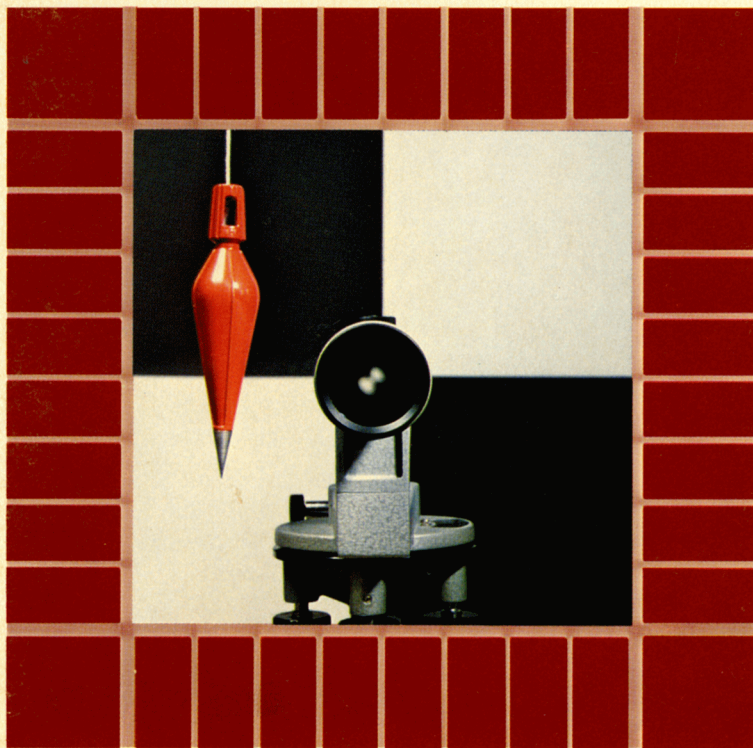


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SURVEYING Applications



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HP-34C

**Surveying
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Introduction

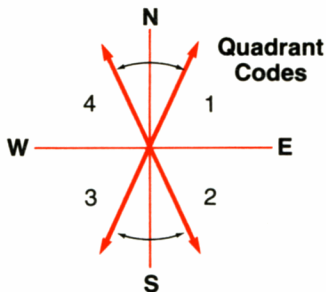
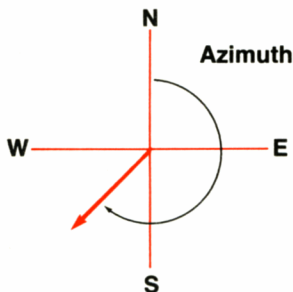
This Applications book was written to help you get the most from your calculator. The programs were chosen to provide useful calculations for many of the commonly encountered problems in surveying. They will provide you with immediate capabilities in your everyday calculations and you will find them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

Introduction	2
Programs	
Azimuth-Bearing Conversions	4
Traverse, Inverse, and Sideshots	7
Traverse Adjustment	21
Bearing-Bearing and Distance-Distance Intersections .	28
Offset and Bearing-Distance Intersections	36
Curve Solutions	43
Horizontal Curve Layout	50
Appendix	
Formulas	58

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
[x]	012- 61
[x] [y]	013- 21

KEY ENTRY	DISPLAY
$\boxed{h} \boxed{LST} \boxed{x}$	014- 25 0
$\boxed{x}$	015- 61
$\boxed{f} \boxed{COS}$	016- 14 8
$\boxed{f} \boxed{R\pm}$	017- 14 22
$\boxed{x}$	018- 61
$\boxed{-}$	019- 41
$\boxed{f} \boxed{\rightarrow HMS}$	020- 14 6
$\boxed{h} \boxed{RTN}$	021- 25 12
$\boxed{h} \boxed{LBL} \boxed{B}$	022- 25, 13, 12
$\boxed{g} \boxed{\rightarrow H}$	023- 15 6
$\boxed{ENTER\pm}$	024- 31
$\boxed{f} \boxed{SIN}$	025- 14 7
$\boxed{g} \boxed{SIN^{-1}}$	026- 15 7

KEY ENTRY	DISPLAY
$\boxed{g} \boxed{x < 0}$	027- 15 41
$\boxed{CHS}$	028- 32
$\boxed{f} \boxed{\rightarrow HMS}$	029- 14 6
$\boxed{R/S}$	030- 74
$\boxed{g} \boxed{R\pm}$	031- 15 22
9	032- 9
0	033- 0
$\boxed{+}$	034- 71
1	035- 1
$\boxed{+}$	036- 51
$\boxed{h} \boxed{INT}$	037- 25 32
$\boxed{h} \boxed{RTN}$	038- 25 12

REGISTERS			I Unused
$R_0 - R_9$ Unused			

6 Azimuth-Bearing Conversions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set to degrees mode. (Lines 01 thru 21 are for bearing to azimuth, lines 22 thru 38 are for azimuth to bearing.)		9 DEG	
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.

