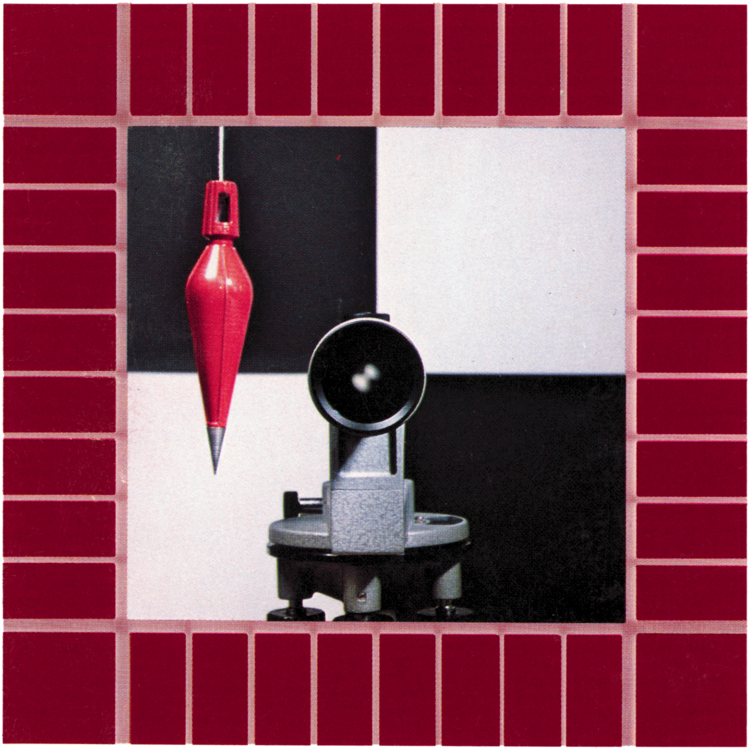
HEWLETT-PACKARD

HP-34C

SURVEYING Applications



NOTICE

HEWLETT PACKARD

HP-34C

Surveying Applications

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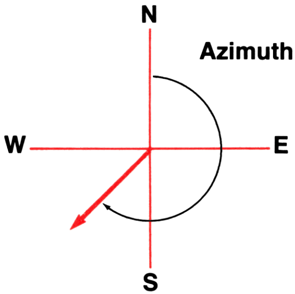
Introduction

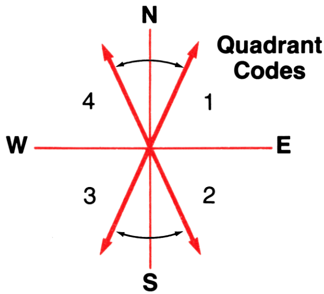
This Applications book was written to help you get the most from your calculator. The programs were chosen to provide useful calculations for many of the commonly encountered problems in surveying. They will provide you with immediate capabilities in your everyday calculations and you will find them useful as guides to programming techniques for writing your own customized software.

We hope that this Surveying Applications book will be a valuable tool in your work and would appreciate your comments about it.

Contents

Azimuth-Bearing Conversions





Angle conventions for azimuth and quadrant bearings as used in this applications book are shown above.

Thus azimuths are measured from the north meridian following North American surveying conventions. Bearings are measured from the meridian in the quadrant in which the line falls. Quadrant codes are shown in the above sketch.

This program provides conversions between bearings and azimuths. Routine A converts bearings to azimuths. Routine B converts azimuths to bearings. You may wish to separate the two parts and only key in one section if all your conversions are in one direction.

KEY ENTRY	DISPLAY
f CLEAR PRGM	000-
h LBL A	001-25, 13, 11
x⇌y	002- 21
g →H	003- 15 6
x⇌y	004- 21
ENTER↑	005- 31
ENTER↑	006- 31

KEY ENTRY	DISPLAY
2	007- 2
+	008- 71
h INT	009- 25 32
h π	010- 25 73
f →D	011- 14 5
×	012- 61
x⇌y	013- 21

KEY ENTRY	DISPLAY	KEY ENTRY	DISPLAY
h LST x	014– 25 0	g x<0	027– 15 41
×	015– 61	CHS	028– 32
f COS	016– 14 8	f →H.MS	029– 14 6
f R↑	017– 14 22	R/S	030– 74
×	018– 61	g R↓	031– 15 22
−	019– 41	9	032– 9
f →H.MS	020– 14 6	0	033– 0
h RTN	021– 25 12	+	034– 71
h LBL B	022– 25, 13, 12	1	035– 1
g →H	023– 15 6	+	036– 51
ENTER↑	024– 31	h INT	037– 25 32
f SIN	025– 14 7	h RTN	038– 25 12
g SIN⁻¹	026– 15 7		

REGISTERS			I Unused
R_0—$R_{.9}$ Unused			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set to			
	degrees mode. (Lines 01 thru		[g] [DEG]	
	21 are for bearing to azimuth,			
	lines 22 thru 38 are for			
	azimuth to bearing.)			
2	To convert bearing to azimuth:			
	Input bearing	BRG (D.MS)	[ENTER↑]	
	Input quadrant	QD	[A]	AZ (D.MS)
3	To convert azimuth to bearing:			
	Input azimuth	AZ (D.MS)	[B]	BRG (D.MS)
			[R/S]	QD

Example 1:

Convert bearing S 34° 56′ 37″ W to an azimuth.

Keystrokes:	**Display:**	
34.5637 [ENTER↑]		
3 [A]	214.5637	AZ (D.MS)

Example 2:

Convert azimuth 162° 15′ 32″ to bearing/quadrant.

Keystrokes:	**Display:**	
162.1532 [B]	17.4428	BRG (D.MS)
[R/S]	2.0000	QD

Traverse, Inverse and Sideshots

This program is designed for reducing field data and solving some of the commonly encountered field traversing problems. Four major routines are provided: 1) Bearing/Azimuth Traverse, 2) Field Angle Traverse, 3) Inverse, and 4) Sideshots. These routines can be used separately, but it is possible at any time to switch from one to another as required. Two additional routines are provided to supplement the four major routines: 5) Closure for Traverses, and 6) Slope Distance Reduction.

This program uses two flags to select an operating mode as follows:

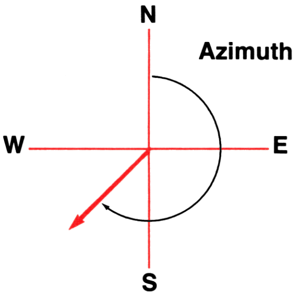
Mode	FA/BRG?	SS/TRA?
Bearing/azimuth angle traverse (BRG-TRA)	h SF 0	h SF 1
Field angle traverse (FA-TRA)	h CF 0	h SF 1
Field angle sideshots (FA-SS)	h CF 0	h CF 1
Bearing/azimuth angle sideshots (BRG-SS)	h SF 0	h CF 1

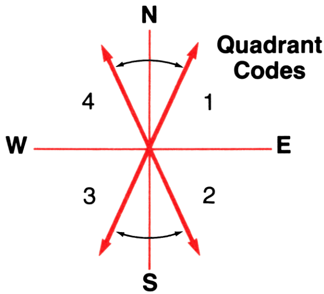
As the table shows, setting flag 0 indicates bearing or azimuth input. Similarly, clearing flag 0 indicates field angle input. The instructions generally call for the selection of angle input to be made at the beginning of the program and left unchanged, but it can be changed at any time if desired. In switching from BRG to FA mode, the last azimuth that was input becomes the reference direction from which the field angles are turned.

The table also shows that setting flag 1 means traverse and clearing flag 1 means sideshots. For sideshots, the transit remains stationary during several shots, while during a traverse, the transit is moved to the next point after each shot. As with FA/BRG angle modes, switching between SS and TRA modes can be done at any time.

Bearing/Azimuth Traverse

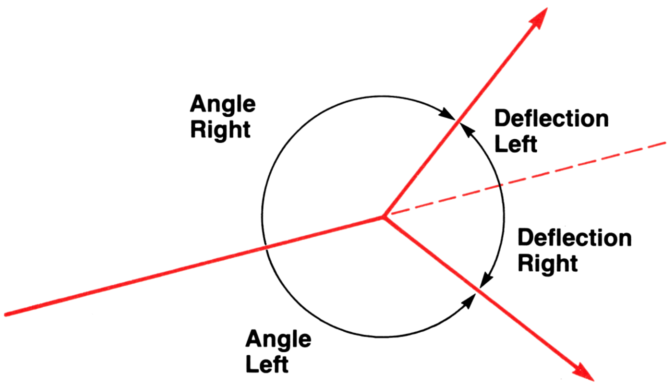
This routine uses quadrant bearings or azimuths and horizontal distances to compute the coordinates of successive points in a traverse. At the end of the traverse, Closure for Traverses can be used to get the total distance traversed, area, and error of closure. Angle conventions for azimuths and quadrant bearings are shown below:





Field Angle Traverse

This routine uses horizontal distances and angles or deflections turned from a reference azimuth to compute the coordinates of successive points in a traverse. At the end of the traverse, Closure for Traverses can be used to get the total distance traversed, area, and error of closure. Angle conventions are shown below:



Inverse

This routine calculates the distance and azimuth of the line joining two points, given the coordinates of the points. A figure may be traversed by entering the coordinates of successive points as in the example. At the end of a traverse, Closure for Traverses can be used to get the total distance traversed and the area.

Sideshots

This routine is used to make sideshots or radials from a point. Any of three methods may be used for a sideshot, 1) input a distance and a field angle turned from a reference azimuth and calculate the coordinates of the point, 2) input a distance and a bearing and calculate the coordinate of a point, 3) input the coordinates of a point and calculate the distance and azimuth of the line to the point.

Closure for Traverses

This routine is designed to be used at the completion of a Field Angle Traverse, Bearing/Azimuth Traverse, or Inverse. From the correct closing coordinates, the following are calculated: Total distance traversed (Σ HD), area, error azimuth, and error distance.

Slope Distance Reduction

This routine calculates the horizontal distance from a Slope Distance and Zenith Angle or Vertical Angle.

