PREFACE

Purpose and Scope

This manual is a guide for engineering personnel conducting surveys in support of military construction. In addition to mathematical considerations, this manual offers a comprehensive analysis of problems which are typical in military surveying. It may be used for both training and reference.

Application

The material contained in this manual is applicable without modification to both nuclear and nonnuclear warfare.

User Information

Users of this publication are encouraged to recommend changes and submit comments for its improvement. Comments should be keyed to the specific page, paragraph, and line of text in which the change is recommended. Reasons will be provided for each comment to insure understanding and complete evaluation. Comments should be prepared, using DA Form 2028 (Recommended Changes to Publications and Blank Forms), and forwarded directly to the Commandant, US Army Engineer School, ATTN: ATZA-TD-P, Fort Belvoir, Virginina 22060-5291.

Roadway Criteria

To insure satisfactory results, study the engineering specifications of the road to be built. If these are not available, use the information provided in table 2-1.

Table 2-1. Road specifications

WIDTHS

One-way road—11.5 feet or 3.5 meters minimum.

Two-way road—23 feet or 7.0 meters minimum.

Shoulders (each side)—4 feet or 1.5 meters minimum.

Clearing—6 feet or 2 meters each side of roadway.

GRADES

Absolute maximum—determined by the lowest maximum gradeability of vehicles using the road.

Normal maximum—10 percent.

Desired maximum—less than 6 percent on sharp curves, less than 4 percent.

HORIZONTAL CURVES

Desired minimum radius—150 feet or 46 meters.

Absolute minimum radius—80 feet or 25 meters.

VERTICAL CURVES

Minimum length on hill summits—125 feet or 40 meters per 4 percent algebraic difference in grades.

Minimum length in hollows—100 feet or 30 meters per 4 percent algebraic difference in grades.

SIGHT DISTANCES

Absolute nonpassing minimum—200 feet or 60 meters.

Absolute passing minimum—350 feet or 110 meters.

SLOPES

Shoulders—¾ inch per foot (in/ft) or 6 percent.

Crown (gravel and dirt)—½ to ¾ in/ft or 4 to 6 percent.

Crown (paved)—¼ to ½ in/ft or 2 to 4 percent.

Cut and fill—variable, but normally about 1 ½ to 1.

DRAINAGE

Take advantage of natural drainage.

Locate above high waterline near streams or creeks.

Grade at least 5 feet or 1.6 meters above groundwater table.

TRAFFIC

Overhead clearance—14 feet or 4.3 meters minimum.

Traffic volume—2,000 vehicles per lane per day.

Load capacity—sustain 18,000 pound equivalent axle load.

Turnouts (single lane)—minimum every ¼ mile or 0.4 kilometers recommended.

CHAPTER 3

CURVES

Section I. SIMPLE HORIZONTAL CURVES

CURVE POINTS

By studying TM 5-232, the surveyor learns to locate points using angles and distances. In construction surveying, the surveyor must often establish the line of a curve for road layout or some other construction.

The surveyor can establish curves of short radius, usually less than one tape length, by holding one end of the tape at the center of the circle and swinging the tape in an arc, marking as many points as desired.

As the radius and length of curve increases, the tape becomes impractical, and the surveyor must use other methods. Measured angles and straight line distances are usually picked to locate selected points, known as stations, on the circumference of the arc.

TYPES OF HORIZONTAL CURVES

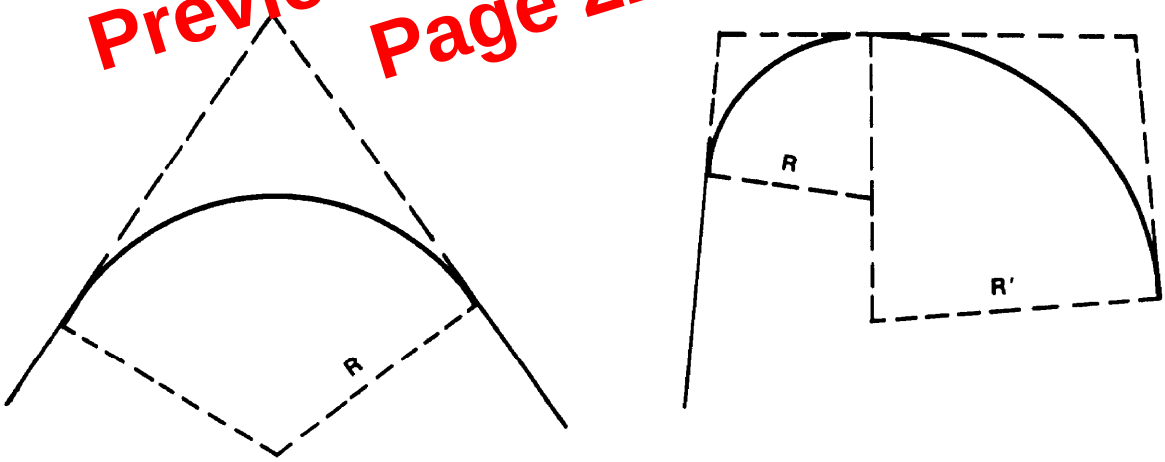
A curve may be simple, compound, reverse, or spiral (figure 3-l). Compound and reverse curves are treated as a combination of two or more simple curves, whereas the spiral curve is based on a varying radius.

Simple

The simple curve is an arc of a circle. It is the most commonly used. The radius of the circle determines the "sharpness" or "flatness" of the curve. The larger the radius, the "flatter" the curve.

Compound

Surveyors often have to use a compound curve because of the terrain. This curve normally consists of two simple curves curving in the same direction and joined together.



SIMPLE CURVE

COMPOUND CURVE

Figure 3-1. Horizontal curves

Laying Out Curve from PT

If a setup on the curve has been made and it is still impossible to set all the remaining stations due to some obstruction, the surveyor can "back in" the remainder of the curve from the PT. Although this procedure has been set up as a method to avoid obstructions, it is widely used for laying out curves. When using the "backing in method," the surveyor sets approximately one half the curve stations from the PC and the remainder from the PT. With this method, any error in the curve is in its center where it is less noticeable.

Road Curves to Right. Occupy the PT, and sight the PI with one half of the I angle on the horizontal circle. The instrument is now oriented so that if the PC is sighted, the instrument will read 0°00'.

The remaining stations can be set by using their deflections and chord distances from the PC or in their reverse order from the PT.

Road Curves to Left. Occupy the PT and sight the PI with 360 degrees minus one half of the I angle on the horizontal circle. The instrument should read 0° 00' if the PC is sighted.

Set the remaining stations by using their deflections and chord distances as if computed from the PC or by computing the deflections in reverse order from the PT.

CHORD CORRECTIONS

Frequently, the surveyor must lay out curves more precisely than is possible by using the chord lengths previously described.

To eliminate the discrepancy between chord and arc lengths, the chords must be corrected using the values taken from the nomography in table A-11. This gives the corrections to be applied if the curve was computed by the arc definition.

Table A-10 gives the corrections to be applied if the curve was computed by the chord definition. The surveyor should recall that the length of a curve computed by the chord definition was the length along the chords. Figure 3-5 illustrates the example given in table A-9. The chord distance from station 18+00 to station 19+00 is 100 feet. The nominal length of the subchords is 50 feet.

INTERMEDIATE STAKE

If the surveyor desires to place a stake at station 18+50, a correction must be applied to the chord since the distance from 18+00 through 18+50 to 19+00 is greater than the chord from 18+00 to 19+00. Therefore, a correction must be applied to the subchords to keep station 19+00 100 feet from 18+00. In figure 3-5, if the chord length is nominally 50 feet, then the correction is 0.19 feet. The chord distance from 18+00 to 18+50 and 18+50 to 19+00 would be 50.19.

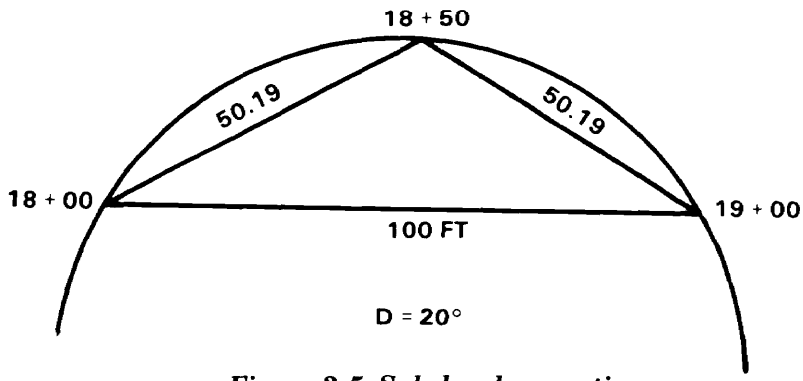


Figure 3-5. Subchord corrections

Section II. OBSTACLES TO CURVE LOCATION

TERRAIN RESTRICTIONS

To solve a simple curve, the surveyor must know three parts. Normally, these will be the PI, I angle, and degree of curve. Sometimes, however, the terrain features limit the size of various elements of the curve. If this happens, the surveyor must determine the degree of curve from the limiting factor.

Inaccessible PI

Under certain conditions, it may be impossible or impractical to occupy the PI. In this case, the surveyor locates the curve elements by using the following steps (figure 3-6).

(1) Mark two intervisible points A and B, one on each of the tangents, so that line AB (a random line connecting the tangents) will clear the obstruction.

(2) Measure angles a and b by setting up at both A and B.

(3) Measure the distance AB.

(4) Compute inaccessible distances AV and BV as follows:

$$I = a + b$$

$$K = 180° - I$$

$$AV = \frac{AB \sin b}{\sin K}$$

$$BV = \frac{AB \sin a}{\sin K}$$

$$PI = Sta\ A + AV$$

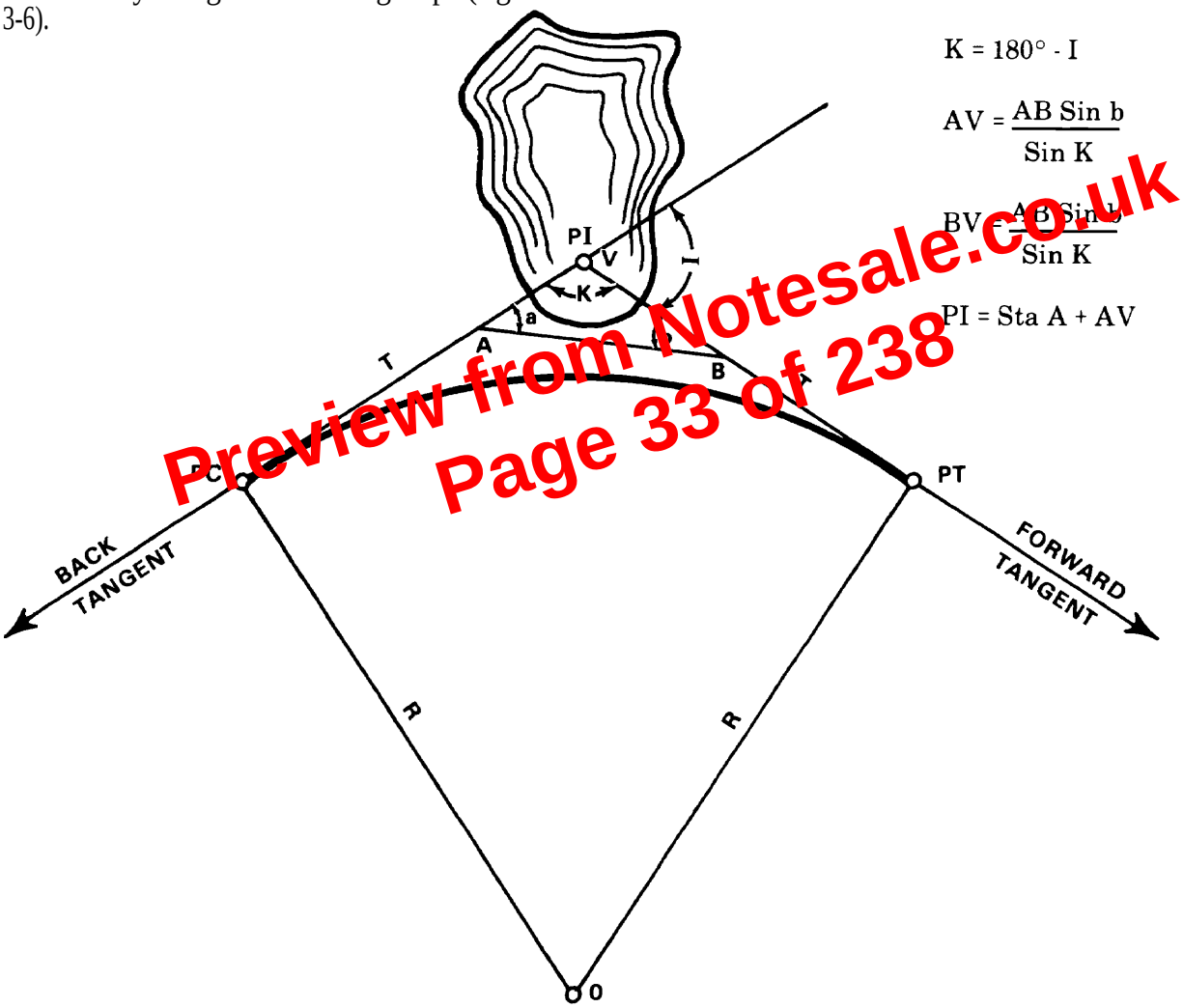
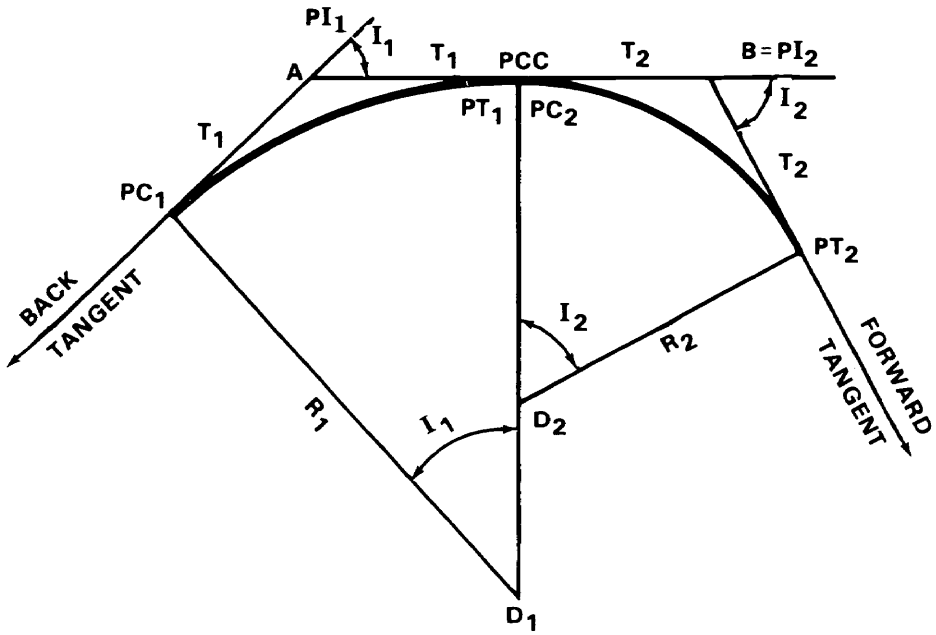
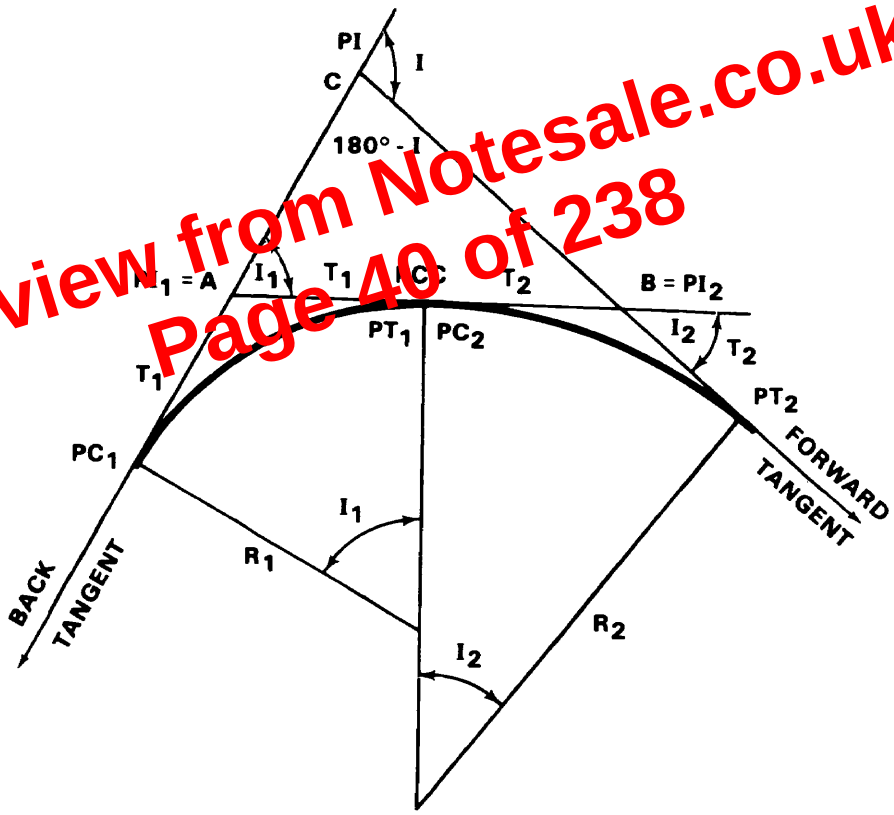


Figure 3-6. Inaccessible PI



a. BETWEEN SUCCESSIVE PIs



b. BETWEEN SUCCESSIVE TANGENTS

Figure 3-11. Compound curves

The stripper shown is 5 squares wide by 60 squares long. Its zero index is placed at the intersection of the ground and side-slope line of the section.

The stripper is moved an interval of 5 squares to the right with zero reading at the bottom. It is then moved another 5 squares to the right with the previous top reading (2.5) now adjacent to the bottom line. The stripper is again moved 5 squares to the right for another interval with the previous top reading (6.0) adjacent to the bottom line.

This process of moving 5 squares to the right and bringing the top reading to the bottom line is continued until the stripper reaches the right edge of the cross section with a final reading of 53.0. Multiply this last reading (53.0) by the strip width used (5) to get the number of squares in the section (265.0). To find the area of the cross section in square feet, multiply the number of squares by the area in square feet of one square.

Double-Meridian-Distance Method

The double-meridian-distance (DMD) method gives a more precise value for a cross-section area than the stripper method. It does, however, involve more effort and time. It is essential that the elevations (latitudes) and the distance from the centerline (departures) of all points on the cross section be known.

The method is based on the theory that the area of a right triangle equals one half of the product of the two sides. Since latitudes and departures are at right angles to each other, the area bounded by the distance, the latitude, and the departure is a right angle. The surveyor can determine this area by taking one half of the product of the latitude and the departure. However, depending on its location, the triangle may add to or subtract from the total area of the irregular figure.

To avoid determining a plus or minus area for each triangle, a slight refinement is made. The departure is added twice. It is first added when determining the DMD of the course and second, when determining the next course's DMD. Multiplying the DMD of each course by its latitude results in twice the area, but the sign of this product illustrates whether the area adds to or subtracts from the figure area.

