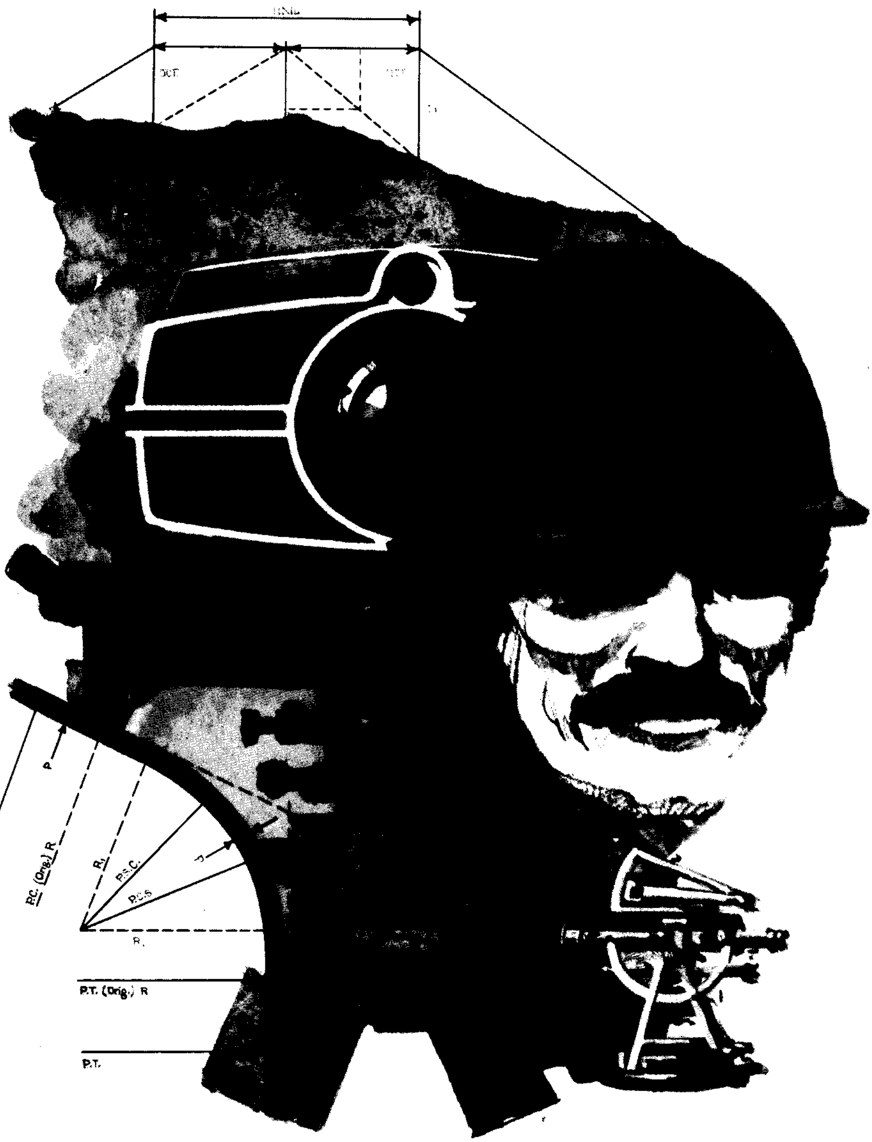
HEWLETT-PACKARD

HP-67/HP-97

Surveying Pac I



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Introduction

The 19 programs of Surveying Pac I are designed to solve many of the commonly encountered problems in surveying. Topics covered include reduction and adjustment of field traverse data, solution of curve and intersection problems, layout of curves, field data reduction, earthwork calculations and coordinate transformations.

We hope that Surveying Pac I will be a valuable tool in your work. We would very much appreciate knowing your reactions to the programs in this pac, and to this end we have provided a questionnaire inside the front cover of this manual. Would you please take a few minutes to give us your comments on these programs? It is in the comments we receive from you that we learn how best to increase the usefulness of programs like these.

CONTENTS

Appendices

A WORD ABOUT PROGRAM USAGE

Each program in this pac is represented by one or more magnetic cards and a section in this manual. The manual provides a description of the program, a set of instructions for using the program, and one or more example problems, each of which includes a list of the actual keystrokes required for its solution. Program listings for all the programs in the pac appear at the back of this manual. Explanatory comments have been incorporated in the listings to facilitate your understanding of the actual working of each program. Thorough study of a commented listing can help you to expand your programming repertoire since interesting techniques can often be found in this way.

On the face of each magnetic card are various mnemonic symbols which provide shorthand instructions to the use of the program. You should first familiarize yourself with a program by running it once or twice while following the complete User Instructions in the manual. Thereafter, the mnemonics on the cards themselves should provide the necessary instructions, including what variables are to be input, which user-definable keys are to be pressed, and what values will be output. A full explanation of the mnemonic symbols for magnetic cards may be found in Appendix A.

This application pac has been designed for both the HP-97 Programmable Printing Calculator and the HP-67 Programmable Pocket Calculator. The most significant difference between the HP-67 and the HP-97 calculators is the printing capability of the HP-97. The two calculators also differ in a few minor ways.

Most of the computed results in this pac are output by PRINT statements: either by the statement PRINTx or by the command PRINT STACK. On the HP-97 these results will be output on the printer. On the HP-67 each PRINT command will be interpreted as a PAUSE: the program will halt, display the result for about 5 seconds, then continue execution. The term "PRINT/PAUSE" is used to describe this output condition.

The lists of keystrokes required to solve example problems indicate the resulting outputs. Those outputs indicated by *** are printed by the HP-97 with the printer in MANUAL mode. These *** outputs are shown by PAUSE on the HP-67. Outputs without stars are displayed on both the HP-97 and HP-67.

If you own an HP-67, you may want more time to copy down the number displayed by a PRINT/PAUSE. All you need to do is press any key on the keyboard. If the command being executed is PRINTx (eight rapid blinks of the decimal point), pressing a key will cause the program to halt. If the command being executed is PRINT STACK (two slow blinks of the decimal per value), the number in the display will remain there until the depressed key is released; then the next register in the stack will be displayed, and so on. After display of all four registers, the program will halt execution if a key was pressed at any time during the display of the stack contents. In both cases execution of the halted program may be re-initiated by pressing R/S.

HP-97 users may also want to keep a permanent record of the values input to a certain program. A convenient way to do this is to set the Print Mode switch to NORMAL before running the program. In this mode all input values and their corresponding user-definable keys will be listed on the printer, thus providing a record of the entire operation of the program.

Another area that could reflect differences between the HP-67 and the HP-97 is in the keystroke solutions to example problems. It is sometimes necessary in these solutions to include operations that involve prefix keys, namely, f on the HP-97 and f, g, and h on the HP-67. For example, the operation 10^x is performed on the HP-97 as f 10^x and on the HP-67 as h 10^x. In such cases, the keystroke solution omits the prefix key and indicates only the operation (as here, 10^x). As you work through the example problems, take care to press appropriate prefix keys (if any) for your calculator.

If you have already worked through a few programs in the Standard Pac, you will understand how to load a program and how to interpret the User Instructions form. If these procedures are not clear to you, take a few minutes to review the sections, Loading a Program and Format of User Instructions, in your Standard Pac.

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. Three additional routines are provided to supplement the four major routines: 5) Slope Distance Reduction, 6) Closure For Traverses, and 7) Curved Sides For Traverses. Each of the seven routines is described individually below, with separate user instructions.

This program uses two mode "switches", labelled on the card as "FA/BRG?" and "SS/TRA?" Each switch "toggles" between zero and one (or one and zero) with each push of the keys (f and A or f and B), allowing you to define four different modes:

Mode	FA/BRG? f A	SS/TRA? f B
Bearing/azimuth angle traverse (BRG-TRA)	1.0000	1.0000
Field angle traverse (FA-TRA)	0.0000	1.0000
Field angle sideshots (FA-SS)	0.0000	0.0000
Bearing/azimuth angle sideshots (BRG-SS)	1.0000	0.0000

As the table shows, a display of 0.0000 after pushing f and A means the calculator is expecting field angle (FA) input. Similarly, a display of 1.0000 after pushing f and A indicates bearing or azimuth angle input (BRG).