KEY ENTRY	DISPLAY
f CLEAR PRGM	000–
h LBL 0	001–25, 13, 0
f REG	002– 14 33
STO 2	003– 23 2
x⇄y	004– 21
STO 1	005– 23 1
h RTN	006– 25 12
h LBL 1	007–25, 13, 1

KEY ENTRY	DISPLAY
h F? 0	008–25, 71, 0
GTO 9	009– 22 9
g →H	010– 15 6
h π	011– 25 73
f →D	012– 14 5
+	013– 51
f →H.MS	014– 14 6
h LBL 2	015–25, 13, 2

KEY ENTRY	DISPLAY
g →H	016– 15 6
h F? 0	017–25, 71, 0
GTO 8	018– 22 8
RCL 0	019– 24 0
+	020– 51
GTO 8	021– 22 8
h LBL 9	022–25, 13, 9
x⇄y	023– 21
g →H	024– 15 6
x⇄y	025– 21
ENTER↑	026– 31
ENTER↑	027– 31
2	028– 2
÷	029– 71
h INT	030– 25 32
h π	031– 25 73
f →D	032– 14 5
×	033– 61
x⇄y	034– 21
h LST X	035– 25 0
×	036– 61
f COS	037– 14 8
f R↑	038– 14 22
×	039– 61
−	040– 41
h LBL 8	041–25, 13, 8
1	042– 1
f →R	043– 14 4
h LBL 7	044–25, 13, 7

KEY ENTRY	DISPLAY
g →P	045– 15 4
x⇄y	046– 21
g x>0	047– 15 51
GTO 9	048– 22 9
3	049– 3
6	050– 6
0	051– 0
+	052– 51
h LBL 9	053–25, 13, 9
h F? 1	054–25, 71, 1
STO 0	055– 23 0
STO f I	056–23, 14, 23
f →H.MS	057– 14 6
h RTN	058– 25 12
h LBL 3	059–25, 13, 3
RCL 6	060– 24 6
R/S	061– 74
g R↓	062– 15 22
RCL 4	063– 24 4
h ABS	064– 25 34
R/S	065– 74
g R↓	066– 15 22
h CF 1	067–25, 61, 1
GSB B	068– 13 12
h SF 1	069–25, 51, 1
h RTN	070– 25 12
h LBL B	071–25, 13, 12
RCL 2	072– 24 2
−	073– 41

KEY ENTRY	DISPLAY
RCL 3	074- 24 3
−	075- 41
x⇄y	076- 21
RCL 1	077- 24 1
−	078- 41
RCL 7	079- 24 7
−	080- 41
GSB 7	081- 13 7
g →H	082- 15 6
x⇄y	083- 21
GSB 9	084- 13 9
f R↑	085- 14 22
RCL 5	086- 24 5
h RTN	087- 25 12
h LBL A	088-25, 13, 11
RCL 0	089- 24 0
x⇄y	090- 21
h F? 1	091-25, 71, 1
GTO 9	092- 22 9
RCL f I	093-24, 14, 23
x⇄y	094- 21
h LBL 9	095-25, 13, 9
h F? 1	096-25, 71, 1
STO + 6	097-23, 51, 6
STO 5	098- 23 5
f →R	099- 14 4
x⇄y	100- 21
h F? 1	101-25, 71, 1
GTO 9	102- 22 9

KEY ENTRY	DISPLAY
RCL 3	103- 24 3
+	104- 51
RCL 2	105- 24 2
+	106- 51
x⇄y	107- 21
RCL 7	108- 24 7
+	109- 51
RCL 1	110- 24 1
+	111- 51
RCL f I	112-24, 14, 23
GTO 8	113- 22 8
h LBL 9	114-25, 13, 9
STO + 3	115-23, 51, 3
h ABS	116- 25 34
STO + 9	117-23, 51, 9
g R↓	118- 15 22
h LST x	119- 25 0
2	120- 2
+	121- 71
RCL 3	122- 24 3
−	123- 41
x⇄y	124- 21
STO + 7	125-23, 51, 7
×	126- 61
STO + 4	127-23, 51, 4
h LST x	128- 25 0
h ABS	129- 25 34
STO + 8	130-23, 51, 8
RCL 3	131- 24 3

KEY ENTRY	DISPLAY
RCL 2	132- 24 2
+	133- 51
RCL 7	134- 24 7
RCL 1	135- 24 1
+	136- 51

KEY ENTRY	DISPLAY
RCL 0	137- 24 0
h LBL 8	138-25, 13, 8
f →H.MS	139- 14 6
g R↓	140- 15 22

REGISTERS			I Az
R_0 Az	R_1 Beg N	R_2 Beg E	R_3 Dep
R_4 Area	R_5 HD	R_6 ΣHD	R_7 Lat
R_8 $\Sigma\|lat\|$	R_9 $\Sigma\|Dep\|$		

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set			
	to degrees mode.		g DEG	
2	Load beginning coordinates:	Beg N	ENTER↑	
		Beg E	GSB 0	
	For Bearing/Azimuth Traverse:			
3	Select bearing/azimuth mode		h SF 0	
4	Select traverse.		h SF 1	
5	Input bearing and	BRG (D.MS)	ENTER↑	

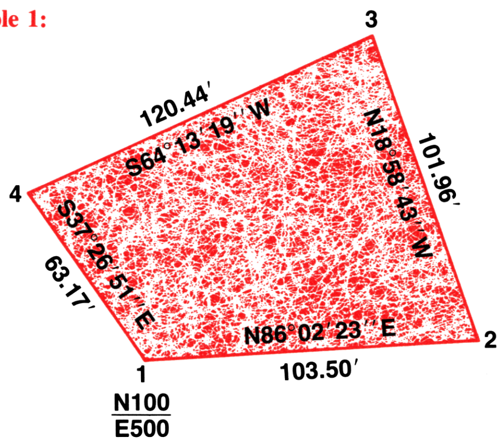
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	quadrant code.	QD	[GSB] 1	AZ (D.MS)
6	Input horizontal distance and			
	compute coordinates.	HD	[A]	N
			[x⇄y]	E
	Repeat steps 5 and 6 for			
	successive courses.			
	For Field Angle Traverse:			
7	Input reference azimuth:			
a	Select field angle mode.		[h] [CF] 0	
b	Select traverse.		[h] [SF] 1	
c	Input Az away from beg. point.	REF AZ (D.MS)	[GSB] 1	AZ (D.MS)
d	or Az toward beg. point.	REF AZ (D.MS)	[GSB] 2	AZ (D.MS)
7′	Or, input reference bearing:			
a	Select bearing mode.		[h] [SF] 0	
b	Select traverse.		[h] [SF] 1	
c	Input bearing toward beg. point	REF BRG (D.MS)	[ENTER↑]	
	and quadrant code.	QD	[GSB] 1	
d	Select field angle.		[h] [CF] 0	
8	Input field angle:			
	angle right	AR (D.MS)	[GSB] 1	
	or angle left	AL (D.MS)	[CHS] [GSB] 1	
	or deflection right	DR (D.MS)	[GSB] 2	
	or deflection left	DL (D.MS)	[CHS] [GSB] 2	
9	Input horizontal distance and			
	compute coordinates.	HD	[A]	N
			[x⇄y]	E

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	Repeat steps 8 and 9 for			
	successive courses.			
	For Inverse Traverse:			
10	Select traverse.		[h] [SF] 1	
11	Input coordinates and compute			
	HD and AZ.	N	[ENTER↑]	
		E	[B]	HD
			[x≷y]	AZ (D.MS)
	Repeat step 11 for successive			
	courses.			
	For Sideshots:			
	To use field angles go to step			
	12. To use bearing or azimuth			
	go to step 19. To inverse from			
	coordinates go to step 23.			
	Field Angle Sideshots			
12	Select bearing/azimuth.		[h] [SF] 0	
13	Select traverse.		[h] [SF] 1	
14	Input reference azimuth	AZ (D.MS)	[GSB] 2	AZ (D.MS)
	or, input reference bearing to	BRG (D.MS)	[ENTER↑]	
	point and quadrant code.	QD	[GSB] 1	AZ (D.MS)
15	Select field angle.		[h] [CF] 0	
16	Select sideshots.		[h] [CF] 1	
17	Input field angle:			
	angle right	AR (D.MS)	[GSB] 1	AZ (D.MS)
	or angle left	AL (D.MS)	[CHS] [GSB] 1	AZ (D.MS)
	or deflection right	DR (D.MS)	[GSB] 2	AZ (D.MS)
	or deflection left	DL (D.MS)	[CHS] [GSB] 2	AZ (D.MS)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
18	Input horizontal distance.	HD	[A]	N
			[x⇄y]	E
	Repeat steps 17 and 18 for			
	successive field angle shots.			
	Bearing/Azimuth Sideshots			
19	Select bearing/azimuth mode.		[h] [SF] 0	
20	Select sideshots.		[h] [CF] 1	
21	Input azimuth	AZ (D.MS)	[GSB] 2	AZ (D.MS)
	or input bearing and	BRG (D.MS)	[ENTER↑]	
	quadrant code.	QD	[GSB] 1	AZ (D.MS)
22	Input horizontal distance.	HD	[A]	N
			[x⇄y]	E
	Repeat steps 21 and 22 for			
	successive bearing/azimuth			
	shots.			
	Inverse Sideshots			
23	Select sideshots.		[h] [CF] 1	
24	Input coordinates of point.	N	[ENTER↑]	
		E	[B]	HD
			[x⇄y]	AZ (D.MS)
	Repeat step 24 for successive			
	inverse shots.			
	For Closure of Traverses:			
25	Input correct closing			
	coordinates.	N	[ENTER↑]	
		E	[GSB] 3	ΣHD
			[R/S]	Area
			[R/S]	Error Distance

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
			x⇄y	Error Azimuth
	For Slope Distance Reduction:			
26	If zenith angle is known go to			
	step 27. If vertical angle is			
	known go to step 31.			
27	Input zenith angle.	Zn Ang.	ENTER↑	
28	Input slope distance.	SD		
29	Calculate HD.		f →R x⇄y	HD
30	Continue with routine at step			
	2, 6, 9, 18 or 22.			
31	Input vertical angle.	Vert. Ang.	ENTER↑	
32	Input slope distance.	SD		
33	Calculate HD.		f →R	HD
34	Continue with routine at step			
	2, 6, 9, 18 or 22.			

