	66	39	13	88	28
29	53	26	98	71	45	18	92	65	39	13	87	29
30	52	25	98	71	44	18	91	65	39	13	87	30
31	52	25	98	71	44	17	91	64	38	12	86	31
32	52	24	97	70	43	17	90	64	38	12	86	32
33	51	24	97	70	43	16	90	63	37	11	85	33
34	51	23	96	69	42	16	89	63	37	11	85	34
35	50	23	96	69	42	15	89	63	36	10	85	35
36	50	22	95	68	42	15	88	62	36	10	84	36
37	49	22	95	68	41	14	88	62	36	10	84	37
38	49	21	94	67	41	14	88	61	35	09	83	38
39	48	21	94	67	40	14	87	61	35	09	83	39
40	48	21	93	67	40	13	87	60	34	08	82	40
41	47	20	93	66	39	13	86	60	34	08	82	41
42	47	20	93	66	39	12	86	59	33	07	82	42
43	46	19	92	65	38	12	85	59	33	07	81	43
44	46	19	92	65	38	11	85	59	33	07	81	44
45	46	18	91	64	38	11	84	58	32	06	80	45
46	45	18	91	64	37	10	84	58	32	06	80	46
47	45	17	90	63	37	10	84	57	31	05	79	47
48	44	17	90	63	36	10	83	57	31	05	79	48
49	44	17	89	62	36	09	83	56	30	04	79	49
50	43	16	89	62	35	09	82	56	30	04	78	50
51	43	16	89	62	35	08	82	56	29	04	78	51
52	42	15	88	61	34	08	81	55	29	03	77	52
53	42	15	88	61	34	07	81	55	29	03	77	53
54	41	14	87	60	34	07	81	54	28	02	76	54
55	41	14	87	60	33	06	80	54	28	02	76	55
56	41	13	86	59	33	06	80	53	27	01	76	56
57	40	13	86	59	32	06	79	53	27	01	75	57
58	40	12	85	58	32	05	79	53	26	00	75	58
59	39	12	85	58	31	05	78	52	26	00	74	59
″ ′	2° 38′ h m	2° 39′ h m	2° 40′ h m	2° 41′ h m	2° 42′ h m	2° 43′ h m	2° 44′ h m	2° 45′ h m	2° 46′ h m	2° 47′ h m	2° 48′ h m	″ ′

°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°
''	2° 49'	2° 50'	2° 51'	2° 52'	2° 53'	2° 54'	2° 55'	2° 56'	2° 57'	2° 58'	2° 59'	''
0	0274	0248	0223	0197	0172	0147	0122	0098	0073	0049	0024	0
1	73	48	22	97	72	47	22	97	73	48	24	1
2	73	47	22	97	71	46	22	97	72	48	23	2
3	73	47	21	96	71	46	21	96	72	47	23	3
4	72	47	21	96	71	46	21	96	71	47	23	4
5	72	46	21	95	70	45	20	96	71	46	22	5
6	71	46	20	95	70	45	20	95	71	46	22	6
7	71	45	20	94	69	44	19	95	70	46	21	7
8	70	45	19	94	69	44	19	94	70	45	21	8
9	70	44	19	94	69	43	19	94	69	45	21	9
10	70	44	19	93	68	43	18	93	69	44	20	10
11	69	44	18	93	68	43	18	93	68	44	20	11
12	69	43	18	92	67	42	17	93	68	44	19	12
13	68	43	17	92	67	42	17	92	68	43	19	13
14	68	42	17	92	66	41	17	92	67	43	19	14
15	67	42	16	91	66	41	16	91	67	42	18	15
16	67	41	16	91	66	41	16	91	66	42	18	16
17	67	41	16	90	65	40	15	91	66	42	17	17
18	66	41	15	90	65	40	15	90	66	41	17	18
19	66	40	15	89	64	39	14	90	65	41	17	19
20	65	40	14	89	64	39	14	89	65	40	16	20
21	65	39	14	89	63	39	14	89	64	40	16	21
22	64	39	13	88	63	38	13	89	64	40	15	22
23	64	38	13	88	63	38	13	88	64	39	15	23
24	64	38	13	87	62	37	12	88	63	39	15	24
25	63	38	12	87	62	37	12	87	63	38	14	25
26	63	37	12	87	61	36	12	87	62	38	14	26
27	62	37	11	86	61	36	11	87	62	38	13	27
28	62	36	11	86	61	36	11	86	62	37	13	28
29	61	36	11	85	60	35	10	86	61	37	12	29
30	61	35	10	85	60	35	10	85	61	36	12	30
31	61	35	10	84	59	34	10	85	60	36	12	31
32	60	35	09	84	59	34	09	84	60	36	11	32
33	60	34	09	84	58	34	09	84	60	35	11	33
34	59	34	08	83	58	33	08	84	59	35	10	34
35	59	33	08	83	58	33	08	83	59	34	10	35
36	58	33	08	82	57	32	07	83	58	34	10	36
37	58	33	07	82	57	32	07	82	58	34	09	37
38	58	32	07	81	56	31	07	82	57	33	09	38
39	57	32	06	81	56	31	06	82	57	33	08	39
40	57	31	06	81	56	31	06	81	57	32	08	40
41	56	31	05	80	55	30	05	81	56	32	08	41
42	56	30	05	80	55	30	05	80	56	31	07	42
43	55	30	05	79	54	29	05	80	55	31	07	43
44	55	30	04	79	54	29	04	80	55	31	06	44
45	55	29	04	79	53	29	04	79	55	30	06	45
46	54	29	03	78	53	28	03	79	54	30	06	46
47	54	28	03	78	53	28	03	78	54	29	05	47
48	53	28	03	77	52	27	03	78	53	29	05	48
49	53	27	02	77	52	27	02	77	53	29	04	49
50	52	27	02	76	51	26	02	77	53	28	04	50
51	52	27	01	76	51	26	01	77	52	28	04	51
52	52	26	01	76	51	26	01	76	52	27	03	52
53	51	26	00	75	50	25	00	76	51	27	03	53
54	51	25	00	75	50	25	00	75	51	27	02	54
55	50	25	00	74	49	24	00	75	51	26	02	55
56	50	24	0199	74	49	24	0099	75	50	26	02	56
57	50	24	99	74	48	24	99	74	50	25	01	57
58	49	24	98	73	48	23	98	74	49	25	01	58
59	49	23	98	73	48	23	98	73	49	26	00	59
''	2° 49'	2° 50'	2° 51'	2° 52'	2° 53'	2° 54'	2° 55'	2° 56'	2° 57'	2° 58'	2° 59'	''
°	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	°

TABLE IV.

COURSES, DISTANCE, DEPARTURE, AND DIFFERENCE OF LATITUDE.

Distance.	C. ¼ Pt.		C. ½ Pt.		C. ¾ Pt.		C. 1 Pt.		C. 1¼ Pt.		C. 1½ Pt.		C. 1¾ Pt.		C. 2 Pts.	
	N.¼E. S.¼E. S.¼W. N.¼W.		N.½E. S.½E. S.½W. N.½W.		N.¾E. S.¾E. S.¾W. N.¾W.		N. by E. S. by E. S. by W. N. by W.		N. by E.¼E. S. by E.¼E. S. by W.¼W. N. by W.¼W.		N. by E.½E. S. by E.½E. S. by W.½W. N. by W.½W.		N. by E.¾E. S. by E.¾E. S. by W.¾W. N. by W.¾W.		N.N.E. S.S.E. S.S.W. N.N.W.	
	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.
1	1	0	1.	.1	1.	0.1	1.	0.2	1.	0.2	1.	0.3	0.9	0.3	0.9	0.4
2	2	0.1	2.	0.2	2.	0.3	2.	0.4	1.9	0.5	1.9	0.6	1.9	0.7	1.8	[illegible]
3	3	0.1	3.	0.3	3.	0.4	2.9	0.6	2.9	0.7	2.9	0.9	2.8	1.	2.8	[illegible]
4	4	0.2	4.	0.4	4.	0.6	3.9	0.8	3.9	1.	3.8	1.2	3.8	1.3	3.7	1.5
5	5	0.2	5.	0.5	4.9	0.7	4.9	1.	4.9	1.2	4.8	1.5	4.7	1.7	4.6	1.9
6	6	0.3	6.	0.6	5.9	0.9	5.9	1.2	5.8	1.5	5.7	1.7	5.6	2.	5.5	2.3
7	7	0.3	7.	0.7	6.9	1.	6.9	1.4	6.8	1.7	6.7	2.	6.6	2.4	6.5	[illegible]
8	8	0.4	8.	0.8	7.9	1.2	7.8	1.6	7.8	1.9	7.7	2.3	7.5	2.7	7.4	[illegible]
9	9	0.4	9.	0.9	8.9	1.3	8.8	1.8	8.7	2.2	8.6	2.6	8.5	3.	8.3	3.4
10	10	0.5	10.	1.	9.9	1.5	9.8	2.	9.7	2.4	9.6	2.9	9.4	3.4	9.2	[illegible]
11	11	0.5	10.9	1.1	10.9	1.6	10.8	2.1	10.7	2.7	10.5	3.2	10.4	3.7	10.2	[illegible]
12	12	0.6	11.9	1.2	11.9	1.8	11.8	2.3	11.6	2.9	11.5	3.5	11.3	4.	11.1	4.6
13	13	0.6	12.9	1.3	12.9	1.9	12.8	2.5	12.6	3.2	12.4	3.8	12.2	4.4	12.	5.
14	14	0.7	13.9	1.4	13.8	2.1	13.7	2.7	13.6	3.4	13.4	4.1	13.2	4.7	12.9	5.4
15	15	0.7	14.9	1.5	14.8	2.2	14.7	2.9	14.6	3.6	14.4	4.4	14.1	5.1	13.9	5.7
16	16	0.8	15.9	1.6	15.8	2.3	15.7	3.1	15.5	3.9	15.3	4.6	15.1	5.4	14.8	6.1
17	17	0.8	16.9	1.7	16.8	2.5	16.7	3.3	16.5	4.1	16.3	4.9	16.	5.7	15.7	6.5
18	18	0.9	17.9	1.8	17.8	2.6	17.7	3.5	17.5	4.4	17.2	5.2	16.9	6.1	16.6	[illegible]
19	19	0.9	18.9	1.9	18.8	2.8	18.6	3.7	18.4	4.6	18.2	5.5	17.9	6.4	17.6	[illegible]
20	20	1.	19.9	2.	19.8	2.9	19.6	3.9	19.4	4.9	19.1	5.8	18.8	6.7	18.5	[illegible]
21	21	1.	20.9	2.1	20.8	3.1	20.6	4.1	20.4	5.1	20.1	6.1	19.8	7.1	19.4	8.
22	22	1.1	21.9	2.2	21.8	3.3	21.6	4.3	21.3	5.3	21.1	6.4	20.7	7.4	20.3	8.4
23	23	1.1	22.9	2.3	22.8	3.4	22.6	4.5	22.3	5.6	22.	6.7	21.7	7.7	21.2	[illegible]
24	24	1.2	23.9	2.4	23.7	3.5	23.5	4.7	23.3	5.8	23.	7.	22.6	8.1	22.2	[illegible]
25	25	1.2	24.9	2.5	24.7	3.7	24.5	4.9	24.3	6.1	23.9	7.3	23.5	8.4	23.1	9.6
26	26	1.3	25.9	2.6	25.7	3.8	25.5	5.1	25.2	6.3	24.9	7.5	24.5	8.8	24.	[illegible]
27	27	1.3	26.9	2.6	26.7	4.	26.5	5.3	26.2	6.6	25.8	7.8	25.4	9.1	24.9	[illegible]
28	28	1.4	27.9	2.7	27.7	4.1	27.5	5.5	27.2	6.8	26.8	8.1	26.4	9.4	25.9	[illegible]
29	29	1.4	28.9	2.8	28.7	4.3	28.4	5.7	28.1	7.	27.8	8.4	27.3	9.6	26.8	11.1
30	30	1.5	29.9	2.9	29.7	4.4	29.4	5.9	29.1	7.3	28.7	8.7	28.2	10.1	27.7	11.5
31	31	1.5	30.8	3.	30.7	4.5	30.4	6.	30.1	7.5	29.7	9.	29.2	10.4	28.6	[illegible]
32	32	1.6	31.8	3.1	31.7	4.7	31.4	6.2	31.	7.8	30.6	9.3	30.1	10.8	29.6	12.2
33	33	1.6	32.8	3.2	32.6	4.8	32.4	6.4	32.	8.	31.6	9.6	31.1	11.1	30.5	12.6
34	34	1.7	33.8	3.3	33.6	5.	33.3	6.6	33.	8.3	32.5	9.9	32.	11.5	31.4	13.
35	35	1.7	34.8	3.4	34.6	5.1	34.3	6.8	34.	8.5	33.5	10.2	33.	11.8	32.3	13.4
36	36	1.8	35.8	3.5	35.6	5.3	35.3	7.	34.9	8.7	34.4	10.5	33.9	12.1	33.3	[illegible]
37	37	1.8	36.8	3.6	36.6	5.4	36.3	7.2	35.9	9.	35.4	10.7	34.8	12.5	34.2	[illegible]
38	38	1.9	37.8	3.7	37.6	5.6	37.3	7.4	36.9	9.2	36.4	11.	35.8	12.8	35.1	14.5
39	39	1.9	38.8	3.8	38.6	5.7	38.3	7.6	37.8	9.5	37.3	11.3	36.7	13.1	36.	14.9
40	40	2.	39.8	3.9	39.6	5.9	39.2	7.8	38.8	9.7	38.3	11.6	37.7	13.5	37.	15.3
41	41	2.	40.8	4.	40.6	6.	40.2	8.	39.8	10.	39.2	11.9	38.6	13.8	37.9	[illegible]
42	41.9	2.1	41.8	4.1	41.5	6.2	41.2	8.2	40.7	10.2	40.2	12.3	39.5	14.1	38.8	16.1
43	42.9	2.1	42.8	4.2	42.5	6.3	42.2	8.4	41.7	10.4	41.1	12.5	40.5	14.5	39.7	16.5
44	43.9	2.2	43.8	4.3	43.5	6.5	43.2	8.6	42.7	10.7	42.1	12.8	41.4	14.8	40.7	[illegible]
45	44.9	2.2	44.8	4.4	44.5	6.6	44.1	8.8	43.7	10.9	43.1	13.1	42.4	15.2	41.6	[illegible]
46	45.9	2.3	45.8	4.5	45.5	6.7	45.1	9.	44.6	11.2	44.	13.4	43.3	15.5	42.4	[illegible]
47	46.9	2.3	46.8	4.6	46.5	6.9	46.1	9.2	45.6	11.4	45.	13.6	44.3	15.8	43.5	[illegible]
48	47.9	2.4	47.8	4.7	47.5	7.	47.1	9.4	46.6	11.7	45.9	13.9	45.2	16.2	44.3	18.4
49	48.9	2.4	48.8	4.8	48.5	7.2	48.1	9.6	47.5	11.9	46.9	14.2	46.1	16.5	45.3	[illegible]
50	49.9	2.5	49.8	4.9	49.5	7.3	49.	9.8	48.5	12.1	47.8	14.5	47.1	16.8	46.2	19.1
	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.
Distance.	W.¼N. W.¼S. E.¼S. E.¼N.		W.½N. W.½S. E.½S. E.½N.		W.¾N. W.¾S. E.¾S. E.¾N.		W. by N. W. by S. E. by S. E. by N.		W. by N.¾N. W. by S.¾S. E. by S.¾S. E. by N.¾N.		W. by N.½N. W. by S.½S. E. by S.½S. E. by N.½N.		W. by N.¼N. W. by S.¼S. E. by S.¼S. E. by N.¼N.		W.N.W. W.S.W. E.S.E. E.N.E.	
	C. 7¾ Pts.		C. 7½ Pts.		C. 7¼ Pts.		C. 7 Pts.		C. 6¾ Pts.		C. 6½ Pts.		C. 6¼ Pts.		C. 6 Pts.	

C. 2¼ Pts.		C. 2½ Pts.		C. 2¾ Pts.		C. 3 Pts.		C. 3¼ Pts.		C. 3½ Pts.		C. 3¾ Pts.		C. 4 Pts.	
N.N.E.¼E. S.S.E.¼E.	S.S.W.¼W. N.N.W.¼W.	N.N.E.½E. S.S.E.½E.	S.S.W.½W. N.N.W.½W.	N.N.E.¾E. S.S.E.¾E.	S.S.W.¾W. N.N.W.¾W.	N.E. by N. S.E. by S.	S.W. by S. N.W. by N.	N.E.¾N. S.E.¾S.	S.W.¾S. N.W.¾N.	N.E.½N. S.E.½S.	S.W.½S. N.W.½N.	N.E.¼N. S.E.¼S.	S.W.¼S. N.W.¼N.	N.E. S.E. S.W. N.W.	Distance.
d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat. dep.	
0.9	0.4	0.9	0.5	0.9	0.5	0.8	0.6	0.8	0.6	0.8	0.6	0.7	0.7	0.7	1
1.8	0.9	1.8	0.9	1.7	1.	1.7	1.1	1.6	1.2	1.5	1.3	1.5	1.3	1.4	2
2.7	1.3	2.6	1.4	2.6	1.5	2.5	1.7	2.4	1.8	2.3	1.9	2.3	2.	2.1	3
3.6	1.7	3.5	1.9	3.4	2.1	3.4	2.2	3.2	2.4	3.1	2.5	3.	2.7	2 8	4
4.5	2.1	4.4	2.4	4.3	2.6	4.2	2.8	4.	3.	3.9	3.2	3.7	3.3	3.5	5
5.4	2.6	5.3	2.8	5.1	3.1	5.	3.3	4.8	3.6	4.6	3.8	4.4	4.	4.2	6
6.3	3.	6.2	3.3	6.	3.6	5.8	3.9	5.6	4.2	5.4	4.4	5.2	4.7	4.9	7
7.2	3.4	7.1	3.8	6.9	4.1	6.7	4.4	6.4	4.8	6.2	5.1	5.9	5.4	5.7	8
8.1	3.8	7.9	4.2	7.7	4.6	7.5	5.	7.2	5.4	7.	5.7	6.7	6.1	6.4	9
9.	4.3	8.8	4.7	8.6	5.1	8.3	5.6	8.	6.	7.7	6.3	7.4	6.7	7.1	10
9.9	4.7	9.7	5.2	9.4	5.7	9.1	6.1	8.8	6.6	8.5	7.	8.2	7.4	7.8	11
10.8	5.1	10.6	5.7	10.3	6.2	10.	6.7	9.6	7.1	9.3	7.5	8.9	8.1	8.5	12
11.7	5.6	11.5	6.1	11.2	6.7	10.8	7.2	10.4	7.7	10.	8.2	9.6	8.7	9.2	13
12.7	6.	12.3	6.6	12.	7.2	11.6	7.8	11.2	8.3	10.8	8.9	10.4	9.4	9.9	14
13.6	6.4	13.2	7.1	12.9	7.7	12.5	8.3	12.	8.9	11.6	9.5	11.1	10.1	10.6	15
14.5	6.8	14.1	7.5	13.7	8.2	13.3	8.9	12.9	9.5	12.4	10.2	11.9	10.7	11.3	16
15.4	7.3	15.	8.	14.6	8.8	14.1	9.4	13.7	10.1	13.1	10.8	12.6	11 4	12.	17
16.3	7.7	15.9	8.5	15.4	9.3	15.	10.	14.5	10.7	13.9	11.4	13.3	12.1	12.7	18
17.2	8.1	16.8	9.	16.3	9.8	15.8	10.6	15.3	11.3	14.7	12.1	14.1	12.8	13.4	19
18.1	8.6	17.6	9.4	17.2	10.3	16.6	11.1	16.1	11.9	15.5	12.7	14.8	13.4	14.1	20
19.	9.	18.5	9.9	18.	10.8	17.5	11.7	16.9	12.5	16.2	13.3	15.6	14.1	14.8	21
19.9	9.4	19.4	10.4	18.9	11.3	18.3	12.2	17.7	13.1	17.	14.	16.3	14.8	15.6	22
20 8	9.8	20.3	10.8	19.7	11.8	19.1	12.8	18.5	13.7	17.8	14.6	17.	15.4	16.3	23
21.7	10.3	21.2	11.3	20.6	12.3	20.	13.3	19.3	14.3	18.6	15.2	17.8	16 1	17.	24
22.6	10.7	22.	11.8	21.4	12.9	20.8	13.9	20.1	14.9	19.3	15.9	18.5	16.8	17.7	25
23.5	11.1	22.9	12.3	22.3	13.4	21.6	14.4	20.9	15.5	20.1	16.5	19.3	17.5	18.4	26
24.4	11.5	23.8	12.7	23.2	13.9	22.4	15.	21.7	16.1	20.9	17.1	20.	18.1	19.1	27
25.3	12.	24.7	13.2	24.	14.4	23.3	15.6	22.5	16.7	21.6	17.8	20.7	18.8	19.8	28
26.2	12.4	25.6	13.7	24.9	14.9	24.1	16.1	23.3	17.3	22.4	18.4	21.5	19.5	20.5	29
27.1	12.8	26.4	14.1	25.7	15.4	24.9	16.7	24.1	17.9	23.2	19.	22.2	20.1	21.2	30
28.	13.3	27.3	14.6	26.6	15.9	25.8	17.2	24.9	18.5	24.	19.7	23.	20.8	21.9	31
28.9	13.7	28.2	15.1	27.4	16.5	26.6	17.8	25.7	19.1	24.7	20.3	23.7	21.5	22.6	32
29.8	14.1	29.1	15.6	28.3	17.	27.4	18.3	26.5	19.7	25.5	20.9	24.5	22.2	23.3	33
30.7	14.5	30.	16.	29.2	17.5	28.3	18.9	27.3	20.3	26.3	21.6	25.2	22.8	24.	34
31 6	15.	30.9	16.5	30.	18.	29.1	19.4	28.1	20.8	27.1	22.2	25.9	23.5	24.7	35
32.5	15.4	31.7	17.	30.9	18.5	29.9	20.	28.9	21.4	27.8	22.8	26.7	24.2	25.5	36
33.4	15.8	32.6	17.4	31.7	19.	30.8	20.6	29.7	22.	28.6	23.5	27.4	24.8	26.2	37
34.4	16.2	33.5	17.9	32.6	19.5	31.6	21.1	10.5	22.6	29.4	24.1	28.2	25 5	26.9	38
35.3	16.7	34.4	18.4	33.5	20.1	32.4	21.7	31.3	23.2	30.1	24.7	28.9	26.2	27.6	39
36.3	17.1	35.3	18.9	34.3	20.6	33.3	22.2	32.1	23.8	30.9	25.4	29.6	26.9	28.3	40
37.1	17.5	36.2	19.3	35.2	21.1	34.1	22.8	32.9	24.4	31.7	26.	30.4	27.5	29.	41
38.	18.	37.	19.8	36.	21.6	34.9	23.3	33.7	25.	32.5	26.6	31.1	28.2	29.7	42
38.9	18.4	37.9	20.3	36.9	22.1	35.8	23.9	34.5	25.6	33.2	27.3	31.9	28.9	30.4	43
39.8	18.8	38.8	20.7	37.7	22-6	36.6	24.4	35.3	26.2	34.	27.9	32.6	29.5	31.1	44
40.7	19.2	39.7	21.2	38.6	23.1	37.4	25.	36.1	26.8	34.8	28.5	33.3	30.2	31.8	45
41.6	19.7	40.6	21.7	39.5	23.6	38.2	25 6	36.9	27.4	35.6	29.2	34.1	30.9	32.5	46
42.5	20.1	41.5	22.2	40.3	24.2	39.1	26.1	37.8	28.	36.3	29.8	34.8	31.6	33.2	47
43.4	20.5	42.3	22.6	41.2	24.7	39.9	26.7	38.6	28.6	37.1	30 5	35.6	32.2	33.9	48
44.3	21.	43.2	23.1	42.	25.2	40.7	27.2	39.4	29.2	37.9	31.1	36.3	32.9	34.6	49
45.2	21.4	44.1	23.6	42.9	25.7	41.6	27.8	40.2	29.8	38.7	31.7	37.	33.6	35.4	50
dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep. d. lat.	—
N.W. by W.¼W. S.W. by W.¼W.	S.E. by E.¼E. N.E. by E.¼E.	N.W. by W.½W. S.W. by W.½W.	S.E. by E.½E. N.E. by E.½E.	N.W. by W.¾W. S.W. by W.¾W.	S.E. by E.¾E. N.E. by E.¾E.	N.W. by W. S.W. by W.	S.E. by E. N.E. by E.	N.W.¾W. S.W.¾W.	S.E.¾E. N.E.¾E.	N.W.½W. S.W.½W.	S.E.½E. N.E.½E.	N.W.¼W. S.W.¼W.	S.E.¼E. N.E.¼E.	N.W. S.W. S.E. N.E.	Distance.
C. 5¾ Pts.		C 5½ Pts.		C. 5¼ Pts.		C. 5 Pts.		C. 4¾ Pts.		C. 4½ Pts.		C. 4¼ Pts.		C. 4 Pts.	

Distance.	C. ¼ Pt.		C. ½ Pt.		C. ¾ Pt.		C. 1 Pt.		C. 1¼ Pt.		C. 1½ Pt.		C. 1¾ Pt.		C. 2 Pts.	
	N. ¼ E. S. ¼ E.	S. ¼ W. N. ¼ W.	N. ½ E. S. ½ E.	S. ½ W. N. ½ W.	N. ¾ E. S. ¾ E.	S. ¾ W. N. ¾ W.	N. by E. S. by E.	S. by W. N. by W.	N. by E. ¼ E. S. by E. ¼ E.	S. by W. ¼ W. N. by W. ¼ W.	N. by E. ½ E. S. by E. ½ E.	S. by W. ½ W. N. by W. ½ W.	N. by E. ¾ E. S. by E. ¾ E.	S. by W. ¾ W. N. by W. ¾ W.	N. N. E. S. S. E.	S. S. W. N. N. W.
	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.
51	50.9	2.5	50.8	5.	50.4	7.5	50.	9.9	49.5	12.4	48.8	14.8	48.	17.2	47.1	19.5
52	51.9	2.6	51.7	5.1	51.4	7.6	51.	10.1	50.4	12.6	49.8	15.1	49.	17.5	48.	19.9
53	52.9	2.6	52.7	5.2	52.4	7.8	52.	10.3	51.4	12.9	50.7	15.4	49.9	17.9	49.	20.3
54	53.9	2.6	53.7	5.3	53.4	7.9	53.	10.5	52.4	13.1	51.7	15.7	50.8	18.2	49.9	20.7
55	54.9	2.7	54.7	5.4	54.4	8.1	53.9	10.7	53.4	13.4	52.6	16.	51.8	18.5	50.8	21.
56	55.9	2.7	55.7	5.5	55.4	8.2	54.9	10.9	54.3	13.6	53.6	16.3	52.7	18.9	51.7	21.4
57	56.9	2.8	56.7	5.6	56.4	8.4	55.9	11.1	55.3	13.8	54.5	16.5	53.7	19.2	52.7	21.8
58	57.9	2.8	57.7	5.7	57.4	8.5	56.9	11.3	56.3	14.1	55.5	16.8	54.6	19.5	53.6	22.2
59	58.9	2.9	58.7	5.8	58.4	8.7	57.9	11.5	57.2	14.3	56.5	17.1	55.6	19.9	54.5	22.6
60	59.9	2.9	59.7	5.9	59.4	8.8	58.8	11.7	58.2	14.6	57.4	17.4	56.5	20.2	55.4	23.
61	60.9	3.	60.7	6.	60.3	9.	59.8	11.9	59.2	14.8	58.4	17.7	57.4	20.6	56.4	23.3
62	61.9	3.	61.7	6.1	61.3	9.1	60.8	12.1	60.1	15.1	59.3	18.	58.4	20.9	57.3	23.7
63	62.9	3.1	62.7	6.2	62.3	9.2	61.8	12.3	61.1	15.3	60.3	18.3	59.3	21.2	58.2	24.1
64	63.9	3.1	63.7	6.3	63.3	9.4	62.8	12.5	62.1	15.6	61.2	18.6	60.3	21.6	59.1	24.5
65	64.9	3.2	64.7	6.4	64.3	9.5	63.8	12.7	63.1	15.8	62.2	18.9	61.2	21.9	60.1	24.9
66	65.9	3.2	65.7	6.5	65.3	9.7	64.7	12.9	64.	16.	63.2	19.2	62.1	22.2	61.	25.3
67	66.9	3.3	66.7	6.6	66.3	9.8	65.7	13.1	65.	16.3	64.1	19.4	63.1	22.6	61.9	25.6
68	67.9	3.4	67.7	6.7	67.3	10.	66.7	13.3	66.	16.5	65.1	19.7	64.	22.9	62.8	26.
69	68.9	3.4	68.7	6.8	68.3	10.1	67.7	13.5	66.9	16.8	66.	20.	65.	23.2	63.7	26.4
70	69.9	3.5	69.7	6.9	69.2	10.3	68.7	13.7	67.9	17.	67.	20.3	65.9	23.6	64.7	26.8
71	70.9	3.5	70.7	7.	70.2	10.4	69.6	13.9	68.9	17.3	67.9	20.6	66.8	23.9	65.6	27.2
72	71.9	3.6	71.7	7.1	71.2	10.6	70.6	14.	69.8	17.5	68.9	20.9	67.8	24.3	66.5	27.6
73	72.9	3.6	72.6	7.2	72.2	10.7	71.6	14.2	70.8	17.7	69.9	21.2	68.7	24.6	67.4	27.9
74	73.9	3.7	73.6	7.3	73.2	10.9	72.6	14.4	71.8	18.	70.8	21.5	69.7	24.9	68.4	28.3
75	74.9	3.7	74.6	7.4	74.2	11.	73.6	14.6	72.8	18.2	71.8	21.8	70.6	25.3	69.3	28.7
76	75.9	3.8	75.6	7.4	75.2	11.2	74.5	14.8	73.7	18.5	72.7	22.1	71.6	25.6	70.2	29.1
77	76.9	3.8	76.6	7.5	76.2	11.3	75.5	15.	74.7	18.7	73.7	22.4	72.5	25.9	71.1	29.5
78	77.9	3.9	77.6	7.6	77.2	11.4	76.5	15.2	75.7	19	74.6	22.6	73.4	26.3	72.1	29.8
79	78.9	3.9	78.6	7.7	78.1	11.6	77.5	15.4	76.6	19.2	75.6	22.9	74.4	26.6	73.	30.2
80	79.9	4.	79.6	7.8	79.1	11.7	78.5	15.6	77.6	19.4	76.6	23.2	75.3	27.	73.9	30.6
81	80.9	4.	80.6	7.9	80.1	11.9	79.4	15.8	78.6	19.7	77.5	23.5	76.3	27.3	74.8	31.
82	81.9	4.1	81.6	8.	81.1	12.	80.4	16.	79.5	19.9	78.5	23.8	77.2	27.6	75.8	31.4
83	82.9	4.1	82.6	8.1	82.1	12.2	81.4	16.2	80.5	20.2	79.4	24.1	78.1	28	76.7	31.8
84	83.9	4.2	83.6	8.2	83.1	12.3	82.4	16.4	81.5	20.4	80.4	24.4	79.1	28.3	77.6	32.1
85	84.9	4.2	84.6	8.3	84.1	12.5	83.4	16.6	82.5	20.7	81.3	24.7	80.	28.6	78.5	32.5
86	85.9	4.3	85.6	8.4	85.1	12.6	84.3	16.8	83.4	20.9	82.3	25.	81.	29.	79.5	32.9
87	86.9	4.3	86.6	8.5	86.1	12.8	85.3	17.	84.4	21.1	83.3	25.3	81.9	29.3	80.4	33.3
88	87.9	4.4	87.6	8.6	87.	12.9	86.3	17.2	85.4	21.4	84.2	25.5	82.9	29.6	81.3	33.7
89	88.9	4.4	88.6	8.7	88.	13.1	87.3	17.4	86.3	21.6	85.2	25.8	83.8	30.	82.2	34.1
90	89.9	4.5	89.6	8.8	89.	13.2	88.3	17.6	87.3	21.9	86.1	26.1	84.7	30.3	83.1	34.4
91	90.9	4.5	90.6	8.9	90.	13.4	89.3	17.8	88.3	22.1	87.1	26.4	85.7	30.7	84.1	34.8
92	91.9	4.6	91.6	9.	91.	13.5	90.2	17.8	89.2	22.4	88.	26.7	86.6	31.	85.	35.2
93	92.9	4.6	92.6	9.1	92.	13.6	91.2	18.1	90.2	22.6	89.	27.	87.6	31.3	85.9	35.6
94	93.9	4.7	93.5	9.2	93.	13.8	92.2	18.3	91.2	22.8	90.	27.3	88.5	31.7	86.8	36.
95	94.9	4.7	94.5	9.3	94.	13.9	93.2	18.5	92.2	23.1	90.9	27.6	89.4	32.	87.8	36.4
96	95.9	4.8	95.5	9.4	95.	14.1	94.2	18.7	93.1	23.3	91.9	27.9	90.4	32.3	88.7	36.7
97	96.9	4.8	96.5	9.5	96.	14.2	95.1	18.9	94.1	23.6	92.8	28.2	91.3	32.7	89.6	37.1
98	97.9	4.9	97.5	9.6	96.9	14.4	96.1	19.1	95.1	23.8	93.8	28.4	92.3	33.	90.5	37.5
99	98.9	4.9	98.5	9.7	97.9	14.5	97.1	19.3	96.	24.1	94.7	28.7	93.2	33.4	91.5	37.9
100	99.9	4.9	99.5	9.8	98.9	14.7	98.1	19.5	97.	24.3	95.7	29.	94.2	33.7	92.4	38.3
Distance.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.
	W. ¾ N. W. ¾ S.	E. ¾ S. E. ¾ N.	W. ½ N. W. ½ S.	E. ½ S. E. ½ N.	W. ¼ N. W. ¼ S.	E. ¼ S. E. ¼ N.	W. by N. W. by S.	E. by S. E. by N.	W. by N. ¾ N. W. by S. ¾ S.	E. by S. ¾ S. E. by N. ¾ N.	W. by N. ½ N. W. by S. ½ S.	E. by S. ½ S. E. by N. ½ N.	W. by N. ¼ N. W. by S. ¼ S.	E. by S. ¼ S. E. by N. ¼ N.	W. N. W. W. S. W.	E. S. E. E. N. E.
	C. 7¾ Pts.		C. 7½ Pts.		C. 7¼ Pts.		C. 7 Pts.		C. 6¾ Pts.		C. 6½ Pts.		C. 6¼ Pts.		C. 6 Pts.	

C. 2¼ Pts.		C. 2½ Pts.		C. 2¾ Pts.		C. 3 Pts.		C. 3¼ Pts.		C. 3½ Pts.		C. 3¾ Pts.		C. 4 Pts.		
N.N.E.¼E. S.S.E.¼E.	S.S.W.¼W. N.N.W.¼W.	N.N.E.½E. S.S.E.½E.	S.S.W.½W. N.N.W.½W.	N.N.E.¾E. S.S.E.¾E.	S.S.W.¾W. N.N.W.¾W.	N.E. by N. S.E. by S.	S.W. by S. N.W. by N.	N.E.¾N. S.E.¾S.	S.W.¾S. N.W.¾N.	N.E.½N. S.E.½S.	S.W.½S. N.W.½N.	N.E.¼N. S.E.¼S.	S.W.¼S. N.W.¼N.	N.E. S.E.	S.W. N.W.	Distance.
d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat	dep.	
46.1	21.8	45.	24.	43.7	26.2	42.4	28.3	41.1	30.4	39.4	32.4	37.8	34.2	36.1		51
47.	22.2	45.9	24.5	44.6	26.7	43.2	28.9	41.8	31.	40.2	33.	38.5	34.9	36.8		52
47.9	22.7	46.7	25	45.5	27.2	44.1	29.4	42.6	31.6	41.	33.6	39.3	35.6	37.5		53
48.8	23.1	47.6	25.5	46.3	27.8	44.9	30.	43.4	32.2	41.7	34.3	40.	36.3	38.2		54
49.7	23.5	48.5	25.9	47.2	28.3	45.7	30.6	44.2	32.8	42.5	34.9	40.8	36.9	38.9		55
50.6	23.9	49.4	26.4	48.	28.8	46.6	31.1	45.	33.4	43.3	35.5	41.5	37.6	39.6		56
51.5	24.4	50.3	26.9	48.9	29.3	47.4	31.7	45.8	34.	44.1	36.2	42.2	38.3	40.3		57
52.4	24.8	51.2	27.3	49.7	29.8	48.2	32.2	46.6	34.6	44.8	36.8	43.	39.	41.		58
53.3	25.2	52.	27.8	50.6	30.3	49.1	32.8	47.4	35.1	45.6	37.4	43.7	39.6	41.7		59
54.2	25.7	52.9	28.3	51.5	30.8	49.9	33.3	48.2	35.7	46.4	38.1	44.5	40.3	42.4		60
55.1	26.1	53.8	28.8	52.3	31.4	50.7	33.9	49.	36.3	47.2	38.7	45.2	41.	43.1		61
56.	26.5	54.7	29.2	53.2	31.9	51.6	34.4	49.8	36.9	47.9	39.3	45.9	41.6	43.8		62
57.	26.9	55.6	29.7	54.	32.4	52.4	35.	50.6	37.5	48.7	40.	46.7	42.3	44.5		63
57.9	27.4	56.4	30.2	54.9	32.9	53.2	35.6	51.4	38.1	49.5	40.6	47.4	43.	45.3		64
58.8	27.8	57.3	30.6	55.8	33.4	54.	36.1	52.2	38.7	50.2	41.2	48.2	43.7	46.		65
59.7	28.2	58.2	31.1	56.6	33.9	54.9	36.7	53.	39.3	51.	41.9	48.9	44.3	46.7		66
60.6	28.6	59.1	31.6	57.5	34.4	55.7	37.2	53.8	39.9	51.8	42.5	49.6	45.	47.4		67
61.5	29.1	60.	32.1	58.3	35.	56.5	37.8	54.6	40.5	52.6	43.1	50.4	45.7	48.1		68
62.4	29.5	60.9	32.5	59.2	35.5	57.4	38.3	55.4	41.1	53.3	43.8	51.1	46.3	48.8		69
63.3	29.9	61.7	33.	60.	36.	58.2	38.9	56.2	41.7	54.1	44.4	51.9	47.	49.5		70
64.2	30.4	62.6	33.5	60.9	36.5	59.	39.4	57.	42.3	54.9	45.	52.6	47.7	50.2		71
65.1	30.8	63.5	33.9	61.8	37.	59.9	40.	57.8	42.9	55.7	45.7	53.3	48.4	50.9		72
66.	31.2	64.4	34.4	62.6	37.5	60.7	40.6	58.6	43.5	56.4	46.3	54.1	49.	51.6		73
66.9	31.6	65.3	34.9	63.5	38.	61.5	41.1	59.4	44.1	57.2	46.9	54.8	49.7	52.3		74
67.8	32.1	66.1	35.4	64.3	38.6	62.4	41.7	60.2	44.7	58.	47.6	55.6	50.4	53.		75
68.7	32.5	67.	35.8	65.2	39.1	63.2	42.2	61.	45.3	58.7	48.2	56.3	51.	53.7		76
69.6	32.9	67.9	36.3	66.	39.6	64.	42.8	61.8	45.9	59.5	48.8	57.1	51.7	54.4		77
70.5	33.3	68.8	36.8	66.9	40.1	64.9	43.3	62.7	46.5	60.3	49.5	57.8	52.4	55.2		78
71.4	33.8	69.7	37.2	67.8	40.6	65.7	43.9	63.5	47.1	61.1	50.1	58.5	53.1	55.9		79
72.3	34.2	70.6	37.7	68.6	41.1	66.5	44.4	64.3	47.7	61.8	50.8	59.3	53.7	56.6		80
73.2	34.6	71.4	38.2	69.5	41.6	67.3	45.	65.1	48.3	62.6	51.4	60.	54.4	57.3		81
74.1	35.1	72.3	38.7	70.3	42.2	68.2	45.6	65.9	48.8	63.4	52.	60.8	55.1	58.		82
75.	35.5	73.2	39.1	71.2	42.7	69.	46.1	66.7	49.4	64.2	52.7	61.5	55.7	58.7		83
75.9	35.9	74.1	39.6	72.	43.2	69.8	46.7	67.5	50.	64.9	53.3	62.2	56.4	59.4		84
76.8	36.3	75.	40.1	72.9	43.7	70.7	47.2	68.3	50.6	65.7	54.9	63.	57.1	60.1		85
77.7	36.8	75.8	40.5	73.8	44.2	71.5	47.8	69.1	51.2	66.5	54.6	63.7	57.8	60.8		86
78.6	37.2	76.7	41.	74.6	44.7	72.3	48.3	69.9	51.8	67.3	55.2	64.5	58.4	61.5		87
79.6	37.6	77.6	41.5	75.5	45.2	73.2	48.9	70.7	52.4	68.	55.8	65.2	59.1	62.2		88
80.5	38.1	78.5	42.	76.3	45.8	74.	49.4	71.5	53.	68.8	56.5	65.9	59.8	62.9		89
81.4	38.5	79.4	42.4	77.2	46.3	74.8	50.	72.3	53.6	69.6	57.1	66.7	60.4	63.6		90
82.3	38.9	80.3	42.9	78.	46.8	75.7	50.6	73.1	54.2	70.3	57.7	67.4	61.1	64.3		91
83.2	39.3	81.1	43.4	78.9	47.3	76.5	51.1	73.9	54.8	71.1	58.4	68.2	61.8	65.1		92
84.1	39.8	82.	43.8	79.8	47.8	77.3	51.7	74.7	55.4	71.9	59.	68.9	62.5	65.8		93
85.	40.2	82.9	44.3	80.6	48.3	78.2	52.2	75.5	56.	72.7	59.6	69.6	63.1	66.5		94
85.9	40.6	83.8	44.8	81.5	48.8	79.	52.8	76.3	56.6	73.4	60.3	70.4	63.8	67.2		95
86.8	41.	84.7	45.3	82.3	49.4	79.8	53.3	77.1	57.2	74.2	60.9	71.1	64.5	67.9		96
87.7	41.5	85.5	45.7	83.2	49.9	80.7	53.9	77.9	57.8	75.	61.5	71.9	65.1	68.6		97
88.6	41.9	86.4	46.2	84.1	50.4	81.5	54.4	78.7	58.4	75.8	62.2	72.6	65.8	69.3		98
89.5	42.3	87.3	46.7	84.9	50.9	82.3	55.	79.5	59.	76.5	62.8	73.4	66.5	70.		99
90.4	42.8	88.2	47.1	85.8	51.4	83.1	55.6	80.3	59.6	77.3	63.4	74.1	67.2	70.7		100
dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	Distance.
N.W. by W.¼W. S.W. by W.¼W.	S.E. by E.¼E. N.E. by E.¼E.	N.W. by W.½W. S.W. by W.½W.	S.E. by E.½E. N.E. by E.½E.	N.W. by W.¾W. S.W. by W.¾W.	S.E. by E.¾E. N.E. by E.¾E.	N.W. by W. S.W. by W.	S.E. by E. N.E. by E.	N.W.¾W. S.W.¾W.	S.E.¾E. N.E.¾E.	N.W.½W. S.W.½W.	S.E.½E. N.E.½E.	N.W.¼W. S.W.¼W.	S.E.¼E. N.E.¼E.	N.W. S.W.	S.E. N.E.	
C. 5¾ Pts.		C. 5½ Pts.		C. 5¼ Pts.		C. 5 Pts.		C. 4¾ Pts.		C. 4½ Pts.		C. 4¼ Pts.		C. 4 Pts.		

. ¼ Pt.		C. ½ Pt.		C. ¾ Pt.		C. 1 Pt.		C. 1¼ Pt.		C. 1½ Pt.		C. 1¾ Pt.		C. 2 Pts.	
S. ¼ E.	S. ¼ W. N. ¼ W.	N. ½ E. S. ½ E.	S. ½ W. N. ½ W.	N. ¾ E. S. ¾ E.	S. ¾ W. N. ¾ W.	N. by E. S. by E.	S. by W. N. by W.	N. by E. ¼ E. S. by E. ¼ E.	S. by W. ¼ W. N. by W. ¼ W.	N. by E. ½ E. S. by E. ½ E.	S. by W. ½ W. N. by W. ½ W.	N. by E. ¾ E. S. by E. ¾ E.	S. by W. ¾ W. N. by W. ¾ W.	N. N. E. S. S. E.	S. S. W. N. N. W.
lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.
.9	5.	100.5	9.9	99.9	14.8	99.1	19.7	98.	24.5	96.7	29.3	95.1	34.	93.3	38.7
.9	5.	101.5	10.	100.9	15.	100.	19.9	98.9	24.8	97.6	29.6	96.	34.4	94.2	39.
.9	5.1	102.5	10.1	101.9	15.1	101.	20.1	99.9	25.	98.6	29.9	97.	34.7	95.2	39.4
.9	5.1	103.5	10.2	102.9	15.3	102.	20.3	100.9	25.3	99.5	30.2	97.9	35.	96.1	39.8
.9	5.2	104.5	10.3	103.9	15.4	103.	20.5	101.9	25.5	100.5	30.5	98.9	35.4	97.	40.2
.9	5.2	105.5	10.4	104.9	15.6	104.	20.7	102.8	25.8	101.4	30.8	99.8	35.7	97.9	40.6
.9	5.3	106.5	10.5	105.8	15.7	104.9	20.9	103.8	26.	102.4	31.1	100.7	36.	98.9	40.9
.9	5.3	107.5	10.6	106.8	15.8	105.9	21.1	104.8	26.2	103.3	31.4	101.7	36.4	99.8	41.3
.9	5.3	108.5	10.7	107.8	16.	106.9	21.3	105.7	26.5	104.3	31.6	102.6	36.7	100.7	41.7
.9	5.4	109.5	10.8	108.8	16.1	107.9	21.5	106.7	26.7	105.3	31.9	103.6	37.1	101.6	42.1
.9	5.4	110.5	10.9	109.8	16.3	108.9	21.7	107.7	27.	106.2	32.2	104.5	37.4	102.6	42.5
.9	5.5	111.5	11.	110.8	16.4	109.8	21.9	108.6	27.2	107.2	32.5	105.5	37.7	103.5	42.9
.9	5.5	112.5	11.1	111.8	16.6	110.8	22.	109.6	27.5	108.1	32.8	106.4	38.1	104.4	43.2
.9	5.6	113.5	11.2	112.8	16.7	111.8	22.2	110.6	27.7	109.1	33.1	107.3	38.4	105.3	43.6
.9	5.6	114.4	11.3	113.8	16.9	112.8	22.4	111.6	27.9	110.	33.4	108.3	38.7	106.2	44.
.9	5.7	115.4	11.4	114.7	17.	113.8	22.6	112.5	28.2	111.	33.7	109.2	39.1	107.2	44.4
.9	5.7	116.4	11.5	115.7	17.2	114.8	22.8	113.5	28.4	112.	34.	110.2	39.4	108.1	44.8
.9	5.8	117.4	11.6	116.7	17.3	115.7	23.	114.5	28.7	112.9	34.3	111.1	39.8	109.	45.2
.9	5.8	118.4	11.7	117.7	17.5	116.7	23.2	115.4	28.9	113.9	34.5	112.	40.1	109.9	45.5
.9	5.9	119.4	11.8	118.7	17.6	117.7	23.4	116.4	29.2	114.8	34.8	113.	40.4	110.9	45.9
.9	5.9	120.4	11.9	119.7	17.8	118.7	23.6	117.4	29.4	115.8	35.1	113.9	40.8	111.8	46.3
.9	6.	121.4	12.	120.7	17.9	119.7	23.8	118.3	29.6	116.7	35.4	114.9	41.1	112.7	46.7
.9	6.	122.4	12.1	121.7	18.	120.6	24.	119.3	29.9	117.7	35.7	115.8	41.4	113.6	47.1
.9	6.1	123.4	12.2	122.7	18.2	121.6	24.2	120.3	30.1	118.7	36.	116.8	41.8	114.6	47.5
.8	6.1	124.4	12.3	123.6	18.3	122.6	24.4	121.3	30.4	119.6	36.3	117.7	42.1	115.5	47.8
.8	6.2	125.4	12.4	124.6	18.5	123.6	24.6	122.2	30.6	120.6	36.6	118.6	42.4	116.4	48.2
.8	6.2	126.4	12.4	125.6	18.6	124.6	24.8	123.2	30.9	121.5	36.9	119.6	42.8	117.3	48.6
.8	6.3	127.4	12.5	126.6	18.8	125.5	25.	124.2	31.1	122.5	37.2	120.5	43.1	118.3	49.
.8	6.3	128.4	12.6	127.6	18.9	126.5	25.2	125.1	31.3	123.4	37.4	121.5	43.5	119.2	49.4
.8	6.4	129.4	12.7	128.6	19.1	127.5	25.4	126.1	31.6	124.4	37.7	122.4	43.8	120.1	49.7
.8	6.4	130.4	12.8	129.6	19.2	128.5	25.6	127.1	31.8	125.4	38.	123.3	44.1	121.	50.1
.8	6.5	131.4	12.9	130.6	19.4	129.5	25.8	128.	32.1	126.3	38.3	124.3	44.5	122.	50.5
.8	6.5	132.4	13.	131.6	19.5	130.4	25.9	129.	32.3	127.3	38.6	125.2	44.8	122.9	50.9
.8	6.6	133.4	13.1	132.5	19.7	131.4	26.1	130.	32.6	128.2	38.9	126.2	45.1	123.8	51.3
.8	6.6	134.3	13.2	133.5	19.8	132.4	26.3	131.	32.8	129.2	39.2	127.1	45.5	124.7	51.7
.8	6.7	135.3	13.3	134.5	20.	133.4	26.5	131.9	33.	130.1	39.5	128.	45.8	125.6	52.
.8	6.7	136.3	13.4	135.5	20.1	134.4	26.7	132.9	33.3	131.1	39.8	129.	46.2	126.6	52.4
.8	6.8	137.3	13.5	136.5	20.2	135.3	26.9	133.9	33.5	132.1	40.1	129.9	46.5	127.5	52.8
.8	6.8	138.3	13.6	137.5	20.4	136.3	27.1	134.8	33.8	133.	40.3	130.9	46.8	128.4	53.2
.8	6.9	139.3	13.7	138.5	20.5	137.3	27.3	135.8	34.	134.	40.6	131.8	47.2	129.3	53.6
.8	6.9	140.3	13.8	139.5	20.7	138.3	27.5	136.8	34.3	134.9	40.9	132.8	47.5	130.3	54.
.8	7.	141.3	13.9	140.5	20.8	139.3	27.7	137.7	34.5	135.9	41.2	133.7	47.8	131.2	54.3
.8	7.	142.3	14.	141.5	21.	140.3	27.9	138.7	34.7	136.8	41.5	134.6	48.2	132.1	54.7
.8	7.1	143.3	14.1	142.4	21.1	141.2	28.1	139.7	35.	137.8	41.8	135.6	48.5	133.	55.1
.8	7.1	144.3	14.2	143.4	21.3	142.2	28.3	140.7	35.2	138.8	42.1	136.5	48.8	134.	55.5
.8	7.2	145.3	14.3	144.4	21.4	143.2	28.5	141.6	35.5	139.7	42.4	137.5	49.2	134.9	55.9
.8	7.2	146.3	14.4	145.4	21.6	144.2	28.7	142.6	35.7	140.7	42.7	138.4	49.5	135.8	56.3
.8	7.3	147.3	14.5	146.4	21.7	145.2	28.9	143.6	36.	141.6	43.	139.3	49.9	136.7	56.6
.8	7.3	148.3	14.6	147.4	21.9	146.1	29.1	144.5	36.2	142.6	43.3	140.3	50.2	137.7	57.
.8	7.4	149.3	14.7	148.4	22.	147.1	29.3	145.5	36.4	143.5	43.5	141.2	50.5	138.6	57.4
.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.
W. ¼ S.	E. ¼ S. E. ¼ N.	W. ½ N. W. ½ S.	E. ½ S. E. ½ N.	W. ¾ N. W. ¾ S.	E. ¾ S. E. ¾ N.	W. by N. W. by S.	E. by S. E. by N.	W. by N. ¾ N. W. by S. ¾ S.	E. by S. ¾ S. E. by N. ¾ N.	W. by N. ½ N. W. by S. ½ S.	E. by S. ½ S. E. by N. ½ N.	W. by N. ¼ N. W. by S. ¼ S.	E. by S. ¼ S. E. by N. ¼ N.	W. N. W. W. S. W.	E. S. E. E. N. E.
7¾ Pts.		C. 7½ Pts.		C. 7¼ Pts.		7 Pts.		C. 6¾ Pts.		C. 6½ Pts.		C. 6¼ Pts.		C. 6 Pts.	

C. 2¼ Pts.		C. 2½ Pts.		C. 2¾ Pts.		C. 3 Pts.		C. 3¼ Pts.		C. 3½ Pts.		C. 3¾ Pts.		C. 4 Pts.
N.N.E.¼E. S.S.E.¼E.	S.S.W.¼W. N.N.W.¼W.	N.N.E.½E. S.S.E.½E.	S.S.W.½W. N.N.W.½W.	N.N.E.¾E. S.S.E.¾E.	S.S.W.¾W. N.N.W.¾W.	N.E. by N. S.E. by S.	S.W. by S. N.W. by N.	N.E.¾N. S.E.¾S.	S.W.¾S. N.W.¾N.	N.E.½N. S.E.½S.	S.W.½S. N.W.½N.	N.E.¼N. S.E.¼S.	S.W.¼S. N.W.¼N.	N.E. S.E. S.W. N.W.
d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d . lat.	dep.	d. lat.	dep.	d. lat. dep.
91.3	43.2	89.1	47.6	86.6	51.9	84.	56.1	81.1	60.2	78.1	64.1	74.8	67.8	71.4
92.2	43.6	90.	48.1	87.5	52.4	84.8	56.7	81.9	60.8	78.8	64.7	75.6	68.5	72.1
93.1	44.	90.8	48.6	88.3	53.	85.6	57.2	82.7	61.4	79.6	65.3	76.3	69.2	72.8
94.	44.5	91.7	49.	89.2	53.5	86.5	57.8	83.5	62.	80.4	66.	77.1	69.8	73.5
94.9	44.9	92.6	49.5	90.1	54.	87.3	58.3	84.3	62.5	81.2	66.6	77.8	70.5	74.2
95.8	45.3	93.5	50.	90.9	54.5	88.1	58.9	85.1	63.1	81.9	67.2	78.5	71.2	75.
96.7	45.7	94.4	50.4	91.8	55.	89.	59.4	85.9	63.7	82.7	67.9	79.3	71.9	75.7
97.6	46.2	95.2	50.9	92.6	55.5	89.8	60.	86.7	64.3	83.5	68.5	80.	72.5	76.4
98.5	46.6	96.1	51.4	93.5	56.	90.6	60.6	87.5	64.9	84.3	69.1	80.8	73.2	77.1
99.4	47.	97.	51.9	94.4	56.6	91.5	61.1	88.4	65.5	85.	69.7	81.5	73.9	77.8
100.3	47.5	97.9	52.3	95.2	57.1	92.3	61.7	89.2	66.1	85.8	70.4	82.2	74.5	78.5
101.2	47.9	98.8	52.8	96.1	57.6	93.1	62.2	90.	66.7	86.6	71.1	83.	75.2	79.2
102.2	48.3	99.7	53.3	96.9	58.1	94.	62.8	90.8	67.3	87.4	71.7	83.8	75.9	79.9
103.1	48.7	100.5	53.7	97.8	58.6	94.8	63.3	91.6	67.9	88.1	72.3	84.5	76.6	80.6
104.	49.2	101.4	54.2	98.6	59.1	95.6	63.9	92.4	68.3	88.9	73.	85.2	77.2	81.3
104.9	49.6	102.3	54.7	99.5	59.6	96.5	64.4	93.2	69.1	89.7	73.6	86.	77.9	82.
105.8	50.	103.2	55.2	100.4	60.2	97.3	65.	94.	69.7	90.4	74.2	86.7	78.6	82.7
106.7	50.5	104.1	55.6	101.2	60.7	98.1	65.5	94.8	70.3	91.2	74.9	87.4	79.2	83.4
107.6	50.9	104.9	56.1	102.1	61.2	98.9	66.1	95.6	70 9	92.	75.5	88.2	79.9	84.1
108.5	51.3	105.8	56.6	102.9	61.7	99.8	66.7	96.4	71.5	92.8	76.1	88.9	80.6	84.9
100.4	51.7	106.7	57.	103.8	62.2	100.6	67.2	97.2	72.1	93.5	76.8	89.7	81.3	85.6
110.3	52.2	107.6	57.5	104.6	62.7	101.4	67.8	98.	72.7	94.3	77.4	90.4	81.9	86.3
111.2	52.6	108.5	58.	105.5	63.2	102.3	68.3	98.8	73.3	95.1	78.	91.1	82.6	87.
112 1	53.	109.4	58.5	106.4	63.7	103.1	68.9	99.6	73.9	95.9	78.7	91.9	83.3	87.7
113.	53.4	110.2	58.9	107.2	64.3	103.9	69.4	100.4	74.5	96.6	79.3	92.6	83.9	88.4
113.9	53.9	111.1	59.4	108.1	64.8	104.8	70.	101.2	75.1	97.4	79.9	93.4	84.6	89.1
114.8	54.3	112.	59.9	108.9	65.3	105.6	70.5	102.	75.7	98.2	80.6	94.1	85.3	89.8
115.7	54.7	112.9	60.3	109.8	65.8	106.4	71.1	102.8	76.2	98.9	81.2	94.8	86.	90.5
116.6	55.2	113.8	60.8	110.6	66.3	107.3	71.7	103.6	76.9	99.7	81.8	95.6	86.6	91.2
117.5	55.6	114.6	61.3	111.5	66.8	108.1	72.2	104.4	77.4	100.5	82.5	96.3	87.3	91.9
118.4	56.	115.5	61.8	112.4	67.3	108.9	72.8	105.2	78.	101.3	83.1	97.1	88.	92.6
119.3	56.4	116.4	62.2	113.2	67.9	109.8	73.3	106.	78.6	102.	83.7	97.8	88.6	93.3
120.2	56.9	117.3	62.7	114.1	68.4	110.6	73.9	106.8	79.2	102.8	84.4	98.5	89.3	94.
121.1	57.3	118.2	63.2	114.9	68.9	111.4	74.4	107.6	79.8	103.6	85.	99.3	90.	94.8
122.	57.7	119.1	63.6	115.8	69.4	112.2	75.	108.4	80.4	104.4	85.6	100.	90.7	95.5
122.9	58.1	119.9	64.1	116.7	69.9	113.1	75.5	109.2	81.	105.1	86.3	100.8	91.3	96.2
123.8	58.6	120.8	64.6	117.5	70.4	113.9	76.1	110.	81.6	105.9	86.9	101.5	92.	96.9
124.8	59.	121.7	65.1	118.4	71.	114.7	76.7	110.8	82.2	106.7	87.5	102.3	92.7	97.6
125.7	59.4	122.6	65.5	119.2	71.5	115.6	77.2	111.6	82.8	107.4	88.2	103.	93.3	98.3
126.6	59.9	123.5	66.	120.1	72.	116.4	77.8	112.4	83.4	108.2	88.8	103.7	94.	99.
127.5	60.3	124.4	66.5	120.9	72.5	117.2	78.3	113.3	84.	109.	89.4	104.5	94.7	99.7
128.4	60.7	125.2	66.9	121.8	73.	118.1	78.9	114.1	84.6	109.8	90.1	105.2	95.4	100.4
129.3	61.1	126.1	67.4	122.7	73.5	118.9	79.4	114.9	85.2	110.5	90.7	106.	96.	101.1
130.2	61.6	127	67.9	123.5	74.	119.7	80.	115.7	85.8	111.3	91.4	106.7	96.7	101.8
131.1	62.	127.9	68.4	124.4	74.5	120.6	80.5	116.5	86.4	112.1	92.1	107.4	97.4	102.5
132.	62.4	128.8	68.8	125.2	75.1	121.4	81.1	117.3	87.	112.9	92.6	108.2	98.	103.2
132.9	62.9	129.6	69.3	126.1	75.6	122.2	81.7	118.1	87.6	113.6	93.3	108.9	98.7	103.9
133.8	63.3	130.5	69.8	126.9	76.1	123.1	82.2	118.9	88.2	114.4	93.9	109.7	99.4	104.7
134.7	63.7	131.4	70.2	127.8	76.6	123.9	82.8	119.7	88.8	115.2	94.5	110.4	100.1	105.4
135.6	64.1	132.3	70.7	128.7	77.1	124.7	83.3	120.5	89.4	116.	95.2	111.1	100.7	106.1
dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep. d. lat.
N.W. by W.¾W. S.W. by W.¾W.	S.E. by E.¾E. N.E. by E.¾E.	N.W. by W.½W. S.W. by W.½W.	S.E. by E.½E. N.E. by E.½E.	N.W. by W.¼W. S.W. by W.¼W.	S.E. by E.¼E. N.E. by E.¼E.	N.W. by W. S.W. by W.	S.E. by E. N.E. by E.	N.W.¾W. S.W.¾W.	S.E.¾E. N.E.¾E.	N.W.½W. S.W.½W.	S.E.½E. N.E.½E.	N.W.¼W. S.W.¼W.	S.E.¼E. N.E.¼E.	N.W. S.W. S.E. N.E.
C. 5¾ Pts.		C. 5½ Pts.		C. 5¼ Pts.		C. 5 Pts.		C. 4¾ Pts.		C. 4½ Pts.		C. 4¼ Pts.		C. 4 Pts.