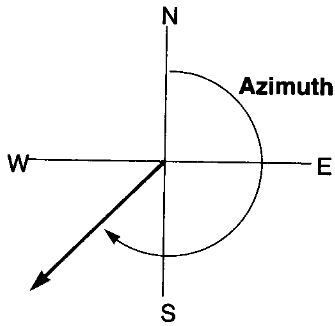
The instructions generally call for the selection of angle input to be made at the beginning of the program and left unchanged, but it can be changed at any time if desired. In switching from BRG to FA mode, the last azimuth that was input becomes the reference direction from which the field angles are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

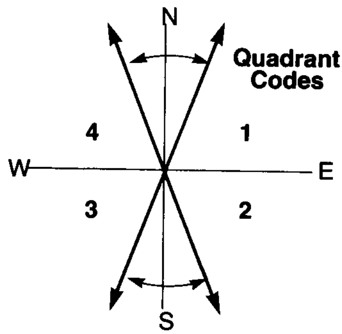
The table also shows that a display of 0.0000 after pushing f and B means sideshots (SS), while a display of 1.0000 after pushing f and B means traverse. For sideshots, the transit remains stationary during several shots, while during a traverse, the transit is moved to the next point after each shot. 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. The routines for

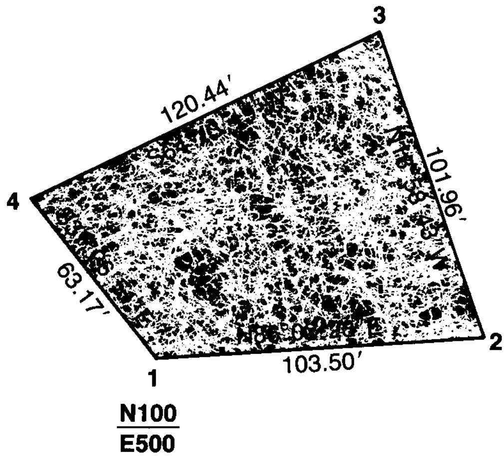
Slope Distance Reduction and Curved Sides for Traverses can be used where slope distances or curves are encountered. At the end of the traverse, Closure for Traverses can be used to get the total distance traversed, area, and error of closure. Angle conventions for azimuths and quadrant bearings are shown below:





STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select bearing traverse by			
	pressing f A, f B.		f A	1.0000*
			f B	1.0000*
3	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	1, N, E
4	Input bearing	BRG (D.MS)	ENTER↑	
	and quadrant code	QD	B	AZ(D.MS)
	or			
	azimuth.	AZ(D.MS)	C	AZ(D.MS)
5	Input horizontal distance and			
	compute coordinates.	HD	E	HD, Point,
				N. E
6	Repeat steps 4 and 5 for			
	successive courses.			
	*If you don't get the output			
	shown, repeat the step.			

Example:



Starting with point 1 with coordinates N100, E500, traverse the figure above and compute the coordinates of the other points.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
f A →	1.0000*
f B →	1.0000*
100 ENTER↑ 500 A →	1.0000 *** Point
	100.0000 *** N
	500.0000 *** E
86.0223 ENTER↑ 1 B →	86.0223 *** AZ
103.5 E →	103.5000 *** HD
	2.0000 *** Point
	107.1482 *** N
	603.2529 *** E
18.5843 ENTER↑ 4 B →	341.0117 *** AZ
101.96 E →	101.9600 *** HD
	3.0000 *** Point
	203.5657 *** N
	570.0939 *** E

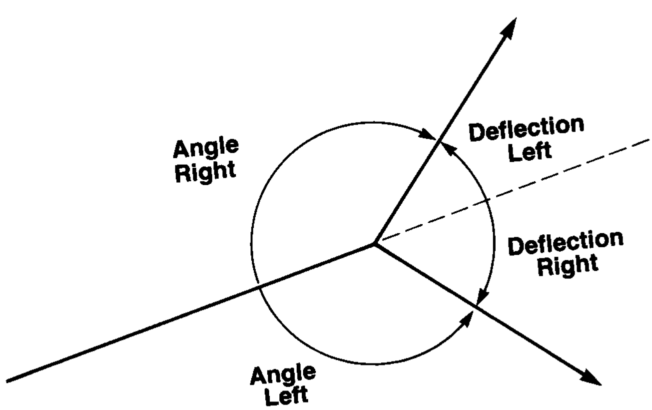
*If you don't get the output shown, repeat the step.

64.1319 ENTER↑ 3 B →	244.1319 *** AZ
120.44 E →	120.4400 *** HD
	4.0000 *** Point
	151.1880 *** N
	461.6395 *** E
37.2651 ENTER↑ 2 B →	142.3309 *** AZ
63.17 E →	63.1700 *** HD
	5.0000 *** Point
	101.0366 *** N
	500.0490 *** E

To avoid reworking this example, you might wish to work next the Closure for Traverse example on page 01-16.

Field Angle Traverse

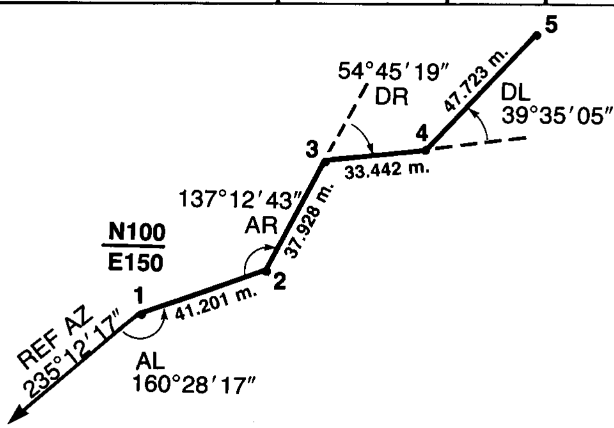
This routine uses horizontal distances and angles or deflections turned from a reference azimuth to compute the coordinates of successive points in a traverse. The routines for Slope Distance Reduction and Curved Sides for Traverses can be used where slope distances or curves are encountered. At the 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:



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select field angle traverse by			
	pressing f A, f B.		f A	0.0000*
			f B	1.0000*
3	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	1, N, E
4	Input reference azimuth †:			
	away from beginning point	REF AZ(D.MS)	B	AZ(D.MS)
	or			
	toward beginning point.	REF AZ(D.MS)	C	AZ(D.MS)
	†A reference bearing toward			
	the point may be used in place			
	of an azimuth:			
4′	Select bearing input by			
	pressing f A.		f A	1.0000*
	Input reference bearing toward			
	beginning point	REF BRG(D.MS)	ENTER↑	
	and quadrant			
	code.	QD	B	AZ(D.MS)
	Select field angle traverse by			
	pressing f A.		f A	0.0000*
	Go to step 5.			
	*If you don't get the output			
	shown, repeat the step.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
5	Input field angle:			
	angle right	AR(D.MS)	B	AZ(D.MS)
	or			
	angle left	AL(D.MS)	CHS B	AZ(D.MS)
	or			
	deflection right	DR(D.MS)	C	AZ(D.MS)
	or			
	deflection left	DL(D.MS)	CHS C	AZ(D.MS)
6	Input horizontal distance and			
	compute coordinates.	HD	E	HD, Point,
				N, E
7	Repeat steps 5 and 6 for			
	successive courses.			

Example:



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

Keystrokes: **Outputs:**

Load side 1 and side 2 .

f A ⟶	0.0000*
f B ⟶	1.0000*
100 ENTER↑ 150 A ⟶	1.0000 *** Point
	100.0000 *** N
	150.0000 *** E

*If you don't get the output shown, repeat the step.

235.1217 B ⟶	55.1217 *** Ref AZ
160.2817 CHS B ⟶	74.4360 *** AZ
(NOTE: 74°43′60″ = 74°44′00″)	
41.201 E ⟶	41.2010 *** HD
	2.0000 *** Point
	110.8487 *** N
	189.7470 *** E
137.1243 B ⟶	31.5643 *** AZ
37.928 E ⟶	37.9280 *** HD
	3.0000 *** Point
	143.0327 *** N
	209.8151 *** E
54.4519 C ⟶	86.4202 *** AZ
33.442 E ⟶	33.4420 *** HD
	4.0000 *** Point
	144.9574 *** N
	243.2017 *** E
39.3505 CHS C ⟶	47.0657 *** AZ
47.723 E ⟶	47.7230 *** HD
	5.0000 *** Point
	177.4338 *** N
	278.1698 *** E

This example could also have been worked by using a reference bearing, as shown below. An azimuth of 235°12′17″ is the same as a bearing of S55°12′17″W. Since the instructions (step 4′) call for a reference bearing toward the beginning point, the bearing is input as N55°12′17″E.

Keystrokes:	Outputs:
f A ⟶	0.0000*
f B ⟶	1.0000*
100 ENTER↑ 150 A ⟶	1.0000 *** Point
	100.0000 *** N
	150.0000 *** E
Select BRG mode to input reference bearing:	
f A ⟶	1.0000*
55.1217 ENTER↑ 1 B ⟶	55.1217 *** Ref AZ
f A ⟶	0.0000*
160.2817 CHS B ⟶	74.4400 *** AZ

*If you don't get the output shown, repeat this step.

41.201 E →	41.2010 ***	HD
	2.0000 ***	Point
	110.8487 ***	N
	189.7470 ***	E

etc.

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. The routines for Slope Distance Reduction and Curved Sides for Traverses may be used where slope distances or curves are encountered. At the end of a traverse, Closure for Traverses can be used to get the total distance traversed and area.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select traverse by pressing			
	f B.		f B	1.0000*
3	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	1, N, E
4	Input coordinates of next point			
	and compute azimuth and			
	horizontal distance for course.			
	Point number, and coordinates			
	of point input are also output,			
	but HD and AZ are left in the x			
	and y registers.	N	ENTER↑	
		E	f C	AZ(D.MS),HD;
				Point, N, E
5	Repeat step 4 for successive			
	courses or go to step 3 for a			
	new starting point.			
	*If you don't get the output			
	shown, repeat the step.			