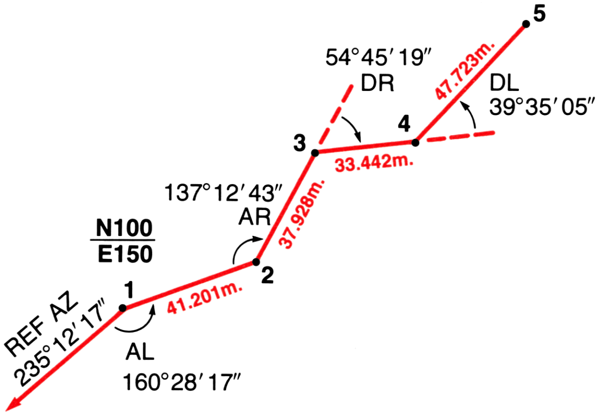
Example 1:



Starting with point 1 with coordinates N100, E500, traverse the figure above and compute the coordinates of the other points. Complete by using the closure routine.

Keystrokes:	**Display:**	
g DEG		
100 ENTER↑		
500 GSB 0		
h SF 0		
h SF 1		
86.0223 ENTER↑		
1 GSB 1	86.0223	AZ (D.MS)
103.5 A	107.1482	N
x≷y	603.2529	E
18.5843 ENTER↑		
4 GSB 1	341.0117	AZ (D.MS)
101.96 A	203.5657	N
x≷y	570.0939	E
64.1319 ENTER↑		
3 GSB 1	244.1319	AZ (D.MS)
120.44 A	151.1880	N
x≷y	461.6395	E
37.2651 ENTER↑		
2 GSB 1	142.3309	AZ (D.MS)
63.17 A	101.0366	N
x≷y	500.0490	E
100 ENTER↑ 500 GSB 3	389.0700	ΣHD
R/S	8,855.4922	Area
R/S	1.0378	Error Distance
x≷y	182.4219	Error Azimuth

Example 2:



Starting with point 1 with coordinates N100, E150, traverse the figure above and compute the coordinates of the other points.

Keystrokes:	**Display:**	
100 [ENTER↑] 150 [GSB] 0		
[h] [CF] 0		
[h] [SF] 1		
235.1217 [GSB] 1	55.1217	REF AZ
160.2817 [CHS] [GSB] 1	74.4360	AZ
41.201 [A]	110.8487	N
[x⇄y]	189.7470	E
137.1243 [GSB] 1	31.5643	AZ
37.928 [A]	143.0327	N
[x⇄y]	209.8151	E
54.4519 [GSB] 2	86.4202	AZ
33.442 [A]	144.9574	N
[x⇄y]	243.2017	E
39.3505 [CHS] [GSB] 2	47.0657	AZ
47.723 [A]	177.4338	N
[x⇄y]	278.1698	E

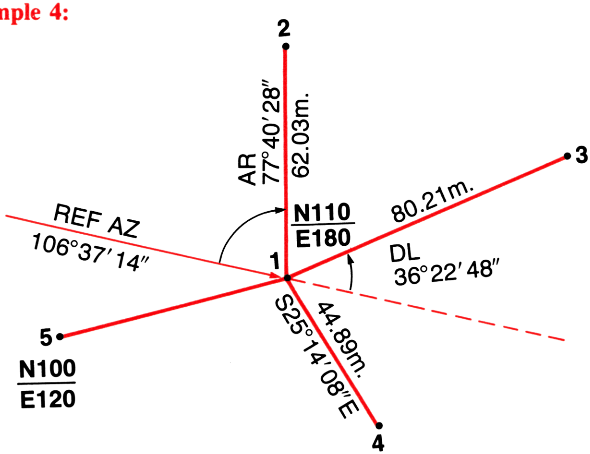
Example 3:

Work the Field Angle Traverse example as an inverse. Input the coordinates of the points and calculate the azimuth and distance of the line joining each pair of points.

Keystrokes:	Display:	
100 [ENTER↑] 150 [GSB] 0		
[h] [SF] 1		
110.8487 [ENTER↑]		
189.7470 [B]	41.2010	HD
[x≷y]	74.4360	AZ
143.0327 [ENTER↑]		
209.8151 [B]	37.9281	HD*
[x≷y]	31.5643	AZ
144.9574 [ENTER↑]		
243.2017 [B]	33.4420	HD
[x≷y]	86.4202	AZ
177.4338 [ENTER↑]		
278.1698 [B]	47.7230	HD
[x≷y]	47.0657	AZ

* The distance in the original example was 37.9280. The discrepancy is caused by inputting the coordinates as 4 decimal place numbers (rounding to 4 places). These points were calculated to 10 decimal places when running the Field Angle Traverse example.

Example 4:



Starting from point 1 with coordinates N110, E180, calculate the side-shots shown in the figure above.

Keystrokes:	Display:	
110 [ENTER↑] 180 [GSB] 0		
Select BRG and TRA modes to input reference azimuth.		
[h] [SF] 0		
[h] [SF] 1		
106.3714 [GSB] 2		
Now select FA and SS modes.		
[h] [CF] 0		
[h] [CF] 1		
77.4028 [GSB] 1	4.1742	AZ
62.03 [A]	171.8558	N
[x⇄y]	184.6455	E
36.2248 [CHS] [GSB] 2	70.1426	AZ
80.21 [A]	137.1167	N
[x⇄y]	255.4873	E
Select BRG mode.		
[h] [SF] 0		
25.1408 [ENTER↑]		
2 [GSB] 1	154.4552	AZ
44.89 [A]	69.3942	N
[x⇄y]	199.1384	E
100 [ENTER↑] 120 [B]	60.8276	HD
[x⇄y]	260.3216	AZ

Traverse Adjustment

This program will adjust a traverse using one of two methods. 1) the compass or Bowditch rule, 2) the transit rule. The data to be adjusted are the coordinates of the traverse. The program is designed so that it can be keyed in after the Traverse Inverse and Sideshots program has been run or certain information can be supplied by the user.

KEY ENTRY	DISPLAY
[f] CLEAR [PRGM]	000-
[h] [LBL] 0	001-25, 13, 0
[h] [CF] 0	002-25, 61, 0
[STO] 1	003- 23 1
[g] [R↓]	004- 15 22
[-]	005- 41
[STO] 7	006- 23 7
[h] [RTN]	007- 25 12
[h] [LBL] 1	008-25, 13, 1
[STO] 2	009- 23 2
[g] [R↓]	010- 15 22
[-]	011- 41
[STO] 3	012- 23 3
[GTO] 3	013- 22 3
[h] [LBL] 2	014-25, 13, 2
[h] [F?] 0	015-25, 71, 0
[GTO] 8	016- 22 8
0	017- 0
[STO] 6	018- 23 6
[STO] 8	019- 23 8
[STO] 9	020- 23 9
[g] [R↓]	021- 15 22
[h] [LBL] 8	022-25, 13, 8
[RCL] [•] 0	023- 24 .0
[x⇄y]	024- 21
[STO] [•] 0	025- 23 .0
[-]	026- 41
[h] [ABS]	027- 25 34
[STO] [+] 9	028-23, 51, 9
[x⇄y]	029- 21
[RCL] 5	030- 24 5
[x⇄y]	031- 21
[STO] 5	032- 23 5
[-]	033- 41
[h] [ABS]	034- 25 34
[STO] [+] 8	035-23, 51, 8
[g] [→P]	036- 15 4
[STO] [+] 6	037-23, 51, 6

KEY ENTRY	DISPLAY
h SF 0	038–25, 51, 0
h RTN	039– 25 12
h LBL 3	040–25, 13, 3
RCL 1	041– 24 1
STO 4	042– 23 4
STO 5	043– 23 5
RCL 2	044– 24 2
STO 0	045– 23 0
STO • 0	046– 23 .0
h RTN	047– 25 12
h LBL A	048–25, 13, 11
RCL • 0	049– 24 .0
CHS	050– 32
x⇄y	051– 21
STO • 0	052– 23 .0
+	053– 51
STO + 0	054–23, 51, 0
x⇄y	055– 21
RCL 5	056– 24 5
CHS	057– 32
x⇄y	058– 21
STO 5	059– 23 5
+	060– 51
STO + 4	061–23, 51, 4
g →P	062– 15 4
RCL 3	063– 24 3
RCL 6	064– 24 6
÷	065– 71
x⇄y	066– 21
×	067– 61
STO − 0	068–23, 41, 0
h LST x	069– 25 0
RCL 7	070– 24 7
RCL 6	071– 24 6
÷	072– 71
×	073– 61
CHS	074– 32
GTO 9	075– 22 9
h LBL B	076–25, 13, 12
RCL • 0	077– 24 .0
CHS	078– 32
x⇄y	079– 21
STO • 0	080– 23 .0
+	081– 51
ENTER↑	082– 31
h ABS	083– 25 34
RCL 9	084– 24 9
÷	085– 71
RCL 3	086– 24 3
×	087– 61
−	088– 41
STO + 0	089–23, 51, 0
x⇄y	090– 21
RCL 5	091– 24 5
−	092– 41
ENTER↑	093– 31
STO + 5	094–23, 51, 5
h ABS	095– 25 34

KEY ENTRY	DISPLAY
RCL 8	096– 24 8
+	097– 71
RCL 7	098– 24 7
×	099– 61
–	100– 41
h LBL 9	101–25, 13, 9

KEY ENTRY	DISPLAY
STO + 4	102–23, 51, 4
RCL 4	103– 24 4
R/S	104– 74
RCL 0	105– 24 0
h RTN	106– 25 12

REGISTERS			I Unused
R_0 Adj E	R_1 Beg. N	R_2 Beg. E	R_3 Error dep
R_4 Adj N	R_5 Lat, N	R_6 ΣHD	R_7 Error lat
R_8 Σ|Lat|	R_9 Σ|Dep|	$R_{.0}$ Dep, E	$R_{.1}$—$R_{.4}$ Unused