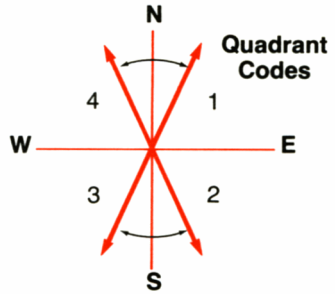
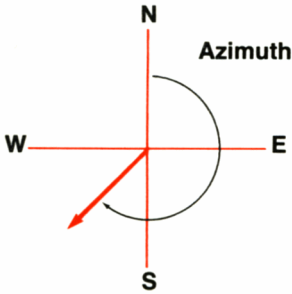
The table also shows that setting flag 1 means traverse and clearing flag 1 means sideshots. For sideshots, the transit remains stationary during several shots, while during a traverse, the transit is moved to the next point after each shot. As with FA/BRG angle modes, switching between SS and TRA modes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

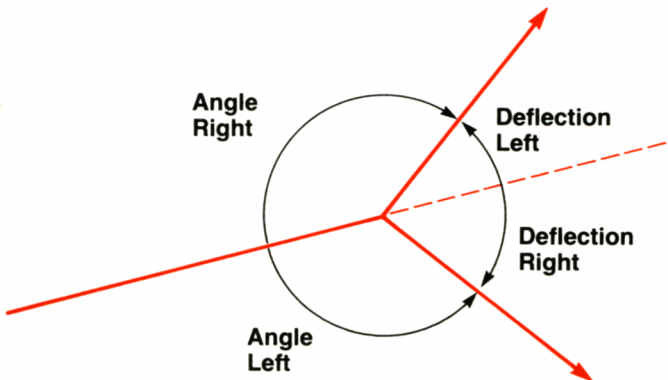
8 Traverse, Inverse and Sideshots

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	KEY ENTRY	DISPLAY
f CLEAR PRGM	000-	h F? 0	008- 25, 71, 0
h LBL 0	001- 25, 13, 0	GTO 9	009- 22 9
f REG	002- 14 33	g →H	010- 15 6
STO 2	003- 23 2	h π	011- 25 73
x↔y	004- 21	f →D	012- 14 5
STO 1	005- 23 1	+	013- 51
h RTN	006- 25 12	f →HMS	014- 14 6
h LBL 1	007- 25, 13, 1	h LBL 2	015- 25, 13, 2

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

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

KEY ENTRY	DISPLAY	KEY ENTRY	DISPLAY
RCL 3	074- 24 3	RCL 3	103- 24 3
-	075- 41	+	104- 51
x₁y	076- 21	RCL 2	105- 24 2
RCL 1	077- 24 1	+	106- 51
-	078- 41	x₁y	107- 21
RCL 7	079- 24 7	RCL 7	108- 24 7
-	080- 41	+	109- 51
GSB 7	081- 13 7	RCL 1	110- 24 1
g →H	082- 15 6	+	111- 51
x₁y	083- 21	RCL f I	112- 24, 14, 23
GSB 9	084- 13 9	GTO 8	113- 22 8
f R+	085- 14 22	h LBL 9	114- 25, 13, 9
RCL 5	086- 24 5	STO + 3	115- 23, 51, 3
h RTN	087- 25 12	h ABS	116- 25 34
h LBL A	088- 25, 13, 11	STO + 9	117- 23, 51, 9
RCL 0	089- 24 0	g R+	118- 15 22
x₁y	090- 21	h LST x	119- 25 0
h F? 1	091- 25, 71, 1	2	120- 2
GTO 9	092- 22 9	÷	121- 71
RCL f I	093- 24, 14, 23	RCL 3	122- 24 3
x₁y	094- 21	-	123- 41
h LBL 9	095- 25, 13, 9	x₁y	124- 21
h F? 1	096- 25, 71, 1	STO + 7	125- 23, 51, 7
STO + 6	097- 23, 51, 6	x	126- 61
STO 5	098- 23 5	STO + 4	127- 23, 51, 4
f →R	099- 14 4	h LST x	128- 25 0
x₁y	100- 21	h ABS	129- 25 34
h F? 1	101- 25, 71, 1	STO + 8	130- 23, 51, 8
GTO 9	102- 22 9	RCL 3	131- 24 3

12 Traverse, Inverse and Sideshots

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 ↔HMS	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 Σ HD	R ₇ Lat
R ₈ Σ lat	R ₉ Σ 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

14 Traverse, Inverse and Sideshots

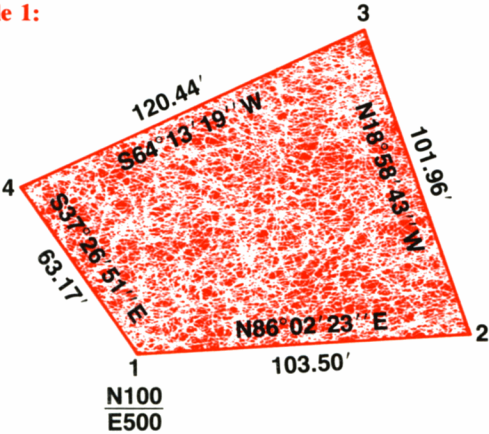
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
	Repeat steps 8 and 9 for successive courses.			
	For Inverse Traverse:			
10	Select traverse.		[h] [SF] 1	
11	Input coordinates and compute HD and AZ.	N	[ENTER]	
		E	[B]	HD
			[x] [y]	AZ (D.MS)
	Repeat step 11 for successive courses.			
	For 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 or, input reference bearing to point and quadrant code.	AZ (D.MS) BRG (D.MS) QD	[GSB] 2 [ENTER] [GSB] 1	AZ (D.MS) 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
			xzY	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 quadrant code.	BRG (D.MS)	ENTER+	
		QD	GSB 1	AZ (D.MS)
22	Input horizontal distance.	HD	A	N
			xzY	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
			xzY	AZ (D.MS)
	Repeat step 24 for successive inverse shots.			
	For Closure of Traverses:			
25	Input correct closing coordinates.	N	ENTER+	
		E	GSB 3	Σ HD
			R/S	Area
			R/S	Error Distance