Example:

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:	**Outputs:**
Load side 1 and side 2	
f B →	1.0000*
100 ENTER↑ 150 A →	1.0000 *** Point
	100.0000 *** N
	150.0000 *** E
110.8487 ENTER↑ 189.7470	
f C →	74.4360 *** AZ
	41.2010 *** HD
	2.0000 *** Point
	110.8487 *** N
	189.7470 *** E
143.0327 ENTER↑ 209.8151	
f C →	31.5643 *** AZ
	37.9281 *** HD†
	3.0000 *** Point
	143.0327 *** N
	209.8151 *** E

†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.

Keystrokes:	**Outputs:**
144.9574 ENTER↑ 243.2017	
f C →	86.4202 *** AZ
	33.4420 *** HD
	4.0000 *** Point
	144.9574 *** N
	243.2017 *** E
177.4338 ENTER↑ 278.1698	
f C →	47.0657 *** AZ
	47.7230 *** HD
	5.0000 *** Point
	177.4338 *** N
	278.1698 *** E

*If you do not get this output, repeat this step.

Sideshots

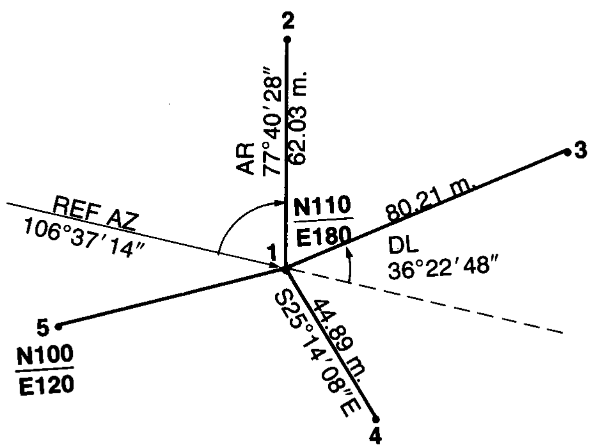
This routine is used to make sideshots or radials from a point. Any of three methods may be used for a sideshot, 1) input a distance and a field angle turned from a reference azimuth and calculate the coordinates of the point, 2) input a distance and a bearing and calculate the coordinate of a point,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

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input beginning coordinates.	BEG N	ENTER↑	
		BEG E	A	Point,
				N, E
	To use field angles, go to step			
	3; to use bearings, go to step 9;			
	to inverse from coordinates,			
	go to step 13.			
3	Select bearing traverse by			
	pressing f A, f B.		f A	1.0000*
			f B	1.0000*
4	Input			
	reference azimuth to point	REF AZ(D.MS)	C	AZ(D.MS)
	or			
	input reference bearing to	BRG(D.MS)	ENTER↑	
	point and quadrant code	QD	B	(AZ(D.MS)
5	Select field angle sideshots by			
	pressing f A, f B.		f A	0.0000*
			f B	0.0000*
	*If you don't get the output			
	shown, repeat the step.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
6	Input field angle:			
	angle right	AR(D.MS)	B	AZ(D.MS)
	or			
	angle left	AL(D.MS)	CHS B	AZ(D.MS)
	or			
	deflection right	DR(D.MS)	C	AZ(D.MS)
	or			
	deflection left	DL(D.MS)	CHS C	AZ(D.MS)
7	Input horizontal distance.	HD	E	HD, Point,
				N. E
8	Repeat steps 6 and 7 for			
	successive field angle shots.			
9	Select bearing/azimuth side-			
	shots by pressing f A,		f A	1.0000*
	f B.		f B	0.0000*
10	Input azimuth	AZ(D.MS)	C	AZ(D.MS)
	or			
	input bearing	BRG(D.MS)	ENTER↑	
	and quadrant code	QD	B	AZ(D.MS)
11	Input horizontal distance.	HD	E	HD, Point,
				N, E
12	Repeat steps 10 and 11 for			
	successive bearing/azmuth			
	shots.			
13	Select sideshots by pressing			
	f B.		f B	0.0000*
14	Input coordinates of next point.	N	ENTER↑	
		E	f C	AZ(D.MS), HD
				Point, N, E
	*If you don't get the output			
	shown, repeat the step.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
15	Repeat line 14 for successive			
	shots.			

Example:



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

Keystrokes: **Outputs:**

Load side 1 and side 2.

110 ENTER↑ 180 A ⟶ 1.0000 *** Point

110.0000 *** N

180.0000 *** E

Select BRG and TRA modes to input reference azimuth:

f A ——→	1.0000*
f B ——→	1.0000*
106.3714 C ——→	106.3714 *** Ref AZ

Now, select FA and SS modes

f A ——→	0.0000*
f B ——→	0.0000*
77.4028 B ——→	4.1742 *** AZ
62.03 E ——→	62.0300 *** HD
	2.0000 *** Point
	171.8558 *** N
	184.6455 *** E
36.2248 CHS C ——→	70.1426 *** AZ
80.21 E ——→	80.2100 *** HD
	3.0000 *** Point
	137.1167 *** N
	255.4873 *** E

Select BRG mode

f A ——→	1.0000*

(NOTE: It is not necessary to press f B since the calculator is still set for sideshots.)

25.1408 ENTER↑ 2 B ——→	154.4552 *** AZ
44.89 E ——→	44.8900 *** HD
	4.0000 *** Point
	69.3942 *** N
	199.1384 *** E

(NOTE: Again, it is not necessary to press f B since the calculator is still set for sideshots.)

100 ENTER↑ 120 f C ——→	260.3216 *** AZ
	60.8276 *** HD
	5.0000 *** Point
	100.0000 *** N
	120.0000 *** E

*If you don't get the output shown, repeat the step.

Slope Distance Reduction

This routine calculates the horizontal distance and elevation change given the slope distance and a vertical angle or zenith angle. Vertical angles must be less than 45° and zenith angles must be greater than 45°.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input slope distance,	SD	ENTER↑	
	and vertical or zenith angle.	VA/ZA(D.MS)	D	Ang(D.MS),
				SD,HD
3	Read elevation change.		x⇄y	ΔEL

Example:

Mr. D. Thomas, a bit of a skeptic when it comes to new fangled electronic instruments, was using a theodolite and chain to check out his new HP-3810 total station. The slope distance he measured of 104.74 feet checked out with the reading on the 3810. His theodolite showed a zenith angle of 87°52′37″. Are the horizontal distance of 104.668 feet and the change in elevation of 3.880 feet indicated by the 3810 correct?

Keystrokes:	Outputs:
104.74 ENTER↑ 87.5237 D ⟶	87.5237 *** ZA
	104.7400 *** SD
	104.6681 *** HD
x⇄y ⟶	3.8802 Δ EL

It looks like Mr. Thomas can put away his theodolite for awhile.

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. The traverse can be closed exactly by inversing from the last point calculated to the correct closing coordinates.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Input correct closing			
	coordinates	N	ENTER↑	
		E	f D	Σ HD
				Area,*
				Error azimuth,
				Error distance,
				Point
				N, E
2	To include the error course in			
	the traverse and adjust the			
	area, input the correct closing			
	coordinates and inverse	N	ENTER↑	
		E	f C	AZ(D.MS),
				HD; Point, N,E
3	Go to step 1 to recalculate			
	Σ HD and area			
	Note: Step 2 may be performed			
	before step 1, and step 3 may be			
	omitted if desired.			
	*For area in acres:	area(ft.^{2})	ENTER↑	area(ft.^{2})
			43560	
			÷	Area(acres)

Example:

Rework the example for the Bearing/Azimuth Traverse routine and then use the Closure for Traverses.

Keystrokes:	**Outputs:**
The last coordinates computed will be ——→	5.0000 *** Point
	101.0366 *** N
	500.0490 *** E
100 ENTER↑ 500 f D ——→	389.0700 *** Σ HD
	8855.4922 *** Area
	182.4219 *** Error AZ
	1.0378 *** Error Dist
	6.0000 *** Point
	100.0000 *** N
	500.0000 *** E

An error of over a foot in 389 feet would be unacceptable in many cases and forcing the traverse to close exactly would not be the solution; but an indication of the effect on area can at least be found this way.

(NOTE: Coordinates do not have to be keyed in, since they should be left from the calculations above.)

f C ——→	182.4219 *** AZ
	1.0378 *** HD
	7.0000 *** Point
	100.0000 *** N
	500.0000 *** E

(NOTE: Pressing R↓ R↓ now will bring the closing coordinates back for closure calculations.)