Distance	C. ¼ Pt.		C. ½ Pt.		C. ¾ Pt.		C. 1 Pt.		C. 1¼ Pt.		C. 1½ Pt.		C. 1¾ Pt.		C. 2 Pts.	
	N. ¼ E. S. ¼ E.	S. ¼ W. N. ¼ W.	N. ½ E. S. ½ E.	S. ½ W. N. ½ W.	N. ¾ E. S. ¾ E.	S. ¾ W. N. ¾ W.	N. by E. S. by E.	S. by W. N. by W.	N. by E. ¼ E. S. by E. ¼ E.	S. by W. ¼ W. N. by W. ¼ W.	N. by E. ½ E. S. by E. ½ E.	S. by W. ½ W. N. by W. ½ W.	N. by E. ¾ E. S. by E. ¾ E.	S. by W. ¾ W. N. by W. ¾ W.	N. N. E. S. S. E.	S. S. W. N. N. W.
	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.
151	150.8	7.4	150.3	14.8	149.4	22.2	148.1	29.5	146.5	36.7	144.5	43.8	142.2	50.9	139.5	57.8
152	151.8	7.5	151.3	14.9	150.4	22.3	149.1	29.7	147.4	36.9	145.5	44.1	143.1	51.2	140.4	58.2
153	152.8	7.5	152.3	15.	151.3	22.4	150.1	29.8	148.4	37.2	146.4	44.4	144.1	51.5	141.4	58.6
154	153.8	7.6	153.3	15.1	152.3	22.6	151.	30.	149.4	37.4	147.4	44.7	145.	51.9	142.3	58.9
155	154.8	7.6	154.3	15.2	153.3	22.7	152.	30.2	150.4	37.7	148.3	45.	145.9	52.2	143.2	59.3
156	155.8	7.7	155.2	15.3	154.3	22.9	153.	30.4	151.3	37.9	149.3	45.3	146.9	52.6	144.1	59.7
157	156.8	7.7	156.2	15.4	155.3	23.	154.	30.6	152.3	38.1	150.2	45.6	147.8	52.9	145.	60.1
158	157.8	7.8	157.2	15.5	156.3	23.2	155.	30.8	153.3	38.4	151.2	45.9	148.8	53.2	146.	60.5
159	158.8	7.8	158.2	15.6	157.3	23.3	155.9	31.	154.2	38.6	152.2	46.2	149.7	53.6	146.9	60.8
160	159.8	7.9	159.2	15.7	158.3	23.5	156.9	31.2	155.2	38.9	153.1	46.4	150.6	53.9	147.8	61.2
161	160.8	7.9	160.2	15.8	159.3	23.6	157.9	31.4	156.2	39.1	154.1	46.7	151.6	54.2	148.7	61.6
162	161.8	7.9	161.2	15.9	160.2	23.8	158.9	31.6	157.1	39.4	155.	47.	152.5	54.6	149.7	62.
163	162.8	8.	162.2	16.	161.2	23.9	159.9	31.8	158.1	39.6	156.	47.3	153.5	54.9	150.6	62.4
164	163.8	8.	163.2	16.1	162.2	24.1	160.8	32.	159.1	39.8	156.9	47.6	154.4	55.2	151.5	62.8
165	164.8	8.1	164.2	16.2	163.2	24.2	161.8	32.2	160.1	40.1	157.9	47.9	155.4	55.6	152.4	63.1
166	165.8	8.1	165.2	16.3	164.2	24.4	162.8	32.4	161.	40.3	158.9	48.2	156.3	55.9	153.4	63.5
167	166.8	8.2	166.2	16.4	165.2	24.5	163.8	32.6	162.	40.6	159.8	48.5	157.2	56.3	154.3	63.9
168	167.8	8.2	167.2	16.5	166.2	24.7	164.8	32.8	163.	40.8	160.8	48.8	158.2	56.6	155.2	64.3
169	168.8	8.3	168.2	16.6	167.2	24.8	165.8	33.	163.9	41.1	161.7	49.1	159.1	56.9	156.1	64.7
170	169.8	8.3	169.2	16.7	168.2	24.9	166.7	33.2	164.9	41.3	162.7	49.3	160.1	57.3	157.1	65.1
171	170.8	8.4	170.2	16.8	169.1	25.1	167.7	33.4	165.9	41.5	163.6	49.6	161.	57.6	158.	65.4
172	171.8	8.4	171.2	16.9	170.1	25.2	168.7	33.6	166.8	41.8	164.6	49.9	161.9	57.9	158.9	65.8
173	172.8	8.5	172.2	17.	171.1	25.4	169.7	33.8	167.8	42.	165.6	50.2	162.9	58.3	159.8	66.2
174	173.8	8.5	173.2	17.1	172.1	25.5	170.7	33.9	168.8	42.3	166.5	50.5	163.8	58.6	160.8	66.6
175	174.8	8.6	174.2	17.2	173.1	25.7	171.6	34.1	169.8	42.5	167.5	50.8	164.8	59.	161.7	67.
176	175.8	8.6	175.2	17.3	174.1	25.8	172.6	34.3	170.7	42.8	168.4	51.1	165.7	59.3	162.6	67.4
177	176.8	8.7	176.1	17.3	175.1	26.	173.6	34.5	171.7	43.	169.4	51.4	166.7	59.6	163.5	67.7
178	177.8	8.7	177.1	17.4	176.1	26.1	174.6	34.7	172.7	43.3	170.3	51.7	167.6	60.	164.5	68.1
179	178.8	8.8	178.1	17.5	177.1	26.3	175.6	34.9	173.6	43.5	171.3	52.	168.5	60.3	165.4	68.5
180	179.8	8.8	179.1	17.6	178.1	26.4	176.5	35.1	174.6	43.7	172.2	52.3	169.5	60.6	166.3	68.9
181	180.8	8.9	180.1	17.7	179.	26.6	177.5	35.3	175.6	44.	173.2	52.5	170.4	61.	167.2	69.3
182	181.8	8.9	181.1	17.8	180.	26.7	178.5	35.5	176.5	44.2	174.2	52.8	171.4	61.3	168.1	69.6
183	182.8	9.	182.1	17.9	181.	26.9	179.5	35.7	177.5	44.5	175.1	53.1	172.3	61.7	169.1	70.
184	183.8	9.	183.1	18.	182.	27.	180.5	35.9	178.5	44.7	176.1	53.4	173.2	62.	170.	70.4
185	184.8	9.1	184.1	18.1	183.	27.1	181.4	36.1	179.5	45.	177.	53.7	174.2	62.3	170.9	70.8
186	185.8	9.1	185.1	18.2	184.	27.3	182.4	36.3	180.4	45.2	178.	54.	175.1	62.7	171.8	71.1
187	186.8	9.2	186.1	18.3	185.	27.4	183.4	36.5	181.4	45.4	178.9	54.3	176.1	63.	172.8	71.5
188	187.8	9.2	187.1	18.4	186.	27.6	184.4	36.7	182.4	45.7	179.9	54.6	177.	63.3	173.7	71.9
189	188.8	9.3	188.1	18.5	187.	27.7	185.4	36.9	183.3	45.9	180.9	54.9	178.	63.7	174.6	72.3
190	189.8	9.3	189.1	18.6	187.9	27.9	186.3	37.1	184.3	46.2	181.8	55.2	178.9	64.	175.5	72.7
191	190.8	9.4	190.1	18.7	188.9	28.	187.3	37.3	185.3	46.4	182.8	55.4	179.8	64.3	176.5	73.1
192	191.8	9.4	191.1	18.8	189.9	28.2	188.3	37.5	186.2	46.7	183.7	55.7	180.8	64.7	177.4	73.4
193	192.8	9.5	192.1	18.9	190.9	28.3	189.3	37.7	187.2	46.9	184.7	56.	181.7	65.	178.3	73.8
194	193.8	9.5	193.1	19.	191.9	28.5	190.3	37.8	188.2	47.1	185.6	56.3	182.7	65.4	179.2	74.2
195	194.8	9.6	194.1	19.1	192.9	28.6	191.3	38.	189.2	47.4	186.6	56.6	183.6	65.7	180.2	74.6
196	195.8	9.6	195.1	19.2	193.9	28.8	192.2	38.2	190.1	47.6	187.6	56.9	184.5	66.	181.1	75.
197	196.8	9.7	196.1	19.3	194.9	28.9	193.2	38.4	191.1	47.9	188.5	57.2	185.5	66.4	182.	75.4
198	197.8	9.7	197.	19.4	195.9	29.1	194.2	38.6	192.1	48.1	189.5	57.5	186.4	66.7	182.9	75.8
199	198.8	9.8	198.	19.5	196.8	29.2	195.2	38.8	193.	48.4	190.4	57.8	187.4	67.	183.9	76.2
200	199.8	9.8	199.	19.6	197.8	29.3	196.2	39.	194.	48.6	191.4	58.1	188.3	67.4	184.8	76.5
	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.
Distance.	W. ¼ N. W. ¼ S.	E. ¼ S. E. ¼ N.	W. ½ N. W. ½ S.	E. ½ S. E. ½ N.	W. ¾ N. W. ¾ S.	E. ¾ S. E. ¾ N.	W. by N. W. by S.	E. by S. E. by N.	W. by N. ¼ N. W. by S. ¼ S.	E. by S. ¼ S. E. by N. ¼ N.	W. by N. ½ N. W. by S. ½ S.	E. by S. ½ S. E. by N. ½ N.	W. by N. ¾ N. W. by S. ¾ S.	E. by S. ¾ S. E. by N. ¾ N.	W. N. W. W. S. W.	E. S. E. E. N. E.
	C. 7¾ Pts.		C. 7½ Pts.		C. 7¼ Pts.		C. 7 Pts.		C. 6¾ Pts.		C. 6½ Pts.		C. 6¼ Pts.		C. 6 Pts.	

C. 2¼ Pts.		C. 2½ Pts.		C. 2¾ Pts.		C. 3 Pts.		C. 3¼ Pts.		C. 3½ Pts.		C. 3¾ Pts.		C. 4 Pts.	
N.N.E.¼E. S.S.E.¼E.	S.S.W.¼W. N.N.W.¼W.	N.N.E.½E. S.S.E.½E.	S.S.W.½W. N.N.W.½W.	N.N.E.¾E. S.S.E.¾E.	S.S.W.¾W. N.N.W.¾W.	N.E. by N. S.E. by S.	S.W. by S. N.W. by N.	N.E.¾N. S.E.¾S.	S.W.¾S. N.W.¾N.	N.E.½N. S.E.½S.	S.W.½S. N.W.½N.	N.E.¼N. S.E.¼S.	S.W.¼S. N.W.¼N.	N.E. S.E. S.W. N.W.	Distance.
d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat. dep.	
136.5	64.6	133.2	71.2	129.5	77.6	125.6	83.9	121.3	90.	116.7	95.8	111.9	101.4	106.8	151
137.4	65.	134.1	71.7	130.4	78.1	126.4	84.4	122.1	90.5	117.5	96.4	112.6	102.1	107.5	152
138.3	65.4	134.9	72.1	131.2	78.7	127.2	85.	122.9	91.1	118.3	97.1	113.4	102.7	108.2	153
139.2	65.8	135.8	72.6	132.1	79.2	128.	85.5	123.7	91.7	119.	97.7	114.1	103.4	108.9	154
140.1	66.3	136.7	73.1	132.9	79.7	128.9	86.1	124.5	92.3	119.8	98.3	114.8	104.1	109.6	155
141.	66.7	137.6	73.5	133.8	80.2	129.7	86.7	125.3	92.9	120.6	99.	115.6	104.8	110.3	156
141.9	67.1	138.5	74.	134.7	80.7	130.5	87.2	126.1	93.5	121.4	99.6	116.3	105.4	111.	157
142.8	67.6	139.3	74.5	135.5	81.2	131.4	87.8	126.9	94.1	122.1	100.2	117.1	106.1	111.7	158
143.7	68.	40.2	75.	136.4	81.7	132.2	88.3	127.7	94.7	122.9	100.9	117.8	106.8	112.4	159
144.6	68.4	141.1	75.4	137.2	82.3	133.	88.9	128.5	95.3	123.7	101.5	118.6	107.4	113.1	160
145.5	68.8	142.	75.9	138.1	82.8	133.9	89.4	129.3	95.9	124.5	102.1	119.3	108.1	113.8	161
146.4	69.3	142.9	76.4	139.	83.3	134.7	90.	130.1	96.5	125.2	102.8	120.	108.8	114.6	162
147.4	69.7	143.8	76.8	139.8	83.8	135.5	90.5	130.9	97.1	126.	103.4	120.8	109.5	115.3	163
148.3	70.1	144.6	77.3	140.7	84.3	136.4	91.1	131.7	97 7	126.8	104.	121.5	110.1	116.	164
149.2	70.5	145.5	77.8	141.5	84.8	137.2	91.7	132.5	98.3	127.5	104.7	122.3	110.8	116.7	165
150.1	71.	146.4	78.3	142.4	85.3	138.	92.2	133.3	98.9	128.3	105.3	123.	111.5	117.4	166
151.	71.4	147.3	78.7	143.2	85.9	138.9	92.8	134.1	99.5	129.1	105.9	123.7	112.2	118.1	167
151.9	71.8	148.2	79.2	144.	86.4	139.7	93.3	134.9	100.1	129.9	106.6	124.5	112.8	118.8	168
152.8	72.3	149.	79.7	144.9	86.9	140.6	93.9	135.7	100.7	130.6	107.2	125.2	113.5	119.5	169
153.7	72.7	149.9	80.1	145.8	87.4	141.4	94.4	136.5	101.3	131.4	107.8	126.	114.2	120.2	170
154.6	73.1	150.8	80.6	146.7	87.9	142.2	95.	137.3	101.9	132.2	108.5	126.7	114.8	120.9	171
155.5	73.5	151.7	81.1	147.5	88.4	143.	95.5	138.2	102.5	133.	109.1	127.4	115.5	121.6	172
156.4	74.	152.6	81.6	148.4	88.9	143.8	96.1	139.	103.1	133.7	109.8	128.2	116.2	122.3	173
157.3	74.4	153.5	82.	149.2	89.5	144.7	96.7	139.8	103.7	134.5	110.4	128.9	116.9	123.	174
158.2	74.8	154.3	82.5	150.1	90.	145.5	97.2	140.6	104.2	135.3	111.	129.7	117.5	123.7	175
159.1	75.3	155.2	83.	151.	90.5	46.3	97.8	141.4	104.8	136.	111.7	130.4	118.2	124.5	176
160.	75.7	156.1	83.4	151.8	91.	147.2	98.3	142.2	105.4	136.8	112.3	131.1	118.9	125.2	177
160.9	76.1	157.	83.9	152.7	91.5	148.	98.9	143.	106.	137.6	112.9	131.9	119.5	125.9	178
161.8	76.5	157.9	84.4	153.5	92.	148.8	99.4	143.8	106.6	138.4	113.6	132.6	120.2	126.6	179
162.7	77.	158.7	84.9	154.4	92.5	149.7	100.	144.6	107.2	139.1	114.2	133.4	120.9	127.3	180
163.6	77.4	159.6	85.3	155.2	93.1	150.5	100.5	145.4	107.8	139.9	114.8	134.1	121.6	128.	181
164.5	77.8	160.5	85.8	156.1	93.6	151.3	101.1	146.2	108.4	140.7	115.5	134.9	122.2	128.7	182
165.4	78.2	161.4	86.3	157.	94.1	152.2	101.7	147.	109.	141.5	116.1	135.6	122.9	129.4	183
166.3	78.7	162.3	86.7	157.8	94.6	153.	102.2	147.8	109.6	142.2	116.7	136.3	123.6	130.1	184
167.2	79.1	163.2	87.2	158.7	95.1	153.8	102.8	148.6	110.2	143.	117.4	137.1	124.2	130.8	185
168.1	79.5	164.	87.7	159.5	95.6	154.7	103.3	149.4	110.8	143.8	118.	137.8	124.9	131.5	186
169.	80.	164.9	88.2	160.4	96.1	155.5	103.9	150.2	111.4	144.6	118.6	138.6	125.6	132.2	187
169.9	80.4	165.8	88.6	161.3	96.7	156.3	104.4	151.	112.	145.3	119.3	139.3	126.3	132.9	188
170.9	80.8	166.7	89.1	162.1	97.2	157.1	105.	151.8	112.6	146.1	119.9	140,	126.9	133 6	189
171.8	81.2	167.6	89.6	163.	97.7	158.	105.5	152.6	113.2	146.9	120.5	140.8	127 6	134.4	190
172.7	81.7	168.4	90.	163.8	98.2	158.8	106.1	153.4	113.8	147.6	121.2	141.5	128.3	135.1	191
173.6	82.1	169.3	90.5	164.7	98.7	159.6	106.7	154.2	114.4	148.4	121.8	142.3	128.9	135.8	192
174.5	82.5	170.2	91.	165.5	99.2	160.5	107.2	155.	115.	149.2	122.4	143.	129.6	136.5	193
175.4	82.9	171.1	91.5	166.4	99.7	161.3	107.8	155.8	115.6	150.	123.1	143.7	130.3	137.2	194
176.3	83.4	172.	91.9	167.3	100.3	162.1	108.3	156.6	116.2	150.7	123.7	144.5	131.	137.9	195
177.2	83.8	172.9	92.4	168.1	100.8	163.	108.9	157.4	116.8	151.5	124.3	145.2	131.6	138.6	196
178.1	84.2	173.7	92.9	169.	101.3	163.8	109.4	158.2	117.4	152.3	125.	146.	132.3	139.3	197
179.	84.7	174.6	93.3	169.8	101.8	164 6	110.	159.	117 9	153.1	125.6	146.7	133.	140.	198
179.9	85.1	175.5	93.8	170.7	102.3	165.5	110.5	159.8	118.5	153.8	126.2	147.4	133.6	140.7	199
180.8	85 5	176.4	94.3	171.5	102.8	166.3	111.1	160.6	119.1	154.6	126.9	148.2	134.3	141.4	200
dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep. d. lat.	Distance.
N.W. by W.¾W. S.W. by W.¾W.	S.E. by E.¾E. N.E. by E.¾E.	N.W. by W.½W. S.W. by W.½W.	S.E. by E.½E. N.E. by E.½E.	N.W. by W.¼W. S.W. by W.¼W.	S.E. by E.¼E. N.E. by E.¼E.	N.W. by W. S.W. by W.	S.E. by E. N.E. by E.	N.W.¾W. S.W.¾W.	S.E.¾E. N.E.¾E.	N.W.½W. S.W.½W.	S.E.½E. N.E.½E.	N.W.¼W. S.W.¼W.	S.E.¼E. N.E.¼E.	N.W. S.W. S.E. N.E.	
C. 5¾ Pts.		C. 5½ Pts.		C. 5¼ Pts.		C. 5 Pts.		C. 4¾ Pts.		C. 4½ Pts.		C. 4¼ Pts.		C. 4 Pts.	

Distance	C. ¼ Pt.		C. ½ Pt.		C. ¾ Pt.		C. 1 Pt.		C. 1¼ Pt.		C. 1½ Pt.		C. 1¾ Pt.		C. 2 Pts.	
	N. ¼ E. S. ¼ E.	S. ¼ W. N. ¼ W.	N. ½ E. S. ½ E.	S. ½ W. N. ½ W.	N. ¾ E. S. ¾ E.	S. ¾ W. N. ¾ W.	N. by E. S. by E.	S. by W. N. by W.	N. by E. ¼ E. S. by E. ¼ E.	S. by W. ¼ W. N. by W. ¼ W.	N. by E. ½ E. S. by E. ½ E.	S. by W. ½ W. N. by W. ½ W.	N. by E. ¾ E. S. by E. ¾ E.	S. by W. ¾ W. N. by W. ¾ W.	N. N. E. S. S. E.	S. S. W. N. N. W.
	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.
201	200.8	9.9	200.	19.7	198.8	29.5	197.1	39.2	195.	48.8	192.3	58.3	189.3	67.7	185.7	76.9
202	201.8	9.9	201.	19.8	199.8	29.6	198.1	39.4	195.9	49.1	193.3	58.6	190.2	68.1	186.6	77.3
203	202.8	10.	202.	19.9	200.8	29.8	199.1	39.6	196.9	49.3	194.3	58.9	191.1	68.4	187.5	77.7
204	203.8	10.	203.	20.	201.8	29.9	200.1	39.8	197.9	49.6	195.2	59.2	192.1	68.7	188.5	78.1
205	204.8	10.1	204.	20.1	202.8	30.1	201.1	40.	198.9	49.8	196.2	59.5	193.	69.1	189.4	78.5
206	205.8	10.1	205.	20.2	203.8	30.2	202.	40.2	199.8	50.1	197.1	59.8	194.	69.4	190.3	78.8
207	206.8	10.2	206.	20.3	204.8	30.4	203.	40.4	200.8	50.3	198.1	60.1	194.9	69.7	191.2	79.2
208	207.7	10.2	207.	20.4	205.7	30.5	204.	40.6	201.8	50.5	199.	60.4	195.8	70.1	192.2	79.6
209	208.7	10.3	208.	20.5	206.7	30.7	205.	40.8	202.7	50.8	200.	60.7	196.8	70.4	193.1	80.
210	209.7	10.3	209.	20.6	207.7	30.8	206.	41.	203.7	51.	201.	61.	197.7	70.7	194.	80.4
211	210.7	10.4	210.	20.7	208.7	31.	206.9	41.2	204.7	51.3	201.9	61.3	198.7	71.1	194.9	80.7
212	211.7	10.4	211.	20.8	209.7	31.1	207.9	41.4	205.6	51.5	202.9	61.5	199.6	71.4	195.9	81.1
213	212.7	10.5	212.	20.9	210.7	31.3	208.9	41.6	206.6	51.8	203.8	61.8	200.5	71.8	196.8	81.5
214	213.7	10.5	213.	21.	211.7	31.4	209.9	41.7	207.6	52.	204.8	62.1	201.5	72.1	197.7	81.9
215	214.7	10.5	214.	21.1	212.7	31.5	210.9	41.9	208.6	52.2	205.7	62.4	202.4	72.4	198.6	82.3
216	215.7	10.6	215.	21.2	213.7	31.7	211.8	42.1	209.5	52.5	206.7	62.7	203.4	72.8	199.6	82.7
217	216.7	10.6	216.	21.3	214.7	31.8	212.8	42.3	210.5	52.7	207.7	63.	204.3	73.1	200.5	83.
218	217.7	10.7	217.	21.4	215.6	32.	213.8	42.5	211.5	53.	208.6	63.3	205.3	73.4	201.4	83.4
219	218.7	10.7	217.9	21.5	216.6	32.1	214.8	42.7	212.4	53.2	209.6	63.6	206.2	73.8	202.3	83.8
220	219.7	10.8	218.9	21.6	217.6	32.3	215.8	42.9	213.4	53.5	210.5	63.9	207.1	74.1	203.3	84.2
221	220.7	10.8	219.9	21.7	218.6	32.4	216.8	43.1	214.4	53.7	211.5	64.2	208.1	74.5	204.2	84.6
222	221.7	10.8	220.9	21.8	219.6	32.6	217.7	43.3	215.3	53.9	212.4	64.4	209.	74.8	205.1	85.
223	222.7	10.9	221.9	21.9	220.6	32.7	218.7	43.5	216.3	54.2	213.4	64.7	210.	75.1	206.	85.3
224	223.7	11.	222.9	22.	221.6	32.9	219.7	43.7	217.3	54.4	214.4	65.	210.9	75.5	206.9	85.7
225	224.7	11.	223.9	22.1	222.6	33.	220.7	43.9	218.3	54.7	215.3	65.3	211.8	75.8	207.9	86.1
226	225.7	11.1	224.9	22.2	223.6	33.2	221.7	44.1	219.2	54.9	216.3	65.6	212.8	76.1	208.8	86.5
227	226.7	11.1	225.9	22.2	224.5	33.3	222.6	44.3	220.2	55.2	217.2	65.9	213.7	76.5	209.7	86.9
228	227.7	11.2	226.9	22.3	225.5	33.5	223.6	44.5	221.2	55.4	218.2	66.2	214.7	76.8	210.6	87.3
229	228.7	11.2	227.9	22.4	226.5	33.6	224.6	44.7	222.1	55.6	219.1	66.5	215.6	77.1	211.6	87.6
230	229.7	11.3	228.9	22.5	227.5	33.7	225.6	44.9	223.1	55.9	220.1	66.8	216.6	77.5	212.5	88.
231	230.7	11.3	229.9	22.6	228.5	33.9	226.6	45.1	224.1	56.1	221.1	67.1	217.5	77.8	213.4	88.4
232	231.7	11.4	230.9	22.7	229.5	34.	227.5	45.3	225.	56.4	222.	67.3	218.4	78.2	214.3	88.8
233	232.7	11.4	231.9	22.8	230.5	34.2	228.5	45.5	226.	56.6	223.	67.6	219.4	78.5	215.3	89.2
234	233.7	11.5	232.9	22.9	231.5	34.3	229.5	45.7	227.	56.9	223.9	67.9	220.3	78.8	216.2	89.5
235	234.7	11.5	233.9	23.	232.5	34.5	230.5	45.8	228.	57.1	224.9	68.2	221.3	79.2	217.1	89.9
236	235.7	11.6	234.9	23.1	233.4	34.6	231.5	46.	228.9	57.3	225.8	68.5	222.2	79.5	218.	90.3
237	236.7	11.6	235.9	23.2	234.4	34.8	232.4	46.2	229.9	57.6	226.8	68.8	223.1	79.8	219.	90.7
238	237.7	11.7	236.9	23.3	235.4	34.9	233.4	46.4	230.9	57.8	227.8	69.1	224.1	80.2	219.9	91.1
239	238.7	11.7	237.8	23.4	236.4	35.1	234.4	46.6	231.8	58.1	228.7	69.4	225.	80.5	220.8	91.5
240	239.7	11.8	238.8	23.5	237.4	35.2	235.4	46.8	232.8	58.3	229.7	69.7	226.	80.9	221.7	91.8
241	240.7	11.8	239.8	23.6	238.4	35.3	236.4	47.	233.8	58.6	230.6	70.	226.9	81.2	222.7	92.2
242	241.7	11.9	240.8	23.7	239.4	35.5	237.4	47.2	234.7	58.8	231.6	70.2	227.9	81.5	223.6	92.6
243	242.7	11.9	241.8	23.8	240.4	35.7	238.3	47.4	235.7	59.	232.5	70.5	228.8	81.9	224.5	93.
244	243.7	12.	242.8	23.9	241.4	35.8	239.3	47.6	236.7	59.3	233.5	70.8	229.7	82.2	225.4	93.4
245	244.7	12.	243.8	24.	242.3	35.9	240.3	47.8	237.7	59.5	234.5	71.1	230.7	82.5	226.4	93.8
246	245.7	12.1	244.8	24.1	243.3	36.1	241.3	48.	238.6	59.8	235.4	71.4	231.6	82.9	227.3	94.1
247	246.7	12.1	245.8	24.2	244.3	36.2	242.3	48.2	239.6	60.	236.4	71.7	232.6	83.2	228.2	94.5
248	247.7	12.2	246.8	24.3	245.3	36.4	243.3	48.4	240.6	60.3	237.3	72.	233.5	83.5	229.1	94.9
249	248.7	12.2	247.8	24.4	246.3	36.5	244.2	48.6	241.5	60.5	238.3	72.3	234.4	83.9	230.	95.3
250	249.7	12.3	248.8	24.5	247.3	36.7	245.2	48.8	242.5	60.7	239.2	72.6	235.4	84.2	231.	95.7
	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.
Distance.	W. ¾ N. W. ¾ S.	E. ¾ S. E. ¾ N.	W. ½ N. W. ½ S.	E. ½ S. E. ½ N.	W. ¼ N. W. ¼ S.	E. ¼ S. E. ¼ N.	W. by N. W. by S.	E. by S. E. by N.	W. by N. ¾ N. W. by S. ¾ S.	E. by S. ¾ S. E. by N. ¾ N.	W. by N. ½ N. W. by S. ½ S.	E. by S. ½ S. E. by N. ½ N.	W. by N. ¼ N. W. by S. ¼ S.	E. by S. ¼ S. E. by N. ¼ N.	W. N. W. W. S. W.	E. S. E. E. N. E.
	C. 7¾ Pts.		C. 7½ Pts.		C. 7¼ Pts.		C. 7 Pts.		C. 6¾ Pts.		C. 6½ Pts.		C. 6¼ Pts.		C. 6 Pts.	

C. 2¼ Pts.		C. 2½ Pts.		C. 2¾ Pts.		C. 3 Pts.		C. 3¼ Pts.		C. 3½ Pts.		C. 3¾ Pts.		C. 4 Pts.	
N. N. E. ¼ E. S. S. E. ¼ E.	S. S. W. ¼ W. N. N. W. ¼ W.	N. N. E. ½ E. S. S. E. ½ E.	S. S. W. ½ W. N. N. W. ½ W.	N. N. E. ¾ E. S. S. E. ¾ E.	S. S. W. ¾ W. N. N. W. ¾ W.	N. E. by N. S. E. by S.	S. W. by S. N. W. by N.	N. E. ¾ N. S. E. ¾ S.	S. W. ¾ S. N. W. ¾ N.	N. E. ½ N. S. E. ½ S.	S. W. ½ S. N. W. ½ N.	N. E. ¼ N. S. E. ¼ S.	S. W. ¼ S. N. W. ¼ N.	N. E. S. E. S. W. N. W.	Distance.
d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat dep.	
181.7	85.9	177.3	94.8	172.4	103.3	167.1	111.7	161.4	119.7	155.4	127.5	148.9	135.	142.1	201
182.6	86.4	178.1	95.2	173.3	103.8	168.	112.2	162.4	120.3	156.1	128.1	149.7	135.7	142.8	202
183.5	86.8	179.	95.7	174.1	104.4	168.8	112.8	163.1	120.9	156.9	128.8	150.4	136.3	143.5	203
184.4	87.2	179.9	96.2	175.	104.9	169.6	113.3	163.9	121.5	157.7	129.4	151.2	137.	144.2	204
185.3	87.6	180.8	96.6	175.8	105.4	170.5	113.9	164.7	122.1	158.5	130.1	151.9	137.7	145.	205
186.2	88.1	181.7	97.1	176.7	105.9	171.3	114.4	165.5	122.7	159.2	130.7	152.6	138.3	145.7	206
187.1	88.5	182.6	97.7	177.5	106.4	172.1	115.	166.3	123.3	160.	131.3	153.4	139.	146.4	207
188.	88.9	183.4	98.1	178.4	106.9	172.9	115.5	167.1	123.9	160.8	132.	154.1	139.7	147.1	208
188.9	89.4	184.3	98.5	179.3	107.4	173.8	116.1	167.9	124.5	161.6	132.6	154.9	140.4	147.8	209
189.8	89.8	185.2	99.	180.1	108.	174.6	116.7	168.7	125.1	162.3	133.2	155.6	141.	148.5	210
190.7	90.2	186.1	99.5	181.	108.5	175.4	117.2	169.5	125.7	163.1	133.9	156.3	141.7	149.2	211
191.6	90.6	187.	99.9	181.8	109.	176.3	117.8	170.3	126.3	163.9	134.5	157.1	142.4	149.9	212
192.5	91.1	187.8	100.4	182.7	109.5	177.1	118.3	171.1	126.9	164.7	135.1	157.8	143.	150.6	213
193.5	91.5	188.7	100.9	183.6	110.	177.9	118.9	171.9	127.5	165.4	135.8	158.6	143.7	151.3	214
194.4	91.9	189.6	101.4	184.4	110.5	178.8	119.4	172.7	128.1	166.2	136.4	159.3	144.4	152.	215
195.3	92.4	190.5	101.8	185.3	111.	179.6	120.	173.5	128.7	167.	137.	160.	145.1	152.7	216
196.2	92.8	191.4	102.3	186.1	111.6	180.4	120.5	174.3	129.3	167.7	137.7	160.8	145.7	153.4	217
197.1	93.2	192.3	102.8	187.	112.1	181.3	121.1	175.1	129.9	168.5	138.3	161.5	146.4	154.1	218
198.	93.6	193.1	103.2	187.8	112.6	182.1	121.7	175.9	130.5	169.3	138.9	162.3	147.1	154.9	219
198.9	94.1	194.	103.7	188.7	113.1	182.9	122.2	176.7	131.1	170.1	139.6	163.	147.7	155.6	220
199.8	94.5	194.9	104.2	189.6	113.6	183.8	122.8	177.5	131.6	170.8	140.2	163.8	148.4	156.3	221
200.7	94.9	195.8	104.7	190.4	114.1	184.6	123.3	178.3	132.2	171.6	140.8	164.5	149.1	157.	222
201.6	95.3	196.7	105.1	191.3	114.6	185.4	123.9	179.1	132.8	172.4	141.5	165.2	149.8	157.7	223
202.5	95.8	197.6	105.6	192.1	115.2	186.2	124.4	179.9	133.4	173.2	142.1	166.	150.4	158.4	224
203.4	96.2	198.4	106.1	193.	115.7	187.1	125.	180.7	134.	173.9	142.7	166.7	151.1	159.1	225
204.3	96.6	199.3	106.5	193.8	116.2	187.9	125.5	181.5	134.6	174.7	143.4	167.5	151.8	159.8	226
205.2	97.1	200.2	107.	194.7	116.7	188.7	126.1	182.3	135.2	175.5	144.	168.2	152.4	160.5	227
206.1	97.5	201.1	107.5	195.6	117.2	189.6	126.7	183.1	135.8	176.2	144.6	168.9	153.1	161.2	228
207.	97.9	202.	107.9	196.4	117.7	190.4	127.2	183.9	136.4	177.	145.3	169.7	153.8	161.9	229
207.9	98.3	202.8	108.4	197.3	118.2	191.2	127.8	184.7	137.	177.8	145.9	170.4	154.5	162.6	230
208.8	98.8	203.7	108.9	198.1	118.8	192.1	128.3	185.5	137.6	178.6	146.5	171.2	155.1	163.3	231
209.7	99.2	204.6	109.4	199.	119.3	192.9	128.9	186.3	138.2	179.3	147.2	171.9	155.8	164.	232
210.6	99.6	205.5	109.8	199.9	119.8	193.7	129.4	187.1	138.8	180.1	147.8	172.6	156.5	164.8	233
211.5	100.	206.4	110.3	200.7	120.3	194.6	130.	188.	139.4	180.9	148.4	173.4	157.1	165.5	234
212.4	100.5	207.3	110.8	201.6	120.8	195.4	130.5	188.8	140.	181.7	149.1	174.1	157.8	166.2	235
213.3	100.9	208.1	111.2	202.4	121.3	196.2	131.1	189.6	140.6	182.4	149.7	174.9	158.5	166.9	236
214.2	101.3	209.	111.7	203.3	121.8	197.1	131.7	190.4	141.2	183.2	150.4	175.6	159.2	167.6	237
215.1	101.8	209.9	112.2	204.1	122.4	197.9	132.2	191.2	141.8	184.	151.	176.3	159.8	168.3	238
216.1	102.2	210.8	112.7	205.	122.9	198.7	132.8	192.	142.4	184.7	151.6	177.1	160.5	169.	239
217.	102.6	211.7	113.1	205.9	123.4	199.6	133.3	192.8	143.	185.5	152.3	177.8	161.2	169.7	240
217.9	103.	212.5	113.6	206.7	123.9	200.4	133.9	193.6	143.6	186.3	152.9	178.6	161.8	170.4	241
218.8	103.5	213.4	114.1	207.6	124.4	201.2	134.4	194.4	144.2	187.1	153.5	179.3	162.5	171.1	242
219.7	103.9	214.3	114.5	208.4	124.9	202.	135.	195.2	144.8	187.8	154.2	180.1	163.2	171.8	243
220.6	104.3	215.2	115.	209.3	125.4	202.9	135.5	196.	145.4	188.6	154.8	180.8	163.9	172.5	244
221.5	104.8	216.1	115.5	210.1	126.	203.7	136.1	196.8	145.9	189.4	155.4	181.5	164.5	173.2	245
222.4	105.2	217.	116.	211.	126.5	204.5	136.7	197.6	146.5	190.2	156.1	182.3	165.2	173.9	246
223.3	105.6	217.8	116.4	211.9	127.	205.4	137.2	198.4	147.1	190.9	156.7	183.	165.9	174.7	247
224.2	106.	218.7	116.9	212.7	127.5	206.2	137.8	199.2	147.7	191.7	157.3	183.8	166.5	175.4	248
225.1	106.5	219.6	117.4	213.6	128.	207.	138.3	200.	148.3	192.5	158.	184.5	167.2	176.1	249
226.	106.9	220.5	117.8	214.4	128.5	207.9	138.9	200.8	148.9	193.3	158.6	185.2	167.9	176.8	250
dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep. d. lat.	
N. W. by W. ¼ W. S. W. by W. ¼ W.	S. E. by E. ¼ E. N. E. by E. ¼ E.	N. W. by W. ½ W. S. W. by W. ½ W.	S. E. by E. ½ E. N. E. by E. ½ E.	N. W. by W. ¾ W. S. W. by W. ¾ W.	S. E. by E. ¾ E. N. E. by E. ¾ E.	N. W. by W. S. W. by W.	S. E. by E. N. E. by E.	N. W. ¾ W. S. W. ¾ W.	S. E. ¾ E. N. E. ¾ E.	N. W. ½ W. S. W. ½ W.	S. E. ½ E. N. E. ½ E.	N. W. ¼ W. S. W. ¼ W.	S. E. ¼ E. N. E. ¼ E.	N. W. S. W. S. E. N. E.	Distance.
C. 5¾ Pts.		C. 5½ Pts.		C. 5¼ Pts.		C. 5 Pts.		C. 4¾ Pts.		C. 4½ Pts.		C. 4¼ Pts.		C. 4 Pts.	

Distance.	C. ¼ Pt.		C. ½ Pt.		C. ¾ Pt.		C. 1 Pt.		C. 1¼ Pt.		C. 1½ Pt.		C. 1¾ Pt.		C. 2 Pts.	
	N. ¼ E. S. ¼ E.	S. ¼ W. N. ¼ W.	N. ½ E. S. ½ E.	S. ½ W. N. ½ W.	N. ¾ E. S. ¾ E.	S. ¾ W. N. ¾ W.	N. by E. S. by E.	S. by W. N. by W.	N. by E. ¼ E. S. by E. ¼ E.	S. by W. ¼ W. N. by W. ¼ W.	N. by E. ½ E. S. by E. ½ E.	S. by W. ½ W. N. by W. ½ W.	N. by E. ¾ E. S. by E. ¾ E.	S. by W. ¾ W. N. by W. ¾ W.	N. N. E. S. S. E.	S. S. W. N. N. W.
	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.
251	250.7	12.3	249.8	24.6	248.3	36.8	246.2	49.	243.5	61.	240.2	72.9	236.3	84.6	231.9	96.1
252	251.7	12.4	250.8	24.7	249.3	37.	247.2	49.2	244.4	61.2	241.1	73.2	237.3	84.9	232.8	96.4
253	252.7	12.4	251.8	24.8	250.3	37.1	248.1	49.4	245.4	61.5	242.1	73.4	238.2	85.2	233.7	96.8
254	253.7	12.5	252.8	24.9	251.3	37.3	249.1	49.6	246.4	61.7	243.1	73.7	239.2	85.6	234.7	97.2
255	254.7	12.5	253.8	25.	252.2	37.4	250.1	49.7	247.4	62.	244.	74.	240.1	85.9	235.6	97.6
256	255.7	12.6	254.8	25.1	253.2	37.6	251.1	49.9	248.3	62.2	245.	74.3	241.	86.2	236.5	98.
257	256.7	12.6	255.8	25.2	254.2	37.7	252.1	50.1	249.3	62.5	245.9	74.6	242.	86.6	237.4	98.3
258	257.7	12.7	256.8	25.3	255.2	37.9	253.	50.3	250.3	62.7	246.9	74.9	242.9	86.9	238.4	98.7
259	258.7	12.7	257.8	25.4	256.2	38.	254.	50.5	251.2	62.9	247.8	75.2	243.9	87.3	239.3	99.1
260	259.7	12.8	258.7	25.5	257.2	38.1	255.	50.7	252.2	63.2	248.8	75.5	244.8	87.6	240.2	99.5
261	260.7	12.8	259.7	25.6	258.2	38.3	256.	50.9	253.2	63.4	249.8	75.8	245.7	87.9	241.1	99.9
262	261.7	12.9	260.7	25.7	259.2	38.4	257.	51.1	254.1	63.7	250.7	76.1	246.7	88.3	242.1	100.3
263	262.7	12.9	261.7	25.8	260.2	38.6	257.9	51.3	255.1	63.9	251.7	76.3	247.6	88.6	243.	100.6
264	263.7	13.	262.7	25.9	261.1	38.7	258.9	51.5	256.1	64.1	252.6	76.6	248.6	88.9	243.9	101.
265	264.7	13.	263.7	26.	262.1	38.9	259.9	51.7	257.	64.4	253.6	76.9	249.5	89.3	244.8	101.4
266	265.7	13.1	264.7	26.1	263.1	39.	260.9	51.9	258.	64.6	254.5	77.2	250.5	89.6	245.8	101.8
267	266.7	13.1	265.7	26.2	264.1	39.2	261.9	52.1	259.	64.9	255.5	77.5	251.4	89.9	246.7	102.2
268	267.7	13.2	266.7	26.3	265.1	39.3	262.9	52.3	259.9	65.1	256.5	77.8	252.3	90.3	247.6	102.6
269	268.7	13.2	267.7	26.4	266.1	39.5	263.8	52.5	260.9	65.4	257.4	78.1	253.3	90.6	248.5	102.9
270	269.7	13.2	268.7	26.5	267.1	39.6	264.8	52.7	261.9	65.6	258.4	78.4	254.2	91.	249.4	103.3
271	270.7	13.3	269.7	26.6	268.1	39.8	265.8	52.9	262.8	65.8	259.3	78.7	255.2	91.3	250.4	103.7
272	271.7	13.3	270.7	26.7	269.1	39.9	266.8	53.1	263.8	66.1	260.3	79.	256.1	91.6	251.3	104.1
273	272.7	13.4	271.7	26.8	270.	40.1	267.8	53.3	264.8	66.3	261.2	79.2	257.	92.	252.2	104.5
274	273.7	13.4	272.7	26.9	271.	40.2	268.7	53.5	265.8	66.6	262.2	79.5	258.	92.3	253.1	104.9
275	274.7	13.5	273.7	27.	272.	40.4	269.7	53.6	266.7	66.8	263.2	79.8	258.9	92.6	254.1	105.2
276	275.7	13.5	274.7	27.1	273.	40.5	270.7	53.8	267.7	67.1	264.1	80.1	259.9	93.	255.	105.6
277	276.7	13.6	275.7	27.2	274.	40.6	271.7	54.	268.7	67.3	265.1	80.4	260.8	93.3	255.9	106.
278	277.7	13.6	276.7	27.2	275.	40.8	272.7	54.2	269.6	67.5	266.	80.7	261.7	93.7	256.8	106.4
279	278.7	13.7	277.7	27.3	276.	40.9	273.6	54.4	270.6	67.8	267.	81.	262.7	94.	257.8	106.8
280	279.7	13.7	278.7	27.4	277.	41.1	274.6	54.6	271.6	68.	267.9	81.3	263.6	94.3	258.7	107.2
281	280.7	13.8	279.6	27.5	278.	41.2	275.6	54.8	272.5	68.3	268.9	81.6	264.6	94.7	259.6	107.5
282	281.7	13.8	280.6	27.6	278.9	41.4	276.6	55.	273.5	68.5	269.9	81.9	265.5	95.	260.5	107.9
283	282.7	13.9	281.6	27.7	279.9	41.5	277.6	55.2	274.5	68.8	270.8	82.2	266.5	95.3	261.5	108.3
284	283.7	13.9	282.6	27.8	280.9	41.7	278.5	55.4	275.5	69.1	271.8	82.4	267.4	95.7	262.4	108.7
285	284.7	14.	283.6	27.9	281.9	41.8	279.5	55.6	276.4	69.2	272.7	82.7	268.3	96.	263.3	109.1
286	285.7	14.	284.6	28.	282.9	42.	280.5	55.8	277.4	69.5	273.7	83.	269.3	96.4	264.2	109.4
287	286.7	14.1	285.6	28.1	283.9	42.1	281.5	56.	278.4	69.7	274.6	83.3	270.2	96.7	265.2	109.8
288	287.7	14.1	286.6	28.2	284.9	42.3	282.5	56.2	279.3	70.	275.6	83.6	271.2	97.	266.1	110.2
289	288.7	14.2	287.6	28.3	285.9	42.4	283.4	56.4	280.3	70.2	276.6	83.9	272.1	97.4	267.	110.6
290	289.7	14.2	288.6	28.4	286.9	42.6	284.4	56.6	281.3	70.5	277.5	84.2	273.	97.7	267.9	111.
291	290.6	14.3	289.6	28.5	287.9	42.7	285.4	56.8	282.2	70.7	278.5	84.5	274.	98.	268.8	111.4
292	291.6	14.3	290.6	28.6	288.8	42.8	286.4	57.	283.2	71.	279.4	84.8	274.9	98.4	269.8	111.7
293	292.6	14.4	291.6	28.7	289.8	43.	287.4	57.2	284.2	71.2	280.4	85.1	275.9	98.7	270.7	112.1
294	293.6	14.4	292.6	28.8	290.8	43.1	288.4	57.4	285.2	71.4	281.3	85.3	276.8	99.	271.6	112.5
295	294.6	14.5	293.6	28.9	291.8	43.3	289.3	57.6	286.1	71.7	282.3	85.6	277.8	99.4	272.5	112.9
296	295.6	14.5	294.6	29.	292.8	43.4	290.3	57.7	287.1	71.9	283.3	85.9	278.7	99.7	273.5	113.3
297	296.6	14.6	295.6	29.1	293.8	43.6	291.3	57.9	288.1	72.2	284.2	86.2	279.6	100.1	274.4	113.7
298	297.6	14.6	296.6	29.2	294.8	43.7	292.3	58.1	289.1	72.4	285.2	86.5	280.6	100.4	275.3	114.
299	298.6	14.7	297.6	29.3	295.8	43.9	293.3	58.3	290.	72.7	286.1	86.8	281.5	100.7	276.2	114.4
300	299.6	14.7	298.6	29.4	296.8	44.	294.2	58.5	291.	72.9	287.1	87.1	282.5	101.1	277.2	114.8
Distance.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.
	W. ¼ N. W. ¼ S.	E. ¼ S. E. ¼ N.	W. ½ N. W. ½ S.	E. ½ S. E. ½ N.	W. ¾ N. W. ¾ S.	E. ¾ S. E. ¾ N.	W. by N. W. by S.	E. by S. E. by N.	W. by N. ¾ N. W. by S. ¾ S.	E. by S. ¾ S. E. by N. ¾ N.	W. by N. ½ N. W. by S. ½ S.	E. by S. ½ S. E. by N. ½ N.	W. by N. ¼ N. W. by S. ¼ S.	E. by S. ¼ S. E. by N. ¼ N.	W. N. W. W. S. W.	E. S. E. E. N. E.
	C. 7¾ Pts.		C. 7½ Pts.		C. 7¼ Pts.		C. 7 Pts.		C. 6¾ Pts.		C. 6½ Pts.		C. 6¼ Pts.		C. 6 Pts.	

C. 2¼ Pts.		C. 2½ Pts.		C. 2¾ Pts.		C. 3 Pts.		C. 3¼ Pts.		C. 3½ Pts.		C. 3¾ Pts.		C. 4 Pts.	
N.N.E.¼E. S.S.E.¼E.	S.S.W.¼W. N.N.W.¼W.	N.N.E.½E. S.S.E.½E.	S.S.W.½W. N.N.W.½W.	N.N.E.¾E. S.S.E.¾E.	S.S.W.¾W. N.N.W.¾W.	N.E. by N. S.E. by S.	S.W. by S. N.W. by N.	N.E.¾N. S.E.¾S.	S.W.¾S. N.W.¾N.	N.E.½N. S.E.½S.	S.W.½S. N.W.½N.	N.E.¼N. S.E.¼S.	S.W.¼S. N.W.¼N.	N.E. S.E. S.W. N.W.	Distance.
d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat dep.	
226.9	107.3	221.4	118.3	215.3	129.	208.7	139.4	201.6	149.5	194.	159.2	186.	168.6	177.5	251
227.8	107.7	222.2	118.8	216.1	129.6	209.5	140.	202.4	150.1	194.8	159.9	186.7	169.2	178.2	252
228.7	108.2	223.1	119.3	217.	130.1	210.4	140.5	203.2	150.7	195.6	160.5	187.5	169.9	178.9	253
229.6	108.6	224.	119.7	217.9	130.6	211.2	141.1	204.	151.3	196.3	161.1	188.2	170.6	179.6	254
230.5	109.	224.9	120.2	218.7	131.1	212.	141.7	204.8	151.9	197.1	161.8	188.9	171.2	180.3	255
231.4	109.5	225.8	120.7	219.6	131.6	212.9	142.2	205.6	152.5	197.9	162.4	189.7	171.9	181.	256
232.3	109.9	226.7	121.1	220.4	132.1	213.7	142.8	206.4	153.1	198.7	163.	190.4	172.6	181.7	257
233.2	110.3	227.5	121.6	221.3	132.6	214.5	143.3	207.2	153.7	199.4	163.7	191.2	173.3	182.4	258
234.1	110.7	228.4	122.1	222.2	133.2	215.4	143.9	208.	154.3	200.2	164.3	191.9	173.9	183.1	259
235.	111.2	229.3	122.6	223.	133.7	216.2	144.4	208.8	154.9	201.	164.9	192.6	174.6	183.8	260
235.9	111.6	230.2	123.	223.9	134.2	217.	145.	209.6	155.5	201.8	165.6	193.4	175.3	184.6	261
236.8	112.	231.1	123.5	224.7	134.7	217.8	145.5	210.4	156.1	202.5	166.2	194.1	175.9	185.3	262
237.7	112.4	231.9	124.	225.6	135.2	218.7	146.1	211.2	156.7	203.3	166.8	194.9	176.6	186.	263
238.7	112.9	232.8	124.4	226.4	135.7	219.5	146.7	212.	157.3	204.1	167.5	195.6	177.3	186.7	264
239.6	113.3	233.7	124.9	227.3	136.2	220.3	147.2	212.8	157.9	204.8	168.1	196.4	178.	187.4	265
240.5	113.7	234.6	125.4	228.2	136.8	221.2	147.8	213.7	158.5	205.6	168.7	197.1	178.6	188.1	266
241.4	114.2	235.5	125.9	229.	137.3	222.	148.3	214.5	159.1	206.4	169.4	197.8	179.3	188.8	267
242.3	114.6	236.4	126.3	229.9	137.8	222.8	148.9	215.3	159.6	207.2	170.	198.6	180.	189.5	268
243.2	115.	237.2	126.8	230.7	138.3	223.7	149.4	216.1	160.2	207.9	170.7	199.3	180.6	190.2	269
244.1	115.4	238.1	127.3	231.6	138.8	224.5	150.	216.9	160.8	208.7	171.3	200.1	181.3	190.9	270
245.	115.9	239.	127.7	232.4	139.3	225.3	150.5	217.7	161.4	209.5	171.9	200.8	182.	191.6	271
245.9	116.3	239.9	128.2	233.3	139.8	226.2	151.1	218.5	162.	210.3	172.6	201.5	182.7	192.3	272
246.8	116.7	240.8	128.7	234.2	140.4	227.	151.7	219.3	162.6	211.	173.2	202.3	183.3	193.	273
247.7	117.2	241.6	129.2	235.	140.9	227.8	152.2	220.1	163.2	211.8	173.8	203.	184.	193.7	274
248.6	117.6	242.5	129.6	235.9	141.4	228.7	152.8	220.9	163.8	212.6	174.5	203.8	184.7	194.5	275
249.5	118.	243.4	130.1	236.7	141.9	229.5	153.3	221.7	164.4	213.4	175.1	204.5	185.4	195.2	276
250.4	118.4	244.3	130.6	237.6	142.4	230.3	153.9	222.5	165.	214.1	175.7	205.2	186.	195.9	277
251.3	118.9	245.2	131.	238.4	142.9	231.1	154.4	223.3	165.6	214.9	176.4	206.	186.7	196.6	278
252.2	119.3	246.1	131.5	239.3	143.4	232.	155.	224.1	166.2	215.7	177.	206.7	187.4	197.3	279
253.1	119.7	246.9	132.	240.2	143.9	232.8	155.5	224.9	166.8	216.4	177.6	207.5	188.	198.	280
254.	120.1	247.8	132.5	241.	144.5	233.6	156.1	225.7	167.4	217.2	178.3	208.2	188.7	198.7	281
254.9	120.6	248.7	132.9	241.9	145.	234.5	156.7	226.5	168.	218.	178.9	208.9	189.4	199.4	282
255.8	121.	249.6	133.4	242.7	145.5	235.3	157.2	227.3	168.6	218.8	179.5	209.7	190.1	200.1	283
256.7	121.4	250.5	133.9	243.6	146.	236.1	157.8	228.1	169.2	219.5	180.2	210.4	190.7	200.8	284
257.6	121.9	251.3	134.3	244.5	146.5	237.	158.3	228.9	169.8	220.3	180.8	211.2	191.4	201.5	285
258.5	122.3	252.2	134.8	245.3	147.	237.8	158.9	229.7	170.4	221.1	181.4	211.9	192.1	202.2	286
259.4	122.7	253.1	135.3	246.2	147.5	238.6	159.4	230.5	171.	221.9	182.1	212.7	192.7	202.9	287
260.3	123.1	254.	135.8	247.	148.1	239.5	160.	231.3	171.6	222.6	182.7	213.4	193.4	203.6	288
261.3	123.6	254.9	136.2	247.9	148.6	240.3	160.5	232.1	172.2	223.4	183.3	214.1	194.1	204.4	289
262.2	124.	255.8	136.7	248.7	149.1	241.1	161.1	232.9	172.8	224.2	184.	214.9	194.8	205.1	290
263.1	124.4	256.6	137.2	249.6	149.6	242.	161.7	233.7	173.3	224.9	184.6	215.6	195.4	205.8	291
264.	124.8	257.5	137.6	250.5	150.1	242.8	162.2	234.5	173.9	225.7	185.2	216.4	196.1	206.5	292
264.9	125.3	258.4	138.1	251.3	150.6	243.6	162.8	235.3	174.5	226.5	185.9	217.1	196.8	207.2	293
265.8	125.7	259.3	138.6	252.2	151.1	244.5	163.3	236.1	175.1	227.3	186.5	217.8	197.4	207.9	294
266.7	126.1	260.2	139.1	253.	151.7	245.3	163.9	236.9	175.7	228.	187.1	218.6	198.1	208.6	295
267.6	126.6	261.	139.5	253.9	152.2	246.1	164.4	237.7	176.3	228.8	187.8	219.3	198.8	209.3	296
268.5	127.	261.9	140.	254.7	152.7	246.9	165.	238.6	176.9	229.6	188.4	220.1	199.5	210.	297
269.4	127.4	262.8	140.5	255.6	153.2	247.8	165.5	239.4	177.5	230.4	189.	220.8	200.1	210.7	298
270.3	127.8	263.7	140.9	256.5	153.7	248.6	166.1	240.2	178.1	231.1	189.7	221.5	200.8	211.4	299
271.2	128.3	264.6	141.4	257.3	154.2	249.4	166.7	241.	178.7	231.9	190.3	222.3	201.5	212.1	300
dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep.	d. lat.	dep. d. lat.	Distance.
N.W.by W.¾W. S.W.by W.¾W.	S.E.by E.¾E. N.E.by E.¾E.	N.W.by W.½W. S.W.by W.½W.	S.E.by E.½E. N.E.by E.½E.	N.W.by W.¼W. S.W.by W.¼W.	S.E.by E.¼E. N.E.by E.¼E.	N.W.by W. S.W.by W.	S.E.by E. N.E.by E.	N.W.¾W. S.W.¾W.	S.E.¾E. N.E.¾E.	N.W.½W. S.W.½W.	S.E.½E. N.E.½E.	N.W.¼W. S.W.¼W.	S.E.¼E. N.E.¼E.	N.W. S.W. S.E. N.E.	
C. 5¾ Pts.		C. 5½ Pts.		C. 5¼ Pts.		C. 5 Pts.		C. 4¾ Pts.		C. 4½ Pts.		C. 4¼ Pts.		C. 4 Pts.	

TABLE V.

DISTANCE, DIFFERENCE OF LATITUDE, AND DEPARTURE.

Course 1°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.	61	61.	1.1	121	121.	2.1	181	181.	3.2	241	241.	4.2
2	2.	0.	62	62.	1.1	2	122.	2.1	2	182.	3.2	2	242.	4.2
3	3.	0.1	63	63.	1.1	3	123.	2.1	3	183.	3.2	3	243.	4.2
4	4.	0.1	64	64.	1.1	4	124.	2.2	4	184.	3.2	4	244.	4.3
5	5.	0.1	65	65.	1.1	5	125.	2.2	5	185.	3.2	5	245.	4.3
6	6.	0.1	66	66.	1.2	6	126.	2.2	6	186.	3.2	6	246.	4.3
7	7.	0.1	67	67.	1.2	7	127.	2.2	7	187.	3.3	7	247.	4.3
8	8.	0.1	68	68.	1.2	8	128.	2.2	8	188.	3.3	8	248.	4.3
9	9.	0.2	69	69.	1.2	9	129.	2.3	9	189.	3.3	9	249.	4.3
10	10.	0.2	70	70.	1.2	130	130.	2.3	190	190.	3.3	250	250.	4.4
11	11.	0.2	71	71.	1.2	1	131.	2.3	1	191.	3.3	1	251.	4.4
12	12.	0.2	72	72.	1.3	2	132.	2.3	2	192.	3.4	2	252.	4.4
13	13.	0.2	73	73.	1.3	3	133.	2.3	3	193.	3.4	3	253.	4.4
14	14.	0.2	74	74.	1.3	4	134.	2.3	4	194.	3.4	4	254.	4.4
15	15.	0.3	75	75.	1.3	5	135.	2.4	5	195.	3.4	5	255.	4.5
16	16.	0.3	76	76.	1.3	6	136.	2.4	6	196.	3.4	6	256.	4.5
17	17.	0.3	77	77.	1.3	7	137.	2.4	7	197.	3.4	7	257.	4.5
18	18.	0.3	78	78.	1.4	8	138.	2.4	8	198.	3.5	8	258.	4.5
19	19.	0.3	79	79.	1.4	9	139.	2.4	9	199.	3.5	9	259.	4.5
20	20.	0.3	80	80.	1.4	140	140.	2.4	200	200.	3.5	260	260.	4.5
21	21.	0.4	81	81.	1.4	1	141.	2.5	1	201.	3.5	1	261.	4.6
22	22.	0.4	82	82.	1.4	2	142.	2.5	2	202.	3.5	2	262.	4.6
23	23.	0.4	83	83.	1.4	3	143.	2.5	3	203.	3.5	3	263.	4.6
24	24.	0.4	84	84.	1.5	4	144.	2.5	4	204.	3.6	4	264.	4.6
25	25.	0.4	85	85.	1.5	5	145.	2.5	5	205.	3.6	5	265.	4.6
26	26.	0.5	86	86.	1.5	6	146.	2.5	6	206.	3.6	6	266.	4.6
27	27.	0.5	87	87.	1.5	7	147.	2.6	7	207.	3.6	7	267.	4.7
28	28.	0.5	88	88.	1.5	8	148.	2.6	8	208.	3.6	8	268.	4.7
29	29.	0.5	89	89.	1.6	9	149.	2.6	9	209.	3.6	9	269.	4.7
30	30.	0.5	90	90.	1.6	150	150.	2.6	210	210.	3.7	270	270.	4.7
31	31.	0.5	91	91.	1.6	1	151.	2.6	1	211.	3.7	1	271.	4.7
32	32.	0.6	92	92.	1.6	2	152.	2.7	2	212.	3.7	2	272.	4.7
33	33.	0.6	93	93.	1.6	3	153.	2.7	3	213.	3.7	3	273.	4.8
34	34.	0.6	94	94.	1.6	4	154.	2.7	4	214.	3.7	4	274.	4.8
35	35.	0.6	95	95.	1.7	5	155.	2.7	5	215.	3.8	5	275.	4.8
36	36.	0.6	96	96.	1.7	6	156.	2.7	6	216.	3.8	6	276.	4.8
37	37.	0.6	97	97.	1.7	7	157.	2.7	7	217.	3.8	7	277.	4.8
38	38.	0.7	98	98.	1.7	8	158.	2.8	8	218.	3.8	8	278.	4.9
39	39.	0.7	99	99.	1.7	9	159.	2.8	9	219.	3.8	9	279.	4.9
40	40.	0.7	100	100.	1.7	160	160.	2.8	220	220.	3.8	280	280.	4.9
41	41.	0.7	1	101.	1.8	1	161.	2.8	1	221.	3.9	1	281.	4.9
42	42.	0.7	2	102.	1.8	2	162.	2.8	2	222.	3.9	2	282.	4.9
43	43.	0.8	3	103.	1.8	3	163.	2.8	3	223.	3.9	3	283.	4.9
44	44.	0.8	4	104.	1.8	4	164.	2.9	4	224.	3.9	4	284.	5.
45	45.	0.8	5	105.	1.8	5	165.	2.9	5	225.	3.9	5	285.	5.
46	46.	0.8	6	106.	1.8	6	166.	2.9	6	226.	3.9	6	286.	5.
47	47.	0.8	7	107.	1.9	7	167.	2.9	7	227.	4.	7	287.	5.
48	48.	0.8	8	108.	1.9	8	168.	2.9	8	228.	4.	8	288.	5.
49	49.	0.9	9	109.	1.9	9	169.	2.9	9	229.	4.	9	289.	5.
50	50.	0.9	110	110.	1.9	170	170.	3.	230	230.	4.	290	290.	5.1
51	51.	0.9	1	111.	1.9	1	171.	3.	1	231.	4.	1	291.	5.1
52	52.	0.9	2	112.	2.	2	172.	3.	2	232.	4.	2	292.	5.1
53	53.	0.9	3	113.	2.	3	173.	3.	3	233.	4.1	3	293.	5.1
54	54.	0.9	4	114.	2.	4	174.	3.	4	234.	4.1	4	294.	5.1
55	55.	1.	5	115.	2.	5	175.	3.1	5	235.	4.1	5	295.	5.1
56	56.	1.	6	116.	2.	6	176.	3.1	6	236.	4.1	6	296.	5.2
57	57.	1.	7	117.	2.	7	177.	3.1	7	237.	4.1	7	297.	5.2
58	58.	1.	8	118.	2.1	8	178.	3.1	8	238.	4.2	8	298.	5.2
59	59.	1.	9	119.	2.1	9	179.	3.1	9	239.	4.2	9	299.	5.2
60	60.	1.	120	120.	2.1	180	180.	3.1	240	240.	4.2	300	300.	5.2
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 89°.