A step-by-step procedure to work out a DMD area is given below and illustrated in figure 4-5.

(1) Compute and record all the latitudes and departures.

(2) Select the far left station (D) as the first point and D-E as the first course to avoid negative areas in the DMD.

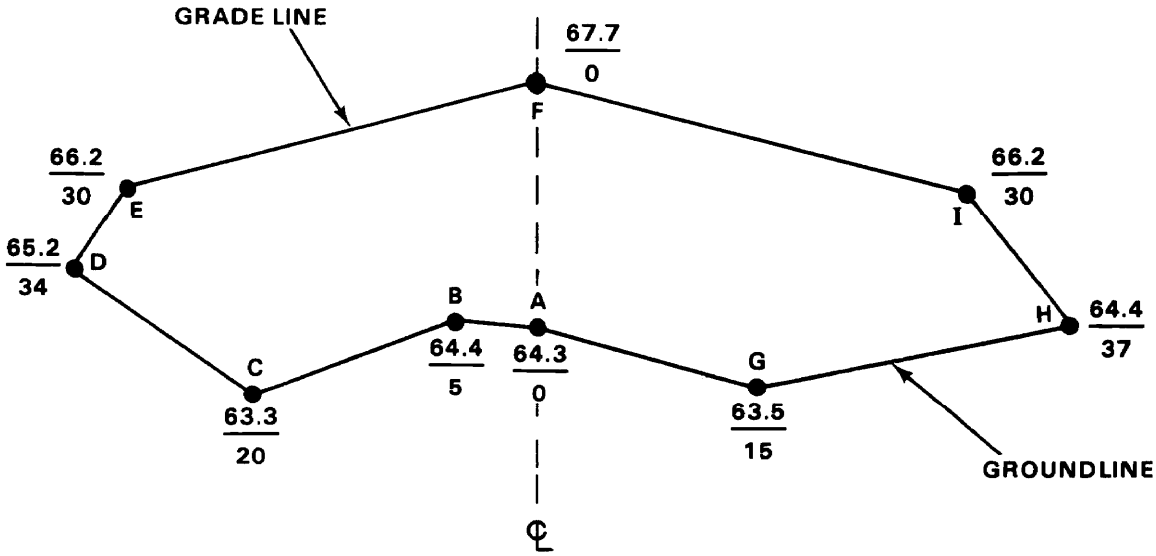
(3) The DMD of the first course equals the departure of the course itself, 4.0.

(4) The DMD of any other course (E-F) equals the DMD of the preceding course (D-E) plus the departure of the preceding course (D-E) and the departure of the course (E-F) itself or 4.0 + 4.0 + 30,0 = 38.0. For the next course (F-I), the same procedure is followed. Add together the DMD of the preceding course, the departure of the preceding course, and the departure of the course itself, or 38.0 + 30.0 + 30.0 = 98.0.

(5) The DMD of the last course is numerically equal to its departure but with the opposite sign (+14.0).

(6) Multiply each DMD value by its latitude. Positive products are entered under north double areas and negative products under south double areas.

(7) The sum of all north double areas minus the sum of all the south double areas, DISREGARDING THE SIGNS, equals twice the cross-section areas. Divide this double area by 2 to get the true cross-section area.



COURSE	LATITUDE	DEPARTURE	D.M.D.	NORTH Double Area (+)	South Double Area (−)
D-E	+1.0	+4.0	4.0	4.0	
E-F	+1.5	+38.0	38.0	57.0	
F-I	-1.5	+98.0	98.0		147.0
I-H	-1.8	+135.0	135.0		243.0
H-G	-0.9	-120.0	120.0		108.0
G-A	+0.8	-15.0	83.0	66.4	
A-B	+0.1	-5.0	63.0	6.3	
B-C	-1.1	-15.0	43.0		47.3
C-D	+1.9	-14.0	14.0	26.6	
				+160.3	-545.3

Difference = 545.3 − 160.3 = 385.0

Area: $385.0/2 = 192.5\ ft^2$

Figure 4-5. Cross-section area by double-meridian-distance method

Procedures

The following are rules for using a planimeter,

- Always measure cut and fill areas separately.
- Check the accuracy of the planimeter as a measuring device to guard against errors due to temperature changes and other noncompensating factors. A simple method of testing its consistency of operation is to trace an area of 1 square inch with the arm set for a 1:1 ratio. The disk, drum, and vernier combined should read 1.000 for this area.
- Before measuring a specific area, determine the scale of the plot and set the adjustable arm of the planimeter according to the chart in the planimeter case. Check the setting by carefully tracing a known area, such as five large squares on the cross-section paper, and verifying the reading on the disk, drum, and vernier. If the reading is inconsistent with the known area, readjust the arm settings until a satisfactory reading is obtained.
- To measure an area, set the anchor point of the adjusted planimeter at a convenient position outside the plotted area; place the tracing point on a selected point on the perimeter of the cross section; take an initial reading from the disk, drum, and vernier; continue tracing the perimeter clockwise, keeping the tracing point carefully on the line being followed; and when the tracing point closes on the initial point, again take a reading from the disk, drum, and vernier. The difference between the initial reading and the final reading gives a value proportional to the area being traced.
- Make two independent measurements of the area to insure accurate results. Make the second measurement with the tracing point placed at a point on the opposite side of the first measurement. This procedure gives two compensating readings. The mean of these readings is more accurate than either one individually.
- To measure plotted areas larger than the capacity of the planimeter, divide the areas into sections and measure each separately.

Section III. EARTH AND ROCK EXCAVATION

CLASSES OF EXCAVATED MATERIAL

Excavated material is usually classified as common excavation, loose rock, and solid rock. Although classifying excavation material is not a survey function, the surveyor must differentiate among the different types so excavation records will match the construction work. When performing surveys to determine quantities of excavated materials, the surveyor must record common excavation, loose-rock excavation, and solid-rock excavation data separately in the field notes.

Common excavation involves the moving of earth or of earth with detached boulders less than one-half cubic yard in volume. Loose-rock excavation involves the moving of consolidated materials which have been loosened without blasting with picks, bars, or simple air and mechanical devices. Solid-rock excavation involves the moving of rock from solid beds or the breaking up of boulders measuring 1 cubic yard or more by means of explosives.

Figure 4-7. Typical grid layout for borrow pits

each corner. These are selected to bring all crosspieces to the same elevation.

(2) The surveyor marks these stakes at the grade of the top of the foundation or at some whole number of inches or feet above or below the top of the foundation. Use a level to mark the same grade or elevation on all stakes.

(3) Nail 1- by 6-inch boards to the stakes to the top edge of the boards and flush with the grade marks. Mark the distance in crayon on these boards.

(4) Locate the prolongation of the building lines on the batter boards by using an instrument or a line and plumb bob.

(5) Drive nails into the top edges of the batter boards to mark the building line.

INTERIOR TRANSFER OF LINE AND GRADE

Occasionally, it is necessary to transfer lines and grades from outside to inside a building and to the upper stories for establishing wall faces, floor levels, and columns or for setting machinery precisely. The surveyor does this by traversing and leveling.

Location

The surveyor locates instrument stations outside of the building to establish a line that, when extended, will intersect the building at a window or doorway. The instrument is set on the station farthest from the building and sighted on the point nearest the building. The surveyor transfers the line to the building by sighting the instrument on a plumb bob held in an upper-story window.

From this point, the line is extended in any direction inside the building by setting up on the point and using the outside stations as a backsight. The line is prolonged by double centering. Because of the short sights used, the surveyor may accurately set an angle that is to be turned to clear an obstruction and then measure by repetition.

Direct Leveling

To transfer vertical control into a building, the surveyor uses direct leveling, if possible. For elevation transfer to an upper story, a steel tape is suspended with a weight attached to the lower or zero end. To insure accuracy, the weight should approximately equal the normal tension of the fully supported tape minus one half of the weight of the suspended portion of the tape. A level is set up on the first floor, and a reading is taken on the suspended tape.

Another reading is taken on the tape with a level set on the upper floor. This gives data from which the HI of the instrument on the upper floor are computed. A rod is now held on some point on the upper floor to be used as a benchmark and its elevation determined. The surveyor may also establish elevations on the second floor by using the rod upside down (often called an inverted rod) and marking the elevation on a wall.

Section II. UTILITIES LAYOUT

DRAINAGE

Utilities drainage refers to the sewer systems for surface water and liquid waste. The design and location of a drainage or storm sewer system will depend upon the size and topography of the area to be drained, the intensity of rainfall expected, the runoff characteristics of the area, and the location of the disposal point. The area to be drained includes the installation and any area around it that will drain into the installation. The intensity of the rainfall in inches per hour is based on records of past storms. The runoff characteristics are determined by the type of soil and ground cover.

$$\text{Linear Error (eL)} = \sqrt{(eN)^2 + (eE)^2}$$

$$eL = \sqrt{(-0.09)^2 + (-0.05)^2}$$

$$eL = \sqrt{0.0106} = 0.1029$$

Allowable Error

The surveyor then computes the allowable error (AE) using the appropriate accuracy ratio (1/5,000 or 1/3,000) and the total length of the traverse.

$$\frac{1}{5{,}000} :: \frac{AE}{\text{Length of Traverse}}$$

$$AE = \frac{1 \times \text{Length of Traverse}}{5{,}000}$$

$$AE = \frac{1 \times 1901.26}{5{,}000} = 0.3802$$

Compare this to the linear error of closure. If the AE is greater than the eL, the traverse is good and can be adjusted. If it is not good, it must be rerun.

Ratio of Accuracy

The ratio of accuracy provides a method of determining the traverse accuracy and comparing it to established standards. The ratio of accuracy is the ratio of the eL to the total length of the traverse, after it is reduced to a common ratio and rounded down.

$$\frac{eL}{\text{Total Length}} = \frac{0.1029}{1{,}901.26} = \frac{0.1029 \div 0.1029}{1{,}901.26 \div 0.1029}$$

$$= \frac{1}{18{,}476.77} \text{ or } \frac{1}{18{,}000}$$

If the accuracy ratio does not fall within allowable limits, the traverse must be rerun. It is very possible that the distances as measured are correct and that the error can be attributed to large, compensating angular errors.

COORDINATE ADJUSTMENT

The surveyor makes the adjustment of the traverse using the compass rule. The compass rule says that, for any leg of the traverse, the correction to be given to the dN or dE is to the total correction for dN or dE as the length of the leg is to the total length of the traverse. The total correction for dN or dE is numerically equal to the eN or eE, but with the opposite sign.

Formulas

In figure 7-7, the dN is -0.09 and the dE is -0.05 and the total corrections are +0.09 and +0.05, respectively. Note the following formulas:

dN Correction per station =

$$\frac{\text{Total dN Correction} \times \text{Distance to Station}}{\text{Length of Traverse}}$$

dE Correction per station =

$$\frac{\text{Total dE Correction} \times \text{Distance to Station}}{\text{Length of Traverse}}$$

For the first leg in the traverse in figure 7-7, the corrections are computed as follows:

$$\text{dN Correction} = \frac{+0.09}{1{,}901.26} \times 568.78 = +0.03$$

$$\text{dE Correction} = \frac{+0.05}{1{,}901.26} \times 568.78 = +0.01$$

Loop Traverse

When adjusting a loop traverse, the surveyor applies the correction to the dNs and dEs prior to computing the coordinates. The total correction must equal the total error. Sometimes, due to round off, the total

correction will not equal the total error. If this happens and the difference is one, reduce the correction to the shortest line or increase the longest line. When the error is greater than one, you may arbitrarily reduce/increase the corrections until the total correction equals the total error.

The coordinate of the previous station ±dN± correction equals the coordinate of the next station. From figure 7-7, you compute as follows:

Sta A	7,486.79	5,497.53
	+ 192.19	+ 535.35
Sta B	7,678.98	6,032.88

When adjusting a traverse that starts and ends on two different stations, the surveyor computes the coordinates before the error is determined. In this case, the correction per leg is determined in the same manner as shown, but the correction is applied directly to the coordinates. The correction to be applied after the first leg is equal to the correction computed for the first leg. The correction to be applied after the second leg is equal to the correction for the first leg plus the correction computed for the second leg. The correction for the third leg equals the first correction plus the second correction plus the correction computed for the third leg and so on throughout the traverse. The last correction must be equal to the total correction required.

DESIGNATION _____ DATE _____ 19___

STA	FIELD ANGLE	CORRECTION +/-	ADJUSTED ANGLE	ADJUSTED AZIMUTH	DISTANCE FEET
A-Az				120°00'00"	
A	310°15'	+15"	310°15'15"		
A-B				70°15'15"	5[illegible]
B-A				2[illegible]15'15"	
B	270°57'	+15"	270°57'15"		
B-C				[illegible]	[illegible]14
C-B				341°12'30"	
C	313°28'	+15"	313°28'15"		
C-A				299°40'45"	783.74
A-C				119°40'45"	
A	5°19'	+15"	5°19'15"		
A-Az				120°00'00"	
TOTAL		+60"			1901.26

LATITUDE dN	CORRECTION +/-	NORTHING	DEPARTURE dE	CORRECTION +/-	EASTING
		7486.79			5497.53
+192.16	+0.03	7[illegible].19	+535.34	+0.01	+535.35
	2	7678.98			6032.88
-519.49	+0.03	-519.47	+176.76	+0.01	+176.77
		7159.51		3	6209.65
+327.24	+0.04	+327.28	-712.15	+0.02	-712.12
		7486.79			5497.53
-0.09	+0.09		-0.05	+0.05	

Figure 7-7. Traverse computation of a loop traverse

Table A-1. Natural trigonometric functions (continued)

3°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00′	0.052 336	4.83	0.052 408	4.85	19.0811	17.60	0.998 630	.27	60′
01	.052 626	4.85	.052 699	4.87	18.9755	17.40	.998 614	.25	59
02	.052 917	4.83	.052 991	4.87	18.8711	17.22	.998 599	.27	58
03	.053 207	4.85	.053 283	4.87	18.7678	17.03	.998 583	.25	57
04	.053 498	4.83	.053 575	4.85	18.6656	16.85	.998 568	.27	56
05	.053 788	4.85	.053 866	4.87	18.5645	16.66	.998 552	.25	55
06	.054 079	4.83	.054 158	4.87	18.4645	16.50	.988 537	.27	54
07	.054 369	4.85	.054 450	4.87	18.3655	16.30	.998 521	.27	53
08	.054 660	4.83	.054 742	4.85	18.2677	16.15	.998 505	.27	52
09	.054 950	4.85	.055 033	4.87	18.1708	15.97	.998 489	.27	51
10	0.055 241	4.83	0.055 325	4.87	18.0750	15.80	0.998 473	.27	50
11	.055 501	4.85	.055 617	4.87	17.9802	15.65	.998 457	.27	49
12	.055 822	4.83	.055 909	4.85	17.8863	15.48	.998 441	.28	48
13	.056 112	4.83	.056 200	4.87	17.7934	15.32	.998 424	.27	47
14	.056 402	4.85	.056 492	4.87	17.7015	15.15	.998 408	.27	46
15	.056 693	4.83	.056 784	4.87	17.6106	15.02	.998 392	.28	45
16	.056 983	4.85	.057 076	4.87	17.5205	14.85	.998 375	.27	44
17	.057 274	4.83	.057 368	4.87	17.4314	14.70	.998 359	.28	43
18	.057 564	4.83	.057 660	4.85	17.3432	14.57	.998 342	.28	42
19	.057 854	4.85	.057 951	4.87	17.2558	14.42	.998 325	.28	41
20	0.058 145	4.83	0.058 243	4.87	17.1693	14.27	0.998 308	.28	40
21	.058 435	4.85	.058 535	4.87	17.0837	14.12	.998 291	.28	39
22	.058 726	4.83	.058 827	4.87	16.9990	14.00	.998 274	.28	38
23	.059 016	4.83	.059 119	4.87	16.9150	13.85	.998 257	.28	37
24	.059 306	4.85	.059 411	4.87	16.8319	13.72	.998 240	.28	36
25	.059 597	4.83	.059 703	4.87	16.7496	13.58	.998 223	.30	35
26	.059 887	4.83	.059 995	4.87	16.6681	13.45	.998 205	.28	34
27	.060 177	4.85	.060 287	4.87	16.5874	13.32	.998 188	.30	33
28	.060 468	4.83	.060 579	4.87	16.5075	13.20	.998 170	.28	32
29	.060 758	4.85	.060 871	4.87	16.4283	13.08	.998 153	.30	31
30	0.061 049	4.83	0.061 163	4.87	16.3499	12.95	0.998 135	.30	30
31	.061 339	4.83	.061 455	4.87	16.2722	12.83	.998 117	.30	29
32	.061 629	4.85	.061 747	4.87	16.1952	12.70	.998 099	.30	28
33	.061 920	4.83	.062 039	4.87	16.1191	12.58	.998 081	.30	27
34	.062 210	4.83	.062 331	4.87	16.0437	12.47	.998 063	.30	26
35	.062 500	4.85	.062 623	4.87	15.9687	12.37	.998 045	.30	25
36	.062 791	4.83	.062 915	4.87	15.8945	12.23	.998 027	.32	24
37	.063 081	4.83	.063 207	4.87	15.8211	12.13	.998 008	.30	23
38	.063 371	4.83	.063 499	4.87	15.7483	12.02	.997 990	.30	22
39	.063 661	4.85	.063 791	4.87	15.6762	11.90	.997 972	.32	21
40	0.063 952	4.83	0.064 083	4.87	15.6048	11.80	0.997 953	.32	20
41	.064 242	4.83	.064 375	4.87	15.5340	11.70	.997 934	.30	19
42	.064 532	4.85	.064 667	4.87	15.4638	11.58	.997 916	.32	18
43	.064 823	4.83	.064 959	4.87	15.3943	11.48	.997 897	.32	17
44	.065 113	4.83	.065 251	4.87	15.3254	11.38	.997 878	.32	16
45	.065 403	4.83	.065 543	4.88	15.2571	11.30	.997 859	.32	15
46	.065 693	4.85	.065 836	4.87	15.1893	11.18	.997 840	.32	14
47	.065 984	4.83	.066 128	4.87	15.1222	11.08	.997 821	.33	13
48	.066 274	4.83	.066 420	4.87	15.0557	10.98	.997 801	.32	12
49	.066 564	4.83	.066 712	4.87	14.9898	10.90	.997 782	.32	11
50	0.066 854	4.85	0.067 004	4.87	14.9244	10.80	0.997 763	.33	10
51	.067 145	4.83	.067 296	4.88	14.8596	10.70	.997 743	.32	09
52	.067 435	4.83	.067 589	4.87	14.7954	10.62	.997 724	.33	08
53	.067 725	4.83	.067 881	4.87	14.7317	10.53	.997 704	.33	07
54	.068 015	4.83	.068 173	4.87	14.6685	10.43	.997 684	.33	06
55	.068 306	4.83	.068 465	4.88	14.6059	10.35	.997 665	.32	05
56	.068 596	4.83	.068 758	4.87	14.5438	10.25	.997 645	.33	04
57	.068 886	4.83	.069 050	4.87	14.4823	10.18	.997 625	.33	03
58	.069 176	4.83	.069 342	4.88	14.4212	10.08	.997 604	.35	02
59	.069 466	4.83	.069 635	4.87	14.3607	10.00	.997 584	.33	01
60	0.069 756		0.069 927		14.3007		0.997 564		00
	Cos	d."	Cot	d."	Tan	d."	Sin	d."	