R↓ R↓ ——→	500.0000 E
f D ——→	390.1078 *** Σ HD
	8855.4668 *** Area
	270.0000 *** Error AZ
	2.450000000–09 *** Error Dist
	8.0000 *** Point
	100.0000 *** N
	500.0000 *** E

The error distance is now on the order of 10^{-9} or essentially zero. The new area calculation is only about .03 square feet different. The final area in acres can be found as follows:

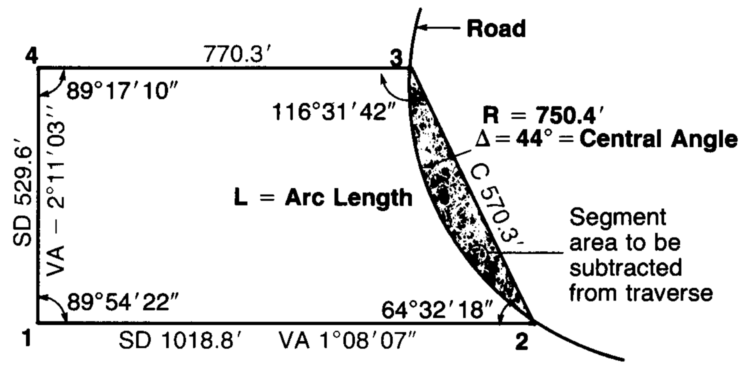
8855 ENTER↑ 43560 ÷ ⟶ 0.2033 Area

Curved Sides for Traverses

This routine is designed to be used with the Field Angle Traverse, Bearing/Azimuth Traverse and Inverse routines to include a circular curved side. After traversing or inversing along the chord from the beginning point of the curve (PC) to the end point of the curve (PT), the central angle and radius are input. The segment area and arc length are calculated for use in the Closure for Traverses routine to calculate distance traversed and area. If the central angle or the radius are not known, they may be calculated using the Curve Solutions program. But, be sure to reset the proper traverse mode using f A, f B when you return from Curve Solutions before proceeding with Traverse, Inverse and Sideshots.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Traverse along the chord from			
	the beginning point of the curve			
	(PC) to the end point of the			
	curve (PT) just as you would for			
	any course in the traverse.			
	Then before proceeding with			
	traverse, perform step 2			
	below.			
2	Input central angle	Δ(D.MS)	ENTER↑	
	and radius (positive if			
	segment area is to be added			
	to traverse, negative if			
	segment area is to be sub-			
	tracted from traverse).	R	f E	Segment area,
				Chord,
				Arc length,
				Δ,
				Radius

Example:



The purchase of a piece of property is being considered, but there is some question as to the exact size as it is bordered by a road on one end. The sketch above shows a rough survey, what is the correct area?

Keystrokes:	**Outputs:**
This problem can be solved as a field angle traverse.	
f A ⟶	0.0000*
f B ⟶	1.0000*
Arbitrarily make point 1 NO, EO.	
0 ENTER↑ 0 A ⟶	1.0000 *** Point
	0.0000 *** N
	0.0000 *** E
Use a reference azimuth away from point 1 of 0°.	
0 B ⟶	180.0000 *** AZ
89.5422 B ⟶	89.5422 *** AZ
1018.8 ENTER↑ 1.0807 D ⟶	1.0807 *** VA
	1018.8000 *** SD

*If you don't get the output shown, repeat this step.

E →	1018.6000	***	HD
	2.0000	***	Point
	1.6691	***	N
	1018.5986	***	E
64.3218 B →	334.2640	***	AZ
570.3 E →	570.3000	***	HD
	3.0000	***	Point
	516.1752	***	N
	772.5792	***	E
44 ENTER↑ 750.4			
CHS f E →	-20633.8201	***	Seg. area
	570.3000	***	C
	576.2658	***	L
	44.0000	***	Δ
	-750.4000	***	R
116.3142 B →	270.5822	***	AZ
770.3 E →	770.3000	***	HD
	4.0000	***	Point
	529.2529	***	N
	2.3902	***	E
89.1710 B →	180.1532	***	AZ
529.6 ENTER↑ 2.1103 CHS D →	-2.1103	***	VA
	529.6000	***	SD
E →	529.2152	***	HD
	5.0000	***	Point
	0.0431	***	N
	-0.0010	***	E
0 ENTER↑ 0 f D →	2894.3811	***	Σ HD
	445437.4280	***	Area
	178.3656	***	Error AZ
	0.0431	***	Error Dist
	6.0000	***	Point
	0.0000	***	N
	2.900000000-11	***	E
445437 ENTER↑ 43560 ÷ →	10.2258		Area

The error of closure is .04 feet and the area is 445,437 square feet or 10.2 acres.

TRAVERSE ADJUSTMENT

This program was designed to adjust a traverse using one of two methods, 1) the compass or Bowditch rule, 2) Crandall's rule. The data to be adjusted can consist of either coordinates of points or latitudes and departures for each leg.

Compass Rule

If the Traverse, Inverse and Sideshots program has just been run and step 2 on the Closure for Traverses routine has *not* been executed, the storage registers will be all set to start the adjustment. Otherwise, the total distance traversed and error latitude and error departure must be stored. If coordinates are to be used rather than latitudes and departures, the beginning coordinates must be input as well. When the registers are set up, the adjustment is computed. Then, for each pair of coordinates or latitudes and departures, the corrected values can be computed.

Example:

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

error latitude = 1.0366
error departure = 0.0490
distance traversed = 389.0700

Adjust the coordinates using the Compass rule.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
f A ——→	0.0000
f C ——→	0.0000*
(Print/pause is off.)	

*If you don't get the output shown, repeat the step.

100 ENTER↑ 500 C →	1.0000	Point
1.0366 ENTER↑ .049 D →	1.0366	ER L
389.07 STO 6 E →	1.0000	
107.1482 ENTER↑ 603.2529 A →	106.8724 ***	N
	603.2399 ***	E
	2.000	Point
203.5657 ENTER↑ 570.0939 A →	203.0183 ***	N
	570.0680 ***	E
	3.000	Point
151.188 ENTER↑ 461.6395 A →	150.3197 ***	N
	461.5985 ***	E
	4.000	Point
101.0366 ENTER↑ 500.049 A →	100.0000 ***	N
	500.0000 ***	E

***Shown by PRINT on HP-97 and PAUSE on HP-67.

Crandall's Rule

Crandall's rule adjustment works like the compass rule, but once the storage registers are set up, all of the coordinates or latitudes and departures must be input before the adjustment is computed. Then, after computing the adjustment, the values must be reinput and the corrected values computed.

Example:

The latitudes and departures from the Bearing/Azimuth Traverse example are shown below:

leg	LAT	DEP
1	7.1482	103.2529
2	96.4175	-33.1589
3	-52.3777	-108.4545
4	-50.1513	38.4095

error latitude = 1.0366
error departure = 0.049

Adjust the latitudes and departures using Crandall's rule.

Keystrokes:	Outputs:	
Load side 1 and side 2.		
f B →	1.0000	
f C →	0.0000*	
(Print/pause is off.)		
1.0366 ENTER↑ .049 D →	1.0366	ER L
7.1482 ENTER↑ 103.2529 B →	2.0000	Point
96.4175 ENTER↑ 33.1589		
CHS B →	3.0000	Point
52.3777 CHS ENTER↑ 108.4545		
CHS B →	4.0000	Point
50.1513 CHS ENTER↑ 38.4095 B →	5.0000	Point
E →	1.0000	
f C →	1.0000*	
(Print/pause is on.)		
7.1482 ENTER↑ 103.2529 B →	2.0000 ***	Point
	7.1482 ***	L
	103.2529 ***	D
	7.1418 ***	L
	103.1610 ***	D
96.4175 ENTER↑ 33.1589 CHS B →	3.0000 ***	Point
	96.4175 ***	L
	-33.1589 ***	D
	95.8163 ***	L
	-32.9521 ***	D
52.3777 CHS ENTER↑ 108.4545		
CHS B →	4.0000 ***	Point
	-52.3777 ***	L
	-108.4545 ***	D
	-52.5513 ***	L
	-108.8140 ***	D
50.1513 CHS ENTER↑ 38.4095		
B →	5.0000 ***	Point
	-50.1513 ***	L
	38.4095 ***	D
	-50.4067 ***	L
	38.6051 ***	D

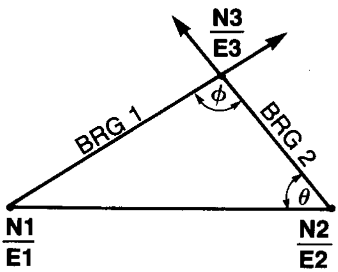
*If you don't get the output shown, repeat this step.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select Compass rule		f A	0.0000
	or Crandall's rule.		f B	1.0000
3	If you want your inputs shown			
	by print/pause, press f C.			
	A 1.0000 indicates print/pause			
	is on.			
	A 0.0000 indicates			
	print/pause is off.*		f C	0.0000/1.0000
4	If the Traverse, Inverse and			
	Sideshots program has just			
	been run and step 2 on the			
	Closure for Traverses routine			
	was *not* executed, go to step 8.			
5	If data consists of coordinates			
	rather than latitudes and			
	departures, input the beginning			
	coordinates.	BEG N	ENTER↑	
		BEG E	C	1.0000
6	Input error latitude**	ER L	ENTER↑	
	and error departure**	ER D	D	ER L
	*If pressing f C gives			
	undesired output, press			
	f C again.			
	**Error latitude and departure			
	are distances in the North and			
	East direction respectively			
	from the correct closing point to			
	the computed final point.			