16 Traverse, Inverse and Sideshots

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
			$\boxed{x \div y}$	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.	$\boxed{\text{ENTER}+}$	
28	Input slope distance.	SD		
29	Calculate HD.		$\boxed{f} \boxed{\div R} \boxed{x \div y}$	HD
30	Continue with routine at step 2, 6, 9, 18 or 22.			
31	Input vertical angle.	Vert. Ang.	$\boxed{\text{ENTER}+}$	
32	Input slope distance.	SD		
33	Calculate HD.		$\boxed{f} \boxed{\div R}$	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.

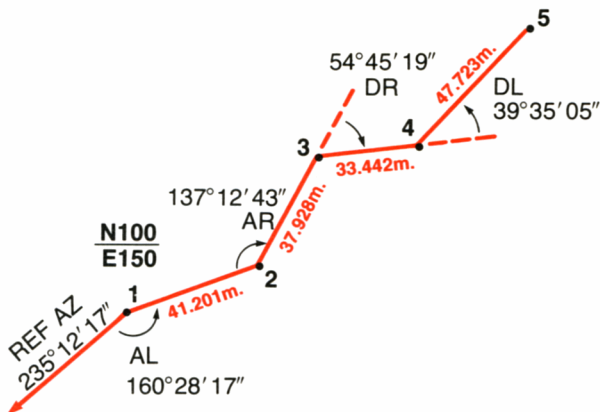
Keystrokes:

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
xz y	603.2529	E
18.5843 ENTER		
4 GSB 1	341.0117	AZ (D.MS)
101.96 A	203.5657	N
xz y	570.0939	E
64.1319 ENTER		
3 GSB 1	244.1319	AZ (D.MS)
120.44 A	151.1880	N
xz y	461.6395	E
37.2651 ENTER		
2 GSB 1	142.3309	AZ (D.MS)
63.17 A	101.0366	N
xz y	500.0490	E
100 ENTER 500 GSB 3	389.0700	Σ HD
R/S	8,855.4922	Area
R/S	1.0378	Error Distance
xz y	182.4219	Error Azimuth

18 Traverse, Inverse and Sideshots

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

160.2817 **CHS** **GSB** 1

41.201 **A**

x **y**

137.1243 **GSB** 1

37.928 **A**

x **y**

54.4519 **GSB** 2

33.442 **A**

x **y**

39.3505 **CHS** **GSB** 2

47.723 **A**

x **y**

55.1217

74.4360

110.8487

189.7470

31.5643

143.0327

209.8151

86.4202

144.9574

243.2017

47.0657

177.4338

278.1698

REF AZ

AZ

N

E

AZ

N

E

AZ

N

E

AZ

N

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

xzy 74.4360 AZ

143.0327 **ENTER**

209.8151 **B** 37.9281 HD*

xzy 31.5643 AZ

144.9574 **ENTER**

243.2017 **B** 33.4420 HD

xzy 86.4202 AZ

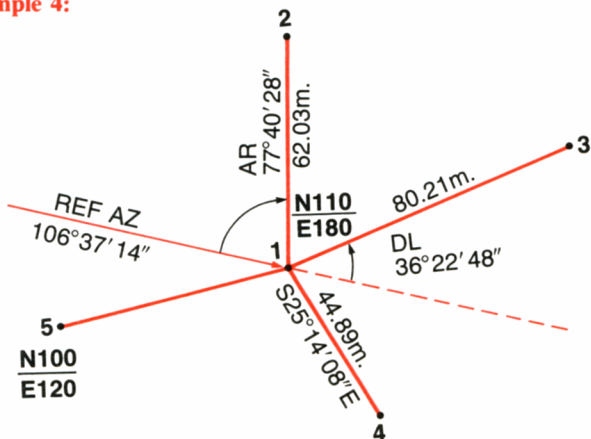
177.4338 **ENTER**

278.1698 **B** 47.7230 HD

xzy 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:



20 Traverse, Inverse and Sideshots

Starting from point 1 with coordinates N110, E180, calculate the sideshots 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

xzY

184.6455 E

36.2248 **CHS** **GSB** 2

70.1426 AZ

80.21 **A**

137.1167 N

xzY

255.4873 E

Select BRG mode.

h **SF** 0

25.1408 **ENTER**

2 **GSB** 1

154.4552 AZ

44.89 **A**

69.3942 N

xzY

199.1384 E

100 **ENTER** 120 **B**

60.8276 HD

xzY

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

KEY ENTRY	DISPLAY
[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

22 Traverse Adjustment

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

[x]	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
[x]	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
[x]	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	KEY ENTRY	DISPLAY
RCL 8	096- 24 8	STO + 4	102-23, 51, 4
+	097- 71	RCL 4	103- 24 4
RCL 7	098- 24 7	R/S	104- 74
x	099- 61	RCL 0	105- 24 0
-	100- 41	h RTN	106- 25 12
h LBL 9	101-25, 13, 9		

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.		9 DEG	
2	If a closed traverse has just been run via the Traverse, Inverse and Sideshots program, 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	

24 Traverse Adjustment

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 E	ENTER +	
			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 . Or for transit rule store $\Sigma lat $ and $\Sigma dep $.	ΣHD $\Sigma lat $ $\Sigma dep $	STO 6 STO 8 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.