Table A-1. Natural trigonometric functions (continued)

14°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00'	0.241 922	4.70	0.249 328	5.15	4.010 78	8.27	0.970 296	1.18	60
01	.242 204	4.70	.249 637	5.15	.005 82	8.27	.970 225	1.17	59
02	.242 486	4.72	.249 946	5.15	.000 86	8.23	.970 155	1.18	58
03	.242 769	4.70	.250 255	5.15	3.995 92	8.22	.970 084	1.17	57
04	.243 051	4.70	.250 564	5.15	.990 99	8.20	.970 014	1.18	56
05	.243 333	4.70	.250 873	5.17	.986 07	8.17	.969 943	1.18	55
06	.243 615	4.70	.251 183	5.15	.981 17	8.17	.969 872	1.18	54
07	.243 897	4.70	.251 492	5.15	.976 27	8.13	.969 801	1.18	53
08	.244 179	4.70	.251 801	5.17	.971 39	8.13	.969 730	1.18	52
09	.244 461	4.70	.252 111	5.15	.966 51	8.10	.969 659	1.18	51
10	0.244 743	4.70	0.252 420	5.15	3.961 65	8.08	0.969 588	1.18	50
11	.245 025	4.70	.252 729	5.17	.956 80	8.07	.969 517	1.20	49
12	.245 307	4.70	.253 039	5.15	.951 96	8.05	.969 445	1.18	48
13	.245 589	4.70	.253 348	5.17	.947 13	8.02	.969 374	1.20	47
14	.245 871	4.70	.253 658	5.17	.942 32	8.02	.969 302	1.18	46
15	.246 153	4.70	.253 968	5.15	.937 51	8.00	.969 231	1.20	45
16	.246 435	4.70	.254 277	5.17	.932 71	7.97	.969 159	1.18	44
17	.246 717	4.70	.254 587	5.17	.927 93	7.95	.969 088	1.20	43
18	.246 999	4.70	.254 897	5.17	.923 16	7.95	.969 016	1.20	42
19	.247 281	4.70	.255 207	5.15	.918 39	7.92	.968 944	1.20	41
20	0.247 563	4.70	0.255 516	5.17	3.913 64	7.90	0.968 872	1.20	40
21	.247 845	4.68	.255 826	5.17	.908 90	7.88	.968 800	1.20	39
22	.248 126	4.70	.256 136	5.17	.904 17	7.87	.968 728	1.22	38
23	.248 408	4.70	.256 446	5.17	.899 45	7.85	.968 655	1.20	37
24	.248 690	4.70	.256 756	5.17	.894 74	7.83	.968 583	1.20	36
25	.248 972	4.68	.257 066	5.18	.890 04	7.80	.968 511	1.22	35
26	.249 253	4.70	.257 377	5.17	.885 36	7.80	.968 438	1.20	34
27	.249 535	4.70	.257 687	5.17	.880 68	7.78	.968 366	1.22	33
28	.249 817	4.68	.257 997	5.17	.876 01	7.75	.968 293	1.22	32
29	.250 098	4.70	.258 307	5.18	.871 36	7.75	.968 220	1.20	31
30	0.250 380	4.70	0.258 618	5.17	3.866 71	7.72	0.968 148	1.22	30
31	.250 662	4.68	.258 928	5.17	.862 08	7.72	.968 075	1.22	29
32	.250 943	4.70	.259 238	5.18	.857 45	7.68	.968 002	1.22	28
33	.251 225	4.68	.259 549	5.17	.852 84	7.67	.967 929	1.22	27
34	.251 506	4.70	.259 859	5.18	.848 24	7.67	.967 856	1.23	26
35	.251 788	4.68	.260 170	5.17	.843 64	7.63	.967 782	1.22	25
36	.252 069	4.70	.260 480	5.18	.839 06	7.62	.967 709	1.22	24
37	.252 351	4.68	.260 791	5.18	.834 49	7.62	.967 636	1.23	23
38	.252 632	4.70	.261 102	5.18	.829 92	7.58	.967 562	1.22	22
39	.252 914	4.68	.261 413	5.17	.825 37	7.57	.967 489	1.23	21
40	0.253 195	4.70	0.261 723	5.18	3.820 83	7.55	0.967 415	1.22	20
41	.253 477	4.68	.262 034	5.18	.816 30	7.55	.967 342	1.23	19
42	.253 758	4.68	.262 345	5.18	.811 77	7.52	.967 268	1.23	18
43	.254 039	4.70	.262 656	5.18	.807 26	7.50	.967 194	1.23	17
44	.254 321	4.68	.262 967	5.18	.802 76	7.48	.967 120	1.23	16
45	.254 602	4.68	.263 278	5.18	.798 27	7.48	.967 046	1.23	15
46	.254 883	4.70	.263 589	5.18	.793 78	7.45	.966 972	1.23	14
47	.255 165	4.68	.263 900	5.18	.789 31	7.43	.966 898	1.25	13
48	.255 446	4.68	.264 211	5.20	.784 85	7.42	.966 823	1.23	12
49	.255 727	4.68	.264 523	5.18	.780 40	7.42	.966 749	1.23	11
50	0.256 008	4.68	0.264 834	5.18	3.775 95	7.38	0.966 675	1.25	10
51	.256 289	4.70	.265 145	5.20	.771 52	7.38	.966 600	1.23	09
52	.256 571	4.68	.265 457	5.18	.767 09	7.35	.966 526	1.25	08
53	.256 852	4.68	.265 768	5.18	.762 68	7.33	.966 451	1.25	07
54	.257 133	4.68	.266 079	5.20	.758 28	7.33	.966 376	1.25	06
55	.257 414	4.68	.266 391	5.18	.753 88	7.30	.966 301	1.25	05
56	.257 695	4.68	.266 702	5.20	.749 50	7.30	.966 226	1.25	04
57	.257 976	4.68	.267 014	5.20	.745 12	7.28	.966 151	1.25	03
58	.258 257	4.68	.267 326	5.18	.740 75	7.25	.966 076	1.25	02
59	.258 538	4.68	.267 637	5.20	.736 40	7.25	.966 001	1.25	01
60	0.258 819		0.267 949		3.732 05		0.965 926		00
	Sin	d."	Tan	d."	Cot	d."	Cos	d."	

Table A-1. Natural trigonometric functions (continued)

15°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00′	0.258 819	4.68	0.267 949	5.20	3.732 05	7.23	0.965 926	1.27	60′
01	.259 100	4.68	.268 261	5.20	.727 71	7.22	.965 850	1.25	59
02	.259 381	4.68	.268 573	5.20	.723 38	7.18	.965 775	1.25	58
03	.259 662	4.68	.268 885	5.20	.719 07	7.18	.965 700	1.27	57
04	.259 943	4.68	.269 197	5.20	.714 76	7.17	.965 624	1.27	56
05	.260 224	4.68	.269 509	5.20	.710 46	7.17	.965 548	1.25	55
06	.260 505	4.67	.269 821	5.20	.706 16	7.13	.965 473	1.27	54
07	.260 785	4.68	.270 133	5.20	.701 88	7.12	.965 397	1.27	53
08	.261 066	4.68	.270 445	5.20	.697 61	7.10	.965 321	1.27	52
09	.261 347	4.68	.270 757	5.20	.693 35	7.10	.965 245	1.27	51
10	0.261 628	4.67	0.271 069	5.22	3.689 09	7.07	0.965 169	1.27	50
11	.261 908	4.68	.271 382	5.20	.684 85	7.07	.965 093	1.28	49
12	.262 189	4.68	.271 694	5.20	.680 61	7.05	.965 016	1.27	48
13	.262 470	4.68	.272 006	5.22	.676 38	7.02	.964 940	1.27	47
14	.262 751	4.67	.272 319	5.20	.672 17	7.02	.964 864	1.28	46
15	.263 031	4.68	.272 631	5.22	.667 96	7.00	.964 787	1.27	45
16	.263 312	4.67	.272 944	5.20	.663 76	6.98	.964 711	1.28	44
17	.263 592	4.68	.273 256	5.22	.659 57	6.98	.964 634	1.28	43
18	.263 873	4.68	.273 569	5.22	.655 38	6.95	.964 557	1.27	42
19	.264 154	4.67	.273 882	5.20	.651 21	6.93	.964 481	1.28	41
20	0.264 434	4.68	0.274 194	5.22	3.647 05	6.93	0.964 404	1.28	40
21	.264 715	4.67	.274 507	5.22	.642 89	6.92	.964 327	1.28	39
22	.264 995	4.68	.274 820	5.22	.638 74	6.88	.964 250	1.28	38
23	.265 276	4.67	.275 133	5.22	.634 61	6.88	.964 173	1.30	37
24	.265 556	4.68	.275 446	5.22	.630 48	6.87	.964 095	1.28	36
25	.265 837	4.67	.275 759	5.22	.626 36	6.87	.964 018	1.28	35
26	.266 117	4.67	.276 072	5.22	.622 24	6.83	.963 94	1.30	34
27	.266 397	4.68	.276 385	5.22	.618 14	6.82	.963 863	1.28	33
28	.266 678	4.67	.276 698	5.22	.614 05	6.8	.963 786	1.30	32
29	.266 958	4.67	.277 011	5.23	.609 96	6.80	.963 708	1.30	31
30	0.267 238	4.68	0.277 325	5.22	3.605 88	6.78	0.963 630	1.28	30
31	.267 519	4.67	.277 638	5.22	.601 81	6.77	.963 553	1.30	29
32	.267 799	4.67	.277 95	5.23	.597 75	6.75	.963 475	1.30	28
33	.268 079	4.67	.278 265	5.22	.593 7	6.73	.963 397	1.30	27
34	.268 359	4.68	.278 578	5.22	.589 66	6.73	.963 319	1.30	26
35	.268 640	4.67	.278 891	5.22	.585 62	6.70	.963 241	1.30	25
36	.268 92	4.67	.279 205	5.23	.581 60	6.70	.963 163	1.32	24
37	.269 200	4.67	.279 51	5.22	.577 58	6.68	.963 084	1.30	23
38	.269 480	4.67	.279 832	5.23	.573 57	6.67	.963 006	1.30	22
39	.269 760	4.67	.280 146	5.23	.569 57	6.67	.962 928	1.32	21
40	0.270 040	4.67	0.280 460	5.22	3.565 57	6.63	0.962 849	1.32	20
41	.270 320	4.67	.280 773	5.23	.561 59	6.63	.962 770	1.30	19
42	.270 600	4.67	.281 087	5.23	.557 61	6.62	.962 692	1.32	18
43	.270 880	4.67	.281 401	5.23	.553 64	6.60	.962 613	1.32	17
44	.271 160	4.67	.281 715	5.23	.549 68	6.58	.962 534	1.32	16
45	.271 440	4.67	.282 029	5.23	.545 73	6.57	.962 455	1.32	15
46	.271 720	4.67	.282 343	5.23	.541 79	6.57	.962 376	1.32	14
47	.272 000	4.67	.282 657	5.23	.537 85	6.53	.962 297	1.32	13
48	.272 280	4.67	.282 971	5.25	.533 93	6.53	.962 218	1.32	12
49	.272 560	4.67	.283 286	5.23	.530 01	6.53	.962 139	1.33	11
50	0.272 840	4.67	0.283 600	5.23	3.526 09	6.50	0.962 059	1.32	10
51	.273 120	4.67	.283 914	5.25	.522 19	6.50	.961 980	1.32	09
52	.273 400	4.65	.284 229	5.23	.518 29	6.47	.961 901	1.33	08
53	.273 679	4.67	.284 543	5.23	.514 41	6.47	.961 821	1.33	07
54	.273 959	4.67	.284 857	5.25	.510 53	6.45	.961 741	1.32	06
55	.274 239	4.67	.285 172	5.25	.506 66	6.45	.961 662	1.33	05
56	.274 519	4.65	.285 487	5.23	.502 79	6.42	.961 582	1.33	04
57	.274 798	4.67	.285 801	5.25	.498 94	6.42	.961 502	1.33	03
58	.275 078	4.67	.286 116	5.25	.495 09	6.40	.961 422	1.33	02
59	.275 358	4.65	.286 431	5.23	.491 25	6.40	.961 342	1.33	01
60	0.275 637		0.286 745		3.487 41		0.961 262		00
	Sin	d."	Tan	d."	Cot	d."	Cos	d."	

Table A-1. Natural trigonometric functions (continued)

21°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00'	0.358 368	4.53	0.383 864	5.57	2.605 089	37.72	0.933 580	1.73	60'
01	.358 640	4.52	.384 198	5.57	.602 826	37.67	.933 476	1.73	59
02	.358 911	4.53	.384 532	5.57	.600 566	37.62	.933 372	1.75	58
03	.359 183	4.52	.384 866	5.57	.598 309	37.55	.933 267	1.73	57
04	.359 454	4.52	.385 200	5.57	.596 056	37.48	.933 168	1.75	56
05	.359 725	4.52	.385 534	5.57	.593 807	37.43	.933 058	1.73	55
06	.359 997	4.52	.385 868	5.57	.591 561	37.38	.932 954	1.75	54
07	.360 268	4.53	.386 202	5.57	.589 318	37.33	.932 849	1.75	53
08	.360 540	4.52	.386 536	5.58	.587 078	37.27	.932 744	1.75	52
09	.360 811	4.52	.386 871	5.57	.584 842	37.22	.932 639	1.75	51
10	0.361 082	4.52	0.387 205	5.58	2.582 609	37.15	.932 534	1.75	50
11	.361 353	4.53	.387 540	5.57	.580 380	37.10	.932 429	1.75	49
12	.361 625	4.52	.387 874	5.58	.578 154	37.05	.932 324	1.75	48
13	.361 896	4.52	.388 209	5.58	.575 931	36.98	.932 219	1.77	47
14	.362 167	4.52	.388 544	5.58	.573 712	36.93	.932 113	1.75	46
15	.362 438	4.52	.388 879	5.58	.571 496	36.88	.932 008	1.77	45
16	.362 709	4.52	.389 214	5.58	.569 283	36.82	.931 902	1.75	44
17	.362 980	4.52	.389 549	5.58	.567 074	36.78	.931 797	1.77	43
18	.363 251	4.52	.389 884	5.58	.564 867	36.70	.931 691	1.75	42
19	.363 522	4.52	.390 219	5.58	.562 665	36.67	.931 586	1.77	41
20	0.363 793	4.52	0.390 554	5.58	2.560 465	36.60	0.931 480	1.77	40
21	.364 064	4.52	.390 889	5.60	.558 269	36.55	.931 374	1.77	39
22	.364 335	4.52	.391 225	5.58	.556 076	36.50	.931 268	1.77	38
23	.364 606	4.52	.391 560	5.60	.553 886	36.45	.931 162	1.77	37
24	.364 877	4.52	.391 896	5.58	.551 699	36.38	.931 056	1.78	36
25	.365 148	4.50	.392 231	5.60	.549 516	36.33	.930 [illegible]	1.78	35
26	.365 418	4.52	.392 567	5.60	.547 336	36.28	.930 [illegible]	1.77	34
27	.365 689	4.52	.392 903	5.60	.545 459	36.23	.930 737	1.77	33
28	.365 960	4.52	.393 239	5.58	.542 985	36.17	.930 631	1.78	32
29	.366 231	4.50	.393 574	5.60	.540 818	36.12	.930 524	1.77	31
30	o.366 501	4.52	0.393 910	5.62	2.538 648	36.07	0.930 418	1.78	30
31	.366 772	4.50	.394 247	5.60	.536 484	36.02	.930 311	1.78	29
32	.367 042	4.52	.394 583	5.60	.534 323	35.97	.930 204	1.78	28
33	.367 313	4.52	.394 919	5.60	.532 164	35.90	.930 097	1.78	27
34	.367 584	4.50	.395 255	5.62	.530 [illegible]	35.85	.929 990	1.77	26
35	.367 854	4.52	.395 592	5.60	.527 860	35.80	.929 884	1.80	25
36	.368 [illegible]	4.50	.395 928	5.62	.525 712	35.75	.929 776	1.78	24
37	.368 395	4.50	.396 265	5.60	.523 567	35.70	.929 669	1.78	23
38	.368 665	4.52	.396 601	5.62	.521 425	35.65	.929 562	1.78	22
39	.368 936	4.50	.396 938	5.62	.519 286	35.58	.929 455	1.78	21
40	0.369 206	4.50	0.397 275	5.60	2.517 151	35.55	.929 348	1.80	20
41	.369 476	4.52	.397 611	5.62	.515 018	35.48	.929 240	1.78	19
42	.369 747	4.50	.397 948	5.62	.512 889	35.43	.929 133	1.80	18
43	.370 017	4.50	.398 285	5.62	.510 763	35.38	.929 025	1.80	17
44	.370 287	4.50	.398 622	5.63	.508 640	35.33	.928 917	1.78	16
45	.370 557	4.52	.398 960	5.62	.506 520	35.28	.928 810	1.80	15
46	.370 828	4.50	.399 297	5.62	.504 403	35.23	.928 702	1.80	14
47	.371 098	4.50	.399 634	5.62	.502 289	35.18	.928 594	1.80	13
48	.371 368	4.50	.399 971	5.63	.500 178	35.12	.928 486	1.80	12
49	.371 638	4.50	.400 309	5.62	.498 071	35.08	.928 378	1.80	11
50	0.371 908	4.50	0.400 646	5.63	2.495 966	35.02	0.928 270	1.82	10
51	.372 178	4.50	.400 984	5.63	.493 865	34.98	.928 161	1.80	09
52	.372 448	4.50	.401 322	5.63	.491 766	34.92	.928 053	1.80	08
53	.372 718	4.50	.401 660	5.62	.489 671	34.88	.927 945	1.82	07
54	.372 988	4.50	.401 997	5.63	.487 578	34.82	.927 836	1.80	06
55	.373 258	4.50	.402 335	5.63	.485 489	34.78	.927 728	1.82	05
56	.373 528	4.48	.402 673	5.63	.483 402	34.72	.927 619	1.82	04
57	.373 797	4.50	.403 011	5.65	.481 319	34.67	.927 510	1.80	03
58	.374 067	4.50	.403 350	5.63	.479 239	34.63	.927 402	1.82	02
59	.374 337	4.50	.403 688	5.63	.477 161	34.57	.927 293	1.82	01
60	0.374 607		0.404 026		2.475 087		0.927 184		00
	Cos	d"	Cot	d"	Tan	d"	Sin	d"	

Table A-1. Natural trigonometric functions (continued)