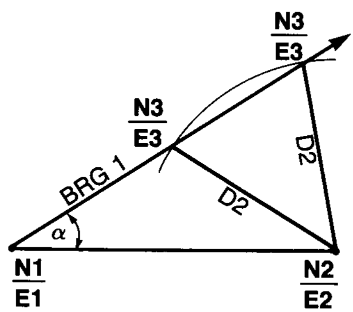
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
7	For compass rule adjustment			
	only, input total distance			
	traversed.	Σ HD	STO 6	
8	For Compass rule go to step 11.			
	For Crandall's rule, go to step 9.			
9	Input coordinates of next point	N	ENTER↑	
	or	E	A	Point
	latitude and departure of			
	next leg.	L	ENTER↑	
		D	B	Point
10	Repeat step 9 until final point is			
	reached.			
11	Compute adjustment.		E	1.0000
12	Beginning with the first point or			
	leg to be corrected, compute			
	the corrected values:			
	coordinates of next point	N	ENTER↑	
		E	A	corrected N,E
	or			
	latitude and departure of			
	next leg.	L	ENTER↑	
		D	B	corrected L,D
13	Repeat step 12 until all values			
	have been corrected.			

INTERSECTIONS

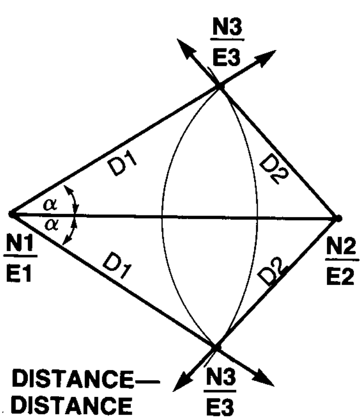
This program is designed to compute the coordinates of the point of intersection of two lines. The required information is the coordinates of a point of each line and a bearing (or azimuth) or distance for the line. The missing bearings and distances are also computed. If one line is given by a point and bearing and a second point is given, the offset from the second point to the line can be computed.



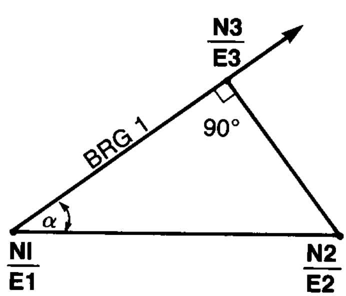
BEARING—BEARING



BEARING—DISTANCE

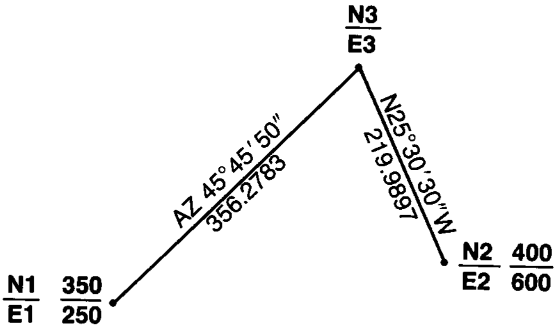


DISTANCE—DISTANCE



OFFSET FROM A POINT TO A LINE

Example:



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

Keystrokes:	**Outputs:**	
Load side 1 and side 2		
350 ENTER↑ 250 A →	350.0000	N1
400 ENTER↑ 600 B →	400.0000	N2
45.455 D →	45.7639	AZ1 (D.d)
25.303 ENTER↑ 4 C →	334.4917	AZ2 (D.d)
f A →	350.0000 ***	N1
	250.0000 ***	E1
	356.2783 ***	D1
	45.4550 ***	AZ1
	400.0000 ***	N2
	600.0000 ***	E2
	219.9897 ***	D2
	334.2930 ***	AZ2
	598.5457 ***	N3
	505.2631 ***	E3

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

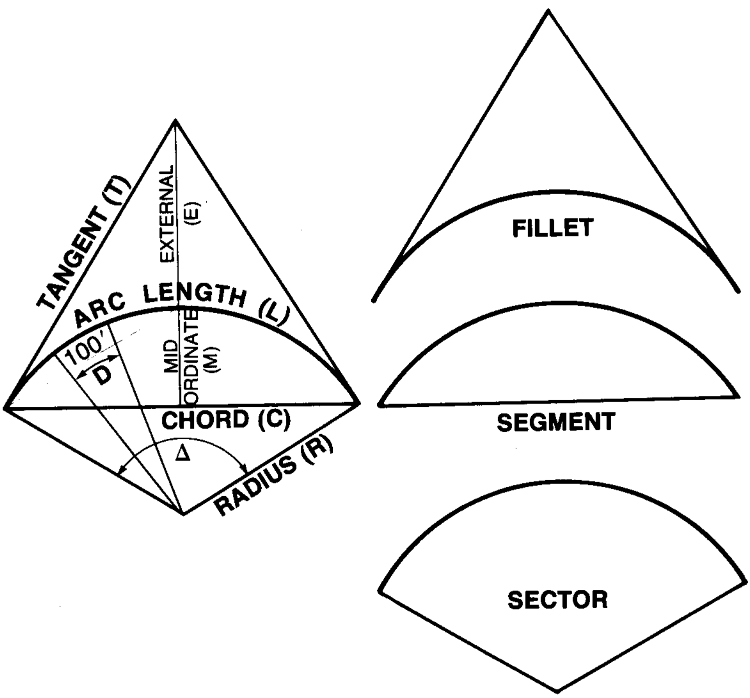
Try working some of the other intersections. Remember, Bearing-Distance and Distance-Distance have two possible solutions each. Answers may vary slightly due to rounding of input values.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input coordinates of point 1.	N1	ENTER↑	
		E1	A	N1
3	Input coordinates of point 2.	N2	ENTER↑	
		E2	B	N2
4	For Bearing-Bearing, go to			
	Step 5. For Bearing-Distance,			
	go to step 9. For Distance-			
	Distance, go to step 13. For			
	Offset from a point to a line,			
	go to step 16.			
5	Input bearing 1	BRG1(D.MS)	ENTER↑	
	and quadrant	QD	C	AZ1(D.d)
	or			
	azimuth 1	AZ1(D.MS)	D	AZ1(D.d)
6	Input bearing 2	BRG2(D.MS)	ENTER↑	
	and quadrant	QD	C	AZ2(D.d)
	or			
	azimuth 2.	AZ2(D.MS)	D	AZ2(D.d)
7	Compute intersection.		f A	N1, E1,
				D1, AZ1;
				N2, E2,
				D2, AZ2;
				N3, E3
8	Go to step 2 for next			
	intersection.			
9	Input bearing 1	BRG1(D.MS)	ENTER↑	
	and quadrant	QD	C	AZ1(D.d)
	or			
	azimuth 1.	AZ1(D.MS)	D	AZ1(D.d)
10	Input distance 2.	D2	E	D2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
11	Compute intersection. (Output			
	as shown on step 7.)		f B	
12	Go to step 2 for next			
	intersection.			
13	Input distance 1.	D1	E	D1
14	Input distance 2.	D2	E	D2
15	Compute intersection. (Output			
	as shown on step 7.)		f C	
16	Input bearing 1	BRG1(D.MS)	ENTER↑	
	and quadrant	QD	C	AZ1(D.d)
	or			
	azimuth 1.	AZ1(D.MS)	D	AZ1(D.d)
17	Compute intersection. (Output			
	as shown on step 7.)		D	
18	Go to step 2 for next			
	intersection.			

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

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input* radius	R	[A]	R
	or degree of curve	D(D.MS)	[CHS] [A]	
	or central angle.	Δ(D.MS)	[B]	
3	Input arc length	L	[C]	
	or chord	C	[D]	
	or tangent	T	[E]	
	or mid ordinate	M	[f] [A]	
	or external.	E	[f] [B]	
4	Compute radius, degree of			
	curve, central angle and arc			
	length.		[f] [C]	R,D(D.MS)
				Δ(D.MS),
				L
5	Compute tangent, chord, mid			
	ordinate, and external.		[f] [D]	T,C,M,E
6	Compute ▽, ⌒, △.		[f] [E]	0,▽,⌒,△
7	Go to step 2 or step 3 for new			
	inputs.			
	*If both radius and central angle			
	(or degree of curve and central			
	angle) are known, input both			
	on 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:	**Outputs:**
Load side 1 and side 2.	
100 [A] ⟶	100.0000 R

Keystrokes	Outputs
150 [C] [f] [C] →	100.0000 *** R
	57.1745 *** D (D.MS)
	85.5637 *** Δ (D.MS)
	150.0000 *** L
[f] [D] →	93.1596 *** T
	136.3278 *** C
	26.8311 *** M
	36.6701 *** E
[f] [E] →	0.0000 ***
	7500.0000 *** ▽
	2512.5251 *** ⌒
	1815.9646 *** △

If another pair of parameters for this curve are used as inputs, the computed parameters may differ somewhat from those shown above due to rounding. Using D = 57°17′45″ and Δ = 85°56′37″ from the above example, compute the other parameters.