26 Traverse Adjustment

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**

R/S

203.0183

570.0680

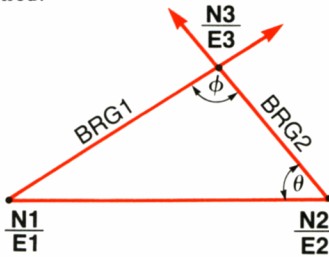
N3

E3

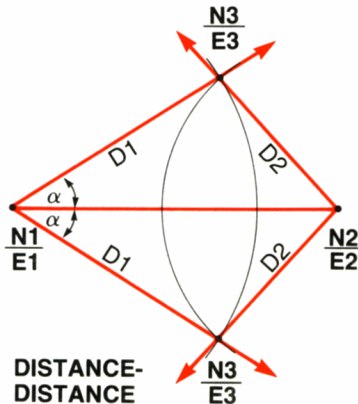
Bearing-Bearing and Distance-Distance Intersections

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	KEY ENTRY	DISPLAY
f CLEAR PRGM	000-	h LBL 9	026-25, 13, 9
h LBL 0	001-25, 13, 0	RCL 6	027-24 6
x y	002-21	STO 4	028-23 4
g →H	003-15 6	g R+	029-15 22
x y	004-21	STO 6	030-23 6
ENTER →	005-31	f →HMS	031-14 6
ENTER →	006-31	h RTN	032-25 12
2	007-2	h LBL 2	033-25, 13, 2
+	008-71	RCL 7	034-24 7
h INT	009-25 32	STO 5	035-23 5
h π	010-25 73	g R+	036-15 22
f →D	011-14 5	STO 7	037-23 7
x	012-61	h RTN	038-25 12
x y	013-21	h LBL A	039-25, 13, 11
h LST x	014-25 0	GSB 7	040-13 7
x	015-61	RCL 6	041-24 6
f COS	016-14 8	RCL 9	042-24 9
f R+	017-14 22	-	043-41
x	018-61	f SIN	044-14 7
-	019-41	RCL 8	045-24 8
1	020-1	x	046-61
f →R	021-14 4	RCL 6	047-24 6
GSB 8	022-13 8	RCL 4	048-24 4
GTO 9	023-22 9	-	049-41
h LBL 1	024-25, 13, 1	f SIN	050-14 7
g →H	025-15 6	+	051-71

30 Bearing-Bearing and Distance-Distance Intersections

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] [x²]	058- 15 3
[RCL] 7	059- 24 7
[g] [x²]	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] [+HMS]	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] [+HMS]	107- 14 6
[R/S]	108- 74
[x↔y]	109- 21

KEY ENTRY	DISPLAY
[h] [RTN]	110- 25 12
[h] [LBL] 7	111-25, 13, 7
[RCL] 3	112- 24 3
[RCL] 1	113- 24 1
[—]	114- 41
[RCL] 2	115- 24 2
[RCL] 0	116- 24 0
[—]	117- 41
[GSB] 8	118- 13 8
[STO] 9	119- 23 9
[x↔y]	120- 21
[STO] 8	121- 23 8

KEY ENTRY	DISPLAY
[h] [RTN]	122- 25 12
[h] [LBL] 8	123-25, 13, 8
[g] [→P]	124- 15 4
[x↔y]	125- 21
[g] [x>0]	126- 15 51
[h] [RTN]	127- 25 12
3	128- 3
6	129- 6
0	130- 0
[+]	131- 51
[h] [RTN]	132- 25 12

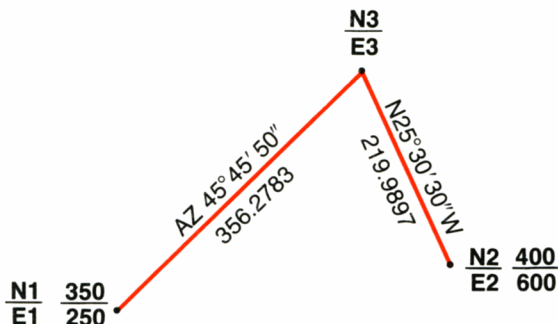
REGISTERS			I AZ1
R ₀ N1	R ₁ E1	R ₂ N2	R ₃ E2
R ₄ AZ1	R ₅ D1	R ₆ AZ2	R ₇ D2
R ₈ D12	R ₉ AZ12	R ₁₀ Unused	

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

32 Bearing-Bearing and Distance-Distance Intersections

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 coor-			
	dinates go to step 9. For a new			
	Bearing-Bearing intersection			
	with the same coordinates go to			
	step 5. For new beginning coor-			
	dinates go to step 2.			

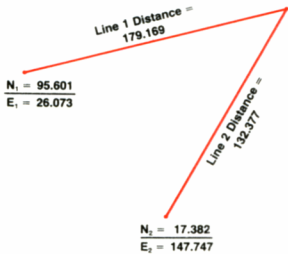
Example 1:

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

34 Bearing-Bearing and Distance-Distance Intersections

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

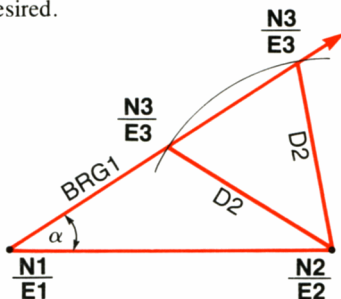
Notice from the diagram that the desired solution is above both points. The solution just calculated is below them and we therefore require the second solution.