26°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00'	0.438 371	4.37	0.487 733	6.00	2.050 304	25.22	0.898 794	2.13	60'
01	.438 633	4.35	.488 093	6.00	.048 791	25.18	.898 666	2.12	59
02	.438 894	4.35	.488 453	6.00	.047 280	25.15	.898 539	2.13	58
03	.439 155	4.37	.488 813	6.02	.045 771	25.13	.898 411	2.13	57
04	.439 417	4.35	.489 174	6.00	.044 263	25.08	.898 283	2.12	56
05	.439 678	4.35	.489 534	6.02	.042 758	25.07	.898 156	2.13	55
06	.439 939	4.35	.489 895	6.02	.041 254	25.03	.898 028	2.13	54
07	.440 200	4.37	.490 256	6.02	.039 752	25.00	.897 900	2.15	53
08	.440 462	4.35	.490 617	6.02	.038 252	24.98	.897 771	2.13	52
09	.440 723	4.35	.490 978	6.02	.036 753	24.95	.897 643	2.13	51
10	0.440 984	4.35	0.491 339	6.02	2.035 256	24.90	.897 515	2.13	50
11	.441 245	4.35	.491 700	6.02	.033 762	24.90	.897 387	2.15	49
12	.441 506	4.35	.492 061	6.02	.032 268	24.85	.897 258	2.13	48
13	.441 767	4.35	.492 422	6.03	.030 777	24.83	.897 130	2.15	47
14	.442 028	4.35	.492 784	6.02	.029 287	24.80	.897 001	2.13	46
15	.442 289	4.35	.493 145	6.03	.027 799	24.77	.896 873	2.15	45
16	.442 550	4.33	.493 507	6.03	.026 313	24.73	.896 744	2.15	44
17	.442 810	4.35	.493 869	6.03	.024 829	24.72	.896 615	2.15	43
18	.443 071	4.35	.494 231	6.03	.023 346	24.68	.896 486	2.13	42
19	.443 332	4.35	.494 593	6.03	.021 865	24.65	.896 358	2.15	41
20	0.443 593	4.33	0.494 955	6.03	2.020 386	24.62	0.896 229	2.17	40
21	.443 853	4.35	.495 317	6.03	.018 909	24.60	.896 099	2.15	39
22	.444 114	4.35	.495 679	6.05	.017 433	24.57	.895 970	2.15	38
23	.444 375	4.33	.496 042	6.03	.015 959	24.53	.895 841	2.15	37
24	.444 635	4.35	.495 404	6.05	.014 487	24.52	.895 712	2.17	36
25	.444 896	4.33	.496 767	6.05	.013 016	24.47	.895 582	2.15	35
26	.445 156	4.35	.497 130	6.03	.011 548	24.45	.895 453	2.1	34
27	.445 417	4.33	.497 492	6.05	.010 081	24.43	.895 323	2.15	33
28	.445 677	4.33	.497 855	6.05	.008 615	24.38	.895 194	2.17	32
29	.445 937	4.35	.498 218	6.07	.007 152	24.37	.895 064	2.17	31
30	0.446 198	4.33	0.498 582	6.05	2.005 690	24.35	0.894 934	2.15	30
31	.446 458	4.33	.498 945	6.05	.004 229	24.30	.894 804	2.17	29
32	.446 718	4.35	.499 308	6.07	.002 771	24.28	.894 675	2.17	28
33	.446 979	4.33	.499 672	6.05	2.001 314	24.25	.894 545	2.17	27
34	.447 239	4.33	.500 035	6.07	1.999 859	24.22	.894 415	2.18	26
35	.447 499	4.33	.500 399	6.07	1.998 406	24.20	.894 284	2.17	25
36	.447 759	4.33	.500 763	6.07	1.996 954	24.17	.894 154	2.17	24
37	.448 01	4.33	.501 127	6.07	.995 504	24.15	.894 024	2.17	23
38	.448 279	4.33	.501 491	6.07	.994 055	24.10	.894 894	2.18	22
39	.448 539	4.33	.501 855	6.07	.992 609	24.08	.893 763	2.17	21
40	0.448 799	4.33	0.502 219	6.07	1.991 164	24.07	0.893 633	2.18	20
41	.449 059	4.33	.502 583	6.08	.989 720	24.02	.893 502	2.18	19
42	.449 319	4.33	.502 948	6.07	.988 279	24.00	.893 371	2.17	18
43	.449 579	4.33	.503 312	6.08	.986 839	23.98	.893 241	2.18	17
44	.449 839	4.32	.503 677	6.07	.985 400	23.93	.893 110	2.18	16
45	.450 098	4.33	.504 041	6.08	.983 964	23.92	.892 979	2.18	15
46	.450 358	4.33	.504 406	6.08	.982 529	23.90	.892 848	2.18	14
47	.450 618	4.33	.504 771	6.08	.981 095	23.85	.892 717	2.18	13
48	.450 878	4.32	.505 136	6.10	.979 664	23.85	.892 586	2.18	12
49	.451 137	4.33	.505 502	6.08	.978 233	23.80	.892 455	2.20	11
50	0.451 397	4.32	0.505 867	6.08	1.976 805	23.78	0.892 323	2.18	10
51	.451 656	4.33	.506 232	6.10	.975 378	23.75	.892 192	2.18	09
52	.451 916	4.32	.506 598	6.08	.973 953	23.72	.892 061	2.20	08
53	.452 175	4.33	.506 963	6.10	.972 530	23.70	.891 929	2.18	07
54	.452 435	4.32	.507 329	6.10	.971 108	23.68	.891 798	2.20	06
55	.452 694	4.32	.507 695	6.10	.969 687	23.63	.891 666	2.20	05
56	.452 953	4.33	.508 061	6.10	.968 269	23.62	.891 534	2.20	04
57	.453 213	4.32	.508 427	6.10	.966 852	23.60	.891 402	2.20	03
58	.453 472	4.32	.508 793	6.10	.965 436	23.55	.891 270	2.18	02
59	.453 731	4.32	.509 159	6.10	.964 023	23.53	.891 139	2.20	01
60	0.453 990		0.509 525		1.962 611		0.891 007		00
	Sin	d."	Tan	d."	Cot	d."	Cos	d."	

Table A-1. Natural trigonometric functions (continued)

29°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00'	0.484 810	4.23	0.554 309	6.33	1.804 048	20.62	.874 620	2.35	60'
01	.485 064	4.23	.554 689	6.35	.802 811	20.60	.874 479	2.35	59
02	.485 318	4.25	.555 070	6.33	.801 575	20.57	.874 338	2.37	58
03	.485 573	4.23	.555 450	6.35	.800 341	20.55	.874 196	2.35	57
04	.485 827	4.23	.555 831	6.35	.799 108	20.53	.874 055	2.35	56
05	.486 081	4.23	.556 212	6.35	.797 876	20.52	.873 914	2.37	55
06	.486 335	4.25	.556 593	6.35	.796 645	20.48	.874 772	2.35	54
07	.486 590	4.23	.556 974	6.35	.795 416	20.47	.873 631	2.37	53
08	.486 844	4.23	.557 355	6.35	.794 188	20.43	.873 489	2.37	52
09	.487 098	4.23	.557 736	6.37	.792 962	20.43	.873 347	2.35	51
10	0.487 352	4.23	0.558 118	6.35	1.791 736	20.40	0.873 206	2.37	50
11	.487 606	4.23	.558 499	6.37	.790 512	20.38	.873 064	2.37	49
12	.487 860	4.23	.558 881	6.37	.789 289	20.35	.872 922	2.37	48
13	.488 114	4.22	.559 263	6.37	.788 068	20.35	.872 780	2.37	47
14	.488 367	4.23	.559 645	6.37	.786 847	20.32	.872 638	2.37	46
15	.488 621	4.23	.560 027	6.37	.785 628	20.28	.872 496	2.37	45
16	.488 875	4.23	.560 409	6.37	.784 411	20.28	.872 354	2.37	44
17	.489 129	4.22	.560 791	6.38	.783 194	20.25	.872 212	2.38	43
18	.489 382	4.23	.561 174	6.37	.781 979	20.23	.872 069	2.37	42
19	.489 636	4.23	.561 556	6.38	.780 765	20.22	.871 927	2.38	41
20	0.489 890	4.22	0.561 939	6.38	1.779 552	20.18	0.871 784	2.37	40
21	.490 143	4.23	.562 322	6.38	.778 341	20.17	.871 642	2.38	39
22	.490 397	4.22	.562 705	6.38	.777 131	20.15	.871 499	2.37	38
23	.490 650	4.23	.563 088	6.38	.775 922	20.13	.871 357	2.38	37
24	.490 904	4.22	.563 471	6.38	.774 714	20.10	.871 214	2.38	36
25	.491 157	4.23	.563 854	6.40	.773 508	20.10	.871 07[illegible]	2.38	35
26	.491 411	4.22	.564 238	6.38	.772 302	20.07	.870 928	2.38	34
27	.491 664	4.22	.564 621	6.40	.771 098	20.03	.870 785	2.38	33
28	.491 917	4.22	.565 005	6.40	.769 8[illegible]	20.03	.870 642	2.38	32
29	.492 170	4.23	.565 389	6.40	.76[illegible]	20.00	.870 499	2.38	31
30	0.492 424	4.22	0.565 773	.40	1.767 494	19.9[illegible]	0.870 356	2.40	30
31	.492 677	4.22	.566 157	6.40	.766 295	19.97	.870 212	2.38	29
32	.492 930	4.22	.566 541	6.40	.765 [illegible]7	19.93	.870 069	2.38	28
33	.493 183	4.22	.566 925	6.42	.763 90[illegible]	19.93	.869 926	2.40	27
34	.493 436	4.22	.567 310	6.40	.762 705	19.90	.869 782	2.38	26
35	.493 689	4.22	.567 694	6.42	.761 511	19.88	.869 639	2.40	25
36	.493 942	4.22	.568 07[illegible]	6.42	.760 318	19.85	.869 495	2.40	24
37	.494 195	4.22	.568 [illegible]64	6.42	.759 127	19.85	.869 351	2.40	23
38	.494 448	4.20	.568 8[illegible]	6.42	.757 936	19.82	.869 207	2.38	22
39	.494 700	4.22	.569 234	6.42	.756 747	19.80	.869 064	2.40	21
40	0.494 953	4.22	0.569 619	6.42	1.755 559	19.78	0.868 920	2.40	20
41	.495 206	4.22	.570 004	6.43	.754 372	19.75	.868 776	2.40	19
42	.495 459	4.20	.570 390	6.43	.753 187	19.75	.868 632	2.42	18
43	.495 711	4.22	.570 776	6.42	.752 002	19.72	.868 487	2.40	17
44	.495 964	4.22	.571 161	6.43	.750 819	19.70	.868 343	2.40	16
45	.496 217	4.20	.571 547	6.43	.749 637	19.68	.868 199	2.42	15
46	.496 469	4.22	.571 933	6.43	.748 456	19.65	.868 054	2.40	14
47	.496 722	4.20	.572 319	6.43	.747 277	19.65	.867 910	2.42	13
48	.496 974	4.20	.572 705	6.45	.746 098	19.62	.867 765	2.40	12
49	.497 226	4.22	.573 092	6.43	.744 921	19.60	.867 621	2.42	11
50	0.497 479	4.20	0.573 478	6.45	1.743 745	19.57	0.867 476	2.42	10
51	.497 731	4.20	.573 865	6.45	.742 571	19.57	.867 331	2.40	09
52	.497 983	4.22	.574 252	6.43	.741 397	19.53	.867 187	2.42	08
53	.498 236	4.20	.574 638	6.47	.740 225	19.53	.867 042	2.42	07
54	.498 488	4.20	.575 026	6.45	.739 053	19.50	.866 897	2.42	06
55	.498 740	4.20	.575 413	6.45	.737 883	19.48	.866 752	2.42	05
56	.498 992	4.20	.575 800	6.45	.736 714	19.45	.866 607	2.43	04
57	.499 244	4.20	.576 187	6.47	.735 547	19.45	.866 461	2.42	03
58	.499 496	4.20	.576 575	6.45	.734 380	19.42	.866 316	2.42	02
59	.499 748	4.20	.576 962	6.47	.733 215	19.40	.866 171	2.43	01
60	0.500 000		0.577 350		1.732 051		0.866 025		00
	Sin	d."	Tan	d."	Cot	d."	Cos	d."	

Table A-1. Natural trigonometric functions (continued)

35°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00'	0.573 576	3.98	0.700 208	7.22	1.428 148	14.73	0.819 152	2.78	60'
01	.573 815	3.97	.700 641	7.23	.427 264	14.72	.818 985	2.78	59
02	.574 053	3.97	.701 075	7.23	.426 381	14.70	.818 818	2.78	58
03	.574 291	3.97	.701 509	7.23	.425 499	14.70	.818 651	2.78	57
04	.574 529	3.97	.701 943	7.23	.424 617	14.68	.818 484	2.78	56
05	.574 767	3.97	.702 377	7.25	.423 736	14.67	.818 317	2.78	55
06	.575 005	3.97	.702 812	7.23	.422 856	14.65	.818 150	2.80	54
07	.575 243	3.97	.703 246	7.25	.421 977	14.65	.817 982	2.78	53
08	.575 481	3.97	.703 681	7.25	.421 098	14.63	.817 815	2.78	52
09	.575 719	3.97	.704 116	7.25	.420 220	14.62	.817 648	2.80	51
10	0.575 957	3.97	0.704 551	7.27	1.419 343	14.62	0.817 480	2.78	50
11	.576 195	3.95	.704 987	7.25	.418 466	14.60	.817 313	2.80	49
12	.576 432	3.97	.705 422	7.27	.417 590	14.58	.817 145	2.80	48
13	.576 670	3.97	.705 858	7.27	.416 715	14.57	.816 977	2.80	47
14	.576 908	3.95	.706 294	7.27	.415 841	14.57	.816 809	2.78	46
15	.577 145	3.97	.706 730	7.27	.414 967	14.55	.816 642	2.80	45
16	.577 383	3.95	.707 166	7.28	.414 094	14.53	.816 474	2.80	44
17	.577 620	3.97	.707 603	7.27	.413 222	14.52	.816 306	2.80	43
18	.577 858	3.95	.708 039	7.28	.412 351	14.52	.816 138	2.82	42
19	.578 095	3.95	.708 476	7.28	.411 480	14.50	.815 969	2.80	41
20	0.578 332	3.97	0.708 913	7.28	1.410 610	14.50	0.815 801	2.80	40
21	.578 570	3.95	.709 350	7.30	.409 740	14.47	.815 633	2.80	39
22	.578 807	3.95	.709 788	7.28	.408 872	14.47	.815 465	2.82	38
23	.579 044	3.95	.710 225	7.30	.408 004	14.45	.815 296	2.80	37
24	.579 281	3.95	.710 663	7.30	.407 137	14.45	.815 128	2.82	36
25	.579 518	3.95	.711 101	7.30	.406 270	14.43	.814 [illegible]	2.80	35
26	.579 755	3.95	.711 539	7.30	.405 404	14.42	.814 79[illegible]	2.82	34
27	.579 992	3.95	.711 977	7.32	.404 539	14.[illegible]0	.814 622	2.82	33
28	.580 229	3.95	.712 416	7.30	.403 675	14.[illegible]0	.814 453	2.82	32
29	.580 466	3.95	.712 854	7.32	.402 811	14.38	.814 284	2.80	31
30	0.580 703	3.95	0.713 293	7.32	1.401 948	14.[illegible]	0.814 116	2.82	30
31	.580 940	3.93	.713 732	7.32	.401 086	14.3[illegible]	.813 947	2.82	29
32	.581 176	3.95	.714 1[illegible]	7.33	.400 224	14.[illegible]	.813 778	2.83	28
33	.581 413	3.95	.714 6[illegible]	7.32	.399 36[illegible]	14.35	.813 608	2.82	27
34	.581 650	3.93	.715 050	7.33	.398 50[illegible]	14.32	.813 439	2.82	26
35	.581 886	3.95	.715 490	7.33	.397 644	14.32	.813 270	2.82	25
36	.582 12[illegible]	3.93	.715 930	7.33	.396 785	14.30	.813 101	2.83	24
37	.582 359	3.95	.716 370	7.33	.395 927	14.28	.812 931	2.82	23
38	.582 596	3.93	.716 8[illegible]	7.33	.395 070	14.28	.812 762	2.83	22
39	.582 832	3.95	.717 250	7.35	.394 213	14.27	.812 592	2.82	21
40	0.583 069	3.93	0.717 691	7.35	1.393 357	14.25	0.812 423	2.83	20
41	.583 305	3.93	.718 132	7.35	.392 502	14.25	.812 253	2.82	19
42	.583 541	3.93	.718 573	7.35	.391 647	14.23	.812 084	2.83	18
43	.583 777	3.95	.719 014	7.35	.390 793	14.22	.811 914	2.83	17
44	.584 014	3.93	.719 455	7.37	.389 940	14.20	.811 744	2.83	16
45	.584 250	3.93	.719 897	7.37	.389 088	14.20	.811 574	2.83	15
46	.584 486	3.93	.720 339	7.37	.388 236	14.18	.811 404	2.83	14
47	.584 722	3.93	.720 781	7.37	.387 385	14.18	.811 234	2.83	13
48	.584 958	3.93	.721 223	7.37	.386 534	14.17	.811 064	2.83	12
49	.585 194	3.92	.721 665	7.38	.385 684	14.15	.810 894	2.85	11
50	0.585 429	3.93	0.722 108	7.37	1.384 835	14.13	0.810 723	2.83	10
51	.585 665	3.93	.722 550	7.38	.383 987	14.13	.810 553	2.83	09
52	.585 901	3.93	.722 993	7.38	.383 139	14.12	.810 383	2.85	08
53	.586 137	3.92	.723 436	7.38	.382 292	14.10	.810 212	2.83	07
54	.586 372	3.93	.723 879	7.40	.381 446	14.10	.810 042	2.85	06
55	.586 608	3.93	.724 323	7.38	.380 600	14.08	.809 871	2.85	05
56	.586 844	3.92	.724 766	7.40	.379 755	14.07	.809 700	2.83	04
57	.587 079	3.92	.725 210	7.40	.378 911	14.07	.809 530	2.85	03
58	.587 314	3.93	.725 654	7.40	.378 067	14.05	.809 359	2.85	02
59	.587 550	3.92	.726 098	7.42	.377 224	14.03	.809 188	2.85	01
60	0.587 785		0.726 543		1.376 382		0.809 017		00
	Sin	d."	Tan	d."	Cot	d."	Cos	d."	