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set			
	degrees mode.		g DEG	
2	If a closed traverse has just			
	been run via the Traverse,			
	Inverse and Sideshots pro-			
	gram, go to step 9.			
3	Input beginning and ending			
	coordinates:			
	Closing northing (calculated)	N_{Cal}	ENTER↑	
	Closing northing (correct)	N_{Cor}	ENTER↑	
	Beginning northing	N_{Beg}	GSB 0	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	Closing easting (calculated)	E_{Cal}	[ENTER↑]	
	Closing easting (correct)	E_{Cor}	[ENTER↑]	
	Beginning easting	E_{Beg}	[GSB] 1	
4	If an open traverse was previously run via the Traverse Inverse and Sideshots program, go to step 9.			
5	If the sum of the horizontal distances (ΣHD) for compass rule or the sums of the absolute values of the latitudes and departures ($\Sigma\|lat\|$ and $\Sigma\|dep\|$) for transit rule are known, go to step 8.			
6	Calculate ΣHD, $\Sigma\|lat\|$, and $\Sigma\|dep\|$:			
	Key in the unadjusted coordinates for point 2 and process them.	N	[ENTER↑]	
		E	[GSB] 2	
7	Repeat step 6 for all points in succession until the unadjusted closing coordinates have been processed, then go to step 9.			
8	For compass rule store ΣHD.	ΣHD	[STO] 6	
	Or for transit rule store $\Sigma\|lat\|$	$\Sigma\|lat\|$	[STO] 8	
	and $\Sigma\|dep\|$.	$\Sigma\|dep\|$	[STO] 9	
9	Initialize*.		[GSB] 3	
10	For compass rule go to step 12.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
11	For transit rule go to step 13.			
	Compass Rule:			
12	Key in coordinates for point 2			
	and adjust.	N_{unadj}	ENTER↑	
	(Repeat this step for all points.)	E_{unadj}	A	N_{adj}
			R/S	E_{adj}
	Transit Rule:			
13	Key in coordinates for point 2			
	and adjust.	N_{unadj}	ENTER↑	
	(Repeat this step for all points.)	E_{unadj}	B	N_{adj}
			R/S	E_{adj}
	* If a mistake is made during			
	adjusting (steps 12 or 13)			
	return to step 9.			

Example 1:

The coordinates from the Bearing/Azimuth Traverse example are shown below:

Pt. no.	N	E
1	100.0000	500.0000
2	107.1482	603.2529
3	203.5657	570.0939
4	151.1880	461.6395
5	101.0366	500.0490

distance traversed = 389.0700

Adjust the coordinates using the Compass rule.

Keystrokes:	Display:	
101.0366 ENTER↑		
100 ENTER↑ GSB 0		
500.049 ENTER↑		
500 ENTER↑ GSB 1		
389.07 STO 6 GSB 3		
107.1482 ENTER↑		
603.2529 A	106.8724	N2
R/S	603.2399	E2
203.5657 ENTER↑		
570.0939 A	203.0183	N3
R/S	570.0680	E3
151.188 ENTER↑		
461.6395 A	150.3197	N4
R/S	461.5985	E4
101.0366 ENTER↑		
500.049 A	100.0000	N5, N1
R/S	500.0000	E5, E1

Example 2:

Assume the traverse in the above example was an open traverse ending at point 3 with the correct ending coordinates N = 203.0183 and E = 570.0680. Adjust this traverse using the transit rule.

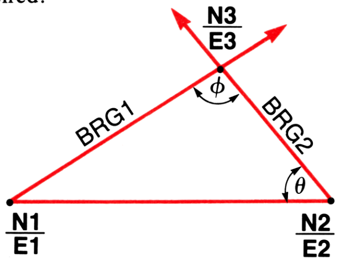
Keystrokes:	Display:	
203.5657 ENTER↑		
203.0183 ENTER↑		
100 GSB 0		
570.0939 ENTER↑		
570.0680 ENTER↑		
500 GSB 1		
107.1482 ENTER↑		
603.2529 GSB 2		
203.5657 ENTER↑		
570.0939 GSB 2		
GSB 3		
107.1482 ENTER↑		
603.2529 B	107.1104	N2
R/S	603.2333	E2

Keystroke:	Display:	
203.5657 [ENTER↑]		
570.0939 [B]	203.0183	N3
[R/S]	570.0680	E3

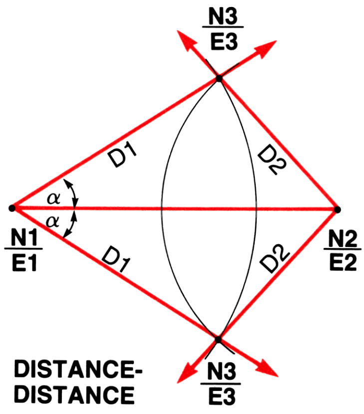
Bearing-Bearing and Distance-Distance Intersections

This program is designed to compute the coordinates of a point of intersection of two lines. The required information is the coordinates of a point of each line and either a distance for both lines or azimuth/bearings for both lines.

Along with the coordinates of the intersection the azimuths and distances are output, if desired.



BEARING-BEARING



DISTANCE-DISTANCE

Notice from the diagram above that a Distance-Distance intersection will have two solutions. Both solutions can be computed.

KEY ENTRY	DISPLAY
f CLEAR PRGM	000-
h LBL 0	001- 25, 13, 0
x⇄y	002- 21
g →H	003- 15 6
x⇄y	004- 21
ENTER↑	005- 31
ENTER↑	006- 31
2	007- 2
+	008- 71
h INT	009- 25 32
h π	010- 25 73
f →D	011- 14 5
×	012- 61
x⇄y	013- 21
h LST X	014- 25 0
×	015- 61
f COS	016- 14 8
f R↓	017- 14 22
×	018- 61
−	019- 41
1	020- 1
f →R	021- 14 4
GSB 8	022- 13 8
GTO 9	023- 22 9
h LBL 1	024- 25, 13, 1
g →H	025- 15 6

KEY ENTRY	DISPLAY
h LBL 9	026- 25, 13, 9
RCL 6	027- 24 6
STO 4	028- 23 4
g R↓	029- 15 22
STO 6	030- 23 6
f →H.MS	031- 14 6
h RTN	032- 25 12
h LBL 2	033- 25, 13, 2
RCL 7	034- 24 7
STO 5	035- 23 5
g R↓	036- 15 22
STO 7	037- 23 7
h RTN	038- 25 12
h LBL A	039- 25, 13, 11
GSB 7	040- 13 7
RCL 6	041- 24 6
RCL 9	042- 24 9
−	043- 41
f SIN	044- 14 7
RCL 8	045- 24 8
×	046- 61
RCL 6	047- 24 6
RCL 4	048- 24 4
−	049- 41
f SIN	050- 14 7
+	051- 71

KEY ENTRY	DISPLAY
STO 5	052– 23 5
GTO 6	053– 22 6
h LBL B	054–25, 13, 12
GSB 7	055– 13 7
RCL 5	056– 24 5
g →P	057– 15 4
g x^2	058– 15 3
RCL 7	059– 24 7
g x^2	060– 15 3
−	061– 41
RCL 8	062– 24 8
+	063– 71
RCL 5	064– 24 5
+	065– 71
2	066– 2
+	067– 71
g $\cos^{-1}$	068– 15 8
RCL 9	069– 24 9
x⇄y	070– 21
−	071– 41
STO f I	072–23, 14, 23
h LST x	073– 25 0
RCL 9	074– 24 9
+	075– 51
STO 4	076– 23 4
GSB 6	077– 13 6
R/S	078– 74
RCL 4	079– 24 4
f x⇄I	080– 14 21

KEY ENTRY	DISPLAY
STO 4	081– 23 4
h LBL 6	082–25, 13, 6
RCL 4	083– 24 4
RCL 5	084– 24 5
f →R	085– 14 4
RCL 0	086– 24 0
+	087– 51
R/S	088– 74
x⇄y	089– 21
RCL 1	090– 24 1
+	091– 51
R/S	092– 74
RCL 3	093– 24 3
−	094– 41
x⇄y	095– 21
RCL 2	096– 24 2
−	097– 41
GSB 8	098– 13 8
f →H.MS	099– 14 6
R/S	100– 74
x⇄y	101– 21
R/S	102– 74
RCL 4	103– 24 4
RCL 5	104– 24 5
f →R	105– 14 4
GSB 8	106– 13 8
f →H.MS	107– 14 6
R/S	108– 74
x⇄y	109– 21

KEY ENTRY	DISPLAY	KEY ENTRY	DISPLAY
h RTN	110- 25 12	h RTN	122- 25 12
h LBL 7	111-25, 13, 7	h LBL 8	123-25, 13, 8
RCL 3	112- 24 3	g →P	124- 15 4
RCL 1	113- 24 1	x⇄y	125- 21
−	114- 41	g x>0	126- 15 51
RCL 2	115- 24 2	h RTN	127- 25 12
RCL 0	116- 24 0	3	128- 3
−	117- 41	6	129- 6
GSB 8	118- 13 8	0	130- 0
STO 9	119- 23 9	+	131- 51
x⇄y	120- 21	h RTN	132- 25 12
STO 8	121- 23 8		