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

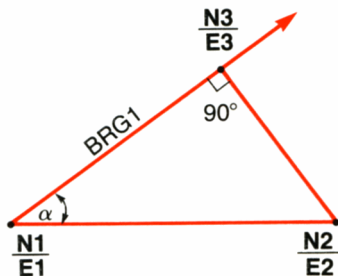
Offset and Bearing-Distance Intersections

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
f CLEAR PRGM	000-
h LBL 0	001- 25, 13, 0
x z y	002- 21
g + H	003- 15 6
x z 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
x	012- 61
x z y	013- 21
h LST x	014- 25 0
x	015- 61
f COS	016- 14 8
f R +	017- 14 22
x	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

KEY ENTRY	DISPLAY
g + H	025- 15 6
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 + HMS	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
x	046- 61
STO 7	047- 23 7
h LBL B	048- 25, 13, 12
GSB 7	049- 13 7

KEY ENTRY	DISPLAY
$\boxed{\text{RCL}} \ 7$	050- 24 7
$\boxed{\text{G}} \ \boxed{\text{x}^2}$	051- 15 3
$\boxed{\text{RCL}} \ 6$	052- 24 6
$\boxed{\text{STO}} \ 4$	053- 23 4
$\boxed{\text{RCL}} \ 9$	054- 24 9
$\boxed{-}$	055- 41
$\boxed{\text{RCL}} \ 8$	056- 24 8
$\boxed{\text{f}} \ \boxed{\rightarrow\text{R}}$	057- 14 4
$\boxed{\text{G}} \ \boxed{\text{R}\dagger}$	058- 15 22
$\boxed{\text{G}} \ \boxed{\text{x}^2}$	059- 15 3
$\boxed{-}$	060- 41
$\boxed{\text{f}} \ \boxed{\sqrt{\text{x}}}$	061- 14 3
$\boxed{\text{f}} \ \boxed{\text{R}\dagger}$	062- 14 22
$\boxed{\text{x}\dagger\text{y}}$	063- 21
$\boxed{-}$	064- 41
$\boxed{\text{STO}} \ \boxed{\text{f}} \ \boxed{\text{I}}$	065- 23, 14, 23
$\boxed{\text{h}} \ \boxed{\text{LST x}}$	066- 25 0
$\boxed{\text{f}} \ \boxed{\text{R}\dagger}$	067- 14 22
$\boxed{+}$	068- 51
$\boxed{\text{STO}} \ 5$	069- 23 5
$\boxed{\text{GSB}} \ 6$	070- 13 6
$\boxed{\text{R/S}}$	071- 74
$\boxed{\text{RCL}} \ 5$	072- 24 5
$\boxed{\text{f}} \ \boxed{\text{x}\dagger\text{I}}$	073- 14 21
$\boxed{\text{STO}} \ 5$	074- 23 5
$\boxed{\text{h}} \ \boxed{\text{LBL}} \ 6$	075- 25, 13, 6
$\boxed{\text{RCL}} \ 4$	076- 24 4
$\boxed{\text{RCL}} \ 5$	077- 24 5
$\boxed{\text{f}} \ \boxed{\rightarrow\text{R}}$	078- 14 4

KEY ENTRY	DISPLAY
$\boxed{\text{RCL}} \ 0$	079- 24 0
$\boxed{+}$	080- 51
$\boxed{\text{R/S}}$	081- 74
$\boxed{\text{x}\dagger\text{y}}$	082- 21
$\boxed{\text{RCL}} \ 1$	083- 24 1
$\boxed{+}$	084- 51
$\boxed{\text{R/S}}$	085- 74
$\boxed{\text{RCL}} \ 3$	086- 24 3
$\boxed{-}$	087- 41
$\boxed{\text{x}\dagger\text{y}}$	088- 21
$\boxed{\text{RCL}} \ 2$	089- 24 2
$\boxed{-}$	090- 41
$\boxed{\text{GSB}} \ 8$	091- 13 8
$\boxed{\text{f}} \ \boxed{\rightarrow\text{HMS}}$	092- 14 6
$\boxed{\text{R/S}}$	093- 74
$\boxed{\text{x}\dagger\text{y}}$	094- 21
$\boxed{\text{R/S}}$	095- 74
$\boxed{\text{RCL}} \ 4$	096- 24 4
$\boxed{\text{RCL}} \ 5$	097- 24 5
$\boxed{\text{f}} \ \boxed{\rightarrow\text{R}}$	098- 14 4
$\boxed{\text{GSB}} \ 8$	099- 13 8
$\boxed{\text{f}} \ \boxed{\rightarrow\text{HMS}}$	100- 14 6
$\boxed{\text{R/S}}$	101- 74
$\boxed{\text{x}\dagger\text{y}}$	102- 21
$\boxed{\text{h}} \ \boxed{\text{RTN}}$	103- 25 12
$\boxed{\text{h}} \ \boxed{\text{LBL}} \ 7$	104- 25, 13, 7
$\boxed{\text{RCL}} \ 3$	105- 24 3
$\boxed{\text{RCL}} \ 1$	106- 24 1
$\boxed{-}$	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	