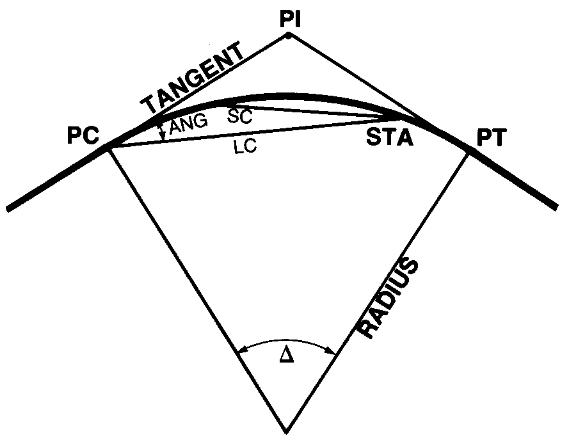
Keystrokes:	**Outputs:**
57.1745 [CHS] [A] →	99.9999 R
85.5637 [B] [f] [C] →	99.9999 *** R
	57.1745 *** D (D.MS)
	85.5637 *** Δ (D.MS)
	149.9998 *** L
[f] [D] →	93.1595 *** T
	136.3275 *** C
	26.8311 *** M
	36.6700 *** E
[f] [E] →	0.0000 ***
	7499.9808 ***
	2512.5156 ***
	1815.9568 *** △

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 or, if a stationing interval is given, the field data for successive stations can be computed automatically.

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.

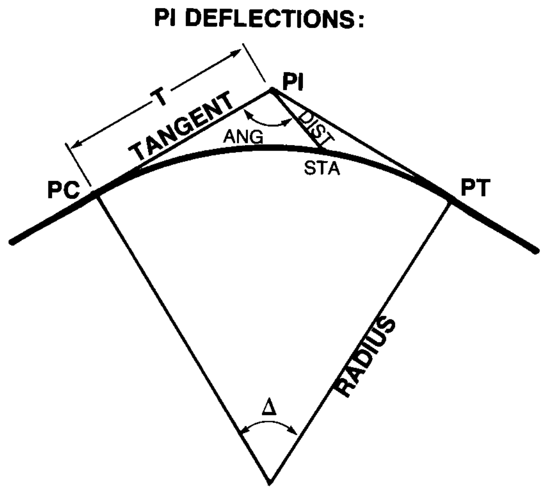
PC DEFLECTIONS:



PC Deflections:

Field data output for PC deflections consist of:

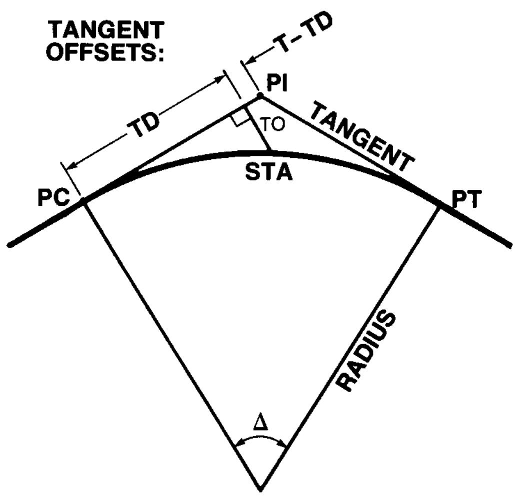
- STA —current station
- ANG —deflection angle from tangent to long chord
- LC —long chord from PC to current station
- SC —short chord from previous station to current station
- Δ —central angle
- PI —point of intersection of tangents
- PC, PT —ends of curve



PI Deflections:

Field data output for PI deflections consists of:

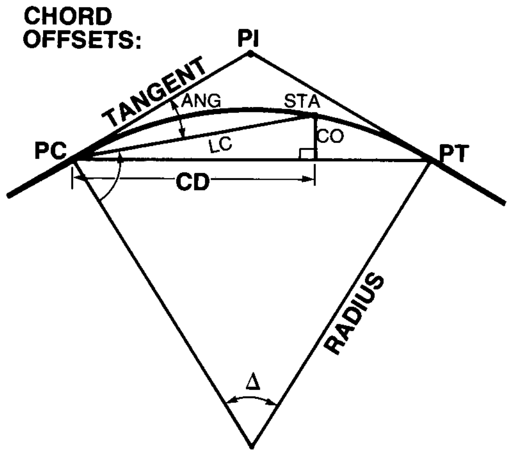
STA —current station
ANG —deflection angle from tangent to line joining PI and current station
DIST —distance from PI to current station



Tangent Offsets:

Field data output for tangent offsets consists of:

STA —current station
TD —tangent distance
TO —tangent offset
T —distance from PC to PI



Chord Offsets:

Field data output for chord offsets consists of:

STA —current station
CD —chord distance
CO —chord offset
L —length of curve from PC to PT.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input beginning station of			
	curve	PC	A	PC
	or station at intersection of			
	tangents.	PI	f A	PI
3	Input radius	R	f B	
	or degree of curve.	D(D.MS)	CHS	
			f B	
4	Input central angle.	Δ(D.MS)	f C	R,D(D.MS),
				Δ(D.MS),
				L, 0, PT,
				PI, PC
5	Input station	STA		
6	Compute: PC deflection		B	SC, LC,
				ANG(D.MS),
				STA
	or PI deflection		C	0, DIST,
				ANG(D.MS),
				STA
	or tangent offset		D	0, TO,
				TD, STA
	or chord offset.		E	0, CO,
				CD, STA

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
7	Repeat steps 5 and 6 for next			
	station or go to step 8 for			
	automatic stationing.			
8	Input stationing interval**	INT		
	and select:			
	auto-pause		f D	INT
	or auto-halt		f E	INT
9	Go to step 6 and select layout			
	method. Program will begin			
	computing field data from the			
	current station. If you selected			
	auto-halt on step 8, after each			
	output the calculator will halt.			
	Press R/S to continued with the			
	next station. If you selected			
	auto-pause, the calculator will			
	proceed to each successive			
	station without halting.			
	**Note: It is not necessary to			
	input the interval if it has been			
	done previously. Just press the			
	auto pause or auto-halt key			
	without keying in a number.			

Example 1:

Compute field data for PC deflections for a curve with a central angle of 35°30′ and a degree of curve of 12°30′. Start at station 8+00 and use a stationing interval of 100 feet up to and including the station at the PT. The station at the PI is 9+32.12.

Keystrokes:	Outputs:		
Load side 1 and side 2.			
932.12 f A →	932.1200		PI
12.3 CHS f B 35.3 f C →	458.3662	***	R
	12.30000	***	D (D.MS)
	35.3000	***	Δ (D.MS)
	284.0000	***	L
	0.0000	***	
	1069.3958	***	PT
	932.1200	***	PI
	785.3958	***	PC
800 B →	14.6036	***	SC
	14.6036	***	LC
	0.5446	***	ANG
	800.0000	***	STA
100 f D →	100.0000		INT
B →	99.8018	***	SC
	114.3059	***	LC
	7.0946	***	ANG
	900.0000	***	STA
	99.8018	***	SC
	212.6495	***	LC
	13.2446	***	ANG
	1000.0000	***	STA
	69.3296	***	SC
	279.4790	***	LC
	17.4500	***	ANG
	1069.3958	***	STA

Example 2:

Compute field data for tangent offsets for a curve with a central angle of 35°30′ and a radius of 458.366 feet. Start at station 8+00 and use a stationing interval of 100 feet up to and including the station at the PT. The station at the PC is 7+85.4.

Keystrokes:	Outputs:		
Load side 1 and side 2. (Skip this step if you just worked the previous example.)			
785.4 **A** →	785.4000		PC
458.366 **f** **B** 35.3 **f** **C** →	458.3660	***	R
	12.3000	***	D (D.MS)
	35.3000	***	Δ (D.MS)
	283.9999	***	L
	0.0000	***	
	1069.3999	***	PT
	932.1241	***	PI
	785.4000	***	PC
800 **D** →	0.0000	***	
	0.2325	***	TO
	14.5975	***	TD
	800.0000	***	STA
100 **f** **D** →	100.0000		INT
D →	0.0000	***	
	14.2516	***	TO
	113.4098	***	TD
	900.0000	***	STA
	0.0000	***	
	49.3253	***	TO
	206.8455	***	TD
	1000.0000	***	STA
	0.0000	***	
	85.2031	***	TO
	266.1745	***	TD
	1069.3999	***	STA

To get the other parameters of the curve, proceed as shown below using the Curve Solutions program.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
f C →	458.3660 *** R
	12.3000 *** D (D.MS)
	35.3000 *** Δ (D.MS)
	283.9999 *** L
f D →	146.7241 *** T
	279.4789 *** C
	21.8201 *** M
	22.9108 *** E
f E →	0.0000 ***
	65087.9385 *** ▽
	4085.2701 *** ⌓
	2165.4065 *** △

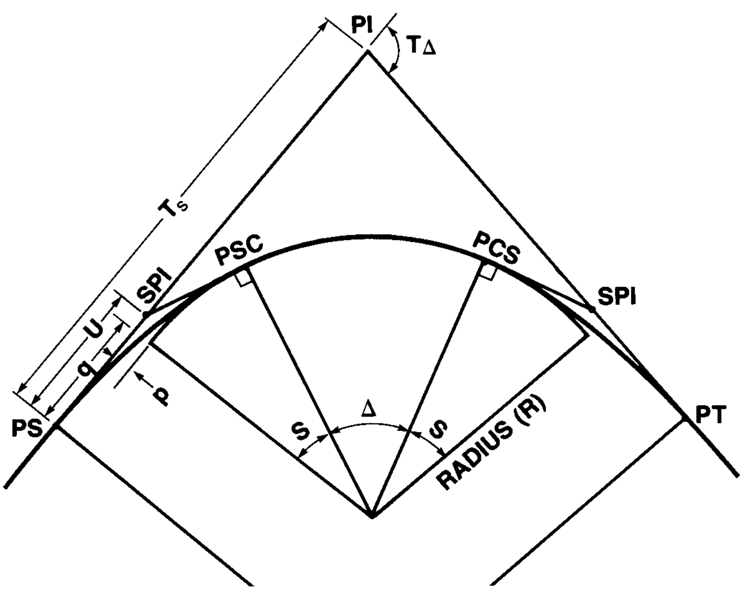
***Shown by PRINT on HP-97 and by PAUSE on HP-67.