Table A-1. Natural trigonometric functions (continued)

41°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00′	0.656 059	3.67	0.869 287	8.52	1.150 368	11.25	0.754 710	3.18	60′
01	.656 279	3.65	.869 798	8.52	.149 693	11.25	.754 519	3.18	59
02	.656 498	3.65	.870 309	8.52	.149 018	11.25	.754 328	3.18	58
03	.656 717	3.67	.870 820	8.53	.148 343	11.23	.754 137	3.18	57
04	.656 937	3.65	.871 332	8.52	.147 669	11.23	.753 946	3.18	56
05	.657 156	3.65	.871 843	8.55	.146 995	11.22	.753 755	3.20	55
06	.657 375	3.65	.872 356	8.53	.146 322	11.22	.753 563	3.18	54
07	.657 594	3.67	.872 868	8.55	.145 649	11.22	.753 372	3.18	53
08	.657 814	3.65	.873 381	8.55	.144 976	11.20	.753 181	3.20	52
09	.658 033	3.65	.873 894	8.55	.144 304	11.18	.752 989	3.18	51
10	0.658 252	3.65	0.874 407	8.55	1.143 633	11.20	0.752 798	3.20	50
11	.658 471	3.63	.874 920	8.57	.142 961	11.17	.752 606	3.18	49
12	.658 689	3.65	.875 434	8.57	.142 291	11.17	.752 415	3.20	48
13	.658 908	3.65	.875 948	8.57	.141 621	11.17	.752 223	3.18	47
14	.659 127	3.65	.876 462	8.57	.140 951	11.17	.752 032	3.20	46
15	.659 346	3.63	.876 976	8.58	.140 281	11.13	.751 840	3.20	45
16	.659 564	3.65	.877 491	8.58	.139 613	11.15	.751 648	3.20	44
17	.659 783	3.65	.878 006	8.58	.138 944	11.13	.751 456	3.20	43
18	.660 002	3.63	.878 521	8.60	.138 276	11.12	.751 264	3.20	42
19	.660 220	3.65	.879 037	8.60	.137 609	11.13	.751 072	3.20	41
20	0.660 439	3.63	0.879 553	8.60	1.136 941	11.10	0.750 880	3.20	40
21	.660 657	3.63	.880 069	8.60	.136 275	11.10	.750 688	3.20	39
22	.660 875	3.65	.880 585	8.62	.135 609	11.10	.750 496	3.22	38
23	.661 094	3.63	.881 102	8.62	.134 943	11.10	.750 303	3.20	37
24	.661 312	3.63	.881 619	8.62	.134 277	11.08	.750 111	3.20	36
25	.661 530	3.63	.882 136	8.62	.133 612	11.07	.749 919	3.22	35
26	.661 748	3.63	.882 653	8.63	.132 948	11.07	.749 727	3.20	34
27	.661 966	3.63	.883 171	8.63	.132 284	11.07	.749 534	3.22	33
28	.662 184	3.63	.883 689	8.63	.131 620	11.05	.749 341	3.22	32
29	.662 402	3.63	.884 207	8.63	.130 957	11.05	.749 148	3.20	31
30	0.662 620	3.63	0.884 725	8.65	1.130 294	11.03	0.748 956	3.22	30
31	.662 838	3.63	.885 244	8.65	.129 632	11.03	.748 763	3.22	29
32	.663 056	3.62	.885 763	8.65	.128 970	11.02	.748 570	3.22	28
33	.663 273	3.63	.886 282	8.67	.128 309	11.02	.748 377	3.22	27
34	.663 491	3.63	.886 802	8.65	.127 647	11.02	.748 184	3.22	26
35	.663 709	3.62	.887 321	8.67	.126 987	11.00	.747 991	3.22	25
36	.663 926	3.63	.887 842	8.67	.126 327	11.00	.747 798	3.22	24
37	.664 144	3.62	.888 362	8.67	.125 667	10.98	.747 605	3.22	23
38	.664 361	3.63	.888 883	8.68	.125 008	10.98	.747 412	3.23	22
39	.664 579	3.62	.889 403	8.68	.124 349	10.97	.747 218	3.22	21
40	0.664 796	3.62	0.889 924	8.70	1.123 691	10.97	0.747 025	3.22	20
41	.665 013	3.62	.890 446	8.68	.123 033	10.97	.746 832	3.23	19
42	.665 230	3.63	.890 967	8.70	.122 375	10.95	.746 638	3.22	18
43	.665 448	3.62	.891 489	8.72	.121 718	10.93	.746 445	3.23	17
44	.665 665	3.62	.892 012	8.70	.121 062	10.95	.746 251	3.23	16
45	.665 882	3.62	.892 534	8.72	.120 405	10.92	.746 057	3.22	15
46	.666 099	3.62	.893 057	8.72	.119 750	10.93	.745 864	3.23	14
47	.666 316	3.60	.893 580	8.72	.119 094	10.92	.745 670	3.23	13
48	.666 532	3.62	.894 103	8.73	.118 439	10.90	.745 476	3.23	12
49	.666 749	3.62	.894 627	8.73	.117 785	10.92	.745 282	3.23	11
50	0.666 966	3.62	0.895 151	8.73	1.117 130	10.88	0.745 088	3.23	10
51	.667 183	3.60	.895 675	8.73	.116 477	10.90	.744 894	3.23	09
52	.667 399	3.62	.896 199	8.75	.115 823	10.87	.744 700	3.23	08
53	.667 616	3.62	.896 724	8.75	.115 171	10.88	.744 506	3.23	07
54	.667 833	3.60	.897 249	8.75	.114 518	10.87	.744 312	3.25	06
55	.668 049	3.60	.897 774	8.75	.113 866	10.85	.744 117	3.23	05
56	.668 265	3.62	.898 299	8.77	.113 215	10.87	.743 923	3.25	04
57	.668 482	3.60	.898 825	8.77	.112 563	10.83	.743 728	3.23	03
58	.668 698	3.60	.899 351	8.77	.111 913	10.85	.743 534	3.25	02
59	.668 914	3.62	.899 877	8.78	.111 262	10.82	.743 339	3.23	01
60	0.669 131		0.900 404		1.110 613		0.743 145		00
	Sin	d."	Tan	d."	Cot	d."	Cos	d."	

Table A-1. Natural trigonometric functions (continued)

44°

	Sin	d."	Tan	d."	Cot	d."	Cos	d."	
00′	0.694 658	3.50	0.965 689	9.37	1.035 530	10.03	0.719 340	3.37	60′
01	.694 868	3.48	.966 251	9.38	.034 928	10.05	.719 138	3.37	59
02	.695 077	3.48	.966 814	9.38	.034 325	10.02	.718 936	3.38	58
03	.695 286	3.48	.967 377	9.38	.033 724	10.03	.718 733	3.37	57
04	.695 495	3.48	.967 940	9.40	.033 122	10.02	.718 531	3.37	56
05	.695 704	3.48	.968 504	9.38	.032 521	10.02	.718 329	3.38	55
06	.695 913	3.48	.969 067	9.42	.031 920	10.02	.718 126	3.37	54
07	.696 122	3.47	.969 632	9.40	.031 319	10.00	.717 924	3.38	53
08	.696 330	3.48	.970 196	9.42	.030 719	9.98	.717 721	3.37	52
09	.696 539	3.48	.970 761	9.42	.030 120	10.00	.717 519	3.38	51
10	0.696 748	3.48	0.971 326	9.43	1.029 520	9.98	0.717 316	3.38	50
11	.696 957	3.47	.971 892	9.43	.028 921	9.97	.717 113	3.37	49
12	.697 165	3.48	.972 458	9.43	.028 323	9.98	.716 911	3.38	48
13	.697 374	3.47	.973 024	9.43	.027 724	9.97	.716 708	3.38	47
14	.697 582	3.47	.973 590	9.45	.027 126	9.95	.716 505	3.38	46
15	.697 790	3.48	.974 157	9.45	.026 529	9.97	.716 302	3.38	45
16	.697 999	3.47	.974 724	9.45	.025 931	9.93	.716 099	3.38	44
17	.698 207	3.47	.975 291	9.47	.025 335	9.95	.715 896	3.38	43
18	.698 415	3.47	.975 859	9.47	.024 738	9.93	.715 693	3.38	42
19	.698 623	3.48	.976 427	9.48	.024 142	9.93	.715 490	3.40	41
20	0.698 832	3.47	0.976 996	9.47	1.023 546	9.92	0.715 286	3.38	40
21	.699 040	3.47	.977 564	9.48	.022 951	9.92	.715 083	3.38	39
22	.699 248	3.45	.978 133	9.50	.022 356	9.92	.714 880	3.40	38
23	.699 455	3.47	.978 703	9.48	.021 761	9.92	.714 676	3.38	37
24	.699 663	3.47	.979 272	9.50	.021 166	9.90	.714 473	3.40	36
25	.699 871	3.47	.979 842	9.52	.020 572	9.88	.714 269	3.38	35
26	.700 079	3.47	.980 413	9.50	.019 979	9.90	.714 066	3.40	34
27	.700 287	3.45	.980 983	9.52	.019 385	9.88	.713 862	3.40	33
28	.700 494	3.47	.981 554	9.53	.018 792	9.87	.713 658	3.40	32
29	.700 702	3.45	.982 126	9.52	.018 200	9.88	.713 454	3.40	31
30	0.700 909	3.47	0.982 697	9.53	1.017 607	9.87	0.713 250	3.38	30
31	.701 117	3.45	.983 269	9.55	.017 015	9.85	.713 047	3.40	29
32	.701 324	3.45	.983 842	9.53	.016 424	9.85	.712 843	3.40	28
33	.701 531	3.47	.984 414	9.55	.015 833	9.85	.712 639	3.42	27
34	.701 739	3.45	.984 987	9.55	.015 242	9.83	.712 434	3.40	26
35	.701 946	3.45	.985 560	9.57	.014 651	9.83	.712 230	3.40	25
36	.702 153	3.45	.986 134	9.57	.014 061	9.83	.712 026	3.40	24
37	.702 360	3.45	.986 708	9.57	.013 471	9.82	.711 822	3.42	23
38	.702 567	3.45	.987 282	9.57	.012 882	9.82	.711 617	3.40	22
39	.702 774	3.45	.987 857	9.58	.012 293	9.82	.711 413	3.40	21
40	0.702 981	3.45	0.988 432	9.58	1.011 704	9.82	0.711 209	3.42	20
41	.703 188	3.45	.988 007	9.58	.011 115	9.80	.711 004	3.42	19
42	.703 395	3.43	.989 582	9.60	.010 527	9.80	.710 799	3.40	18
43	.703 601	3.45	.990 158	9.62	.009 939	9.78	.710 595	3.42	17
44	.703 808	3.45	.990 735	9.60	.009 352	9.78	.710 390	3.42	16
45	.704 015	3.43	.991 311	9.62	.008 765	9.78	.710 185	3.40	15
46	.704 221	3.45	.991 888	9.62	.008 178	9.77	.709 981	3.42	14
47	.704 428	3.43	.992 465	9.63	.007 592	9.77	.709 776	3.42	13
48	.704 634	3.45	.993 043	9.63	.007 006	9.77	.709 571	3.42	12
49	.704 841	3.43	.993 621	9.63	.006 420	9.75	.709 366	3.42	11
50	0.705 047	3.43	0.994 199	9.65	1.005 835	9.75	0.709 161	3.42	10
51	.705 253	3.43	.994 778	9.65	.005 250	9.75	.708 956	3.43	09
52	.705 459	3.43	.995 357	9.65	.004 665	9.73	.708 750	3.43	08
53	.705 665	3.45	.995 936	9.65	.004 081	9.73	.708 545	3.42	07
54	.705 872	3.43	.996 515	9.67	.003 497	9.73	.708 340	3.43	06
55	.706 078	3.43	.997 095	9.68	.002 913	9.72	.708 134	3.42	05
56	.706 284	3.42	.997 676	9.67	.002 330	9.72	.707 929	3.42	04
57	.706 489	3.43	.998 256	9.68	.001 747	9.72	.707 724	3.43	03
58	.706 695	3.43	.998 837	9.68	.001 164	9.70	.707 518	3.43	02
59	.706 901	3.43	.999 418	9.70	.000 582	9.70	.707 312	3.42	01
60	0.707 107		1.000 000		1.000 000		0.707 107		00
	Cos	d."	Cot	d."	Tan	d."	Sin	d."	

Table A-2. Stadia reduction

Stadia work involves observing—

- The angle by which the line of sight departs from a horizontal line. This reading is the argument for entering the table.
- The rod interval intercepted by the stadia wires, which are usually adjusted so that the distance to the rod is exactly 100 times the reading on the rod when the telescope is level.

The table gives horizontal distances and differences of elevation for unit readings on the rod and for angle of elevation from 0° to 30°.

Example. Rod reading is 3.25 feet and angle of inclination is 5° 35′.

Horizontal Distance = 99.05 x 3.25 = 321.91 ft

Difference of Elevation = 9.68 x 3.25 = 31.46 ft

Stadia Reduction Formulas. The following formulas are used in computing stadia reductions.

Horizontal Distance = (Rod Interval x 100) $\cos^2 a$

Vertical Distance = (Rod Interval x 100) $\frac{1}{2} \sin^2 a$

a = Angle of inclination

Table A-2. Stadia reduction (continued)

Minutes	4°		5°		6°		7°	
	Hor. dist.	Diff. elev.	Hor. dist.	Diff. elev.	Hor. dist.	Diff. elev.	Hor. dist.	Diff. elev.
0	99.51	6.69	99.24	8.68	98.91	10.40	98.51	12.10
2	99.51	7.02	99.23	8.74	98.90	10.45	98.50	12.15
4	99.50	7.07	99.22	8.80	98.88	10.51	98.48	12.21
6	99.49	7.13	99.21	8.85	98.87	10.57	98.47	12.26
8	99.48	7.19	99.20	8.91	98.86	10.62	98.46	12.32
10	99.47	7.25	99.19	8.97	98.85	10.68	98.44	12.38
12	99.46	7.30	99.18	9.03	98.83	10.74	98.43	12.43
14	99.46	7.36	99.17	9.08	98.82	10.79	98.41	12.49
16	99.45	7.42	99.16	9.14	98.81	10.85	98.40	12.55
18	99.44	7.48	99.15	9.20	98.80	10.91	98.39	12.60
20	99.43	7.53	99.14	9.25	98.78	10.96	98.37	12.66
22	99.42	7.59	99.13	9.31	98.77	11.02	98.36	12.72
24	99.41	7.65	99.11	9.37	98.76	11.08	98.34	12.77
26	99.40	7.71	99.10	9.43	98.74	11.13	98.33	12.83
28	99.39	7.76	99.09	9.48	98.73	11.19	98.31	12.88
30	99.38	7.82	99.08	9.54	98.72	11.25	98.29	12.94
32	99.38	7.88	99.07	9.60	98.71	11.30	98.28	13.00
34	99.37	7.94	99.06	9.65	98.69	11.36	98.27	13.05
36	99.36	7.99	99.05	9.71	98.68	11.42	98.25	13.11
38	99.35	8.05	99.04	9.77	98.67	11.47	98.24	13.17
40	99.34	8.11	99.03	9.83	98.65	11.53	98.22	13.22
42	99.33	8.17	99.01	9.88	98.64	11.59	98.20	13.28
44	99.32	8.22	99.00	9.94	98.63	11.64	98.19	13.33
46	99.31	8.28	98.99	10.00	98.61	11.70	98.17	13.39
48	99.30	8.34	98.98	10.05	98.60	11.76	98.16	13.45
50	99.29	8.40	98.97	10.11	98.58	11.81	98.14	13.50
52	99.28	8.45	98.96	10.17	98.57	11.87	98.13	13.56
54	99.27	8.51	98.94	10.22	98.56	11.93	98.11	13.61
56	99.26	8.57	99.93	10.28	98.54	11.98	98.10	13.67
58	99.25	8.63	98.92	10.34	98.53	12.04	98.08	13.73
60	99.24	8.68	98.91	10.40	98.51	12.10	98.06	13.78

Table A-2. Stadia reduction (continued)

Minutes	20°		21°		22°		23°	
	Hor. dist.	Diff. elev.	Hor. dist.	Diff. elev.	Hor. dist.	Diff. elev.	Hor. dist.	Diff. elev.
0	88.30	32.14	87.16	33.46	85.97	34.73	84.73	35.97
2	88.26	32.18	87.12	33.50	85.93	34.77	84.69	36.01
4	88.23	32.23	87.08	33.54	85.89	34.82	84.65	36.05
6	88.19	32.27	87.04	33.59	85.85	34.86	84.61	36.09
8	88.15	32.32	87.00	33.63	85.80	34.90	84.57	36.13
10	88.11	32.36	86.96	33.67	85.76	34.94	84.52	36.17
12	88.08	32.41	86.92	33.72	85.72	34.98	84.48	36.21
14	88.04	32.45	86.88	33.76	85.68	35.02	84.44	36.25
16	88.00	32.49	86.84	33.80	85.64	35.07	84.40	36.29
18	87.96	32.54	86.80	33.84	85.60	35.11	84.35	36.33
20	87.93	32.58	86.77	33.89	85.56	35.15	84.31	36.37
22	87.89	32.63	86.73	33.93	85.52	35.19	84.27	36.41
24	87.85	32.67	86.69	33.97	85.48	35.23	84.23	36.45
26	87.81	32.72	86.65	34.01	85.44	35.27	84.18	36.49
28	87.77	32.76	86.61	34.06	85.40	35.31	84.14	36.53
30	87.74	32.80	86.57	34.10	85.36	35.36	84.10	36.57
32	87.70	32.85	86.53	34.14	85.31	35.40	84.06	36.61
34	87.66	32.89	86.49	34.18	85.27	35.44	84.01	36.65
36	87.62	32.93	86.45	34.23	85.23	35.48	83.97	36.69
38	87.58	32.98	86.41	34.27	85.19	35.52	83.93	36.73
40	87.54	33.02	86.37	34.31	85.15	35.56	83.89	36.77
42	87.51	33.07	86.33	34.35	85.11	35.60	83.84	36.80
44	87.47	33.11	86.29	34.40	85.07	35.64	83.80	36.84
46	87.43	33.15	86.25	34.44	85.02	35.68	83.76	36.88
48	87.39	33.20	86.21	34.48	84.98	35.72	83.72	36.92
50	87.35	33.24	86.17	34.52	84.94	35.76	83.67	36.96
52	87.31	33.28	86.13	34.57	84.90	35.80	83.63	37.00
54	87.27	33.33	86.09	34.61	84.86	35.85	83.59	37.04
56	87.24	33.37	86.05	34.65	84.82	35.89	83.54	37.08
58	87.20	33.41	86.01	34.69	84.77	35.93	83.50	37.12
60	87.16	33.46	85.97	34.73	84.73	35.97	83.46	37.16

Table A-4. Useful constants and formulas (continued)

b. Fundamental relations.

$$\sin A = \frac{1}{\csc A}; \cos A = \frac{1}{\sec A}; \tan A = \frac{1}{\cot A} = \frac{\sin A}{\cos A}$$

$$\csc A = \frac{1}{\sin A}; \sec A = \frac{1}{\cos A}; \cot A = \frac{1}{\tan A} = \frac{\cos A}{\sin A}$$

$$\sin^2 A + \cos^2 A = 1; \sec^2 A - \tan^2 A = 1; \csc^2 A - \cot^2 A = 1$$

c. Functions of multiple angles.

$$\sin 2A = 2 \sin A \cos A$$
$$\cos 2A = 2\cos^2 A - 1 = 1 - 2\sin^2 A = \cos^2 A - \sin^2 A$$
$$\sin 3A = 3 \sin A - 4 \sin^3 A;$$
$$\cos 3A = 4\cos^3 A - 3 \cos A$$

d. Functions of half angles.

$$\sin \frac{A}{2} = \pm \sqrt{\frac{1 - \cos A}{2}} \qquad \cos \frac{A}{2} = \pm \sqrt{\frac{1 + \cos A}{2}}$$

$$\tan \frac{A}{2} = \pm \frac{1 - \cos A}{\sin A} = \frac{\sin A}{1 + \cos A} = \pm \sqrt{\frac{1 - \cos A}{1 + \cos A}}$$

e. Powers of functions.

$$\sin^2 A = \tfrac{1}{2}(1 - \cos 2A) \qquad \cos^2 A = \tfrac{1}{2}(1 + \cos 2A)$$
$$\sin^3 A = \tfrac{1}{4}(3 \sin A - \sin 3A); \quad A = \tfrac{1}{4}(\cos 3A + 3 \cos A)$$

f. Sum and difference of angles.

$$\sin (A \pm B) = \sin A \cos B \pm \cos A \sin B$$
$$\cos (A \pm) = \cos A \cos B \pm \sin A \sin B$$

$$\tan (A \pm B) = \frac{\tan A \pm \tan B}{1 \mp \tan A \tan B}$$

g. Sums, differences, and products of functions.