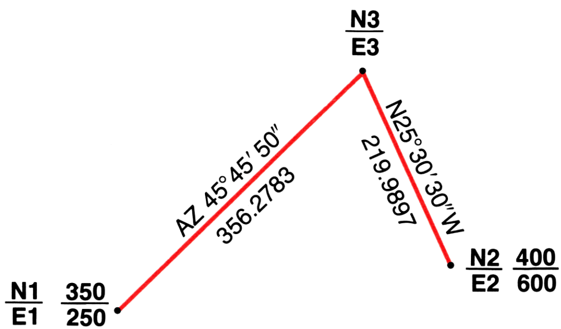
REGISTERS			I AZ1
R_0 N1	R_1 E1	R_2 N2	R_3 E2
R_4 AZ1	R_5 D1	R_6 AZ2	R_7 D2
R_8 D12	R_9 AZ12	$R_{.0}$ Unused	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set to			
	degrees mode.		g DEG	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
2	Store coordinates of point 1.	N1	[STO] 0	
		E1	[STO] 1	
3	Store coordinates of point 2.	N2	[STO] 2	
		E2	[STO] 3	
4	For Distance-Distance, go to			
	step 9. For Bearing-Bearing			
	go to step 5.			
5	Input bearing 1	BRG1 (D.MS)	[ENTER↑]	
	and quadrant	QD	[GSB] 0	AZ1 (D.MS)
	or azimuth 1.	AZ1 (D.MS)	[GSB] 1	AZ1 (D.MS)
6	Input bearing 2	BRG2 (D.MS)	[ENTER↑]	
	and quadrant	QD	[GSB] 0	AZ2 (D.MS)
	or azimuth 2	AZ2 (D.MS)	[GSB] 1	AZ2 (D.MS)
7	Compute intersection.		[A]	N3
			[R/S]	E3
			[R/S]	AZ2 (D.MS)
			[R/S]	D2
			[R/S]	AZ1 (D.MS)
			[R/S]	D1
8	Go to step 13.			
	Distance-Distance			
	Intersection:			
9	Input Distance 1.	D1	[GSB] 2	
10	Input Distance 2.	D2	[GSB] 2	
11	Compute intersection:		[B]	N3
			[R/S]	E3
			[R/S]	AZ2 (D.MS)
			[R/S]	D2
			[R/S]	AZ1 (D.MS)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
			[R/S]	D1
12	For the second Distance-Distance solution continue by pressing [R/S]. Outputs are as above.			
13	For a new Distance-Distance intersection with the same coordinates go to step 9. For a new Bearing-Bearing intersection with the same coordinates go to step 5. For new beginning coordinates go to step 2.			

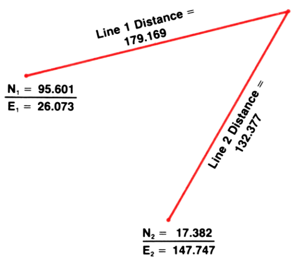
Example 1:



Using the figure shown above, compute the bearing-bearing intersection.

Keystrokes:	Display:	
350 [STO] 0		
250 [STO] 1		
400 [STO] 2		
600 [STO] 3		
45.4550 [GSB] 1	45.4550	AZ1 (D.MS)
25.3030 [ENTER↑]		
4 [GSB] 0	334.2930	AZ2 (D.MS)
[A]	598.5457	N3
[R/S]	505.2631	E3
[R/S]	334.2930	AZ2 (D.MS)
[R/S]	219.9897	D2
[R/S]	45.4550	AZ1 (D.MS)
[R/S]	356.2783	D1

Example 2:



Find the intersection from the data and diagram shown above.

Keystrokes:	Display:	
95.601 [STO] 0		
26.073 [STO] 1		
17.382 [STO] 2		
147.747 [STO] 3		
179.169 [GSB] 2		
132.377 [GSB] 2 [B]	-80.5716	N3
[R/S]	58.7034	E3
[R/S]	222.1619	AZ2 (D.MS)

[R/S]	*132.3770*	D2
[R/S]	*169.3024*	AZ1 (D.MS)
[R/S]	*179.1690*	D1

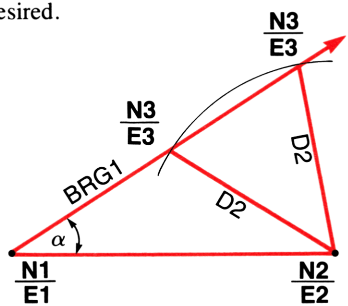
Notice from the diagram that the desired solution is above both points. The solution just calculated is below them and we therefore require the second solution.

[R/S]	*139.0558*	N3
[R/S]	*199.8925*	E3
[R/S]	*23.1154*	AZ2 (D.MS)
[R/S]	*132.3770*	D2
[R/S]	*75.5750*	AZ1 (D.MS)
[R/S]	*179.1690*	D1

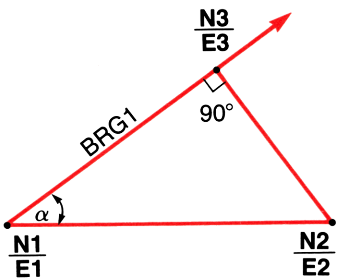
Offset and Bearing-Distance Intersections

This program is designed to compute the coordinates of a point of intersection of two lines. The required information is the coordinates of a point of each line and either a distance along a line (for an offset), or an azimuth/bearing of one line and a distance along the other.

Along with the coordinates of intersection, the azimuths and distances are output if desired.



BEARING-DISTANCE



OFFSET FROM A POINT TO A LINE

Notice from the diagram above that Bearing-Distance intersection may have two solutions. Both solutions can be computed. (If only one solution exists it will be re-output.)

KEY ENTRY	DISPLAY	KEY ENTRY	DISPLAY
f CLEAR PRGM	000-	g →H	025- 15 6
h LBL 0	001-25, 13, 0	h LBL 9	026-25, 13, 9
x⇄y	002- 21	RCL 6	027- 24 6
g →H	003- 15 6	STO 4	028- 23 4
x⇄y	004- 21	g R↓	029- 15 22
ENTER↑	005- 31	STO 6	030- 23 6
ENTER↑	006- 31	f →H.MS	031- 14 6
2	007- 2	h RTN	032- 25 12
+	008- 71	h LBL 2	033-25, 13, 2
h INT	009- 25 32	RCL 7	034- 24 7
h π	010- 25 73	STO 5	035- 23 5
f →D	011- 14 5	g R↓	036- 15 22
×	012- 61	STO 7	037- 23 7
x⇄y	013- 21	h RTN	038- 25 12
h LST X	014- 25 0	h LBL A	039-25, 13, 11
×	015- 61	GSB 7	040- 13 7
f COS	016- 14 8	RCL 6	041- 24 6
f R↑	017- 14 22	RCL 9	042- 24 9
×	018- 61	−	043- 41
−	019- 41	f SIN	044- 14 7
1	020- 1	RCL 8	045- 24 8
f →R	021- 14 4	×	046- 61
GSB 8	022- 13 8	STO 7	047- 23 7
GTO 9	023- 22 9	h LBL B	048-25, 13, 12
h LBL 1	024-25, 13, 1	GSB 7	049- 13 7

KEY ENTRY	DISPLAY
RCL 7	050- 24 7
g x²	051- 15 3
RCL 6	052- 24 6
STO 4	053- 23 4
RCL 9	054- 24 9
−	055- 41
RCL 8	056- 24 8
f →R	057- 14 4
g R↓	058- 15 22
g x²	059- 15 3
−	060- 41
f √x	061- 14 3
f R↓	062- 14 22
x⇄y	063- 21
−	064- 41
STO f I	065- 23, 14, 23
h LST x	066- 25 0
f R↓	067- 14 22
+	068- 51
STO 5	069- 23 5
GSB 6	070- 13 6
R/S	071- 74
RCL 5	072- 24 5
f x⇄I	073- 14 21
STO 5	074- 23 5
h LBL 6	075- 25, 13, 6
RCL 4	076- 24 4
RCL 5	077- 24 5
f →R	078- 14 4
RCL 0	079- 24 0
+	080- 51
R/S	081- 74
x⇄y	082- 21
RCL 1	083- 24 1
+	084- 51
R/S	085- 74
RCL 3	086- 24 3
−	087- 41
x⇄y	088- 21
RCL 2	089- 24 2
−	090- 41
GSB 8	091- 13 8
f →H.MS	092- 14 6
R/S	093- 74
x⇄y	094- 21
R/S	095- 74
RCL 4	096- 24 4
RCL 5	097- 24 5
f →R	098- 14 4
GSB 8	099- 13 8
f →H.MS	100- 14 6
R/S	101- 74
x⇄y	102- 21
h RTN	103- 25 12
h LBL 7	104- 25, 13, 7
RCL 3	105- 24 3
RCL 1	106- 24 1
−	107- 41

KEY ENTRY	DISPLAY	KEY ENTRY	DISPLAY
RCL 2	108- 24 2	g →P	117- 15 4
RCL 0	109- 24 0	x⇄y	118- 21
−	110- 41	g x>0	119- 15 51
GSB 8	111- 13 8	h RTN	120- 25 12
STO 9	112- 23 9	3	121- 3
x⇄y	113- 21	6	122- 6
STO 8	114- 23 8	0	123- 0
h RTN	115- 25 12	+	124- 51
h LBL 8	116-25, 13, 8	h RTN	125- 25 12

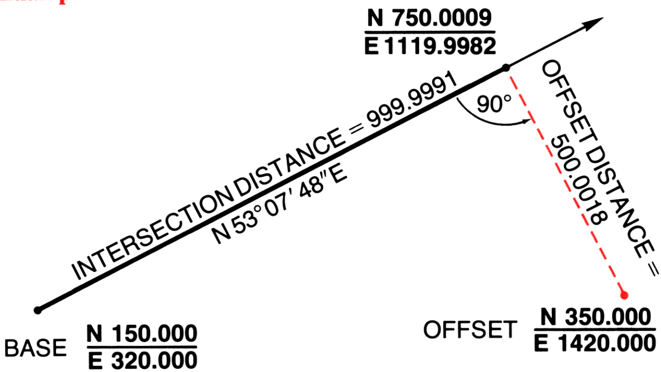
REGISTERS			I AZ1
R_0 N1	R_1 E1	R_2 N2	R_3 E2
R_4 AZ1	R_5 D1	R_6 AZ2	R_7 D2
R_8 D12	R_9 AZ12	$R_{.0}$—$R_{.1}$ Unused	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set to			
	degrees mode.		g DEG	
2	Store coordinates of point one.	N1	STO 0	
		E1	STO 1	
3	Store coordinates of point two.	N2	STO 2	
		E2	STO 3	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
4	For Bearing-Distance go to step			
	8. For offset go to step 5.			
	Offset:			
5	Input bearing 1	BRG1 (D.MS)	[ENTER↑]	
	and quadrant	QD	[GSB] 0	AZ1 (D.MS)
	or azimuth 1.	AZ1 (D.MS)	[GSB] 1	AZ1 (D.MS)
6	Compute intersection.		[A]	N3
			[R/S]	E3
			[R/S]	AZ2 (D.MS)
			[R/S]	D2
			[R/S]	AZ1 (D.MS)
			[R/S]	D1
7	Go to step 11.			
	Bearing-Distance:			
8	Input bearing 1	BRG1 (D.MS)	[ENTER↑]	
	and quadrant	QD	[GSB] 0	AZ1 (D.MS)
	or azimuth 1.	AZ1 (D.MS)	[GSB] 1	AZ1 (D.MS)
9	Input distance 2.	D2	[GSB] 2	
10	Compute intersection.		[B]	N3
			[R/S]	E3
			[R/S]	AZ2 (D.MS)
			[R/S]	D2
			[R/S]	AZ1 (D.MS)
			[R/S]	D1
	Continue pressing [R/S] for			
	the second solution. Outputs			
	are in the same order.			
11	For a new Bearing-Distance			
	intersection go to step 8. For a			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	new offset go to step 5. For new			
	beginning coordinates go to			
	step 2.			