SPIRAL CURVE LAYOUT

This program is used with the Horizontal Curve Layout program to calculate the field data for layout of spiral curves by either of two methods; 1) deflection angles and chord distances from the beginning station of the spiral (PS), or 2) tangent distances and offsets to the spiral. The required information on the spiral is the PS station, radius (or degree of curve) of the central circular curve, and length of the spiral. For equal exit and entrance spirals to a central circular curve, the station (PI) and angle (TΔ) at the intersection of the tangents is required.

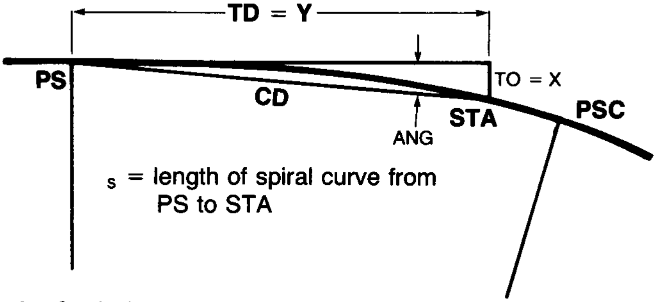
Field data for any specified station can be calculated, or if a stationing interval is given, the field data for successive stations can be computed automatically. After computing data for the equal entrance and exit spirals, the Horizontal Curve Layout program can be used to compute field data for the central circular curve.

The Horizontal Curve Layout program is also used to load a set of constants into the secondary registers for use by the Spiral Curve Layout program.



L = Length of spiral curve from PS to PSC.

D = Degree of central circular curve = central angle per 100 ft. of arc.



ℓ_s = length of spiral curve from PS to STA

Example:

Compute field data for layout of entrance and exit transition spirals 300 feet long. The PI station is 35 + 290.48 and the intersection angle is 40°00′00″. The spirals are transitions to a central circular curve (degree of curve = 6°00′). Deflection angles and distances are needed at 100 foot intervals from the first even station inside the PS (PT).

Keystrokes:	**Outputs:**	
Load side 1 and side 2 of Horizontal Curve Layout.		
[f] [E] [R/S] →	6894720.00	
(Spiral constants have now been loaded into the secondary registers.)		
Load side 1 and side 2 of Spiral Curve Layout.		
35290.48 [ENTER↑] 40 [f] [A] →	35290.4800	PI
6 [CHS] [B] →	954.9297	R
300 [f] [B] →	300.0000 ***	L
	9.0000 ***	S (D.MS)
	5.5960 ***	D (D.MS)
	954.9297 ***	R
	0.0000 ***	
	35758.2759 ***	PT
	35290.4800 ***	PI
	34791.6093 ***	PS
	0.0000 ***	
	35091.6093 ***	PSC
	34991.8684 ***	SPI
	34791.6093 ***	PS

Keystrokes	Output		
34800 C	0.0000	***	
	8.3907	***	CD
	0.0008	***	ANG
	34800.0000	***	STA
100 f C	100.0000		INT
C	0.0000	***	
	108.3887	***	CD
	0.2330	***	ANG
	34900.0000	***	STA
	0.0000	***	
	208.3375	***	CD
	1.2651	***	ANG
	35000.0000	***	STA
	0.0000	***	
	299.6711	***	CD
	2.5958	***	ANG
	35091.6093	***	PSC
E	0.0000	***	
	35458.2759	***	PCS
	35558.0168	***	SPI
	35758.2759	***	PT
35700 C	0.0000	***	
	58.2758	***	CD
	0.0648	***	ANG
	35700.0000	***	STA
100 CHS f C	-100.0000		-INT
C	0.0000	***	
	158.2625	***	CD
	0.5006	***	ANG
	35600.0000	***	STA
	0.0000	***	
	258.1204	***	CD
	2.1324	***	ANG
	35500.0000	***	STA
	0.0000	***	
	299.6711	***	CD
	2.5958	***	ANG
	35458.2759	***	STA

Field data for the central circular curve can now be computed as follows:

E →	Ignore Output	
Load side 1 and side 2 of Horizontal Curve Layout program.		
RCL 3 A →	35091.6093	PSC
RCL A f B RCL B		
→H.MS f C →	954.9297 ***	R
	5.5960 ***	D
	22.0000 ***	Δ
	366.6667 ***	L
	0.0000 ***	
	35458.2759 ***	PT
	35277.2288 ***	PI
	35091.6093 ***	PC
35100 B →	8.3907 ***	SC
	8.3907 ***	LC
	0.1506 ***	ANG
	35100.0000 ***	STA
100 f D →	100.0000	INT
B →	99.9543 ***	SC
	108.3326 ***	LC
	3.1506 ***	ANG
	35200.0000 ***	STA
	99.9543 ***	SC
	207.9775 ***	LC
	6.1506 ***	ANG
	35300.0000 ***	STA
	99.9543 ***	SC
	307.0523 ***	LC
	9.1506 ***	ANG
	35400.0000 ***	STA
	58.2669 ***	SC
	364.4183 ***	LC
	11.0000 ***	ANG
	35458.2759 ***	STA

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2 of			
	Horizontal Curve Layout			
	Program.		f E	
			R/S	
2	Load side 1 and side 2 of			
	Spiral Curve Layout Program.			
3	Input station at beginning of			
	spiral or station and angle at	PS	A	PS
	intersection of tangents.	PI	ENTER↑	
		TΔ(D.MS)	f A	PI
4	Input radius of circular curve	R	B	R
	or degree of curve of circular			
	curve.	D(D.MS)	CHS B	R
5	Input length of spiral curve.	L	f B	L ,S(D.MS),
				D(D.MS), R
6	If PS was input, go to step 8.			
7	Additional output if PI was input.			0, PT,
				PI, PS
8	Additional output for entrance			
	spiral.			0, PSC,
				SPI, PS
9	Input station.	STA		
10	Compute:			
	PS deflection		C	0, CD,
				ANG(D.MS)
				STA
	or tangent offset.		D	0, TO,
				TD, STA
11	Repeat steps 9 and 10 for next			
	station or go to step 12 for			
	automatic stationing.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
12	Input stationing interval*	INT		
	and select			
	auto-pause		f C	INT
	or auto-halt		f D	INT
13	Go to step 10 and select layout			
	method. Program will begin			
	computing field data from the			
	current station. If you selected			
	auto-halt on step 12, after each			
	output the calculator will halt.			
	Press R/S to continue with the			
	next station. If you selected			
	auto-pause, the calculator will			
	proceed to each successive			
	station without halting.			
14	If PI was input, field data for the			
	exit spiral can be computed as			
	follows:			
15	Additional output for exit spiral.		E	0, PCS,SPI,
				PT
	*Note: It is not necessary to			
	input the interval if it has been			
	done previously. Just press the			
	auto-pause or auto-halt key			
	without keying in a number.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
16	Go to step 9 to compute field			
	data. If you want to station			
	automatically from the PT to the			
	PCS, use a negative interval on			
	step 12. When you are through			
	with the exit spiral, the central			
	circular curve can be stationed			
	by proceeding with step 17.			
17	Return to the entrance spiral.		E	Ignore output
18	Load side 1 and side 2 of			
	the Horizontal Curve Layout			
	program.			
19	Recall and Input PC		RCL 3	
			A	PSC
20	Recall and Input R		RCL A	
			f B	
21	Recall and Input Δ		RCL B	
			→H.MS	
			f C	R,D(D.MS),
				Δ(D.MS), L,
				0,PT,PI,PC
22	Continue with step 5 of			
	Horizontal Curve Layout.			

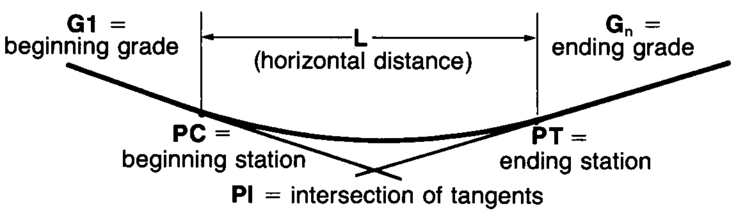
VERTICAL CURVES AND GRADES

This program computes station and elevation data for vertical curves* and straight grades. The required information for a vertical curve is the beginning station (or station at intersection of tangents), elevation, beginning grade, ending grade and one of the following: 1) length of the curve, 2) elevation at high or low point, or 3) station and elevation through which the curve passes. Required information for a straight grade is beginning station, elevation and grade. Stations at specified elevations can be computed as well as elevations at specified stations. If a stationing interval is given, elevations at successive stations can be computed automatically.