$$\sin A \pm \sin B = 2 \sin \tfrac{1}{2}(A \pm B) \cos \tfrac{1}{2}(A \mp B)$$
$$\cos A + \cos B = 2 \cos \tfrac{1}{2}(A + B) \cos \tfrac{1}{2}(A - B)$$
$$\cos A - \cos B = -2 \sin \tfrac{1}{2}(A + B) \sin \tfrac{1}{2}(A - B)$$

$$\tan A \pm \tan B = \frac{\sin (A \pm B)}{\cos A \cos B}$$

Table A-4. Useful constants and formulas (continued)

$\sin^2 A - \sin^2 B = \sin (A + B) \sin (A - B)$
$\cos^2 A - \cos^2 B = - \sin (A + B) ;\sin (A - B)$
$\cos^2 A - \sin^2 B = \cos (A + B) \cos (A - B)$
$\sin A \sin B = \frac{1}{2} \cos (A - B) - \frac{1}{2} \cos (A + B)$
$\cos A \cos B = \frac{1}{2} \cos (A - B) + \frac{1}{2} \cos (A + B)$
$\sin A \cos B = \frac{1}{2} \sin (A + B) + \frac{1}{2} \sin (A - B)$

The relations for angles greater than 90° are shown in the following tabulation where x represents an angle in the first quadrant where all the functions are positive.

angle	sine	cosine	tangent	cotangent
x	+ sin x	+ cos x	+ tan x	+ cot x
90° + x	+ cos x	- sin x	- cot x	- tan x
180° + x	- sin x	- cos x	+ tan x	+ cot x
270° + x	- cos x	+ sin x	- cot x	- tan x

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24. $\sin A = 2 \sin \frac{1}{2} A \cos \frac{1}{2} A = \sqrt{1 - \cos^2 A} = \tan A \cos A$

25. $\cos A = 2 \cos^2 \frac{1}{2} A - 1 = 2 \sin^2 \frac{1}{2} A = \cos^2 \frac{1}{2} A - \sin^2 \frac{1}{2} A$

26. $\tan A = \frac{\sin A}{\cos A} = \frac{\sin 2 A}{1 + \cos 2 A}$

27. $\cot A = \frac{\cos A}{\sin A} = \frac{\sin 2 A}{1 - \cos 2 A} = \frac{\sin 2 A}{\text{vers } 2 A}$

28. $\text{vers } A = 1 - \cos A = \sin A \tan \frac{1}{2} A = 2 \sin^2 \frac{1}{2} A$

29. $\text{exsec } A = \sec A - 1 = \tan A \tan \frac{1}{2} A = \frac{\text{vers } A}{\cos A}$

30. $\sin 2 A = 2 \sin A \cos A$

31. $\cos 2 A = 2 \cos^2 A - 1 = \cos^2 A - \sin^2 A = 1 - 2 \sin^2 A$

32. $\tan 2 A = \frac{2 \tan A}{1 - \tan^2 A}$

33. $\cot 2 A = \frac{\cot^2 A - 1}{2 \cot A}$

34. $\text{vers } 2 A = 2 \sin^2 A = 2 \sin A \cos A \tan A$

35. $\text{exsec } 2 A = \frac{2 \tan^2 A}{1 - \tan^2 A}$

36. $\sin^2 A + \cos^2 A = 1$

37. $\sin (A \pm B) = \sin A \cdot \cos B \pm \sin B \cdot \cos A$

38. $\cos (A \pm B) = \cos A \cdot \cos B \mp \sin A \cdot \sin B$

39. $\sin A + \sin B = 2 \sin \frac{1}{2} (A + B) \cos \frac{1}{2} (A - B)$

40. $\sin A - \sin B = 2 \cos \frac{1}{2} (A + B) \sin \frac{1}{2} (A - B)$

41. $\cos A + \cos B = 2 \cos \frac{1}{2} (A + B) \cos \frac{1}{2} (A - B)$

42. $\cos B - \cos A = 2 \sin \frac{1}{2} (A + B) \sin \frac{1}{2} (A - B)$

43. $\sin^2 A - \sin^2 B = \cos^2 B - \cos^2 A = \sin (A + B) \sin (A - B)$

44. $\cos^2 A - \sin^2 B = \cos (A + B) \cos (A - B)$

45. $\tan A + \tan B = \frac{\sin (A + B)}{\cos A \cdot \cos B}$

46. $\tan A - \tan B = \frac{\sin (A - B)}{\cos A \cdot \cos B}$

47. $\sin 3 A = 3 \sin A - 4 \sin^2 A$

48. $\cos 3 A = 4 \cos^2 A - 3 \cos A$

49. $\sin \frac{A}{2} = \pm \sqrt{\frac{1 - \cos A}{2}}$

Table A-4. Useful constants and formulas (continued)

50. $\cos \frac{A}{2} = \pm\sqrt{\frac{1 + \cos A}{2}}$

51. $\tan \frac{A}{2} = \pm \frac{1 - \cos A}{\sin A} = \frac{\sin A}{1 + \cos A} = \pm\sqrt{\frac{1 - \cos A}{1 + \cos A}}$

52. $\sin^2 A = \frac{1}{2}(1 - \cos 2A)$

53. $\cos^2 A = \frac{1}{2}(1 + \cos 2A)$

54. $\sin^2 A = \frac{1}{4}(3 \sin A - \sin 3A)$

55. $\cos^2 A = \frac{1}{4}(\cos 3A + 3 \cos A)$

56. $\sin A \sin B = \frac{1}{2}\cos(A - B) - \frac{1}{2}\cos(A + B)$

57. $\cos A \cos B = \frac{1}{2}\cos(A - B) + \frac{1}{2}\cos(A + B)$

58. $\sin A \cos B = \frac{1}{2}\sin(A + B) + \frac{1}{2}\sin A - B$

	0°	30°	45°	60°	90°	120°	135°	150°	180°	270
Sine	0	1/2	1/2 $\sqrt{2}$	1/2 $\sqrt{3}$	1	1/2 $\sqrt{3}$	1/2 $\sqrt{2}$	1/2	0	-1
Cosine	1	1/2 $\sqrt{3}$	1/2 $\sqrt{2}$	1/2	0	-1/2	-1/2 $\sqrt{2}$	-1/2 $\sqrt{3}$	-1	0
Tangent ...	0	1/3 $\sqrt{3}$	1	$\sqrt{3}$	$\pm\infty$	- $\sqrt{3}$	-1	-1/3 $\sqrt{3}$	0	$\pm\infty$
Cotangent .	$\pm\infty$	$\sqrt{3}$	1	1/3 $\sqrt{3}$	0	-1/3 $\sqrt{3}$	-1	- $\sqrt{3}$	$\pm\infty$	0
Secant	1	2/3 $\sqrt{3}$	$\sqrt{2}$	2	$\pm\infty$	-2	- $\sqrt{2}$	-2/3 $\sqrt{3}$	-1	$\pm\infty$
Cosecant ..	$\pm\infty$	2	$\sqrt{2}$	2/3 $\sqrt{3}$	1	2/3 $\sqrt{3}$	$\sqrt{2}$	2	$\pm\infty$	-1

Lineal feet	x .00019	= miles
Lineal yards	x .000	= miles
Square inches	x .00	= square feet
Square feet	x .111	= square yards
Square yards	x .0002067	= acres
Acres	x 4840.0	= square yards
Cubic inches	x .00058	= cubic feet
Cubic feet	x .03704	= cubic yards
Links	x .22	= yards
Links	x .66	= feet
Feet	x .15	= links

360° = 21600′ = 1296000″
Circumference of circle (r = radius) = $2\pi r$, or πd
Radius = arc of 57.2957790°
Arc of 1° (radius = 1) = .017453292
Arc of 1′ (radius = 1) = .000290888
Arc of 1″ (radius = 1) = .000004848

1 radian	= $\frac{180°}{\pi}$ = 57.2957790° = 57°17′44.8″ (nearly)
1 radian	= 1018.6 mile
1 degree	= 0.0174533 radians
1 minute	= 0.0002909 radians
1 mil	= 0.0009817 radians
π radians	= 180°
$\frac{\pi}{2}$ radians	= 90°

Area of circle (r = radius) ..... πr^2
Area of sector of circle (length of arc = L; r = radius) ..... 1/2 Lr
Area of segment of parabola (c = chord; m = mid. ord.) ..... 2/3 cm
Area of segment of circle (ap) ..... 2/3 cm

Table A-5. Functions of 1° curves (continued)

	20°				21°				
	LC	M	E	T	LC	M	E	T	
0	1990.0	87.50	88.39	1010.4	2088.5	95.95	97.58	1062.0	0
2	1993.3	87.34	88.69	1012.1	2091.8	96.26	97.90	1063.7	2
4	1996.6	87.63	88.99	1013.8	2095.0	96.56	98.21	1065.4	4
6	1999.8	87.92	89.29	1015.5	2098.3	96.87	98.53	1067.2	6
8	2003.1	88.21	89.59	1017.2	2101.6	97.17	98.84	1068.9	8
10	2006.4	88.50	89.89	1019.0	2104.9	97.48	99.16	1070.6	10
12	2009.7	88.79	90.19	1020.7	2108.1	97.79	99.48	1072.4	12
14	2013.0	89.08	90.49	1022.4	2111.4	98.09	99.79	1074.1	14
16	2016.3	89.37	90.79	1024.1	2114.7	98.40	100.1	1075.8	16
18	2019.5	89.66	91.09	1025.8	2118.0	98.70	100.4	1077.5	18
20	2022.8	89.96	91.40	1027.6	2121.2	99.00	100.7	1079.3	20
22	2026.1	90.25	91.71	1029.3	2124.5	99.39	101.1	1081.0	22
24	2029.4	90.55	92.01	1031.0	2127.8	99.60	101.4	1082.7	24
26	2032.7	90.85	92.32	1032.7	2131.0	99.90	101.7	1084.4	26
28	2036.0	91.15	92.62	1034.4	2134.3	100.2	102.0	1086.2	28
30	2039.2	91.45	92.93	1036.1	2137.6	100.5	102.3	1087.9	30
32	2042.5	91.74	93.24	1037.9	2140.9	100.8	102.7	1089.6	32
34	2045.8	92.04	93.54	1039.6	2144.1	101.1	103.0	1091.3	34
36	2049.1	92.34	93.85	1041.3	2147.4	101.4	103.3	1093.1	36
38	2052.4	92.64	94.15	1043.0	2150.7	101.7	103.6	1094.8	38
40	2055.7	92.94	94.46	1044.8	2154.0	102.1	104.0	1096.5	40
42	2058.9	93.24	94.78	1046.5	2157.2	102.4	104.3	1098.3	42
44	2062.2	93.54	95.09	1048.2	2160.5	102.7	104.6	1100.0	44
46	2065.5	93.84	95.40	1049.9	2163.8	103.0	104.9	1101.7	46
48	2068.8	94.14	95.71	1051.7	2167.1	103.3	105.3	1103.4	48
50	2072.1	94.44	96.03	1053.4	2170.3	103.6	105.6	1105.2	50
52	2075.4	94.74	96.34	1055.1	2173.6	103.9	105.9	1106.9	52
54	2078.6	95.04	96.65	1056.8	2176.9	104.2	106.3	1108.6	54
56	2081.9	95.34	96.96	1058.6	2180.1	104.5	106.6	1110.3	56
58	2085.2	95.64	97.27	1060.3	2183.4	104.8	106.9	1112.1	58
60	2088.5	95.95	97.58	1062.0	2186.7	105.2	107.2	1113.8	60

	22°				23°				
	LC	M	E	T	LC	M	E	T	
0	2186.7	105.2	107.2	1113.8	2284.8	115.0	117.1	1165.8	0
2	2190.0	105.6	107.6	1115.5	2288.1	115.4	117.5	1167.5	2
4	2193.2	105.9	107.9	1117.3	2291.3	115.7	118.1	1169.2	4
6	2196.5	106.3	108.2	1119.0	2294.6	116.0	118.4	1171.0	6
8	2199.8	106.6	108.6	1120.7	2297.8	116.4	118.8	1172.7	8
10	2203.0	106.8	108.8	1122.4	2301.1	116.7	119.1	1174.4	10
12	2206.3	107.1	109.2	1124.2	2304.4	117.0	119.5	1176.5	12
14	2209.6	107.4	109.6	1125.9	2307.6	117.4	119.8	1177.9	14
16	2212.9	107.7	109.9	1127.6	2310.9	117.7	120.4	1179.7	16
18	2216.1	108.0	110.2	1129.4	2314.1	118.1	120.5	1181.4	18
20	2219.4	108.4	110.6	1131.1	2317.4	118.4	120.9	1183.1	20
22	2222.7	108.7	110.9	1132.8	2320.7	118.7	121.2	1184.9	22
24	2225.9	109.0	111.2	1134.6	2323.9	119.1	121.6	1186.6	24
26	2229.2	109.4	111.6	1136.3	2327.2	119.4	121.9	1188.4	26
28	2232.5	109.7	111.9	1138.0	2330.4	119.8	122.3	1190.1	28
30	2235.7	110.0	112.3	1139.7	2333.7	120.1	122.6	1191.8	30
32	2239.0	110.4	112.6	1141.5	2337.0	120.4	123.0	1193.6	32
34	2242.3	110.7	112.9	1143.2	2340.2	120.8	123.3	1195.3	34
36	2245.6	111.0	113.3	1144.9	2343.5	121.1	123.7	1197.1	36
38	2248.8	111.4	113.6	1146.7	2346.7	121.5	124.1	1198.8	38
40	2252.1	111.7	113.9	1148.4	2350.0	121.8	124.4	1200.5	40
42	2255.4	112.0	114.3	1150.1	2353.3	122.1	124.8	1202.3	42
44	2258.6	112.3	114.6	1151.9	2356.5	122.5	125.1	1204.0	44
46	2261.9	112.7	115.0	1153.6	2359.8	122.8	125.5	1205.8	46
48	2265.2	113.0	115.3	1155.4	2363.0	123.2	125.8	1207.5	48
50	2268.4	113.3	115.7	1157.1	2366.3	123.5	126.2	1209.2	50
52	2271.7	113.7	116.0	1158.8	2369.6	123.8	126.6	1211.0	52
54	2275.0	114.0	116.3	1160.6	2372.8	124.2	126.9	1212.7	54
56	2278.3	114.3	116.7	1162.3	2376.1	124.5	127.3	1214.5	56
58	2281.5	114.7	117.0	1164.0	2379.3	124.9	127.6	1216.2	58
60	2284.8	115.0	117.4	1165.8	2382.6	125.2	128.0	1218.0	60

Table A-5. Functions of 1° curves (continued)

	32°				33°				
	LC	M	E	T	LC	M	E	T	
0	3158.8	222.0	230.9	1643.1	3245.9	236.0	246.1	1697.3	0
2	3162.0	222.5	231.4	1644.9	3258.1	236.4	246.6	1699.1	2
4	3165.2	222.9	231.9	1646.7	3261.3	236.9	247.1	1700.9	4
6	3168.4	223.4	232.4	1648.5	3264.5	237.4	247.7	1702.7	6
8	3171.6	223.8	232.9	1650.3	3267.7	237.9	248.2	1704.5	8
10	3174.8	224.3	233.4	1652.1	3270.8	238.4	248.7	1706.4	10
12	3178.0	224.8	233.9	1653.9	3274.0	238.9	249.2	1708.2	12
14	3181.2	225.2	234.4	1655.7	3277.2	239.3	249.7	1710.0	14
16	3184.4	225.7	234.9	1657.5	3280.4	239.8	250.2	1711.8	16
18	3187.6	226.1	235.4	1659.3	3283.6	240.3	250.8	1713.6	18
20	3190.8	226.6	235.9	1661.1	3286.8	240.8	251.3	1715.5	20
22	3194.0	227.1	236.4	1662.9	3290.0	241.2	251.8	1717.3	22
24	3197.2	227.5	236.9	1664.7	3293.2	241.7	252.3	1719.1	24
26	3200.4	228.0	237.4	1666.5	3296.4	242.2	252.9	1720.9	26
28	3203.6	228.4	237.9	1668.3	3299.6	242.7	253.4	1722.7	28
30	3206.8	228.9	238.4	1670.1	3302.7	243.2	253.9	1724.6	30
32	3210.0	229.4	239.0	1671.9	3305.9	243.6	254.4	1726.4	32
34	3213.2	229.8	239.5	1673.7	3309.1	244.1	255.0	1728.2	34
36	3216.5	230.3	240.0	1675.5	3312.3	244.6	255.5	1730.0	36
38	3219.7	230.7	240.5	1677.4	3315.5	245.1	256.0	1731.8	38
40	3222.9	231.2	241.0	1679.2	3318.7	245.6	256.5	1733.6	40
42	3226.1	231.7	241.5	1681.0	3321.9	246.0	257.1	1735.5	42
44	3229.3	232.2	242.0	1682.8	3325.1	246.5	257.6	1737.3	44
46	3232.5	232.6	242.5	1684.6	3328.3	247.0	258.1	1739.1	46
48	3235.7	233.1	243.0	1686.4	3331.5	247.5	258.6	1740.9	48
50	3238.9	233.5	243.5	1688.2	3334.6	248.0	259.2	1742.7	50
52	3242.1	234.0	244.1	1690.0	3337.8	248.4	259.7	1744.6	52
54	3245.3	234.5	244.6	1691.8	3341.0	248.9	260.2	1746.4	54
56	3248.5	235.0	245.1	1693.7	3344.2	249.4	260.8	1748.2	56
58	3251.7	235.5	245.6	1695.5	3347.4	249.9	261.3	1750.0	58
60	3254.9	236.0	246.1	1697.3	3350.6	250.4	261.8	1751.8	60

	34°				35°				
	LC	M	E	T	LC	M	E	T	
0	3350.6	250.4	261.8	1751.8	3446.1	265.2	278.1	1806.7	0
2	3353.8	250.9	262.3	1753.7	3449.3	265.7	278.6	1808.5	2
4	3357.0	251.2	262.9	1755.5	3452.5	266.2	279.2	1810.3	4
6	3360.1	251.7	263.4	1757.3	3455.6	266.7	279.7	1812.2	6
8	3363.3	252.2	263.9	1759.1	3458.8	267.2	280.3	1814.0	8
10	3366.5	252.7	264.5	1761.0	3462.0	267.7	280.8	1815.8	10
12	3369.7	253.2	265.0	1762.8	3465.2	268.2	281.4	1817.7	12
14	3372.9	253.7	265.6	1764.6	3468.3	268.7	281.9	1819.5	14
16	3376.1	254.2	266.1	1766.4	3471.5	269.2	282.5	1821.3	16
18	3379.2	254.7	266.7	1768.3	3474.7	269.7	283.0	1823.2	18
20	3382.4	255.2	267.2	1770.1	3477.9	270.2	283.6	1825.0	20
22	3385.6	255.7	267.7	1771.9	3481.0	270.7	284.2	1826.8	22
24	3388.8	256.2	268.3	1773.7	3484.2	271.2	284.7	1828.7	24
26	3392.0	256.7	268.8	1775.6	3487.4	271.7	285.3	1830.5	26
28	3395.2	257.2	269.3	1777.4	3490.6	272.2	285.9	1832.3	28
30	3398.3	257.7	269.9	1779.2	3493.7	272.7	286.4	1834.2	30
32	3401.5	258.2	270.4	1781.0	3496.9	273.2	287.0	1836.0	32
34	3404.7	258.7	271.0	1782.9	3500.1	273.7	287.5	1837.8	34
36	3407.9	259.2	271.5	1784.7	3503.3	274.2	288.1	1839.7	36
38	3411.1	259.7	272.0	1786.5	3506.5	274.7	288.7	1841.5	38
40	3414.3	260.2	272.6	1788.4	3509.6	275.2	289.2	1843.4	40
42	3417.4	260.7	273.1	1790.2	3512.8	275.7	289.8	1845.2	42
44	3420.6	261.2	273.7	1792.0	3516.0	276.2	290.4	1847.1	44
46	3423.8	261.7	274.2	1793.9	3519.2	276.7	290.9	1848.9	46
48	3427.0	262.2	274.8	1795.7	3522.3	277.2	291.5	1850.7	48
50	3430.2	262.7	275.3	1797.5	3525.5	277.7	292.0	1852.6	50
52	3433.4	263.2	275.9	1799.3	3528.7	278.2	292.6	1854.4	52
54	3436.5	263.7	276.4	1801.2	3531.9	278.7	293.2	1856.3	54
56	3439.7	264.2	277.0	1803.0	3535.0	279.2	293.7	1858.1	56
58	3442.9	264.7	277.5	1804.8	3538.2	279.8	294.3	1859.9	58
60	3446.1	265.2	278.1	1806.7	3241.4	280.4	294.9	1861.8	60