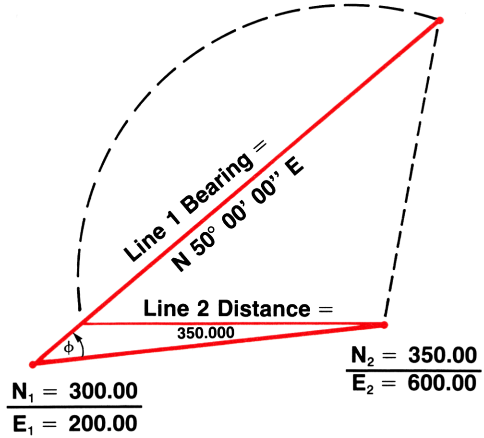
Example 1:



Using the figure above compute the offset intersection.

Keystrokes:	Display:	
150 [STO] 0		
320 [STO] 1		
350 [STO] 2		
1420 [STO] 3		
53.0748 [ENTER↑]		
1 [GSB] 0		
[A]	750.0009	N3
[R/S]	1,119.9982	E3
[R/S]	323.0748	AZ2 (D.MS)
[R/S]	500.0018	D2
[R/S]	53.0748	AZ1 (D.MS)
[R/S]	999.9991	D1

Example 2:



Obtain both possible bearing-distance intersections from the above diagram.

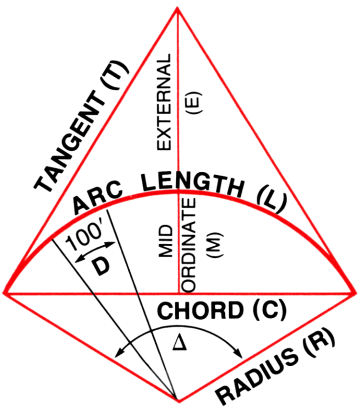
Keystrokes:	Display:	
300 STO 0		
200 STO 1		
350 STO 2		
600 STO 3		
50 ENTER↑		
1 GSB 0	50.0000	AZ1 (D.MS)
350 GSB 2 B	693.2096	N3
R/S	668.6089	E3
R/S	11.1817	AZ2 (D.MS)
R/S	350.0000	D2
R/S	50.0000	AZ1 (D.MS)
R/S	611.7255	D1

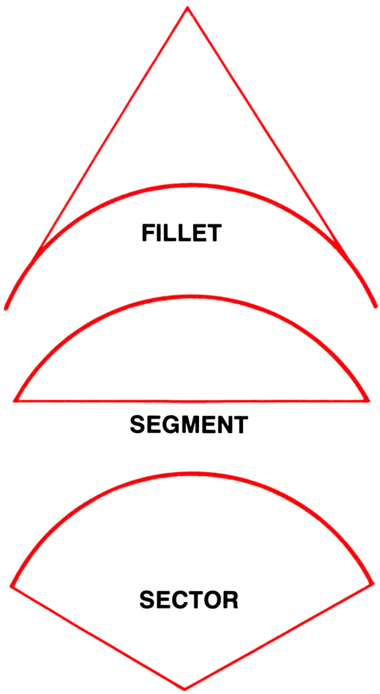
Now obtain the second solution.

R/S	342.0311	N3
R/S	250.0907	E3
R/S	268.4143	AZ2 (D.MS)
R/S	350.0000	D2
R/S	50.0000	AZ1 (D.MS)
R/S	65.3888	D1

Curve Solutions

This program is designed to compute parameters for circular curves. Two parameters must be known, either 1) both radius (degree of curve) and central angle, or 2) one of the above plus one of the following: arc length, chord, tangent, mid ordinate or external. All eight parameters can be output as well as the areas of the fillet, segment and sector.





M= Mid Ordinate
E= External
R= Radius
D= Degree of Curve
Δ= Central Angle
L= Arc Length
T= Tangent
C= Chord

KEY ENTRY	DISPLAY	KEY ENTRY	DISPLAY
f CLEAR PRGM	000–	GTO 9	022– 22 9
h LBL 1	001–25, 13, 1	RCL 1	023– 24 1
g →H	002– 15 6	2	024– 2
EEX	003– 33	×	025– 61
2	004– 2	+	026– 71
x⇄y	005– 21	STO 0	027– 23 0
+	006– 71	h RTN	028– 25 12
f →D	007– 14 5	h LBL 9	029–25, 13, 9
h LBL 2	008–25, 13, 2	RCL 0	030– 24 0
STO 0	009– 23 0	+	031– 71
h SF 0	010–25, 51, 0	2	032– 2
h RTN	011– 25 12	+	033– 71
h LBL 3	012–25, 13, 3	STO 1	034– 23 1
g →H	013– 15 6	h RTN	035– 25 12
2	014– 2	h LBL 5	036–25, 13, 5
+	015– 71	2	037– 2
STO 1	016– 23 1	+	038– 71
h CF 0	017–25, 61, 0	h F? 0	039–25, 71, 0
h RTN	018– 25 12	GTO 9	040– 22 9
h LBL 4	019–25, 13, 4	RCL 1	041– 24 1
f →D	020– 14 5	f SIN	042– 14 7
h F? 0	021–25, 71, 0	+	043– 71

KEY ENTRY	DISPLAY
STO 0	044– 23 0
h RTN	045– 25 12
h LBL 9	046–25, 13, 9
RCL 0	047– 24 0
+	048– 71
g SIN⁻¹	049– 15 7
STO 1	050– 23 1
h RTN	051– 25 12
h LBL 6	052–25, 13, 6
h F? 0	053–25, 71, 0
GTO 9	054– 22 9
RCL 1	055– 24 1
2	056– 2
+	057– 71
f TAN	058– 14 9
+	059– 71
GTO 7	060– 22 7
h LBL 9	061–25, 13, 9
RCL 0	062– 24 0
+	063– 71
1	064– 1
+	065– 51
h 1/x	066– 25 2
g COS⁻¹	067– 15 8
STO 1	068– 23 1
h RTN	069– 25 12
h LBL 7	070–25, 13, 7
h F? 0	071–25, 71, 0
GTO 9	072– 22 9

KEY ENTRY	DISPLAY
RCL 1	073– 24 1
f TAN	074– 14 9
+	075– 71
STO 0	076– 23 0
h RTN	077– 25 12
h LBL 9	078–25, 13, 9
RCL 0	079– 24 0
+	080– 71
g TAN⁻¹	081– 15 9
STO 1	082– 23 1
h RTN	083– 25 12
h LBL 8	084–25, 13, 8
h F? 0	085–25, 71, 0
GTO 9	086– 22 9
1	087– 1
RCL 1	088– 24 1
f COS	089– 14 8
−	090– 41
+	091– 71
STO 0	092– 23 0
h RTN	093– 25 12
h LBL 9	094–25, 13, 9
RCL 0	095– 24 0
+	096– 71
1	097– 1
x⇄y	098– 21
−	099– 41
g COS⁻¹	100– 15 8
STO 1	101– 23 1

KEY ENTRY	DISPLAY
h RTN	102- 25 12
h LBL A	103-25, 13, 11
EEX	104- 33
2	105- 2
RCL 0	106- 24 0
R/S	107- 74
+	108- 71
f →D	109- 14 5
f →H.MS	110- 14 6
R/S	111- 74
RCL 1	112- 24 1
2	113- 2
×	114- 61
f →H.MS	115- 14 6
R/S	116- 74
h LST x	117- 25 0
RCL 0	118- 24 0
×	119- 61
g →R	120- 15 5
STO 2	121- 23 2
h RTN	122- 25 12
h LBL B	123-25, 13, 12
RCL 1	124- 24 1
f TAN	125- 14 9
RCL 0	126- 24 0
×	127- 61
STO 4	128- 23 4
R/S	129- 74
RCL 1	130- 24 1
f SIN	131- 14 7
RCL 0	132- 24 0
×	133- 61
2	134- 2
×	135- 61
STO 3	136- 23 3
R/S	137- 74
1	138- 1
RCL 1	139- 24 1
f COS	140- 14 8
−	141- 41
RCL 0	142- 24 0
×	143- 61
R/S	144- 74
RCL 1	145- 24 1
2	146- 2
+	147- 71
f TAN	148- 14 9
RCL 4	149- 24 4
×	150- 61
h RTN	151- 25 12
h LBL 0	152-25, 13, 0
RCL 0	153- 24 0
g x^2	154- 15 3
RCL 1	155- 24 1
×	156- 61
g →R	157- 15 5
R/S	158- 74
ENTER↑	159- 31

KEY ENTRY	DISPLAY
ENTER↑	160- 31
RCL 1	161- 24 1
RCL 0	162- 24 0
f →R	163- 14 4
×	164- 61
−	165- 41
R/S	166- 74

KEY ENTRY	DISPLAY
RCL 1	167- 24 1
f TAN	168- 14 9
RCL 0	169- 24 0
g x^2	170- 15 3
×	171- 61
f R↑	172- 14 22
−	173- 41

REGISTERS			I Unused
R_0 R	R_1 Δ/2	R_2 L	R_3 C
R_4 T			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set			
	degrees mode.		g DEG	
2	Input* degree of curve	D (D.MS)	GSB 1	
	or radius	R	GSB 2	
	or central angle.	Δ (D.MS)	GSB 3	
3	Input arc length	L	GSB 4	
	or chord	C	GSB 5	
	or external	E	GSB 6	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	or tangent	T	[GSB] 7	
	or mid ordinate	M	[GSB] 8	
4	Compute radius, degree of			
	curve, central angle and arc			
	length.		[A]	R
			[R/S]	D (D.MS)
			[R/S]	Δ (D.MS)
			[R/S]	L
5	Compute tangent, chord, mid			
	ordinate, and external.		[B]	T
			[R/S]	C
			[R/S]	M
			[R/S]	E
6	Compute		[GSB] 0	(sector area)
			[R/S]	(segment area)
			[R/S]	(fillet area)
7	Go to step 2 or 3 for new inputs.			
	* If both radius and central			
	angle (or degree of curve and			
	central angle) are known, input			
	both in step 2 and omit step 3.			