Course 2°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.	61	61.	2.1	121	120.9	4.2	181	180.9	6.3	241	240.9	8.4
2	2.	0.1	62	62.	2.2	2	121.9	4.3	2	181.9	6.4	2	241.9	8.4
3	3.	0.1	63	63.	2.2	3	122.9	4.3	3	182.9	6.4	3	242.9	8.5
4	4.	0.1	64	64.	2.2	4	123.9	4.3	4	183.9	6.4	4	243.9	8.5
5	5.	0.2	65	65.	2.3	5	124.9	4.4	5	184.9	6.5	5	244.9	8.6
6	6.	0.2	66	66.	2.3	6	125.9	4.4	6	185.9	6.5	6	245.9	8.6
7	7.	0.2	67	67.	2.3	7	126.9	4.4	7	186.9	6.5	7	246.8	8.6
8	8.	0.3	68	68.	2.4	8	127.9	4.5	8	187.9	6.6	8	247.8	8.7
9	9.	0.3	69	69.	2.4	9	128.9	4.5	9	188.9	6.6	9	248.8	8.7
10	10.	0.3	70	70.	2.4	130	129.9	4.5	190	189.9	6.6	250	249.8	8.7
11	11.	0.4	71	71.	2.5	1	130.9	4.6	1	190.9	6.7	1	250.8	8.8
12	12.	0.4	72	72.	2.5	2	131.9	4.6	2	191.9	6.7	2	251.8	8.8
13	13.	0.5	73	73.	2.5	3	132.9	4.6	3	192.9	6.7	3	252.8	8.8
14	14.	0.5	74	74.	2.6	4	133.9	4.7	4	193.9	6.8	4	253.8	8.9
15	15.	0.5	75	75.	2.6	5	134.9	4.7	5	194.9	6.8	5	254.8	8.9
16	16.	0.6	76	76.	2.7	6	135.9	4.7	6	195.9	6.8	6	255.8	8.9
17	17.	0.6	77	77.	2.7	7	136.9	4.8	7	196.9	6.9	7	256.8	9.
18	18.	0.6	78	78.	2.7	8	137.9	4.8	8	197.9	6.9	8	257.8	9.
19	19.	0.7	79	79.	2.8	9	138.9	4.9	9	198.9	6.9	9	258.8	9.
20	20.	0.7	80	80.	2.8	140	139.9	4.9	200	199.9	7.	260	259.8	9.1
21	21.	0.7	81	81.	2.8	1	140.9	4.9	1	200.9	7.	1	260.8	9.1
22	22.	0.8	82	82.	2.9	2	141.9	5.	2	201.9	7.	2	261.8	9.1
23	23.	0.8	83	82.9	2.9	3	142.9	5.	3	202.9	7.1	3	262.8	9.2
24	24.	0.8	84	83.9	2.9	4	143.9	5.	4	203.9	7.1	4	263.8	9.2
25	25.	0.9	85	84.9	3.	5	144.9	5.1	5	204.9	7.2	5	264.8	9.2
26	26.	0.9	86	85.9	3.	6	145.9	5.1	6	205.9	7.2	6	265.8	9.3
27	27.	0.9	87	86.9	3.	7	146.9	5.1	7	206.9	7.2	7	266.8	9.3
28	28.	1.	88	87.9	3.1	8	147.9	5.2	8	207.9	7.3	8	267.8	9.4
29	29.	1.	89	88.9	3.1	9	148.9	5.2	9	208.9	7.3	9	268.8	9.4
30	30.	1.	90	89.9	3.1	150	149.9	5.2	210	209.9	7.3	270	269.8	9.4
31	31.	1.1	91	90.9	3.2	1	150.9	5.3	1	210.9	7.4	1	270.8	9.5
32	32.	1.1	92	91.9	3.2	2	151.9	5.3	2	211.9	7.4	2	271.8	9.5
33	33.	1.2	93	92.9	3.2	3	152.9	5.3	3	212.9	7.4	3	272.8	9.5
34	34.	1.2	94	93.9	3.3	4	153.9	5.4	4	213.9	7.5	4	273.8	9.6
35	35.	1.2	95	94.9	3.3	5	154.9	5.4	5	214.9	7.5	5	274.8	9.6
36	36.	1.3	96	95.9	3.4	6	155.9	5.4	6	215.9	7.5	6	275.8	9.6
37	37.	1.3	97	96.9	3.4	7	156.9	5.5	7	216.9	7.6	7	276.8	9.7
38	38.	1.3	98	97.9	3.4	8	157.9	5.5	8	217.9	7.6	8	277.8	9.7
39	39.	1.4	99	98.9	3.5	9	158.9	5.5	9	218.9	7.6	9	278.8	9.7
40	40.	1.4	100	99.9	3.5	160	159.9	5.6	220	219.9	7.7	280	279.8	9.8
41	41.	1.4	1	100.9	3.5	1	160.9	5.6	1	220.9	7.7	1	280.8	9.8
42	42.	1.5	2	101.9	3.6	2	161.9	5.7	2	221.9	7.7	2	281.8	9.8
43	43.	1.5	3	102.9	3.6	3	162.9	5.7	3	222.9	7.8	3	282.8	9.9
44	44.	1.5	4	103.9	3.6	4	163.9	5.7	4	223.9	7.8	4	283.8	9.9
45	45.	1.6	5	104.9	3.7	5	164.9	5.8	5	224.9	7.9	5	284.8	9.9
46	46.	1.6	6	105.9	3.7	6	165.9	5.8	6	225.9	7.9	6	285.8	10.
47	47.	1.6	7	106.9	3.7	7	166.9	5.8	7	226.9	7.9	7	286.8	10.
48	48.	1.7	8	107.9	3.8	8	167.9	5.9	8	227.9	8.	8	287.8	10.1
49	49.	1.7	9	108.9	3.8	9	168.9	5.9	9	228.9	8.	9	288.8	10.1
50	50.	1.7	110	109.9	3.8	170	169.9	5.9	230	229.9	8.	290	289.8	10.1
51	51.	1.8	1	110.9	3.9	1	170.9	6.	1	230.9	8.1	1	290.8	10.2
52	52.	1.8	2	111.9	3.9	2	171.9	6.	2	231.9	8.1	2	291.8	10.2
53	53.	1.8	3	112.9	3.9	3	172.9	6.	3	232.9	8.1	3	292.8	10.2
54	54.	1.9	4	113.9	4.	4	173.9	6.1	4	233.9	8.2	4	293.8	10.3
55	55.	1.9	5	114.9	4.	5	174.9	6.1	5	234.9	8.2	5	294.8	10.3
56	56.	2.	6	115.9	4.	6	175.9	6.1	6	235.9	8.2	6	295.8	10.3
57	57.	2.	7	116.9	4.1	7	176.9	6.2	7	236.9	8.3	7	296.8	10.4
58	58.	2.	8	117.9	4.1	8	177.9	6.2	8	237.9	8.3	8	297.8	10.4
59	59.	2.1	9	118.9	4.2	9	178.9	6.2	9	238.9	8.3	9	298.8	10.4
60	60.	2.1	120	119.9	4.2	180	179.9	6.3	240	239.9	8.4	300	299.8	10.5
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 88°

Course 3°.

Distance, Diff. Latitude and Departure

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.1	61	60.9	3.2	121	120.8	6.3	181	180.8	9.5	241	240.7	12.6
2	2.	0.1	62	61.9	3.2	2	121.8	6.4	2	181.8	9.5	2	241.7	12.7
3	3.	0.2	63	62.9	3.3	3	122.8	6.4	3	182.7	9.6	3	242.7	12.7
4	4.	0.2	64	63.9	3.3	4	123.8	6.5	4	183.7	9.6	4	243.7	12.8
5	5.	0.3	65	64.9	3.4	5	124.8	6.5	5	184.7	9.7	5	244.7	12.8
6	6.	0.3	66	65.9	3.5	6	125.8	6.6	6	185.7	9.7	6	245.7	12.9
7	7.	0.4	67	66.9	3.5	7	126.8	6.6	7	186.7	9.8	7	246.7	12.9
8	8.	0.4	68	67.9	3.6	8	127.8	6.7	8	187.7	9.8	8	247.7	13.
9	9.	0.5	69	68.9	3.6	9	128.8	6.8	9	188.7	9.9	9	248.7	13.
10	10.	0.5	70	69.9	3.7	130	129.8	6.8	190	189.7	9.9	250	249.7	13.1
11	11.	0.6	71	70.9	3.7	1	130.8	6.9	1	190.7	10	1	250.7	13.1
12	12.	0.6	72	71.9	3.8	2	131.8	6.9	2	191.7	10.	2	251.7	13.2
13	13.	0.7	73	72.9	3.8	3	132.8	7.	3	192.7	10.1	3	252.7	13.2
14	14.	0.7	74	73.9	3.9	4	133.8	7.	4	193.7	10.2	4	253.7	13.3
15	15.	0.8	75	74.9	3.9	5	134.8	7.1	5	194.7	10.2	5	254.7	13.3
16	16.	0.8	76	75.9	4.	6	135.8	7.1	6	195.7	10.3	6	255.6	13.4
17	17.	0.9	77	76.9	4.	7	136.8	7.2	7	196.7	10.3	7	256.6	13.5
18	18.	0.9	78	77.9	4.1	8	137.8	7.2	8	197.7	10.4	8	257.6	13.5
19	19.	1.	79	78.9	4.1	9	138.8	7.3	9	198.7	10.4	9	258.6	13.6
20	20.	1.	80	79.9	4.2	140	139.8	7.3	200	199.7	10.5	260	259.6	13.6
21	21.	1.1	81	80.9	4.2	1	140.8	7.4	1	200.7	10.5	1	260.6	13.7
22	22.	1.2	82	81.9	4.3	2	141.8	7.4	2	201.7	10.6	2	261.6	13.7
23	23.	1.2	83	82.9	4.3	3	142.8	7.5	3	202.7	10.6	3	262.6	13.8
24	24.	1.3	84	83.9	4.4	4	143.8	7.5	4	203.7	10.7	4	263.6	13.8
25	25.	1.3	85	84.9	4.4	5	144.8	7.6	5	204.7	10.7	5	264.6	13.9
26	26.	1.4	86	85.9	4.5	6	145.8	7.6	6	205.7	10.8	6	265.6	13.9
27	27.	1.4	87	86.9	4.6	7	146.8	7.7	7	206.7	10.8	7	266.6	14.
28	28.	1.5	88	87.9	4.6	8	147.8	7.7	8	207.7	10.9	8	267.6	14.
29	29.	1.5	89	88.9	4.7	9	148.8	7.8	9	208.7	10.9	9	268.6	14.1
30	30.	1.6	90	89.9	4.7	150	149.8	7.9	210	209.7	11.	270	269.6	14.1
31	31.	1.6	91	90.9	4.8	1	150.8	7.9	1	210.7	11.	1	270.6	14.2
32	32.	1.7	92	91.9	4.8	2	151.8	8.	2	211.7	11.1	2	271.6	14.2
33	33.	1.7	93	92.9	4.9	3	152.8	8.	3	212.7	11.1	3	272.6	14.3
34	34.	1.8	94	93.9	4.9	4	153.8	8.1	4	213.7	11.2	4	273.6	14.3
35	35.	1.8	95	94.9	5.	5	154.8	8.1	5	214.7	11.3	5	274.6	14.4
36	36.	1.9	96	95.9	5.	6	155.8	8.2	6	215.7	11.3	6	275.6	14.4
37	36.9	1.9	97	96.9	5.1	7	156.8	8.2	7	216.7	11.4	7	276.6	14.5
38	37.9	2.	98	97.9	5.1	8	157.8	8.3	8	217.7	11.4	8	277.6	14.5
39	38.9	2.	99	98.9	5.2	9	158.8	8.3	9	218.7	11.5	9	278.6	14.6
40	39.9	2.1	100	99.9	5.2	160	159.8	8.4	220	219.7	11.5	280	279.6	14.7
41	40.9	2.1	1	100.9	5.3	1	160.8	8.4	1	220.7	11.6	1	280.6	14.7
42	41.9	2.2	2	101.9	5.3	2	161.8	8.5	2	221.7	11.6	2	281.6	14.8
43	42.9	2.3	3	102.9	5.4	3	162.8	8.5	3	222.7	11.7	3	282.6	14.8
44	43.9	2.3	4	103.9	5.4	4	163.8	8.6	4	223.7	11.7	4	283.6	14.9
45	44.9	2.4	5	104.9	5.5	5	164.8	8.6	5	224.7	11.8	5	284.6	14.9
46	45.9	2.4	6	105.9	5.5	6	165.8	8.7	6	225.7	11.8	6	285.6	15.
47	46.9	2.5	7	106.9	5.6	7	166.8	8.7	7	226.7	11.9	7	286.6	15.
48	47.9	2.5	8	107.9	5.7	8	167.8	8.8	8	227.7	11.9	8	287.6	15.1
49	48.9	2.6	9	108.9	5.7	9	168.8	8.8	9	228.7	12.	9	288.6	15.1
50	49.9	2.6	110	109.8	5.8	170	169.8	8.9	230	229.7	12.	290	289.6	15.2
51	50.9	2.7	1	110.8	5.8	1	170.8	8.9	1	230.7	12.1	1	290.6	15.2
52	51.9	2.7	2	111.8	5.9	2	171.8	9.	2	231.7	12.1	2	291.6	15.3
53	52.9	2.8	3	112.8	5.9	3	172.8	9.1	3	232.7	12.2	3	292.6	15.3
54	53.9	2.8	4	113.8	6.	4	173.8	9.1	4	233.7	12.2	4	293.6	15.4
55	54.9	2.9	5	114.8	6.	5	174.8	9.2	5	234.7	12.3	5	294.6	15.4
56	55.9	2.9	6	115.8	6.1	6	175.8	9.2	6	235.7	12.4	6	295.6	15.5
57	56.9	3.	7	116.8	6.1	7	176.8	9.3	7	236.7	12.4	7	296.6	15.5
58	57.9	3.	8	117.8	6.2	8	177.8	9.3	8	237.7	12.5	8	297.6	15.6
59	58.9	3.1	9	118.8	6.2	9	178.8	9.4	9	238.7	12.5	9	298.6	15.6
60	59.9	3.1	120	119.8	6.3	180	179.8	9.4	240	239.7	12.6	300	299.6	15.7
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 87°.

Course 4°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.1	61	60.9	4.3	121	120.7	8.4	181	180.6	12.6	241	240.4	16.8
2	2.	0.1	62	61.8	4.3	2	121.7	8.5	2	181.6	12.7	2	241.4	16.9
3	3.	0.2	63	62.8	4.4	3	122.7	8.6	3	182.6	12.8	3	242.4	17.
4	4.	0.3	64	63.8	4.5	4	123.7	8.6	4	183.6	12.8	4	243.4	17.
5	5.	0.3	65	64.8	4.5	5	124.7	8.7	5	184.5	12.9	5	244.4	17.1
6	6.	0.4	66	65.8	4.6	6	125.7	8.8	6	185.5	13.	6	245.4	17.2
7	7.	0.5	67	66.8	4.7	7	126.7	8.9	7	186.5	13.	7	246.4	17.2
8	8.	0.6	68	67.8	4.7	8	127.7	8.9	8	187.5	13.1	8	247.4	17.3
9	9.	0.6	69	68.8	4.8	9	128.7	9.	9	188.5	13.2	9	248.4	17.4
10	10.	0.7	70	69.8	4.9	130	129.7	9.1	190	189.5	13.3	250	249.4	17.4
11	11.	0.8	71	70.8	5.	1	130.7	9.1	1	190.5	13.3	1	250.4	17.5
12	12.	0.8	72	71.8	5.	2	131.7	9.2	2	191.5	13.4	2	251.4	17.6
13	13.	0.9	73	72.8	5.1	3	132.7	9.3	3	192.5	13.5	3	252.4	17.6
14	14.	1.	74	73.8	5.2	4	133.7	9.3	4	193.5	13.5	4	253.4	17.7
15	15.	1.	75	74.8	5.2	5	134.7	9.4	5	194.5	13.6	5	254.4	17.8
16	16.	1.1	76	75.8	5.3	6	135.7	9.5	6	195.5	13.7	6	255.4	17.9
17	17.	1.2	77	76.8	5.4	7	136.7	9.6	7	196.5	13.7	7	256.4	17.9
18	18.	1.3	78	77.8	5.4	8	137.7	9.6	8	197.5	13.8	8	257.4	18.
19	19.	1.3	79	78.8	5.5	9	138.7	9.7	9	198.5	13.9	9	258.4	18.1
20	20.	1.4	80	79.8	5.6	140	139.7	9.8	200	199.5	14.	260	259.4	18.1
21	20.9	1.5	81	80.8	5.7	1	140.7	9.8	1	200.5	14.	1	260.4	18.2
22	21.9	1.5	82	81.8	5.7	2	141.7	9.9	2	201.5	14.1	2	261.4	18.3
23	22.9	1.6	83	82.8	5.8	3	142.7	10.	3	202.5	14.2	3	262.4	18.3
24	23.9	1.7	84	83.8	5.9	4	143.6	10.	4	203.5	14.2	4	263.4	18.4
25	24.9	1.7	85	84.8	5.9	5	144.6	10.1	5	204.5	14.3	5	264.4	18.5
26	25.9	1.8	86	85.8	6.	6	145.6	10.2	6	205.5	14.4	6	265.4	18.6
27	26.9	1.9	87	86.8	6.1	7	146.6	10.3	7	206.5	14.4	7	266.3	18.7
28	27.9	2.	88	87.8	6.1	8	147.6	10.3	8	207.5	14.5	8	267.3	18.7
29	28.9	2.	89	88.8	6.2	9	148.6	10.4	9	208.5	14.6	9	268.3	18.8
30	29.9	2.1	90	89.8	6.3	150	149.6	10.5	210	209.5	14.6	270	269.3	18.8
31	30.9	2.2	91	90.8	6.3	1	150.6	10.5	1	210.5	14.7	1	270.3	18.9
32	31.9	2.2	92	91.8	6.4	2	151.6	10.6	2	211.5	14.8	2	271.3	19.
33	32.9	2.3	93	92.8	6.5	3	152.6	10.7	3	212.5	14.9	3	272.3	19.
34	33.9	2.4	94	93.8	6.6	4	153.6	10.7	4	213.5	14.9	4	273.3	19.1
35	34.9	2.4	95	94.8	6.6	5	154.6	10.8	5	214.5	15.	5	274.3	19.2
36	35.9	2.5	96	95.8	6.7	6	155.6	10.9	6	215.5	15.1	6	275.3	19.2
37	36.9	2.6	97	96.8	6.8	7	156.6	11.	7	216.5	15.1	7	276.3	19.3
38	37.9	2.7	98	97.8	6.8	8	157.6	11.	8	217.5	15.2	8	277.3	19.4
39	38.9	2.7	99	98.8	6.9	9	158.6	11.1	9	218.5	15.3	9	278.3	19.5
40	39.9	2.8	100	99.8	7.	160	159.6	11.2	220	219.5	15.3	280	279.3	19.5
41	40.9	2.9	1	100.8	7.	1	160.6	11.2	1	220.5	15.4	1	280.3	19.6
42	41.9	2.9	2	101.8	7.1	2	161.6	11.3	2	221.5	15.5	2	281.3	19.7
43	42.9	3.	3	102.7	7.2	3	162.6	11.4	3	222.5	15.6	3	282.3	19.7
44	43.9	3.1	4	103.7	7.3	4	163.6	11.4	4	223.5	15.6	4	283.3	19.8
45	44.9	3.1	5	104.7	7.3	5	164.6	11.5	5	224.5	15.7	5	284.3	19.9
46	45.9	3.2	6	105.7	7.4	6	165.6	11.6	6	225.4	15.8	6	285.3	20.
47	46.9	3.3	7	106.7	7.5	7	166.6	11.6	7	226.4	15.8	7	286.3	20.
48	47.9	3.3	8	107.7	7.5	8	167.6	11.7	8	227.4	15.9	8	287.3	20.1
49	48.9	3.4	9	108.7	7.6	9	168.6	11.8	9	228.4	16.	9	288.3	20.2
50	49.9	3.5	110	109.7	7.7	170	169.6	11.9	230	229.4	16.	290	289.3	20.2
51	50.9	3.6	1	110.7	7.7	1	170.6	11.9	1	230.4	16.1	1	290.3	20.3
52	51.9	3.6	2	111.7	7.8	2	171.6	12.	2	231.4	16.2	2	291.3	20.4
53	52.9	3.7	3	112.7	7.9	3	172.6	12.1	3	232.4	16.3	3	292.3	20.4
54	53.9	3.8	4	113.7	8.	4	173.6	12.1	4	233.4	16.3	4	293.3	20.5
55	54.9	3.8	5	114.7	8.	5	174.6	12.2	5	234.4	16.4	5	294.3	20.6
56	55.9	3.9	6	115.7	8.1	6	175.6	12.3	6	235.4	16.5	6	295.3	20.6
57	56.9	4.	7	116.7	8.2	7	176.6	12.3	7	236.4	16.5	7	296.3	20.7
58	57.9	4.	8	117.7	8.2	8	177.6	12.4	8	237.4	16.6	8	297.3	20.8
59	58.9	4.1	9	118.7	8.3	9	178.6	12.5	9	238.4	16.7	9	298.3	20.9
60	59.9	4.2	120	119.7	8.4	180	179.6	12.6	240	239.4	16.7	300	299.3	20.9
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude

Course 86°.

Course 5°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.1	61	60.8	5.3	121	120.5	10.5	181	180.3	15.8	241	240.1	21.
2	2.	0.2	62	61.8	5.4	2	121.5	10.6	2	181.3	15.9	2	241.1	21.1
3	3.	0.3	63	62.8	5.5	3	122.5	10.7	3	182.3	15.9	3	242.1	21.2
4	4.	0.3	64	63.8	5.6	4	123.5	10.8	4	183.3	16.	4	243.1	21.3
5	5.	0.4	65	64.8	5.7	5	124.5	10.9	5	184.3	16.1	5	244.1	21.4
6	6.	0.5	66	65.7	5.8	6	125.5	11.	6	185.3	16.2	6	245.1	21.4
7	7.	0.6	67	66.7	5.8	7	126.5	11.1	7	186.3	16.3	7	246.1	21.5
8	8.	0.7	68	67.7	5.9	8	127.5	11.2	8	187.3	16.4	8	247.1	21.6
9	9.	0.8	69	68.7	6.	9	128.5	11.2	9	188.3	16.5	9	248.1	21.7
10	10.	0.9	70	69.7	6.1	130	129.5	11.3	190	189.3	16.6	250	249.	21.8
11	11.	1.	71	70.7	6.2	1	130.5	11.4	1	190.3	16.6	1	250.	21.9
12	12.	1.	72	71.7	6.3	2	131.5	11.5	2	191.3	16.7	2	251.	22.
13	13.	1.1	73	72.7	6.4	3	132.5	11.6	3	192.3	16.8	3	252.	22.1
14	13.9	1.2	74	73.7	6.4	4	133.5	11.7	4	193.3	16.9	4	253.	22.1
15	14.9	1.3	75	74.7	6.5	5	134.5	11.8	5	194.3	17.	5	254.	22.2
16	15.9	1.4	76	75.7	6.6	6	135.5	11.9	6	195.3	17.1	6	255.	22.3
17	16.9	1.5	77	76.7	6.7	7	136.5	11.9	7	196.3	17.2	7	256.	22.4
18	17.9	1.6	78	77.7	6.8	8	137.5	12.	8	197.2	17.3	8	257.	22.5
19	18.9	1.7	79	78.7	6.9	9	138.5	12.1	9	198.2	17.3	9	258.	22.6
20	19.9	1.7	80	79.7	7.	140	139.5	12.2	200	199.2	17.4	260	259.	22.7
21	20.9	1.8	81	80.7	7.1	1	140.5	12.3	1	200.2	17.5	1	260.	22.7
22	21.9	1.9	82	81.7	7.1	2	141.5	12.4	2	201.2	17.6	2	261.	22.8
23	22.9	2.	83	82.7	7.2	3	142.5	12.5	3	202.2	17.7	3	262.	22.9
24	23.9	2.1	84	83.7	7.3	4	143.5	12.6	4	203.2	17.8	4	263.	23.
25	24.9	2.2	85	84.7	7.4	5	144.4	12.6	5	204.2	17.9	5	264.	23.1
26	25.9	2.3	86	85.7	7.5	6	145.4	12.7	6	205.2	18.	6	265.	23.2
27	26.9	2.4	87	86.7	7.6	7	146.4	12.8	7	206.2	18.	7	266.	23.3
28	27.9	2.4	88	87.7	7.7	8	147.4	12.9	8	207.2	18.1	8	267.	23.4
29	28.9	2.5	89	88.7	7.8	9	148.4	13.	9	208.2	18.2	9	268.	23.4
30	29.9	2.6	90	89.7	7.8	150	149.4	13.1	210	209.2	18.3	270	269.	23.5
31	30.9	2.7	91	90.7	7.9	1	150.4	13.2	1	210.2	18.4	1	270.	23.6
32	31.9	2.8	92	91.6	8.	2	151.4	13.2	2	211.2	18.5	2	271.	23.7
33	32.9	2.9	93	92.6	8.1	3	152.4	13.3	3	212.2	18.6	3	272.	23.8
34	33.9	3.	94	93.6	8.2	4	153.4	13.4	4	213.2	18.7	4	273.	23.9
35	34.9	3.1	95	94.6	8.3	5	154.4	13.5	5	214.2	18.7	5	274.	24.
36	35.9	3.1	96	95.6	8.4	6	155.4	13.6	6	215.2	18.8	6	274.9	24.1
37	36.9	3.2	97	96.6	8.5	7	156.4	13.7	7	216.2	18.9	7	275.9	24.1
38	37.9	3.3	98	97.6	8.5	8	157.4	13.8	8	217.2	19.	8	276.9	24.2
39	38.9	3.4	99	98.6	8.6	9	158.4	13.9	9	218.2	19.1	9	277.9	24.3
40	39.8	3.5	100	99.6	8.7	160	159.4	13.9	220	219.2	19.2	280	278.9	24.4
41	40.8	3.6	1	100.6	8.8	1	160.4	14.	1	220.2	19.3	1	279.9	24.5
42	41.8	3.7	2	101.6	8.9	2	161.4	14.1	2	221.2	19.3	2	280.9	24.6
43	42.8	3.7	3	102.6	9.	3	162.4	14.2	3	222.2	19.4	3	281.9	24.7
44	43.8	3.8	4	103.6	9.1	4	163.4	14.3	4	223.1	19.5	4	282.9	24.8
45	44.8	3.9	5	104.6	9.2	5	164.4	14.4	5	224.1	19.6	5	283.9	24.9
46	45.8	4.	6	105.6	9.2	6	165.4	14.5	6	225.1	19.7	6	284.9	24.9
47	46.8	4.1	7	106.6	9.3	7	166.4	14.6	7	226.1	19.8	7	285.9	25.
48	47.8	4.2	8	107.6	9.4	8	167.4	14.6	8	227.1	19.9	8	286.9	25.1
49	48.8	4.3	9	108.6	9.5	9	168.4	14.7	9	228.1	20.	9	287.9	25.2
50	49.8	4.4	110	109.6	9.6	170	169.4	14.8	230	229.1	20.	290	288.9	25.3
51	50.8	4.4	1	110.6	9.7	1	170.3	14.9	1	230.1	20.1	1	289.9	25.4
52	51.8	4.5	2	111.6	9.8	2	171.3	15.	2	231.1	20.2	2	290.9	25.4
53	52.8	4.6	3	112.6	9.8	3	172.3	15.1	3	232.1	20.3	3	291.9	25.5
54	53.8	4.7	4	113.6	9.9	4	173.3	15.2	4	233.1	20.4	4	292.9	25.6
55	54.8	4.8	5	114.6	10.	5	174.3	15.3	5	234.1	20.5	5	293.9	25.7
56	55.8	4.9	6	115.6	10.1	6	175.3	15.3	6	235.1	20.6	6	294.9	25.8
57	56.8	5.	7	116.6	10.2	7	176.3	15.4	7	236.1	20.7	7	295.9	25.9
58	57.8	5.1	8	117.6	10.3	8	177.3	15.5	8	237.1	20.7	8	296.9	26.
59	58.8	5.1	9	118.5	10.4	9	178.3	15.6	9	238.1	20.8	9	297.9	26.1
60	59.8	5.2	120	119.5	10.5	180	179.3	15.7	240	239.1	20.9	300	298.9	26.1
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 85°.

Course 6°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.1	61	60.7	6.4	121	120.3	12.6	181	180.	18.9	241	239.7	25.2
2	2.	0.2	62	61.7	6.5	2	121.3	12.8	2	181.	19.	2	240.7	25.3
3	3.	0.3	63	62.7	6.6	3	122.3	12.9	3	182.	19.1	3	241.7	25.4
4	4.	0.4	64	63.6	6.7	4	123.3	13.	4	183.	19.2	4	242.7	25.5
5	5.	0.5	65	64.6	6.8	5	124.3	13.1	5	184.	19.3	5	243.7	25.6
6	6.	0.6	66	65.6	6.9	6	125.3	13.2	6	185.	19.4	6	244.7	25.7
7	7.	0.7	67	66.6	7.	7	126.3	13.3	7	186.	19.5	7	245.6	25.8
8	8.	0.8	68	67.6	7.1	8	127.3	13.4	8	187.	19.7	8	246.6	25.9
9	9.	0.9	69	68.6	7.2	9	128.3	13.5	9	188.	19.8	9	247.6	26.
10	9.9	1.	70	69.6	7.3	130	129.3	13.6	190	189.	19.9	250	248.6	26.1
11	10.9	1.1	71	70.6	7.4	1	130.3	13.7	1	190.	20.	1	249.6	26.2
12	11.9	1.3	72	71.6	7.5	2	131.3	13.8	2	190.9	20.1	2	250.6	26.3
13	12.9	1.4	73	72.6	7.6	3	132.3	13.9	3	191.9	20.2	3	251.6	26.4
14	13.9	1.5	74	73.6	7.7	4	133.3	14.	4	192.9	20.3	4	252.6	26.6
15	14.9	1.6	75	74.6	7.8	5	134.3	14.1	5	193.9	20.4	5	253.6	26.7
16	15.9	1.7	76	75.6	7.9	6	135.3	14.2	6	194.9	20.5	6	254.6	26.8
17	16.9	1.8	77	76.6	8.	7	136.2	14.3	7	195.9	20.6	7	255.6	26.9
18	17.9	1.9	78	77.6	8.2	8	137.2	14.4	8	196.9	20.7	8	256.6	27.
19	18.9	2.	79	78.6	8.3	9	138.2	14.5	9	197.9	20.8	9	257.6	27.1
20	19.9	2.1	80	79.6	8.4	140	139.2	14.6	200	198.9	20.9	260	258.6	27.2
21	20.9	2.2	81	80.6	8.5	1	140.2	14.7	1	199.9	21.	1	259.6	27.3
22	21.9	2.3	82	81.6	8.6	2	141.2	14.8	2	200.9	21.1	2	260.6	27.4
23	22.9	2.4	83	82.5	8.7	3	142.2	14.9	3	201.9	21.2	3	261.6	27.5
24	23.9	2.5	84	83.5	8.8	4	143.2	15.1	4	202.9	21.3	4	262.6	27.6
25	24.9	2.6	85	84.5	8.9	5	144.2	15.2	5	203.9	21.4	5	263.5	27.7
26	25.9	2.7	86	85.5	9.	6	145.2	15.3	6	204.9	21.5	6	264.5	27.8
27	26.9	2.8	87	86.5	9.1	7	146.2	15.4	7	205.9	21.6	7	265.5	27.9
28	27.9	2.9	88	87.5	9.2	8	147.2	15.5	8	206.9	21.7	8	266.5	28.
29	28.8	3.	89	88.5	9.3	9	148.2	15.6	9	207.9	21.8	9	267.5	28.1
30	29.8	3.1	90	89.5	9.4	150	149.2	15.7	210	208.8	22.	270	268.5	28.2
31	30.8	3.2	91	90.5	9.5	1	150.2	15.8	1	209.8	22.1	1	269.5	28.3
32	31.8	3.3	92	91.5	9.6	2	151.2	15.9	2	210.8	22.2	2	270.5	28.4
33	32.8	3.4	93	92.5	9.7	3	152.2	16.	3	211.8	22.3	3	271.5	28.5
34	33.8	3.6	94	93.5	9.8	4	153.2	16.1	4	212.8	22.4	4	272.5	28.6
35	34.8	3.7	95	94.5	9.9	5	154.2	16.2	5	213.8	22.5	5	273.5	28.7
36	35.8	3.8	96	95.5	10.	6	155.1	16.3	6	214.8	22.6	6	274.5	28.8
37	36.8	3.9	97	96.5	10.1	7	156.1	16.4	7	215.8	22.7	7	275.5	29.
38	37.8	4.	98	97.5	10.2	8	157.1	16.5	8	216.8	22.8	8	276.5	29.1
39	38.8	4.1	99	98.5	10.3	9	158.1	16.6	9	217.8	22.9	9	277.5	29.2
40	39.8	4.2	100	99.5	10.5	160	159.1	16.7	220	218.8	23.	280	278.5	29.3
41	40.8	4.3	1	100.4	10.6	1	160.1	16.8	1	219.8	23.1	1	279.5	29.4
42	41.8	4.4	2	101.4	10.7	2	161.1	16.9	2	220.8	23.2	2	280.5	29.5
43	42.8	4.5	3	102.4	10.8	3	162.1	17.	3	221.8	23.3	3	281.4	29.6
44	43.8	4.6	4	103.4	10.9	4	163.1	17.1	4	222.8	23.4	4	282.4	29.7
45	44.8	4.7	5	104.4	11.	5	164.1	17.2	5	223.8	23.5	5	283.4	29.8
46	45.7	4.8	6	105.4	11.1	6	165.1	17.4	6	224.8	23.6	6	284.4	29.9
47	46.7	4.9	7	106.4	11.2	7	166.1	17.5	7	225.8	23.7	7	285.4	30.
48	47.7	5.	8	107.4	11.3	8	167.1	17.6	8	226.8	23.8	8	286.4	30.1
49	48.7	5.1	9	108.4	11.4	9	168.1	17.7	9	227.7	23.9	9	287.4	30.2
50	49.7	5.2	110	109.4	11.5	170	169.1	17.8	230	228.7	24.	290	288.4	30.3
51	50.7	5.3	1	110.4	11.6	1	170.1	17.9	1	229.7	24.1	1	289.4	30.4
52	51.7	5.4	2	111.4	11.7	2	171.1	18.	2	230.7	24.3	2	290.4	30.5
53	52.7	5.5	3	112.4	11.8	3	172.1	18.1	3	231.7	24.4	3	291.4	30.6
54	53.7	5.6	4	113.4	11.9	4	173.	18.2	4	232.7	24.5	4	292.4	30.7
55	54.7	5.7	5	114.4	12.	5	174.	18.3	5	233.7	24.6	5	293.4	30.8
56	55.7	5.9	6	115.4	12.1	6	175.	18.4	6	234.7	24.7	6	294.4	30.9
57	56.7	6.	7	116.4	12.2	7	176.	18.5	7	235.7	24.8	7	295.4	31.
58	57.7	6.1	8	117.4	12.3	8	177.	18.6	8	236.7	24.9	8	296.4	31.1
59	58.7	6.2	9	118.3	12.4	9	178.	18.7	9	237.7	25.	9	297.4	31.3
60	59.7	6.3	120	119.3	12.5	180	179.	18.8	240	238.7	25.1	300	298.4	31.4
dist.	dep.	d. lat.	dist.	dep.	d lat	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 84°.

Course 7°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.1	61	60.5	7.4	121	120.1	14.7	181	179.7	22.1	241	239.2	29.4
2	2.	0.2	62	61.5	7.6	2	121.1	14.9	2	180.6	22.2	2	240.2	29.5
3	3.	0.4	63	62.5	7.7	3	122.1	15.	3	181.6	22.3	3	241.2	29.6
4	4.	0.5	64	63.5	7.8	4	123.1	15.1	4	182.6	22.4	4	242.2	29.7
5	5.	0.6	65	64.5	7.9	5	124.1	15.2	5	183.6	22.5	5	243.2	29.9
6	6.	0.7	66	65.5	8.	6	125.1	15.4	6	184.6	22.7	6	244.2	30.
7	6.9	0.9	67	66.5	8.2	7	126.1	15.5	7	185.6	22.8	7	245.2	30.1
8	7.9	1.	68	67.5	8.3	8	127.	15.6	8	186.6	22.9	8	246.2	30.2
9	8.9	1.1	69	68.5	8.4	9	128.	15.7	9	187.6	23.	9	247.1	30.3
10	9.9	1.2	70	69.5	8.5	130	129.	15.8	190	188.6	23.2	250	248.1	30.5
11	10.9	1.3	71	70.5	8.7	1	130.	16.	1	189.6	23.3	1	249.1	30.6
12	11.9	1.5	72	71.5	8.8	2	131.	16.1	2	190.6	23.4	2	250.1	30.7
13	12.9	1.6	73	72.5	8.9	3	132.	16.2	3	191.6	23.5	3	251.1	30.8
14	13.9	1.7	74	73.4	9.	4	133.	16.3	4	192.6	23.6	4	252.1	31.
15	14.9	1.8	75	74.4	9.1	5	134.	16.5	5	193.5	23.8	5	253.1	31.1
16	15.9	1.9	76	75.4	9.3	6	135.	16.6	6	194.5	23.9	6	254.1	31.2
17	16.9	2.1	77	76.4	9.4	7	136.	16.7	7	195.5	24.	7	255.1	31.3
18	17.9	2.2	78	77.4	9.5	8	137.	16.8	8	196.5	24.1	8	256.1	31.4
19	18.9	2.3	79	78.4	9.6	9	138.	16.9	9	197.5	24.3	9	257.1	31.6
20	19.9	2.4	80	79.4	9.7	140	139.	17.1	200	198.5	24.4	260	258.1	31.7
21	20.9	2.6	81	80.4	9.9	1	139.9	17.2	1	199.5	24.5	1	259.1	31.8
22	21.8	2.7	82	81.4	10.	2	140.9	17.3	2	200.5	24.6	2	260.	31.9
23	22.8	2.8	83	82.4	10.1	3	141.9	17.4	3	201.5	24.7	3	261.	32.1
24	23.8	2.9	84	83.4	10.2	4	142.9	17.5	4	202.5	24.9	4	262.	32.2
25	24.8	3.	85	84.4	10.4	5	143.9	17.7	5	203.5	25.	5	263.	32.3
26	25.8	3.2	86	85.4	10.5	6	144.9	17.8	6	204.5	25.1	6	264.	32.4
27	26.8	3.3	87	86.4	10.6	7	145.9	17.9	7	205.5	25.2	7	265.	32.5
28	27.8	3.4	88	87.3	10.7	8	146.9	18.	8	206.4	25.3	8	266.	32.7
29	28.8	3.5	89	88.3	10.8	9	147.9	18.2	9	207.4	25.5	9	267.	32.8
30	29.8	3.7	90	89.3	11.	150	148.9	18.3	210	208.4	25.6	270	268.	32.9
31	30.8	3.8	91	90.3	11.1	1	149.9	18.4	1	209.4	25.7	1	269.	33.
32	31.8	3.9	92	91.3	11.2	2	150.9	18.5	2	210.4	25.8	2	270.	33.1
33	32.8	4.	93	92.3	11.3	3	151.9	18.6	3	211.4	26.	3	271.	33.3
34	33.8	4.1	94	93.3	11.5	4	152.9	18.8	4	212.4	26.1	4	272.	33.4
35	34.7	4.3	95	94.3	11.6	5	153.8	18.9	5	213.4	26.2	5	273.	33.5
36	35.7	4.4	96	95.3	11.7	6	154.8	19.	6	214.4	26.3	6	273.9	33.6
37	36.7	4.5	97	96.3	11.8	7	155.8	19.1	7	215.4	26.4	7	274.9	33.8
38	37.7	4.6	98	97.3	11.9	8	156.8	19.3	8	216.4	26.6	8	275.9	33.9
39	38.7	4.8	99	98.3	12.1	9	157.8	19.4	9	217.4	26.7	9	276.9	34.
40	39.7	4.9	100	99.3	12.2	160	158.8	19.5	220	218.4	26.8	280	277.9	34.1
41	40.7	5.	1	100.2	12.3	1	159.8	19.6	1	219.4	26.9	1	278.9	34.2
42	41.7	5.1	2	101.2	12.4	2	160.8	19.7	2	220.3	27.1	2	279.9	34.3
43	42.7	5.2	3	102.2	12.6	3	161.8	19.9	3	221.3	27.2	3	280.9	34.5
44	43.7	5.4	4	103.2	12.7	4	162.8	20.	4	222.3	27.3	4	281.9	34.6
45	44.7	5.5	5	104.2	12.8	5	163.8	20.1	5	223.3	27.4	5	282.9	34.7
46	45.7	5.6	6	105.2	12.9	6	164.8	20.2	6	224.3	27.5	6	283.9	34.9
47	46.7	5.7	7	106.2	13.	7	165.8	20.4	7	225.3	27.7	7	284.9	35.
48	47.6	5.8	8	107.2	13.2	8	166.7	20.5	8	226.3	27.8	8	285.9	35.1
49	48.6	6.	9	108.2	13.3	9	167.7	20.6	9	227.3	27.9	9	286.8	35.2
50	49.6	6.1	110	109.2	13.4	170	168.7	20.7	230	228.3	28.	290	287.8	35.3
51	50.6	6.2	1	110.2	13.5	1	169.7	20.8	1	229.3	28.2	1	288.8	35.5
52	51.6	6.3	2	111.2	13.6	2	170.7	21.	2	230.3	28.3	2	289.8	35.6
53	52.6	6.5	3	112.2	13.8	3	171.7	21.1	3	231.3	28.4	3	290.8	35.7
54	53.6	6.6	4	113.2	13.9	4	172.7	21.2	4	232.3	28.5	4	291.8	35.8
55	54.6	6.7	5	114.1	14.	5	173.7	21.3	5	233.2	28.6	5	292.8	36.
56	55.6	6.8	6	115.1	14.1	6	174.7	21.4	6	234.2	28.8	6	293.8	36.1
57	56.6	6.9	7	116.1	14.3	7	175.7	21.6	7	235.2	28.9	7	294.8	36.2
58	57.6	7.1	8	117.1	14.4	8	176.7	21.7	8	236.2	29.	8	295.8	36.3
59	58.6	7.2	9	118.1	14.5	9	177.7	21.8	9	237.2	29.1	9	296.8	36.4
60	59.6	7.3	120	119.1	14.6	180	178.7	21.9	240	238.2	29.2	300	297.8	36.6
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 83°.

Course 8°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.1	61	60.4	8.5	121	119.8	16.8	181	179.2	25.2	241	238.7	33.5
2	2.	0.3	62	61.4	8.6	2	120.8	17.	2	180.2	25.3	2	239.6	33.7
3	3.	0.4	63	62.4	8.8	3	121.8	17.1	3	181.2	25.5	3	240.6	33.8
4	4.	0.6	64	63.4	8.9	4	122.8	17.3	4	182.2	25.6	4	241.6	34.
5	5.	0.7	65	64.4	9.	5	123.8	17.4	5	183.2	25.7	5	242.6	34.1
6	5.9	0.8	66	65.4	9.2	6	124.8	17.5	6	184.2	25.9	6	243.6	34.2
7	6.9	1.	67	66.3	9.3	7	125.8	17.7	7	185.2	26.	7	244.6	34.4
8	7.9	1.1	68	67.3	9.5	8	126.8	17.8	8	186.2	26.2	8	245.6	34.5
9	8.9	1.3	69	68.3	9.6	9	127.7	18.	9	187.2	26.3	9	246.6	34.7
10	9.9	1.4	70	69.3	9.7	130	128.7	18.1	190	188.2	26.4	250	247.6	34.8
11	10.9	1.5	71	70.3	9.9	1	129.7	18.2	1	189.1	26.6	1	248.6	34.9
12	11.9	1.7	72	71.3	10.	2	130.7	18.4	2	190.1	26.7	2	249.5	35.1
13	12.9	1.8	73	72.3	10.2	3	131.7	18.5	3	191.1	26.9	3	250.5	35.2
14	13.9	1.9	74	73.3	10.3	4	132.7	18.6	4	192.1	27.	4	251.5	35.3
15	14.9	2.1	75	74.3	10.4	5	133.7	18.8	5	193.1	27.1	5	252.5	35.5
16	15.8	2.2	76	75.3	10.6	6	134.7	18.9	6	194.1	27.3	6	253.5	35.6
17	16.8	2.4	77	76.3	10.7	7	135.7	19.1	7	195.1	27.4	7	254.5	35.8
18	17.8	2.5	78	77.2	10.9	8	136.7	19.2	8	196.1	27.6	8	255.5	35.9
19	18.8	2.6	79	78.2	11.	9	137.7	19.3	9	197.1	27.7	9	256.5	36.
20	19.8	2.8	80	79.2	11.1	140	138.6	19.5	200	198.1	27.8	260	257.5	36.2
21	20.8	2.9	81	80.2	11.3	1	139.6	19.6	1	199.	28.	1	258.5	36.3
22	21.8	3.1	82	81.2	11.4	2	140.6	19.8	2	200.	28.1	2	259.5	36.5
23	22.8	3.2	83	82.2	11.6	3	141.6	19.9	3	201.	28.3	3	260.4	36.6
24	23.8	3.3	84	83.2	11.7	4	142.6	20.	4	202.	28.4	4	261.4	36.7
25	24.7	3.5	85	84.2	11.8	5	143.6	20.2	5	203.	28.5	5	262.4	36.9
26	25.7	3.6	86	85.2	12.	6	144.6	20.3	6	204.	28.7	6	263.4	37.
27	26.7	3.8	87	86.2	12.1	7	145.6	20.5	7	205.	28.8	7	264.4	37.2
28	27.7	3.9	88	87.1	12.2	8	146.6	20.6	8	206.	28.9	8	265.4	37.3
29	28.7	4.	89	88.1	12.4	9	147.5	20.7	9	207.	29.1	9	266.4	37.4
30	29.7	4.2	90	89.1	12.5	150	148.5	20.9	210	208.	29.2	270	267.4	37.6
31	30.7	4.3	91	90.1	12.7	1	149.5	21.	1	208.9	29.4	1	268.4	37.7
32	31.7	4.5	92	91.1	12.8	2	150.5	21.2	2	209.9	29.5	2	269.4	37.9
33	32.7	4.6	93	92.1	12.9	3	151.5	21.3	3	210.9	29.6	3	270.3	38.
34	33.7	4.7	94	93.1	13.1	4	152.5	21.4	4	211.9	29.8	4	271.3	38.1
35	34.6	4.9	95	94.1	13.2	5	153.5	21.6	5	212.9	29.9	5	272.3	38.3
36	35.6	5.	96	95.1	13.4	6	154.5	21.7	6	213.9	30.1	6	273.3	38.4
37	36.6	5.1	97	96.1	13.5	7	155.5	21.9	7	214.9	30.2	7	274.3	38.6
38	37.6	5.3	98	97.	13.6	8	156.5	22.	8	215.9	30.3	8	275.3	38.7
39	38.6	5.4	99	98.	13.8	9	157.5	22.1	9	216.8	30.5	9	276.3	38.8
40	39.6	5.6	100	99.	13.9	160	158.4	22.3	220	217.9	30.6	280	277.3	39.
41	40.6	5.7	1	100.	14.1	1	159.4	22.4	1	218.8	30.8	1	278.3	39.1
42	41.6	5.8	2	101.	14.2	2	160.4	22.5	2	219.8	30.9	2	279.3	39.2
43	42.6	6.	3	102.	14.3	3	161.4	22.7	3	220.8	31.	3	280.2	39.4
44	43.6	6.1	4	103.	14.5	4	162.4	22.8	4	221.8	31.2	4	281.2	39.5
45	44.6	6.3	5	104.	14.6	5	163.4	23.	5	222.8	31.3	5	282.2	39.6
46	45.5	6.4	6	105.	14.8	6	164.4	23.1	6	223.8	31.5	6	283.2	39.8
47	46.5	6.5	7	106.	14.9	7	165.4	23.2	7	224.8	31.6	7	284.2	39.9
48	47.5	6.7	8	106.9	15.	8	166.4	23.4	8	225.8	31.7	8	285.2	40.1
49	48.5	6.8	9	107.9	15.2	9	167.4	23.5	9	226.8	31.9	9	286.2	40.2
50	49.5	7.	110	108.9	15.3	170	168.3	23.7	230	227.8	32.	290	287.2	40.4
51	50.5	7.1	1	109.9	15.4	1	169.3	23.8	1	228.8	32.1	1	288.2	40.5
52	51.5	7.2	2	110.9	15.6	2	170.3	23.9	2	229.7	32.3	2	289.2	40.6
53	52.5	7.4	3	111.9	15.7	3	171.3	24.1	3	230.7	32.4	3	290.1	40.8
54	53.5	7.5	4	112.9	15.9	4	172.3	24.2	4	231.7	32.6	4	291.1	40.9
55	54.5	7.7	5	113.9	16.	5	173.3	24.4	5	232.7	32.7	5	292.1	41.1
56	55.5	7.8	6	114.9	16.1	6	174.3	24.5	6	233.7	32.8	6	293.1	41.2
57	56.4	7.9	7	115.9	16.3	7	175.3	24.6	7	234.7	33.	7	294.1	41.3
58	57.4	8.1	8	116.9	16.4	8	176.3	24.8	8	235.7	33.1	8	295.1	41.5
59	58.4	8.2	9	117.8	16.6	9	177.3	24.9	9	236.7	33.3	9	296.1	41.6
60	59.4	8.4	120	118.8	16.7	180	178.2	25.1	240	237.7	33.4	300	297.1	41.8
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 82°.

Course 9°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.2	61	60.2	9.5	121	119.5	18.9	181	178.8	28.3	241	238.	37.7
2	2.	0.3	62	61.2	9.7	2	120.5	19.1	2	179.8	28.5	2	239.	37.9
3	3.	0.5	63	62.2	9.9	3	121.5	19.2	3	180.7	28.6	3	240.	38.
4	4.	0.6	64	63.2	10.	4	122.5	19.4	4	181.7	28.8	4	241.	38.2
5	4.9	0.8	65	64.2	10.2	5	123.5	19.6	5	182.7	28.9	5	242.	38.3
6	5.9	0.9	66	65.2	10.3	6	124.4	19.7	6	183.7	29.1	6	243.	38.5
7	6.9	1.1	67	66.2	10.5	7	125.4	19.9	7	184.7	29.3	7	244.	38.6
8	7.9	1.3	68	67.2	10.6	8	126.4	20.	8	185.7	29.4	8	244.9	38.8
9	8.9	1.4	69	68.2	10.8	9	127.4	20.2	9	186.7	29.6	9	245.9	39.
10	9.9	1.6	70	69.1	11.	130	128.4	20.3	190	187.7	29.7	250	246.9	39.1
11	10.9	1.7	71	70.1	11.1	1	129.4	20.5	1	188.6	29.9	1	247.9	39.3
12	11.9	1.9	72	71.1	11.3	2	130.4	20.6	2	189.6	30.	2	248.9	39.4
13	12.8	2.	73	72.1	11.4	3	131.4	20.8	3	190.6	30.2	3	249.9	39.6
14	13.8	2.2	74	73.1	11.6	4	132.4	21.	4	191.6	30.3	4	250.9	39.7
15	14.8	2.3	75	74.1	11.7	5	133.3	21.1	5	192.6	30.5	5	251.9	39.9
16	15.8	2.5	76	75.1	11.9	6	134.3	21.3	6	193.6	30.7	6	252.8	40.
17	16.8	2.7	77	76.1	12.	7	135.3	21.4	7	194.6	30.8	7	253.8	40.2
18	17.8	2.8	78	77.	12.2	8	136.3	21.6	8	195.6	31.	8	254.8	40.4
19	18.8	3.	79	78.	12.4	9	137.3	21.7	9	196.5	31.1	9	255.8	40.5
20	19.7	3.1	80	79.	12.5	140	138.3	21.9	200	197.5	31.3	260	256.8	40.7
21	20.7	3.3	81	80.	12.7	1	139.3	22.1	1	198.5	31.4	1	257.8	40.8
22	21.7	3.4	82	81.	12.8	2	140.3	22.2	2	199.5	31.6	2	258.8	41.
23	22.7	3.6	83	82.	13.	3	141.2	22.4	3	200.5	31.8	3	259.8	41.1
24	23.7	3.8	84	83.	13.1	4	142.2	22.5	4	201.5	31.9	4	260.7	41.3
25	24.7	3.9	85	84.	13.3	5	143.2	22.7	5	202.5	32.1	5	261.7	41.5
26	25.7	4.1	86	84.9	13.5	6	144.2	22.8	6	203.5	32.2	6	262.7	41.6
27	26.7	4.2	87	85.9	13.6	7	145.2	23.	7	204.5	32.4	7	263.7	41.8
28	27.6	4.4	88	86.9	13.8	8	146.2	23.2	8	205.4	32.5	8	264.7	41.9
29	28.6	4.5	89	87.9	13.9	9	147.2	23.3	9	206.4	32.7	9	265.7	42.1
30	29.6	4.7	90	88.9	14.1	150	148.2	23.5	210	207.4	32.9	270	266.7	42.2
31	30.6	4.8	91	89.9	14.2	1	149.1	23.6	1	208.4	33.	1	267.7	42.4
32	31.6	5.	92	90.9	14.4	2	150.1	23.8	2	209.4	33.2	2	268.7	42.6
33	32.6	5.2	93	91.9	14.5	3	151.1	23.9	3	210.4	33.3	3	269.6	42.7
34	33.6	5.3	94	92.8	14.7	4	152.1	24.1	4	211.4	33.5	4	270.6	42.8
35	34.6	5.5	95	93.8	14.9	5	153.1	24.2	5	212.4	33.6	5	271.6	43.
36	35.5	5.6	96	94.8	15.	6	154.1	24.4	6	213.3	33.8	6	272.6	43.2
37	36.5	5.8	97	95.8	15.2	7	155.1	24.6	7	214.3	33.9	7	273.6	43.3
38	37.5	5.9	98	96.8	15.3	8	156.1	24.7	8	215.3	34.1	8	274.6	43.5
39	38.5	6.1	99	97.8	15.5	9	157.	24.9	9	216.3	34.3	9	275.6	43.6
40	39.5	6.3	100	98.8	15.6	160	158.	25.	220	217.3	34.4	280	276.6	43.8
41	40.5	6.4	1	99.8	15.8	1	159.	25.2	1	218.3	34.6	1	277.5	44.
42	41.5	6.6	2	100.7	16.	2	160.	25.3	2	219.3	34.7	2	278.5	44.1
43	42.5	6.7	3	101.7	16.1	3	161.	25.5	3	220.3	34.9	3	279.5	44.3
44	43.5	6.9	4	102.7	16.3	4	162.	25.7	4	221.2	35.	4	280.5	44.4
45	44.4	7.	5	103.7	16.4	5	163.	25.8	5	222.2	35.2	5	281.5	44.6
46	45.4	7.2	6	104.7	16.6	6	164.	26.	6	223.2	35.4	6	282.5	44.7
47	46.4	7.4	7	105.7	16.7	7	164.9	26.1	7	224.2	35.5	7	283.5	44.9
48	47.4	7.5	8	106.7	16.9	8	165.9	26.3	8	225.2	35.7	8	284.5	45.1
49	48.4	7.7	9	107.7	17.1	9	166.9	26.4	9	226.2	35.8	9	285.4	45.2
50	49.4	7.8	110	108.6	17.2	170	167.9	26.6	230	227.2	36.	290	286.4	45.4
51	50.4	8.	1	109.6	17.4	1	168.9	26.8	1	228.2	36.1	1	287.4	45.5
52	51.4	8.1	2	110.6	17.5	2	169.9	26.9	2	229.1	36.3	2	288.4	45.7
53	52.3	8.3	3	111.6	17.7	3	170.9	27.1	3	230.1	36.4	3	289.4	45.8
54	53.3	8.4	4	112.6	17.8	4	171.9	27.2	4	231.1	36.6	4	290.4	46.
55	54.3	8.6	5	113.6	18.	5	172.8	27.4	5	232.1	36.8	5	291.4	46.1
56	55.3	8.8	6	114.6	18.1	6	173.8	27.5	6	233.1	36.9	6	292.4	46.3
57	56.3	8.9	7	115.6	18.3	7	174.8	27.7	7	234.1	37.1	7	293.3	46.5
58	57.3	9.1	8	116.5	18.5	8	175.8	27.8	8	235.1	37.2	8	294.3	46.6
59	58.3	9.2	9	117.5	18.6	9	176.8	28.	9	236.1	37.4	9	295.3	46.8
60	59.3	9.4	120	118.5	18.8	180	177.8	28.2	240	237.	37.5	300	296.3	46.9
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance Departure and Diff. Latitude.

Course 81°.

Course 10°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.2	61	60.1	10.6	121	119.2	21.	181	178.3	31.4	241	237.3	41.8
2	2.	0.3	62	61.1	10.8	2	120.1	21.2	2	179.2	31.6	2	238.3	42.
3	3.	0.5	63	62.	10.9	3	121.1	21.4	3	180.2	31.8	3	239.3	42.2
4	3.9	0.7	64	63.	11.1	4	122.1	21.5	4	181.2	32.	4	240.3	42.4
5	4.9	0.9	65	64.	11.3	5	123.1	21.7	5	182.2	32.1	5	241.3	42.5
6	5.9	1.	66	65.	11.5	6	124.1	21.9	6	183.2	32.3	6	242.3	42.7
7	6.9	1.2	67	66.	11.6	7	125.1	22.1	7	184.2	32.5	7	243.2	42.9
8	7.9	1.4	68	67.	11.8	8	126.1	22.2	8	185.1	32.6	8	244.2	43.1
9	8.9	1.6	69	68.	12.	9	127.	22.4	9	186.1	32.8	9	245.2	43.2
10	9.8	1.7	70	68.9	12.2	130	128.	22.6	190	187.1	33.	250	246.2	43.4
11	10.8	1.9	71	69.9	12.3	1	129.	22.7	1	188.1	33.2	1	247.2	43.6
12	11.8	2.1	72	70.9	12.5	2	130.	22.9	2	189.1	33.3	2	248.2	43.8
13	12.8	2.3	73	71.9	12.7	3	131.	23.1	3	190.1	33.5	3	249.2	43.9
14	13.8	2.4	74	72.9	12.8	4	132.	23.3	4	191.1	33.7	4	250.1	44.1
15	14.8	2.6	75	73.9	13.	5	132.9	23.4	5	192.	33.9	5	251.1	44.3
16	15.7	2.8	76	74.8	13.2	6	133.9	23.6	6	193.	34.	6	252.1	44.5
17	16.7	3.	77	75.8	13.4	7	134.9	23.8	7	194.	34.2	7	253.1	44.6
18	17.7	3.1	78	76.8	13.5	8	135.9	24.	8	195.	34.4	8	254.1	44.8
19	18.7	3.3	79	77.8	13.7	9	136.9	24.1	9	196.	34.6	9	255.1	45.
20	19.7	3.5	80	78.8	13.9	140	137.9	24.3	200	197.	34.7	260	256.1	45.1
21	20.7	3.6	81	79.8	14.1	1	138.9	24.5	1	197.9	34.9	1	257.	45.3
22	21.7	3.8	82	80.8	14.2	2	139.8	24.7	2	198.9	35.1	2	258.	45.5
23	22.6	4.	83	81.7	14.4	3	140.8	24.8	3	199:9	35.3	3	259.	45.7
24	23.6	4.2	84	82.7	14.6	4	141.8	25.	4	200.9	35.4	4	260.	45.8
25	24.6	4.3	85	83.7	14.8	5	142.8	25.2	5	201.9	35.6	5	261.	46.
26	25.6	4.5	86	84.7	14.9	6	143.8	25.4	6	202.9	35.8	6	262.	46.2
27	26.6	4.7	87	85.7	15.1	7	144.8	25.5	7	203.9	35.9	7	262.9	46.4
28	27.6	4.9	88	86.7	15.3	8	145.8	25.7	8	204.8	36.1	8	263.9	46.5
29	28.5	5.	89	87.6	15.5	9	146.7	25.9	9	205.8	36.3	9	264.9	46.7
30	29.5	5.2	90	88.6	15.6	150	147.7	26.	210	206.8	36.5	270	265.9	46.9
31	30.5	5.4	91	89.6	15.8	1	148.7	26.2	1	207.8	36.6	1	266.9	47.1
32	31.5	5.6	92	90.6	16.	2	149.7	26.4	2	208.8	36.8	2	267.9	47.2
33	32.5	5.7	93	91.6	16.1	3	150.7	26.6	3	209.8	37.	3	268.9	47.4
34	33.5	5.9	94	92.6	16.3	4	151.7	26.7	4	210.7	37.2	4	269.8	47.6
35	34.5	6.1	95	93.6	16.5	5	152.6	26.9	5	211.7	37.3	5	270.8	47.8
36	35.4	6.3	96	94.5	16.7	6	153.6	27.1	6	212.7	37.5	6	271.8	47.9
37	36.4	6.4	97	95.5	16.8	7	154.6	27.3	7	213.7	37.7	7	272.8	48.1
38	37.4	6.6	98	96.5	17.	8	155.6	27.4	8	214.7	37.9	8	273.8	48.3
39	38.4	6.8	99	97.5	17.2	9	156.6	27.6	9	215.7	38.	9	274.8	48.4
40	39.4	6.9	100	98.5	17.4	160	157.6	27.8	220	216.7	38.2	280	275.7	48.6
41	40.4	7.1	1	99.5	17.5	1	158.6	28.	1	217.6	38.4	1	276.7	48.8
42	41.4	7.3	2	100.5	17.7	2	159.5	28.1	2	218.6	38.5	2	277.7	49.
43	42.3	7.5	3	101.4	17.9	3	160.5	28.3	3	219.6	38.7	3	278.7	49.1
44	43.3	7.6	4	102.4	18.1	4	161.5	28.5	4	220.6	38.9	4	279.7	49.3
45	44.3	7.8	5	103.4	18.2	5	162.5	28.7	5	221.6	39.1	5	280.7	49.5
46	45.3	8.	6	104.4	18.4	6	163.5	28.8	6	222.6	39.2	6	281.7	49.7
47	46.3	8.2	7	105.4	18.6	7	164.5	29.	7	223.6	39.4	7	282.6	49.8
48	47.3	8.3	8	106.4	18.8	8	165.4	29.2	8	224.5	39.6	8	283.6	50.
49	48.3	8.5	9	107.3	18.9	9	166.4	29.3	9	225.5	39.8	9	284.6	50.2
50	49.2	8.7	110	108.3	19.1	170	167.4	29.5	230	226.5	39.9	290	285.6	50.4
51	50.2	8.9	1	109.3	19.3	1	168.4	29.7	1	227.5	40.1	1	286.6	50.5
52	51.2	9.	2	110.3	19.4	2	169.4	29.9	2	228.5	40.3	2	287.6	50.7
53	52.2	9.2	3	111.3	19.6	3	170.4	30.	3	229.5	40.5	3	288.5	50.9
54	53.2	9.4	4	112.3	19.8	4	171.4	30.2	4	230.4	40.6	4	289.5	51.1
55	54.2	9.6	5	113.3	20.	5	172.3	30.4	5	231.4	40.8	5	290.5	51.2
56	55.1	9.7	6	114.2	20.1	6	173.3	30.6	6	232.4	41.	6	291.5	51.4
57	56.1	9.9	7	115.2	20.3	7	174.3	30.7	7	233.4	41.2	7	292.5	51.6
58	57.1	10.1	8	116.2	20.5	8	175.3	30.9	8	234.4	41.3	8	293.5	51.7
59	58.1	10.2	9	117.2	20.7	9	176.3	31.1	9	235.4	41.5	9	294.5	51.9
60	59.1	10.4	120	118.2	20.8	180	177.3	31.3	240	236.4	41.7	300	295.4	52.1
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 80°.