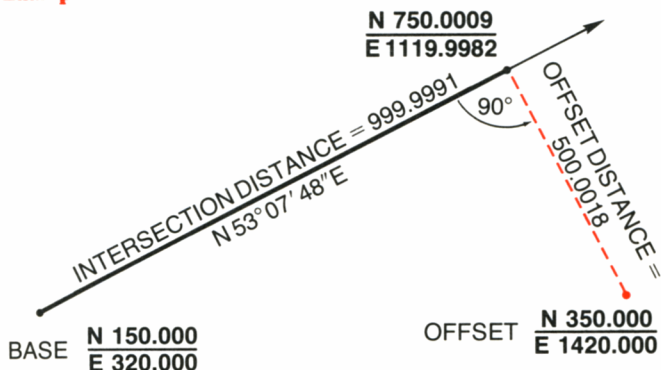
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Key in the program and set to degrees mode.		g DEG	
2	Store coordinates of point one.	N1	STO 0	
		E1	STO 1	
3	Store coordinates of point two.	N2	STO 2	
		E2	STO 3	

40

Offset and Bearing-Distance Intersections

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:

150 **[STO]** 0
 320 **[STO]** 1
 350 **[STO]** 2
 1420 **[STO]** 3
 53.0748 **[ENTER]**
 1 **[GSB]** 0
[A]
[R/S]
[R/S]
[R/S]
[R/S]
[R/S]
[R/S]

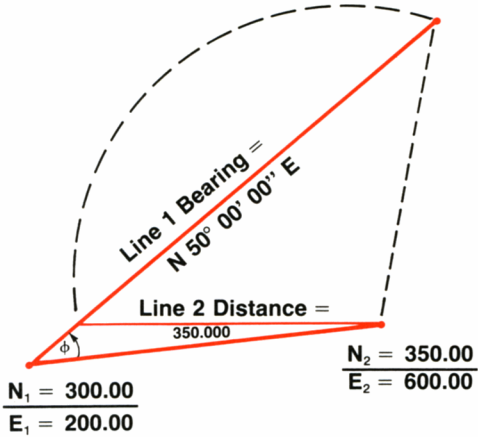
Display:

750.0009
1,119.9982
323.0748
500.0018
53.0748
999.9991

N3
 E3
 AZ2 (D.MS)
 D2
 AZ1 (D.MS)
 D1

42 Offset and Bearing-Distance Intersections

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
350 [GSB] 2 [B]
[R/S]
[R/S]
[R/S]
[R/S]
[R/S]

50.0000
693.2096
668.6089
11.1817
350.0000
50.0000
611.7255

AZ1 (D.MS)
N3
E3
AZ2 (D.MS)
D2
AZ1 (D.MS)
D1

Now obtain the second solution.

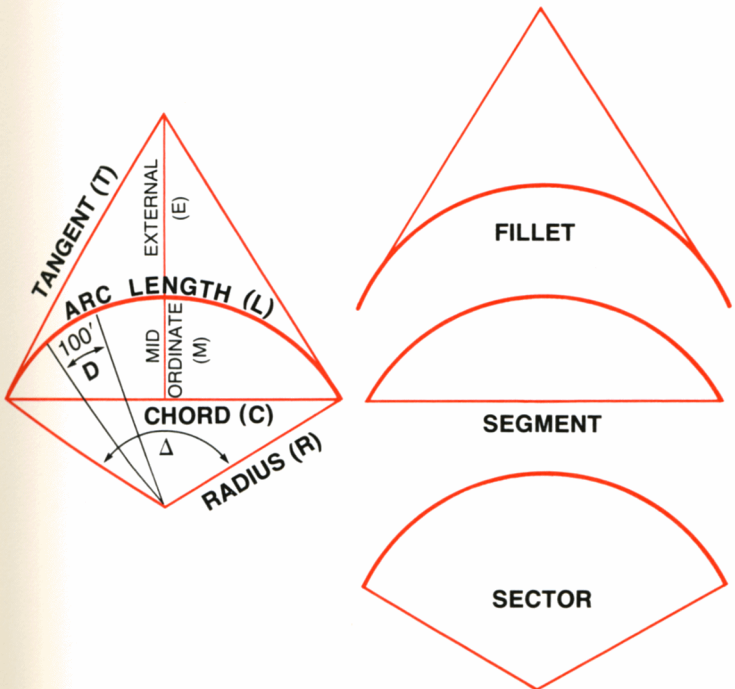
[R/S]
[R/S]
[R/S]
[R/S]
[R/S]
[R/S]

342.0311
250.0907
268.4143
350.0000
50.0000
65.3888

N3
E3
AZ2 (D.MS)
D2
AZ1 (D.MS)
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.