Example:

Given a curve of radius 100 feet with an arc length of 150 feet, compute the other parameters.

Keystrokes:	Display:	
100 [GSB] 2		
150 [GSB] 4		
[A]	100.0000	R
[R/S]	57.1745	D (D.MS)
[R/S]	85.5637	Δ (D.MS)
[R/S]	150.0000	L
[B]	93.1596	T
[R/S]	136.3278	C
[R/S]	26.8311	M
[R/S]	36.6701	E
[GSB] 0	7,500.0000	(sector area)
[R/S]	2,512.5251	(segment area)
[R/S]	1,815.9646	(fillet area)

Horizontal Curve Layout

This program calculates the field data for layout of a horizontal circular curve by one of four methods: 1) PC deflections and chord lengths, 2) PI deflections and distances, 3) tangent distances and offsets, and 4) chord distances and offsets. The required information on the curve is the PC or PI station, radius or degree of curve, and central angle. Field data for any specified station can be computed.

The Curve Solutions program can be used to compute the necessary inputs for this program or to compute the other curve parameters after this program has been run.

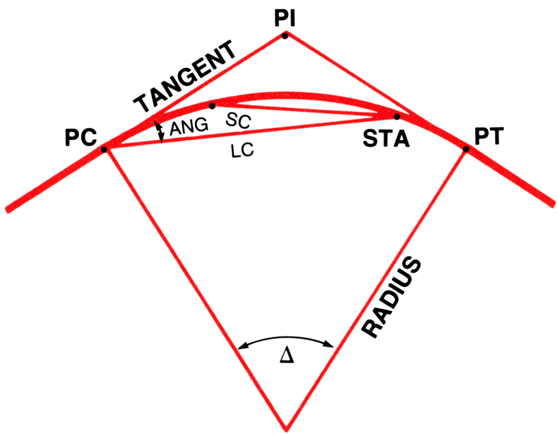
General output:

R or D= radius or degree of curve, whichever is unknown.

L= length of curve from PC to PT.

PT, PC= ends of curve.

PI= point of intersection of tangents.



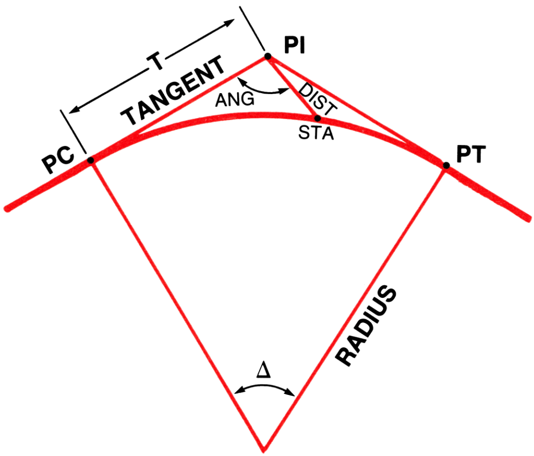
Field data for PC deflections consists of:

STA= current station

ANG= deflection angle from tangent to long chord

LC= long chord from PC to current station

SC= short chord from previous station to current station

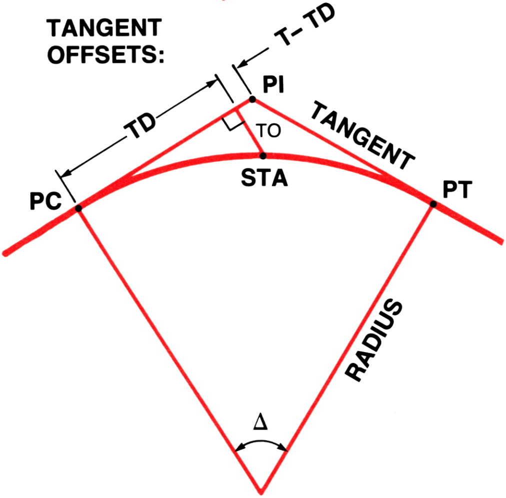


Field data for PI deflections consists of:

STA= current station

ANG= deflection angle from tangent to line joining PI and current station

DIST= distance from PI to current station

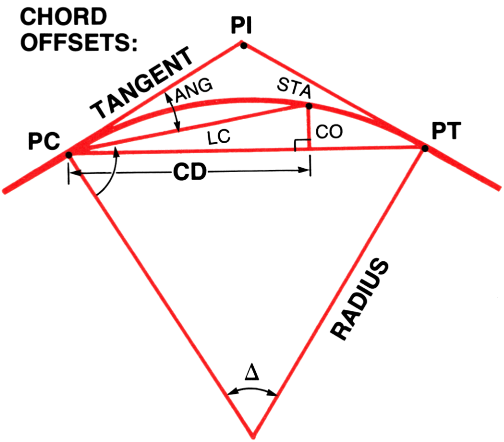


Field data for tangent offsets consists of:

STA= current station

TD= tangent distance

TO= tangent offset



Field data for chord offsets consists of:

STA= current station

CD= chord distance

CO= chord offset

KEY ENTRY	DISPLAY	KEY ENTRY	DISPLAY
f CLEAR PRGM	000–	f →D	024– 14 5
h LBL 0	001–25, 13, 0	GSB 9	025– 13 9
STO 1	002– 23 1	RCL 3	026– 24 3
h SF 2	003–25, 51, 2	h RTN	027– 25 12
h RTN	004– 25 12	h LBL 9	028–25, 13, 9
h LBL 1	005–25, 13, 1	STO 3	029– 23 3
STO 5	006– 23 5	g →R	030– 15 5
h CF 2	007–25, 61, 2	2	031– 2
h RTN	008– 25 12	×	032– 61
h LBL 2	009–25, 13, 2	STO 0	033– 23 0
GSB 9	010– 13 9	h RTN	034– 25 12
2	011– 2	h LBL A	035–25, 13, 11
0	012– 0	g →H	036– 15 6
0	013– 0	2	037– 2
RCL 0	014– 24 0	÷	038– 71
÷	015– 71	STO 4	039– 23 4
f →H.MS	016– 14 6	RCL 0	040– 24 0
h RTN	017– 25 12	×	041– 61
h LBL 3	018–25, 13, 3	STO 6	042– 23 6
g →H	019– 15 6	R/S	043– 74
EEX	020– 33	RCL 4	044– 24 4
2	021– 2	f TAN	045– 14 9
x⇄y	022– 21	RCL 3	046– 24 3
÷	023– 71	×	047– 61

KEY ENTRY	DISPLAY
STO 7	048– 23 7
RCL 1	049– 24 1
h F? 2	050–25, 71, 2
GTO 9	051– 22 9
RCL 5	052– 24 5
RCL 7	053– 24 7
−	054– 41
STO 1	055– 23 1
h LBL 9	056–25, 13, 9
RCL 6	057– 24 6
+	058– 51
R/S	059– 74
RCL 1	060– 24 1
STO 2	061– 23 2
R/S	062– 74
RCL 7	063– 24 7
+	064– 51
h RTN	065– 25 12
h LBL 4	066–25, 13, 4
4	067– 4
+	068– 51
STO f I	069–23, 14, 23
h RTN	070– 25 12
h LBL B	071–25, 13, 12
RCL 2	072– 24 2
−	073– 41
STO + 2	074–23, 51, 2
GSB 9	075– 13 9
RCL 2	076 24 2

KEY ENTRY	DISPLAY
RCL 1	077– 24 1
−	078– 41
GSB 9	079– 13 9
RCL 5	080– 24 5
GTO f I	081–22, 14, 23
h LBL 9	082–25, 13, 9
RCL 0	083– 24 0
+	084– 71
STO 5	085– 23 5
f SIN	086– 14 7
RCL 3	087– 24 3
×	088– 61
2	089– 2
×	090– 61
h RTN	091– 25 12
h LBL 5	092–25, 13, 5
f →H.MS	093– 14 6
R/S	094– 74
g R↓	095– 15 22
R/S	096– 74
g R↓	097– 15 22
h RTN	098– 25 12
h LBL 6	099–25, 13, 6
x⇄y	100– 21
f →R	101– 14 4
CHS	102– 32
RCL 7	103– 24 7
+	104– 51
g →P	105– 15 4

KEY ENTRY	DISPLAY
[R/S]	106- 74
[x⇄y]	107- 21
[f] [→H.MS]	108- 14 6
[h] [RTN]	109- 25 12
[h] [LBL] 8	110-25, 13, 8
[RCL] 4	111- 24 4
[x⇄y]	112- 21
[−]	113- 41
[h] [LBL] 7	114-25, 13, 7
[x⇄y]	115- 21
[f] [→R]	116- 14 4
[R/S]	117- 74
[x⇄y]	118- 21
[h] [RTN]	119- 25 12

REGISTERS			I Routine
R_0 FT/DEF	R_1 PC	R_2 STA	R_3 R
R_4 Δ/2	R_5 ANG, PI	R_6 L	R_7 T
R_8—$R_{.2}$ Unused			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set			
	degrees mode.		[g] [DEG]	
2	Input beginning station of curve.	PC	[GSB] 0	
	or station at intersection of	PI	[GSB] 1	
	tangents.			
3	Input radius	R	[GSB] 2	D (D.MS)
	or degree of curve.	D (D.MS)	[GSB] 3	R
4	Input central angle.	Δ (D.MS)	[A]	L

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
			[R/S]	PT
			[R/S]	PC
			[R/S]	PI
5	Select type of computation:			
	PC deflection	1	[GSB] 4	
	or PI deflection	2	[GSB] 4	
	or tangent offset	3	[GSB] 4	
	or chord offset.	4	[GSB] 4	
6	Input station and compute.			
	Outputs are as follows:			
	For PC deflection	STA	[B]	ANG
			[R/S]	LC
			[R/S]	SC
	or PI deflection	STA	[B]	ANG
			[R/S]	DIST
	or tangent offset	STA	[B]	TD
			[R/S]	TO
	or chord offset	STA	[B]	CD
			[R/S]	CO
7	Go to step 5 for a new type of			
	computation. Go to step 6 for a			
	new STA. Go to step 2 for a new			
	curve.			