Course 11°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.2	61	59.9	11.6	121	118.8	23.1	181	177.7	34.5	241	236.6	46.
2	2.	0.4	62	60.9	11.8	2	119.8	23.3	2	178.7	34.7	2	237.6	46.2
3	2.9	0.6	63	61.8	12.	3	120.7	23.5	3	179.6	34.9	3	238.5	46.4
4	3.9	0.8	64	62.8	12.2	4	121.7	23.7	4	180.6	35.1	4	239.5	46.6
5	4.9	1.	65	63.8	12.4	5	122.7	23.9	5	181.6	35.3	5	240.5	46.7
6	5.9	1.1	66	64.8	12.6	6	123.7	24.	6	182.6	35.5	6	241.5	46.9
7	6.9	1.3	67	65.8	12.8	7	124.7	24.2	7	183.6	35.7	7	242.5	47.1
8	7.9	1.5	68	66.8	13.	8	125.6	24.4	8	184.5	35.9	8	243.4	47.3
9	8.8	1.7	69	67.7	13.2	9	126.6	24.6	9	185.5	36.1	9	244.4	47.5
10	9.8	1.9	70	68.7	13.4	130	127.6	24.8	190	186.5	36.3	250	245.4	47.7
11	10.8	2.1	71	69.7	13.5	1	128.6	25.	1	187.5	36.4	1	246.4	47.9
12	11.8	2.3	72	70.7	13.7	2	129.6	25.2	2	188.5	36.6	2	247.4	48.1
13	12.8	2.5	73	71.7	13.9	3	130.6	25.4	3	189.5	36.8	3	248.4	48.3
14	13.7	2.7	74	72.6	14.1	4	131.5	25.6	4	190.4	37.	4	249.3	48.5
15	14.7	2.9	75	73.6	14.3	5	132.5	25.8	5	191.4	37.2	5	250.3	48.7
16	15.7	3.1	76	74.6	14.5	6	133.5	26.	6	192.4	37.4	6	251.3	48.8
17	16.7	3.2	77	75.6	14.7	7	134.5	26.1	7	193.4	37.6	7	252.3	49.
18	17.7	3.4	78	76.6	14.9	8	135.5	26.3	8	194.4	37.8	8	253.3	49.2
19	18.7	3.6	79	77.5	15.1	9	136.4	26.5	9	195.3	38.	9	254.2	49.4
20	19.6	3.8	80	78.5	15.3	140	137.4	26.7	200	196.3	38.2	260	255.2	49.6
21	20.6	4.	81	79.5	15.5	1	138.4	26.9	1	197.3	38.4	1	256.2	49.8
22	21.6	4.2	82	80.5	15.6	2	139.4	27.1	2	198.3	38.5	2	257.2	50.
23	22.6	4.4	83	81.5	15.8	3	140.4	27.3	3	199.3	38.7	3	258.2	50.2
24	23.6	4.6	84	82.5	16.	4	141.4	27.5	4	200.3	38.9	4	259.1	50.4
25	24.5	4.8	85	83.4	16.2	5	142.3	27.7	5	201.2	39.1	5	260.1	50.6
26	25.5	5.	86	84.4	16.4	6	143.3	27.9	6	202.2	39.3	6	261.1	50.8
27	26.5	5.2	87	85.4	16.6	7	144.3	28.	7	203.2	39.5	7	262.1	50.9
28	27.5	5.3	88	86.4	16.8	8	145.3	28.2	8	204.2	39.7	8	263.1	51.1
29	28.5	5.5	89	87.4	17.	9	146.3	28.4	9	205.2	39.9	9	264.1	51.3
30	29.4	5.7	90	88.3	17.2	150	147.2	28.6	210	206.1	40.1	270	265.	51.5
31	30.4	5.9	91	89.3	17.4	1	148.2	28.8	1	207.1	40.3	1	266.	51.7
32	31.4	6.1	92	90.3	17.6	2	149.2	29.	2	208.1	40.5	2	267.	51.9
33	32.4	6.3	93	91.3	17.7	3	150.2	29.2	3	209.1	40.6	3	268.	52.1
34	33.4	6.5	94	92.3	17.9	4	151.2	29.4	4	210.1	40.8	4	269.	52.3
35	34.4	6.7	95	93.3	18.1	5	152.2	29.6	5	211.	41.	5	269.9	52.5
36	35.3	6.9	96	94.2	18.3	6	153.1	29.8	6	212.	41.2	6	270.9	52.7
37	36.3	7.1	97	95.2	18.5	7	154.1	30.	7	213.	41.4	7	271.9	52.9
38	37.3	7.3	98	96.2	18.7	8	155.1	30.1	8	214.	41.6	8	272.9	53.
39	38.3	7.4	99	97.2	18.9	9	156.1	30.3	9	215.	41.8	9	273.9	53.2
40	39.3	7.6	100	98.2	19.1	160	157.1	30.5	220	216.	42.	280	274.9	53.4
41	40.2	7.8	1	99.1	19.3	1	158.	30.7	1	216.9	42.2	1	275.8	53.6
42	41.2	8.	2	100.1	19.5	2	159.	30.9	2	217.9	42.4	2	276.8	53.8
43	42.2	8.2	3	101.1	19.7	3	160.	31.1	3	218.9	42.6	3	277.8	54.
44	43.2	8.4	4	102.1	19.8	4	161.	31.3	4	219.9	42.7	4	278.8	54.2
45	44.2	8.6	5	103.1	20.	5	162.	31.5	5	220.9	42.9	5	279.8	54.4
46	45.2	8.8	6	104.1	20.2	6	163.	31.7	6	221.8	43.1	6	280.7	54.6
47	46.1	9.	7	105.	20.4	7	163.9	31.9	7	222.8	43.3	7	281.7	54.8
48	47.1	9.2	8	106.	20.6	8	164.9	32.1	8	223.8	43.5	8	282.7	55.
49	48.1	9.3	9	107.	20.8	9	165.9	32.2	9	224.8	43.7	9	283.7	55.1
50	49.1	9.5	110	108.	21.	170	166.9	32.4	230	225.8	43.9	290	284.7	55.3
51	50.1	9.7	1	109.	21.2	1	167.9	32.6	1	226.8	44.1	1	285.7	55.5
52	51.	9.9	2	109.9	21.4	2	168.8	32.8	2	227.7	44.3	2	286.6	55.7
53	52.	10.1	3	110.9	21.6	3	169.8	33.	3	228.7	44.5	3	287.6	55.9
54	53.	10.3	4	111.9	21.8	4	170.8	33.2	4	229.7	44.6	4	288.6	56.1
55	54.	10.5	5	112.9	21.9	5	171.8	33.4	5	230.7	44.8	5	289.6	56.3
56	55.	10.7	6	113.9	22.1	6	172.8	33.6	6	231.7	45.	6	290.6	56.5
57	56.	10.9	7	114.9	22.3	7	173.7	33.8	7	232.6	45.2	7	291.5	56.7
58	56.9	11.1	8	115.8	22.5	8	174.7	34.	8	233.6	45.4	8	292.5	56.9
59	57.9	11.3	9	116.8	22.7	9	175.7	34.2	9	234.6	45.6	9	293.5	57.1
60	58.9	11.4	120	117.8	22.9	180	176.7	34.3	240	235.6	45.8	300	294.5	57.2
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 79°.

Course 12°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.2	61	59.7	12.7	121	118.4	25.2	181	177.	37.6	241	235.7	50.1
2	2.	0.4	62	60.6	12.9	2	119.3	25.4	2	178.	37.8	2	236.7	50.3
3	2.9	0.6	63	61.6	13.1	3	120.3	25.6	3	179.	38.	3	237.7	50.5
4	3.9	0.8	64	62.6	13.3	4	121.3	25.8	4	180.	38.3	4	238.7	50.7
5	4.9	1.	65	63.6	13.5	5	122.3	26.	5	181.	38.5	5	239.6	50.9
6	5.9	1.2	66	64.6	13.7	6	123.2	26.2	6	181.9	38.7	6	240.6	51.1
7	6.8	1.5	67	65.5	13.9	7	124.2	26.4	7	182.9	38.9	7	241.6	51.4
8	7.8	1.7	68	66.5	14.1	8	125.2	26.6	8	183.9	39.1	8	242.6	51.6
9	8.8	1.9	69	67.5	14.3	9	126.2	26.8	9	184.9	39.3	9	243.6	51.8
10	9.8	2.1	70	68.5	14.6	130	127.2	27.	190	185.8	39.5	250	244.5	52.
11	10.8	2.3	71	69.4	14.8	1	128.1	27.2	1	186.8	39.7	1	245.5	52.2
12	11.7	2.5	72	70.4	15.	2	129.1	27.4	2	187.8	39.9	2	246.5	52.4
13	12.7	2.7	73	71.4	15.2	3	130.1	27.7	3	188.8	40.1	3	247.5	52.6
14	13.7	2.9	74	72.4	15.4	4	131.1	27.9	4	189.8	40.3	4	248.4	52.8
15	14.7	3.1	75	73.4	15.6	5	132.	28.1	5	190.7	40.5	5	249.4	53.
16	15.6	3.3	76	74.3	15.8	6	133.	28.3	6	191.7	40.8	6	250.4	53.2
17	16.6	3.5	77	75.3	16.	7	134.	28.5	7	192.7	41.	7	251.4	53.4
18	17.6	3.7	78	76.3	16.2	8	135.	28.7	8	193.7	41.2	8	252.4	53.6
19	18.6	4.	79	77.3	16.4	9	136.	28.9	9	194.7	41.4	9	253.3	53.8
20	19.6	4.2	80	78.3	16.6	140	136.9	29.1	200	195.6	41.6	260	254.3	54.1
21	20.5	4.4	81	79.2	16.8	1	137.9	29.3	1	196.6	41.8	1	255.3	54.3
22	21.5	4.6	82	80.2	17.	2	138.9	29.5	2	197.6	42.	2	256.3	54.5
23	22.5	4.8	83	81.2	17.3	3	139.9	29.7	3	198.6	42.2	3	257.3	54.7
24	23.5	5.	84	82.2	17.5	4	140.9	29.9	4	199.5	42.4	4	258.2	54.9
25	24.4	5.2	85	83.1	17.7	5	141.8	30.1	5	200.5	42.6	5	259.2	55.1
26	25.4	5.4	86	84.1	17.9	6	142.8	30.4	6	201.5	42.8	6	260.2	55.3
27	26.4	5.6	87	85.1	18.1	7	143.8	30.6	7	202.5	43.	7	261.2	55.5
28	27.4	5.8	88	86.1	18.3	8	144.8	30.8	8	203.5	43.2	8	262.1	55.7
29	28.4	6.	89	87.1	18.5	9	145.7	31.	9	204.4	43.5	9	263.1	55.9
30	29.3	6.2	90	88.	18.7	150	146.7	31.2	210	205.4	43.7	270	264.1	56.1
31	30.3	6.4	91	89.	18.9	1	147.7	31.4	1	206.4	43.9	1	265.1	56.3
32	31.3	6.7	92	90.	19.1	2	148.7	31.6	2	207.4	44.1	2	266.1	56.6
33	32.3	6.9	93	91.	19.3	3	149.7	31.8	3	208.3	44.3	3	267.	56.8
34	33.3	7.1	94	91.9	19.5	4	150.6	32.	4	209.3	44.5	4	268.	57.
35	34.2	7.3	95	92.9	19.8	5	151.6	32.2	5	210.3	44.7	5	269.	57.2
36	35.2	7.5	96	93.9	20.	6	152.6	32.4	6	211.3	44.9	6	270.	57.4
37	36.2	7.7	97	94.9	20.2	7	153.6	32.6	7	212.3	45.1	7	270.9	57.6
38	37.2	7.9	98	95.9	20.4	8	154.5	32.9	8	213.2	45.3	8	271.9	57.8
39	38.1	8.1	99	96.8	20.6	9	155.5	33.1	9	214.2	45.5	9	272.9	58.
40	39.1	8.3	100	97.8	20.8	160	156.5	33.3	220	215.2	45.7	280	273.9	58.2
41	40.1	8.5	1	98.8	21.	1	157.5	33.5	1	216.2	45.9	1	274.9	58.4
42	41.1	8.7	2	99.8	21.2	2	158.5	33.7	2	217.1	46.2	2	275.8	58.6
43	42.1	8.9	3	100.7	21.4	3	159.4	33.9	3	218.1	46.4	3	276.8	58.8
44	43.	9.1	4	101.7	21.6	4	160.4	34.1	4	219.1	46.6	4	277.8	59.
45	44.	9.4	5	102.7	21.8	5	161.4	34.3	5	220.1	46.8	5	278.8	59.3
46	45.	9.6	6	103.7	22.	6	162.4	34.5	6	221.1	47.	6	279.8	59.5
47	46.	9.8	7	104.7	22.2	7	163.4	34.7	7	222.	47.2	7	280.7	59.7
48	47.	10.	8	105.7	22.5	8	164.3	34.9	8	223.	47.4	8	281.7	59.9
49	47.9	10.2	9	106.6	22.7	9	165.3	35.1	9	224.	47.6	9	282.7	60.1
50	48.9	10.4	110	107.6	22.9	170	166.3	35.3	230	225.	47.8	290	283.7	60.3
51	49.9	10.6	1	108.6	23.1	1	167.3	35.6	1	226.	48.	1	284.6	60.5
52	50.9	10.8	2	109.6	23.3	2	168.2	35.8	2	226.9	48.2	2	285.6	60.7
53	51.8	11.	3	110.5	23.5	3	169.2	36.	3	227.9	48.4	3	286.6	60.9
54	52.8	11.2	4	111.5	23.7	4	170.2	36.2	4	228.9	48.7	4	287.6	61.1
55	53.8	11.4	5	112.5	23.9	5	171.2	36.4	5	229.9	48.9	5	288.6	61.3
56	54.8	11.6	6	113.5	24.1	6	172.2	36.6	6	230.8	49.1	6	289.5	61.5
57	55.8	11.9	7	114.4	24.3	7	173.1	36.8	7	231.8	49.3	7	290.5	61.7
58	56.7	12.1	8	115.4	24.5	8	174.1	37.	8	232.8	49.5	8	291.5	62.
59	57.7	12.3	9	116.4	24.7	9	175.1	37.2	9	233.8	49.7	9	292.5	62.2
60	58.7	12.5	120	117.4	24.9	180	176.1	37.4	240	234.8	49.9	300	293.4	62.4
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 78°.

Course 13°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.2	61	59.4	13.7	121	117.9	27.2	181	176.4	40.7	241	234.8	54.2
2	1.9	0.4	62	60.4	13.9	2	118.9	27.4	2	177.3	40.9	2	235.8	54.4
3	2.9	0.7	63	61.4	14.2	3	119.8	27.7	3	178.3	41.2	3	236.8	54.7
4	3.9	0.9	64	62.4	14.4	4	120.8	27.9	4	179.3	41.4	4	237.7	54.9
5	4.9	1.1	65	63.3	14.6	5	121.8	28.1	5	180.3	41.6	5	238.7	55.1
6	5.8	1.3	66	64.3	14.8	6	122.8	28.3	6	181.2	41.8	6	239.7	55.3
7	6.8	1.6	67	65.3	15.1	7	123.7	28.6	7	182.2	42.1	7	240.7	55.6
8	7.8	1.8	68	66.3	15.3	8	124.7	28.8	8	183.2	42.3	8	241.6	55.8
9	8.8	2.	69	67.2	15.5	9	125.7	29.	9	184.2	42.5	9	242.6	56.
10	9.7	2.2	70	68.2	15.7	130	126.7	29.2	190	185.1	42.7	250	243.6	56.2
11	10.7	2.5	71	69.2	16.	1	127.6	29.5	1	186.1	43.	1	244.6	56.5
12	11.7	2.7	72	70.2	16.2	2	128.6	29.7	2	187.1	43.2	2	245.5	56.7
13	12.7	2.9	73	71.1	16.4	3	129.6	29.9	3	188.1	43.4	3	246.5	56.9
14	13.6	3.1	74	72.1	16.6	4	130.6	30.1	4	189.	43.6	4	247.5	57.1
15	14.6	3.4	75	73.1	16.9	5	131.5	30.4	5	190.	43.9	5	248.5	57.4
16	15.6	3.6	76	74.1	17.1	6	132.5	30.6	6	191.	44.1	6	249.4	57.6
17	16.6	3.8	77	75.	17.3	7	133.5	30.8	7	192.	44.3	7	250.4	57.8
18	17.5	4.	78	76.	17.5	8	134.5	31.	8	192.9	44.5	8	251.4	58.
19	18.5	4.3	79	77.	17.8	9	135.4	31.3	9	193.9	44.8	9	252.4	58.3
20	19.5	4.5	80	77.9	18.	140	136.4	31.5	200	194.9	45.	260	253.3	58.5
21	20.5	4.7	81	78.9	18.2	1	137.4	31.7	1	195.8	45.2	1	254.3	58.7
22	21.4	4.9	82	79.9	18.4	2	138.4	31.9	2	196.8	45.4	2	255.3	58.9
23	22.4	5.2	83	80.9	18.7	3	139.3	32.2	3	197.8	45.7	3	256.3	59.2
24	23.4	5.4	84	81.8	18.9	4	140.3	32.4	4	198.8	45.9	4	257.2	59.4
25	24.4	5.6	85	82.8	19.1	5	141.3	32.6	5	199.7	46.1	5	258.2	59.6
26	25.3	5.8	86	83.8	19.3	6	142.3	32.8	6	200.7	46.3	6	259.2	59.8
27	26.3	6.1	87	84.8	19.6	7	143.2	33.1	7	201.7	46.6	7	260.2	60.1
28	27.3	6.3	88	85.7	19.8	8	144.2	33.3	8	202.7	46.8	8	261.1	60.3
29	28.3	6.5	89	86.7	20.	9	145.2	33.5	9	203.6	47.	9	262.1	60.5
30	29.2	6.7	90	87.7	20.2	150	146.2	33.7	210	204.6	47.2	270	263.1	60.7
31	30.2	7.	91	88.7	20.5	1	147.1	34.	1	205.6	47.5	1	264.1	61.
32	31.2	7.2	92	89.6	20.7	2	148.1	34.2	2	206.6	47.7	2	265.	61.2
33	32.1	7.4	93	90.6	20.9	3	149.1	34.4	3	207.5	47.9	3	266.	61.4
34	33.1	7.6	94	91.6	21.1	4	150.1	34.6	4	208.5	48.1	4	267.	61.6
35	34.1	7.9	95	92.6	21.4	5	151.	34.9	5	209.5	48.4	5	268.	61.9
36	35.1	8.1	96	93.5	21.6	6	152.	35.1	6	210.5	48.6	6	268.9	62.1
37	36.1	8.3	97	94.5	21.8	7	153.	35.3	7	211.4	48.8	7	269.9	62.3
38	37.	8.5	98	95.5	22.	8	154.	35.5	8	212.4	49.	8	270.9	62.5
39	38.	8.8	99	96.5	22.3	9	154.9	35.8	9	213.4	49.3	9	271.8	62.8
40	39.	9.	100	97.4	22.5	160	155.9	36.	220	214.4	49.5	280	272.8	63.
41	39.9	9.2	1	98.4	22.7	1	156.9	36.2	1	215.3	49.7	1	273.8	63.2
42	40.9	9.4	2	99.4	22.9	2	157.8	36.4	2	216.3	49.9	2	274.8	63.4
43	41.9	9.7	3	100.4	23.2	3	158.8	36.7	3	217.3	50.2	3	275.7	63.7
44	42.9	9.9	4	101.3	23.4	4	159.8	36.9	4	218.3	50.4	4	276.7	63.9
45	43.8	10.1	5	102.3	23.6	5	160.8	37.1	5	219.2	50.6	5	277.7	64.1
46	44.8	10.3	6	103.3	23.8	6	161.7	37.3	6	220.2	50.8	6	278.7	64.3
47	45.8	10.6	7	104.3	24.1	7	162.7	37.6	7	221.2	51.1	7	279.6	64.6
48	46.8	10.8	8	105.2	24.3	8	163.7	37.8	8	222.2	51.3	8	280.6	64.8
49	47.7	11.	9	106.2	24.5	9	164.7	38.	9	223.1	51.5	9	281.6	65.
50	48.7	11.2	110	107.2	24.7	170	165.6	38.2	230	224.1	51.7	290	282.6	65.2
51	49.7	11.5	1	108.2	25.	1	166.6	38.5	1	225.1	52.	1	283.5	65.5
52	50.7	11.7	2	109.1	25.2	2	167.6	38.7	2	226.1	52.2	2	284.5	65.7
53	51.6	11.9	3	110.1	25.4	3	168.6	38.9	3	227.	52.4	3	285.5	65.9
54	52.6	12.1	4	111.1	25.6	4	169.5	39.1	4	228.	52.6	4	286.4	66.1
55	53.6	12.4	5	112.1	25.9	5	170.5	39.4	5	229.	52.9	5	287.4	66.4
56	54.6	12.6	6	113.	26.1	6	171.5	39.6	6	230.	53.1	6	288.4	66.6
57	55.5	12.8	7	114.	26.3	7	172.5	39.8	7	230.9	53.3	7	289.4	66.8
58	56.5	13.	8	115.	26.5	8	173.4	40.	8	231.9	53.5	8	290.4	67.
59	57.5	13.3	9	116.	26.8	9	174.4	40.3	9	232.9	53.8	9	291.3	67.3
60	58.5	13.5	120	116.9	27.	180	175.4	40.5	240	233.8	54.	300	292.3	67.5
dist.	dep.	d.lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 77°.

Course 14°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.2	61	59.2	14.8	121	117.4	29.3	181	175.6	43.8	241	233.8	58.3
2	1.9	0.5	62	60.2	15.	2	118.4	29.5	2	176.6	44.	2	234.8	58.5
3	2.9	0.7	63	61.1	15.2	3	119.3	29.8	3	177.6	44.3	3	235.8	58.8
4	3.9	1.	64	62.1	15.5	4	120.3	30.	4	178.5	44.5	4	236.8	59.
5	4.9	1.2	65	63.1	15.7	5	121.3	30.2	5	179.5	44.8	5	237.7	59.3
6	5.8	1.5	66	64.	16.	6	122.3	30.5	6	180.5	45.	6	238.7	59.5
7	6.8	1.7	67	65.	16.2	7	123.2	30.7	7	181.4	45.2	7	239.7	59.8
8	7.8	1.9	68	66.	16.5	8	124.2	31.	8	182.4	45.5	8	240.6	60.
9	8.7	2.2	69	67.	16.7	9	125.2	31.2	9	183.4	45.7	9	241.6	60.2
10	9.7	2.4	70	67.9	16.9	130	126.1	31.4	190	184.4	46.	250	242.6	60.5
11	10.7	2.7	71	68.9	17.2	1	127.1	31.7	1	185.3	46.2	1	243.5	60.7
12	11.6	2.9	72	69.9	17.4	2	128.1	31.9	2	186.3	46.4	2	244.5	61.
13	12.6	3.1	73	70.8	17.7	3	129.	32.2	3	187.3	46.7	3	245.5	61.2
14	13.6	3.4	74	71.8	17.9	4	130.	32.4	4	188.2	46.9	4	246.5	61.4
15	14.6	3.6	75	72.8	18.1	5	131.	32.7	5	189.2	47.2	5	247.4	61.7
16	15.5	3.9	76	73.7	18.4	6	132.	32.9	6	190.2	47.4	6	248.4	61.9
17	16.5	4.1	77	74.7	18.6	7	132.9	33.1	7	191.1	47.7	7	249.4	62.2
18	17.5	4.4	78	75.7	18.9	8	133.9	33.4	8	192.1	47.9	8	250.3	62.4
19	18.4	4.6	79	76.7	19.1	9	134.9	33.6	9	193.1	48.1	9	251.3	62.7
20	19.4	4.8	80	77.6	19.4	140	135.8	33.9	200	194.1	48.4	260	252.3	62.9
21	20.4	5.1	81	78.6	19.6	1	136.8	34.1	1	195.	48.6	1	253.2	63.1
22	21.3	5.3	82	79.6	19.8	2	137.8	34.4	2	196.	48.9	2	254.2	63.4
23	22.3	5.6	83	80.5	20.1	3	138.8	34.6	3	197.	49.1	3	255.2	63.6
24	23.3	5.8	84	81.5	20.3	4	139.7	34.8	4	197.9	49.4	4	256.2	63.9
25	24.3	6.	85	82.5	20.6	5	140.7	35.1	5	198.9	49.6	5	257.1	64.1
26	25.2	6.3	86	83.4	20.8	6	141.7	35.3	6	199.9	49.8	6	258.1	64.4
27	26.2	6.5	87	84.4	21.	7	142.6	35.6	7	200.9	50.1	7	259.1	64.6
28	27.2	6.8	88	85.4	21.3	8	143.6	35.8	8	201.8	50.3	8	260.	64.8
29	28.1	7.	89	86.4	21.5	9	144.6	36.	9	202.8	50.6	9	261.	65.1
30	29.1	7.3	90	87.3	21.8	150	145.5	36.3	210	203.8	50.8	270	262.	65.3
31	30.1	7.5	91	88.3	22.	1	146.5	36.5	1	204.7	51.	1	263.	65.6
32	31.	7.7	92	89.3	22.3	2	147.5	36.8	2	205.7	51.3	2	263.9	65.8
33	32.	8.	93	90.2	22.5	3	148.5	37.	3	206.7	51.5	3	264.9	66.
34	33.	8.2	94	91.2	22.7	4	149.4	37.3	4	207.6	51.8	4	265.9	66.3
35	34.	8.5	95	92.2	23.	5	150.4	37.5	5	208.6	52.	5	266.8	66.5
36	34.9	8.7	96	93.1	23.2	6	151.4	37.7	6	209.6	52.3	6	267.8	66.8
37	35.9	9.	97	94.1	23.5	7	152.3	38.	7	210.6	52.5	7	268.8	67.
38	36.9	9.2	98	95.1	23.7	8	153.3	38.2	8	211.5	52.7	8	269.7	67.3
39	37.8	9.4	99	96.1	24.	9	154.3	38.5	9	212.5	53.	9	270.7	67.5
40	38.8	9.7	100	97.	24.2	160	155.2	38.7	220	213.5	53.2	280	271.7	67.7
41	39.8	9.9	1	98.	24.4	1	156.2	38.9	1	214.4	53.5	1	272.7	68.
42	40.8	10.2	2	99.	24.7	2	157.2	39.2	2	215.4	53.7	2	273.6	68.2
43	41.7	10.4	3	99.9	24.9	3	158.2	39.4	3	216.4	53.9	3	274.6	68.5
44	42.7	10.6	4	100.9	25.2	4	159.1	39.7	4	217.3	54.2	4	275.6	68.7
45	43.7	10.9	5	101.9	25.4	5	160.1	39.9	5	218.3	54.4	5	276.5	68.9
46	44.6	11.1	6	102.9	25.6	6	161.1	40.2	6	219.3	54.7	6	277.5	69.2
47	45.6	11.4	7	103.8	25.9	7	162.	40.4	7	220.3	54.9	7	278.5	69.4
48	46.6	11.6	8	104.8	26.1	8	163.	40.6	8	221.2	55.2	8	279.4	69.7
49	47.5	11.9	9	105.8	26.4	9	164.	40.9	9	222.2	55.4	9	280.4	69.9
50	48.5	12.1	110	106.7	26.6	170	165.	41.1	230	223.2	55.6	290	281.4	70.2
51	49.5	12.3	1	107.7	26.9	1	165.9	41.4	1	224.1	55.9	1	282.4	70.4
52	50.5	12.6	2	108.7	27.1	2	166.9	41.6	2	225.1	56.1	2	283.3	70.6
53	51.4	12.8	3	109.6	27.3	3	167.9	41.9	3	226.1	56.4	3	284.3	70.9
54	52.4	13.1	4	110.6	27.6	4	168.8	42.1	4	227.	56.6	4	285.3	71.1
55	53.4	13.3	5	111.6	27.8	5	169.8	42.3	5	228.	56.9	5	286.2	71.4
56	54.3	13.5	6	112.6	28.1	6	170.8	42.6	6	229.	57.1	6	287.2	71.6
57	55.3	13.8	7	113.5	28.3	7	171.7	42.8	7	230.	57.3	7	288.2	71.9
58	56.3	14.	8	114.5	28.5	8	172.7	43.1	8	230.9	57.6	8	289.1	72.1
59	57.2	14.3	9	115.5	28.8	9	173.7	43.3	9	231.9	57.8	9	290.1	72.3
60	58.2	14.5	120	116.4	29.	180	174.7	43.5	240	232.9	58.1	300	291.1	72.6
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 76°.

Course 15°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.3	61	58.9	15.8	121	116.9	31.3	181	174.8	46.8	241	232.8	62.4
2	1.9	0.5	62	59.9	16.	2	117.8	31.6	2	175.8	47.1	2	233.8	62.6
3	2.9	0.8	63	60.9	16.3	3	118.8	31.8	3	176.8	47.4	3	234.7	62.9
4	3.9	1.	64	61.8	16.6	4	119.8	32.1	4	177.7	47.6	4	235.7	63.2
5	4.8	1.3	65	62.8	16.8	5	120.7	32.4	5	178.7	47.9	5	236.7	63.4
6	5.8	1.6	66	63.8	17.1	6	121.7	32.6	6	179.7	48.1	6	237.6	63.7
7	6.8	1.8	67	64.7	17.3	7	122.7	32.9	7	180.6	48.4	7	238.6	63.9
8	7.7	2.1	68	65.7	17.6	8	123.6	33.1	8	181.6	48.7	8	239.5	64.2
9	8.7	2.3	69	66.6	17.9	9	124.6	33.4	9	182.6	48.9	9	240.5	64.4
10	9.7	2.6	70	67.6	18.1	130	125.6	33.6	190	183.5	49.2	250	241.5	64.7
11	10.6	2.8	71	68.6	18.4	1	126.5	33.9	1	184.5	49.4	1	242.4	65.
12	11.6	3.1	72	69.5	18.6	2	127.5	34.2	2	185.5	49.7	2	243.4	65.2
13	12.6	3.4	73	70.5	18.9	3	128.5	34.4	3	186.4	50.	3	244.4	65.5
14	13.5	3.6	74	71.5	19.2	4	129.4	34.7	4	187.4	50.2	4	245.3	65.7
15	14.5	3.9	75	72.4	19.4	5	130.4	34.9	5	188.4	50.5	5	246.3	66.
16	15.5	4.1	76	73.4	19.7	6	131.4	35.2	6	189.3	50.7	6	247.3	66.3
17	16.4	4.4	77	74.4	19.9	7	132.3	35.5	7	190.3	51.	7	248.2	66.5
18	17.4	4.7	78	75.3	20.2	8	133.3	35.7	8	191.3	51.2	8	249.2	66.8
19	18.4	4.9	79	76.3	20.4	9	134.3	36.	9	192.2	51.5	9	250.2	67.
20	19.3	5.2	80	77.3	20.7	140	135.2	36.2	200	193.2	51.8	260	251.1	67.3
21	20.3	5.4	81	78.2	21.	1	136.2	36.5	1	194.2	52.	1	252.1	67.6
22	21.3	5.7	82	79.2	21.2	2	137.2	36.8	2	105.1	52.3	2	253.1	67.8
23	22.2	6.	83	80.2	21.5	3	138.1	37.	3	196.1	52.5	3	254.	68.1
24	23.2	6.2	84	81.1	21.7	4	139.1	37.3	4	197.	52.8	4	255.	68.3
25	24.1	6.5	85	82.1	22.	5	140.1	37.5	5	198.	53.1	5	256.	68.6
26	25.1	6.7	86	83.1	22.3	6	141.	37.8	6	199.	53.3	6	256.9	68.8
27	26.1	7.	87	84.	22.5	7	142.	38.	7	199.9	53.6	7	257.9	69.1
28	27.	7.2	88	85.	22.8	8	143.	38.3	8	200.9	53.8	8	258.9	69.4
29	28.	7.5	89	86.	23.	9	143.9	38.6	9	201.9	54.1	9	259.8	69.6
30	29.	7.8	90	86.9	23.3	150	144.9	38.8	210	202.8	54.4	270	260.8	69.9
31	29.9	8.	91	87.9	23.6	1	145.9	39.1	1	203.8	54.6	1	261.8	70.1
32	30.9	8.3	92	88.9	23.8	2	146.8	39.3	2	204.8	54.9	2	262.7	70.4
33	31.9	8.5	93	89.8	24.1	3	147.8	39.6	3	205.7	55.1	3	263.7	70.7
34	32.8	8.8	94	90.8	24.3	4	148.8	39.9	4	206.7	55.4	4	264.7	70.9
35	33.8	9.1	95	91.8	24.6	5	149.7	40.1	5	207.7	55.6	5	265.6	71.2
36	34.8	9.3	96	92.7	24.8	6	150.7	40.4	6	208.6	55.9	6	266.6	71.4
37	35.7	9.6	97	93.7	25.1	7	151.7	40.6	7	209.6	56.2	7	267.6	71.7
38	36.7	9.8	98	94.7	25.4	8	152.6	40.9	8	210.6	56.4	8	268.5	72.
39	37.7	10.1	99	95.6	25.6	9	153.6	41.2	9	211.5	56.7	9	269.5	72.2
40	38.6	10.4	100	96.6	25.9	160	154.5	41.4	220	212.5	56.9	280	270.5	72.5
41	39.6	10.6	1	97.6	26.1	1	155.5	41.7	1	213.5	57.2	1	271.4	72.7
42	40.6	10.9	2	98.5	26.4	2	156.5	41.9	2	214.4	57.5	2	272.4	73.
43	41.5	11.1	3	99.5	26.7	3	157.4	42.2	3	215.4	57.7	3	273.4	73.2
44	42.5	11.4	4	100.5	26.9	4	158.4	42.4	4	216.4	58.	4	274.3	73.5
45	43.5	11.6	5	101.4	27.2	5	159.4	42.7	5	217.3	58.2	5	275.3	73.8
46	44.4	11.9	6	102.4	27.4	6	160.3	43.	6	218.3	58.5	6	276.3	74.
47	45.4	12.2	7	103.4	27.7	7	161.3	43.2	7	219.3	58.8	7	277.2	74.3
48	46.4	12.4	8	104.3	28.	8	162.3	43.5	8	220.2	59.	8	278.2	74.5
49	47.3	12.7	9	105.3	28.2	9	163.2	43.7	9	221.2	59.3	9	279.2	74.8
50	48.3	12.9	110	106.3	28.5	170	164.2	44.	230	222.2	59.5	290	280.1	75.1
51	49.3	13.2	1	107.2	28.7	1	165.2	44.3	1	223.1	59.8	1	281.1	75.3
52	50.2	13.5	2	108.2	29.	2	166.1	44.5	2	224.1	60.	2	282.1	75.6
53	51.2	13.7	3	109.1	29.2	3	167.1	44.8	3	225.1	60.3	3	283.	75.8
54	52.2	14.	14	110.1	29.5	4	168.1	45.	4	226.	60.6	4	284.	76.1
55	53.1	14.2	15	111.1	29.8	5	169.	45.3	5	227.	60.8	5	284.9	76.4
56	54.1	14.5	16	112.	30.	6	170.	45.6	6	228.	61.1	6	285.9	76.6
57	55.1	14.8	17	113.	30.3	7	171.	45.8	7	228.9	61.3	7	286.9	76.9
58	56.	15.	18	114.	30.5	8	171.9	46.1	8	229.9	61.6	8	287.8	77.1
59	57.	15.3	19	114.9	30.8	9	172.9	46.3	9	230.9	61.9	9	288.8	77.4
60	58.	15.5	120	115.9	31.1	180	173.9	46.6	240	231.8	62.1	300	289.8	77.6
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude

Course 75°.

Course 16°

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep
1	1.	0.3	61	58.6	16.8	121	116.3	33.4	181	174.	49.9	241	231.7	66.4
2	1.9	0.6	2	59.6	17.1	2	117.3	33.6	2	174.9	50.2	2	232.6	66.7
3	2.9	0.8	3	60.6	17.4	3	118.2	33.9	3	175.9	50.4	3	233.6	67.
4	3.8	1.1	4	61.5	17.6	4	119.2	34.2	4	176.9	50.7	4	234.5	67.3
5	4.8	1.4	5	62.5	17.9	5	120.2	34.5	5	177.8	51.	5	235.5	67.5
6	5.8	1.7	6	63.4	18.2	6	121.1	34.7	6	178.8	51.3	6	236.5	67.8
7	6.7	1.9	7	64.4	18.5	7	122.1	35.	7	179.8	51.5	7	237.4	68.1
8	7.7	2.2	8	65.4	18.7	8	123.	35.3	8	180.7	51.8	8	238.4	68.4
9	8.7	2.5	9	66.3	19.	9	124.	35.6	9	181.7	52.1	9	239.4	68.6
10	9.6	2.8	70	67.3	19.3	130	125.	35.8	190	182.6	52.4	250	240.3	68.9
11	10.6	3.	1	68.2	19.6	1	125.9	36.1	1	183.6	52.6	1	241.3	69.2
12	11.5	3.3	2	69.2	19.8	2	126.9	36.4	2	184.6	52.9	2	242.2	69.5
13	12.5	3.6	3	70.2	20.1	3	127.8	36.7	3	185.5	53.2	3	243.2	69.7
14	13.5	3.9	4	71.1	20.4	4	128.8	36.9	4	186.5	53.5	4	244.2	70.
15	14.4	4.1	5	72.1	20.7	5	129.8	37.2	5	187.4	53.7	5	245.1	70.3
16	15.4	4.4	6	73.1	20.9	6	130.7	37.5	6	188.4	54.	6	246.1	70.6
17	16.3	4.7	7	74.	21.2	7	131.7	37.8	7	189.4	54.3	7	247.	70.8
18	17.3	5.	8	75.	21.5	8	132.7	38.	8	190.3	54.6	8	248.	71.1
19	18.3	5.2	9	75.9	21.8	9	133.6	38.3	9	191.3	54.9	9	249.	71.4
20	19.2	5.5	80	76.9	22.1	140	134.6	38.6	200	192.3	55.1	260	249.9	71.7
21	20.2	5.8	1	77.9	22.3	1	135.5	38.9	1	193.2	55.4	1	250.9	71.9
22	21.1	6.1	2	78.8	22.6	2	136.5	39.1	2	194.2	55.7	2	251.9	72.2
23	22.1	6.3	3	79.8	22.9	3	137.5	39.4	3	195.1	56.	3	252.8	72.5
24	23.1	6.6	4	80.7	23.2	4	138.4	39.7	4	196.1	56.2	4	253.8	72.8
25	24.	6.9	5	81.7	23.4	5	139.4	40.	5	197.1	56.5	5	254.7	73.
26	25.	7.2	6	82.7	23.7	6	140.3	40.2	6	198.	56.8	6	255.7	73.3
27	26.	7.4	7	83.6	24.	7	141.3	40.5	7	199.	57.1	7	256.7	73.6
28	26.9	7.7	8	84.6	24.3	8	142.3	40.8	8	199.9	57.3	8	257.6	73.9
29	27.9	8.	9	85.6	24.5	9	143.2	41.1	9	200.9	57.6	9	258.6	74.1
30	28.8	8.3	90	86.5	24.8	150	144.2	41.3	210	201.9	57.9	270	259.5	74.4
31	29.8	8.5	1	87.5	25.1	1	145.2	41.6	1	202.8	58.2	1	260.5	74.7
32	30.8	8.8	2	88.4	25.4	2	146.1	41.9	2	203.8	58.4	2	261.5	75.
33	31.7	9.1	3	89.4	25.6	3	147.1	42.2	3	204.7	58.7	3	262.4	75.2
34	32.7	9.4	4	90.4	25.9	4	148.	42.4	4	205.7	59.	4	263.4	75.5
35	33.6	9.6	5	91.3	26.2	5	149.	42.7	5	206.7	59.3	5	264.3	75.8
36	34.6	9.9	6	92.3	26.5	6	150.	43.	6	207.6	59.5	6	265.3	76.1
37	35.6	10.2	7	93.2	26.7	7	150.9	43.3	7	208.6	59.8	7	266.3	76.4
38	36.5	10.5	8	94.2	27.	8	151.9	43.6	8	209.6	60.1	8	267.2	76.6
39	37.5	10.7	9	95.2	27.3	9	152.8	43.8	9	210.5	60.4	9	268.2	76.9
40	38.5	11.	100	96.1	27.6	160	153.8	44.1	220	211.5	60.6	280	269.2	77.2
41	39.4	11.3	1	97.1	27.8	1	154.8	44.4	1	212.4	60.9	1	270.1	77.5
42	40.4	11.6	2	98.	28.1	2	155.7	44.7	2	213.4	61.2	2	271.1	77.7
43	41.3	11.9	3	99.	28.4	3	156.7	44.9	3	214.4	61.5	3	272.	78.
44	42.3	12.1	4	100.	28.7	4	157.6	45.2	4	215.3	61.7	4	273.	78.3
45	43.3	12.4	5	100.9	28.9	5	158.6	45.5	5	216.3	62.	5	274.	78.6
46	44.2	12.7	6	101.9	29.2	6	159.6	45.8	6	217.2	62.3	6	274.9	78.8
47	45.2	13.	7	102.9	29.5	7	160.5	46.	7	218.2	62.6	7	275.9	79.1
48	46.1	13.2	8	103.8	29.8	8	161.5	46.3	8	219.2	62.8	8	276.8	79.4
49	47.1	13.5	9	104.8	30.	9	162.5	46.6	9	220.1	63.1	9	277.8	79.7
50	48.1	13.8	110	105.7	30.3	170	163.4	46.9	230	221.1	63.4	290	278.8	79.9
51	49.	14.1	1	106.7	30.6	1	164.4	47.1	1	222.1	63.7	1	279.7	80.2
52	50.	14.3	2	107.7	30.9	2	165.3	47.4	2	223.	63.9	2	280.7	80.5
53	50.9	14.6	3	108.6	31.1	3	166.3	47.7	3	224.	64.2	3	281.6	80.8
54	51.9	14.9	4	109.6	31.4	4	167.3	48.	4	224.9	64.5	4	282.6	81.
55	52.9	15.2	5	110.5	31.7	5	168.2	48.2	5	225.9	64.8	5	283.6	81.3
56	53.8	15.4	6	111.5	32.	6	169.2	48.5	6	226.9	65.1	6	284.5	81.6
57	54.8	15.7	7	112.5	32.2	7	170.1	48.8	7	227.8	65.3	7	285.5	81.9
58	55.8	16.	8	113.4	32.5	8	171.1	49.1	8	228.8	65.6	8	286.5	82.1
59	56.7	16.3	9	114.4	32.8	9	172.1	49.3	9	229.7	65.9	9	287.4	82.4
60	57.7	16.5	120	115.4	33.1	180	173.	49.6	240	230.7	66.2	300	288.4	82.7
dist.	dep.	d. lat	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 74°.

Course 17°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.3	61	58.3	17.8	121	115.7	35.4	181	173.1	52.9	241	230.5	70.5
2	1.9	0.6	62	59.3	18.1	2	116.7	35.7	2	174.	53.2	2	231.4	70.8
3	2.9	0.9	63	60.2	18.4	3	117.6	36.	3	175.	53.5	3	232.4	71.
4	3.8	1.2	64	61.2	18.7	4	118.6	36.3	4	176.	53.8	4	233.3	71.3
5	4.8	1.5	65	62.2	19.	5	119.5	36.5	5	176.9	54.1	5	234.3	71.6
6	5.7	1.8	66	63.1	19.3	6	120.5	36.8	6	177.9	54.4	6	235.3	71.9
7	6.7	2.	67	64.1	19.6	7	121.5	37.1	7	178.8	54.7	7	236.2	72.2
8	7.7	2.3	68	65.	19.9	8	122.4	37.4	8	179.8	55.	8	237.2	72.5
9	8.6	2.6	69	66.	20.2	9	123.4	37.7	9	180.7	55.3	9	238.1	72.8
10	9.6	2.9	70	66.9	20.5	130	124.3	38.	190	181.7	55.6	250	239.1	73.1
11	10.5	3.2	71	67.9	20.8	1	125.3	38.3	1	182.7	55.8	1	240.	73.4
12	11.5	3.5	72	68.9	21.1	2	126.2	38.6	2	183.6	56.1	2	241.	73.7
13	12.4	3.8	73	69.8	21.3	3	127.2	38.9	3	184.6	56.4	3	241.9	74.
14	13.4	4.1	74	70.8	21.6	4	128.1	39.2	4	185.5	56.7	4	242.9	74.3
15	14.3	4.4	75	71.7	21.9	5	129.1	39.5	5	186.5	57.	5	243.9	74.6
16	15.3	4.7	76	72.7	22.2	6	130.1	39.8	6	187.4	57.3	6	244.8	74.8
17	16.3	5.	77	73.6	22.5	7	131.	40.1	7	188.4	57.6	7	245.8	75.1
18	17.2	5.3	78	74.6	22.8	8	132.	40.3	8	189.3	57.9	8	246.7	75.4
19	18.2	5.6	79	75.5	23.1	9	132.9	40.6	9	190.3	58.2	9	247.7	75.7
20	19.1	5.8	80	76.5	23.4	140	133.9	40.9	200	191.3	58.5	260	248.6	76.
21	20.1	6.1	81	77.5	23.7	1	134.8	41.2	1	192.2	58.8	1	249.6	76.3
22	21.	6.4	82	78.4	24.	2	135.8	41.5	2	193.2	59.1	2	250.6	76.6
23	22.	6.7	83	79.4	24.3	3	136.8	41.8	3	194.1	59.4	3	251.5	76.9
24	23.	7.	84	80.3	24.6	4	137.7	42.1	4	195.1	59.6	4	252.5	77.2
25	23.9	7.3	85	81.3	24.9	5	138.7	42.4	5	196.	59.9	5	253.4	77.5
26	24.9	7.6	86	82.2	25.1	6	139.6	42.7	6	197.	60.2	6	254.4	77.8
27	25.8	7.9	87	83.2	25.4	7	140.6	43.	7	198.	60.5	7	255.3	78.1
28	26.8	8.2	88	84.2	25.7	8	141.5	43.3	8	198.9	60.8	8	256.3	78.4
29	27.7	8.5	89	85.1	26.	9	142.5	43.6	9	199.9	61.1	9	257.2	78.6
30	28.7	8.8	90	86.1	26.3	150	143.4	43.9	210	200.8	61.4	270	258.2	78.9
31	29.6	9.1	91	87.	26.6	1	144.4	44.1	1	201.8	61.7	1	259.2	79.2
32	30.6	9.4	92	88.	26.9	2	145.4	44.4	2	202.7	62.	2	260.1	79.5
33	31.6	9.6	93	88.9	27.2	3	146.3	44.7	3	203.7	62.3	3	261.1	79.8
34	32.5	9.9	94	89.9	27.5	4	147.3	45.	4	204.6	62.6	4	262.	80.1
35	33.5	10.2	95	90.8	27.8	5	148.2	45.3	5	205.6	62.9	5	263.	80.4
36	34.4	10.5	96	91.8	28.1	6	149.2	45.6	6	206.6	63.2	6	263.9	80.7
37	35.4	10.8	97	92.8	28.4	7	150.1	45.9	7	207.5	63.4	7	264.9	81.
38	36.3	11.1	98	93.7	28.7	8	151.1	46.2	8	208.5	63.7	8	265.9	81.3
39	37.3	11.4	99	94.7	28.9	9	152.1	46.5	9	209.4	64.	9	266.8	81.6
40	38.3	11.7	100	95.6	29.2	160	153.	46.8	220	210.4	64.3	280	267.8	81.9
41	39.2	12.	1	96.6	29.5	1	154.	47.1	1	211.3	64.6	1	268.7	82.2
42	40.2	12.3	2	97.5	29.8	2	154.9	47.4	2	212.3	64.9	2	269.7	82.4
43	41.1	12.6	3	98.5	30.1	3	155.9	47.7	3	213.3	65.2	3	270.6	82.7
44	42.1	12.9	4	99.5	30.4	4	156.8	47.9	4	214.2	65.5	4	271.6	83.
45	43.	13.2	5	100.4	30.7	5	157.8	48.2	5	215.2	65.8	5	272.5	83.3
46	44.	13.4	6	101.4	31.	6	158.7	48.5	6	216.1	66.1	6	273.5	83.6
47	44.9	13.7	7	102.3	31.3	7	159.7	48.8	7	217.1	66.4	7	274.5	83.9
48	45.9	14.	8	103.3	31.6	8	160.7	49.1	8	218.	66.7	8	275.4	84.2
49	46.9	14.3	9	104.2	31.9	9	161.6	49.4	9	219.	67.	9	276.4	84.5
50	47.8	14.6	110	105.2	32.2	170	162.6	49.7	230	220.	67.2	290	277.3	84.8
51	48.8	14.9	1	106.1	32.5	1	163.5	50.	1	220.9	67.5	1	278.3	85.1
52	49.7	15.2	2	107.1	32.7	2	164.5	50.3	2	221.9	67.8	2	279.2	85.4
53	50.7	15.5	3	108.1	33.	3	165.4	50.6	3	222.8	68.1	3	280.2	85.7
54	51.6	15.8	4	109.	33.3	4	166.4	50.9	4	223.8	68.4	4	281.2	86.
55	52.6	16.1	5	110.	33.6	5	167.4	51.2	5	224.7	68.7	5	282.1	86.2
56	53.6	16.4	6	110.9	33.9	6	168.3	51.5	6	225.7	69.	6	283.1	86.5
57	54.5	16.7	7	111.9	34.2	7	169.3	51.7	7	226.6	69.3	7	284.	86.8
58	55.5	17.	8	112.8	34.5	8	170.2	52.	8	227.6	69.6	8	285.	87.1
59	56.4	17.2	9	113.8	34.8	9	171.2	52.3	9	228.6	69.9	9	285.9	87.4
60	57.4	17.5	120	114.8	35.1	180	172.1	52.6	240	229.5	70.2	300	286.9	87.7
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 73°.

Course 18°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	1.	0.3	61	58.	18.9	121	115.1	37.4	181	172.1	55.9	241	229.2	74.5
2	1.9	0.6	62	59.	19.2	2	116.	37.7	2	173.1	56.2	2	230.2	74.8
3	2.9	0.9	63	59.9	19.5	3	117.	38.	3	174.	56.6	3	231.1	75.1
4	3.8	1.2	64	60.9	19.8	4	117.9	38.3	4	175.	56.9	4	232.1	75.4
5	4.8	1.5	65	61.8	20.1	5	118.9	38.6	5	175.9	57.2	5	233.	75.7
6	5.7	1.9	66	62.8	20.4	6	119.8	38.9	6	176.9	57.5	6	234.	76.
7	6.7	2.2	67	63.7	20.7	7	120.8	39.2	7	177.8	57.8	7	234.9	76.3
8	7.6	2.5	68	64.7	21.	8	121.7	39.6	8	178.8	58 1	8	235.9	76.6
9	8.6	2.8	69	65.6	21.3	9	122.7	39.9	9	179.7	58.4	9	236.8	76.9
10	9.5	3.1	70	66.6	21.6	130	123.6	40.2	190	180.7	58.7	250	237.8	77.3
11	10.5	3.4	71	67.5	21.9	1	124.6	40.5	1	181.7	59.	1	238.7	77.6
12	11.4	3.7	72	68.5	22.2	2	125.5	40.8	2	182.6	59.3	2	239.7	77.9
13	12.4	4.	73	69.4	22.6	3	126.5	41.1	3	183.6	59.6	3	240.6	78.2
14	13.3	4.3	74	70.4	22.9	4	127.4	41.4	4	184.5	59.9	4	241.6	78.5
15	14.3	4.6	75	71.3	23.2	5	128.4	41.7	5	185.5	60 3	5	242.5	78.8
16	15.2	4.9	76	72.3	23.5	6	129.3	42.	6	186.4	60.6	6	243.5	79.1
17	16.2	5.3	77	73.2	23.8	7	130.3	42.3	7	187.4	60.9	7	244.4	79.4
18	17.1	5.6	78	74.2	24.1	8	131.2	42.6	8	188.3	61.2	8	245.4	79.7
19	18.1	5.9	79	75.1	24.4	9	132.2	43.	9	189.3	61.5	9	246.3	80.
20	19.	6.2	80	76.1	24.7	140	133.1	43.3	200	190.2	61.8	260	247.3	80.3
21	20.	6.5	81	77.	25.	1	134.1	43.6	1	191.2	62.1	1	248.2	80.7
22	20.9	6.8	82	78.	25.3	2	135.1	43.9	2	192.1	62.4	2	249.2	81.
23	21.9	7.1	83	78.9	25.6	3	136.	44.2	3	193.1	62.7	3	250.1	81 3
24	22.8	7.4	84	79.9	26.	4	137.	44.5	4	194.	63.	4	251.1	81.6
25	23.8	7.7	85	80.8	26.3	5	137.9	44.8	5	195.	63.3	5	252.	81.9
26	24.7	8.	86	81.8	26.6	6	138.9	45.1	6	195.9	63.7	6	253.	82.2
27	25.7	8.3	87	82.7	26.9	7	139.8	45.4	7	196.9	64.	7	253.9	82.5
28	26.6	8.7	88	83.7	27.2	8	140.8	45.7	8	197.8	64.3	8	254.9	82.8
29	27.6	9.	89	84.6	27.5	9	141.7	46.	9	198.8	64.6	9	255.8	83.1
30	28.5	9.3	90	85.6	27.8	150	142.7	46.4	210	199.7	64 9	270	256.8	83.4
31	29.5	9.6	91	86.5	28.1	1	143.6	46.7	1	200.7	65.2	1	257.7	83.7
32	30.4	9.9	92	87.5	28.4	2	144.6	47.	2	201 6	65.5	2	258.7	84.1
33	31.4	10.2	93	88.4	28.7	3	145.5	47.3	3	202.6	65.8	3	259.6	84.4
34	32.3	10.5	94	89.4	29.	4	146.5	47.6	4	203.5	66.1	4	260.6	84.7
35	33.3	10.8	95	90.4	29.4	5	147.4	47.9	5	204.5	66.4	5	261.5	85.
36	34.2	11.1	96	91.3	29.7	6	148.4	48.2	6	205.4	66.7	6	262.5	85.3
37	35.2	11.4	97	92.3	30.	7	149.3	48.5	7	206.4	67.1	7	263.4	85.6
38	36.1	11.7	98	93.2	30.3	8	150.3	48.9	8	207.3	67.4	8	264.4	85.9
39	37.1	12.1	99	94.2	30.6	9	151.2	49.1	9	208.3	67.7	9	265.3	86.2
40	38.	12.4	100	95.1	30.9	160	152.2	49.4	220	209.2	68.	280	266.3	86.5
41	39.	12.7	1	96.1	31.2	1	153.1	49.8	1	210.2	68.3	1	267.2	86.8
42	39.9	13.	2	97.	31.5	2	154.1	50.1	2	211.1	68.6	2	268.2	87.1
43	40.9	13.3	3	98.	31.8	3	155.	50.4	3	212.1	68.9	3	269.1	87.5
44	41.8	13.6	4	98.9	32.1	4	156.	50.7	4	213.	69.2	4	270.1	87.8
45	42.8	13.9	5	99.9	32.4	5	156.9	51.	5	214.	69.5	5	271.1	88.1
46	43.7	14.2	6	100.8	32.8	6	157.9	51.3	6	214.9	69.8	6	272.	88.4
47	44.7	14.5	7	101.8	33.1	7	158.8	51.6	7	215.9	70.1	7	273.	88.7
48	45.7	14.8	8	102.7	33.4	8	159.8	51.9	8	216.8	70.5	8	273.9	89.
49	46.6	15.1	9	103.7	33.7	9	160.7	52.2	9	217.8	70.8	9	274.9	89.3
50	47.6	15.5	110	104.6	34.	170	161.7	52.5	230	218.7	71.1	290	275.8	89.6
51	48.5	15.8	1	105.6	34.3	1	162.6	52.8	1	219.7	71.4	1	276.8	89.9
52	49.5	16.1	2	106.5	34.6	2	163.6	53.2	2	220.6	71.7	2	277.7	90.2
53	50.4	16.4	3	107.5	34.9	3	164.5	53.5	3	221.6	72.	3	278.7	90.5
54	51.4	16.7	4	108.4	35.2	4	165.5	53.8	4	222.5	72.3	4	279.6	90.9
55	52.3	17.	5	109.4	35.5	5	166.4	54.1	5	223.5	72.6	5	280.6	91.2
56	53.3	17.3	6	110.3	35.8	6	167.4	54.4	6	224.4	72.9	6	281.5	91.5
57	54.2	17.6	7	111.3	36.2	7	168.3	54.7	7	225.4	73.2	7	282.5	91.8
58	55.2	17.9	8	112.2	36.5	8	169.3	55.	8	226.4	73.5	8	283.4	92.1
59	56.1	18.2	9	113.2	36.8	9	170.2	55.3	9	227.3	73.9	9	284.4	92.4
60	57.1	18.5	120	114.1	37.1	180	171.2	55.6	240	228.3	74.2	300	285.3	92.7
dist.	dep.	d.lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 72°.

Course 19°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.3	61	57.7	19.9	121	114.4	39.4	181	171.1	58.9	241	227.9	78.5
2	1.9	0.7	62	58.6	20.2	2	115.4	39.7	2	172.1	59.3	2	228.8	78.8
3	2.8	1.	63	59.6	20.5	3	116.3	40.	3	173.	59.6	3	229.8	79.1
4	3.8	1.3	64	60.5	20.8	4	117.2	40.4	4	174.	59.9	4	230.7	79.4
5	4.7	1.6	65	61.5	21.2	5	118.2	40.7	5	174.9	60.2	5	231.7	79.8
6	5.7	2.	66	62.4	21.5	6	119.1	41.	6	175.9	60.6	6	232.6	80.1
7	6.6	2.3	67	63.3	21.8	7	120.1	41.3	7	176.8	60.9	7	233.5	80.4
8	7.6	2.6	68	64.3	22.1	8	121.	41.7	8	177.8	61.2	8	234.5	80.7
9	8.5	2.9	69	65.2	22.5	9	122.	42.	9	178.7	61.5	9	235.4	81.1
10	9.5	3.3	70	66.2	22.8	130	122.9	42.3	190	179.6	61.9	250	236.4	81.4
11	10.4	3.6	71	67.1	23.1	1	123.9	42.6	1	180.6	62.2	1	237.3	81.7
12	11.3	3.9	72	68.1	23.4	2	124.8	43.	2	181.5	62.5	2	238.3	82.
13	12.3	4.2	73	69.	23.8	3	125.8	43.3	3	182.5	62.8	3	239.2	82.4
14	13.2	4.6	74	70.	24.1	4	126.7	43.6	4	183.4	63.2	4	240.2	82.7
15	14.2	4.9	75	70.9	24.4	5	127.6	44.	5	184.4	63.5	5	241.1	83.
16	15.1	5.2	76	71.9	24.7	6	128.6	44.3	6	185.3	63.8	6	242.1	83.3
17	16.1	5.5	77	72.8	25.1	7	129.5	44.6	7	186.3	64.1	7	243.	83.7
18	17.	5.9	78	73.8	25.4	8	130.5	44.9	8	187.2	64.5	8	243.9	84.
19	18.	6.2	79	74.7	25.7	9	131.4	45.3	9	188.2	64.8	9	244.9	84.3
20	18.9	6.5	80	75.6	26.	140	132.4	45.6	200	189.1	65.1	260	245.8	84.6
21	19.9	6.8	81	76.6	26.4	1	133.3	45.9	1	190.	65.4	1	246.8	85.
22	20.8	7.2	82	77.5	26.7	2	134.3	46.2	2	191.	65.8	2	247.7	85.3
23	21.7	7.5	83	78.5	27.	3	135.2	46.6	3	191.9	66.1	3	248.7	85.6
24	22.7	7.8	84	79.4	27.3	4	136.2	46.9	4	192.9	66.4	4	249.6	86.
25	23.6	8.1	85	80.4	27.7	5	137.1	47.2	5	193.8	66.7	5	250.6	86.3
26	24.6	8.5	86	81.3	28.	6	138.	47.5	6	194.8	67.1	6	251.5	86.6
27	25.5	8.8	87	82.3	28.3	7	139.	47.9	7	195.7	67.4	7	252.5	86.9
28	26.5	9.1	88	83.2	28.7	8	139.9	48.2	8	196.7	67.7	8	253.4	87.3
29	27.4	9.4	89	84.2	29.	9	140.9	48.5	9	197.6	68.	9	254.3	87.6
30	28.4	9.8	90	85.1	29.3	150	141.8	48.8	210	198.6	68.4	270	255.3	87.9
31	29.3	10.1	91	86.	29.6	1	142.8	49.2	1	199.5	68.7	1	256.2	88.2
32	30.3	10.4	92	87.	30.	2	143.7	49.5	2	200.4	69.	2	257.2	88.6
33	31.2	10.7	93	87.9	30.3	3	144.7	49.8	3	201.4	69.3	3	258.1	88.9
34	32.1	11.1	94	88.9	30.6	4	145.6	50.1	4	202.3	69.7	4	259.1	89.2
35	33.1	11.4	95	89.8	30.9	5	146.6	50.5	5	203.3	70.	5	260.	89.5
36	34.	11.7	96	90.8	31.3	6	147.5	50.8	6	204.2	70.3	6	261.	89.9
37	35.	12.	97	91.7	31.6	7	148.4	51.1	7	205.2	70.6	7	261.9	90.2
38	35.9	12.4	98	92.7	31.9	8	149.4	51.4	8	206.1	71.	8	262.9	90.5
39	36.9	12.7	99	93.6	32.2	9	150.3	51.8	9	207.1	71.3	9	263.8	90.8
40	37.8	13.	100	94.6	32.6	160	151.3	52.1	220	208.	71.6	280	264.7	91.2
41	38.8	13.3	1	95.5	32.9	1	152.2	52.4	1	209.	72.	1	265.7	91.5
42	39.7	13.7	2	96.4	33.2	2	153.2	52.7	2	209.9	72.3	2	266.6	91.8
43	40.7	14.	3	97.4	33.5	3	154.1	53.1	3	210.9	72.6	3	267.6	92.1
44	41.6	14.3	4	98.3	33.9	4	155.1	53.4	4	211.8	72.9	4	268.5	92.5
45	42.5	14.7	5	99.3	34.2	5	156.	53.7	5	212.7	73.3	5	269.5	92.8
46	43.5	15.	6	100.2	34.5	6	157.	54.	6	213.7	73.6	6	270.4	93.1
47	44.4	15.3	7	101.2	34.8	7	157.9	54.4	7	214.6	73.9	7	271.4	93.4
48	45.4	15.6	8	102.1	35.2	8	158.8	54.7	8	215.6	74.2	8	272.3	93.8
49	46.3	16.	9	103.1	35.5	9	159.8	55.	9	216.5	74.6	9	273.3	94.1
50	47.3	16.3	110	104.	35.8	170	160.7	55.3	230	217.5	74.9	290	274.2	94.4
51	48.2	16.6	1	105.	36.1	1	161.7	55.7	1	218.4	75.2	1	275.1	94.7
52	49.2	16.9	2	105.9	36.5	2	162.6	56.	2	219.4	75.5	2	276.1	95.1
53	50.1	17.3	3	106.8	36.8	3	163.6	56.3	3	220.3	75.9	3	277.	95.4
54	51.1	17.6	4	107.8	37.1	4	164.5	56.6	4	221.3	76.2	4	278.	95.7
55	52.	17.9	5	108.7	37.4	5	165.5	57.	5	222.2	76.5	5	278.9	96.
56	52.9	18.2	6	109.7	37.8	6	166.4	57.3	6	223.1	76.8	6	279.9	96.4
57	53.9	18.6	7	110.6	38.1	7	167.4	57.6	7	224.1	77.2	7	280.8	96.7
58	54.8	18.9	8	111.6	38.4	8	168.3	58.	8	225.	77.5	8	281.8	97.
59	55.8	19.2	9	112.5	38.7	9	169.2	58.3	9	226.	77.8	9	282.7	97.3
60	56.7	19.5	120	113.5	39.1	180	170.2	58.6	240	226.9	78.1	300	283.7	97.7
dist.	dep.	d. lat	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 71°.