44 Curve Solutions

M= Mid Ordinate

E= External

R= Radius

D= Degree of Curve

Δ = Central Angle

L= Arc Length

T= Tangent

C= Chord

KEY ENTRY	DISPLAY
[f] CLEAR [PRGM]	000-
[h] [LBL] 1	001- 25, 13, 1
[g] [+H]	002- 15 6
[EEEX]	003- 33
2	004- 2
[xzy]	005- 21
[+]	006- 71
[f] [+D]	007- 14 5
[h] [LBL] 2	008- 25, 13, 2
[STO] 0	009- 23 0
[h] [SF] 0	010- 25, 51, 0
[h] [RTN]	011- 25 12
[h] [LBL] 3	012- 25, 13, 3
[g] [+H]	013- 15 6
2	014- 2
[+]	015- 71
[STO] 1	016- 23 1
[h] [CF] 0	017- 25, 61, 0
[h] [RTN]	018- 25 12
[h] [LBL] 4	019- 25, 13, 4
[f] [+D]	020- 14 5
[h] [F?] 0	021- 25, 71, 0

KEY ENTRY	DISPLAY
[GTO] 9	022- 22 9
[RCL] 1	023- 24 1
2	024- 2
[x]	025- 61
[+]	026- 71
[STO] 0	027- 23 0
[h] [RTN]	028- 25 12
[h] [LBL] 9	029- 25, 13, 9
[RCL] 0	030- 24 0
[+]	031- 71
2	032- 2
[+]	033- 71
[STO] 1	034- 23 1
[h] [RTN]	035- 25 12
[h] [LBL] 5	036- 25, 13, 5
2	037- 2
[+]	038- 71
[h] [F?] 0	039- 25, 71, 0
[GTO] 9	040- 22 9
[RCL] 1	041- 24 1
[f] [SIN]	042- 14 7
[+]	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
[x₁y]	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] [$\rightarrow$D]	109- 14 5
[f] [$\rightarrow$HMS]	110- 14 6
[R/S]	111- 74
[RCL] 1	112- 24 1
2	113- 2
[x]	114- 61
[f] [$\rightarrow$HMS]	115- 14 6
[R/S]	116- 74
[h] [LST x]	117- 25 0
[RCL] 0	118- 24 0
[x]	119- 61
[g] [$\rightarrow$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
[x]	127- 61
[STO] 4	128- 23 4
[R/S]	129- 74
[RCL] 1	130- 24 1

KEY ENTRY	DISPLAY
[f] [SIN]	131- 14 7
[RCL] 0	132- 24 0
[x]	133- 61
2	134- 2
[x]	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
[x]	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
[x]	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
[x]	156- 61
[g] [$\rightarrow$R]	157- 15 5
[R/S]	158- 74
[ENTER$\rightarrow$]	159- 31

KEY ENTRY	DISPLAY
ENTER	160- 31
RCL 1	161- 24 1
RCL 0	162- 24 0
f →R	163- 14 4
x	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 x²	170- 15 3
x	171- 61
f R+	172- 14 22
-	173- 41

REGISTERS			I Unused
R_0 R	$R_1 \Delta/2$	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:100 **GSB** 2150 **GSB** 4**A****R/S****R/S****R/S****B****R/S****R/S****R/S****GSB** 0**R/S****R/S****Display:****100.0000****57.1745****85.5637****150.0000****93.1596****136.3278****26.8311****36.6701****7,500.0000****2,512.5251****1,815.9646**

R

D (D.MS)

 Δ (D.MS)

L

T

C

M

E

(sector area)

(segment area)

(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.

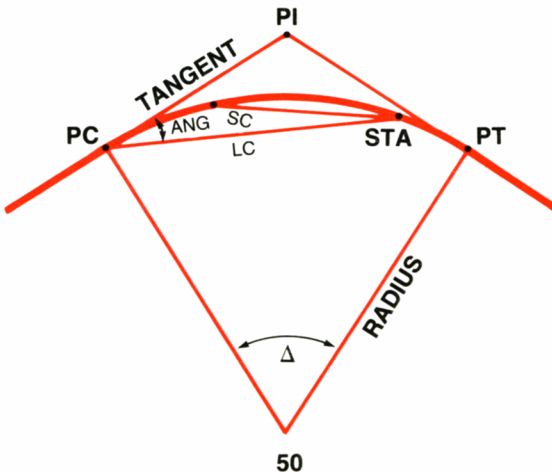
General output:

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.



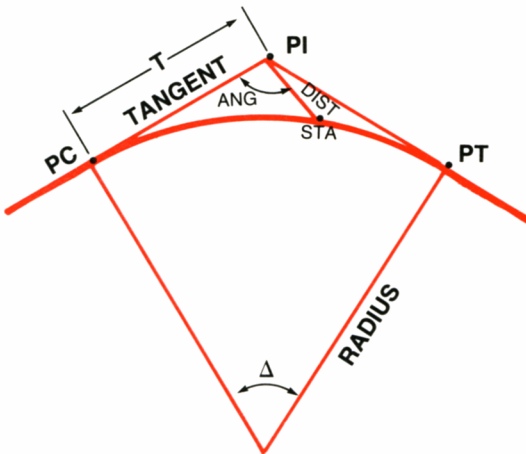
Field data for PC deflections consists of:

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

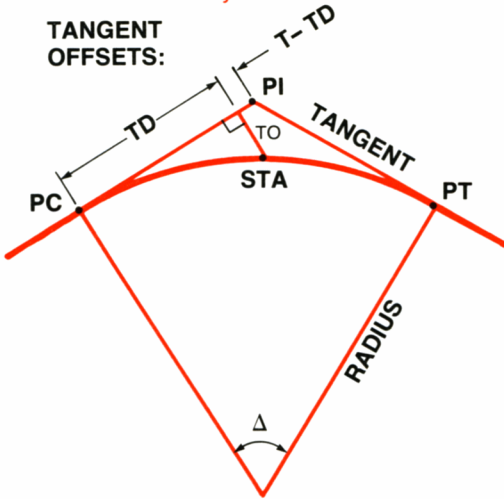


Field data for PI deflections consists of:

STA= current station

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

DIST= distance from PI to current station

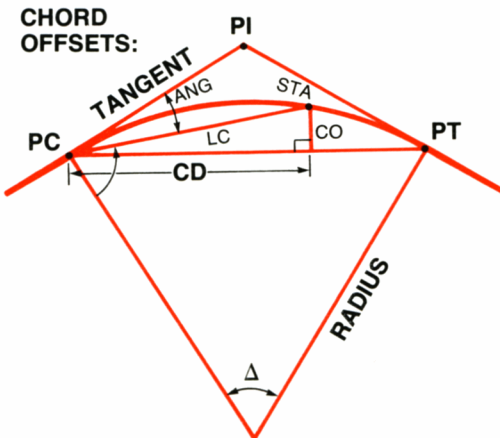


Field data for tangent offsets consists of:

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
f CLEAR PRGM	000-
h LBL 0	001- 25, 13, 0
STO 1	002- 23 1
h SF 2	003- 25, 51, 2
h RTN	004- 25 12
h LBL 1	005- 25, 13, 1
STO 5	006- 23 5
h CF 2	007- 25, 61, 2
h RTN	008- 25 12
h LBL 2	009- 25, 13, 2
GSB 9	010- 13 9
2	011- 2
0	012- 0
0	013- 0
RCL 0	014- 24 0
+	015- 71
f →HMS	016- 14 6
h RTN	017- 25 12
h LBL 3	018- 25, 13, 3
g →H	019- 15 6
EEX	020- 33
2	021- 2
x↔y	022- 21
+	023- 71

KEY ENTRY	DISPLAY
f →D	024- 14 5
GSB 9	025- 13 9
RCL 3	026- 24 3
h RTN	027- 25 12
h LBL 9	028- 25, 13, 9
STO 3	029- 23 3
g →R	030- 15 5
2	031- 2
x	032- 61
STO 0	033- 23 0
h RTN	034- 25 12
h LBL A	035- 25, 13, 11
g →H	036- 15 6
2	037- 2
+	038- 71
STO 4	039- 23 4
RCL 0	040- 24 0
x	041- 61
STO 6	042- 23 6
R/S	043- 74
RCL 4	044- 24 4
f TAN	045- 14 9
RCL 3	046- 24 3
x	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
x	088- 61
2	089- 2
x	090- 61
h RTN	091- 25 12
h LBL 5	092-25, 13, 5
f →HMS	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
x²y	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
XZ Y	107- 21
f →HMS	108- 14 6
h RTN	109- 25 12
h LBL 8	110-25, 13, 8
RCL 4	111- 24 4
XZ Y	112- 21

KEY ENTRY	DISPLAY
-	113- 41
h LBL 7	114-25, 13, 7
XZ Y	115- 21
f →R	116- 14 4
R/S	117- 74
XZ 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.		9 DEG	
2	Input beginning station of curve.	PC	GSB 0	
	or station at intersection of tangents.	PI	GSB 1	
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

56 Horizontal Curve Layout

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 $35^{\circ}30'$ and a degree of curve of $12^{\circ}30'$. 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

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

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

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

where:

AZ = Azimuth

BRG = Bearing

QD = Quadrant

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

Traverse Inverse and Sideshots

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

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

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

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

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

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 $\frac{1}{2}$ 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

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

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

Transit Rule

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

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

where:

C_L = Correction to latitude of a course

C_D = Correction to departure of a course

ΔN = Closing latitude

ΔE = Closing departure

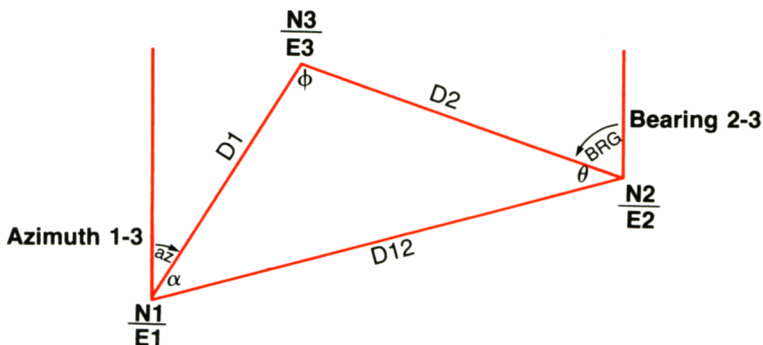
Dist = Length of course to be corrected

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:

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

For distance-distance case:

$$20. \text{Bearing } 13 = \text{bearing } 12 \pm \alpha$$

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

For offset from a point to a line:

$$22. D2 = (D12) \sin \alpha, \text{ then use 19.}$$

Curve Solutions

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

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

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

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

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

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

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

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

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

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

$$33. \text{ Fillet area} = RT - \text{Sector area}$$

where:

L = Arc length

R = Radius

Δ = Central angle

C = Chord

T = Tangent

E = External

M = Mid ordinate

Horizontal Curve Layout

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

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

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

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

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

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

$$40. LC = 2 R \sin (\text{defl. ang.})$$

$$41. TO = LC \sin (\text{defl. ang.})$$

$$42. TD = LC \cos (\text{defl. ang.})$$

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

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

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

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

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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