Table A-5. Functions of 1° curves (continued)

	40°				41°				
	LC	M	E	T	LC	M	E	T	
0	3919.5	345.6	367.7	2085.5	4013.4	362.9	387.4	2142.3	0
2	3922.6	346.1	368.4	2087.4	4016.5	363.4	388.1	2144.2	2
4	3925.8	346.7	369.0	2089.3	4019.6	364.0	388.8	2146.1	4
6	3928.9	347.2	369.7	2091.2	4022.7	364.5	389.4	2148.0	6
8	3932.0	347.8	370.3	2093.1	4025.9	365.1	390.1	2149.9	8
10	3935.1	348.4	371.0	2095.0	4029.0	365.6	390.7	2151.9	10
12	3938.3	348.9	371.6	2096.9	4032.1	366.2	391.4	2153.8	12
14	3941.4	349.5	372.3	2098.8	4035.2	366.8	392.1	2155.7	14
16	3944.5	350.1	372.9	2100.7	4038.3	367.4	392.7	2157.6	16
18	3947.7	350.7	373.6	2102.6	4041.4	368.0	393.4	2159.5	18
20	3950.8	351.3	374.3	2104.5	4044.6	368.6	394.1	2161.4	20
22	3953.9	351.8	374.9	2106.3	4047.7	369.2	394.7	2163.3	22
24	3957.1	352.4	375.6	2108.2	4050.8	369.8	395.4	2165.2	24
26	3960.2	353.0	376.2	2110.1	4053.9	370.4	396.1	2167.1	26
28	3963.3	353.6	376.9	2112.0	4057.0	371.0	396.8	2169.0	28
30	3966.4	354.2	377.5	2113.9	4060.1	371.6	397.5	2170.9	30
32	3969.6	354.7	378.2	2115.8	4063.3	372.2	398.1	2172.8	32
34	3972.7	355.3	378.8	2117.7	4066.4	372.8	398.8	2174.7	34
36	3975.8	355.9	379.5	2119.6	4069.5	373.4	399.5	2176.6	36
38	3979.0	356.5	380.1	2121.5	4072.6	374.0	400.2	2178.5	38
40	3982.1	357.1	380.8	2123.4	4075.7	374.6	400.9	2180.4	40
42	3985.2	357.6	381.4	2125.3	4078.8	375.2	401.5	2182.4	42
44	3988.4	358.2	382.1	2127.2	4082.0	375.8	402.2	2184.3	44
46	3991.5	358.8	382.8	2129.1	4085.1	376.4	402.9	2186.2	46
48	3994.6	359.4	383.4	2131.0	4088.2	377.0	403.6	2188.1	48
50	3997.7	360.0	384.1	2132.9	4091.3	377.6	404.3	2190.0	50
52	4000.9	360.5	384.8	2134.7	4094.4	378.2	404.9	2191.9	52
54	4004.0	361.1	385.4	2136.6	4097.5	378.8	405.6	2193.8	54
56	4007.1	361.7	386.1	2138.5	4100.7	379.4	406.3	2195.7	56
58	4010.3	362.3	386.8	2140.4	4103.8	380.0	407.0	2197.6	58
60	4013.4	362.9	387.4	2142.3	4106.9	380.6	407.7	2199.5	60

	42°				43°				
	LC	M	E	T	LC	M	E	T	
0	4106.9	380.6	407.7	2199.5	4200.1	398.7	428.6	2257.1	0
2	4110.0	381.2	408.3	2201.4	4203.2	399.3	429.3	2259.0	2
4	4113.1	381.8	409.0	2203.3	4206.3	399.9	430.0	2261.0	4
6	4116.2	382.4	409.7	2205.3	4209.4	400.5	430.7	2262.9	6
8	4119.3	383.0	410.4	2207.2	4212.5	401.1	431.4	2264.8	8
10	4122.4	383.6	411.1	2209.1	4215.6	401.7	432.1	2266.7	10
12	4125.5	384.2	411.8	2211.0	4218.7	402.4	432.8	2268.7	12
14	4128.6	384.8	412.5	2212.9	4221.8	403.0	433.5	2270.6	14
16	4131.8	385.4	413.2	2214.9	4224.9	403.6	434.2	2272.5	16
18	4134.9	386.0	413.9	2216.8	4228.0	404.2	434.9	2274.5	18
20	4138.0	386.6	414.6	2218.7	4231.0	404.8	435.6	2276.4	20
22	4141.1	387.2	415.3	2220.6	4234.2	405.4	436.3	2278.3	22
24	4144.2	387.8	416.0	2222.5	4237.3	406.1	437.0	2280.2	24
26	4147.3	388.4	416.6	2224.4	4240.4	406.7	437.8	2282.2	26
28	4150.4	389.0	417.3	2226.4	4243.5	407.3	438.5	2284.1	28
30	4153.5	389.6	418.0	2228.3	4246.5	407.9	439.2	2286.0	30
32	4156.6	390.2	418.7	2230.2	4249.6	408.5	439.9	2288.0	32
34	4159.7	390.8	419.4	2232.1	4252.7	409.1	440.6	2289.9	34
36	4162.8	391.4	420.1	2234.0	4255.8	409.8	441.4	2291.8	36
38	4165.9	392.0	420.8	2236.0	4258.9	410.4	442.1	2293.8	38
40	4169.0	392.6	421.5	2237.9	4262.0	411.0	442.8	2295.7	40
42	4172.1	393.2	422.2	2239.8	4265.1	411.6	443.5	2297.7	42
44	4175.2	393.8	422.9	2241.7	4268.2	412.2	444.2	2299.6	44
46	4178.4	394.4	423.6	2243.6	4271.3	412.8	445.0	2301.5	46
48	4181.5	395.0	424.3	2245.6	4274.4	413.5	445.7	2303.5	48
50	4184.6	395.6	425.0	2247.5	4277.5	414.1	446.4	2305.4	50
52	4187.7	396.2	425.7	2249.4	4280.6	414.7	447.1	2307.3	52
54	4190.8	396.8	426.4	2251.3	4283.7	415.3	447.8	2309.3	54
56	4193.9	397.4	427.1	2253.3	4286.8	415.9	448.6	2311.2	56
58	4197.0	398.0	427.8	2255.2	4289.9	416.5	449.3	2313.1	58
60	4200.1	398.7	428.6	2257.1	4293.0	417.2	450.0	2315.1	60

Table A-5. Functions of 1° curves (continued)

	84°				85°				
	LC	M	E	T	LC	M	E	T	
0	7668.3	1471.8	1980.5	5159.3	7742.4	1505.4	2041.8	5250.6	0
2	7670.8	1472.9	1982.5	5162.3	7744.8	1506.5	2043.9	5253.6	2
4	7673.2	1474.0	1984.5	5165.3	7747.3	1507.6	2046.0	5256.7	4
6	7675.7	1475.1	1986.6	5168.4	7749.7	1508.8	2048.0	5259.8	6
8	7678.2	1476.2	1988.6	5171.4	7752.2	1509.9	2050.1	5262.9	8
10	7680.6	1477.4	1990.6	5174.4	7754.6	1511.0	2052.2	5266.0	10
12	7683.1	1478.5	1992.7	5177.5	7757.1	1512.2	2054.2	5269.0	12
14	7685.6	1479.6	1994.7	5180.7	7759.5	1513.3	2056.3	5272.1	14
16	7688.1	1480.7	1996.7	5183.5	7762.0	1514.4	2058.4	5275.4	16
18	7690.5	1481.8	1998.8	5186.6	7764.4	1515.6	2060.5	5278.3	18
20	7693.0	1483.0	2000.8	5189.6	7766.9	1516.7	2062.6	5281.4	20
22	7695.5	1484.1	2002.8	5192.6	7769.3	1517.8	2064.7	5284.4	22
24	7697.9	1485.2	2004.9	5195.6	7771.8	1519.0	2066.8	5287.5	24
26	7700.4	1486.3	2006.9	5198.7	7774.2	1520.1	2068.9	5290.6	26
28	7702.9	1487.4	2008.9	5201.7	7776.7	1521.2	2071.0	5293.7	28
30	7705.3	1488.6	2011.0	5204.7	7779.1	1522.4	2073.1	5296.7	30
32	7707.8	1489.7	2013.0	5207.8	7781.5	1523.5	2075.2	5299.8	32
34	7710.3	1490.8	2015.0	5210.8	7784.0	1524.6	2077.3	5302.9	34
36	7712.8	1491.9	2017.0	5213.9	7786.4	1525.8	2079.4	5306.1	36
38	7715.2	1493.0	2019.1	5216.9	7788.9	1526.9	2081.5	5309.2	38
40	7717.7	1494.2	2021.2	5220.0	7791.3	1528.0	2083.7	5312.3	40
42	7720.2	1495.3	2023.2	5223.1	7793.8	1529.2	2085.8	5315.4	42
44	7722.6	1496.4	2025.3	5226.1	7796.2	1530.3	2087.9	5318.5	44
46	7725.1	1497.5	2027.4	5229.2	7798.7	1531.4	2090.0	5321.6	46
48	7727.6	1498.6	2029.4	5232.2	7801.1	1532.6	2092.1	5324.7	48
50	7730.0	1499.8	2031.5	5235.5	7803.6	1533.7	2094.2	5327.8	50
52	7732.5	1500.9	2033.6	5238.3	7806.0	1534.8	2096.3	5330.9	52
54	7735.0	1502.0	2035.6	5241.4	7808.5	1536.0	2098.4	5334.0	54
56	7737.5	1503.1	2037.7	5244.5	7810.9	1537.1	2100.6	5337.1	56
58	7739.9	1504.2	2039.8	5247.5	7813.4	1538.2	2102.7	5340.2	58
60	7742.4	1505.4	2041.8	5250.6	7815.8	1539.3	2104.8	5343.3	60

	86°				87°				
	LC	M	E	T	LC	M	E	T	
0	7815.8	1539.3	2104.8	5343.3	7888.5	1573.6	2169.5	5447.7	0
2	7818.2	1540.4	2106.9	5346.4	7890.9	1574.8	2171.6	5450.7	2
4	7820.6	1541.6	2109.0	5349.5	7893.3	1575.9	2173.8	5453.9	4
6	7823.1	1542.7	2111.1	5352.7	7895.7	1577.1	2176.0	5457.1	6
8	7825.5	1543.9	2113.4	5355.8	7898.2	1578.2	2178.2	5460.3	8
10	7827.9	1545.0	2115.5	5358.9	7900.6	1579.4	2180.4	5463.4	10
12	7830.3	1546.1	2117.6	5362.0	7903.0	1580.5	2182.5	5466.6	12
14	7832.8	1547.3	2119.8	5365.2	7905.4	1581.7	2184.7	5459.8	14
16	7835.2	1548.4	2121.9	5368.3	7907.8	1582.9	2186.9	5463.0	16
18	7837.6	1549.6	2124.1	5371.4	7910.2	1584.0	2189.1	5466.2	18
20	7840.0	1550.7	2126.2	5374.6	7912.6	1585.1	2191.3	5469.4	20
22	7842.4	1551.8	2128.3	5377.7	7915.0	1586.3	2193.5	5472.5	22
24	7844.9	1553.0	2130.5	5380.8	7917.4	1587.4	2195.7	5475.7	24
26	7847.3	1554.1	2132.6	5383.9	7919.8	1588.6	2197.9	5478.9	26
28	7849.7	1555.3	2134.8	5387.1	7922.2	1589.7	2200.1	5482.1	28
30	7852.1	1556.4	2136.9	5390.2	7924.6	1590.9	2202.3	5485.3	30
32	7854.6	1557.5	2139.0	5393.4	7927.1	1592.0	2204.5	5488.5	32
34	7857.0	1558.7	2141.2	5396.5	7929.5	1593.2	2206.8	5491.7	34
36	7859.4	1559.8	2143.3	5399.7	7931.9	1594.3	2209.0	5494.9	36
38	7861.8	1561.0	2145.5	5402.8	7934.3	1595.5	2211.2	5498.1	38
40	7864.3	1562.1	2147.7	5406.0	7936.7	1596.6	2213.4	5501.3	40
42	7866.7	1563.2	2149.8	5409.1	7939.1	1597.8	2215.6	5504.5	42
44	7869.1	1564.4	2152.0	5412.3	7941.5	1598.9	2217.8	5507.7	44
46	7871.5	1565.5	2154.2	5415.4	7943.9	1600.1	2220.0	5510.9	46
48	7874.0	1566.7	2156.4	5418.6	7946.3	1601.2	2222.3	5514.1	48
50	7876.4	1567.8	2158.6	5421.8	7948.7	1602.4	2224.5	5517.3	50
52	7878.8	1568.9	2160.7	5424.9	7951.2	1603.5	2226.7	5520.5	52
54	7881.2	1570.1	2162.9	5428.1	7953.6	1604.7	2228.9	5523.7	54
56	7883.6	1571.2	2165.1	5431.2	7956.0	1605.8	2231.1	5526.9	56
58	7886.1	1572.4	2167.3	5434.4	7958.4	1607.0	2233.3	5530.1	58
60	7888.5	1573.6	2169.5	5437.5	7960.8	1608.2	2235.6	5533.3	60

Table A-8. Squares, cubes, square roots, and cube roots (continued)

No.	Square	Cube	Square Root	Cube Root	No.	Square	Cube	Square Root	Cube Root
641	410881	263374721	25.3180	8.6222	691	477481	329939371	26.2869	8.8408
642	412164	264609288	25.3377	8.6267	692	478864	331373888	26.3059	8.8451
643	413449	265847707	25.3574	8.6312	693	490249	332812557	26.3249	8.8493
644	414736	267089984	25.3772	6.6357	694	481636	334255384	26.3439	8.8536
645	416025	268336125	25.3969	8.6401	695	483025	335702375	26.3629	8.8578
646	417316	269586136	25.4165	8.6446	696	484416	337153536	26.3818	8.8621
647	418609	270840023	25.4362	8.6490	697	485809	338608873	26.4008	8.8663
648	419904	272097792	25.4558	8.6535	698	487204	340068392	26.4197	8.8706
649	421201	273359449	25.4755	8.6579	699	488601	341532099	26.4386	8.8748
650	422500	274625000	25.4951	8.6624	700	490000	343000000	26.4575	8.8790
651	423801	275894451	25.5147	8.6668	701	491401	344472101	26.4764	8.8833
652	425104	277167808	25.5343	8.6713	702	492804	345948408	26.4953	8.8875
653	426409	278445077	25.5539	8.6757	703	494209	347428927	26.5141	8.8917
654	427716	279726264	25.5734	8.6801	704	495616	348913664	26.5330	8.8959
655	429025	281011375	25.5930	8.6845	705	497025	350402625	26.5518	8.9001
656	430336	282300416	25.6125	8.6890	706	498436	351895816	26.5707	8.9043
657	431649	283593393	25.6320	8.6934	707	499849	353393243	26.5895	8.9085
658	432964	284890312	25.6515	8.6978	708	501264	354894912	26.6083	8.9127
659	434281	286191179	25.6710	8.7022	709	502681	356400829	26.6271	8.9169
660	435600	287496000	25.6905	8.7066	710	504100	357911000	26.6458	8.9211
661	436921	288804781	25.7099	8.7110	711	505521	359425431	26.6646	8.9253
662	438244	290117528	25.7294	8.7154	712	506944	360944128	26.6833	8.9295
663	439569	291434247	25.7488	8.7198	713	508369	362467097	26.7021	8.9337
664	440896	292754944	25.7682	8.7241	714	509796	363994344	26.7208	8.9378
665	442225	294079625	25.7876	8.7285	715	511225	365525875	26.7395	8.9420
666	443556	295408296	25.8070	8.7329	716	512656	367061696	26.7582	8.9462
667	444889	296740963	25.8263	8.7373	717	514089	368601813	26.7769	8.9503
668	446224	298077632	25.8457	8.7416	718	515524	370146232	26.7955	8.9545
669	447561	299418309	25.8650	8.7460	719	516961	371694959	26.8142	8.9587
670	448900	300763000	25.8844	8.7503	720	518400	373248000	26.8328	8.9628
671	450241	302111711	25.9037	8.7547	721	519841	374805361	26.8514	8.9670
672	451584	303464448	25.9230	8.7590	722	521284	376367048	26.8701	8.9711
673	452929	304821217	25.9422	8.7634	723	522729	377933067	26.8887	8.9752
674	454276	306182024	25.9615	8.7677	724	524176	379503424	26.9072	8.9794
675	455625	307546875	25.9808	8.7721	725	525625	381078125	26.9258	8.9835
676	456976	308915776	26.0000	8.7764	726	527076	382657176	26.9444	8.9876
677	458329	310288733	26.0192	8.7807	727	528529	384240583	26.9629	8.9918
678	459684	311665752	26.0384	8.7850	728	529984	385828352	26.9815	8.9959
679	461041	313046839	26.0576	8.7893	729	531441	387420489	27.0000	9.0000
680	462400	314432000	26.0768	8.7937	730	532900	389017000	27.0185	9.0041
681	463761	315821241	26.0960	8.7980	731	534361	390617891	27.0370	9.0082
682	465124	317214568	26.1151	8.8023	732	535824	392223168	27.0555	9.0123
683	466489	318611987	26.1343	8.8066	733	537289	393832837	27.0740	9.0164
684	467856	320013504	26.1543	8.8109	734	538756	395446904	27.0924	9.0205
685	469225	321419125	26.1725	8.8152	735	540225	397065375	27.1109	9.0246
686	470596	322828856	26.1916	8.8194	736	541696	398688256	27.1293	9.0287
687	471969	324242703	26.2107	8.8237	737	543169	400315553	27.1477	9.0328
688	473344	325660673	26.2298	8.8280	738	544644	401947272	27.1662	9.0369
689	474721	327083769	26.2488	8.8323	739	546121	403583419	27.1846	9.0410
690	476100	328509000	26.2679	8.8366	740	547600	405224000	27.2029	9.0450

Table A-9. Functions of the 10-chord spiral (continued)