Course 20°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.3	61	57.3	20.9	121	113.7	41.4	181	170.1	61.9	241	226.5	82.4
2	1.9	0.7	62	58.3	21.2	2	114.6	41.7	2	171.	62.2	2	227.4	82.8
3	2.8	1.	63	59.2	21.5	3	115.6	42.1	3	172.	62.6	3	228.3	83.1
4	3.8	1.4	64	60.1	21.9	4	116.5	42.4	4	172.9	62.9	4	229.3	83.5
5	4.7	1.7	65	61.1	22.2	5	117.5	42.8	5	173.8	63.3	5	230.2	83.8
6	5.6	2.1	66	62.	22.6	6	118.4	43.1	6	174.8	63.6	6	231.2	84.1
7	6.6	2.4	67	63.	22.9	7	119.3	43.4	7	175.7	64.	7	232.1	84.5
8	7.5	2.7	68	63.9	23.3	8	120.3	43.8	8	176.7	64.3	8	233.	84.8
9	8.5	3.1	69	64.8	23.6	9	121.2	44.1	9	177.6	64.6	9	234.	85.2
10	9.4	3.4	70	65.8	23.9	130	122.2	44.5	190	178.5	65.	250	234.9	85.5
11	10.3	3.8	71	66.7	24.3	1	123.1	44.8	1	179.5	65.3	1	235.9	85.8
12	11.3	4.1	72	67.7	24.6	2	124.	45.1	2	180.4	65.7	2	236.8	86.2
13	12.2	4.4	73	68.6	25.	3	125.	45.5	3	181.4	66.	3	237.7	86.5
14	13.2	4.8	74	69.5	25.3	4	125.9	45.8	4	182.3	66.4	4	238.7	86.9
15	14.1	5.1	75	70.5	25.7	5	126.9	46.2	5	183.2	66.7	5	239.6	87.2
16	15.	5.5	76	71.4	26.	6	127.8	46.5	6	184.2	67.	6	240.6	87.6
17	16.	5.8	77	72.4	26.3	7	128.7	46.9	7	185.1	67.4	7	241.5	87.9
18	16.9	6.2	78	73.3	26.7	8	129.7	47.2	8	186.1	67.7	8	242.4	88.2
19	17.9	6.5	79	74.2	27.	9	130.6	47.5	9	187.	68.1	9	243.4	88.6
20	18.8	6.8	80	75.2	27.4	140	131.6	47.9	200	187.9	68.4	260	244.3	88.9
21	19.7	7.2	81	76.1	27.7	1	132.5	48.2	1	188.9	68.7	1	245.3	89.3
22	20.7	7.5	82	77.1	28.	2	133.4	48.6	2	189.8	69.1	2	246.2	89.6
23	21.6	7.9	83	78.	28.4	3	134.4	48.9	3	190.8	69.4	3	247.1	90.
24	22.6	8.2	84	78.9	28.7	4	135.3	49.3	4	191.7	69.8	4	248.1	90.3
25	23.5	8.6	85	79.9	29.1	5	136.3	49.6	5	192.6	70.1	5	249.	90.6
26	24.4	8.9	86	80.8	29.4	6	137.2	49.9	6	193.6	70.5	6	250.	91.
27	25.4	9.2	87	81.8	29.8	7	138.1	50.3	7	194.5	70.8	7	250.9	91.3
28	26.3	9.6	88	82.7	30.1	8	139.1	50.6	8	195.5	71 1	8	251.8	91.7
29	27.3	9.9	89	83.6	30.4	9	140.	51.	9	196.4	71.5	9	252.8	92.
30	28.2	10.3	90	84.6	30.8	150	141.	51.3	210	197.3	71.8	270	253.7	92.3
31	29.1	10.6	91	85.5	31.1	1	141.9	51.6	1	198.3	72.2	1	254.7	92.7
32	30.1	10.9	92	86.5	31.5	2	142.8	52.	2	199.2	72.5	2	255.6	93.
33	31.	11.3	93	87.4	31.8	3	143.8	52.3	3	200.2	72.9	3	256.5	93.4
34	31.9	11.6	94	88.3	32.1	4	144.7	52.7	4	201.1	73.2	4	257.5	93.7
35	32.9	12.	95	89.3	32.5	5	145.7	53.	5	202.	73.5	5	258.4	94.1
36	33.8	12.3	96	90.2	32.8	6	146.6	53.4	6	203.	73.9	6	259.4	94.4
37	34.8	12.7	97	91.2	33.2	7	147.5	53.7	7	203.9	74.2	7	260.3	94.7
38	35.7	13.	98	92.1	33.5	8	148.5	54.	8	[illegible]	74.6	8	261.2	95.1
39	36.6	13.3	99	93.	33.9	9	149.4	54.4	9	[illegible]	74.9	9	262.2	95.4
40	37.6	13.7	100	94.	34.2	160	150.4	54.7	220	206.7	75.2	280	263.1	95.8
41	38.5	14.	1	94.9	34.5	1	151.3	55.1	1	207.7	75.6	1	264.1	96.1
42	39.5	14.4	2	95.8	34.9	2	152.2	55.4	2	208.6	75.9	2	265.	96.4
43	40.4	14.7	3	96.8	35.2	3	153.2	55.7	3	209.6	76.3	3	265.9	96.8
44	41.3	15.	4	97.7	35.6	4	154.1	56.1	4	210.5	76.6	4	266.9	97.1
45	42.3	15.4	5	98.7	35.9	5	155.	56.4	5	211.4	77.	5	267.8	97.5
46	43.2	15.7	6	99.6	36.3	6	156.	56.8	6	212.4	77.3	6	268.8	97.8
47	44.2	16.1	7	100.5	36.6	7	156.9	57.1	7	213.3	77.6	7	269.7	98.2
48	45.1	16.4	8	101.5	36.9	8	157.9	57.5	8	214.2	78.	8	270.6	98.5
49	46.	16.8	9	102.4	37.3	9	158.8	57.8	9	215.2	78.3	9	271.6	98.8
50	47.	17.1	110	103.4	37.6	170	159.7	58.1	230	216.1	78.7	290	272.5	99.2
51	47.9	17.4	1	104.3	38.	1	160.7	58.5	1	217.1	79.	1	273.5	99.5
52	48.9	17.8	2	105.2	38.3	2	161.6	58.8	2	218.	79.3	2	274.4	99.9
53	49.8	18.1	3	106.2	38.6	3	162.6	59.2	3	218.9	79.7	3	275.3	100.2
54	50.7	18.5	4	107.1	39.	4	163.5	59.5	4	219.9	80.	4	276.3	100.6
55	51.7	18.8	5	108.1	39.3	5	164.4	59.9	5	220.8	80.4	5	277.2	100.9
56	52.6	19.2	6	109.	39.7	6	165.4	60.2	6	221.8	80.7	6	278.1	101.2
57	53.6	19.5	7	109.9	40.	7	166.3	60.5	7	222.7	81.1	7	279.1	101.6
58	54.5	19.8	8	110.9	40.4	8	167.3	60.9	8	223.6	81.4	8	280.	101.9
59	55.4	20.2	9	111.8	40.7	9	168.2	61.2	9	224.6	81.7	9	281.	102.3
60	56.4	20.5	120	112.8	41.	180	169.1	61.6	240	225.5	82.1	300	281.9	102.6
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 70°.

Course 21°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.4	61	56.9	21.9	121	113.	43.4	181	169.	64.9	241	225.	86.4
2	1.9	0.7	62	57.9	22.2	2	113.9	43.7	2	169.9	65.2	2	225.9	86.7
3	2.8	1.1	63	58.8	22.6	3	114.8	44.1	3	170.8	65.6	3	226.9	87.1
4	3.7	1.4	64	59.7	22.9	4	115.8	44.4	4	171.8	65.9	4	227.8	87.4
5	4.7	1.8	65	60.7	23.3	5	116.7	44.8	5	172.7	66.3	5	228.7	87.8
6	5.6	2.2	66	61.6	23.7	6	117.6	45.2	6	173.6	66.7	6	229.7	88.2
7	6.5	2.5	67	62.5	24.	7	118.6	45.5	7	174.6	67.	7	230.6	88.5
8	7.5	2.9	68	63.5	24.4	8	119.5	45.9	8	175.5	67.4	8	231.5	88.9
9	8.4	3.2	69	64.4	24.7	9	120.4	46.2	9	176.4	67.7	9	232.5	89.2
10	9.3	3.6	70	65.4	25.1	130	121.4	46.6	190	177.4	68.1	250	233.4	89.6
11	10.3	3.9	71	66.3	25.4	1	122.3	46.9	1	178.3	68.4	1	234.3	90.
12	11.2	4.3	72	67.2	25.8	2	123.2	47.3	2	179.2	68.8	2	235.3	90.3
13	12.1	4.7	73	68.2	26.2	3	124.2	47.7	3	180.2	69.2	3	236.2	90.7
14	13.1	5.	74	69.1	26.5	4	125.1	48.	4	181.1	69.5	4	237.1	91.
15	14.	5.4	75	70.	26.9	5	126.	48.4	5	182.	69.9	5	238.1	91.4
16	14.9	5.7	76	71.	27.2	6	127.	48.7	6	183.	70.2	6	239.	91.7
17	15.9	6.1	77	71.9	27.6	7	127.9	49.1	7	183.9	70.6	7	239.9	92.1
18	16.8	6.5	78	72.8	28.	8	128.8	49.5	8	184.8	71.	8	240.9	92.5
19	17.7	6.8	79	73.8	28.3	9	129.8	49.8	9	185.8	71.3	9	241.8	92.8
20	18.7	7.2	80	74.7	28.7	140	130.7	50.2	200	186.7	71.7	260	242.7	93.2
21	19.6	7.5	81	75.6	29.	1	131.6	50.5	1	187.6	72.	1	243.7	93.5
22	20.5	7.9	82	76.6	29.4	2	132.6	50.9	2	188.6	72.4	2	244.6	93.9
23	21.5	8.2	83	77.5	29.7	3	133.5	51.2	3	189.5	72.7	3	245.5	94.3
24	22.4	8.6	84	78.4	30.1	4	134.4	51.6	4	190.5	73.1	4	246.5	94.6
25	23.3	9.	85	79.4	30.5	5	135.4	52.	5	191.4	73.5	5	247.4	95.
26	24.3	9.3	86	80.3	30.8	6	136.3	52.3	6	192.3	73.8	6	248.3	95.3
27	25.2	9.7	87	81.2	31.2	7	137.2	52.7	7	193.3	74.2	7	249.3	95.7
28	26.1	10.	88	82.2	31.5	8	138.2	53.	8	194.2	74.5	8	250.2	96.
29	27.1	10.4	89	83.1	31.9	9	139.1	53.4	9	195.1	74.9	9	251.1	96.4
30	28.	10.8	90	84.	32.3	150	140.	53.8	210	196.1	75.3	270	252.1	96.8
31	28.9	11.1	91	85.	32.6	1	141.	54.1	1	197.	75.6	1	253.	97.1
32	29.9	11.5	92	85.9	33.	2	141.9	54.5	2	197.9	76.	2	253.9	97.5
33	30.8	11.8	93	86.8	33.3	3	142.8	54.8	3	198.9	76.3	3	254.9	97.8
34	31.7	12.2	94	87.8	33.7	4	143.8	55.2	4	199.8	76.7	4	255.8	98.2
35	32.7	12.5	95	88.7	34.	5	144.7	55.5	5	200.7	77.	5	256.7	98.6
36	33.6	12.9	96	89.6	34.4	6	145.6	55.9	6	201.7	77.4	6	257.7	98.9
37	34.5	13.3	97	90.6	34.8	7	146.6	56.3	7	202.6	77.8	7	258.6	99.3
38	35.5	13.6	98	91.5	35.1	8	147.5	56.6	8	203.5	78.1	8	259.5	99.6
39	36.4	14.	99	92.4	35.5	9	148.4	57.	9	204.5	78.5	9	260.5	100.
40	37.3	14.3	100	93.4	35.8	160	149.4	57.3	220	205.4	78.8	280	261.4	100.3
41	38.3	14.7	1	94.3	36.2	1	150.3	57.7	1	206.3	79.2	1	262.3	100.7
42	39.2	15.1	2	95.2	36.6	2	151.2	58.1	2	207.3	79.6	2	263.3	101.1
43	40.1	15.4	3	96.2	36.9	3	152.2	58.4	3	208.2	79.9	3	264.2	101.4
44	41.1	15.8	4	97.1	37.3	4	153.1	58.8	4	209.1	80.3	4	265.1	101.8
45	42.	16.1	5	98.	37.6	5	154.	59.1	5	210.1	80.6	5	266.1	102.1
46	42.9	16.5	6	99.	38.	6	155.	59.5	6	211.	81.	6	267.	102.5
47	43.9	16.8	7	99.9	38.3	7	155.9	59.8	7	211.9	81.3	7	267.9	102.9
48	44.8	17.2	8	100.8	38.7	8	156.8	60.2	8	212.9	81.7	8	268.9	103.2
49	45.7	17.6	9	101.8	39.1	9	157.8	60.6	9	213.8	82.1	9	269.8	103.6
50	46.7	17.9	110	102.7	39.4	170	158.7	60.9	230	214.7	82.4	290	270.7	103.9
51	47.6	18.3	1	103.6	39.8	1	159.6	61.3	1	215.7	82.8	1	271.7	104.3
52	48.5	18.6	2	104.6	40.1	2	160.6	61.6	2	216.6	83.1	2	272.6	104.6
53	49.5	19.	3	105.5	40.5	3	161.5	62.	3	217.5	83.5	3	273.5	105.
54	50.4	19.4	4	106.4	40.9	4	162.4	62.4	4	218.5	83.9	4	274.5	105.4
55	51.3	19.7	5	107.4	41.2	5	163.4	62.7	5	219.4	84.2	5	275.4	105.7
56	52.3	20.1	6	108.3	41.6	6	164.3	63.1	6	220.3	84.6	6	276.3	106.1
57	53.2	20.4	7	109.2	41.9	7	165.2	63.4	7	221.3	84.9	7	277.3	106.4
58	54.1	20.8	8	110.2	42.3	8	166.2	63.8	8	222.2	85.3	8	278.2	106.8
59	55.1	21.1	9	111.1	42.6	9	167.1	64.1	9	223.1	85.6	9	279.1	107.2
60	56.	21.5	120	112.	43.	180	168.	64.5	240	224.1	86.	300	280.1	107.5
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 69°

Course 22°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.4	61	56.6	22.9	121	112.2	45.3	181	167.8	67.8	241	223.5	90.3
2	1.9	0.7	62	57.5	23.2	2	113.1	45.7	2	168.7	68.2	2	224.4	90.7
3	2.8	1.1	63	58.4	23.6	3	114.	46.1	3	169.7	68.6	3	225.3	91.
4	3.7	1.5	64	59.3	24.	4	115.	46.5	4	170.6	68.9	4	226.2	91.4
5	4.6	1.9	65	60.3	24.3	5	115.9	46.8	5	171.5	69.3	5	227.2	91.8
6	5.6	2.2	66	61.2	24.7	6	116.8	47.2	6	172.5	69.7	6	228.1	92.2
7	6.5	2.6	67	62.1	25.1	7	117.8	47.6	7	173.4	70.1	7	229.	92.5
8	7.4	3.	68	63.	25.5	8	118.7	47.9	8	174.3	70.4	8	229.9	92.9
9	8.3	3.4	69	64.	25.8	9	119.6	48.3	9	175.2	70.8	9	230.9	93.3
10	9.3	3.7	70	64.9	26.2	130	120.5	48.7	190	176.2	71.2	250	231.8	93.7
11	10.2	4.1	71	65.8	26.6	1	121.5	49.1	1	177.1	71.5	1	232.7	94.
12	11.1	4.5	72	66.8	27.	2	122.4	49.4	2	178.	71.9	2	233.7	94.4
13	12.1	4.9	73	67.7	27.3	3	123.3	49.8	3	178.9	72.3	3	234.6	94.8
14	13.	5.2	74	68.6	27.7	4	124.2	50.2	4	179.9	72.7	4	235.5	95.2
15	13.9	5.6	75	69.5	28.1	5	125.2	50.6	5	180.8	73.	5	236.4	95.5
16	14.8	6.	76	70.5	28.5	6	126.1	50.9	6	181.7	73.4	6	237.4	95.9
17	15.8	6.4	77	71.4	28.8	7	127.	51.3	7	182.7	73.8	7	238.3	96.3
18	16.7	6.7	78	72.3	29.2	8	128.	51.7	8	183.6	74.2	8	239.2	96.6
19	17.6	7.1	79	73.2	29.6	9	128.9	52.1	9	184.5	74.5	9	240.1	97.
20	18.5	7.5	80	74.2	30.	140	129.8	52.4	200	185.4	74.9	260	241.1	97.4
21	19.5	7.9	81	75.1	30.3	1	130.7	52.8	1	186.4	75.3	1	242.	97.8
22	20.4	8.2	82	76.	30.7	2	131.7	53.2	2	187.3	75.7	2	242.9	98.1
23	21.3	8.6	83	77.	31.1	3	132.6	53.6	3	188.2	76.	3	243.8	98.5
24	22.3	9.	84	77.9	31.5	4	133.5	53.9	4	189.1	76.4	4	244.8	98.9
25	23.2	9.4	85	78.8	31.8	5	134.4	54.3	5	190.1	76.8	5	245.7	99.3
26	24.1	9.7	86	79.7	32.2	6	135.4	54.7	6	191.	77.2	6	246.6	99.6
27	25.	10.1	87	80.7	32.6	7	136.3	55.1	7	191.9	77.5	7	247.6	100.
28	26.	10.5	88	81.6	33.	8	137.2	55.4	8	192.9	77.9	8	248.5	100.4
29	26.9	10.9	89	82.5	33.3	9	138.2	55.8	9	193.8	78.3	9	249.4	100.8
30	27.8	11.2	90	83.4	33.7	150	139.1	56.2	210	194.7	78.7	270	250.3	101.1
31	28.7	11.6	91	84.4	34.1	1	140.	56.6	1	195.6	79.	1	251.3	101.5
32	29.7	12.	92	85.3	34.5	2	140.9	56.9	2	196.6	79.4	2	252.2	101.9
33	30.6	12.4	93	86.2	34.8	3	141.9	57.3	3	197.5	79.8	3	253.1	102.3
34	31.5	12.7	94	87.2	35.2	4	142.8	57.7	4	198.4	80.2	4	254.	102.6
35	32.5	13.1	95	88.1	35.6	5	143.7	58.1	5	199.3	80.5	5	255.	103.
36	33.4	13.5	96	89.	36.	6	144.6	58.4	6	200.3	80.9	6	255.9	103.4
37	34.3	13.9	97	89.9	36.3	7	145.6	58.8	7	201.2	81.3	7	256.8	103.8
38	35.2	14.2	98	90.9	36.7	8	146.5	59.2	8	202.1	81.7	8	257.8	104.1
39	36.2	14.6	99	91.8	37.1	9	147.4	59.6	9	203.1	82.	9	258.7	104.5
40	37.1	15.	100	92.7	37.5	160	148.3	59.9	220	204.	82.4	280	259.6	104.9
41	38.	15.4	1	93.6	37.8	1	149.3	60.3	1	204.9	82.8	1	260.5	105.3
42	38.9	15.7	2	94.6	38.2	2	150.2	60.7	2	205.8	83.2	2	261.5	105.6
43	39.9	16.1	3	95.5	38.6	3	151.1	61.1	3	206.8	83.5	3	262.4	106
44	40.8	16.5	4	96.4	39.	4	152.1	61.4	4	207.7	83.9	4	263.3	106.4
45	41.7	16.9	5	97.4	39.3	5	153.	61.8	5	208.6	84.3	5	264.2	106.8
46	42.7	17.2	6	98.3	39.7	6	153.9	62.2	6	209.5	84.7	6	265.2	107.1
47	43.6	17.6	7	99.2	40.1	7	154.8	62.6	7	210.5	85.	7	266.1	107.5
48	44.5	18.	8	100.1	40.5	8	155.8	62.9	8	211.4	85.4	8	267.	107.9
49	45.4	18.4	9	101.1	40.8	9	156.7	63.3	9	212.3	85.8	9	268.	108.3
50	46.4	18.7	110	102.	41.2	170	157.6	63.7	230	213.3	86.2	290	268.9	108.6
51	47.3	19.1	1	102.9	41.6	1	158.5	64.1	1	214.2	86.5	1	269.8	109.
52	48.2	19.5	2	103.8	42.	2	159.5	64.4	2	215.1	86.9	2	270.7	109.4
53	49.1	19.9	3	104.8	42.3	3	160.4	64.8	3	216.	87.3	3	271.7	109.8
54	50.1	20.2	4	105.7	42.7	4	161.3	65.2	4	217.	87.7	4	272.6	110.1
55	51.	20.6	5	106.6	43.1	5	162.3	65.6	5	217.9	88.	5	273.5	110.5
56	51.9	21.	6	107.6	43.5	6	163.2	65.9	6	218.8	88.4	6	274.4	110.9
57	52.8	21.4	7	108.5	43.8	7	164.1	66.3	7	219.7	88.8	7	275.4	111.3
58	53.8	21.7	8	109.4	44.2	8	165.	66.7	8	220.7	89.2	8	276.3	111.6
59	54.7	22.1	9	110.3	44.6	9	166.	67.1	9	221.6	89.5	9	277.2	112.
60	55.6	22.5	120	111.3	45.	180	166.9	67.4	240	222.5	89.9	300	278.2	112.4
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat

Distance, Departure and Diff. Latitude.

Course 68°.

Course 23°

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.4	61	56.2	23.8	121	111.4	47.3	181	166.6	70.7	241	221.8	94.2
2	1.8	0.8	62	57.1	24.2	2	112.3	47.7	2	167.5	71.1	2	222.8	94.6
3	2.8	1.2	63	58.	24.6	3	113.2	48.1	3	168.5	71.5	3	223.7	94.9
4	3.7	1.6	64	58.9	25.	4	114.1	48.5	4	169.4	71.9	4	224.6	95.3
5	4.6	2.	65	59.8	25.4	5	115.1	48.8	5	170.3	72.3	5	225.5	95.7
6	5.5	2.3	66	60.8	25.8	6	116.	49.2	6	171.2	72.7	6	226.4	96.1
7	6.4	2.7	67	61.7	26.2	7	116.9	49.6	7	172.1	73.1	7	227.4	96.5
8	7.4	3.1	68	62.6	26.6	8	117.8	50.	8	173.1	73.5	8	228.3	96.9
9	8.3	3.5	69	63.5	27.	9	118.7	50.4	9	174.	73.8	9	229.2	97.3
10	9.2	3.9	70	64.4	27.4	130	119.7	50.8	190	174.9	74.2	250	230.1	97.7
11	10.1	4.3	71	65.4	27.7	1	120.6	51.2	1	175.8	74.6	1	231.	98.1
12	11.	4.7	72	66.3	28.1	2	121.5	51.6	2	176.7	75.	2	232.	98.5
13	12.	5.1	73	67.2	28.5	3	122.4	52.	3	177.7	75.4	3	232.9	98.9
14	12.9	5.5	74	68.1	28.9	4	123.3	52.4	4	178.6	75.8	4	233.8	99.2
15	13.8	5.9	75	69.	29.3	5	124.3	52.7	5	179.5	76.2	5	234.7	99.6
16	14.7	6.3	76	70.	29.7	6	125.2	53.1	6	180.4	76.6	6	235.6	100.
17	15.6	6.6	77	70.9	30.1	7	126.1	53.5	7	181.3	77.	7	236.6	100.4
18	16.6	7.	78	71.8	30.5	8	127.	53.9	8	182.3	77.4	8	237.5	100.8
19	17.5	7.4	79	72.7	30.9	9	128.	54.3	9	183.2	77.8	9	238.4	101.2
20	18.4	7.8	80	73.6	31.3	140	128.9	54.7	200	184.1	78.1	260	239.3	101.6
21	19.3	8.2	81	74.6	31.6	1	129.8	55.1	1	185.	78.5	1	240.3	102.
22	20.3	8.6	82	75.5	32.	2	130.7	55.5	2	185.9	78.9	2	241.2	102.4
23	21.2	9.	83	76.4	32.4	3	131.6	55.9	3	186.9	79.3	3	242.1	102.8
24	22.1	9.4	84	77.3	32.8	4	132.6	56.3	4	187.8	79.7	4	243.	103.2
25	23.	9.8	85	78.2	33.2	5	133.5	56.7	5	188.7	80.1	5	243.9	103.5
26	23.9	10.2	86	79.2	33.6	6	134.4	57.	6	189.6	80.5	6	244.9	103.9
27	24.9	10.5	87	80.1	34.	7	135.3	57.4	7	190.5	80.9	7	245.8	104.3
28	25.8	10.9	88	81.	34.4	8	136.2	57.8	8	191.5	81.3	8	246.7	104.7
29	26.7	11.3	89	81.9	34.8	9	137.2	58.2	9	192.4	81.7	9	247.6	105.1
30	27.6	11.7	90	82.8	35.2	150	138.1	58.6	210	193.3	82.1	270	248.5	105.5
31	28.5	12.1	91	83.8	35.6	1	139.	59.	1	194.2	82.4	1	249.5	105.9
32	29.5	12.5	92	84.7	35.9	2	139.9	59.4	2	195.1	82.8	2	250.4	106.3
33	30.4	12.9	93	85.6	36.3	3	140.8	59.8	3	196.1	83.2	3	251.3	106.7
34	31.3	13.3	94	86.5	36.7	4	141.8	60.2	4	197.	83.6	4	252.2	107.1
35	32.2	13.7	95	87.4	37.1	5	142.7	60.6	5	197.9	84.	5	253.1	107.5
36	33.1	14.1	96	88.4	37.5	6	143.6	61.	6	198.8	84.4	6	254.1	107.8
37	34.1	14.5	97	89.3	37.9	7	144.5	61.3	7	199.7	84.8	7	255.	108.2
38	35.	14.8	98	90.2	38.3	8	145.4	61.7	8	200.7	85.2	8	255.9	108.6
39	35.9	15.2	99	91.1	38.7	9	146.4	62.1	9	201.6	85.6	9	256.8	109.
40	36.8	15.6	100	92.1	39.1	160	147.3	62.5	220	202.5	86.	280	257.7	109.4
41	37.7	16.	1	93.	39.5	1	148.2	62.9	1	203.4	86.4	1	258.7	109.8
42	38.7	16.4	2	93.9	39.9	2	149.1	63.3	2	204.4	86.7	2	259.6	110.2
43	39.6	16.8	3	94.8	40.2	3	150.	63.7	3	[illegible]	87.1	3	260.5	110.6
44	40.5	17.2	4	95.7	40.6	4	151.	64.1	4	[illegible]	87.5	4	261.4	111.
45	41.4	17.6	5	96.7	41.	5	151.9	64.5	5	[illegible]	87.9	5	262.3	111.4
46	42.3	18.	6	97.6	41.4	6	152.8	64.9	6	208.	88.3	6	263.3	111.7
47	43.3	18.4	7	98.5	41.8	7	153.7	65.3	7	209.	88.7	7	264.2	112.1
48	44.2	18.8	8	99.4	42.2	8	154.6	65.6	8	209.9	89.1	8	265.1	112.5
49	45.1	19.1	9	100.3	42.6	9	155.6	66.	9	210.8	89.5	9	266.	112.9
50	46.	19.5	110	101.3	43.	170	156.5	66.4	230	211.7	89.9	290	266.9	113.3
51	46.9	19.8	1	102.2	43.4	1	157.4	66.8	1	212.6	90.3	1	267.9	113.7
52	47.9	20.3	2	103.1	43.8	2	158.3	67.2	2	213.6	90.6	2	268.8	114.1
53	48.8	20.7	3	104.	44.2	3	159.2	67.6	3	214.5	91.	3	269.7	114.5
54	49.7	21.1	4	104.9	44.5	4	160.2	68.	4	215.4	91.4	4	270.6	114.9
55	50.6	21.5	5	105.9	44.9	5	161.1	68.4	5	216.3	91.8	5	271.5	115.3
56	51.5	21.9	6	106.8	45.3	6	162.	68.8	6	217.2	92.2	6	272.5	115.7
57	52.5	22.3	7	107.7	45.7	7	162.9	69.2	7	218.2	92.6	7	273.4	116.
58	53.4	22.7	8	108.6	46.1	8	163.8	69.6	8	219.1	93.	8	274.3	116.4
59	54.3	23.1	9	109.5	46.5	9	164.8	69.9	9	220.	93.4	9	275.2	116.8
60	55.2	23.4	120	110.5	46.9	180	165.7	70.3	240	220.9	93.8	300	276.2	117.2
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 67°.

Course 24°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.4	61	55.7	24.8	121	110.5	49.2	181	165.4	73.6	241	220.2	98
2	1.8	0.8	62	56.6	25.2	2	111.5	49.6	2	166.3	74.	2	221.1	98.4
3	2.7	1.2	63	57.6	25.6	3	112.4	50.	3	167.2	74.4	3	222.	98.8
4	3.7	1.6	64	58.5	26.	4	113.3	50.4	4	168.1	74.8	4	222.9	99.2
5	4.6	2.	65	59.4	26.4	5	114.2	50.8	5	169.	75.2	5	223.8	99.7
6	5.5	2.4	66	60.3	26.8	6	115.1	51.2	6	169.9	75.7	6	224.7	100.1
7	6.4	2.8	67	61.2	27.3	7	116.	51.7	7	170.8	76.1	7	225.6	100.5
8	7.3	3.3	68	62.1	27.7	8	116.9	52.1	8	171.7	76.5	8	226.6	100.9
9	8.2	3.7	69	63.	28.1	9	117.8	52.5	9	172.7	76.9	9	227.5	101.3
10	9.1	4.1	70	63.9	28.5	130	118.8	52.9	190	173.6	77.3	250	228.4	101.7
11	10.	4.5	71	64.9	28.9	1	119.7	53.3	1	174.5	77.7	1	229.3	102.1
12	11.	4.9	72	65.8	29.3	2	120.6	53.7	2	175.4	78.1	2	230.2	102.5
13	11.9	5.3	73	66.7	29.7	3	121.5	54.1	3	176.3	78.5	3	231.1	102.9
14	12.8	5.7	74	67.6	30.1	4	122.4	54.5	4	177.2	78.9	4	232.	103.3
15	13.7	6.1	75	68.5	30.5	5	123.3	54.9	5	178.1	79.3	5	233.	103.7
16	14.6	6.5	76	69.4	30.9	6	124.2	55.3	6	179.1	79.7	6	233.9	104.1
17	15.5	6.9	77	70.3	31.3	7	125.2	55.7	7	180.	80.1	7	234.8	104.5
18	16.4	7.3	78	71.3	31.7	8	126.1	56.1	8	180.9	80.5	8	235.7	104.9
19	17.4	7.7	79	72.2	32.1	9	127.	56.5	9	181.8	80.9	9	236.6	105.3
20	18.3	8.1	80	73.1	32.5	140	127.9	56.9	200	182.7	81.3	260	237.5	105.8
21	19.2	8.5	81	74.	32.9	1	128.8	57.3	1	183.6	81.8	1	238.4	106.2
22	20.1	8.9	82	74.9	33.4	2	129.7	57.8	2	184.5	82.2	2	239.3	106.6
23	21.	9.4	83	75.8	33.8	3	130.6	58.2	3	185.4	82.6	3	240.3	107.
24	21.9	9.8	84	76.7	34.2	4	131.6	58.6	4	186.4	83.	4	241.2	107.4
25	22.8	10.2	85	77.7	34.6	5	132.5	59.	5	187.3	83.4	5	242.1	107.8
26	23.8	10.6	86	78.6	35.	6	133.4	59.4	6	188.2	83.8	6	243.	108.2
27	24.7	11.	87	79.5	35.4	7	134.3	59.8	7	189.1	84.2	7	243.9	108.6
28	25.6	11.4	88	80.4	35.8	8	135.2	60.2	8	190.	84.6	8	244.8	109.
29	26.5	11.8	89	81.3	36.2	9	136.1	60.6	9	190.9	85.	9	245.7	109.4
30	27.4	12.2	90	82.2	36.6	150	137.	61.	210	191.8	85.4	270	246.7	109.8
31	28.3	12.6	91	83.1	37.	1	137.9	61.4	1	192.8	85.8	1	247.6	110.2
32	29.2	13.	92	84.	37.4	2	138.9	61.8	2	193.7	86.2	2	248.5	110.6
33	30.1	13.4	93	85.	37.8	3	139.8	62.2	3	194.6	86.6	3	249.4	111.
34	31.1	13.8	94	85.9	38.2	4	140.7	62.6	4	195.5	87.	4	250.3	111.4
35	32.	14.2	95	86.8	38.6	5	141.6	63.	5	196.4	87.4	5	251.2	111.9
36	32.9	14.6	96	87.7	39.	6	142.5	63.5	6	197.3	87.9	6	252.1	112.3
37	33.8	15.	97	88.6	39.5	7	143.4	63.9	7	198.2	88.3	7	253.1	112.7
38	34.7	15.5	98	89.5	39.9	8	144.3	64.3	8	199.2	88.7	8	254.	113.1
39	35.6	15.9	99	90.4	40.3	9	145.3	64.7	9	200.1	89.1	9	254.9	113.5
40	36.5	16.3	100	91.4	40.7	160	146.2	65.1	220	201.	89.5	280	255.8	113.9
41	37.5	16.7	1	92.3	41.1	1	147.1	65.5	1	201.9	89.9	1	256.7	114.3
42	38.4	17.1	2	93.2	41.5	2	148.	65.9	2	202.8	90.3	2	257.6	114.7
43	39.3	17.5	3	94.1	41.9	3	148.9	66.3	3	203.7	90.7	3	258.5	115.1
44	40.2	17.9	4	[illegible]	42.3	4	149.8	66.7	4	204.6	91.1	4	259.4	115.5
45	41.1	18.3	5	95.9	42.7	5	150.7	67.1	5	205.5	91.5	5	260.4	115.9
46	42.	18.7	6	96.8	43.1	6	151.6	67.5	6	206.5	91.9	6	261.3	116.3
47	42.9	19.1	7	97.7	43.5	7	152.6	67.9	7	207.4	92.3	7	262.2	116.7
48	43.9	19.5	8	98.7	43.9	8	153.5	68.3	8	208.3	92.7	8	263.1	117.1
49	44.8	19.9	9	99.6	44.3	9	154.4	68.7	9	209.2	93.1	9	264.	117.5
50	45.7	20.3	110	100.5	44.7	170	155.3	69.1	230	210.1	93.5	290	264.9	118.
51	46.6	20.7	1	101.4	45.1	1	156.2	69.6	1	211.	94.	1	265.8	118.4
52	47.5	21.2	2	102.3	45.6	2	157.1	70.	2	211.9	94.4	2	266.8	118.8
53	48.4	21.6	3	103.2	46.	3	158.	70.4	3	212.9	94.8	3	267.7	119.2
54	49.3	22.	4	104.1	46.4	4	159.	70.8	4	213.8	95.2	4	268.6	119.6
55	50.2	22.4	5	105.1	46.8	5	159.9	71.2	5	214.7	95.6	5	269.5	120.
56	51.2	22.8	6	106.	47.2	6	160.8	71.6	6	215.6	96.	6	270.4	120.4
57	52.1	23.2	7	106.9	47.6	7	161.7	72.	7	216.5	96.4	7	271.3	120.8
58	53.	23.6	8	107.8	48.	8	162.6	72.4	8	217.4	96.8	8	272.2	121.2
59	53.9	24.	9	108.7	48.4	9	163.5	72.8	9	218.3	97.2	9	273.2	121.6
60	54.8	24.4	120	109.6	48.8	180	164.4	73.2	240	219.3	97.6	300	274.1	122.
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 66°.

Course 25°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.4	61	55.3	25.8	121	109.7	51.1	181	164.	76.5	241	218.4	101.9
2	1.8	0.8	62	56.2	26.2	2	110.6	51.6	2	164.9	76.9	2	219.3	102.3
3	2.7	1.3	63	57.1	26.6	3	111.5	52.	3	165.9	77.3	3	220.2	102.7
4	3.6	1.7	64	58.	27.	4	112.4	52.4	4	166.8	77.8	4	221.1	103.1
5	4.5	2.1	65	58.9	27.5	5	113.3	52.8	5	167.7	78.2	5	222.	103.5
6	5.4	2.5	66	59.8	27.9	6	114.2	53.2	6	168.6	78.6	6	223.	104.
7	6.3	3.	67	60.7	28.3	7	115.1	53.7	7	169.5	79.	7	223.9	104.4
8	7.3	3.4	68	61.6	28.7	8	116.	54.1	8	170.4	79.5	8	224.8	104.8
9	8.2	3.8	69	62.5	29.2	9	116.9	54.5	9	171.3	79.9	9	225.7	105.2
10	9.1	4.2	70	63.4	29.6	130	117.8	54.9	190	172.2	80.3	250	226.6	105.7
11	10.	4.6	71	64.3	30.	1	118.7	55.4	1	173.1	80.7	1	227.5	106.1
12	10.9	5.1	72	65.3	30.4	2	119.6	55.8	2	174.	81.1	2	228.4	106.5
13	11.8	5.5	73	66.2	30.9	3	120.5	56.2	3	174.9	81.6	3	229.3	106.9
14	12.7	5.9	74	67.1	31.3	4	121.4	56.6	4	175.8	82.	4	230.2	107.3
15	13.6	6.3	75	68.	31.7	5	122.4	57.1	5	176.7	82.4	5	231.1	107.8
16	14.5	6.8	76	68.9	32.1	6	123.3	57.5	6	177.6	82.8	6	232.	108.2
17	15.4	7.2	77	69.8	32.5	7	124.2	57.9	7	178.5	83.3	7	232.9	108.6
18	16.3	7.6	78	70.7	33.	8	125.1	58.3	8	179.4	83.7	8	233.8	109.
19	17.2	8.	79	71.6	33.4	9	126.	58.7	9	180.4	84.1	9	234.7	109.5
20	18.1	8.5	80	72.5	33.8	140	126.9	59.2	200	181.3	84.5	260	235.6	109.9
21	19.	8.9	81	73.4	34.2	1	127.8	59.6	1	182.2	84.9	1	236.5	110.3
22	19.9	9.3	82	74.3	34.7	2	128.7	60.	2	183.1	85.4	2	237.5	110.7
23	20.8	9.7	83	75.2	35.1	3	129.6	60.4	3	184.	85.8	3	238.4	111.1
24	21.8	10.1	84	76.1	35.5	4	130.5	60.9	4	184.9	86.2	4	239.3	111.6
25	22.7	10.6	85	77.	35.9	5	131.4	61.3	5	185.8	86.6	5	240.2	112.
26	23.6	11.	86	77.9	36.3	6	132.3	61.7	6	186.7	87.1	6	241.1	112.4
27	24.5	11.4	87	78.8	36.8	7	133.2	62.1	7	187.6	87.5	7	242.	112.8
28	25.4	11.8	88	79.8	37.2	8	134.1	62.5	8	188.5	87.9	8	242.9	113.3
29	26.3	12.3	89	80.7	37.6	9	135.	63.	9	189.4	88.3	9	243.8	113.7
30	27.2	12.7	90	81.6	38.	150	135.9	63.4	210	190.3	88.7	270	244.7	114.1
31	28.1	13.1	91	82.5	38.5	1	136.9	63.8	1	191.2	89.2	1	245.6	114.5
32	29.	13.5	92	83.4	38.9	2	137.8	64.2	2	192.1	89.6	2	246.5	115.
33	29.9	13.9	93	84.3	39.3	3	138.7	64.7	3	193.	90.	3	247.4	115.4
34	30.8	14.4	94	85.2	39.7	4	139.6	65.1	4	193.9	90.4	4	248.3	115.8
35	31.7	14.8	95	86.1	40.1	5	140.5	65.5	5	194.9	90.9	5	249.2	116.2
36	32.6	15.2	96	87.	40.6	6	141.4	65.9	6	195.8	91.3	6	250.1	116.6
37	33.5	15.6	97	87.9	41.	7	142.3	66.4	7	196.7	91.7	7	251.	117.1
38	34.4	16.1	98	88.8	41.4	8	143.2	66.8	8	197.6	92.1	8	252.	117.5
39	35.3	16.5	99	89.7	41.8	9	144.1	67.2	9	198.5	92.6	9	252.9	117.9
40	36.3	16.9	100	90.6	42.3	160	145.	67.6	220	199.4	93.	280	253.8	118.3
41	37.2	17.3	1	91.5	42.7	1	145.9	68.	1	200.3	93.4	1	254.7	118.8
42	38.1	17.7	2	92.4	43.1	2	146.8	68.5	2	201.2	93.8	2	255.6	119.2
43	39.	18.2	3	93.3	43.5	3	147.7	68.9	3	202.1	94.2	3	256.5	119.6
44	39.9	18.6	4	94.3	44.	4	148.6	69.3	4	203.	94.7	4	257.4	120.
45	40.8	19.	5	95.2	44.4	5	149.5	69.7	5	203.9	95.1	5	258.3	120.4
46	41.7	19.4	6	96.1	44.8	6	150.4	70.2	6	204.8	95.5	6	259.2	120.9
47	42.6	19.9	7	97.	45.2	7	151.4	70.6	7	205.7	95.9	7	260.1	121.3
48	43.5	20.3	8	97.9	45.6	8	152.3	71.	8	206.6	96.4	8	261.	121.7
49	44.4	20.7	9	98.8	46.1	9	153.2	71.4	9	207.5	96.8	9	261.9	122.1
50	45.3	21.1	110	99.7	46.5	170	154.1	71.8	230	208.5	97.2	290	262.8	122.6
51	46.2	21.6	1	100.6	46.9	1	155.	72.3	1	209.4	97.6	1	263.7	123.
52	47.1	22.	2	101.5	47.3	2	155.9	72.7	2	210.3	98.	2	264.6	123.4
53	48.	22.4	3	102.4	47.8	3	156.8	73.1	3	211.2	98.5	3	265.5	123.8
54	48.9	22.8	4	103.3	48.2	4	157.7	73.5	4	212.1	98.9	4	266.5	124.2
55	49.8	23.2	5	104.2	48.6	5	158.6	74.	5	213.	99.3	5	267.4	124.7
56	50.8	23.7	6	105.1	49.	6	159.5	74.4	6	213.9	99.7	6	268.3	125.1
57	51.7	24.1	7	106.	49.4	7	160.4	74.8	7	214.8	100.2	7	269.2	125.5
58	52.6	24.5	8	106.9	49.9	8	161.3	75.2	8	215.7	100.6	8	270.1	125.9
59	53.5	24.9	9	107.9	50.3	9	162.2	75.6	9	216.6	101.	9	271.	126.4
60	54.4	25.4	120	108.8	50.7	180	163.1	76.1	240	217.5	101.4	300	271.9	126.8
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 65°.

Course 26°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.4	61	54.8	26.7	121	108.8	53.	181	162.7	79.3	241	216.6	105.6
2	1.8	0.9	62	55.7	27.2	2	109.7	53.5	2	163.6	79.8	2	217.5	106.1
3	2.7	1.3	63	56.6	27.6	3	110.6	53.9	3	164.5	80.2	3	218.4	106.5
4	3.6	1.8	64	57.5	28.1	4	111.5	54.4	4	165.4	80.7	4	219.3	107.
5	4.5	2.2	65	58.4	28.5	5	112.3	54.8	5	166.3	81.1	5	220.2	107.4
6	5.4	2.6	66	59.3	28.9	6	113.2	55.2	6	167.2	81.5	6	221.1	107.8
7	6.3	3.1	67	60.2	29.4	7	114.1	55.7	7	168.1	82.	7	222.	108.3
8	7.2	3.5	68	61.1	29.8	8	115.	56.1	8	169.	82.4	8	222.9	108.7
9	8.1	3.9	69	62.	30.2	9	115.9	56.5	9	169.9	82.9	9	223.8	109.2
10	9.	4.4	70	62.9	30.7	130	116.8	57.	190	170.8	83.3	250	224.7	109.6
11	9.9	4.8	71	63.8	31.1	1	117.7	57.4	1	171.7	83.7	1	225.6	110.
12	10.8	5.3	72	64.7	31.6	2	118.6	57.9	2	172.6	84.2	2	226.5	110.5
13	11.7	5.7	73	65.6	32.	3	119.5	58.3	3	173.5	84.6	3	227.4	110.9
14	12.6	6.1	74	66.5	32.4	4	120.4	58.7	4	174.4	85.	4	228.3	111.3
15	13.5	6.6	75	67.4	32.9	5	121.3	59.2	5	175.3	85.5	5	229.2	111.8
16	14.4	7.	76	68.3	33.3	6	122.2	59.6	6	176.2	85.9	6	230.1	112.2
17	15.3	7.5	77	69.2	33.8	7	123.1	60.1	7	177.1	86.4	7	231.	112.7
18	16.2	7.9	78	70.1	34.2	8	124.	60.5	8	178.	86.8	8	231.9	113.1
19	17.1	8.3	79	71.	34.6	9	124.9	60.9	9	178.9	87.2	9	232.8	113.5
20	18.	8.8	80	71.9	35.1	140	125.8	61.4	200	179.8	87.7	260	233.7	114.
21	18.9	9.2	81	72.8	35.5	1	126.7	61.8	1	180.7	88.1	1	234.6	114.4
22	19.8	9.6	82	73.7	35.9	2	127.6	62.2	2	181.6	88.6	2	235.5	114.9
23	20.7	10.1	83	74.6	36.4	3	128.5	62.7	3	182.5	89.	3	236.4	115.3
24	21.6	10.5	84	75.5	36.8	4	129.4	63.1	4	183.4	89.4	4	237.3	115.7
25	22.5	11.	85	76.4	37.3	5	130.3	63.6	5	184.3	89.9	5	238.2	116.2
26	23.4	11.4	86	77.3	37.7	6	131.2	64.	6	185.2	90.3	6	239.1	116.6
27	24.3	11.8	87	78.2	38.1	7	132.1	64.4	7	186.1	90.7	7	240.	117.
28	25.2	12.3	88	79.1	38.6	8	133.	64.9	8	186.9	91.2	8	240.9	117.5
29	26.1	12.7	89	80.	39.	9	133.9	65.3	9	187.8	91.6	9	241.8	117.9
30	27.	13.2	90	80.9	39.5	150	134.8	65.8	210	188.7	92.1	270	242.7	118.4
31	27.9	13.6	91	81.8	39.9	1	135.7	66.2	1	189.6	92.5	1	243.6	118.8
32	28.8	14.	92	82.7	40.3	2	136.6	66.6	2	190.5	92.9	2	244.5	119.2
33	29.7	14.5	93	83.6	40.8	3	137.5	67.1	3	191.4	93.4	3	245.4	119.7
34	30.6	14.9	94	84.5	41.2	4	138.4	67.5	4	192.3	93.8	4	246.3	120.1
35	31.5	15.3	95	85.4	41.6	5	139.3	67.9	5	193.2	94.2	5	247.2	120.6
36	32.4	15.8	96	86.3	42.1	6	140.2	68.4	6	194.1	94.7	6	248.1	121.
37	33.3	16.2	97	87.2	42.5	7	141.1	68.8	7	195.	95.1	7	249.	121.4
38	34.2	16.7	98	88.1	43.	8	142.	69.3	8	195.9	95.6	8	249.9	121.9
39	35.1	17.1	99	89.	43.4	9	142.9	69.7	9	196.8	96.	9	250.8	122.3
40	36.	17.5	100	89.9	43.8	160	143.8	70.1	220	197.7	96.4	280	251.7	122.7
41	36.9	18.	1	90.8	44.3	1	144.7	70.6	1	198.6	96.9	1	252.6	123.2
42	37.7	18.4	2	91.7	44.7	2	145.6	71.	2	199.5	97.3	2	253.5	123.6
43	38.6	18.8	3	92.6	45.2	3	146.5	71.5	3	200.4	97.8	3	254.4	124.1
44	39.5	19.3	4	93.5	45.6	4	147.4	71.9	4	201.3	98.2	4	255.3	124.5
45	40.4	19.7	5	94.4	46.	5	148.3	72.3	5	202.2	98.6	5	256.2	124.9
46	41.3	20.2	6	95.3	46.5	6	149.2	72.8	6	203.1	99.1	6	257.1	125.4
47	42.2	20.6	7	96.2	46.9	7	150.1	73.2	7	204.	99.5	7	258.	125.8
48	43.1	21.	8	97.1	47.3	8	151.	73.6	8	204.9	99.9	8	258.9	126.3
49	44.	21.5	9	98.	47.8	9	151.9	74.1	9	205.8	100.4	9	259.8	126.7
50	44.9	21.9	110	98.9	48.2	170	152.8	74.5	230	206.7	100.8	290	260.7	127.1
51	45.8	22.4	1	99.8	48.7	1	153.7	75.	1	207.6	101.3	1	261.5	127.6
52	46.7	22.8	2	100.7	49.1	2	154.6	75.4	2	208.5	101.7	2	262.4	128.
53	47.6	23.2	3	101.6	49.5	3	155.5	75.8	3	209.4	102.1	3	263.3	128.4
54	48.5	23.7	4	102.5	50.	4	156.4	76.3	4	210.3	102.6	4	264.2	128.9
55	49.4	24.1	5	103.4	50.4	5	157.3	76.7	5	211.2	103.	5	265.1	129.3
56	50.3	24.5	6	104.3	50.9	6	158.2	77.2	6	212.1	103.5	6	266.	129.8
57	51.2	25.	7	105.2	51.3	7	159.1	77.6	7	213.	103.9	7	266.9	130.2
58	52.1	25.4	8	106.1	51.7	8	160.	78.	8	213.9	104.3	8	267.8	130.6
59	53.	25.9	9	107.	52.2	9	160.9	78.5	9	214.8	104.8	9	268.7	131.1
60	53.9	26.3	120	107.9	52.6	180	161.8	78.9	240	215.7	105.2	300	269.6	131.5
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 64°.

Course 27°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat	dep	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.5	61	54.4	27.7	121	107.8	54.9	181	161.3	82.2	241	214.7	109.4
2	1.8	0.9	62	55.2	28.1	2	108.7	55.4	2	162.2	82.6	2	215.6	109.9
3	2.7	1.4	63	56.1	28.6	3	109.6	55.8	3	163.1	83.1	3	216.5	110.3
4	3.6	1.8	64	57.	29.1	4	110.5	56.3	4	163.9	83.5	4	217.4	110.8
5	4.5	2.3	65	57.9	29.5	5	111.4	56.7	5	164.8	84.	5	218.3	111.2
6	5.3	2.7	66	58.8	30.	6	112.3	57.2	6	165.7	84.4	6	219.2	111.7
7	6.2	3.2	67	59.7	30.4	7	113.2	57.7	7	166.6	84.9	7	220.1	112.1
8	7.1	3.6	68	60.6	30.9	8	114.	58.1	8	167.5	85.4	8	221.	112.6
9	8.	4.1	69	61.5	31.3	9	114.9	58.6	9	168.4	85.8	9	221.9	113.
10	8.9	4.5	70	62.4	31.8	130	115.8	59.	190	169.3	86.3	250	222.8	113.5
11	9.8	5.	71	63.3	32.2	1	116.7	59.5	1	170.2	86.7	1	223.6	114.
12	10.7	5.4	72	64.2	32.7	2	117.6	59.9	2	171.1	87.2	2	224.5	114.4
13	11.6	5.9	73	65.	33.1	3	118.5	60.4	3	172.	87.6	3	225.4	114.9
14	12.5	6.4	74	65.9	33.6	4	119.4	60.8	4	172.9	88.1	4	226.3	115.3
15	13.4	6.8	75	66.8	34.	5	120.3	61.3	5	173.7	88.5	5	227.2	115.8
16	14.3	7.3	76	67.7	34.5	6	121.2	61.7	6	174.6	89.	6	228.1	116.2
17	15 1	7.7	77	68.6	35.	7	122.1	62.2	7	175.5	89.4	7	229.	116.7
18	16.	8.2	78	69.5	35.4	8	123.	62.7	8	176.4	89.9	8	229.9	117.1
19	16.9	8.6	79	70.4	35.9	9	123.8	63.1	9	177.3	90.3	9	230.8	117.6
20	17.8	9.1	80	71.3	36.3	140	124.7	63.6	200	178.2	90.8	260	231.7	118.
21	18.7	9.5	81	72.2	36.8	1	125.6	64.	1	179.1	91.3	1	232.6	118.5
22	19.6	10.	82	73.1	37.2	2	126.5	64.5	2	180.	91.7	2	233.4	118.9
23	20.5	10.4	83	74.	37.7	3	127.4	64.9	3	180.9	92.2	3	234.3	119.4
24	21.4	10.9	84	74.8	38.1	4	128.3	65.4	4	181.8	92.6	4	235.2	119.9
25	22.3	11.3	85	75.7	38.6	5	129.2	65.8	5	182.7	93.1	5	236.1	120.3
26	23.2	11.8	86	76.6	39.	6	130.1	66.3	6	183.5	93.5	6	237.	120.8
27	24.1	12.3	87	77.5	39.5	7	131.	66.7	7	184.4	94.	7	237.9	121.2
28	24.9	12.7	88	78.4	40.	8	131.9	67.2	8	185.3	94.4	8	238.8	121.7
29	25.8	13.2	89	79.3	40.4	9	132.8	67.6	9	186.2	94.9	9	239.7	122.1
30	26.7	13.6	90	80.2	40.9	150	133.7	68.1	210	187.1	95 3	270	240.6	122.6
31	27 6	14.1	91	81.1	41.3	1	134.5	68.6	1	188.	95.8	1	241.5	123.
32	28.5	14.5	92	82.	41.8	2	135.4	69.	2	188.9	96.2	2	242.4	123.5
33	29.4	15.	93	82.9	42.2	3	136.3	69.5	3	189.8	96.7	3	243.2	123.9
34	30.3	15.4	94	83.8	42.7	4	137.2	69.9	4	190.7	97.2	4	244.1	124.4
35	31.2	15.9	95	84.6	43.1	5	138.1	70.4	5	191.6	97.6	5	245.	124.8
36	32.1	16.3	96	85.5	43.6	6	139.	70.8	6	192.5	98.1	6	245.9	125.3
37	33.	16.8	97	86.4	44.	7	139.9	71.3	7	193.3	98.5	7	246.8	125.8
38	33.9	17.3	98	87.3	44.5	8	140.8	71.7	8	194.2	99.	8	247.7	126.2
39	34.7	17.7	99	88.2	44.9	9	141.7	72.2	9	195.1	99.4	9	248.6	126.7
40	35.6	18.2	100	89.1	45.4	160	142.6	72.6	220	196.	99.9	280	249.5	127.1
41	36.5	18.6	1	90.	45.9	1	143.5	73.1	1	196.9	100.3	1	250 4	127.6
42	37.4	19.1	2	90.9	46.3	2	144.3	73.5	2	197.8	100.8	2	251.3	128.
43	38.3	19.5	3	91.8	46.8	3	145.2	74.	3	198.7	101.2	3	252.2	128.5
44	39.2	20.	4	92.7	47.2	4	146.1	74.5	4	199.6	101.7	4	253.	128.9
45	40.1	20.4	5	93.6	47.7	5	147.	74.9	5	200.5	102.1	5	253.9	129.4
46	41.	20.9	6	94.4	48.1	6	147.9	75.4	6	201.4	102.6	6	254.8	129.8
47	41.9	21.3	7	95.3	48.6	7	148.8	75.8	7	202.3	103.1	7	255.7	130.3
48	42.8	21.8	8	96.2	49.	8	149.7	76.3	8	203.1	103.5	8	256.6	130.7
49	43.7	22.2	9	97.1	49.5	9	150.6	76.7	9	204.	104.	9	257.5	131.2
50	44.6	22.7	110	98.	49.9	170	151.5	77.2	230	204.9	104.4	290	258.4	131.7
51	45.4	23.2	1	98.9	50.4	1	152.4	77.6	1	205.8	104.9	1	259.3	132.1
52	46.3	23.6	2	99.8	50.8	2	153.3	78.1	2	206.7	105.3	2	260.2	132.6
53	47.2	24.1	3	100.7	51.3	3	154.1	78.5	3	207.6	105.8	3	261.1	133.
54	48.1	24.5	4	101.6	51.8	4	155.	79.	4	208.5	106.2	4	262.	133.5
55	49.	25.	5	102.5	52.2	5	155.9	79.4	5	209.4	106.7	5	262.8	133.9
56	49.9	25.4	6	103.4	52.7	6	156.8	79.9	6	210.3	107.1	6	263.7	134.4
57	50.8	25.9	7	104.2	53.1	7	157.7	80.4	7	211.2	107.6	7	264.6	134.8
58	51.7	26.3	8	105.1	53.6	8	158.6	80.8	8	212.1	108.	8	265.5	135.3
59	52.6	26.8	9	106.	54.	9	159.5	81.3	9	213.	108.5	9	266.4	135.7
60	53.5	27.2	120	106.9	54.5	180	160.4	81.7	240	213.8	109.	300	267.3	136.2
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 63°.

Course 28°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.5	61	53.9	28.6	121	106.8	56.8	181	159.8	85.	241	212.8	113.1
2	1.8	0.9	62	54.7	29.1	2	107.7	57.3	2	160.7	85.4	2	213.7	113.6
3	2.6	1.4	63	55.6	29.6	3	108.6	57.7	3	161.6	85.9	3	214.6	114.1
4	3.5	1.9	64	56.5	30.	4	109.5	58.2	4	162.5	86.4	4	215.4	114.6
5	4.4	2.3	65	57.4	30.5	5	110.4	58.7	5	163.3	86.9	5	216.3	115.
6	5.3	2.8	66	58.3	31.	6	111.3	59.2	6	164.2	87.3	6	217.2	115.5
7	6.2	3.3	67	59.2	31.5	7	112.1	59.6	7	165.1	87.8	7	218.1	116.
8	7.1	3.8	68	60.	31.9	8	113.	60.1	8	166.	88.3	8	219.	116.4
9	7.9	4.2	69	60.9	32.4	9	113.9	60.6	9	166.9	88.7	9	219.9	116.9
10	8.8	4.7	70	61.8	32.9	130	114.8	61.	190	167.8	89.2	250	220.7	117.4
11	9.7	5.2	71	62.7	33.3	1	115.7	61.5	1	168.6	89.7	1	221.6	117.8
12	10.6	5.6	72	63.6	33.8	2	116.5	62.	2	169.5	90.1	2	222.5	118.3
13	11.5	6.1	73	64.5	34.3	3	117.4	62.4	3	170.4	90.6	3	223.4	118.8
14	12.4	6.6	74	65.3	34.7	4	118.3	62.9	4	171.3	91.1	4	224.3	119.2
15	13.2	7.	75	66.2	35.2	5	119.2	63.4	5	172.2	91.5	5	225.2	119.7
16	14.1	7.5	76	67.1	35.7	6	120.1	63.8	6	173.1	92.	6	226.	120.2
17	15.	8.	77	68.	36.1	7	121.	64.3	7	173.9	92.5	7	226.9	120.7
18	15.9	8.5	78	68.9	36.6	8	121.8	64.8	8	174.8	93.	8	227.8	121.1
19	16.8	8.9	79	69.8	37.1	9	122.7	65.3	9	175.7	93.4	9	228.7	121.6
20	17.7	9.4	80	70.6	37.6	140	123.6	65.7	200	176.6	93.9	260	229.6	122.1
21	18.5	9.9	81	71.5	38.	1	124.5	66.2	1	177.5	94.4	1	230.4	122.5
22	19.4	10.3	82	72.4	38.5	2	125.4	66.7	2	178.4	94.8	2	231.3	123.
23	20.3	10.8	83	73.3	39.	3	126.3	67.1	3	179.2	95.3	3	232.2	123.5
24	21.2	11.3	84	74.2	39.4	4	127.1	67.6	4	180.1	95.8	4	233.1	123.9
25	22.1	11.7	85	75.1	39.9	5	128.	68.1	5	181.	96.2	5	234.	124.4
26	23.	12.2	86	75.9	40.4	6	128.9	68.5	6	181.9	96.7	6	234.9	124.9
27	23.8	12.7	87	76.8	40.8	7	129.8	69.	7	182.8	97.2	7	235.7	125.3
28	24.7	13.1	88	77.7	41.3	8	130.7	69.5	8	183.7	97.7	8	236.6	125.8
29	25.6	13.6	89	78.6	41.8	9	131.6	70.	9	184.5	98.1	9	237.5	126.3
30	26.5	14.1	90	79.5	42.3	150	132.4	70.4	210	185.4	98.6	270	238.4	126.8
31	27.4	14.6	91	80.3	42.7	1	133.3	70.9	1	186.3	99.1	1	239.3	127.2
32	28.3	15.	92	81.2	43.2	2	134.2	71.4	2	187.2	99.5	2	240.2	127.7
33	29.1	15.5	93	82.1	43.7	3	135.1	71.8	3	188.1	100.	3	241.	128.2
34	30.	16.	94	83.	44.1	4	136.	72.3	4	189.	100.5	4	241.9	128.6
35	30.9	16.4	95	83.9	44.6	5	136.9	72.8	5	189.8	100.9	5	242.8	129.1
36	31.8	16.9	96	84.8	45.1	6	137.7	73.2	6	190.7	101.4	6	243.7	129.6
37	32.7	17.4	97	85.6	45.5	7	138.6	73.7	7	191.6	101.9	7	244.6	130.
38	33.6	17.8	98	86.5	46.	8	139.5	74.2	8	192.5	102.3	8	245.5	130.5
39	34.4	18.3	99	87.4	46.5	9	140.4	74.6	9	193.4	102.8	9	246.3	131.
40	35.3	18.8	100	88.3	46.9	160	141.3	75.1	220	194.2	103.3	280	247.2	131.5
41	36.2	19.2	1	89.2	47.4	1	142.2	75.6	1	195.1	103.8	1	248.1	131.9
42	37.1	19.7	2	90.1	47.9	2	143.	76.1	2	196.	104.2	2	249.	132.4
43	38.	20.2	3	90.9	48.4	3	143.9	76.5	3	196.9	104.7	3	249.9	132.9
44	38.8	20.7	4	91.8	48.8	4	144.8	77.	4	197.8	105.2	4	250.8	133.3
45	39.7	21.1	5	92.7	49.3	5	145.7	77.5	5	198.7	105.6	5	251.6	133.8
46	40.6	21.6	6	93.6	49.8	6	146.6	77.9	6	199.5	106.1	6	252.5	134.3
47	41.5	22.1	7	94.5	50.2	7	147.5	78.4	7	200.4	106.6	7	253.4	134.7
48	42.4	22.5	8	95.4	50.7	8	148.3	78.9	8	201.3	107.	8	254.3	135.2
49	43.3	23.	9	96.2	51.2	9	149.2	79.3	9	202.2	107.5	9	255.2	135.7
50	44.1	23.5	110	97.1	51.6	170	150.1	79.8	230	203.1	108.	290	256.1	136.1
51	45.	23.9	1	98.	52.1	1	151.	80.3	1	204.	108.4	1	256.9	136.6
52	45.9	24.4	2	98.9	52.6	2	151.9	80.7	2	204.8	108.9	2	257.8	137.1
53	46.8	24.9	3	99.8	53.1	3	152.7	81.2	3	205.7	109.4	3	258.7	137.6
54	47.7	25.4	4	100.7	53.5	4	153.6	81.7	4	206.6	109.9	4	259.6	138.
55	48.6	25.8	5	101.5	54.	5	154.5	82.2	5	207.5	110.3	5	260.5	138.5
56	49.4	26.3	6	102.4	54.5	6	155.4	82.6	6	208.4	110.8	6	261.4	139.
57	50.3	26.8	7	103.3	54.9	7	156.3	83.1	7	209.3	111.3	7	262.2	139.4
58	51.2	27.2	8	104.2	55.4	8	157.2	83.6	8	210.1	111.7	8	263.1	139.9
59	52.1	27.7	9	105.1	55.9	9	158.	84.	9	211.	112.2	9	264.	140.4
60	53.	28.2	120	106.	56.3	180	158.9	84.5	240	211.9	112.7	300	264.9	140.8
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 62°.