Example:

Compute field data at stations 8+00 and 9+00 for PC deflections for a curve with a central angle of 35°30′ and a degree of curve of 12°30′. The station at the PI is 9+32.12.

Keystrokes:	Display:	
932.12 [GSB] 1		
12.30 [GSB] 3	458.3662	R
35.30 [A]	284.0000	L
[R/S]	1069.3958	PT
[R/S]	785.3958	PC
[R/S]	932.1200	PI
1 [GSB] 4		
800 [B]	0.5446	ANG
[R/S]	14.6036	LC
[R/S]	14.6036	SC
900 [B]	7.0946	ANG
[R/S]	114.3059	LC
[R/S]	99.8018	SC

Appendix A

Formulas

Bearing-Azimuth Conversions

1. $$\text{Azimuth} = 180\left\{\text{INT}\,\frac{\text{QD}}{2} - \text{BRG}\cos\left[(180)(\text{QD})\right]\right\}$$

2. $$\text{Bearing} = \left|\sin^{-1}(\sin \text{AZ})\right|$$

3. $$\text{Quadrant code} = \text{INT}\left(\frac{\text{AZ}}{90} + 1\right)$$

where:

AZ = Azimuth

BRG = Bearing

QD = Quadrant

INT = Integer portion of number (portion to left of decimal point)

Traverse Inverse and Sideshots

4. $$\text{Latitude}_k = \text{LAT}_k = N_{k+1} - N_k$$

For instance: $\text{LAT}_1 = N_2 - N_1$

5. $$\text{Departure}_k = \text{DEP}_k = E_{k+1} - E_k$$

For instance: $\text{DEP}_4 = E_5 - E_4$

6. $$\text{Area} = \sum_{k=1}^{n} \text{LAT}_k\left(\frac{1}{2}\,\text{DEP}_k + \sum_{j=1}^{k-1}\text{DEP}_j\right)$$

In evaluating equation 6, j assumes all values from 1 to k − 1 for each value of k, before k takes on the next higher value. For instance, for k = 3, the sum of departures 1 and 2 is added to ½ of departure 3, and the result is multiplied by latitude 3.

For n = 3, the three terms of equation 6 (for k = 1, 2 and 3) are:

$$k = 1:\ LAT_1\left(\frac{1}{2}\,DEP_1\right)$$

$$k = 2:\ LAT_2\left(\frac{1}{2}\,DEP_2 + DEP_1\right)$$

$$k = 3:\ LAT_3\left(\frac{1}{2}\,DEP_3 + DEP_1 + DEP_2\right)$$

For n = 3, the area is the sum of these three terms.

where:

n = Number of points in survey.

Traverse Adjustment
Compass Rule

7. $C_L = \dfrac{(\Delta N)(\text{Dist})}{\Sigma \text{Dist}}$

8. $C_D = \dfrac{(\Delta E)(\text{Dist})}{\Sigma \text{Dist}}$

Transit Rule

9. $C_L = \Delta N \, |L| / \Sigma |L|$

10. $C_D = \Delta E \, |D| / \Sigma |D|$

where:

C_L = Correction to latitude of a course

C_D = Correction to departure of a course

ΔN = Closing latitude

ΔE = Closing departure

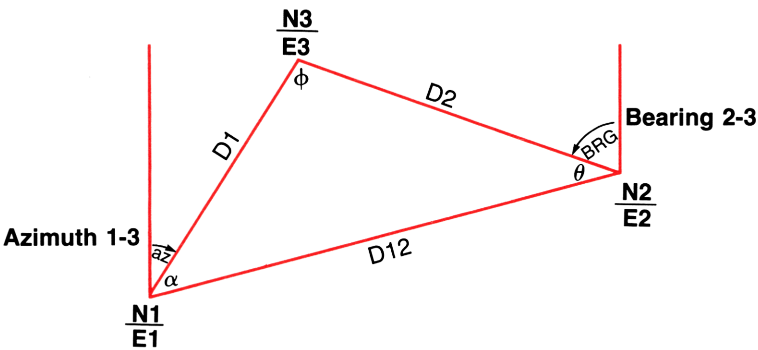
Dist = Length of course to be corrected

ΣDist = Total length of traverse

L = Latitude of a course

D = Departure of a course

Intersections



For any plane triangle with sides and angles as shown, the following relationships exist:

11. $$\frac{D2}{\sin \alpha} = \frac{D12}{\sin \phi} = \frac{D1}{\sin \theta}$$

12. $D2^2 = D12^2 + D1^2 - 2\,(D12)\,(D1)\cos \alpha$

Representative equations for solving the four intersection problems:

13. $D12 = \sqrt{(N_2 - N_1)^2 + (E_2 - E_1)^2}$

14. $$\sin AZ13 = \frac{E3 - E1}{D1}$$

15. $$\cos AZ13 = \frac{N3 - N1}{D1}$$

16. $$\sin BRG23 = \frac{E2 - E3}{D2}$$

17. $$\cos BRG23 = \frac{N2 - N3}{D2}$$

For bearing-bearing case:

18. $$D1 = \frac{(D12)\sin \theta}{\sin \phi}$$

For bearing-distance case:

19. $D1 = (D12)\cos \alpha \pm \sqrt{(D2)^2 - \left[(D12)\sin \alpha\right]^2}$

For distance-distance case:

20. Bearing 13 = bearing 12 $\pm\ \alpha$

21. $$\cos \alpha = \frac{(D12)^2 + (D1)^2 - (D2)^2}{2(D12)(D1)}$$ (Law of Cosines)

For offset from a point to a line:

22. D2 = (D12) sin α, then use 19.

Curve Solutions

23. $$\frac{\Delta}{2} = \tan^{-1}\left(\frac{T}{R}\right) = \sin^{-1}\left(\frac{C}{2R}\right) = \frac{90L}{\pi R}$$

24. $$L = \frac{\pi R \Delta}{180}$$

25. $$C = 2R\sin\left(\frac{\Delta}{2}\right) = 2T\cos\left(\frac{\Delta}{2}\right)$$

26. $$T = R\tan\left(\frac{\Delta}{2}\right)$$

27. $$R = \frac{C}{2\sin(\Delta/2)}$$

28. $$E = T\tan\left(\frac{\Delta}{4}\right)$$

29. $$M = R\left[1 - \cos\left(\frac{\Delta}{2}\right)\right]$$

30. $$\text{Sector area} = \frac{\pi R^2 \Delta}{360} = \frac{LR}{2}$$

31. $$\text{Segment area} = \text{Sector area} - \frac{1}{2}R^2\sin\Delta$$

32. $$\text{Segment area} = \text{Sector area} - \frac{1}{2}CR\cos\left(\frac{\Delta}{2}\right)$$

33. Fillet area = RT − Sector area

where:

L = Arc length

R = Radius

Δ = Central angle

C = Chord

T = Tangent

E = External

M = Mid ordinate

Horizontal Curve Layout

34. $L = \dfrac{\Delta \pi R}{180}$

35. $\text{Deflection angle} = \dfrac{\Delta}{2}$

36. $\text{Defl. ang.} = \dfrac{90L}{\pi R}$

37. $\text{Defl./ft.} = \dfrac{\text{defl. ang.}}{L}$

38. $\text{Ft./defl.} = \dfrac{L}{\text{defl. ang.}} = \dfrac{\pi R}{90}$

39. $D = \dfrac{18{,}000}{\pi R} = \dfrac{200}{\text{ft./defl.}}$

40. LC = 2R sin (defl. ang.)

41. TO = LC sin (defl. ang.)

42. TD = LC cos (defl. ang.)

43. $\text{PI dist.} = \sqrt{(T - TD)^2 + TO^2}$

44. $\text{PI ang.} = \tan^{-1}\left(\dfrac{TO}{T - TD}\right)$

45. $CO = LC \sin\left(\dfrac{\Delta_c}{2} - \text{defl. ang.}\right)$

46. $CD = LC \cos\left(\dfrac{\Delta_c}{2} - \text{defl. ang.}\right)$

where:

NOTE: See figures in program description to clarify definitions.

L = Length of arc subtending central angle Δ and corresponding to long chord LC.

Δ = Central angle of arc L and of long chord LC.

R = Radius.

Deflection angle = Angle from long chord LC to tangent T.

D = Degree of curve = Central angle subtending arc of 100 ft., measured in degrees.

LC = Long chord between PC and station on curve.

TO = Tangent offset = Perpendicular from tangent to station on curve.

TD = Tangent distance = Distance along tangent from PC to right angle intersection of tangent and tangent offset.

PI dist. = Distance from PI to station on curve.

T = Distance from PC to PI.

PI ang. = Angle between tangent and line between PI and station.

CO = Perpendicular distance from chord PC-PT to station on curve.

Δ_c = Central angle of curve = Angle subtended by curve PC-PT and by chord PC-PT.

CD = distance along chord PC-PT from PC to intersection with CO.

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