Δ	A	C/L.	X/L.	Y/L.	Δ	A	C/L.	X/L.	Y/L.
39.6°	13° 08′ 56″	.979 186	.953 514	.222 745	42.4°	14° 04′ 14″	.976 164	.946 877	.237 320
39.7°	13° 10′ 54″	.979 081	.953 284	.223 270	42.5°	14° 06′ 12″	.976 053	.946 632	.237 836
39.8°	13° 12′ 53″	.978 977	.953 054	.223 794	42.6°	14° 08′ 10″	.975 941	.946 387	.238 352
39.9°	13° 14′ 51″	.978 872	.952 823	.224 318	42.7°	14° 10′ 09″	.975 829	.946 142	.238 868
					42.8°	14° 12′ 07″	.975 716	.945 895	.239 383
40.0°	13° 16′ 50″	.978 766	.952 591	.224 841	42.9°	14° 14′ 06″	.975 604	.945 649	.239 898
40.1°	13° 18′ 48″	.978 661	.952 359	.225 365	43.0°	14° 16′ 04″	.975 491	.945 402	.240 413
40.2°	13° 20′ 47″	.978 555	.952 127	.225 888					
40.3°	13° 22′ 46″	.978 440	.951 893	.226 410	43.1°	14° 18′ 02″	.975 378	.945 154	.240 927
40.4°	13° 24′ 44″	.978 343	.951 660	.226 933	43.2°	14° 20′ 01″	.975 264	.944 906	.241 [illegible]
40.5°	13° 26′ 43″	.978 236	.951 426	.227 455	43.3°	14° 21′ 59″	.975 151	.944 657	.241 [illegible]
40.6°	13° 28′ 41″	.978 130	.951 191	.227 977	43.4°	14° 23′ 57″	.975 037	.944 408	.242 469
40.7°	13° 30′ 40″	.978 023	.950 956	.228 498	43.5°	14° 25′ 56″	.974 9[illegible]	.944 15[illegible]	.242 982
40.8°	13° 32′ 38″	.977 915	.950 720	.229 019	43.6°	14° 27′ 54″	.974 80[illegible]	.943 908	.243 495
40.9°	13° 34′ 37″	.977 808	.950 484	.229 540	43.7°	14° 29′ 52″	.974 69[illegible]	.943 657	.244 008
					43.8°	14° 31′ 5[illegible]	.974 579	.943 405	.244 520
41.0°	13° 36′ 35″	.977 700	.950 247	.230 061	43.9°	14° 33′ 49″	.974 464	.943 154	.245 032
41.1°	13° 38′ 34″	.977 592	.950 010	.230 581	44.0°	14° 35′ 47″	.974 348	.942 901	.245 544
41.2°	13° 40′ 32″	.977 484	.949 772	.231 102					
41.3°	13° 42′ 31″	.977 375	.949 533	.231 62[illegible]	44.1°	14° 37′ 45″	.974 233	.942 648	.246 055
41.4°	13° 44′ 29″	.977 266	.949 294	.232 141	44.2°	14° 39′ [illegible]	.974 117	.942 395	.246 567
41.5°	13° 46′ 28″	.977 157	.949 055	.232 660	44.3°	14° 41′ 42″	.974 001	.942 141	.247 077
41.6°	13° 48′ 26″	.977 048	.948 815	.233 17[illegible]	44.4°	14° 43′ 40″	.973 884	.941 887	.247 588
41.7°	13° 50′ 2[illegible]	.976 938	.948 57[illegible]	.233 69[illegible]	44.5°	14° 45′ 38″	.973 768	.941 632	.248 098
41.8°	13° 52′ 2[illegible]	.976 828	.948 334	.234 21[illegible]	44.6°	14° 47′ 37″	.973 651	.941 377	.248 608
41.9°	13° 54′ 22″	.976 718	.948 092	.234 734	44.7°	14° 49′ 35″	.973 534	.941 121	.249 117
					44.8°	14° 51′ 33″	.973 416	.940 864	.249 627
42.0°	13° 56′ 20″	.976 608	.947 850	.235 252	44.9°	14° 53′ 31″	.974 299	.940 608	.250 135
42.1°	13° 58′ 18″	.976 498	.947 608	.235 789	45.0°	14° 55′ 29″	.973 181	.940 350	.250 644
42.2°	14° 00′ 17″	.976 387	.947 365	.236 286					
42.3°	14° 02′ 15″	.976 276	.947 121	.236 803					

Table A-13. Conversion of meters to feet

Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet	Meters	Feet
0		50	164.04167	100	328.08333	150	492.12500	200	656.16667
1	3.28083	1	167.32250	1	331.36417	1	495.40583	1	659.44750
2	6.56167	2	170.60333	2	334.64500	2	498.68667	2	662.72833
3	9.84250	3	173.88417	3	337.92583	3	501.96750	3	666.00917
4	13.12333	4	177.16500	4	341.20667	4	505.24833	4	669.2900
5	16.40417	5	180.44583	5	344.48750	5	508.52917	5	672.57083
6	19.68500	6	183.72667	6	347.76833	6	511.81000	6	675.85167
7	22.96583	7	187.00750	7	351.04917	7	515.09083	7	679.13250
8	26.24667	8	190.28833	8	354.33000	8	518.37167	8	682.41333
9	29.52750	9	193.56917	9	357.61083	9	521.65250	9	685.69417
10	32.80833	60	196.85000	110	360.89167	160	524.93333	210	688.97500
1	36.08917	1	200.13083	1	364.17250	1	528.21417	1	692.25583
2	39.37000	2	203.41167	2	367.45333	2	531.49500	2	695.53667
3	42.65083	3	206.69250	3	370.73417	3	534.77583	3	698.81750
4	45.93167	4	209.97333	4	374.01500	4	538.05667	4	702.09833
5	49.21250	5	213.25417	5	377.29583	5	541.33750	5	705.37917
6	52.49333	6	216.53500	6	380.57667	6	544.61833	6	708.66000
7	55.77417	7	219.81583	7	383.85750	7	547.89917	7	711.94083
8	59.05500	8	223.09667	8	387.13833	8	551.18000	8	715.22167
9	62.33583	9	226.37750	9	390.41917	9	554.46083	9	718.50250
20	65.61667	70	229.65833	120	393.70000	170	557.74167	220	721.78333
1	68.89750	1	232.93917	1	396.98083	1	561.02250	1	725.06417
2	72.17822	2	236.22000	2	400.26167	2	564.30333	2	728.34500
3	75.45917	3	239.50083	3	403.54250	3	567.58417	3	731.62583
4	78.74000	4	242.78167	4	406.82333	4	570.86500	4	734.90667
5	82.02083	5	246.06250	5	410.10417	5	574.14583	5	738.18750
6	85.30167	6	249.34333	6	413.38500	6	577.42667	6	741.46833
7	88.58250	7	252.62417	7	416.66583	7	580.70750	7	744.74917
8	91.86333	8	255.90500	8	419.94667	8	583.98833	8	748.03000
9	95.14417	9	259.18583	9	423.22750	9	587.26917	9	751.31083
30	98.42500	80	262.46667	130	426.50833	180	590.55000	230	754.59167
1	101.70583	1	265.74750	1	429.78917	1	593.83083	1	757.87250
2	104.98667	2	269.02833	2	433.07000	2	597.11167	2	761.15333
3	108.26750	3	272.30917	3	436.35083	3	600.39250	3	764.43417
4	111.54833	4	275.59000	4	439.63167	4	603.67333	4	767.71500
5	114.82917	5	278.87083	5	442.91250	5	606.95417	5	770.99583
6	118.11000	6	282.15167	6	446.19333	6	610.23500	6	774.27667
7	121.39083	7	285.43250	7	449.47417	7	613.51583	7	777.55750
8	124.67167	8	288.71333	8	452.75500	8	616.79667	8	780.83833
9	127.95250	9	291.99417	9	456.03583	9	620.07750	9	784.11917
40	131.23333	90	295.27500	140	459.31667	190	623.35833	240	787.40000
1	134.51417	1	298.55583	1	462.59750	1	626.63917	1	790.68083
2	137.79500	2	301.83667	2	465.87833	2	629.92000	2	793.96167
3	141.07583	3	305.11750	3	469.15917	3	633.20083	3	797.24250
4	144.35667	4	308.39833	4	472.44000	4	636.48167	4	800.52333
5	147.63750	5	311.67917	5	475.72083	5	639.76250	5	803.80417
6	150.91833	6	314.96000	6	479.00167	6	643.04333	6	807.08500
7	154.19917	7	318.24083	7	482.28250	7	646.32417	7	810.36583
8	157.48000	8	321.52167	8	485.56333	8	649.60500	8	813.64667
9	160.76083	9	324.80250	9	488.84417	9	652.88583	9	816.92750

LABELING AND MAILING PROCEDURES

The surveyor normally fills out the mailing label in front of the notebook to the unit conducting the project(s) (figure B-l).

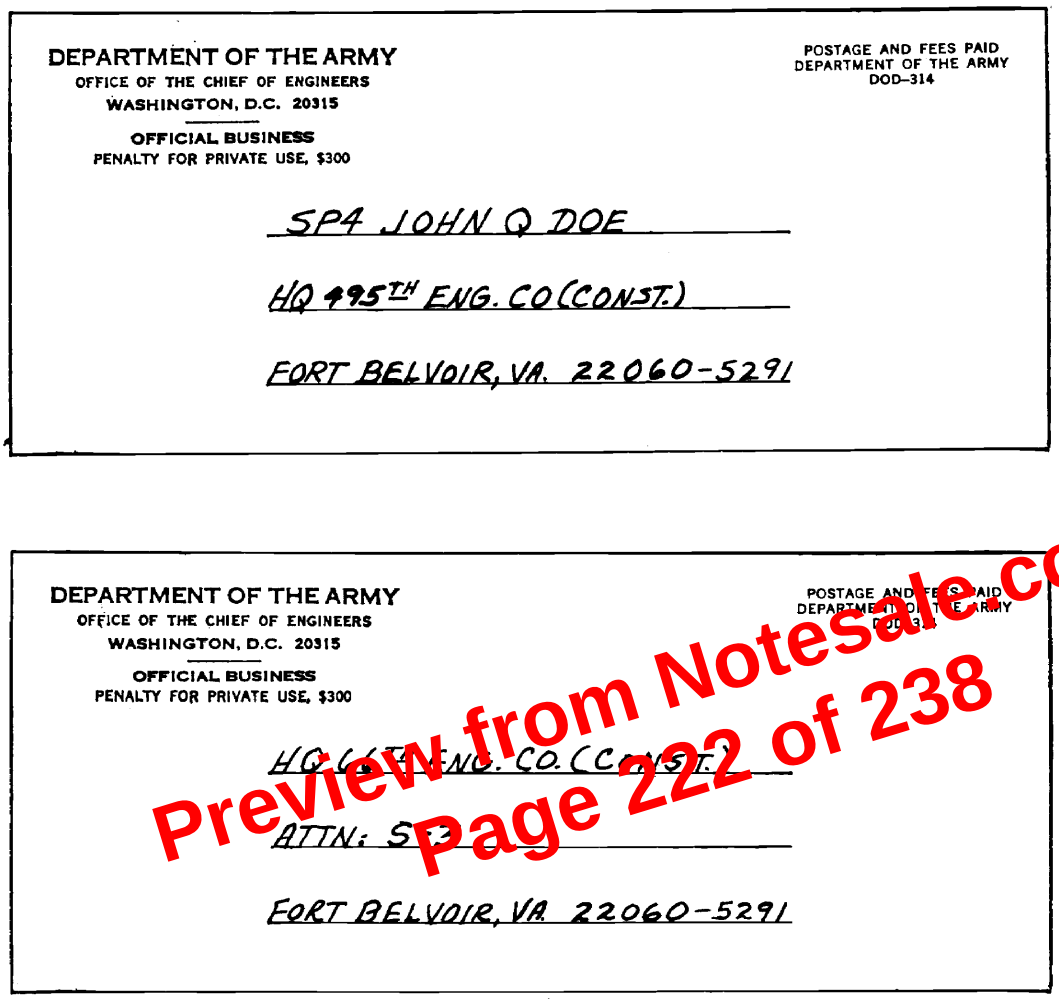
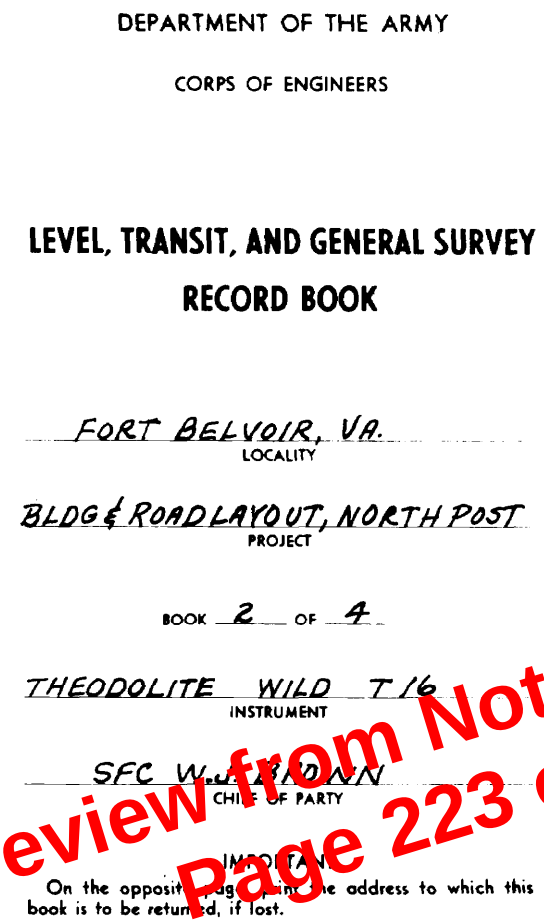


Figure B-1. Mailing label

The front page is to be filled out as required by the unit (figure B-2).


DEPARTMENT OF THE ARMY

CORPS OF ENGINEERS

LEVEL, TRANSIT, AND GENERAL SURVEY
RECORD BOOK

FORT BELVOIR, VA.
LOCALITY

BLDG & ROAD LAYOUT, NORTH POST
PROJECT

BOOK 2 OF 4

THEODOLITE WILD T16
INSTRUMENT

SFC W.J. BRADLEY
CHIEF OF PARTY

IMPORTANT
On the opposite page, print the address to which this book is to be returned, if lost.

Figure B-2. Front page of notebook

HEIGHT OF AN ACCESSIBLE POINT

DESIGNATION HEIGHT OF FLAG POLE DATE 31 JAN 1984

STA	TEL	ZD	VERT ANGLE	DIST
FP←01	D	70°30'	+19°30'	100.000
	R	289°29'	+19°29'	100.010
MEAN			+19°29'30"	100.005 METERS
FP←01	D	91°25'	-01°25'	
	R	268°35'	-01°25'	
MEAN			-01°25'00"	

TAN 19°29'30 X 100.005 = 35.397

TAN 1°25' X 100.005 = 2.473

= 37.870 METERS

↑ HAYWARD
▽ PARMELE
HT CARL
RT CUMMINGS

INST: T16
NO: 2391

REMARKS

WEATHER FAIR
WIND N 8
TEMP 30°

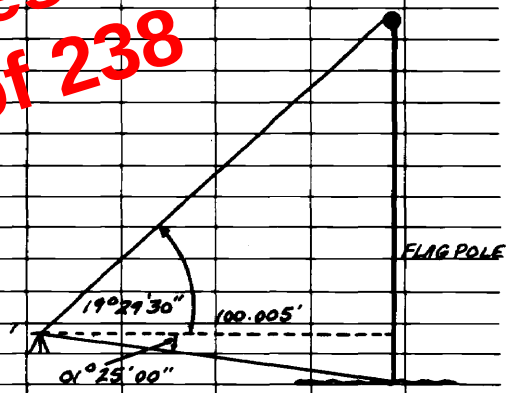


Figure B-16. Height of an accessible point

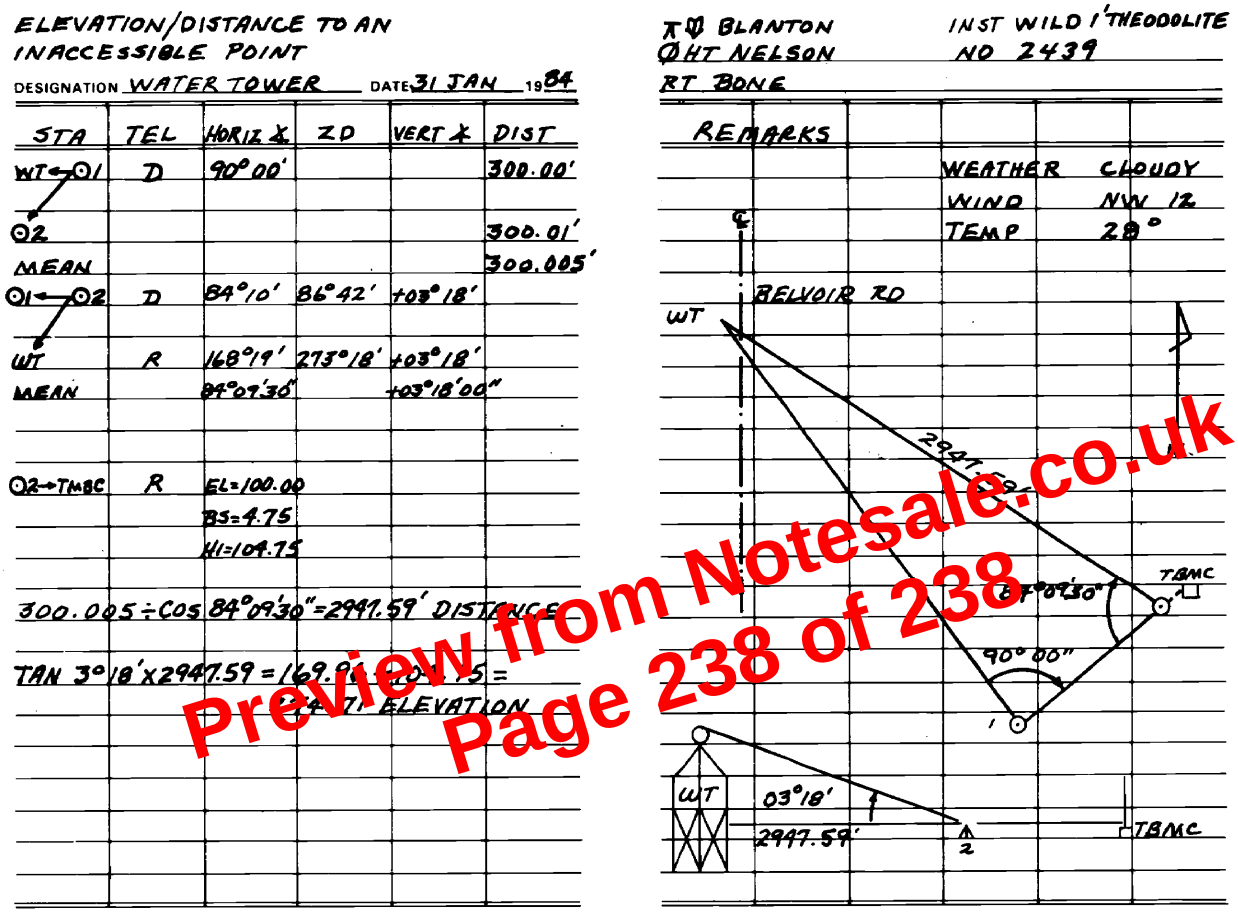


Figure B-17. Elevation/distance to an inaccessible point