Course 29°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.5	61	53.4	29.6	121	105.8	58.7	181	158.3	87.8	241	210.8	116.8
2	1.7	1.	62	54.2	30.1	2	106.7	59.1	2	159.2	88.2	2	211.7	117.3
3	2.6	1.5	63	55.1	30.5	3	107.6	59.6	3	160.1	88.7	3	212.5	117.8
4	3.5	1.9	64	56.	31.	4	108.5	60.1	4	160.9	89.2	4	213.4	118.3
5	4.4	2.4	65	56.9	31.5	5	109.3	60.6	5	161.8	89.7	5	214.3	118.8
6	5.2	2.9	66	57.7	32.	6	110.2	61.1	6	162.7	90.2	6	215.2	119.3
7	6.1	3.4	67	58.6	32.5	7	111.1	61.6	7	163.6	90.7	7	216.	119.7
8	7.	3.9	68	59.5	33.	8	112.	62.1	8	164.4	91.1	8	216.9	120.2
9	7.9	4.4	69	60.3	33.5	9	112.8	62.5	9	165.3	91.6	9	217.8	120.7
10	8.7	4.8	70	61.2	33.9	130	113.7	63.	190	166.2	92.1	250	218.7	121.2
11	9.6	5.3	71	62.1	34.4	1	114.6	63.5	1	167.1	92.6	1	219.5	121.7
12	10.5	5.8	72	63.	34.9	2	115.4	64.	2	167.9	93.1	2	220.4	122.2
13	11.4	6.3	73	63.8	35.4	3	116.3	64.5	3	168.8	93.6	3	221.3	122.7
14	12.2	6.8	74	64.7	35.9	4	117.2	65.	4	169.7	94.1	4	222.2	123.1
15	13.1	7.3	75	65.6	36.4	5	118.1	65.4	5	170.6	94.5	5	223.	123.6
16	14.	7.8	76	66.5	36.8	6	118.9	65.9	6	171.4	95.	6	223.9	124.1
17	14.9	8.2	77	67.3	37.3	7	119.8	66.4	7	172.3	95.5	7	224.8	124.6
18	15.7	8.7	78	68.2	37.8	8	120.7	66.9	8	173.2	96.	8	225.7	125.1
19	16.6	9.2	79	69.1	38.3	9	121.6	67.4	9	174.	96.5	9	226.5	125.6
20	17.5	9.7	80	70.	38.8	140	122.4	67.9	200	174.9	97.	260	227.4	126.1
21	18.4	10.2	81	70.8	39.3	1	123.3	68.4	1	175.8	97.4	1	228.3	126.5
22	19.2	10.7	82	71.7	39.8	2	124.2	68.8	2	176.7	97.9	2	229.2	127.
23	20.1	11.2	83	72.6	40.2	3	125.1	69.3	3	177.5	98.4	3	230.	127.5
24	21.	11.6	84	73.5	40.7	4	125.9	69.8	4	178.4	98.9	4	230.9	128.
25	21.9	12.1	85	74.3	41.2	5	126.8	70.3	5	179.3	99.4	5	231.8	128.5
26	22.7	12.6	86	75.2	41.7	6	127.7	70.8	6	180.2	99.9	6	232.6	129.
27	23.6	13.1	87	76.1	42.2	7	128.6	71.3	7	181.	100.4	7	233.5	129.4
28	24.5	13.6	88	77.	42.7	8	129.4	71.8	8	181.9	100.8	8	234.4	129.9
29	25.4	14.1	89	77.8	43.1	9	130.3	72.2	9	182.8	101.3	9	235.3	130.4
30	26.2	14.5	90	78.7	43.6	150	131.2	72.7	210	183.7	101.8	270	236.1	130.9
31	27.1	15.	91	79.6	44.1	1	132.1	73.2	1	184.5	102.3	1	237.	131.4
32	28.	15.5	92	80.5	44.6	2	132.9	73.7	2	185.4	102.8	2	237.9	131.9
33	28.9	16.	93	81.3	45.1	3	133.8	74.2	3	186.3	103.3	3	238.8	132.4
34	29.7	16.5	94	82.2	45.6	4	134.7	74.7	4	187.2	103.7	4	239.6	132.8
35	30.6	17.	95	83.1	46.1	5	135.6	75.1	5	188.	104.2	5	240.5	133.3
36	31.5	17.5	96	84.	46.5	6	136.4	75.6	6	188.9	104.7	6	241.4	133.8
37	32.4	17.9	97	84.8	47.	7	137.3	76.1	7	189.8	105.2	7	242.3	134.3
38	33.2	18.4	98	85.7	47.5	8	138.2	76.6	8	190.7	105.7	8	243.1	134.8
39	34.1	18.9	99	86.6	48.	9	139.1	77.1	9	191.5	106.2	9	244.	135.3
40	35.	19.4	100	87.5	48.5	160	139.9	77.6	220	192.4	106.7	280	244.9	135.7
41	35.9	19.9	1	88.3	49.	1	140.8	78.1	1	193.3	107.1	1	245.8	136.2
42	36.7	20.4	2	89.2	49.5	2	141.7	78.5	2	194.2	107.6	2	246.6	136.7
43	37.6	20.8	3	90.1	49.9	3	142.6	79.	3	195.	108.1	3	247.5	137.2
44	38.5	21.3	4	91.	50.4	4	143.4	79.5	4	195.9	108.6	4	248.4	137.7
45	39.4	21.8	5	91.8	50.9	5	144.3	80.	5	196.8	109.1	5	249.3	138.2
46	40.2	22.3	6	92.7	51.4	6	145.2	80.5	6	197.7	109.6	6	250.1	138.7
47	41.1	22.8	7	93.6	51.9	7	146.1	81.	7	198.5	110.1	7	251.	139.1
48	42.	23.3	8	94.5	52.4	8	146.9	81.4	8	199.4	110.5	8	251.9	139.6
49	42.9	23.8	9	95.3	52.8	9	147.8	81.9	9	200.3	111.	9	252.8	140.1
50	43.7	24.2	110	96.2	53.3	170	148.7	82.4	230	201.2	111.5	290	253.6	140.6
51	44.6	24.7	1	97.1	53.8	1	149.6	82.9	1	202.	112.	1	254.5	141.1
52	45.5	25.2	2	98.	54.3	2	150.4	83.4	2	202.9	112.5	2	255.4	141.6
53	46.4	25.7	3	98.8	54.8	3	151.3	83.9	3	203.8	113.	3	256.3	142.
54	47.2	26.2	4	99.7	55.3	4	152.2	84.4	4	204.7	113.4	4	257.1	142.5
55	48.1	26.7	5	100.6	55.8	5	153.1	84.8	5	205.5	113.9	5	258.	143.
56	49.	27.1	6	101.5	56.2	6	153.9	85.3	6	206.4	114.4	6	258.9	143.5
57	49.9	27.6	7	102.3	56.7	7	154.8	85.8	7	207.3	114.9	7	259.8	144.
58	50.7	28.1	8	103.2	57.2	8	155.7	86.3	8	208.2	115.4	8	260.6	144.5
59	51.6	28.6	9	104.1	57.7	9	156.6	86.8	9	209.	115.9	9	261.5	145.
60	52.5	29.1	120	105.	58.2	180	157.4	87.3	240	209.9	116.4	300	262.4	145.4
dist.	dep.	d. lat	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 61°.

Course 30°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.5	61	52.8	30.5	121	104.8	60.5	181	156.8	90.5	241	208.7	120.5
2	1.7	1.	62	53.7	31.	2	105.7	61.	2	157.6	91.	2	209.6	121.
3	2.6	1.5	63	54.6	31.5	3	106.5	61.5	3	158.5	91.5	3	210.4	121.5
4	3.5	2.	64	55.4	32.	4	107.4	62.	4	159.3	92.	4	211.3	122.
5	4.3	2.5	65	56.3	32.5	5	108.3	62.5	5	160.2	92.5	5	212.2	122.5
6	5.2	3.	66	57.2	33.	6	109.1	63.	6	161.1	93.	6	213.	123.
7	6.1	3.5	67	58.	33.5	7	110.	63.5	7	161.9	93.5	7	213.9	123.5
8	6.9	4.	68	58.9	34.	8	110.9	64.	8	162.8	94.	8	214.8	124.
9	7.8	4.5	69	59.8	34.5	9	111.7	64.5	9	163.7	94.5	9	215.6	124.5
10	8.7	5.	70	60.6	35.	130	112.6	65.	190	164.5	95.	250	216.5	125.
11	9.5	5.5	71	61.5	35.5	1	113.4	65.5	1	165.4	95.5	1	217.4	125.5
12	10.4	6.	72	62.4	36.	2	114.3	66.	2	166.3	96.	2	218.2	126.
13	11.3	6.5	73	63.2	36.5	3	115.2	66.5	3	167.1	96.5	3	219.1	126.5
14	12.1	7.	74	64.1	37.	4	116.	67.	4	168.	97.	4	220.	127.
15	13.	7.5	75	65.	37.5	5	116.9	67.5	5	168.9	97.5	5	220.8	127.5
16	13.9	8.	76	65.8	38.	6	117.8	68.	6	169.7	98.	6	221.7	128.
17	14.7	8.5	77	66.7	38.5	7	118.6	68.5	7	170.6	98.5	7	222.6	128.5
18	15.6	9.	78	67.5	39.	8	119.5	69.	8	171.5	99.	8	223.4	129.
19	16.5	9.5	79	68.4	39.5	9	120.4	69.5	9	172.3	99.5	9	224.3	129.5
20	17.3	10.	80	69.3	40.	140	121.2	70.	200	173.2	100.	260	225.2	130.
21	18.2	10.5	81	70.1	40.5	1	122.1	70.5	1	174.1	100.5	1	226.	130.5
22	19.1	11.	82	71.	41.	2	123.	71.	2	174.9	101.	2	226.9	131.
23	19.9	11.5	83	71.9	41.5	3	123.8	71.5	3	175.8	101.5	3	227.8	131.5
24	20.8	12.	84	72.7	42.	4	124.7	72.	4	176.7	102.	4	228.6	132.
25	21.7	12.5	85	73.6	42.5	5	125.6	72.5	5	177.5	102.5	5	229.5	132.5
26	22.5	13.	86	74.5	43.	6	126.4	73.	6	178.4	103.	6	230.4	133.
27	23.4	13.5	87	75.3	43.5	7	127.3	73.5	7	179.3	103.5	7	231.2	133.5
28	24.2	14.	88	76.2	44.	8	128.2	74.	8	180.1	104.	8	232.1	134.
29	25.1	14.5	89	77.1	44.5	9	129.	74.5	9	181.	104.5	9	233.	134.5
30	26.	15.	90	77.9	45.	150	129.9	75.	210	181.9	105.	270	233.8	135.
31	26.8	15.5	91	78.8	45.5	1	130.8	75.5	1	182.7	105.5	1	234.7	135.5
32	27.7	16.	92	79.7	46.	2	131.6	76.	2	183.6	106.	2	235.6	136.
33	28.6	16.5	93	80.5	46.5	3	132.5	76.5	3	184.5	106.5	3	236.4	136.5
34	29.4	17.	94	81.4	47.	4	133.4	77.	4	185.3	107.	4	237.3	137.
35	30.3	17.5	95	82.3	47.5	5	134.2	77.5	5	186.2	107.5	5	238.2	137.5
36	31.2	18.	96	83.1	48.	6	135.1	78.	6	187.1	108.	6	239.	138.
37	32.	18.5	97	84.	48.5	7	136	78.5	7	187.9	108.5	7	239.9	138.5
38	32.9	19.	98	84.9	49.	8	136.8	79.	8	188.8	109.	8	240.8	139.
39	33.8	19.5	99	85.7	49.5	9	137.7	79.5	9	189.7	109.5	9	241.6	139.5
40	34.6	20.	100	86.6	50.	160	138.6	80.	220	190.5	110.	280	242.5	140.
41	35.5	20.5	1	87.5	50.5	1	139.4	80.5	1	191.4	110.5	1	243.4	140.5
42	36.4	21.	2	88.3	51.	2	140.3	81.	2	192.3	111.	2	244.2	141.
43	37.2	21.5	3	89.2	51.5	3	141.2	81.5	3	193.1	111.5	3	245.1	141.5
44	38.1	22.	4	90.1	52.	4	142.	82.	4	194.	112.	4	246.	142.
45	39.	22.5	5	90.9	52.5	5	142.9	82.5	5	194.9	112.5	5	246.8	142.5
46	39.8	23.	6	91.8	53.	6	143.8	83.	6	195.7	113.	6	247.7	143.
47	40.7	23.5	7	92.7	53.5	7	144.6	83.5	7	196.6	113.5	7	248.5	143.5
48	41.6	24.	8	93.5	54.	8	145.5	84.	8	197.5	114.	8	249.4	144.
49	42.4	24.5	9	94.4	54.5	9	146.4	84.5	9	198.3	114.5	9	250.3	144.5
50	43.3	25.	110	95.3	55.	170	147.2	85.	230	199.2	115.	290	251.1	145.
51	44.2	25.5	1	96.1	55.5	1	148.1	85.5	1	200.1	115.5	1	252.	145.5
52	45.	26.	2	97.	56.	2	149.	86.	2	200.9	116.	2	252.9	146.
53	45.9	26.5	3	97.9	56.5	3	149.8	86.5	3	201.8	116.5	3	253.7	146.5
54	46.8	27.	4	98.7	57.	4	150.7	87.	4	202.6	117.	4	254.6	147.
55	47.6	27.5	5	99.6	57.5	5	151.6	87.5	5	203.5	117.5	5	255.5	147.5
56	48.5	28.	6	100.5	58.	6	152.4	88.	6	204.4	118.	6	256.3	148.
57	49.4	28.5	7	101.3	58.5	7	153.3	88.5	7	205.2	118.5	7	257.2	148.5
58	50.2	29.	8	102.2	59.	8	154.2	89.	8	206.1	119.	8	258.1	149.
59	51.1	29.5	9	103.1	59.5	9	155.	89.5	9	207.	119.5	9	258.9	149.5
60	52.	30.	120	103.9	60.	180	155.9	90.	240	207.8	120.	300	259.8	150.
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 60°.

Course 31°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.9	0.5	61	52.3	31.4	121	103.7	62.3	181	155.1	93.2	241	206.6	124.1
2	1.7	1.	62	53.1	31.9	2	104.6	62.8	2	156.	93.7	2	207.4	124.6
3	2.6	1.5	63	54.	32.4	3	105.4	63.3	3	156.9	94.3	3	208.3	125.2
4	3.4	2.1	64	54.9	33.	4	106.3	63.9	4	157.7	94.8	4	209.1	125.7
5	4.3	2.6	65	55.7	33.5	5	107.1	64.4	5	158.6	95.3	5	210.	126.2
6	5.1	3.1	66	56.6	34.	6	108.	64.9	6	159.4	95.8	6	210.9	126.7
7	6.	3.6	67	57.4	34.5	7	108.9	65.4	7	160.3	96.3	7	211.7	127.2
8	6.9	4.1	68	58.3	35.	8	109.7	65.9	8	161.1	96.8	8	212.6	127.7
9	7.7	4.6	69	59.1	35.5	9	110.6	66.4	9	162.	97.3	9	213.4	128.2
10	8.6	5.2	70	60.	36.1	130	111.4	67.	190	162.9	97.9	250	214.3	128.8
11	9.4	5.7	71	60.9	36.6	1	112.3	67.5	1	163.7	98.4	1	215.1	129.3
12	10.3	6.2	72	61.7	37.1	2	113.1	68.	2	164.6	98.9	2	216.	129.8
13	11.1	6.7	73	62.6	37.6	3	114.	68.5	3	165.4	99.4	3	216.9	130.3
14	12.	7.2	74	63.4	38.1	4	114.9	69.	4	166.3	99.9	4	217.7	130.8
15	12.9	7.7	75	64.3	38.6	5	115.7	69.5	5	167.1	100.4	5	218.6	131.3
16	13.7	8.2	76	65.1	39.1	6	116.6	70.	6	168.	100.9	6	219.4	131.8
17	14.6	8.8	77	66.	39.7	7	117.4	70.6	7	168.9	101.5	7	220.3	132.4
18	15.4	9.3	78	66.9	40.2	8	118.3	71.1	8	169.7	102.	8	221.1	132.9
19	16.3	9.8	79	67.7	40.7	9	119.1	71.6	9	170.6	102.5	9	222.	133.4
20	17.1	10.3	80	68.6	41.2	140	120.	72.1	200	171.4	103.	260	222.9	133.9
21	18.	10.8	81	69.4	41.7	1	120.9	72.6	1	172.3	103.5	1	223.7	134.4
22	18.9	11.3	82	70.3	42.2	2	121.7	73.1	2	173.1	104.	2	224.6	134.9
23	19.7	11.8	83	71.1	42.7	3	122.6	73.7	3	174.	104.6	3	225.4	135.5
24	20.6	12.4	84	72.	43.3	4	123.4	74.2	4	174.9	105.1	4	226.3	136.
25	21.4	12.9	85	72.9	43.8	5	124.3	74.7	5	175.7	105.6	5	227.1	136.5
26	22.3	13.4	86	73.7	44.3	6	125.1	75.2	6	176.6	106.1	6	228.	137.
27	23.1	13.9	87	74.6	44.8	7	126.	75.7	7	177.4	106.6	7	228.9	137.5
28	24.	14.4	88	75.4	45.3	8	126.9	76.2	8	178.3	107.1	8	229.7	138.
29	24.9	14.9	89	76.3	45.8	9	127.7	76.7	9	179.1	107.6	9	230.6	138.5
30	25.7	15.5	90	77.1	46.4	150	128.6	77.3	210	180.	108.2	270	231.4	139.1
31	26.6	16.	91	78.	46.9	1	129.4	77.8	1	180.9	108.7	1	232.3	139.6
32	27.4	16.5	92	78.9	47.4	2	130.3	78.3	2	181.7	109.2	2	233.1	140.1
33	28.3	17.	93	79.7	47.9	3	131.1	78.8	3	182.6	109.7	3	234.	140.6
34	29.1	17.5	94	80.6	48.4	4	132.	79.3	4	183.4	110.2	4	234.9	141.1
35	30.	18.	95	81.4	48.9	5	132.9	79.8	5	184.3	110.7	5	235.7	141.6
36	30.9	18.5	96	82.3	49.4	6	133.7	80.3	6	185.1	111.2	6	236.6	142.2
37	31.7	19.1	97	83.1	50.	7	134.6	80.9	7	186.	111.8	7	237.4	142.7
38	32.6	19.6	98	84.	50.5	8	135.4	81.4	8	186.9	112.3	8	238.3	143.2
39	33.4	20.1	99	84.9	51.	9	136.3	81.9	9	187.7	112.8	9	239.1	143.7
40	34.3	20.6	100	85.7	51.5	160	137.1	82.4	220	188.6	113.3	280	240.	144.2
41	35.1	21.1	1	86.6	52.	1	138.	82.9	1	189.4	113.8	1	240.9	144.7
42	36.	21.6	2	87.4	52.5	2	138.9	83.4	2	190.3	114.3	2	241.7	145.2
43	36.9	22.1	3	88.3	53.	3	139.7	84.	3	191.1	114.9	3	242.6	145.8
44	37.7	22.7	4	89.1	53.6	4	140.6	84.5	4	192.	115.4	4	243.4	146.3
45	38.6	23.2	5	90.	54.1	5	141.4	85.	5	192.9	115.9	5	244.3	146.8
46	39.4	23.7	6	90.9	54.6	6	142.3	85.5	6	193.7	116.4	6	245.1	147.3
47	40.3	24.2	7	91.7	55.1	7	143.1	86.	7	194.6	116.9	7	246.	147.8
48	41.1	24.7	8	92.6	55.6	8	144.	86.5	8	195.4	117.4	8	246.9	148.3
49	42.	25.2	9	93.4	56.1	9	144.9	87.	9	196.3	117.9	9	247.7	148.8
50	42.9	25.8	110	94.3	56.7	170	145.7	87.6	230	197.1	118.5	290	248.6	149.4
51	43.7	26.3	1	95.1	57.2	1	146.6	88.1	1	198.	119.	1	249.4	149.9
52	44.6	26.8	2	96.	57.7	2	147.4	88.6	2	198.9	119.5	2	250.3	150.4
53	45.4	27.3	3	96.9	58.2	3	148.3	89.1	3	199.7	120.	3	251.2	150.9
54	46.3	27.8	4	97.7	58.7	4	149.1	89.6	4	200.6	120.5	4	252.	151.4
55	47.1	28.3	5	98.6	59.2	5	150.	90.1	5	201.4	121.	5	252.9	151.9
56	48.	28.8	6	99.4	59.7	6	150.9	90.6	6	202.3	121.5	6	253.7	152.5
57	48.9	29.4	7	100.3	60.3	7	151.7	91.2	7	203.1	122.1	7	254.6	153.
58	49.7	29.9	8	101.1	60.8	8	152.6	91.7	8	204.	122.6	8	255.4	153.5
59	50.6	30.4	9	102.	61.3	9	153.4	92.2	9	204.9	123.1	9	256.3	154.
60	51.4	30.9	120	102.9	61.8	180	154.3	92.7	240	205.7	123.6	300	257.1	154.5
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 59°.

Course 32°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.5	61	51.7	32.3	121	102.6	64.1	181	153.5	95.9	241	204.4	127.7
2	1.7	1.1	62	52.6	32.9	2	103.5	64.7	2	154.3	96.4	2	205.2	128.2
3	2.5	1.6	63	53.4	33.4	3	104.3	65.2	3	155.2	97.	3	206.1	128.8
4	3.4	2.1	64	54.3	33.9	4	105.2	65.7	4	156.	97.5	4	206.9	129.3
5	4.2	2.6	65	55.1	34.4	5	106.	66.2	5	156.9	98.	5	207.8	129.8
6	5.1	3.2	66	56.	35.	6	106.9	66.8	6	157.7	98.6	6	208.6	130.4
7	5.9	3.7	67	56.8	35.5	7	107.7	67.3	7	158.6	99.1	7	209.5	130.9
8	6.8	4.2	68	57.7	36.	8	108.6	67.8	8	159.4	99.6	8	210.3	131.4
9	7.6	4.8	69	58.5	36.6	9	109.4	68.4	9	160.3	100.2	9	211.2	131.9
10	8.5	5.3	70	59.4	37.1	130	110.2	68.9	190	161.1	100.7	250	212.	132.5
11	9.3	5.8	71	60.2	37.6	1	111.1	69.4	1	162.	101.2	1	212.9	133.
12	10.2	6.4	72	61.1	38.2	2	111.9	69.9	2	162.8	101.7	2	213.7	133.5
13	11.	6.9	73	61.9	38.7	3	112.8	70.5	3	163.7	102.3	3	214.6	134.1
14	11.9	7.4	74	62.8	39.2	4	113.6	71.	4	164.5	102.8	4	215.4	134.6
15	12.7	7.9	75	63.6	39.7	5	114.5	71.5	5	165.4	103.3	5	216.3	135.1
16	13.6	8.5	76	64.5	40.3	6	115.3	72.1	6	166.2	103.9	6	217.1	135.7
17	14.4	9.	77	65.3	40.8	7	116.2	72.6	7	167.1	104.4	7	217.9	136.2
18	15.3	9.5	78	66.1	41.3	8	117.	73.1	8	167.9	104.9	8	218.8	136.7
19	16.1	10.1	79	67.	41.9	9	117.9	73.7	9	168.8	105.5	9	219.6	137.2
20	17.	10.6	80	67.8	42.4	140	118.7	74.2	200	169.6	106.	260	220.5	137.8
21	17.8	11.1	81	68.7	42.9	1	119.6	74.7	1	170.5	106.5	1	221.3	138.3
22	18.7	11.7	82	69.5	43.5	2	120.4	75.2	2	171.3	107.	2	222.2	138.8
23	19.5	12.2	83	70.4	44.	3	121.3	75.8	3	172.2	107.6	3	223.	139.4
24	20.4	12.7	84	71.2	44.5	4	122.1	76.3	4	173.	108.1	4	223.9	139.9
25	21.2	13.2	85	72.1	45.	5	123.	76.8	5	173.8	108.6	5	224.7	140.4
26	22.	13.8	86	72.9	45.6	6	123.8	77.4	6	174.7	109.2	6	225.6	141.
27	22.9	14.3	87	73.8	46.1	7	124.7	77.9	7	175.5	109.7	7	226.4	141.5
28	23.7	14.8	88	74.6	46.6	8	125.5	78.4	8	176.4	110.2	8	227.3	142.
29	24.6	15.4	89	75.5	47.2	9	126.4	79.	9	177.2	110.8	9	228.1	142.5
30	25.4	15.9	90	76.3	47.7	150	127.2	79.5	210	178.1	111.3	270	229.	143.1
31	26.3	16.4	91	77.2	48.2	1	128.1	80.	1	178.9	111.8	1	229.8	143.6
32	27.1	17.	92	78.	48.8	2	128.9	80.5	2	179.8	112.3	2	230.7	144.1
33	28.	17.5	93	78.9	49.3	3	129.8	81.1	3	180.6	112.9	3	231.5	144.7
34	28.8	18.	94	79.7	49.8	4	130.6	81.6	4	181.5	113.4	4	232.4	145.2
35	29.7	18.5	95	80.6	50.3	5	131.4	82.1	5	182.3	113.9	5	233.2	145.7
36	30.5	19.1	96	81.4	50.9	6	132.3	82.7	6	183.2	114.5	6	234.1	146.3
37	31.4	19.6	97	82.3	51.4	7	133.1	83.2	7	184.	115.	7	234.9	146.8
38	32.2	20.1	98	83.1	51.9	8	134.	83.7	8	184.9	115.5	8	235.8	147.3
39	33.1	20.7	99	84.	52.5	9	134.8	84.3	9	185.7	116.1	9	236.6	147.8
40	33.9	21.2	100	84.8	53.	160	135.7	84.8	220	186.6	116.6	280	237.5	148.4
41	34.8	21.7	1	85.7	53.5	1	136.5	85.3	1	187.4	117.1	1	238.3	148.9
42	35.6	22.3	2	86.5	54.1	2	137.4	85.8	2	188.3	117.6	2	239.1	149.4
43	36.5	22.8	3	87.3	54.6	3	138.2	86.4	3	189.1	118.2	3	240.	150.
44	37.3	23.3	4	88.2	55.1	4	139.1	86.9	4	190.	118.7	4	240.8	150.5
45	38.2	23.8	5	89.	55.6	5	139.9	87.4	5	190.8	119.2	5	241.7	151.
46	39.	24.4	6	89.9	56.2	6	140.8	88.	6	191.7	119.8	6	242.5	151.6
47	39.9	24.9	7	90.7	56.7	7	141.6	88.5	7	192.5	120.3	7	243.4	152.1
48	40.7	25.4	8	91.6	57.2	8	142.5	89.	8	193.4	120.8	8	244.2	152.6
49	41.6	26.	9	92.4	57.8	9	143.3	89.6	9	194.2	121.4	9	245.1	153.1
50	42.4	26.5	110	93.3	58.3	170	144.2	90.1	230	195.1	121.9	290	245.9	153.7
51	43.3	27.	1	94.1	58.8	1	145.	90.6	1	195.9	122.4	1	246.8	154.2
52	44.1	27.6	2	95.	59.4	2	145.9	91.1	2	196.7	122.9	2	247.6	154.7
53	44.9	28.1	3	95.8	59.9	3	146.7	91.7	3	197.6	123.5	3	248.5	155.3
54	45.8	28.6	4	96.7	60.4	4	147.6	92.2	4	198.4	124.	4	249.3	155.8
55	46.6	29.1	5	97.5	60.9	5	148.4	92.7	5	199.3	124.5	5	250.2	156.3
56	47.5	29.7	6	98.4	61.5	6	149.3	93.3	6	200.1	125.1	6	251.	156.9
57	48.3	30.2	7	99.2	62.	7	150.1	93.8	7	201.	125.6	7	251.9	157.4
58	49.2	30.7	8	100.1	62.5	8	151.	94.3	8	201.8	126.1	8	252.7	157.9
59	50.	31.3	9	100.9	63.1	9	151.8	94.9	9	202.7	126.7	9	253.6	158.4
60	50.9	31.8	120	101.8	63.6	180	152.6	95.4	240	203.5	127.2	300	254.4	159.
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude

Course 58°.

Course 33°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.5	61	51.2	33.2	121	101.5	65.9	181	151.8	98.6	241	202.1	131.3
2	1.7	1.1	62	52.	33.8	2	102.3	66.4	2	152.6	99.1	2	203.	131.8
3	2.5	1.6	63	52.8	34.3	3	103.2	67.	3	153.5	99.7	3	203.8	132.3
4	3.4	2.2	64	53.7	34.9	4	104.	67.5	4	154.3	100.2	4	204.6	132.9
5	4.2	2.7	65	54.5	35.4	5	104.8	68.1	5	155.2	100.8	5	205.5	133.4
6	5.	3.3	66	55.4	35.9	6	105.7	68.6	6	156.	101.3	6	206.3	134.
7	5.9	3.8	67	56.2	36.5	7	106.5	69.2	7	156.8	101.8	7	207.2	134.5
8	6.7	4.4	68	57.	37.	8	107.3	69.7	8	157.7	102.4	8	208.	135.1
9	7.5	4.9	69	57.9	37.6	9	108.2	70.3	9	158.5	102.9	9	208.8	135.6
10	8.4	5.4	70	58.7	38.1	130	109.	70.8	190	159.3	103.5	250	209.7	136.2
11	9.2	6.	71	59.5	38.7	1	109.9	71.3	1	160.2	104.	1	210.5	136.7
12	10.1	6.5	72	60.4	39.2	2	110.7	71.9	2	161.	104.6	2	211.3	137.2
13	10.9	7.1	73	61.2	39.8	3	111.5	72.4	3	161.9	105.1	3	212.2	137.8
14	11.7	7.6	74	62.1	40.3	4	112.4	73.	4	162.7	105.7	4	213.	138.3
15	12.6	8.2	75	62.9	40.8	5	113.2	73.5	5	163.5	106.2	5	213.9	138.9
16	13.4	8.7	76	63.7	41.4	6	114.1	74.1	6	164.4	106.7	6	214.7	139.4
17	14.3	9.3	77	64.6	41.9	7	114.9	74.6	7	165.2	107.3	7	215.5	140.
18	15.1	9.8	78	65.4	42.5	8	115.7	75.2	8	166.1	107.8	8	216.4	140.5
19	15.9	10.3	79	66.3	43.	9	116.6	75.7	9	166.9	108.4	9	217.2	141.1
20	16.8	10.9	80	67.1	43.6	140	117.4	76.2	200	167.7	108.9	260	218.1	141.6
21	17.6	11.4	81	67.9	44.1	1	118.3	76.8	1	168.6	109.5	1	218.9	142.2
22	18.5	12.	82	68.8	44.7	2	119.1	77.3	2	169.4	110.	2	219.7	142.7
23	19.3	12.5	83	69.6	45.2	3	119.9	77.9	3	170.3	110.6	3	220.6	143.2
24	20.1	13.1	84	70.4	45.7	4	120.8	78.4	4	171.1	111.1	4	221.4	143.8
25	21.	13.6	85	71.3	46.3	5	121.6	79.	5	171.9	111.7	5	222.2	144.3
26	21.8	14.2	86	72.1	46.8	6	122.4	79.5	6	172.8	112.2	6	223.1	144.9
27	22.6	14.7	87	73.	47.4	7	123.3	80.1	7	173.6	112.7	7	223.9	145.4
28	23.5	15.2	88	73.8	47.9	8	124.1	80.6	8	174.4	113.3	8	224.8	146.
29	24.3	15.8	89	74.6	48.5	9	125.	81.2	9	175.3	113.8	9	225.6	146.5
30	25.2	16.3	90	75.5	49.	150	125.8	81.7	210	176.1	114.4	270	226.4	147.1
31	26.	16.9	91	76.3	49.6	1	126.6	82.2	1	177.	114.9	1	227.3	147.6
32	26.8	17.4	92	77.2	50.1	2	127.5	82.8	2	177.8	115.5	2	228.1	148.1
33	27.7	18.	93	78.	50.7	3	128.3	83.3	3	178.6	116.	3	229.	148.7
34	28.5	18.5	94	78.8	51.2	4	129.2	83.9	4	179.5	116.6	4	229.8	149.2
35	29.4	19.1	95	79.7	51.7	5	130.	84.4	5	180.3	117.1	5	230.6	149.8
36	30.2	19.6	96	80.5	52.3	6	130.8	85.	6	181.2	117.6	6	231.5	150.3
37	31.	20.2	97	81.4	52.8	7	131.7	85.5	7	182.	118.2	7	232.3	150.9
38	31.9	20.7	98	82.2	53.4	8	132.5	86.1	8	182.8	118.7	8	233.2	151.4
39	32.7	21.2	99	83.	53.9	9	133.3	86.6	9	183.7	119.3	9	234.	152.
40	33.5	21.8	100	83.9	54.5	160	134.2	87.1	220	184.5	119.8	280	234.8	152.5
41	34.4	22.3	1	84.7	55.	1	135.	87.7	1	185.3	120.4	1	235.7	153.
42	35.2	22.9	2	85.5	55.6	2	135.9	88.2	2	186.2	120.9	2	236.5	153.6
43	36.1	23.4	3	86.4	56.1	3	136.7	88.8	3	187.	121.5	3	237.3	154.1
44	36.9	24.	4	87.2	56.6	4	137.5	89.3	4	187.9	122.	4	238.2	154.7
45	37.7	24.5	5	88.1	57.2	5	138.4	89.9	5	188.7	122.5	5	239.	155.2
46	38.6	25.1	6	88.9	57.7	6	139.2	90.4	6	189.5	123.1	6	239.9	155.8
47	39.4	25.6	7	89.7	58.3	7	140.1	91.	7	190.4	123.6	7	240.7	156.3
48	40.3	26.1	8	90.6	58.8	8	140.9	91.5	8	191.2	124.2	8	241.5	156.9
49	41.1	26.7	9	91.4	59.4	9	141.7	92.	9	192.1	124.7	9	242.4	157.4
50	41.9	27.2	110	92.3	59.9	170	142.6	92.6	230	192.9	125.3	290	243.2	157.9
51	42.8	27.8	1	93.1	60.5	1	143.4	93.1	1	193.7	125.8	1	244.1	158.5
52	43.6	28.3	2	93.9	61.	2	144.3	93.7	2	194.6	126.4	2	244.9	159.
53	44.4	28.9	3	94.8	61.5	3	145.1	94.2	3	195.4	126.9	3	245.7	159.6
54	45.3	29.4	4	95.6	62.1	4	145.9	94.8	4	196.2	127.4	4	246.6	160.1
55	46.1	30.	5	96.4	62.6	5	146.8	95.3	5	197.1	128.	5	247.4	160.7
56	47.	30.5	6	97.3	63.2	6	147.6	95.9	6	197.9	128.5	6	248.2	161.2
57	47.8	31.	7	98.1	63.7	7	148.4	96.4	7	198.8	129.1	7	249.1	161.8
58	48.6	31.6	8	99.	64.3	8	149.3	96.9	8	199.6	129.6	8	249.9	162.3
59	49.5	32.1	9	99.8	64.8	9	150.1	97.5	9	200.4	130.2	9	250.8	162.8
60	50.3	32.7	120	100.6	65.4	180	151.	98.	240	201.3	130.7	300	251.6	163.4
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat	dist.	dep.	d. lat.	dist.	dep.	d. lat

Distance, Departure and Diff. Latitude.

Course 57°.

Course 34°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.6	61	50.6	34.1	121	100.3	67.7	181	150.1	101.2	241	199.8	134.8
2	1.7	1.1	62	51.4	34.7	2	101.1	68.2	2	150.9	101.8	2	200.6	135.3
3	2.5	1.7	63	52.2	35.2	3	102.	68.8	3	151.7	102.3	3	201.5	135.9
4	3.3	2.2	64	53.1	35.8	4	102.8	69.3	4	152.5	102.9	4	202.3	136.4
5	4.1	2.8	65	53.9	36.3	5	103.6	69.9	5	153.4	103.5	5	203.1	137.
6	5.	3.4	66	54.7	36.9	6	104.5	70.5	6	154.2	104.	6	203.9	137.6
7	5.8	3.9	67	55.5	37.5	7	105.3	71.	7	155.	104.6	7	204.8	138.1
8	6.6	4.5	68	56.4	38.	8	106.1	71.6	8	155.9	105.1	8	205.6	138.7
9	7.5	5.	69	57.2	38.6	9	106.9	72.1	9	156.7	105.7	9	206.4	139.2
10	8.3	5.6	70	58.	39.1	130	107.8	72.7	190	157.5	106.2	250	207.3	139.8
11	9.1	6.2	71	58.9	39.7	1	108.6	73.3	1	158.3	106.8	1	208.1	140.4
12	9.9	6.7	72	59.7	40.3	2	109.4	73.8	2	159.2	107.4	2	208.9	140.9
13	10.8	7.3	73	60.5	40.8	3	110.3	74.4	3	160.	107.9	3	209.7	141.5
14	11.6	7.8	74	61.3	41.4	4	111.1	74.9	4	160.8	108.5	4	210.6	142.
15	12.4	8.4	75	62.2	41.9	5	111.9	75.5	5	161.7	109.	5	211.4	142.6
16	13.3	8.9	76	63.	42.5	6	112.7	76.1	6	162.5	109.6	6	212.2	143.2
17	14.1	9.5	77	63.8	43.1	7	113.6	76.6	7	163.3	110.2	7	213.1	143.7
18	14.9	10.1	78	64.7	43.6	8	114.4	77.2	8	164.1	110.7	8	213.9	144.3
19	15.8	10.6	79	65.5	44.2	9	115.2	77.7	9	165.	111.3	9	214.7	144.8
20	16.6	11.2	80	66.3	44.7	140	116.1	78.3	200	165.8	111.8	260	215.5	145.4
21	17.4	11.7	81	67.2	45.3	1	116.9	78.8	1	166.6	112.4	1	216.4	145.9
22	18.2	12.3	82	68.	45.9	2	117.7	79.4	2	167.5	113.	2	217.2	146.5
23	19.1	12.9	83	68.8	46.4	3	118.6	80.	3	168.3	113.5	3	218.	147.1
24	19.9	13.4	84	69.6	47.	4	119.4	80.5	4	169.1	114.1	4	218.9	147.6
25	20.7	14.	85	70.5	47.5	5	120.2	81.1	5	170.	114.6	5	219.7	148.2
26	21.6	14.5	86	71.3	48.1	6	121.	81.6	6	170.8	115.2	6	220.5	148.7
27	22.4	15.1	87	72.1	48.6	7	121.9	82.2	7	171.6	115.8	7	221.4	149.3
28	23.2	15.7	88	73.	49.2	8	122.7	82.8	8	172.4	116.3	8	222.2	149.9
29	24.	16.2	89	73.8	49.8	9	123.5	83.3	9	173.3	116.9	9	223.	150.4
30	24.9	16.8	90	74.6	50.3	150	124.4	83.9	210	174.1	117.4	270	223.8	151.
31	25.7	17.3	91	75.4	50.9	1	125.2	84.4	1	174.9	118.	1	224.7	151.5
32	26.5	17.9	92	76.3	51.4	2	126.	85.	2	175.8	118.5	2	225.5	152.1
33	27.4	18.5	93	77.1	52.	3	126.8	85.6	3	176.6	119.1	3	226.3	152.7
34	28.2	19.	94	77.9	52.6	4	127.7	86.1	4	177.4	119.7	4	227.2	153.2
35	29.	19.6	95	78.8	53.1	5	128.5	86.7	5	178.2	120.2	5	228.	153.8
36	29.8	20.1	96	79.6	53.7	6	129.3	87.2	6	179.1	120.8	6	228.8	154.3
37	30.7	20.7	97	80.4	54.2	7	130.2	87.8	7	179.9	121.3	7	229.6	154.9
38	31.5	21.2	98	81.2	54.8	8	131.	88.4	8	180.7	121.9	8	230.5	155.5
39	32.3	21.8	99	82.1	55.4	9	131.8	88.9	9	181.6	122.5	9	231.3	156.
40	33.2	22.4	100	82.9	55.9	160	132.6	89.5	220	182.4	123.	280	232.1	156.6
41	34.	22.9	1	83.7	56.5	1	133.5	90.	1	183.2	123.6	1	233.	157.1
42	34.8	23.5	2	84.6	57.	2	134.3	90.6	2	184.	124.1	2	233.8	157.7
43	35.6	24.	3	85.4	57.6	3	135.1	91.1	3	184.9	124.7	3	234.6	158.3
44	36.5	24.6	4	86.2	58.2	4	136.	91.7	4	185.7	125.3	4	235.4	158.8
45	37.3	25.2	5	87.	58.7	5	136.8	92.3	5	186.5	125.8	5	236.3	159.4
46	38.1	25.7	6	87.9	59.3	6	137.6	92.8	6	187.4	126.4	6	237.1	159.9
47	39.	26.3	7	88.7	59.8	7	138.4	93.4	7	188.2	126.9	7	237.9	160.5
48	39.8	26.8	8	89.5	60.4	8	139.3	93.9	8	189.	127.5	8	238.8	161.
49	40.6	27.4	9	90.4	61.	9	140.1	94.5	9	189.8	128.1	9	239.6	161.6
50	41.5	28.	110	91.2	61.5	170	140.9	95.1	230	190.7	128.6	290	240.4	162.2
51	42.3	28.5	1	92.	62.1	1	141.8	95.6	1	191.5	129.2	1	241.2	162.7
52	43.1	29.1	2	92.9	62.6	2	142.6	96.2	2	192.3	129.7	2	242.1	163.3
53	43.9	29.6	3	93.7	63.2	3	143.4	96.7	3	193.2	130.3	3	242.9	163.8
54	44.8	30.2	4	94.5	63.7	4	144.3	97.3	4	194.	130.9	4	243.7	164.4
55	45.6	30.8	5	95.3	64.3	5	145.1	97.9	5	194.8	131.4	5	244.6	165.
56	46.4	31.3	6	96.2	64.9	6	145.9	98.4	6	195.7	132.	6	245.4	165.5
57	47.3	31.9	7	97.	65.4	7	146.7	99.	7	196.5	132.5	7	246.2	166.1
58	48.1	32.4	8	97.8	66.	8	147.6	99.5	8	197.3	133.1	8	247.1	166.6
59	48.9	33.	9	98.7	66.5	9	148.4	100.1	9	198.1	133.6	9	247.9	167.2
60	49.7	33.6	120	99.5	67.1	180	149.2	100.7	240	199.	134.2	300	248.7	167.8
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 56°.

Course 35°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.6	61	50.	35.	121	99.1	69.4	181	148.3	103.8	241	197.4	138.2
2	1.6	1.1	62	50.8	35.6	2	99.9	70.	2	149.1	104.4	2	198.2	138.8
3	2.5	1.7	63	51.6	36.1	3	100.8	70.5	3	149.9	105.	3	199.1	139.4
4	3.3	2.3	64	52.4	36.7	4	101.6	71.1	4	150.7	105.5	4	199.9	140.
5	4.1	2.9	65	53.2	37.3	5	102.4	71.7	5	151.5	106.1	5	200.7	140.5
6	4.9	3.4	66	54.1	37.9	6	103.2	72.3	6	152.4	106.7	6	201.5	141.1
7	5.7	4.	67	54.9	38.4	7	104.	72.8	7	153.2	107.3	7	202.3	141.7
8	6.6	4.6	68	55.7	39.	8	104.9	73.4	8	154.	107.8	8	203.1	142.2
9	7.4	5.2	69	56.5	39.6	9	105.7	74.	9	154.8	108.4	9	204.	142.8
10	8.2	5.7	70	57.3	40.2	130	106.5	74.6	190	155.6	109.	250	204.8	143.4
11	9.	6.3	71	58.2	40.7	1	107.3	75.1	1	156.5	109.6	1	205.6	144.
12	9.8	6.9	72	59.	41.3	2	108.1	75.7	2	157.3	110.1	2	206.4	144.5
13	10.6	7.5	73	59.8	41.9	3	108.9	76.3	3	158.1	110.7	3	207.2	145.1
14	11.5	8.	74	60.6	42.4	4	109.8	76.9	4	158.9	111.3	4	208.1	145.7
15	12.3	8.6	75	61.4	43.	5	110.6	77.4	5	159.7	111.8	5	208.9	146.3
16	13.1	9.2	76	62.3	43.6	6	111.4	78.	6	160.6	112.4	6	209.7	146.8
17	13.9	9.8	77	63.1	44.2	7	112.2	78.6	7	161.4	113.	7	210.5	147.4
18	14.7	10.3	78	63.9	44.7	8	113.	79.2	8	162.2	113.6	8	211.3	148.
19	15.6	10.9	79	64.7	45.3	9	113.9	79.7	9	163.	114.1	9	212.2	148.6
20	16.4	11.5	80	65.5	45.9	140	114.7	80.3	200	163.8	114.7	260	213.	149.1
21	17.2	12.	81	66.4	46.5	1	115.5	80.9	1	164.6	115.3	1	213.8	149.7
22	18.	12.6	82	67.2	47.	2	116.3	81.4	2	165.5	115.9	2	214.6	150.3
23	18.8	13.2	83	68.	47.6	3	117.1	82.	3	166.3	116.4	3	215.4	150.9
24	19.7	13.8	84	68.8	48.2	4	118.	82.6	4	167.1	117.	4	216.3	151.4
25	20.5	14.3	85	69.6	48.8	5	118.8	83.2	5	167.9	117.6	5	217.1	152.
26	21.3	14.9	86	70.4	49.3	6	119.6	83.7	6	168.7	118.2	6	217.9	152.6
27	22.1	15.5	87	71.3	49.9	7	120.4	84.3	7	169.6	118.7	7	218.7	153.1
28	22.9	16.1	88	72.1	50.5	8	121.2	84.9	8	170.4	119.3	8	219.5	153.7
29	23.8	16.6	89	72.9	51.	9	122.1	85.5	9	171.2	119.9	9	220.4	154.3
30	24.6	17.2	90	73.7	51.6	150	122.9	86.	210	172.	120.5	270	221.2	154.9
31	25.4	17.8	91	74.5	52.2	1	123.7	86.6	1	172.8	121.	1	222.	155.4
32	26.2	18.4	92	75.4	52.8	2	124.5	87.2	2	173.7	121.6	2	222.8	156.
33	27.	18.9	93	76.2	53.3	3	125.3	87.8	3	174.5	122.2	3	223.6	156.6
34	27.9	19.5	94	77.	53.9	4	126.1	88.3	4	175.3	122.7	4	224.4	157.2
35	28.7	20.1	95	77.8	54.5	5	127.	88.9	5	176.1	123.3	5	225.3	157.7
36	29.5	20.6	96	78.6	55.1	6	127.8	89.5	6	176.9	123.9	6	226.1	158.3
37	30.3	21.2	97	79.5	55.6	7	128.6	90.1	7	177.8	124.5	7	226.9	158.9
38	31.1	21.8	98	80.3	56.2	8	129.4	90.6	8	178.6	125.	8	227.7	159.5
39	31.9	22.4	99	81.1	56.8	9	130.2	91.2	9	179.4	125.6	9	228.5	160.
40	32.8	22.9	100	81.9	57.4	160	131.1	91.8	220	180.2	126.2	280	229.4	160.6
41	33.6	23.5	1	82.7	57.9	1	131.9	92.3	1	181.	126.8	1	230.2	161.2
42	34.4	24.1	2	83.6	58.5	2	132.7	92.9	2	181.9	127.3	2	231.	161.7
43	35.2	24.7	3	84.4	59.1	3	133.5	93.5	3	182.7	127.9	3	231.8	162.3
44	36.	25.2	4	85.2	59.7	4	134.3	94.1	4	183.5	128.5	4	232.6	162.9
45	36.9	25.8	5	86.	60.2	5	135.2	94.6	5	184.3	129.1	5	233.5	163.5
46	37.7	26.4	6	86.8	60.8	6	136.	95.2	6	185.1	129.6	6	234.3	164.
47	38.5	27.	7	87.6	61.4	7	136.8	95.8	7	185.9	130.2	7	235.1	164.6
48	39.3	27.5	8	88.5	61.9	8	137.6	96.4	8	186.8	130.8	8	235.9	165.2
49	40.1	28.1	9	89.3	62.5	9	138.4	96.9	9	187.6	131.3	9	236.7	165.8
50	41.	28.7	110	90.1	63.1	170	139.3	97.5	230	188.4	131.9	290	237.6	166.3
51	41.8	29.3	1	90.9	63.7	1	140.1	98.1	1	189.2	132.5	1	238.4	166.9
52	42.6	29.8	2	91.7	64.2	2	140.9	98.7	2	190.	133.1	2	239.2	167.5
53	43.4	30.4	3	92.6	64.8	3	141.7	99.2	3	190.9	133.6	3	240.	168.1
54	44.2	31.	4	93.4	65.4	4	142.5	99.8	4	191.7	134.2	4	240.8	168.6
55	45.1	31.5	5	94.2	66.	5	143.4	100.4	5	192.5	134.8	5	241.6	169.2
56	45.9	32.1	6	95.	66.5	6	144.2	100.9	6	193.3	135.4	6	242.5	169.8
57	46.7	32.7	7	95.8	67.1	7	145.	101.5	7	194.1	135.9	7	243.3	170.4
58	47.5	33.3	8	96.7	67.7	8	145.8	102.1	8	195.	136.5	8	244.1	170.9
59	48.3	33.8	9	97.5	68.3	9	146.6	102.7	9	195.8	137.1	9	244.9	171.5
60	49.1	34.4	120	98.3	68.8	180	147.4	103.2	240	196.6	137.7	300	245.7	172.1
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 55°.

Course 36°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.6	61	49.4	35.9	121	97.9	71.1	181	146.4	106.4	241	195.	141.7
2	1.6	1.2	62	50.2	36.4	2	98.7	71.7	2	147.2	107.	2	195.8	142.2
3	2.4	1.8	63	51.	37.	3	99.5	72.3	3	148.1	107.6	3	196.6	142.8
4	3.2	2.4	64	51.8	37.6	4	100.3	72.9	4	148.9	108.2	4	197.4	143.4
5	4.	2.9	65	52.6	38.2	5	101.1	73.5	5	149.7	108.7	5	198.2	144.
6	4.9	3.5	66	53.4	38.8	6	101.9	74.1	6	150.5	109.3	6	199.	144.6
7	5.7	4.1	67	54.2	39.4	7	102.7	74.6	7	151.3	109.9	7	199.8	145.2
8	6.5	4.7	68	55.	40.	8	103.6	75.2	8	152.1	110.5	8	200.6	145.8
9	7.3	5.3	69	55.8	40.6	9	104.4	75.8	9	152.9	111.1	9	201.4	146.4
10	8.1	5.9	70	56.6	41.1	130	105.2	76.4	190	153.7	111.7	250	202.3	146.9
11	8.9	6.5	71	57.4	41.7	1	106.	77.	1	154.5	112.3	1	203.1	147.5
12	9.7	7.1	72	58.2	42.3	2	106.8	77.6	2	155.3	112.9	2	203.9	148.1
13	10.5	7.6	73	59.1	42.9	3	107.6	78.2	3	156.1	113.4	3	204.7	148.7
14	11.3	8.2	74	59.9	43.5	4	108.4	78.8	4	156.9	114.	4	205.5	149.3
15	12.1	8.8	75	60.7	44.1	5	109.2	79.4	5	157.8	114.6	5	206.3	149.9
16	12.9	9.4	76	61.5	44.7	6	110.	79.9	6	158.6	115.2	6	207.1	150.5
17	13.8	10.	77	62.3	45.3	7	110.8	80.5	7	159.4	115.8	7	207.9	151.1
18	14.6	10.6	78	63.1	45.8	8	111.6	81.1	8	160.2	116.4	8	208.7	151.6
19	15.4	11.2	79	63.9	46.4	9	112.5	81.7	9	161.	117.	9	209.5	152.2
20	16.2	11.8	80	64.7	47.	140	113.3	82.3	200	161.8	117.6	260	210.3	152.8
21	17.	12.3	81	65.5	47.6	1	114.1	82.9	1	162.6	118.1	1	211.2	153.4
22	17.8	12.9	82	66.3	48.2	2	114.9	83.5	2	163.4	118.7	2	212.	154.
23	18.6	13.5	83	67.1	48.8	3	115.7	84.1	3	164.2	119.3	3	212.8	154.6
24	19.4	14.1	84	68.	49.4	4	116.5	84.6	4	165.	119.9	4	213.6	155.2
25	20.2	14.7	85	68.8	50.	5	117.3	85.2	5	165.8	120.5	5	214.4	155.8
26	21.	15.3	86	69.6	50.5	6	118.1	85.8	6	166.7	121.1	6	215.2	156.4
27	21.8	15.9	87	70.4	51.1	7	118.9	86.4	7	167.5	121.7	7	216.	156.9
28	22.7	16.5	88	71.2	51.7	8	119.7	87.	8	168.3	122.3	8	216.8	157.5
29	23.5	17.	89	72.	52.3	9	120.5	87.6	9	169.1	122.8	9	217.6	158.1
30	24.3	17.6	90	72.8	52.9	150	121.4	88.2	210	169.9	123.4	270	218.4	158.7
31	25.1	18.2	91	73.6	53.5	1	122.2	88.8	1	170.7	124.	1	219.2	159.3
32	25.9	18.8	92	74.4	54.1	2	123.	89.3	2	171.5	124.6	2	220.1	159.9
33	26.7	19.4	93	75.2	54.7	3	123.8	89.9	3	172.3	125.2	3	220.9	160.5
34	27.5	20.	94	76.	55.3	4	124.6	90.5	4	173.1	125.8	4	221.7	161.1
35	28.3	20.6	95	76.9	55.8	5	125.4	91.1	5	173.9	126.4	5	222.5	161.6
36	29.1	21.2	96	77.7	56.4	6	126.2	91.7	6	174.7	127.	6	223.3	162.2
37	29.9	21.7	97	78.5	57.	7	127.	92.3	7	175.6	127.5	7	224.1	162.8
38	30.7	22.3	98	79.3	57.6	8	127.8	92.9	8	176.4	128.1	8	224.9	163.4
39	31.6	22.9	99	80.1	58.2	9	128.6	93.5	9	177.2	128.7	9	225.7	164.
40	32.4	23.5	100	80.9	58.8	160	129.4	94.	220	178.	129.3	280	226.5	164.6
41	33.2	24.1	1	81.7	59.4	1	130.3	94.6	1	178.8	129.9	1	227.3	165.2
42	34.	24.7	2	82.5	60.	2	131.1	95.2	2	179.6	130.5	2	228.1	165.8
43	34.8	25.3	3	83.3	60.5	3	131.9	95.8	3	180.4	131.1	3	229.	166.3
44	35.6	25.9	4	84.1	61.1	4	132.7	96.4	4	181.2	131.7	4	229.8	166.9
45	36.4	26.5	5	84.9	61.7	5	133.5	97.	5	182.	132.3	5	230.6	167.5
46	37.2	27.	6	85.8	62.3	6	134.3	97.6	6	182.8	132.8	6	231.4	168.1
47	38.	27.6	7	86.6	62.9	7	135.1	98.2	7	183.6	133.4	7	232.2	168.7
48	38.8	28.2	8	87.4	63.5	8	135.9	98.7	8	184.5	134.	8	233.	169.3
49	39.6	28.8	9	88.2	64.1	9	136.7	99.3	9	185.3	134.6	9	233.8	169.9
50	40.5	29.4	110	89.	64.7	170	137.5	99.9	230	186.1	135.2	290	234.6	170.5
51	41.3	30.	1	89.8	65.2	1	138.3	100.5	1	186.9	135.8	1	235.4	171.
52	42.1	30.6	2	90.6	65.8	2	139.2	101.1	2	187.7	136.4	2	236.2	171.6
53	42.9	31.2	3	91.4	66.4	3	140.	101.7	3	188.5	137.	3	237.	172.2
54	43.7	31.7	4	92.2	67.	4	140.8	102.3	4	189.3	137.5	4	237.9	172.8
55	44.5	32.3	5	93.	67.6	5	141.6	102.9	5	190.1	138.1	5	238.7	173.4
56	45.3	32.9	6	93.8	68.2	6	142.4	103.5	6	190.9	138.7	6	239.5	174.
57	46.1	33.5	7	94.7	68.8	7	143.2	104.	7	191.7	139.3	7	240.3	174.6
58	46.9	34.1	8	95.5	69.4	8	144.	104.6	8	192.5	139.9	8	241.1	175.2
59	47.7	34.7	9	96.3	69.9	9	144.8	105.2	9	193.4	140.5	9	241.9	175.7
60	48.5	35.3	120	97.1	70.5	180	145.6	105.8	240	194.2	141.1	300	242.7	176.3
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 54°.

Course 37°.

Distance, Diff. Latitude and Departure

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.6	61	48.7	36.7	121	96.6	72.8	181	144.6	108.9	241	192.5	145.
2	1.6	1.2	62	49.5	37.3	2	97.4	73.4	2	145.4	109.5	2	193.3	145.6
3	2.4	1.8	63	50.3	37.9	3	98.2	74.	3	146.2	110.1	3	194.1	146.2
4	3.2	2.4	64	51.1	38.5	4	99.	74.6	4	146.9	110.7	4	194.9	146.8
5	4.	3.	65	51.9	39.1	5	99.8	75.2	5	147.7	111.3	5	195.7	147.4
6	4.8	3.6	66	52.7	39.7	6	100.6	75.8	6	148.5	111.9	6	196.5	148.
7	5.6	4.2	67	53.5	40.3	7	101.4	76.4	7	149.3	112.5	7	197.3	148.6
8	6.4	4.8	68	54.3	40.9	8	102.2	77.	8	150.1	113.1	8	198.1	149.3
9	7.2	5.4	69	55.1	41.5	9	103.	77.6	9	150.9	113.7	9	198.9	149.9
10	8.	6.	70	55.9	42.1	130	103.8	78.2	190	151.7	114.3	250	199.7	150.5
11	8.8	6.6	71	56.7	42.7	1	104.6	78.8	1	152.5	114.9	1	200.5	151.1
12	9.6	7.2	72	57.5	43.3	2	105.4	79.4	2	153.3	115.5	2	201.3	151.7
13	10.4	7.8	73	58.3	43.9	3	106.2	80.	3	154.1	116.2	3	202.1	152.3
14	11.2	8.4	74	59.1	44.5	4	107.	80.6	4	154.9	116.8	4	202.9	152.9
15	12.	9.	75	59.9	45.1	5	107.8	81.2	5	155.7	117.4	5	203.7	153.5
16	12.8	9.6	76	60.7	45.7	6	108.6	81.8	6	156.5	118.	6	204.5	154.1
17	13.6	10.2	77	61.5	46.3	7	109.4	82.4	7	157.3	118.6	7	205.2	154.7
18	14.4	10.8	78	62.3	46.9	8	110.2	83.1	8	158.1	119.2	8	206.	155.3
19	15.2	11.4	79	63.1	47.5	9	111.	83.7	9	158.9	119.8	9	206.8	155.9
20	16.	12.	80	63.9	48.1	140	111.8	84.3	200	159.7	120.4	260	207.6	156.5
21	16.8	12.6	81	64.7	48.7	1	112.6	84.9	1	160.5	121.	1	208.4	157.1
22	17.6	13.2	82	65.5	49.3	2	113.4	85.5	2	161.3	121.6	2	209.2	157.7
23	18.4	13.8	83	66.3	50.	3	114.2	86.1	3	162.1	122.2	3	210.	158.3
24	19.2	14.4	84	67.1	50.6	4	115.	86.7	4	162.9	122.8	4	210.8	158.9
25	20.	15.	85	67.9	51.2	5	115.8	87.3	5	163.7	123.4	5	211.6	159.5
26	20.8	15.6	86	68.7	51.8	6	116.6	87.9	6	164.5	124.	6	212.4	160.1
27	21.6	16.2	87	69.5	52.4	7	117.4	88.5	7	165.3	124.6	7	213.2	160.7
28	22.4	16.9	88	70.3	53.	8	118.2	89.1	8	166.1	125.2	8	214.	161.3
29	23.2	17.5	89	71.1	53.6	9	119.	89.7	9	166.9	125.8	9	214.8	161.9
30	24.	18.1	90	71.9	54.2	150	119.8	90.3	210	167.7	126.4	270	215.6	162.5
31	24.8	18.7	91	72.7	54.8	1	120.6	90.9	1	168.5	127.	1	216.4	163.1
32	25.6	19.3	92	73.5	55.4	2	121.4	91.5	2	169.3	127.6	2	217.2	163.7
33	26.4	19.9	93	74.3	56.	3	122.2	92.1	3	170.1	128.2	3	218.	164.3
34	27.2	20.5	94	75.1	56.6	4	123.	92.7	4	170.9	128.8	4	218.8	164.9
35	28.	21.1	95	75.9	57.2	5	123.8	93.3	5	171.7	129.4	5	219.6	165.5
36	28.8	21.7	96	76.7	57.8	6	124.6	93.9	6	172.5	130.	6	220.4	166.1
37	29.5	22.3	97	77.5	58.4	7	125.4	94.5	7	173.3	130.6	7	221.2	166.7
38	30.3	22.9	98	78.3	59.	8	126.2	95.1	8	174.1	131.2	8	222.	167.3
39	31.1	23.5	99	79.1	59.6	9	127.	95.7	9	174.9	131.8	9	222.8	167.9
40	31.9	24.1	100	79.9	60.2	160	127.8	96.3	220	175.7	132.4	280	223.6	168.5
41	32.7	24.7	1	80.7	60.8	1	128.6	96.9	1	176.5	133.	1	224.4	169.1
42	33.5	25.3	2	81.5	61.4	2	129.4	97.5	2	177.3	133.6	2	225.2	169.7
43	34.3	25.9	3	82.3	62.	3	130.2	98.1	3	178.1	134.2	3	226.	170.3
44	35.1	26.5	4	83.1	62.6	4	131.	98.7	4	178.9	134.8	4	226.8	170.9
45	35.9	27.1	5	83.9	63.2	5	131.8	99.3	5	179.7	135.4	5	227.6	171.5
46	36.7	27.7	6	84.7	63.8	6	132.6	99.9	6	180.5	136.	6	228.4	172.1
47	37.5	28.3	7	85.5	64.4	7	133.4	100.5	7	181.3	136.6	7	229.2	172.7
48	38.3	28.9	8	86.3	65.	8	134.2	101.1	8	182.1	137.2	8	230.	173.3
49	39.1	29.5	9	87.1	65.6	9	135.	101.7	9	182.9	137.8	9	230.8	173.9
50	39.9	30.1	110	87.8	66.2	170	135.8	102.3	230	183.7	138.4	290	231.6	174.5
51	40.7	30.7	1	88.6	66.8	1	136.6	102.9	1	184.5	139.	1	232.4	175.1
52	41.5	31.3	2	89.4	67.4	2	137.4	103.5	2	185.3	139.6	2	233.2	175.7
53	42.3	31.9	3	90.2	68.	3	138.2	104.1	3	186.1	140.2	3	234.	176.3
54	43.1	32.5	4	91.	68.6	4	139.	104.7	4	186.9	140.8	4	234.8	176.9
55	43.9	33.1	5	91.8	69.2	5	139.8	105.3	5	187.7	141.4	5	235.6	177.5
56	44.7	33.7	6	92.6	69.8	6	140.6	105.9	6	188.5	142.	6	236.4	178.1
57	45.5	34.3	7	93.4	70.4	7	141.4	106.5	7	189.3	142.6	7	237.2	178.7
58	46.3	34.9	8	94.2	71.	8	142.2	107.1	8	190.1	143.2	8	238.	179.3
59	47.1	35.5	9	95.	71.6	9	143.	107.7	9	190.9	143.8	9	238.8	179.9
60	47.9	36.1	120	95.8	72.2	180	143.8	108.3	240	191.7	144.4	300	239.6	180.5
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 53°.

Course 38°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.6	61	48.1	37.6	121	95.3	74.5	181	142.6	111.4	241	189.9	148.4
2	1.6	1.2	62	48.9	38.2	2	96.1	75.1	2	143.4	112.1	2	190.7	149.
3	2.4	1.8	63	49.6	38.8	3	96.9	75.7	3	144.2	112.7	3	191.5	149.6
4	3.2	2.5	64	50.4	39.4	4	97.7	76.3	4	145.	113.3	4	192.3	150.2
5	3.9	3.1	65	51.2	40.	5	98.5	77.	5	145.8	113.9	5	193.1	150.8
6	4.7	3.7	66	52.	40.6	6	99.3	77.6	6	146.6	114.5	6	193.9	151.5
7	5.5	4.3	67	52.8	41.2	7	100.1	78.2	7	147.4	115.1	7	194.6	152.1
8	6.3	4.9	68	53.6	41.9	8	100.9	78.8	8	148.1	115.7	8	195.4	152.7
9	7.1	5.5	69	54.4	42.5	9	101.7	79.4	9	148.9	116.4	9	196.2	153.3
10	7.9	6.2	70	55.2	43.1	130	102.4	80.	190	149.7	117.	250	197.	153.9
11	8.7	6.8	71	55.9	43.7	1	103.2	80.7	1	150.5	117.6	1	197.8	154.5
12	9.5	7.4	72	56.7	44.3	2	104.	81.3	2	151.3	118.2	2	198.6	155.1
13	10.2	8.	73	57.5	44.9	3	104.8	81.9	3	152.1	118.8	3	199.4	155.8
14	11.	8.6	74	58.3	45.6	4	105.6	82.5	4	152.9	119.4	4	200.2	156.4
15	11.8	9.2	75	59.1	46.2	5	106.4	83.1	5	153.7	120.1	5	200.9	157.
16	12.6	9.9	76	59.9	46.8	6	107.2	83.7	6	154.5	120.7	6	201.7	157.6
17	13.4	10.5	77	60.7	47.4	7	108.	84.3	7	155.2	121.3	7	202.5	158.2
18	14.2	11.1	78	61.5	48.	8	108.7	85.	8	156.	121.9	8	203.3	158.8
19	15.	11.7	79	62.3	48.6	9	109.5	85.6	9	156.8	122.5	9	204.1	159.5
20	15.8	12.3	80	63.	49.3	140	110.3	86.2	200	157.6	123.1	260	204.9	160.1
21	16.5	12.9	81	63.8	49.9	1	111.1	86.8	1	158.4	123.7	1	205.7	160.7
22	17.3	13.5	82	64.6	50.5	2	111.9	87.4	2	159.2	124.4	2	206.5	161.3
23	18.1	14.2	83	65.4	51.1	3	112.7	88.	3	160.	125.	3	207.2	161.9
24	18.9	14.8	84	66.2	51.7	4	113.5	88.7	4	160.8	125.6	4	208.	162.5
25	19.7	15.4	85	67.	52.3	5	114.3	89.3	5	161.5	126.2	5	208.8	163.2
26	20.5	16.	86	67.8	52.9	6	115.	89.9	6	162.3	126.8	6	209.6	163.8
27	21.3	16.6	87	68.6	53.6	7	115.8	90.5	7	163.1	127.4	7	210.4	164.4
28	22.1	17.2	88	69.3	54.2	8	116.6	91.1	8	163.9	128.1	8	211.2	165.
29	22.9	17.9	89	70.1	54.8	9	117.4	91.7	9	164.7	128.7	9	212.	165.6
30	23.6	18.5	90	70.9	55.4	150	118.2	92.3	210	165.5	129.3	270	212.8	166.2
31	24.4	19.1	91	71.7	56.	1	119.	93.	1	166.3	129.9	1	213.6	166.8
32	25.2	19.7	92	72.5	56.6	2	119.8	93.6	2	167.1	130.5	2	214.3	167.5
33	26.	20.3	93	73.3	57.3	3	120.6	94.2	3	167.8	131.1	3	215.1	168.1
34	26.8	20.9	94	74.1	57.9	4	121.4	94.8	4	168.6	131.8	4	215.9	168.7
35	27.6	21.5	95	74.9	58.5	5	122.1	95.4	5	169.4	132.4	5	216.7	169.3
36	28.4	22.2	96	75.6	59.1	6	122.9	96.	6	170.2	133.	6	217.5	169.9
37	29.2	22.8	97	76.4	59.7	7	123.7	96.7	7	171.	133.6	7	218.3	170.5
38	29.9	23.4	98	77.2	60.3	8	124.5	97.3	8	171.8	134.2	8	219.1	171.2
39	30.7	24.	99	78.	61.	9	125.3	97.9	9	172.6	134.8	9	219.9	171.8
40	31.5	24.6	100	78.8	61.6	160	126.1	98.5	220	173.4	135.4	280	220.6	172.4
41	32.3	25.2	1	79.6	62.2	1	126.9	99.1	1	174.2	136.1	1	221.4	173.
42	33.1	25.9	2	80.4	62.8	2	127.7	99.7	2	174.9	136.7	2	222.2	173.6
43	33.9	26.5	3	81.2	63.4	3	128.4	100.4	3	175.7	137.3	3	223.	174.2
44	34.7	27.1	4	82.	64.	4	129.2	101.	4	176.5	137.9	4	223.8	174.8
45	35.5	27.7	5	82.7	64.6	5	130.	101.6	5	177.3	138.5	5	224.6	175.5
46	36.2	28.3	6	83.5	65.3	6	130.8	102.2	6	178.1	139.1	6	225.4	176.1
47	37.	28.9	7	84.3	65.9	7	131.6	102.8	7	178.9	139.8	7	226.2	176.7
48	37.8	29.6	8	85.1	66.5	8	132.4	103.4	8	179.7	140.4	8	226.9	177.3
49	38.6	30.2	9	85.9	67.1	9	133.2	104.	9	180.5	141.	9	227.7	177.9
50	39.4	30.8	110	86.7	67.7	170	134.	104.7	230	181.2	141.6	290	228.5	178.5
51	40.2	31.4	1	87.5	68.3	1	134.7	105.3	1	182.	142.2	1	229.3	179.2
52	41.	32.	2	88.3	69.	2	135.5	105.9	2	182.8	142.8	2	230.1	179.8
53	41.8	32.6	3	89.	69.6	3	136.3	106.5	3	183.6	143.4	3	230.9	180.4
54	42.6	33.2	4	89.8	70.2	4	137.1	107.1	4	184.4	144.1	4	231.7	181.
55	43.3	33.9	5	90.6	70.8	5	137.9	107.7	5	185.2	144.7	5	232.5	181.6
56	44.1	34.5	6	91.4	71.4	6	138.7	108.4	6	186.	145.3	6	233.3	182.2
57	44.9	35.1	7	92.2	72.	7	139.5	109.	7	186.8	145.9	7	234.	182.9
58	45.7	35.7	8	93.	72.6	8	140.3	109.6	8	187.5	146.5	8	234.8	183.5
59	46.5	36.3	9	93.8	73.3	9	141.1	110.2	9	188.3	147.1	9	235.6	184.1
60	47.3	36.9	120	94.6	73.9	180	141.8	110.8	240	189.1	147.8	300	236.4	184.7
dist.	dep.	d.lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 52°.

Course 39°

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.6	61	47.4	38.4	121	94.	76.1	181	140.7	113.9	241	187.3	151.7
2	1.6	1.3	62	48.2	39.	2	94.8	76.8	2	141.4	114.5	2	188.1	152.3
3	2.3	1.9	63	49.	39.6	3	95.6	77.4	3	142.2	115.2	3	188.8	152.9
4	3.1	2.5	64	49.7	40.3	4	96.4	78.	4	143.	115.8	4	189.6	153.6
5	3.9	3.1	65	50.5	40.9	5	97.1	78.7	5	143.8	116.4	5	190.4	154.2
6	4.7	3.8	66	51.3	41.5	6	97.9	79.3	6	144.5	117.1	6	191.2	154.8
7	5.4	4.4	67	52.1	42.2	7	98.7	79.9	7	145.3	117.7	7	192.	155.4
8	6.2	5.	68	52.8	42.8	8	99.5	80.6	8	146.1	118.3	8	192.7	156.1
9	7.	5.7	69	53.6	43.4	9	100.3	81.2	9	146.9	118.9	9	193.5	156.7
10	7.8	6.3	70	54.4	44.1	130	101.	81.8	190	147.7	119.6	250	194.3	157.3
11	8.5	6.9	71	55.2	44.7	1	101.8	82.4	1	148.4	120.2	1	195.1	158.
12	9.3	7.6	72	56.	45.3	2	102.6	83.1	2	149.2	120.8	2	195.8	158.6
13	10.1	8.2	73	56.7	45.9	3	103.4	83.7	3	150.	121.5	3	196.6	159.2
14	10.9	8.8	74	57.5	46.6	4	104.1	84.3	4	150.8	122.1	4	197.4	159.8
15	11.7	9.4	75	58.3	47.2	5	104.9	85.	5	151.5	122.7	5	198.2	160.5
16	12.4	10.1	76	59.1	47.8	6	105.7	85.6	6	152.3	123.3	6	198.9	161.1
17	13.2	10.7	77	59.8	48.5	7	106.5	86.2	7	153.1	124.	7	199.7	161.7
18	14.	11.3	78	60.6	49.1	8	107.2	86.8	8	153.9	124.6	8	200.5	162.4
19	14.8	12.	79	61.4	49.7	9	108.	87.5	9	154.7	125.2	9	201.3	163.
20	15.5	12.6	80	62.2	50.3	140	108.8	88.1	200	155.4	125.9	260	202.1	163.6
21	16.3	13.2	81	62.9	51.	1	109.6	88.7	1	156.2	126.5	1	202.8	164.3
22	17.1	13.8	82	63.7	51.6	2	110.4	89.4	2	157.	127.1	2	203.6	164.9
23	17.9	14.5	83	64.5	52.2	3	111.1	90.	3	157.8	127.8	3	204.4	165.5
24	18.7	15.1	84	65.3	52.9	4	111.9	90.6	4	158.5	128.4	4	205.2	166.1
25	19.4	15.7	85	66.1	53.5	5	112.7	91.3	5	159.3	129.	5	205.9	166.8
26	20.2	16.4	86	66.8	54.1	6	113.5	91.9	6	160.1	129.6	6	206.7	167.4
27	21.	17.	87	67.6	54.8	7	114.2	92.5	7	160.9	130.3	7	207.5	168.
28	21.8	17.6	88	68.4	55.4	8	115.	93.1	8	161.6	130.9	8	208.3	168.7
29	22.5	18.3	89	69.2	56.	9	115.8	93.8	9	162.4	131.5	9	209.1	169.3
30	23.3	18.9	90	69.9	56.6	150	116.6	94.4	210	163.2	132.2	270	209.8	169.9
31	24.1	19.5	91	70.7	57.3	1	117.3	95.	1	164.	132.8	1	210.6	170.5
32	24.9	20.1	92	71.5	57.9	2	118.1	95.7	2	164.8	133.4	2	211.4	171.2
33	25.6	20.8	93	72.3	58.5	3	118.9	96.3	3	165.5	134.	3	212.2	171.8
34	26.4	21.4	94	73.1	59.2	4	119.7	96.9	4	166.3	134.7	4	212.9	172.4
35	27.2	22.	95	73.8	59.8	5	120.5	97.5	5	167.1	135.3	5	213.7	173.1
36	28.	22.7	96	74.6	60.4	6	121.2	98.2	6	167.9	135.9	6	214.5	173.7
37	28.8	23.3	97	75.4	61.	7	122.	98.8	7	168.6	136.6	7	215.3	174.3
38	29.5	23.9	98	76.2	61.7	8	122.8	99.4	8	169.4	137.2	8	216.	175.
39	30.3	24.5	99	76.9	62.3	9	123.6	100.1	9	170.2	137.8	9	216.8	175.6
40	31.1	25.2	100	77.7	62.9	160	124.3	100.7	220	171.	138.5	280	217.6	176.2
41	31.9	25.8	1	78.5	63.6	1	125.1	101.3	1	171.7	139.1	1	218.4	176.8
42	32.6	26.4	2	79.3	64.2	2	125.9	101.9	2	172.5	139.7	2	219.2	177.5
43	33.4	27.1	3	80.	64.8	3	126.7	102.6	3	173.3	140.3	3	219.9	178.1
44	34.2	27.7	4	80.8	65.4	4	127.5	103.2	4	174.1	141.	4	220.7	178.7
45	35.	28.3	5	81.6	66.1	5	128.2	103.8	5	174.9	141.6	5	221.5	179.4
46	35.7	28.9	6	82.4	66.7	6	129.	104.5	6	175.6	142.2	6	222.3	180.
47	36.5	29.6	7	83.2	67.3	7	129.8	105.1	7	176.4	142.9	7	223.	180.6
48	37.3	30.2	8	83.9	68.	8	130.6	105.7	8	177.2	143.5	8	223.8	181.2
49	38.1	30.8	9	84.7	68.6	9	131.3	106.4	9	178.	144.1	9	224.6	181.9
50	38.9	31.5	110	85.5	69.2	170	132.1	107.	230	178.7	144.7	290	225.4	182.5
51	39.6	32.1	1	86.3	69.9	1	132.9	107.6	1	179.5	145.4	1	226.1	183.1
52	40.4	32.7	2	87.	70.5	2	133.7	108.2	2	180.3	146.	2	226.9	183.8
53	41.2	33.4	3	87.8	71.1	3	134.4	108.9	3	181.1	146.6	3	227.7	184.4
54	42.	34.	4	88.6	71.7	4	135.2	109.5	4	181.9	147.3	4	228.5	185.
55	42.7	34.6	5	89.4	72.4	5	136.	110.1	5	182.6	147.9	5	229.3	185.6
56	43.5	35.2	6	90.1	73.	6	136.8	110.8	6	183.4	148.5	6	230.	186.3
57	44.3	35.9	7	90.9	73.6	7	137.6	111.4	7	184.2	149.1	7	230.8	186.9
58	45.1	36.5	8	91.7	74.3	8	138.3	112.	8	185.	149.8	8	231.6	187.5
59	45.9	37.1	9	92.5	74.9	9	139.1	112.6	9	185.7	150.4	9	232.4	188.2
60	46.6	37.8	120	93.3	75.5	180	139.9	113.3	240	186.5	151.	300	233.1	188.8
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 51°.

Course 40°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.6	61	46.7	39.2	121	92.7	77.8	181	138.7	116.3	241	184.6	154.9
2	1.5	1.3	62	47.5	39.9	2	93.5	78.4	2	139.4	117.	2	185.4	155.6
3	2.3	1.9	63	48.3	40.5	3	94.2	79.1	3	140.2	117.6	3	186.1	156.2
4	3.1	2.6	64	49.	41.1	4	95.	79.7	4	141.	118.3	4	186.9	156.8
5	3.8	3.2	65	49.8	41.8	5	95.8	80.3	5	141.7	118.9	5	187.7	157.5
6	4.6	3.9	66	50.6	42.4	6	96.5	81.	6	142.5	119.6	6	188.4	158.1
7	5.4	4.5	67	51.3	43.1	7	97.3	81.6	7	143.3	120.2	7	189.2	158.8
8	6.1	5.1	68	52.1	43.7	8	98.1	82.3	8	144.	120.8	8	190.	159.4
9	6.9	5.8	69	52.9	44.4	9	98.8	82.9	9	144.8	121.5	9	190.7	160.1
10	7.7	6.4	70	53.6	45.	130	99.6	83.6	190	145.5	122.1	250	191.5	160.7
11	8.4	7.1	71	54.4	45.6	1	100.4	84.3	1	146.3	122.8	1	192.3	161.3
12	9.2	7.7	72	55.2	46.3	2	101.1	84.8	2	147.1	123.4	2	193.	162.
13	10.	8.4	73	55.9	46.9	3	101.9	85.5	3	147.8	124.1	3	193.8	162.6
14	10.7	9.	74	56.7	47.6	4	102.6	86.1	4	148.6	124.7	4	194.6	163.3
15	11.5	9.6	75	57.5	48.2	5	103.4	86.8	5	149.4	125.3	5	195.3	163.9
16	12.3	10.3	76	58.2	48.9	6	104.2	87.4	6	150.1	126.	6	196.1	164.6
17	13.	10.9	77	59.	49.5	7	104.9	88.1	7	150.9	126.6	7	196.9	165.2
18	13.8	11.6	78	59.8	50.1	8	105.7	88.7	8	151.7	127.3	8	197.6	165.8
19	14.6	12.2	79	60.5	50.8	9	106.5	89.3	9	152.4	127.9	9	198.4	166.5
20	15.3	12.9	80	61.3	51.4	140	107.2	90.	200	153.2	128.6	260	199.2	167.1
21	16.1	13.5	81	62.	52.1	1	108.	90.6	1	154.	129.2	1	199.9	167.8
22	16.9	14.1	82	62.8	52.7	2	108.8	91.3	2	154.7	129.8	2	200.7	168.4
23	17.6	14.8	83	63.6	53.4	3	109.5	91.9	3	155.5	130.5	3	201.5	169.1
24	18.4	15.4	84	64.3	54.	4	110.3	92.6	4	156.3	131.1	4	202.2	169.7
25	19.2	16.1	85	65.1	54.6	5	111.1	93.2	5	157.	131.8	5	203.	170.3
26	19.9	16.7	86	65.9	55.3	6	111.8	93.8	6	157.8	132.4	6	203.8	171.
27	20.7	17.4	87	66.6	55.9	7	112.6	94.5	7	158.6	133.1	7	204.5	171.6
28	21.4	18.	88	67.4	56.6	8	113.4	95.1	8	159.3	133.7	8	205.3	172.3
29	22.2	18.6	89	68.2	57.2	9	114.1	95.8	9	160.1	134.3	9	206.1	172.9
30	23.	19.3	90	68.9	57.9	150	114.9	96.4	210	160.9	135.	270	206.8	173.6
31	23.7	19.9	91	69.7	58.5	1	115.7	97.1	1	161.6	135.6	1	207.6	174.2
32	24.5	20.6	92	70.5	59.1	2	116.4	97.7	2	162.4	136.3	2	208.4	174.8
33	25.3	21.2	93	71.2	59.8	3	117.2	98.3	3	163.2	136.9	3	209.1	175.5
34	26.	21.9	94	72.	60.4	4	118.	99.	4	163.9	137.6	4	209.9	176.1
35	26.8	22.5	95	72.8	61.1	5	118.7	99.6	5	164.7	138.2	5	210.7	176.8
36	27.6	23.1	96	73.5	61.7	6	119.5	100.3	6	165.5	138.8	6	211.4	177.4
37	28.3	23.8	97	74.3	62.4	7	120.3	100.9	7	166.2	139.5	7	212.2	178.1
38	29.1	24.4	98	75.1	63.	8	121.	101.6	8	167.	140.1	8	213.	178.7
39	29.9	25.1	99	75.8	63.6	9	121.8	102.2	9	167.8	140.8	9	213.7	179.3
40	30.6	25.7	100	76.6	64.3	160	122.6	102.8	220	168.5	141.4	280	214.5	180.
41	31.4	26.4	1	77.4	64.9	1	123.3	103.5	1	169.3	142.1	1	215.3	180.6
42	32.2	27.	2	78.1	65.6	2	124.1	104.1	2	170.1	142.7	2	216.	181.3
43	32.9	27.6	3	78.9	66.2	3	124.9	104.8	3	170.8	143.3	3	216.8	181.9
44	33.7	28.3	4	79.7	66.8	4	125.6	105.4	4	171.6	144.	4	217.6	182.6
45	34.5	28.9	5	80.4	67.5	5	126.4	106.1	5	172.4	144.6	5	218.3	183.2
46	35.2	29.6	6	81.2	68.1	6	127.2	106.7	6	173.1	145.3	6	219.1	183.8
47	36.	30.2	7	82.	68.8	7	127.9	107.3	7	173.9	145.9	7	219.9	184.5
48	36.8	30.9	8	82.7	69.4	8	128.7	108.	8	174.7	146.6	8	220.6	185.1
49	37.5	31.5	9	83.5	70.1	9	129.5	108.6	9	175.4	147.2	9	221.4	185.8
50	38.3	32.1	110	84.3	70.7	170	130.2	109.3	230	176.2	147.8	290	222.2	186.4
51	39.1	32.8	1	85.	71.3	1	131.	109.9	1	177.	148.5	1	222.9	187.1
52	39.8	33.4	2	85.8	72.	2	131.8	110.6	2	177.7	149.1	2	223.7	187.7
53	40.6	34.1	3	86.6	72.6	3	132.5	111.2	3	178.5	149.8	3	224.5	188.3
54	41.4	34.7	4	87.3	73.3	4	133.3	111.8	4	179.3	150.4	4	225.2	189.
55	42.1	35.4	5	88.1	73.9	5	134.1	112.5	5	180.	151.1	5	226.	189.6
56	42.9	36.	6	88.9	74.6	6	134.8	113.1	6	180.8	151.7	6	226.7	190.3
57	43.7	36.6	7	89.6	75.2	7	135.6	113.8	7	181.6	152.3	7	227.5	190.9
58	44.4	37.3	8	90.4	75.8	8	136.4	114.4	8	182.3	153.	8	228.3	191.6
59	45.2	37.9	9	91.2	76.5	9	137.1	115.1	9	183.1	153.6	9	229.	192.2
60	46.	38.6	120	91.9	77.1	180	137.9	115.7	240	183.9	154.3	300	229.8	192.8
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 50°.

Course 41°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.8	0.7	61	46.	40.	121	91.3	79.4	181	136.6	118.7	241	181.9	158.1
2	1.5	1.3	62	46.8	40.7	2	92.1	80.	2	137.4	119.4	2	182.6	158.8
3	2.3	2.	63	47.5	41.3	3	92.8	80.7	3	138.1	120.1	3	183.4	159.4
4	3.	2.6	64	48.3	42.	4	93.6	81.4	4	138.9	120.7	4	184.1	160.1
5	3.8	3.3	65	49.1	42.6	5	94.3	82.	5	139.6	121.4	5	184.9	160.7
6	4.5	3.9	66	49.8	43.3	6	95.1	82.7	6	140.4	122.	6	185.7	161.4
7	5.3	4.6	67	50.6	44.	7	95.8	83.3	7	141.1	122.7	7	186.4	162.
8	6.	5.2	68	51.3	44.6	8	96.6	84.	8	141.9	123.3	8	187.2	162.7
9	6.8	5.9	69	52.1	45.3	9	97.4	84.6	9	142.6	124.	9	187.9	163.4
10	7.5	6.6	70	52.8	45.9	130	98.1	85.3	190	143.4	124.7	250	188.7	164.
11	8.3	7.2	71	53.6	46.6	1	98.9	85.9	1	144.1	125.3	1	189.4	164.7
12	9.1	7.9	72	54.3	47.2	2	99.6	86.6	2	144.9	126.	2	190.2	165.3
13	9.8	8.5	73	55.1	47.9	3	100.4	87.3	3	145.7	126.6	3	190.9	166.
14	10.6	9.2	74	55.8	48.5	4	101.1	87.9	4	146.4	127.3	4	191.7	166.6
15	11.3	9.8	75	56.6	49.2	5	101.9	88.6	5	147.2	127.9	5	192.5	167.3
16	12.1	10.5	76	57.4	49.9	6	102.6	89.2	6	147.9	128.6	6	193.2	168.
17	12.8	11.2	77	58.1	50.5	7	103.4	89.9	7	148.7	129.2	7	194.	168.6
18	13.6	11.8	78	58.9	51.2	8	104.1	90.5	8	149.4	129.9	8	194.7	169.3
19	14.3	12.5	79	59.6	51.8	9	104.9	91.2	9	150.2	130.6	9	195.5	169.9
20	15.1	13.1	80	60.4	52.5	140	105.7	91.8	200	150.9	131.2	260	196.2	170.6
21	15.8	13.8	81	61.1	53.1	1	106.4	92.5	1	151.7	131.9	1	197.	171.2
22	16.6	14.4	82	61.9	53.8	2	107.2	93.2	2	152.5	132.5	2	197.7	171.9
23	17.4	15.1	83	62.6	54.5	3	107.9	93.8	3	153.2	133.2	3	198.5	172.5
24	18.1	15.7	84	63.4	55.1	4	108.7	94.5	4	154.	133.8	4	199.2	173.2
25	18.9	16.4	85	64.2	55.8	5	109.4	95.1	5	154.7	134.5	5	200.	173.9
26	19.6	17.1	86	64.9	56.4	6	110.2	95.8	6	155.5	135.1	6	200.8	174.5
27	20.4	17.7	87	65.7	57.1	7	110.9	96.4	7	156.2	135.8	7	201.5	175.2
28	21.1	18.4	88	66.4	57.7	8	111.7	97.1	8	157.	136.5	8	202.3	175.8
29	21.9	19.	89	67.2	58.4	9	112.5	97.8	9	157.7	137.1	9	203.	176.5
30	22.6	19.7	90	67.9	59.	150	113.2	98.4	210	158.5	137.8	270	203.8	177.1
31	23.4	20.3	91	68.7	59.7	1	114.	99.1	1	159.2	138.4	1	204.5	177.8
32	24.2	21.	92	69.4	60.4	2	114.7	99.7	2	160.	139.1	2	205.3	178.4
33	24.9	21.6	93	70.2	61.	3	115.5	100.4	3	160.8	139.7	3	206.	179.1
34	25.7	22.3	94	70.9	61.7	4	116.2	101.	4	161.5	140.4	4	206.8	179.8
35	26.4	23.	95	71.7	62.3	5	117.	101.7	5	162.3	141.1	5	207.5	180.4
36	27.2	23.6	96	72.5	63.	6	117.7	102.3	6	163.	141.7	6	208.3	181.1
37	27.9	24.3	97	73.2	63.6	7	118.5	103.	7	163.8	142.4	7	209.1	181.7
38	28.7	24.9	98	74.	64.3	8	119.2	103.7	8	164.5	143.	8	209.8	182.4
39	29.4	25.6	99	74.7	64.9	9	120.	104.3	9	165.3	143.7	9	210.6	183.
40	30.2	26.2	100	75.5	65.6	160	120.8	105.	220	166.	144.3	280	211.3	183.7
41	30.9	26.9	1	76.2	66.3	1	121.5	105.6	1	166.8	145.	1	212.1	184.4
42	31.7	27.6	2	77.	66.9	2	122.3	106.3	2	167.5	145.6	2	212.8	185.
43	32.5	28.2	3	77.7	67.6	3	123.	106.9	3	168.3	146.3	3	213.6	185.7
44	33.2	28.9	4	78.5	68.2	4	123.8	107.6	4	169.1	147.	4	214.3	186.3
45	34.	29.5	5	79.2	68.9	5	124.5	108.2	5	169.8	147.6	5	215.1	187.
46	34.7	30.2	6	80.	69.5	6	125.3	108.9	6	170.6	148.3	6	215.8	187.6
47	35.5	30.8	7	80.8	70.2	7	126.	109.6	7	171.3	148.9	7	216.6	188.3
48	36.2	31.5	8	81.5	70.9	8	126.8	110.2	8	172.1	149.6	8	217.4	188.9
49	37.	32.1	9	82.3	71.5	9	127.5	110.9	9	172.8	150.2	9	218.1	189.6
50	37.7	32.8	110	83.	72.2	170	128.3	111.5	230	173.6	150.9	290	218.9	190.3
51	38.5	33.5	1	83.8	72.8	1	129.1	112.2	1	174.3	151.5	1	219.6	190.9
52	39.2	34.1	2	84.5	73.5	2	129.8	112.8	2	175.1	152.2	2	220.4	191.6
53	40.	34.8	3	85.3	74.1	3	130.6	113.5	3	175.8	152.9	3	221.1	192.2
54	40.8	35.4	4	86.	74.8	4	131.3	114.2	4	176.6	153.5	4	221.9	192.9
55	41.5	36.1	5	86.8	75.4	5	132.1	114.8	5	177.4	154.2	5	222.6	193.5
56	42.3	36.7	6	87.5	76.1	6	132.8	115.5	6	178.1	154.8	6	223.4	194.2
57	43.	37.4	7	88.3	76.8	7	133.6	116.1	7	178.9	155.5	7	224.1	194.8
58	43.8	38.1	8	89.1	77.4	8	134.3	116.8	8	179.6	156.1	8	224.9	195.5
59	44.5	38.7	9	89.8	78.1	9	135.1	117.4	9	180.4	156.8	9	225.7	196.2
60	45.3	39.4	120	90.6	78.7	180	135.8	118.1	240	181.1	157.5	300	226.4	196.8
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 49°.

Course 42°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.7	0.7	61	45.3	40.8	121	89.9	81.	181	134.5	121.1	241	179.1	161.3
2	1.5	1.3	62	46.1	41.5	2	90.7	81.6	2	135.3	121.8	2	179.8	161.9
3	2.2	2.	63	46.8	42.2	3	91.4	82.3	3	136.	122.5	3	180.6	162.6
4	3.	2.7	64	47.6	42.8	4	92.1	83.	4	136.7	123.1	4	181.3	163.3
5	3.7	3.3	65	48.3	43.5	5	92.9	83.6	5	137.5	123.8	5	182.1	163.9
6	4.5	4.	66	49.	44.2	6	93.6	84.3	6	138.2	124.5	6	182.8	164.6
7	5.2	4.7	67	49.8	44.8	7	94.4	85.	7	139.	125.1	7	183.6	165.3
8	5.9	5.4	68	50.5	45.5	8	95.1	85.6	8	139.7	125.8	8	184.3	165.9
9	6.7	6.	69	51.3	46.2	9	95.9	86.3	9	140.5	126.5	9	185.	166.6
10	7.4	6.7	70	52.	46.8	130	96.6	87.	190	141.2	127.1	250	185.8	167.3
11	8.2	7.4	71	52.8	47.5	1	97.4	87.7	1	141.9	127.8	1	186.5	168.
12	8.9	8.	72	53.5	48.2	2	98.1	88.3	2	142.7	128.5	2	187.3	168.6
13	9.7	8.7	73	54.2	48.8	3	98.8	89.	3	143.4	129.1	3	188.	169.3
14	10.4	9.4	74	55.	49.5	4	99.6	89.7	4	144.2	129.8	4	188.8	170.
15	11.1	10.	75	55.7	50.2	5	100.3	90.3	5	144.9	130.5	5	189.5	170.6
16	11.9	10.7	76	56.5	50.9	6	101.1	91.	6	145.7	131.1	6	190.2	171.3
17	12.6	11.4	77	57.2	51.5	7	101.8	91.7	7	146.4	131.8	7	191.	172.
18	13.4	12.	78	58.	52.2	8	102.6	92.3	8	147.1	132.5	8	191.7	172.6
19	14.1	12.7	79	58.7	52.9	9	103.3	93.	9	147.9	133.2	9	192.5	173.3
20	14.9	13.4	80	59.5	53.5	140	104.	93.7	200	148.6	133.8	260	193.2	174.
21	15.6	14.1	81	60.2	54.2	1	104.8	94.3	1	149.4	134.5	1	194.	174.6
22	16.3	14.7	82	60.9	54.9	2	105.5	95.	2	150.1	135.2	2	194.7	175.3
23	17.1	15.4	83	61.7	55.5	3	106.3	95.7	3	150.9	135.8	3	195.4	176.
24	17.8	16.1	84	62.4	56.2	4	107.	96.4	4	151.6	136.5	4	196.2	176.7
25	18.6	16.7	85	63.2	56.9	5	107.8	97.	5	152.3	137.2	5	196.9	177.3
26	19.3	17.4	86	63.9	57.5	6	108.5	97.7	6	153.1	137.8	6	197.7	178.
27	20.1	18.1	87	64.7	58.2	7	109.2	98.4	7	153.8	138.5	7	198.4	178.7
28	20.8	18.7	88	65.4	58.9	8	110.	99.	8	154.6	139.2	8	199.2	179.3
29	21.6	19.4	89	66.1	59.6	9	110.7	99.7	9	155.3	139.8	9	199.9	180.
30	22.3	20.1	90	66.9	60.2	150	111.5	100.4	210	156.1	140.5	270	200.6	180.7
31	23.	20.7	91	67.6	60.9	1	112.2	101.	1	156.8	141.2	1	201.4	181.3
32	23.8	21.4	92	68.4	61.6	2	113.	101.7	2	157.5	141.9	2	202.1	182.
33	24.5	22.1	93	69.1	62.2	3	113.7	102.4	3	158.3	142.5	3	202.9	182.7
34	25.3	22.8	94	69.9	62.9	4	114.4	103.	4	159.	143.2	4	203.6	183.3
35	26.	23.4	95	70.6	63.6	5	115.2	103.7	5	159.8	143.9	5	204.4	184.
36	26.8	24.1	96	71.3	64.2	6	115.9	104.4	6	160.5	144.5	6	205.1	184.7
37	27.5	24.8	97	72.1	64.9	7	116.7	105.1	7	161.3	145.2	7	205.9	185.3
38	28.2	25.4	98	72.8	65.6	8	117.4	105.7	8	162.	145.9	8	206.6	186.
39	29.	26.1	99	73.6	66.2	9	118.2	106.4	9	162.7	146.5	9	207.3	186.7
40	29.7	26.8	100	74.3	66.9	160	118.9	107.1	220	163.5	147.2	280	208.1	187.4
41	30.5	27.4	1	75.1	67.6	1	119.6	107.7	1	164.2	147.9	1	208.8	188.
42	31.2	28.1	2	75.8	68.3	2	120.4	108.4	2	165.	148.5	2	209.6	188.7
43	32.	28.8	3	76.5	68.9	3	121.1	109.1	3	165.7	149.2	3	210.3	189.4
44	32.7	29.4	4	77.3	69.6	4	121.9	109.7	4	166.5	149.9	4	211.1	190.
45	33.4	30.1	5	78.	70.3	5	122.6	110.4	5	167.2	150.6	5	211.8	190.7
46	34.2	30.8	6	78.8	70.9	6	123.4	111.1	6	168.	151.2	6	212.5	191.4
47	34.9	31.4	7	79.5	71.6	7	124.1	111.7	7	168.7	151.9	7	213.3	192.
48	35.7	32.1	8	80.3	72.3	8	124.8	112.4	8	169.4	152.6	8	214.	192.7
49	36.4	32.8	9	81.	72.9	9	125.6	113.1	9	170.2	153.2	9	214.8	193.4
50	37.2	33.5	110	81.7	73.6	170	126.3	113.8	230	170.9	153.9	290	215.5	194.
51	37.9	34.1	1	82.5	74.3	1	127.1	114.4	1	171.7	154.6	1	216.3	194.7
52	38.6	34.8	2	83.2	74.9	2	127.8	115.1	2	172.4	155.2	2	217.	195.4
53	39.4	35.5	3	84.	75.6	3	128.6	115.8	3	173.2	155.9	3	217.7	196.1
54	40.1	36.1	4	84.7	76.3	4	129.3	116.4	4	173.9	156.6	4	218.5	196.7
55	40.9	36.8	5	85.5	77.	5	130.1	117.1	5	174.6	157.2	5	219.2	197.4
56	41.6	37.5	6	86.2	77.6	6	130.8	117.8	6	175.4	157.9	6	220.	198.1
57	42.4	38.1	7	86.9	78.3	7	131.5	118.4	7	176.1	158.6	7	220.7	198.7
58	43.1	38.8	8	87.7	79.	8	132.3	119.1	8	176.9	159.3	8	221.5	199.4
59	43.8	39.5	9	88.4	79.6	9	133.	119.8	9	177.6	159.9	9	222.2	200.1
60	44.6	40.1	120	89.2	80.3	180	133.8	120.4	240	178.4	160.6	300	222.9	200.7
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 48°.

Course 43°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.7	0.7	61	44.6	41.6	121	88.5	82.5	181	132.4	123.4	241	176.3	164.4
2	1.5	1.4	62	45.3	42.3	2	89.2	83.2	2	133.1	124.1	2	177.	165.
3	2.2	2.	63	46.1	43.	3	90.	83.9	3	133.8	124.8	3	177.7	165.7
4	2.9	2.7	64	46.8	43.6	4	90.7	84.6	4	134.6	125.5	4	178.5	166.4
5	3.7	3.4	65	47.5	44.3	5	91.4	85.2	5	135.3	126.2	5	179.2	167.1
6	4.4	4.1	66	48.3	45.	6	92.2	85.9	6	136.	126.9	6	179.9	167.8
7	5.1	4.8	67	49.	45.7	7	92.9	86.6	7	136.8	127.5	7	180.6	168.5
8	5.9	5.5	68	49.7	46.4	8	93.6	87.3	8	137.5	128.2	8	181.4	169.1
9	6.6	6.1	69	50.5	47.1	9	94.3	88.	9	138.2	128.9	9	182.1	169.8
10	7.3	6.8	70	51.2	47.7	130	95.1	88.7	190	139.	129.6	250	182.8	170.5
11	8.	7.5	71	51.9	48.4	1	95.8	89.3	1	139.7	130.3	1	183.6	171.2
12	8.8	8.2	72	52.7	49.1	2	96.5	90.	2	140.4	130.9	2	184.3	171.9
13	9.5	8.9	73	53.4	49.8	3	97.3	90.7	3	141.2	131.6	3	185.	172.5
14	10.2	9.5	74	54.1	50.5	4	98.	91.4	4	141.9	132.3	4	185.8	173.2
15	11.	10.2	75	54.9	51.1	5	98.7	92.1	5	142.6	133.	5	186.5	173.9
16	11.7	10.9	76	55.6	51.8	6	99.5	92.8	6	143.3	133.7	6	187.2	174.6
17	12.4	11.6	77	56.3	52.5	7	100.2	93.4	7	144.1	134.4	7	188.	175.3
18	13.2	12-3	78	57.	53.2	8	100.9	94.1	8	144.8	135.	8	188.7	176.
19	13.9	13.	79	57.8	53.9	9	101.7	94.8	9	145.5	135.7	9	189.4	176.6
20	14.6	13.6	80	58.5	54.6	140	102.4	95.5	200	146.3	136.4	260	190.2	177.3
21	15.4	14.3	81	59.2	55.2	1	103.1	96.2	1	147.	137.1	1	190.9	178.
22	16.1	15	82	60.	55.9	2	103.9	96.8	2	147.7	137.8	2	191.6	178.7
23	16.8	15.7	83	00.7	56.6	3	104.6	97.5	3	148.5	138.4	3	192.3	179.4
24	17.6	16.4	84	61 4	57.3	4	105.3	98.2	4	149.2	139.1	4	193.1	180.
25	18.3	17.	85	62.2	58.	5	106.	98 9	5	149.9	139.8	5	193.8	180.7
26	19.	17.7	86	62.9	58.7	6	106.8	99.6	6	150.7	140.5	6	194.5	181.4
27	19.7	18.4	87	63.6	59.3	7	107.5	100.3	7	151.4	141.2	7	195.3	182.1
28	20.5	19.1	88	64.4	60.	8	108.2	100.9	8	152.1	141.9	8	196.	182.8
29	21.2	19.8	89	65.1	60.7	9	109.	101.6	9	152.9	142.5	9	196.7	183.5
30	21.9	20.5	90	65.8	61.4	150	109.7	102.3	210	153.6	143.2	270	197.5	184.1
31	22.7	21.1	91	66.6	62.1	1	110.4	103.	1	154.3	143.9	1	198.2	184.8
32	23.4	21.8	92	67.3	62.7	2	111.2	103.7	2	155.	144.6	2	198.9	185.5
33	24.1	22.5	93	68.	63.4	3	111.9	104.3	3	155.8	145.3	3	199.7	186.2
34	24.9	23.2	94	68.7	64.1	4	112.6	105.	4	156.5	145.9	4	200.4	186.9
35	25.6	23.9	95	69.5	64.8	5	113.4	105.7	5	157.2	146.6	5	201.1	187.5
36	26.3	24.6	96	70.2	65.5	6	114.1	106.4	6	158.	147.3	6	201.9	188.2
37	27.1	25.2	97	70.9	66.2	7	114.8	107.1	7	158.7	148.	7	202.6	188.9
38	27.8	25.9	98	71.7	66.8	8	115.6	107.8	8	159.4	148.7	8	203.3	189.6
39	28.5	26.6	99	72.4	67.5	9	116.3	108.4	9	160.2	149.4	9	204.	190.3
40	29.3	27.3	100	73.1	68.2	160	117.	109.1	220	160.9	150.	280	204.8	191.
41	30.	28.	1	73.9	68.9	1	117.7	109.8	1	161.6	150.7	1	205.5	191.6
42	30.7	28.6	2	74.6	69.6	2	118.5	110.5	2	162.4	151.4	2	206.2	192.3
43	31.4	29.3	3	75.3	70.2	3	119.2	111.2	3	163.1	152.1	3	207.	193.
44	32.2	30.	4	76.1	70.9	4	119.9	111.8	4	163.8	152.8	4	207.7	193.7
45	32.9	30.7	5	76.8	71.6	5	120.7	112.5	5	164.6	153.4	5	208.4	194.4
46	33.6	31.4	6	77.5	72.3	6	121.4	113.2	6	165.3	154.1	6	209.2	195.1
47	34.4	32.1	7	78.3	73.	7	122.1	113.9	7	166.	154.8	7	209.9	195.7
48	35.1	32.7	8	79.	73.7	8	122.9	114 6	8	166.7	155.5	8	210.6	196.4
49	35.8	33.4	9	79.7	74.3	9	123.6	115.3	9	167.5	156.2	9	211.4	197.1
50	36.6	34.1	110	80.4	75.	170	124.3	115.9	230	168.2	156.9	290	212.1	197.8
51	37.3	34.8	1	81.2	75.7	1	125.1	116.6	1	168.9	157.5	1	212.8	198.5
52	38.	35.5	2	81.9	76.4	2	125.8	117.3	2	169.7	158.2	2	213.6	199.1
53	38.8	36.1	3	82.6	77.1	3	126.5	118.	3	170.4	158.9	3	214.3	199.8
54	39.5	36.8	4	83.4	77.7	4	127.3	118.7	4	171.1	159.6	4	215.	200.5
55	40.2	37.5	5	84.1	78.4	5	128.	119.3	5	171.9	160.3	5	215.7	201.2
56	41.	38.2	6	84.8	79.1	6	128.7	120.	6	172.6	161.	6	216.5	201.9
57	41.7	38.9	7	85.6	79.8	7	129.4	120.7	7	173.3	161.6	7	217.2	202.6
58	42.4	39.6	8	86.3	80.5	8	130.2	121.4	8	174.1	162.3	8	217.9	203.2
59	43.1	40.2	9	87.	81.2	9	130.9	122.1	9	174.8	163.	9	218.7	203.9
60	43.9	40.9	120	87.8	81.8	180	131.6	122.8	240	175.5	163.7	300	219.4	204.6
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude

Course 47°.

Course 44°.

Distance, Diff. Latitude and Departure.

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.7	0.7	61	43.9	42.4	121	87.	84.1	181	130.2	125.7	241	173.4	167.4
2	1.4	1.4	62	44.6	43.1	2	87.8	84.7	2	130.9	126.4	2	174.1	168.1
3	2.2	2.1	63	45.3	43.8	3	88.5	85.4	3	131.6	127.1	3	174.8	168.8
4	2.9	2.8	64	46.	44.5	4	89.2	86.1	4	132.4	127.8	4	175.5	169.5
5	3.6	3.5	65	46.8	45.2	5	89.9	86.8	5	133.1	128.5	5	176.2	170.2
6	4.3	4.2	66	47.5	45.8	6	90.6	87.5	6	133.8	129.2	6	177.	170.9
7	5.	4.9	67	48.2	46.5	7	91.4	88.2	7	134.5	129.9	7	177.7	171.6
8	5.8	5.6	68	48.9	47.2	8	92.1	88.9	8	135.2	130.6	8	178.4	172.3
9	6.5	6.3	69	49.6	47.9	9	92.8	89.6	9	136.	131.3	9	179.1	173.
10	7.2	6.9	70	50.4	48.6	130	93.5	90.3	190	136.7	132.	250	179.8	173.7
11	7.9	7.6	71	51.1	49.3	1	94.2	91.	1	137.4	132.7	1	180.6	174.4
12	8.6	8.3	72	51.8	50.	2	95.	91.7	2	138.1	133.4	2	181.3	175.1
13	9.4	9.	73	52.5	50.7	3	95.7	92.4	3	138.8	134.1	3	182.	175.7
14	10.1	9.7	74	53.2	51.4	4	96.4	93.1	4	139.6	134.8	4	182.7	176.4
15	10.8	10.4	75	54.	52.1	5	97.1	93.8	5	140.3	135.5	5	183.4	177.1
16	11.5	11.1	76	54.7	52.8	6	97.8	94.5	6	141.	136.2	6	184.2	177.8
17	12.2	11.8	77	55.4	53.5	7	98.5	95.2	7	141.7	136.8	7	184.9	178.5
18	12.9	12.5	78	56.1	54.2	8	99.3	95.9	8	142.4	137.5	8	185.6	179.2
19	13.7	13.2	79	56.8	54.9	9	100.	96.6	9	143.1	138.2	9	186.3	179.9
20	14.4	13.9	80	57.5	55.6	140	100.7	97.3	200	143.9	138.9	260	187.	180.6
21	15.1	14.6	81	58.3	56.3	1	101.4	97.9	1	144.6	139.6	1	187.7	181.3
22	15.8	15.3	82	59.	57.	2	102.1	98.6	2	145.3	140.3	2	188.5	182.
23	16.5	16.	83	59.7	57.7	3	102.9	99.3	3	146.	141.	3	189.2	182.7
24	17.3	16.7	84	60.4	58.4	4	103.6	100.	4	146.7	141.7	4	189.9	183.4
25	18.	17.4	85	61.1	59.	5	104.3	100.7	5	147.5	142.4	5	190.6	184.1
26	18.7	18.1	86	61.9	59.7	6	105.	101.4	6	148.2	143.1	6	191.3	184.8
27	19.4	18.8	87	62.6	60.4	7	105.7	102.1	7	148.9	143.8	7	192.1	185.5
28	20.1	19.5	88	63.3	61.1	8	106.5	102.8	8	149.6	144.5	8	192.8	186.2
29	20.9	20.1	89	64.	61.8	9	107.2	103.5	9	150.3	145.2	9	193.5	186.9
30	21.6	20.8	90	64.7	62.5	150	107.9	104.2	210	151.1	145.9	270	194.2	187.6
31	22.3	21.5	91	65.5	63.2	1	108.6	104.9	1	151.8	146.6	1	194.9	188.3
32	23.	22.2	92	66.2	63.9	2	109.3	105.6	2	152.5	147.3	2	195.7	188.9
33	23.7	22.9	93	66.9	64.6	3	110.1	106.3	3	153.2	148.	3	196.4	189.6
34	24.5	23.6	94	67.6	65.3	4	110.8	107.	4	153.9	148.7	4	197.1	190.3
35	25.2	24.3	95	68.3	66.	5	111.5	107.7	5	154.7	149.4	5	197.8	191.
36	25.9	25.	96	69.1	66.7	6	112.2	108.4	6	155.4	150.	6	198.5	191.7
37	26.6	25.7	97	69.8	67.4	7	112.9	109.1	7	156.1	150.7	7	199.3	192.4
38	27.3	26.4	98	70.5	68.1	8	113.7	109.8	8	156.8	151.4	8	200.	193.1
39	28.1	27.1	99	71.2	68.8	9	114.4	110.5	9	157.5	152.1	9	200.7	193.8
40	28.8	27.8	100	71.9	69.5	160	115.1	111.1	220	158.3	152.8	280	201.4	194.5
41	29.5	28.5	1	72.7	70.2	1	115.8	111.8	1	159.	153.5	1	202.1	195.2
42	30.2	29.2	2	73.4	70.9	2	116.5	112.5	2	159.7	154.2	2	202.9	195.9
43	30.9	29.9	3	74.1	71.5	3	117.3	113.2	3	160.4	154.9	3	203.6	196.6
44	31.7	30.6	4	74.8	72.2	4	118.	113.9	4	161.1	155.6	4	204.3	197.3
45	32.4	31.3	5	75.5	72.9	5	118.7	114.6	5	161.9	156.3	5	205.	198
46	33.1	32.	6	76.3	73.6	6	119.4	115.3	6	162.6	157.	6	205.7	198.7
47	33.8	32.6	7	77.	74.3	7	120.1	116.	7	163.3	157.7	7	206.5	199.4
48	34.5	33.3	8	77.7	75.	8	120.8	116.7	8	164.	158.4	8	207.2	200.1
49	35.2	34.	9	78.4	75.7	9	121.6	117.4	9	164.7	159.1	9	207.9	200.8
50	36.	34.7	110	79.1	76.4	170	122.3	118.1	230	165.4	159.8	290	208.6	201.5
51	36.7	35.4	1	79.8	77.1	1	123.	118.8	1	166.2	160.5	1	209.3	202.1
52	37.4	36.1	2	80.6	77.8	2	123.7	119.5	2	166.9	161.2	2	210.	202.8
53	38.1	36.8	3	81.3	78.5	3	124.4	120.2	3	167.6	161.9	3	210.8	203.5
54	38.8	37.5	4	82.	79.2	4	125.2	120.9	4	168.3	162.6	4	211.5	204.2
55	39.6	38.2	5	82.7	79.9	5	125.9	121.6	5	169.	163.2	5	212.2	204.9
56	40.3	38.9	6	83.4	80.6	6	126.6	122.3	6	169.8	163.9	6	212.9	205.6
57	41.	39.6	7	84.2	81.3	7	127.3	123.	7	170.5	164.6	7	213.6	206.3
58	41.7	40.3	8	84.9	82.	8	128.	123.6	8	171.2	165.3	8	214.4	207.
59	42.4	41.	9	85.6	82.7	9	128.8	124.3	9	171.9	166.	9	215.1	207.7
60	43.2	41.7	120	86.3	83.4	180	129.5	125.	240	172.6	166.7	300	215.8	208.4
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 46°.

Course 45°.

Distance, Diff. Latitude and Departure

dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.	dist.	d. lat.	dep.
1	0.7	0.7	61	43.1	43.1	121	85.6	85.6	181	128.	128.	241	170.4	170.4
2	1.4	1.4	62	43.8	43.8	2	86.3	86.3	2	128.7	128.7	2	171.1	171.1
3	2.1	2.1	63	44.5	44.5	3	87.	87.	3	129.4	129.4	3	171.8	171.8
4	2.8	2.8	64	45.3	45.3	4	87.7	87.7	4	130.1	130.1	4	172.5	172.5
5	3.5	3.5	65	46.	46.	5	88.4	88.4	5	130.8	130.8	5	173.2	173.2
6	4.2	4.2	66	46.7	46.7	6	89.1	89.1	6	131.5	131.5	6	173.9	173.9
7	4.9	4.9	67	47.4	47.4	7	89.8	89.8	7	132.2	132.2	7	174.7	174.7
8	5.7	5.7	68	48.1	48.1	8	90.5	90.5	8	132.9	132.9	8	175.4	175.4
9	6.4	6.4	69	48.8	48.8	9	91.2	91.2	9	133.6	133.6	9	176.1	176.1
10	7.1	7.1	70	49.5	49.5	130	91.9	91.9	190	134.4	134.4	250	176.8	176.8
11	7.8	7.8	71	50.2	50.2	1	92.6	92.6	1	135.1	135.1	1	177.5	177.5
12	8.5	8.5	72	50.9	50.9	2	93.3	93.3	2	135.8	135.8	2	178.2	178.2
13	9.2	9.2	73	51.6	51.6	3	94.	94.	3	136.5	136.5	3	178.9	178.9
14	9.9	9.9	74	52.3	52.3	4	94.8	94.8	4	137.2	137.2	4	179.6	179.6
15	10.6	10.6	75	53.	53.	5	95.5	95.5	5	137.9	137.9	5	180.3	180.3
16	11.3	11.3	76	53.7	53.7	6	96.2	96.2	6	138.6	138.6	6	181.	181.
17	12.	12.	77	54.4	54.4	7	96.9	96.9	7	139.3	139.3	7	181.7	181.7
18	12.7	12.7	78	55.2	55.2	8	97.6	97.6	8	140.	140.	8	182.4	182.4
19	13.4	13.4	79	55.9	55.9	9	98.3	98.3	9	140.7	140.7	9	183.1	183.1
20	14.1	14.1	80	56.6	56.6	140	99.	99.	200	141.4	141.4	260	183.8	183.8
21	14.8	14.8	81	57.3	57.3	1	99.7	99.7	1	142.1	142.1	1	184.6	184.6
22	15.6	15.6	82	58.	58.	2	100.4	100.4	2	142.8	142.8	2	185.3	185.3
23	16.3	16.3	83	58.7	58.7	3	101.1	101.1	3	143.5	143.5	3	186.	186.
24	17.	17.	84	59.4	59.4	4	101.8	101.8	4	144.2	144.2	4	186.7	186.7
25	17.7	17.7	85	60.1	60.1	5	102.5	102.5	5	145.	145.	5	187.4	187.4
26	18.4	18.4	86	60.8	60.8	6	103.2	103.2	6	145.7	145.7	6	188.1	188.1
27	19.1	19.1	87	61.5	61.5	7	103.9	103.9	7	146.4	146.4	7	188.8	188.8
28	19.8	19.8	88	62.2	62.2	8	104.7	104.7	8	147.1	147.1	8	189.5	189.5
29	20.5	20.5	89	62.9	62.9	9	105.4	105.4	9	147.8	147.8	9	190.2	190.2
30	21.2	21.2	90	63.6	63.6	150	106.1	106.1	210	148.5	148.5	270	190.9	190.9
31	21.9	21.9	91	64.3	64.3	1	106.8	106.8	1	149.2	149.2	1	191.6	191.6
32	22.6	22.6	92	65.1	65.1	2	107.5	107.5	2	149.9	149.9	2	192.3	192.3
33	23.3	23.3	93	65.8	65.8	3	108.2	108.2	3	150.6	150.6	3	193.	193.
34	24.	24.	94	66.5	66.5	4	108.9	108.9	4	151.3	151.3	4	193.7	193.7
35	24.7	24.7	95	67.2	67.2	5	109.6	109.6	5	152.	152.	5	194.5	194.5
36	25.5	25.5	96	67.9	67.9	6	110.3	110.3	6	152.7	152.7	6	195.2	195.2
37	26.2	26.2	97	68.6	68.6	7	111.	111.	7	153.4	153.4	7	195.9	195.9
38	26.9	26.9	98	69.3	69.3	8	111.7	111.7	8	154.1	154.1	8	196.6	196.6
39	27.6	27.6	99	70.	70.	9	112.4	112.4	9	154.9	154.9	9	197.3	197.3
40	28.3	28.3	100	70.7	70.7	160	113.1	113.1	220	155.6	155.6	280	198.	198.
41	29.	29.	1	71.4	71.4	1	113.8	113.8	1	156.3	156.3	1	198.7	198.7
42	29.7	29.7	2	72.1	72.1	2	114.6	114.6	2	157.	157.	2	199.4	199.4
43	30.4	30.4	3	72.8	72.8	3	115.3	115.3	3	157.7	157.7	3	200.1	200.1
44	31.1	31.1	4	73.5	73.5	4	116.	116.	4	158.4	158.4	4	200.8	200.8
45	31.8	31.8	5	74.2	74.2	5	116.7	116.7	5	159.1	159.1	5	201.5	201.5
46	32.5	32.5	6	75.	75.	6	117.4	117.4	6	159.8	159.8	6	202.2	202.2
47	33.2	33.2	7	75.7	75.7	7	118.1	118.1	7	160.5	160.5	7	202.9	202.9
48	33.9	33.9	8	76.4	76.4	8	118.8	118.8	8	161.2	161.2	8	203.6	203.6
49	34.6	34.6	9	77.1	77.1	9	119.5	119.5	9	161.9	161.9	9	204.4	204.4
50	35.4	35.4	110	77.8	77.8	170	120.2	120.2	230	162.6	162.6	290	205.1	205.1
51	36.1	36.1	1	78.5	78.5	1	120.9	120.9	1	163.3	163.3	1	205.8	205.8
52	36.8	36.8	2	79.2	79.2	2	121.6	121.6	2	164.	164.	2	206.5	206.5
53	37.5	37.5	3	79.9	79.9	3	122.3	122.3	3	164.8	164.8	3	207.2	207.2
54	38.2	38.2	4	80.6	80.6	4	123.	123.	4	165.5	165.5	4	207.9	207.9
55	38.9	38.9	5	81.3	81.3	5	123.7	123.7	5	166.2	166.2	5	208.6	208.6
56	39.6	39.6	6	82.	82.	6	124.5	124.5	6	166.9	166.9	6	209.3	209.3
57	40.3	40.3	7	82.7	82.7	7	125.2	125.2	7	167.6	167.6	7	210.	210.
58	41.	41.	8	83.4	83.4	8	125.9	125.9	8	168.3	168.3	8	210.7	210.7
59	41.7	41.7	9	84.1	84.1	9	126.6	126.6	9	169.	169.	9	211.4	211.4
60	42.4	42.4	120	84.9	84.9	180	127.3	127.3	240	169.7	169.7	300	212.1	212.1
dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.	dist.	dep.	d. lat.

Distance, Departure and Diff. Latitude.

Course 45°.

TABLE VI.

MERIDIONAL PARTS.

Meridional Parts.

′	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	′
0	0	60	120	180	240	300	361	421	482	542	603	664	725	787	848	0
1	1	61	21	81	41	01	62	22	83	43	04	65	26	88	50	1
2	2	62	22	82	42	02	63	23	84	44	05	66	27	89	51	2
3	3	63	23	83	43	03	64	24	85	45	06	67	28	90	52	3
4	4	64	24	84	44	04	65	25	86	46	07	68	29	91	53	4
5	5	65	25	85	45	05	66	26	87	47	08	69	30	92	54	5
6	6	66	26	86	46	06	67	27	88	48	09	70	31	93	55	6
7	7	67	27	87	47	07	68	28	89	49	10	71	32	94	56	7
8	8	68	28	88	48	08	69	29	90	50	11	72	33	95	57	8
9	9	69	29	89	49	09	70	30	91	51	12	73	35	96	58	9
10	10	70	30	90	50	10	71	31	92	52	13	74	36	97	59	10
11	11	71	31	91	51	11	72	32	93	53	14	75	37	98	60	11
12	12	72	32	92	52	12	73	33	94	54	15	76	38	99	61	12
13	13	73	33	93	53	13	74	34	95	55	16	77	39	800	62	13
14	14	74	34	94	54	14	75	35	96	56	17	78	40	01	63	14
15	15	75	35	95	55	15	76	36	97	57	18	79	41	02	64	15
16	16	76	36	96	56	16	77	37	98	58	19	80	42	03	65	16
17	17	77	37	97	57	17	78	38	99	59	20	81	43	04	66	17
18	18	78	38	98	58	18	79	39	500	60	21	82	44	05	67	18
19	19	79	39	99	59	19	80	40	01	61	22	83	45	06	68	19
20	20	80	40	200	60	20	81	41	02	62	23	84	46	07	69	20
21	21	81	41	01	61	21	82	42	03	63	24	85	47	08	70	21
22	22	82	42	02	62	22	83	43	04	65	25	86	48	09	71	22
23	23	83	43	03	63	23	84	44	05	66	26	88	49	10	72	23
24	24	84	44	04	64	24	85	45	06	67	27	89	50	11	73	24
25	25	85	45	05	65	25	86	46	07	68	28	90	51	12	74	25
26	26	86	46	06	66	26	87	47	08	69	29	91	52	13	75	26
27	27	87	47	07	67	27	88	48	09	70	31	92	53	14	76	27
28	28	88	48	08	68	28	89	49	10	71	32	93	54	16	77	28
29	29	89	49	09	69	29	90	50	11	72	33	94	55	17	78	29
30	30	90	50	10	70	30	91	51	12	73	34	95	56	18	79	30
31	31	91	51	11	71	32	92	52	13	74	35	96	57	19	80	31
32	32	92	52	12	72	33	93	53	14	75	36	97	58	20	82	32
33	33	93	53	13	73	34	94	54	15	76	37	98	59	21	83	33
34	34	94	54	14	74	35	95	55	16	77	38	99	60	22	84	34
35	35	95	55	15	75	36	96	56	17	78	39	700	61	23	85	35
36	36	96	56	16	76	37	97	57	18	79	40	01	62	24	86	36
37	37	97	57	17	77	38	98	58	19	80	41	02	63	25	87	37
38	38	98	58	18	78	39	99	59	20	81	42	03	64	26	88	38
39	39	99	59	19	79	40	400	60	21	82	43	04	65	27	89	39
40	40	100	60	20	80	41	01	61	22	83	44	05	66	28	90	40
41	41	01	61	21	81	42	02	62	23	84	45	06	67	29	91	41
42	42	02	62	22	82	43	03	63	24	85	46	07	68	30	92	42
43	43	03	63	23	83	44	04	64	25	86	47	08	69	31	93	43
44	44	04	64	24	84	45	05	65	26	87	48	09	70	32	94	44
45	45	05	65	25	85	46	06	66	27	88	49	10	71	33	95	45
46	46	06	66	26	86	47	07	67	28	89	50	11	72	34	96	46
47	47	07	67	27	87	48	08	68	29	90	51	12	73	35	97	47
48	48	08	68	28	88	49	09	69	30	91	52	13	74	36	98	48
49	49	09	69	29	89	50	10	70	31	92	53	14	75	37	99	49
50	50	10	70	30	90	51	11	71	32	93	54	15	76	38	900	50
51	51	11	71	31	91	52	12	72	33	94	55	16	78	39	01	51
52	52	12	72	32	92	53	13	73	34	95	56	17	79	40	02	52
53	53	13	73	33	93	54	14	74	35	96	57	18	80	41	03	53
54	54	14	74	34	94	55	15	75	36	97	58	19	81	42	04	54
55	55	15	75	35	95	56	16	77	37	98	59	20	82	43	05	55
56	56	16	76	36	96	57	17	78	38	99	60	21	83	44	06	56
57	57	17	77	37	97	58	18	79	39	600	61	22	84	45	07	57
58	58	18	78	38	98	59	19	80	40	01	62	23	85	46	08	58
59	59	119	179	239	299	360	420	481	541	02	663	724	786	847	909	59
′	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	′

Meridional Parts.

'	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	'
0	910	973	1035	1098	1161	1225	1289	1354	1419	1484	1550	1616	1684	1751	0
1	11	74	36	99	63	26	90	55	20	85	51	18	85	52	1
2	12	75	37	1100	64	27	91	56	21	86	52	19	86	53	2
3	14	76	38	01	65	28	92	57	22	87	53	20	87	55	3
4	15	77	39	02	66	29	93	58	23	88	54	21	88	56	4
5	16	78	41	03	67	30	95	59	24	90	56	22	89	57	5
6	17	79	42	05	68	32	96	60	25	91	57	23	90	58	6
7	18	80	43	06	69	33	97	61	26	92	58	24	91	59	7
8	19	81	44	07	70	34	98	62	27	93	59	25	92	60	8
9	20	82	45	08	71	35	99	63	28	94	60	26	94	61	9
10	21	83	46	09	72	36	1300	64	30	95	61	28	95	62	10
11	22	84	47	10	73	37	01	66	31	96	62	29	96	64	11
12	23	85	48	11	74	38	02	67	32	97	63	30	97	65	12
13	24	86	49	12	75	39	03	68	33	98	64	31	98	66	13
14	25	87	50	13	76	40	04	69	34	99	65	32	99	67	14
15	26	88	51	14	77	41	05	70	35	1500	67	33	1700	68	15
16	27	89	52	15	78	42	06	71	36	02	68	34	01	69	16
17	28	90	53	16	79	43	07	72	37	03	69	35	03	70	17
18	29	91	54	17	81	44	08	73	38	04	70	37	04	72	18
19	30	93	55	18	82	45	10	74	39	05	71	38	05	73	19
20	31	94	56	19	83	46	11	75	40	06	72	39	06	74	20
21	32	95	57	20	84	48	12	76	41	07	73	40	07	75	21
22	33	96	58	21	85	49	13	77	43	08	74	41	08	76	22
23	34	97	59	22	86	50	14	79	44	09	75	42	09	77	23
24	35	98	60	23	87	51	15	80	45	10	77	43	11	78	24
25	36	99	61	25	88	52	16	81	46	11	78	44	12	80	25
26	37	1000	63	26	89	53	17	82	47	13	79	45	13	81	26
27	38	01	64	27	90	54	18	83	48	14	80	47	14	82	27
28	39	02	65	28	91	55	19	84	49	15	81	48	15	83	28
29	41	03	66	29	92	56	20	85	50	16	82	49	16	84	29
30	42	04	67	30	93	57	21	86	51	17	83	50	17	85	30
31	43	05	68	31	94	58	22	87	52	18	84	51	18	86	31
32	44	06	69	32	95	59	24	88	53	19	85	52	20	87	32
33	45	07	70	33	96	60	25	89	55	20	87	53	21	88	33
34	46	08	71	34	98	61	26	90	56	21	88	54	22	89	34
35	47	09	72	35	99	62	27	92	57	22	89	56	23	91	35
36	48	10	73	36	1200	64	28	93	58	24	90	57	24	92	36
37	49	11	74	37	01	65	29	94	59	25	91	58	25	93	37
38	50	12	75	38	02	66	30	95	60	26	92	59	26	94	38
39	51	13	76	39	03	67	31	96	61	27	93	60	27	95	39
40	52	14	77	40	04	68	32	97	62	28	94	61	29	97	40
41	53	15	78	41	05	69	33	98	63	29	95	62	30	98	41
42	54	16	79	42	06	70	34	99	64	30	96	63	31	99	42
43	55	18	80	44	07	71	35	1400	65	31	98	64	32	1800	43
44	56	19	81	45	08	72	36	01	67	32	99	66	33	01	44
45	57	20	82	46	09	73	38	02	68	33	1600	67	34	02	45
46	58	21	84	47	10	74	39	03	69	35	01	68	35	03	46
47	59	22	85	48	11	75	40	05	70	36	02	69	36	05	47
48	60	23	86	49	12	76	41	06	71	37	03	70	38	06	48
49	61	24	87	50	13	77	42	07	72	38	04	71	39	07	49
50	62	25	88	51	15	78	43	08	73	39	05	72	40	08	50
51	63	26	89	52	16	80	44	09	74	40	06	73	41	09	51
52	64	27	90	53	17	81	45	10	75	41	08	75	42	10	52
53	65	28	91	54	18	82	46	11	76	42	09	76	43	11	53
54	66	29	92	55	19	83	47	12	77	43	10	77	44	13	54
55	68	30	93	56	20	84	48	13	79	44	11	78	46	14	55
56	69	31	94	57	21	85	49	14	80	46	12	79	47	15	56
57	70	32	95	58	22	86	50	15	81	47	13	80	48	16	57
58	71	33	96	59	23	87	52	16	82	48	14	81	49	17	58
59	972	1034	1097	1160	1224	1288	1353	1418	1483	1549	1615	1682	1750	1818	59
'	15°	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°	'

Meridional Parts.

′	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	′
0	1819	1888	1958	2028	2100	2171	2244	2318	2393	2468	2545	2623	2702	2782	0
1	21	90	59	30	01	73	46	19	94	70	46	24	03	83	1
2	22	91	60	31	02	74	47	20	95	71	48	25	04	84	2
3	23	92	62	32	03	75	48	22	96	72	49	27	06	86	3
4	24	93	63	33	04	76	49	23	98	73	50	28	07	87	4
5	25	94	64	34	06	78	50	24	99	75	51	29	08	88	5
6	26	95	65	35	07	79	52	25	2400	76	53	31	10	90	6
7	27	96	66	37	08	80	53	27	01	77	54	32	11	91	7
8	29	98	67	38	09	81	54	28	03	78	55	33	12	92	8
9	30	99	69	39	10	82	55	29	04	80	57	34	14	94	9
10	31	1900	70	40	11	84	57	30	05	81	58	36	15	95	10
11	32	01	71	41	13	85	58	32	06	82	59	37	16	97	11
12	33	02	72	43	14	86	59	33	08	84	60	38	18	98	12
13	34	03	73	44	15	87	60	34	09	85	62	40	19	99	13
14	35	05	74	45	16	88	61	35	10	86	63	41	20	2801	14
15	37	06	76	46	17	90	63	37	11	87	64	42	22	02	15
16	38	07	77	47	19	91	64	38	13	89	66	44	23	03	16
17	39	08	78	48	20	92	65	39	14	90	67	45	24	05	17
18	40	09	79	50	21	93	66	40	15	91	68	46	26	06	18
19	41	10	80	51	22	94	68	42	16	92	69	48	27	07	19
20	42	11	81	52	23	96	69	43	18	94	71	49	28	09	20
21	43	13	83	53	25	97	70	44	19	95	72	50	29	10	21
22	45	14	84	54	26	98	71	45	20	96	73	51	31	11	22
23	46	15	85	56	27	2300	72	46	22	98	75	53	32	13	23
24	47	16	86	57	28	01	74	48	23	99	76	54	33	14	24
25	48	17	87	58	29	02	75	49	24	2500	77	55	35	15	25
26	49	19	88	59	31	03	76	50	25	01	78	57	36	17	26
27	50	20	90	60	32	04	77	51	27	03	80	58	37	18	27
28	52	21	91	61	33	05	79	53	28	04	81	59	39	20	28
29	53	22	92	63	34	07	80	54	29	05	82	61	40	21	29
30	54	23	93	64	35	08	81	55	30	06	84	62	42	22	30
31	55	25	94	65	37	09	82	56	32	08	85	63	43	24	31
32	56	26	95	66	38	10	83	58	33	09	86	65	44	25	32
33	57	27	97	67	39	11	85	59	34	10	88	66	46	26	33
34	58	28	98	69	40	13	86	60	35	12	89	67	47	28	34
35	60	29	99	70	41	14	87	61	37	13	90	69	48	29	35
36	61	31	2000	71	43	15	88	63	38	14	91	70	50	30	36
37	62	32	01	72	44	16	90	64	39	15	93	71	51	32	37
38	63	33	02	73	45	17	91	65	40	17	94	73	52	33	38
39	64	34	04	75	46	19	92	66	42	18	95	74	54	34	39
40	65	35	05	76	47	20	93	68	43	19	97	75	55	36	40
41	66	36	06	77	49	21	95	69	44	21	98	76	56	37	41
42	68	37	07	78	50	22	96	70	45	22	99	78	58	39	42
43	69	38	08	79	51	24	97	71	47	23	2601	79	59	40	43
44	70	39	10	80	52	25	98	73	48	24	02	80	60	41	44
45	71	41	11	82	53	26	99	74	49	26	03	82	62	43	45
46	72	42	12	83	55	27	2301	75	51	27	04	83	63	44	46
47	73	43	13	84	56	28	02	76	52	28	06	84	64	45	47
48	75	44	14	85	57	30	03	78	53	30	07	86	66	47	48
49	76	45	15	86	58	31	04	79	54	31	08	87	67	48	49
50	77	46	17	88	59	32	06	80	56	32	10	88	68	49	50
51	78	48	18	89	61	33	07	81	57	33	11	90	70	51	51
52	79	49	19	90	62	35	08	83	58	35	12	91	71	52	52
53	80	50	20	91	63	36	09	84	59	36	14	92	72	54	53
54	81	51	21	92	64	37	11	85	61	37	15	94	74	55	54
55	83	52	22	94	65	38	12	86	62	38	16	95	75	56	55
56	84	53	24	95	67	39	13	88	63	40	17	96	76	58	56
57	85	55	25	96	68	41	14	89	64	41	19	98	78	59	57
58	86	56	26	97	69	42	16	90	66	42	20	99	79	60	58
59	1887	1957	2027	2098	2170	2243	2317	2391	2467	2544	2621	2700	2780	2862	59
′	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°	42°	′

Meridional Parts.

′	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	′
0	2863	2946	3030	3116	3203	3292	3382	3474	3569	3665	3764	3865	3968	4074	0
1	64	47	31	17	04	93	84	76	70	67	65	66	70	76	1
2	66	49	33	18	06	95	85	78	72	68	67	68	71	77	2
3	67	50	34	20	07	96	87	79	74	70	69	70	73	79	3
4	69	51	36	21	09	98	88	81	75	72	70	71	75	81	4
5	70	53	37	23	10	99	90	82	77	73	72	73	77	83	5
6	71	54	38	24	12	3301	91	84	78	75	74	75	78	85	6
7	73	56	40	26	13	02	93	85	80	77	75	77	80	86	7
8	74	57	41	27	14	03	94	87	82	78	77	78	82	88	8
9	75	58	43	29	16	05	96	88	83	80	79	80	84	90	9
10	77	60	44	30	17	06	97	90	85	81	80	82	85	92	10
11	78	61	46	31	19	08	98	92	86	83	82	83	87	94	11
12	80	63	47	33	20	09	3400	93	88	85	84	85	89	95	12
13	81	64	48	34	22	11	02	95	90	86	85	87	91	97	13
14	82	65	50	35	23	12	03	96	91	88	87	89	92	99	14
15	84	67	51	36	25	14	05	98	93	90	89	90	94	4101	15
16	85	68	53	37	26	16	07	99	94	91	90	92	96	03	16
17	86	70	54	40	28	17	08	3501	96	93	92	94	98	04	17
18	88	71	55	42	29	19	10	03	98	95	94	95	99	06	18
19	89	72	57	43	31	20	11	04	99	96	95	97	4001	08	19
20	91	74	58	44	32	22	13	06	3601	98	97	99	03	10	20
21	92	75	60	46	34	23	14	07	02	99	99	3901	05	12	21
22	93	76	61	47	35	25	16	09	04	3701	3800	02	06	13	22
23	95	78	63	49	37	26	17	10	06	03	02	04	08	15	23
24	96	79	64	50	38	28	19	12	07	04	04	06	10	17	24
25	97	81	65	52	40	29	20	14	09	06	66	07	12	19	25
26	99	82	67	53	41	31	22	15	10	08	07	09	14	21	26
27	2900	83	68	55	42	32	23	17	12	09	09	11	15	22	27
28	02	85	70	56	44	34	25	18	14	11	11	13	17	24	28
29	03	86	71	57	45	35	27	20	15	13	12	14	19	26	29
30	04	88	73	59	47	37	28	21	17	14	14	16	21	28	30
31	06	89	74	60	48	38	30	23	18	16	16	18	22	30	31
32	07	91	75	62	50	40	31	25	20	17	17	19	24	32	32
33	08	92	77	63	51	41	33	26	22	19	19	21	26	33	33
34	10	93	78	65	53	43	34	28	23	21	21	23	28	34	34
35	11	95	80	66	54	44	36	29	25	22	22	25	29	37	35
36	13	96	81	68	56	46	37	31	26	24	24	26	31	39	36
37	14	98	83	69	57	47	38	32	28	26	26	28	33	41	37
38	15	99	84	71	59	49	40	34	30	27	27	30	35	42	38
39	17	3000	85	72	60	50	41	36	31	29	29	32	37	44	39
40	18	02	87	73	62	52	43	37	33	31	31	33	38	46	40
41	19	03	88	75	63	53	45	39	34	32	32	35	40	48	41
42	21	05	90	76	65	55	47	40	36	34	34	37	42	50	42
43	22	06	91	78	66	56	48	42	38	36	36	38	44	52	43
44	24	07	93	79	68	58	50	43	39	37	38	40	45	53	44
45	25	09	94	81	69	59	51	45	41	39	39	42	47	55	45
46	26	10	95	82	71	61	53	47	43	41	41	44	49	57	46
47	28	12	97	84	72	62	54	48	44	42	43	45	51	59	47
48	29	13	98	85	74	64	56	50	46	44	44	47	52	61	48
49	31	14	3100	87	75	65	57	51	47	46	46	49	54	62	49
50	32	16	01	88	77	67	59	53	49	47	48	51	56	64	50
51	33	17	03	90	78	68	60	55	51	49	49	52	58	66	51
52	35	19	04	91	80	70	62	56	52	50	51	54	60	68	52
53	36	20	05	92	81	71	64	58	54	52	53	56	61	70	53
54	37	21	07	94	83	73	65	59	55	54	54	58	63	72	54
55	39	23	08	95	84	74	67	61	57	55	56	59	65	73	55
56	40	24	10	97	86	76	68	62	59	57	58	61	67	75	56
57	42	26	11	98	87	78	70	64	60	59	60	63	69	77	57
58	43	27	13	3200	89	79	71	66	62	60	61	64	70	79	58
59	2944	3029	3114	01	3290	3381	3473	3567	3664	3762	3863	3966	4072	4181	59
′	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°	55°	56°	′

Meridional Parts.

′	57°	58°	59°	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°	′
0	4183	4294	4409	4527	4649	4775	4905	5039	5179	5324	5474	5631	5795	5966	0
1	84	96	11	29	51	77	07	42	81	26	77	33	97	69	1
2	86	98	13	31	53	79	09	44	84	28	79	36	5800	72	2
3	88	4300	15	33	55	81	12	46	86	31	82	39	03	75	3
4	90	02	17	35	57	84	14	49	88	33	84	42	06	78	4
5	92	04	19	37	60	86	16	51	91	36	87	44	09	81	5
6	94	06	21	39	62	88	18	53	93	38	89	47	11	84	6
7	96	08	23	41	64	90	20	55	96	41	92	50	14	86	7
8	97	09	25	43	66	92	23	58	98	43	95	52	17	89	8
9	99	11	27	45	68	94	25	60	5200	46	97	55	20	92	9
10	4201	13	29	47	70	96	27	62	03	48	5500	58	23	95	10
11	03	15	31	49	72	98	29	65	05	51	02	60	25	98	11
12	05	17	33	51	74	4801	31	67	07	53	05	63	28	6001	12
13	07	18	34	53	76	03	34	69	10	56	07	66	31	04	13
14	08	20	36	55	78	05	36	71	12	58	10	68	34	07	14
15	10	22	38	57	80	07	38	74	14	61	13	71	37	10	15
16	12	24	40	59	83	09	40	76	17	63	15	74	39	13	16
17	14	26	42	62	84	11	43	78	19	66	18	76	42	16	17
18	16	28	44	64	87	14	45	81	22	68	20	79	45	19	18
19	18	30	46	66	89	16	47	83	24	71	23	82	48	22	19
20	20	32	48	68	91	18	49	85	26	73	26	85	51	25	20
21	21	34	50	70	93	20	51	88	29	76	28	87	54	28	21
22	23	36	52	72	95	22	54	90	31	78	31	90	56	31	22
23	25	38	54	74	97	24	56	92	34	80	33	93	59	34	23
24	27	40	56	76	99	26	58	95	36	83	36	95	62	37	24
25	29	42	58	78	4701	29	60	97	38	85	39	98	65	40	25
26	31	44	60	80	03	31	63	99	41	88	41	5701	68	43	26
27	32	45	62	82	05	33	65	5102	43	90	44	04	71	46	27
28	34	47	64	84	07	35	67	04	46	93	46	06	74	49	28
29	36	49	66	86	10	37	69	06	48	95	49	09	76	52	29
30	38	51	68	88	12	39	72	08	50	98	52	12	79	55	30
31	40	53	70	90	14	42	74	11	53	5401	54	15	82	58	31
32	42	55	72	92	16	44	76	13	55	03	57	17	85	61	32
33	44	57	74	94	18	46	78	15	58	06	59	20	88	64	33
34	46	59	76	96	20	48	81	18	60	08	62	23	91	67	34
35	47	61	78	98	22	50	83	20	63	11	65	25	94	70	35
36	49	63	80	4600	24	52	85	22	65	13	67	28	96	73	36
37	51	65	82	02	26	55	87	25	67	16	70	31	99	76	37
38	53	67	84	04	28	57	90	27	70	18	73	34	5902	79	38
39	55	69	86	06	31	59	92	29	73	21	75	36	05	82	39
40	57	70	88	08	33	61	94	32	75	23	78	39	08	85	40
41	59	72	90	10	35	63	96	34	77	26	80	42	11	88	41
42	60	74	92	12	37	65	99	36	80	28	83	45	14	91	42
43	62	76	94	14	39	68	5001	39	82	31	86	47	17	94	43
44	64	78	95	16	41	70	03	41	84	33	88	50	19	97	44
45	66	80	97	18	43	72	05	43	87	36	91	53	22	6100	45
46	68	82	99	20	45	74	08	46	89	38	94	56	25	03	46
47	70	84	4501	23	47	76	10	48	92	41	96	58	28	06	47
48	72	86	03	25	50	79	13	51	94	43	99	61	31	09	48
49	74	88	05	27	52	81	14	53	97	46	5602	64	34	12	49
50	75	90	07	29	54	83	17	55	99	48	04	67	37	15	50
51	78	92	09	31	56	85	19	58	5301	51	07	70	40	18	51
52	80	94	11	33	58	87	21	60	04	54	10	72	43	21	52
53	82	96	13	35	60	90	23	62	06	56	12	75	46	24	53
54	84	98	15	37	62	92	26	65	09	59	15	78	48	27	54
55	85	99	17	39	64	94	28	67	11	61	17	81	51	30	55
56	87	4401	19	41	66	96	30	69	14	64	20	83	54	33	56
57	89	03	21	43	68	98	33	72	16	66	23	86	57	36	57
58	91	05	23	45	71	4901	35	74	19	69	25	89	60	40	58
59	4292	07	4525	4647	4773	03	5037	5176	5321	5471	5628	5792	5963	6143	59
′	57°	58°	59°	60°	61°	62°	63°	64°	65°	66°	67°	68°	69°	70°	′

Meridional Parts.

′	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	′
0	6146	6335	6534	6746	6970	7210	7467	7745	8046	8375	8739	9145	9606	10137	0
1	49	38	38	49	74	14	72	49	51	81	45	53	14	147	1
2	52	41	41	53	78	18	76	54	56	87	52	60	22	156	2
3	55	45	45	57	82	22	81	59	61	93	58	67	31	166	3
4	58	48	48	60	86	27	85	64	67	98	65	74	39	176	4
5	61	51	52	64	90	31	90	68	72	8404	71	82	47	185	5
6	64	54	55	68	94	35	94	73	77	10	78	89	55	195	6
7	67	58	58	71	97	39	98	78	83	16	84	96	64	205	7
8	70	61	62	75	7001	43	7503	83	88	22	91	9203	72	215	8
9	73	64	65	79	05	47	07	88	93	27	97	11	80	224	9
10	77	67	69	82	09	52	12	93	99	33	8804	18	89	234	10
11	80	71	72	86	13	56	16	98	8104	39	10	25	97	244	11
12	83	74	76	90	17	60	21	7803	09	45	17	33	9706	254	12
13	86	77	79	93	21	64	25	08	15	51	23	40	14	264	13
14	89	80	83	97	25	68	30	13	20	57	30	48	23	274	14
15	92	84	86	6801	29	73	35	17	25	63	30	55	31	284	15
16	95	87	90	04	33	77	39	22	31	69	43	62	40	294	16
17	98	90	93	08	37	81	44	27	36	74	49	70	48	304	17
18	6201	94	97	12	41	85	48	32	41	80	56	77	57	314	18
19	05	97	6600	15	45	89	53	37	47	86	63	85	65	324	19
20	08	6400	03	19	48	94	57	42	52	92	69	92	74	334	20
21	11	03	07	23	52	98	62	47	58	98	76	9300	83	345	21
22	14	07	10	26	56	7302	66	52	63	8504	83	07	91	355	22
23	17	10	14	30	60	06	71	57	68	10	89	15	9800	365	23
24	20	13	17	34	64	11	76	62	74	16	96	22	09	375	24
25	23	17	21	38	68	15	80	67	79	22	8903	30	17	385	25
26	26	20	24	41	72	19	85	72	85	28	09	37	26	396	26
27	30	23	28	45	76	23	89	77	90	34	16	45	35	406	27
28	33	27	31	49	80	28	94	82	96	40	23	53	44	416	28
29	36	30	35	53	84	33	99	87	8201	46	30	60	53	427	29
30	39	33	39	56	88	36	7603	92	07	52	36	68	61	437	30
31	42	37	42	60	92	41	08	97	12	58	43	76	70	448	31
32	45	40	46	64	96	45	12	7902	18	65	50	83	79	458	32
33	49	43	49	68	7100	49	17	07	23	71	57	91	88	469	33
34	52	47	53	71	04	53	22	12	29	77	63	99	97	479	34
35	55	50	56	75	08	58	26	17	34	83	70	9407	9906	490	35
36	58	53	60	79	12	62	31	22	40	89	77	14	15	501	36
37	61	57	63	83	16	66	36	27	45	95	84	22	24	511	37
38	64	60	67	86	20	71	40	32	51	8601	91	30	33	522	38
39	68	63	70	90	24	75	45	37	56	07	98	38	42	532	39
40	71	67	74	94	28	79	50	42	62	14	9005	45	51	543	40
41	74	70	77	98	32	84	54	48	67	20	12	53	60	554	41
42	77	73	81	6901	36	88	59	53	73	26	18	61	69	565	42
43	80	77	85	05	40	92	64	58	79	32	25	69	78	575	43
44	83	80	88	09	45	97	68	63	84	38	32	77	87	586	44
45	87	83	92	13	49	7401	73	68	90	44	39	85	96	597	45
46	90	87	95	17	53	06	78	73	95	51	46	93	10005	608	46
47	93	90	99	20	57	10	83	78	8301	57	53	9501	015	619	47
48	96	94	6702	24	61	14	87	83	07	63	60	09	024	630	48
49	99	97	06	28	65	19	93	89	12	69	67	17	033	641	49
50	6303	6500	10	32	69	23	97	94	18	76	74	25	043	652	50
51	06	04	13	36	73	27	7702	99	24	82	81	33	052	663	51
52	09	07	17	40	77	31	06	8004	29	88	88	41	061	674	52
53	12	11	20	43	81	36	11	09	35	95	96	49	071	685	53
54	15	14	24	47	85	41	16	14	41	8701	9103	57	080	696	54
55	19	17	28	51	89	45	21	20	47	07	10	65	089	707	55
56	22	21	31	55	94	49	25	25	52	14	17	73	099	718	56
57	25	24	35	59	98	54	30	30	58	20	24	81	108	730	57
58	28	28	38	63	7202	58	35	35	64	26	31	89	118	741	58
59	6332	6531	6742	6966	06	7463	7740	8040	8369	8733	9138	9598	10127	10752	59
′	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°	81°	82°	83°	84°	′

TABLE VII.

AMPLITUDES

Amplitudes.

Declination of the Sun.

lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	lat.
0°	0°	1° 0′	2° 0′	3° 0′	4° 0	5° 0	6° 0′	7° 0′	8° 0′	9° 0′	10° 0′	11° 0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0	2
3	0	0	0	0	0	0	0	1	1	1	1	1	3
4	0	0	0	0	1	1	1	1	1	1	1	2	4
5	0	0	0	1	1	1	1	2	2	2	2	3	5
6	0	0	1	1	1	2	2	2	3	3	3	4	6
7	0	0	1	1	2	2	3	3	4	4	5	5	7
8	0	1	1	2	2	3	4	4	5	5	6	7	8
9	0	1	1	2	3	4	5	5	6	7	8	8	9
10	0	1	2	3	4	5	6	7	7	8	9	10	10
11	0	1	2	3	4	6	7	8	9	10	11	13	11
12	0	1	3	4	5	7	8	9	11	12	14	15	12
13	0	2	3	5	6	8	10	11	13	14	16	18	13
14	0	2	4	6	7	9	11	13	15	17	19	20	14
15	0	2	4	6	8	11	13	15	17	19	21	24	15
16	0	2	5	7	10	12	15	17	19	22	24	27	16
17	0	3	5	8	11	14	17	19	22	25	28	31	17
18	0	3	6	9	12	15	19	22	25	29	3	34	18
19	0	3	7	10	14	17	21	24	28	31	35	38	19
20	0	4	8	12	15	19	23	27	31	35	39	43	20
21	0	4	9	13	17	21	26	30	34	39	43	48	21
22	0	5	9	14	19	24	28	33	38	43	48	53	22
23	0	5	10	16	21	26	31	36	42	47	52	58	23
24	0	6	11	17	23	28	34	40	46	52	57	12 3	24
25	0	6	12	19	25	31	37	44	50	56	11 3	9	25
26	0	7	14	20	27	34	41	48	54	10 1	8	15	26
27	0	7	15	22	29	37	44	52	59	7	14	22	27
28	0	8	16	24	32	40	48	56	9 4	12	21	29	28
29	0	9	17	26	34	43	52	8 1	9	18	27	36	29
30	0	9	19	27	37	47	56	5	15	24	34	44	30
31	0	10	20	30	40	50	7 0	10	21	31	41	52	31
32	0	11	22	32	43	54	5	16	27	38	49	13 0	32
33	0	12	23	35	46	58	10	21	33	45	57	9	33
34	0	12	25	37	50	6 2	15	27	40	53	12 5	18	34
35	0	13	27	40	53	6	20	33	47	11 1	14	28	35
36	0	14	28	43	57	11	25	40	54	9	24	38	36
37	0	15	30	45	5 1	16	30	47	10 2	18	34	48	37
38	0	16	32	48	5	21	37	54	10	27	44	14 1	38
39	0	17	34	52	9	26	44	9 1	19	37	55	13	39
40	0	18	37	55	13	32	51	9	28	47	13 6	25	40
41	0	20	39	59	18	38	58	18	38	58	18	39	41
42	0	21	42	4 2	23	44	8 5	28	48	12 9	31	52	42
43	0	22	44	6	28	51	13	36	58	21	44	15 7	43
44	0	23	47	10	34	58	21	45	11 9	34	58	22	44
45	0	25	50	15	40	7 5	30	55	21	47	14 13	38	45
46	0	26	53	19	46	13	39	10 6	33	13 1	29	57	46
47	0	28	56	24	52	21	49	18	46	16	45	16 15	47
48	0	30	59	29	59	29	59	30	12 0	31	15 2	34	48
49	0	31	3 3	35	6 6	38	9 10	42	15	48	21	54	49
50	0	33	7	40	14	48	22	56	30	14 5	48	17 16	50
51	0	35	11	46	22	58	34	11 10	47	24	16 1	[illegible]	51
52	0	37	15	53	30	8 8	47	25	13 4	43	23	18 3	52
53	0	40	19	59	39	20	10 0	41	22	15 4	46	[illegible]	53
54	0	42	24	5 7	49	32	15	58	42	26	17 11	57	54
55	0	45	29	14	59	44	30	12 16	14 3	50	37	19 [illegible]	55
56	0	47	35	22	7 10	58	46	35	25	16 15	18 5	57	56
57	0	50	40	31	22	9 13	11 4	56	48	42	36	[illegible]	57
58	0	53	47	40	34	28	23	13 18	15 14	17 10	19 8	21 6	58
59	0	57	53	50	47	45	43	41	41	41	42	45	59
60	0	2° 0	4° 0	6° 0	8° 1	10° 2	12° 4	14° 6	16° 10	18° 14	20° 19	22° [illegible]	60
lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	lat.

Declination of the Sun.

Amplitudes.

Declination of the Sun.

lat.	12°		13°		14°		15°		16°		17°		18°		19°		20°		21°		22°		23°		lat.
0°	12°	0'	13°	0'	14°	0'	15°	0'	16°	0'	17°	0'	18°	0'	19°	0'	20°	0'	21°	0'	22°	0'	23°	0'	0°
1		0		0		0		0		0		0		0		0		0		0		0		0	1
2		0		0		0		1		1		1		1		1		1		1		1		1	2
3		1		1		1		1		1		2		2		2		2		2		2		2	3
4		2		2		2		2		2		3		3		3		3		3		3		4	4
5		3		3		3		4		4		4		4		5		5		5		5		6	5
6		4		4		5		5		5		6		6		7		7		7		8		8	6
7		5		6		6		7		7		8		8		9		9		10		10		11	7
8		7		8		8		9		10		10		11		12		12		13		14		14	8
9		9		10		11		11		12		12		14		15		16		16		17		18	9
10		11		12		13		14		15		16		17		18		19		20		21		23	10
11		14		15		16		17		18		20		21		22		23		25		26		27	11
12		16		18		19		21		22		24		25		26		28		30		31		33	12
13		19		21		23		24		26		28		29		31		33		35		37		38	13
14		22		24		26		28		30		32		34		36		38		40		43		45	14
15		26		28		30		33		35		37		39		42		44		47		49		52	15
16		29		32		35		37		40		42		45		48		51		53		56		59	16
17		33		36		39		42		45		48		51		54		58	22	0	23	4	24	7	17
18		38		41		44		47		51		54		58	20	1	21	5		8		12		15	18
19		42		46		49		53		57	18	1	19	5		8		12		16		20		24	19
20		47		51		55		59	17	3		8		12		16		20		25		30		34	20
21		52		57	15	1	16	6		10		15		20		25		29		34		40		44	21
22		57	14	2		7		13		18		23		28		34		30		44		50		55	22
23	13	3		9		14		20		26		31		37		43		49		55	24	1	25	7	23
24		9		15		21		27		34		40		46		53	22	0	23	6		13		19	24
25		16		22		29		36		43		49		56	21	3		10		18		25		32	25
26		22		30		37		44		52		59	20	7		14		22		30		38		46	26
27		30		37		45		53	18	1	19	9		18		26		34		43		52	26	1	27
28		37		46		54	17	3		11		20		29		38		47		57	25	6		16	28
29		45		54	16	3		13		22		32		41		51	23	1	24	11		22		32	29
30		53	15	3		13		23		34		44		54	22	5		16		27		38		49	30
31	14	2		13		24		34		45		57	21	8		19		31		43		55	27	7	31
32		11		23		34		46		58	20	10		22		35		47	25	0	26	13		26	32
33		21		34		46		59	19	11		24		37		51	24	4		18		32		46	33
34		31		45		58	18	11		25		39		53	23	7		22		37		52	28	7	34
35		42		56	17	11		25		40		55	22	10		25		41		57	27	13		29	35
36		54	16	9		24		39		55	21	11		27		44	25	1	26	18		35		53	36
37	15	5		22		38		54	20	11		28		46	24	3		21		40		58	29	18	37
38		18		35		53	19	10		28		47	23	5		24		43	27	3	28	23		44	38
39		31		50	18	8		27		46	22	6		26		46	26	7		28		49	30	11	39
40		45	17	5		25		45	21	5		26		47	25	9		31		54	29	17		40	40
41		59		20		42	20	3		25		48	24	10		33		57	28	21		46	31	11	41
42	16	15		37	19	0		23		46	23	10		34		59	27	24		50	30	16		43	42
43		31		55		19		44	22	8		34	25	0	26	26		53	29	20		49	32	18	43
44		48	18	13		39	21	5		32		59		26		55	28	23		53	31	23		54	44
45	17	6		33	20	0		28		57	24	25		55	27	25		56	30	27		59	33	33	45
46		25		54		23		53	23	23		53	26	25		57	29	30	31	3	32	38	34	14	46
47		45	19	16		47	22	18		50	25	22		57	28	31	30	6		42	33	19		57	47
48	8	6		39	21	12		45	24	20		55	27	30	29	7		44	32	23	34	3	35	44	48
49		29	20	3		38	23	14		51	26	28	28	6		45	31	25	33	7		49	36	33	49
50		52		29	22	7		45	25	24	27	3		44	30	26	32	9		53	35	39	37	26	50
51	19	17		57		36	24	17		59		41	29	25	31	9		55	34	43	36	32	38	23	51
52		44	21	26	23	8		52	26	36	28	21	30	8		56	33	45	35	36	37	29	39	24	52
53	20	13		57		42	25	28	27	16	29	4		54	32	45	34	38	36	33	38	30	40	29	53
54		43	22	30	24	18	26	7		58		50	31	43	33	38	35	35	37	34	39	36	41	40	54
55	21	15	23	5		57		49	28	43	30	39	32	36	34	35	36	36	38	40	40	47	42	56	55
56		50		43	25	38	27	34	29	32	31	31	33	33	35	36	37	42	39	51	42	4	44	20	56
57	22	26	24	24	26	22	28	22	30	24	32	28	34	34	36	43	38	54	41	9	43	27	45	50	57
58	23	6	25	7	27	10	29	14	31	21	33	29	35	40	37	54	40	12	42	33	44	58	47	30	58
59		49		54	28°	1	30	10	32	21	34	35	36	52	39	12	41	37	44	6	46	40	49	21	59
60	24°	34	26°	44		56	31°	10	33°	27	35°	47	38°	10	40°	38	43°	10	45°	47	48°	31	51°	24	60
lat.	12°		13°		14°		15°		16°		17°		18°		19°		20°		21°		22°		23°		lat.

Declination of the Sun.

TABLE VIII.

TIME OF THE SUN'S RISING AND SETTING.

Time of the Sun's rising and setting.

App. time at sunrise / sunset when the lat. and dec. are of different names.* / the same name.

Declination of the Sun.

lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	lat.
0°	6h	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	0°
1	6	0	0	0	0	0	0	0	1	1	1	1	1	1
2	6	0	0	0	1	1	1	1	1	2	2	2	2	2
3	6	0	0	1	1	1	1	1	2	2	2	2	3	3
4	6	0	1	1	1	1	2	2	2	3	3	3	3	4
5	6	0	1	1	1	2	2	2	3	3	4	4	4	5
6	6	0	1	1	2	2	3	3	3	4	4	5	5	6
7	6	0	1	1	2	2	3	3	4	4	5	5	6	7
8	6	0	1	2	2	3	3	4	5	5	6	6	7	8
9	6	0	1	2	3	3	4	4	5	6	6	7	8	9
10	6	1	1	2	3	4	4	5	6	6	7	8	9	10
11	6	1	2	2	3	4	5	5	6	7	8	9	9	11
12	6	1	2	3	3	4	5	6	7	8	9	9	10	12
13	6	1	2	3	4	5	6	6	7	8	9	10	11	13
14	6	1	2	3	4	5	6	7	8	9	10	11	12	14
15	6	1	2	3	4	5	6	8	9	10	11	12	13	15
16	6	1	2	3	5	6	7	8	9	10	12	13	14	16
17	6	1	2	4	5	6	7	9	10	11	12	14	15	17
18	6	1	3	4	5	7	8	9	10	12	13	14	16	18
19	6	1	3	4	6	7	8	10	11	13	14	15	17	19
20	6	1	3	4	6	7	9	10	12	13	15	16	18	20
21	6	2	3	5	6	8	9	11	12	14	16	17	19	21
22	6	2	3	5	6	8	10	11	13	15	16	18	20	22
23	6	2	3	5	7	9	10	12	14	15	17	19	21	23
24	6	2	4	5	7	9	11	13	14	16	18	20	22	24
25	6	2	4	6	7	9	11	13	15	17	19	21	23	25
26	6	2	4	6	8	10	12	14	16	18	20	22	24	26
27	6	2	4	6	8	10	12	14	16	19	21	23	25	27
28	6	2	4	6	9	11	13	15	17	19	22	24	26	28
29	6	2	4	7	9	11	13	16	18	20	22	25	27	29
30	6	2	5	7	9	12	14	16	19	21	23	26	28	30
31	6	2	5	7	10	12	14	17	19	22	24	27	29	31
32	6	2	5	8	10	13	15	18	20	23	25	28	31	32
33	6	3	5	8	10	13	16	18	21	24	26	29	32	33
34	6	3	5	8	11	14	16	19	22	25	27	30	33	34
35	6	3	6	8	11	14	17	20	23	25	28	31	34	35
36	6	3	6	9	12	15	18	20	23	26	29	32	36	36
37	6	3	6	9	12	15	18	21	24	27	31	34	37	37
38	6	3	6	9	13	16	19	22	25	28	32	35	38	38
39	6	3	6	10	13	16	20	23	26	29	33	36	40	39
40	6	3	7	10	13	17	20	24	27	31	34	38	41	40
41	6	3	7	10	14	17	21	25	28	32	35	39	43	41
42	6	4	7	11	14	18	22	25	29	33	37	40	44	42
43	6	4	7	11	15	19	22	26	30	34	38	42	46	43
44	6	4	8	12	15	19	23	27	31	35	39	43	47	44
45	6	4	8	12	16	20	24	28	32	36	41	45	49	45
46	6	4	8	12	17	21	25	29	33	38	42	46	51	46
47	6	4	9	13	17	22	26	30	35	39	44	48	53	47
48	6	4	9	13	18	22	27	31	36	41	45	50	55	48
49	6	5	9	14	18	23	28	32	37	42	47	52	57	49
50	6	5	10	14	19	24	29	34	39	44	49	54	59	50
51	6	5	10	15	20	25	30	35	40	45	50	56	7h 1	51
52	6	5	10	15	21	26	31	36	41	47	52	58	3	52
53	6	5	11	16	21	27	32	38	43	49	54	7h 0	6	53
54	6	6	11	17	22	28	33	39	45	50	56	2	8	54
55	6	6	11	17	23	29	35	40	46	52	58	4	11	55
56	6	6	12	18	24	30	36	42	48	54	7h 1	7	13	56
57	6	6	12	19	25	31	37	44	50	56	3	10	16	57
58	6	6	13	19	26	32	39	45	52	59	6	12	20	58
59	6	7	13	20	27	33	40	47	54	7h 1	8	15	23	59
60	6h	6h 7	6h 14m	6h 21m	6h 28m	6h 35m	6h 42m	6h 49m	6h 56m	4	11	19m	26	60
lat.	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	lat.

* 12h—App. time at SUNRISE, gives the time of setting.

Time of the Sun's rising and setting.

App. time at sunrise / sunset when the lat. and dec. are of different names. / the same name.*

Declination of the Sun.

lat.	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	23° 28′	lat.
0°	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	6h 0m	0°
1	1	1	1	1	1	1	1	1	2	2	2	2	1
2	2	2	2	2	2	3	3	3	3	3	3	3	2
3	3	3	3	3	4	4	4	4	5	5	5	5	3
4	4	4	4	5	5	5	6	6	6	6	7	7	4
5	5	5	5	6	6	7	7	7	8	8	9	9	5
6	6	6	6	7	7	8	8	9	9	10	10	10	6
7	6	7	8	8	9	9	10	10	11	11	12	12	7
8	7	8	9	9	10	10	11	12	12	13	14	14	8
9	8	9	10	10	11	12	13	13	14	15	15	16	9
10	9	10	11	12	12	13	14	15	16	16	17	18	10
11	10	11	12	13	14	14	15	16	17	18	19	19	11
12	11	12	13	14	15	16	17	18	19	20	21	21	12
13	12	13	14	15	16	17	18	19	20	21	22	23	13
14	13	14	15	16	17	19	20	21	22	23	24	25	14
15	14	15	16	18	19	20	21	22	24	25	26	27	15
16	15	16	18	19	20	21	23	24	25	27	28	29	16
17	16	17	19	20	21	23	24	26	27	28	30	31	17
18	17	19	20	21	23	24	26	27	29	30	32	32	18
19	18	20	21	23	24	26	27	29	30	32	34	34	19
20	19	21	22	24	26	27	29	30	32	34	36	36	20
21	20	22	24	25	27	29	30	32	34	36	38	38	21
22	21	23	25	27	28	30	32	34	36	38	39	40	22
23	22	24	26	28	30	32	34	36	38	39	42	42	23
24	24	25	27	29	31	33	35	37	39	41	44	45	24
25	25	27	29	31	33	35	37	39	41	43	46	47	25
26	26	28	30	32	34	36	39	41	43	45	48	49	26
27	27	29	31	34	36	38	40	43	45	48	50	51	27
28	28	30	33	35	37	40	42	45	47	50	52	53	28
29	29	32	34	37	39	42	44	47	49	52	54	56	29
30	31	33	36	38	41	43	46	49	51	54	57	58	30
31	32	34	37	40	42	45	48	51	53	56	59	7h 0	31
32	33	36	39	41	44	47	50	53	56	58	7h 2	3	32
33	34	37	40	43	46	49	52	55	58	7h 1	4	5	33
34	36	39	42	45	48	51	54	57	7h 0	3	7	8	34
35	37	40	43	46	49	53	56	59	2	6	9	11	35
36	39	42	45	48	51	55	58	7h 1	5	8	12	14	36
37	40	43	47	50	53	57	7h 0	4	7	11	15	16	37
38	42	45	48	52	55	59	2	6	10	14	17	19	38
39	43	47	50	54	57	7h 1	5	9	12	16	20	22	39
40	45	48	52	56	59	3	7	11	15	19	23	25	40
41	46	50	54	58	7h 2	6	10	14	18	22	27	29	41
42	48	52	56	7h 0	4	8	12	17	21	25	29	32	42
43	50	54	58	2	6	11	15	19	24	29	33	36	43
44	52	56	7h 0	4	9	13	18	22	27	32	37	39	44
45	53	58	2	7	11	16	21	25	30	35	40	43	45
46	55	7h 0	4	9	14	19	24	29	34	39	44	47	46
47	57	2	7	12	17	22	27	32	37	43	48	51	47
48	59	4	9	14	19	25	30	35	41	47	53	55	48
49	7h 2	7	12	17	22	28	33	39	45	51	57	8h 0	49
50	4	9	14	20	25	31	37	43	49	55	8h 2	5	50
51	6	12	17	23	29	35	41	47	53	8h 0	7	10	51
52	9	14	20	26	32	38	45	51	58	5	12	15	52
53	11	17	23	29	36	42	49	56	8h 2	10	17	21	53
54	14	20	27	33	40	46	53	8h 0	8	15	23	27	54
55	17	23	30	37	44	51	58	5	13	21	29	33	55
56	20	27	34	41	48	55	8h 3	11	19	27	36	40	56
57	23	30	37	45	52	8h 0	8	16	25	34	43	48	57
58	27	34	42	49	57	5	14	22	32	41	51	56	58
59	30	38	46	54	8h 2	11	20	29	39	49	9h 0	9h 5	59
60	34	42	51	59	8	17	26	36	47	58	9	15	60
lat.	13°	14°	15°	16°	17°	18°	19°	20°	21°	22°	23°	23° 28′	lat.

* 12h—App. time at sunset, gives the time of rising

TABLE IX.

Atmospherical Refractions. { Barom. 30 in. / Fa. Therm. 50°					
App. Alt.	Refraction.	Diff. for 10° Therm.	App. Alt.	Refraction.	Diff. for 20° Therm.
10°	5′ 20″	*7″	50°	1′ 49″	*2″
11	4 51	6	51	47	2
12	28	5	52	45	2
13	8	5	53	44	2
14	3 50	5	54	42	2
15	34	4	55	41	2
16	20	4	56	39	2
17	9	4	57	38	2
18	2 58	4	58	36	1
19	48	3	59	35	1
20	39	3	60	34	1
21	31	3	61	32	1
22	23	3	62	31	1
23	17	3	63	30	1
24	10	3	64	28	1
25	4	3	65	27	1
26	1 59	2	66	26	1
27	54	2	67	25	1
28	49	2	68	24	1
29	45	2	69	22	1
30	41	2	70	21	1
31	37	2	71	20	1
32	33	2	72	19	1
33	30	2	73	18	1
34	26	2	74	17	1
35	23	2	75	16	1
36	20	2	76	14	1
37	17	2	77	13	1
38	14	1	78	12	1
39	12	1	79	11	1
40	9	1	80	10	0
41	7	1	81	9	
42	5	1	82	8	
43	2	1	83	7	
44	0	1	84	6	
45	0 58	1	85	5	
46	56	1	86	4	
47	54	1	87	3	
48	52	1	88	2	
49	51	1	89	1	
50	49	0	90	0	

*When the Therm. is below 50° the correction in these columns is addative to the refraction.

Augmentation of the moon's semi-diam't'r.	
Altitude.	Augment.
10°	3″
15	4
20	5
25	7
30	8
35	9
40	10
45	11
50	12
55	13
60	14
70	15
90	16

TABLE XI.

Sun's Alt.	Pl'x in alt.
15°	9″
35	8
45	7
55	6
65	5
70	4
75	3
80	2
85	1

of the principles are both ample, easy, and well arranged.

The work, I know, originated in the *wants* of the students of navigation on board ships, and I confidently believe that it will supply those wants.

L. M. POWELL,
Commander, U. S. Navy.

U. S. NAVY YARD, GOSPORT,
8th January, 1839.

SIR:

I am much pleased with your "Treatise on Navigation." The mathematical investigations it affords of the principles of the science, particularly of nautical astronomy, place it upon different grounds from the treatises upon the subject in common use, and adapt it much better to the purpose of instruction. I am desirous of introducing it, as far as may be practicable, among my own classes; and recommend it to all the younger officers in our naval service, who desire to become acquainted with the theory, as well as the practice of the mathematical part of their profession. Its designation as one of the books to be used in their examination, would, I think, conduce to elevate the standard of mathematical attainments among them.

With great regard,
Your obedient servant.
JOHN H. C. COFFIN.
Prof. of Mathematics, U. S. Navy.

WASHINGTON, 20th Dec., 1842.

DEAR SIR:

I have been much interested in a hasty examination of your work upon *Navigation*, more particularly with that part of it, which relates to "Spherical Trigonometry," and "Nautical Astronomy," two branches of navigation that have been too superficially treated in the most popular works upon the subject, to answer the increasing general information of the practical navigators of the present day.

During the last forty years, but little improvement of this kind has been introduced into the standard works upon navigation, and as a general remark, it may be safely asserted that they are behind the wants of those who use them.

Ever anxious for the general diffusion of such important knowledge in our profession, I trust you will be encouraged to introduce the work into the navy as a *Text-Book*. I remain, respectfully, etc.,

JAMES GLYNN,
Commander, U. S. Navy.

Lt. M. F. MAURY, U. S. N.

U. S. SHIP DALE, 23d Oct., 1843.

I feel great pleasure in recommending Maury's Navigation as a work of real usefulness and importance to the young officers of our navy.

It imbodies whatever can be of utility to the navigator, in a concise and perspicuous manner; and its explanations and references calculated to excite, in youthful and in[...]us minds, a desire for the higher [...]atical attainments. Having used the work myself, I know its value, and, therefore, hope it will become the authorized book of study for the midshipmen of our navy.

THOS. A. DORNIN,
Commander, U. S. Navy.

FLAG SHIP PENNSYLVANIA,
November 4th, 1843.

MY DEAR SIR:

I have, with great pleasure and care, examined your book on Navigation, and do decidedly recommend and prefer it to any other in use. The mathematical principles condensed in such a form, is a sufficient recommendation to every student of navigation, and I recommend it to all mathematicians and young officers belonging to, and at schools attached to the navy, and should think that the Hon. Secretary of the Navy would so order it.

I have the pleasure to remain, with regard,
Your obedient servant,
E. P. KENNEDY,

Lt. M. F. MAURY, U. S. N. P. C., Norfolk.

U. S. SHIP PENNSYLVANIA,
Nov. 3d, 1843.

SIR:

I have been much gratified in the perusal of your Treatise on Navigation; and think it well adapted for use as a school book, and one best calculated, of any that I have seen, to induce a love for the prosecution of the study of navigation as a science, and not merely as an art.

I am, very respectfully,
Your obedient servant,
A. G. PENDLETON,
Prof. of Mathematics, U. S. Navy.

Lt. M. F. MAURY, U. S. N.

U. S. SHIP OHIO, BOSTON,
Nov. 14th, 1843.

SIR:

I have examined, with a good deal of attention, your Treatise on Navigation, and find it embraces all the elements necessary to constitute a scientific navigator. It would, I believe, be found a valuable auxiliary in our naval schools.

The work of Dr. Bowditch, although eminently useful as a *practical* one, fails almost entirely in the development of the principles from which its rules are derived.

It seems, therefore, desirable, that some work explaining more fully the *theory* of navigation should be put into the hands of our midshipmen, in order that they may become, as we all desire, *scientific*, as well as practical navigators.

Hoping that the pleasure of furnishing such a work for the younger officers of the service may be yours,

I remain, very respectfully,
Your obedient servant,
JOS. T. HUSTON,
Prof. of Mathematics, U. S. Navy.

Lt. M. F. MAURY, U. S. N.

U. S. SHIP BOSTON, BOSTON,
Nov. 15th, 1843.

DEAR SIR:

I am much pleased to learn, through the

Army and Navy Chronicle, that a new edition of your valuable Navigator is soon to be published.

I cannot doubt the success of a large second edition, and I am confident that it will add to your reputation, and secure for your book the celebrity which it deserves. Its merit is recognised in the navy, and I would recommend it in all schools of navigation, particularly on account of the manner in which many difficult and obscure points are made easy and plain.

Respectfully, etc.,
G. J. PENDERGRAST.
Commander U. S. Navy.
Lt. M. F. Maury, U. S. Navy.

Wilmington, Del. Nov. 5th, 1843.

I consider Maury's Treatise on Navigation, the very work that has long been wanting in our schools, and I hope it will eventually be used in all of them (particularly the naval ones) instead of Bowditch's Practical Navigator; for I think it far superior as a book of instruction.

J. SHUBRICK,
Commander, U. S. N.

Norfolk, Nov. 7th, 1843.

I think Maury's Navigation is admirably adapted for the instruction of the young officers of the Navy. All the problems are deduced from theorems, in such a manner as to give the young seaman a correct idea of the theory as well as the practice of navigation. The methods are simple and accurate, and the tables well and carefully constructed. The work contains all that the student of navigation can require; and, were it made the authorized text book of the Navy, the standard of mathematical attainments among midshipmen, would be greatly elevated.

R. B. CUNNINGHAM.
Commander, U. S. Navy.

November 8th, 1843.

I possess a copy of Maury's Navigation, and consider it a valuable text-book for all nautical students, whether in the United States Naval Service, or in the commercial marine.

The author, Lieutenant M. F. Maury, U. S. Navy, is a man of science, and has produced this work under the advantage of knowing from experience what the nautical student and practical navigator require.

S. P. LEE,
Lt. U. S. Navy.

U. S. Naval Hospital,
New York, Nov. 10th, 1843.

Sir:

Your volume seems to me well calculated to achieve the object for which it seems designed: namely, to demonstrate the formulas of Nautical Astronomy, and explain the principles upon which the art of navigation is founded. A better book for schools of navigation, than yours, I am persuaded does not exist in our language. But after the expression of favourable opinions of it, by such men as Bowditch, Alexander Dallas Bache, P. J. Rodriguez, Edward C. Ward, and John H. C. Coffin, all eminently qualified to judge of such a work, few can doubt its worth or set any value upon the opinion of,

Very respectfully,
Your obedient servant,
W. S. W. RUSCHENBERGER,
Surgeon, U. S. N.
Lieut. M. F. Maury, U. S. Navy.

U. S. Ship Cumberland,
Boston, Nov. 14th, 1843.

Dear Sir:

From the cursory examination I have given your treatise on navigation, I, for one, am proud that so useful and valuable a work has been furnished by one of our own corps.

With the improvements you propose to add in the new edition you are preparing, I doubt not it will possess advantages over other works of the kind, and be found a valuable auxiliary in our naval schools.

Very truly yours,
JOSEPH SMITH,
Captain U. S. Navy.
Lieut. M. F. Maury, U. S. Navy.

Washington City, Nov. 23d, 1843.

Dear Maury,

I take this occasion to express to you the pleasure I feel, in noticing the announcement of a new edition of your treatise on navigation. Its subject matter being strictly professional, has called for the close scan of many of your brother officers, myself of the number. Its worthiness to become the text book of our young naval officers, may, with propriety, be judged of by those who are called on to exhibit a certificate of having been closely examined on, and found to possess a thorough knowledge of the subject treated of in your book alluded to.

Without an exception, all of our brother officers, and they are many whom I have heard descant freely on the merits of your work on navigation, pronounced it to be the best text book on that subject extant. In a full concurrence with that opinion,

I am with much esteem,
Respectfully yours truly,
WM. W. HUNTER,
Lieut. U. S. Navy.
Lieut. M. F. Maury, U. S. Navy.

U. S. Brig Perry,
Norfolk, Va., Nov. 24th, 1843.

Dear Sir:

I am pleased to learn you are preparing an improved edition of your Navigation, more especially with the view of instructing the midshipmen in the theory of navigation. To carry the student beyond the mechanical solution of nautical problems, into a comprehension of those principles of Mathematics and Astronomy, upon whi[ch] these problems are based, seems to h[ave] been wanting in most treatises on Nav[iga]tion.

Even Dr. Bowditch's invaluable epitome, that has laid every American, who has to trace his way on the great deep, under a lasting debt of gratitude, is wholly practical in its method. But the value of a Class Book proposing to teach the young officer the theory of one branch of his profession, which imbues his mind with some tincture of science, and raises him above the blind worker of mechanical problems, need not be enlarged upon; though it cannot be better appreciated than by those in the profession, who were deprived of the many advantages now offered to our midshipmen, and who were compelled to prepare for their examination with a Practical Navigator for their sole instructor, and a campstool between two guns, for their study room.

Uniformity in instruction too is a matter of great importance, and not doubting that the superior authority, who alone can prescribe the book to be taught, will fully appreciate the honorable contribution afforded by your work, to the character and benefit of the Navy, and that it will be made the standard at the examination of midshipmen, I remain, my dear sir,

Very sincerely, &c.
S. F. DUPONT,
Commander, U. S. N.

Lieut. M. F. Maury, U. S. Navy.

St. Augustine, E. Florida,
Nov. 27th, 1843.

My opinion can contribute nothing to the established reputation of your valuable work. I can only say, that when I first looked through it, I considered it as thoroughly supplying the great desideratum of a midshipman's study of navigation, and remarked to those who were present, "How unfortunate were we, in not having such a book when we were students of navigation." My opinion has been confirmed by that of other and more competent judges, and I believe that throughout the entire service, there has not been a disparaging voice raised against it. I regard it as being to Bowditch what Bowditch was to Hamilton Moore.

Respectfully, &c.
WM. F. LYNCH,
Lieut. U. S. Navy.

Lieut. M. F. Maury.

Yale College, Conn.
October 26th, 1843.

This valuable work on Navigation, theoretical and practical, it seems to me desirable to have placed in the hands of every naval officer, who may have occasion to navigate a ship or to explain the principles of Nautical Astronomy. These are well brought out, and illustrated with examples of their application, which render the treatise clear and intelligible, and adapt it well [illegible] the purposes of a text book for learners. [illegible]his book as a guide in the *rationale* [illegible]ciples of navigation, and Bowditch [illegible]npanion in the practical computations, the young officers of our Navy may be well prepared for the important and responsible duties of navigators. Having formerly used the work at sea, while engaged as an instructor in the naval service of the U. S., I cordially give it this recommendation.

JAMES NOONEY, Jr.
Tutor in Nat. Philosophy,
Late Prof. of Math. U. S. N.

Surveying Schr. Gallatin,
Philadelphia, Dec. 13th, 1843.

Dear Sir:

I have learnt with pleasure that a second edition of your work on Navigation will shortly be published.

I have always considered this book, from its general arrangement, and the kinds of solution employed, as decidedly the best work for students extant.

Believe me, truly yours,
(Signed) GEO. S. BLAKE.

Lt. M. F. Maury, U. S. N. Washington.

Opinion of Capt. M'Intosh, U. S. N.
New York, Dec. 12th, 1843.

It affords me great pleasure to state, that I consider your work on Navigation, as one of the very best now extant, and most cheerfully recommend it as most suitable for a school book for midshipmen.

Lieut. Maury.

Opinion of Capt. Percival, U. S. N.
U. S. Ship Constitution,
Gosport, Dec. 14th, 1843.

In compliance with your request, I have perused Maury's "New Theoretical, and Practical Treatise on Navigation," and have found it, as far as I am able to judge, a convenient reference, in illustrating the principles of Nautical Astronomy. Its explanations of the principles of Spherical Trigonometry, and its application of them to the solutions of the various astronomical problems, so essential in navigation, render it a book, in my opinion, not only useful as a supplement to our first (Bowditch's) standard work on the subject; but valuable in itself: an acquisition to the nautical student, who, if he is desirous of acquiring a correct, and practical knowledge of his profession, may be largely aided by the study thereof.

Lt. M. F. Maury, U. S. N.

Opinion of Capt. Forrest, U. S. N.
Washington, Dec. 18th, 1843.

I take much pleasure in recommending your "New Theoretical and Practical Treatise on Navigation." The explanations and illustrations are rendered clear and comprehensive, and I believe it to be just such a production as we require for the instruction of the young officers of our Navy, as well as others desirous of obtaining a well grounded and accurate knowledge of the science.

Lt. M. F. Maury, U. S. N.

Opinion of the U. S. Naval Lyceum, Brooklyn, New York.
BROOKLYN, Dec. 20th, 1843.

The undersigned, a committee to which was referred Lieut. Maury's "Treatise on Navigation," report that they have carefully examined the same, and are of opinion that it is a work well adapted for the instruction of the young officers of the Navy, as all the problems and formulæ that are necessary in their profession, are there brought together in a condensed form, and so clearly, and concisely demonstrated, that the student may easily inform himself of the theory and principles on which his practice is founded; and the accompanying tables are so constructed as to facilitate his calculations; all of which are systematically arranged, with a simplicity that has heretofore been generally wanting in works on Navigation. They would therefore recommend the same to be adopted for the use of the Naval schools.

Signed,
J. H. STRINGHAM,
WM. D. NEWMAN,
ALEX. C. GIBSON.

The following opinions have already appeared in print, but as they have in all probability escaped the notice of many to whom these pages will be presented, they are again inserted here.

"*U. S. N. S., New York, January* 19, 1836.

"Dear Sir,—I have had much pleasure in the perusal of your "New Theoretical and Practical Treatise on Navigation;" the plan and arrangements of which are original; it contains little or nothing superfluous, and every part of it appears to be as clear and intelligible as the nature of the subject will admit. Such a work has long been wanted in our Naval Schools, and on board our vessels of war. I intend to make use of it in the Naval School on this station; and I recommend it to be used by all the professors of Mathematics and Nautical Science, in the Navy of the United States.

"Yours Respectfully,
"EDW. C. WARD,
"Prof. Math. U. S. Navy."

"Passed Midshipman M. F. Maury,
"U. S. Navy."

"*U. S. Navy Yard, Gosport, March* 7, 1836.

"I have examined a Treatise on Navigation written by M. F. Maury of the U. S. Navy; and have no hesitation in recommending it to the students of that science. The explanations are clear, the rules are illustrated by many examples, and the new arrangement of some of the tables simplify the calculations of the navigator. Mr. Maury is deserving of great credit for the work, and I wish him every success.

P. J. RODRIGUEZ.