*This program is based on an equal tangent parabolic vertical curve.

Example:

Compute elevations for stations along a 400 foot vertical curve with a PI station at 14 + 24.08 and elevation 104.77. The beginning grade is –5.1% and the ending grade is 2.4%. Use a stationing interval of 100 feet, starting with the first even station after the PC.



Keystrokes:	**Outputs:**
Load side 1 and side 2	
1424.08 CHS ENTER↑ 104.77	
ENTER↑ 5.1 CHS ENTER↑ 2.4 B →	–1424.08 *** PI
	104.77 *** ELI
	–5.10 *** G1
	2.40 *** Gn

400 C	→	1224.08 *** PC
		114.97 *** EL1
1300 E	→	1300.00 *** STA
		111.64 *** EL
100 f D	→	1400.00 *** STA
		108.90 *** EL
		1500.00 *** STA
		108.04 *** EL
		1600.00 *** STA
		109.05 *** EL
		1624.08 *** STA
		109.57 *** EL
What is the station and elevation of the low point?		
f C	→	1496.08 *** STA_0
		108.03 *** EL_0
What stations would have an elevation of 109.00 feet?		
109 D	→	109.00 *** EL
		1597.59 *** STA
		1394.57 *** STA

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

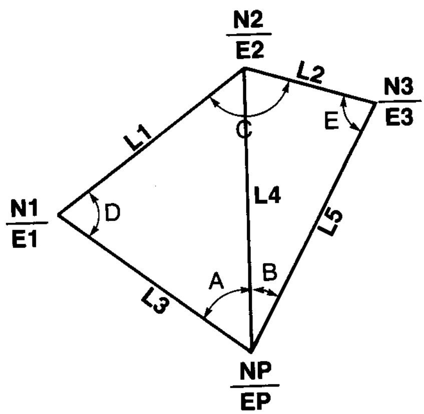
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	For a grade go to step 3. For a			
	vertical curve, go to step 5.			
3	Input beginning station	STA1	ENTER↑	
	and elevation	EL1	ENTER↑	
	and grade.	GR%	A	STA1,EL1,G1,ϕ
4	Go to step 8.			
5	Input beginning station	PC	ENTER↑	
	or station at intersection of			
	tangents	PI	CHS	
			ENTER↑	
6	Input elevation of station input			
	at step 5	EL	ENTER↑	
	and beginning grade	G1%	ENTER↑	
	and ending grade.	Gn%	B	PC(−PI),EL,G1
7	Input horizontal length of curve	L	C	Gn, PC, EL1
	or elevation of high or low			
	point	EL_0	f A	PC, EL1
	or a station and elevation			
	through which the curve			
	passes.	STA	ENTER↑	
		EL	f B	PC, EL1
8	To compute stations at			
	specified elevations, go to			
	step 9. To compute elevations			
	at specified stations, go to			
	step 11. To compute the low or			
	high point of a vertical curve, go			
	to step 14.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
9	Input elevation and compute			
	station (Two stations will be			
	output for a vertical curve. If			
	Error is displayed, no point with			
	the specified elevation exists			
	on the curve.).	EL	D	EL, STA
10	Repeat step 9 for next			
	elevation.			
11	Input station and compute			
	elevation.	STA	E	STA, EL
12	Repeat step 11 for next station			
	or go to step 13 for automatic			
	stationing.			
13	Input stationing interval and			
	select: auto-pause		f D	STA, EL
	or auto-halt.		f E	STA, EL
	Program will begin computing			
	from the current station.			
	If you selected auto-halt on			
	step 13, the program will halt			
	after each output. Press R/S to			
	proceed to the next station.			
	If you selected auto-pause, the			
	calculator will pause at each			
	output and then continue to the			
	next station without halting. It			
	will finally halt at the PT for a			
	vertical curve. For a grade,			
	press R/S during the pause			
	displaying elevation when you			
	want to halt the program.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
14	Compute the station and			
	elevation of the low or high			
	point of the curve.		f C	STA_0, EL_0

RESECTION

This program is designed to solve the "three point problem" or resection which is a method of locating a point from three known points. Required information are the distances between points 1 and 2 and points 2 and 3, and the angle C. Alternatively, the coordinates of the three points may be used. The angles A and B must also be known. The points must be arranged in clockwise order as 1, 2, 3, P. The angles D and E are computed. The five distances between the points can be computed. If coordinates for the three points were input, coordinates of point P can also be computed.



Example:

The coordinates of three points are known:

N1 = 232	E1 = 307
N2 = 356	E2 = 468
N3 = 224	E3 = 561

From a fourth point angles are turned between points 1 and 2 and points 2 and 3.

A = 62°45′05″
B = 46°51′00″

What are the coordinates of the unknown point and the lengths of the lines joining the points?

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
232 ENTER↑ 307 A ⟶	232.0000 *** N1
	307.0000 *** E1

356 ENTER↑ 468 B → 356.0000 *** N2
468.0000 *** E2

224 ENTER↑ 561 C → 224.0000 *** N3
561.0000 *** E3

62.4505 ENTER↑ 46.51 D → 62.4505 *** A (D.MS)
46.5100 *** B (D.MS)

E → 75.1900 *** D (D.MS)
87.3106 *** E (D.MS)

f E → 138.5604 *** NP
427.8368 *** EP

f D → 203.2166 *** L1
161.4714 *** L2
152.7498 *** L3
221.1178 *** L4
158.2162 *** L5

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	If L1, L2 and C are known, go to			
	step 3. If the coordinates of the			
	three points are known, go to			
	step 6.			
3	Input the distance between			
	points 1 and 2.	L1	ENTER↑	
	and the distance between			
	points 2 and 3.	L2	f A	L1, L2
4	Input angle C.	C (D.MS)	f B	C (D.MS)
5	Go to step 7.			
6	Input coordinates.	N1	ENTER↑	
		E1	A	N1, E1
		N2	ENTER↑	
		E2	B	N2, E2
		N3	ENTER↑	
		E3	C	N3, E3

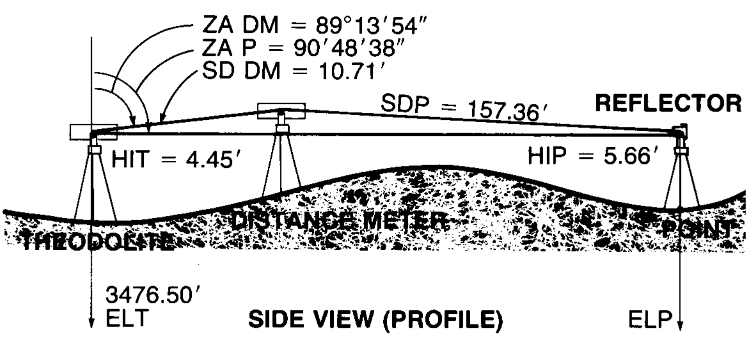
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
7	Input angles A and B.	A (D.MS)	ENTER↑	
		B (D.MS)	D	A(D.MS),
				B(D.MS)
8	Compute resection.		E	D (D.MS)
				E (D.MS)
9	If coordinates of the three points			
	were input, compute the			
	coordinates of point P.		f E	NP, EP
10	Optional: compute all lengths			
	L1-L5.		f D	L1, L2
				L3, L4,
				L5

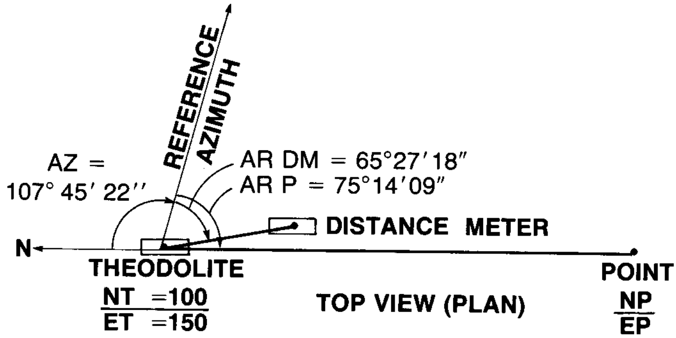
TWO INSTRUMENT RADIAL SURVEY

This program uses a two instrument radial survey technique to determine the coordinates of a point. The required information consists of the coordinates of the theodolite, elevation and height of instrument for the theodolite, reference azimuth (or bearing), angle right at the theodolite from reference azimuth to distance meter, slope distance and vertical (or zenith) angle from theodolite to distance meter, angle right at theodolite from reference azimuth to unknown point, slope distance from distance meter to point, vertical (or zenith) angle from theodolite to point and height of instrument for the prism at the point. The horizontal distance and azimuth from the theodolite to the point are computed as well as the coordinates and elevation of the point.

Example:

The theodolite is set up at N100, E150 at elevation 3476.50 feet and instrument height above ground of 4.45 feet. The reference azimuth taken from a backsight is 107°45′22″. The distance meter is set up and located from the theodolite by an angle right from the reference of 65°27′18″, a slope distance of 10.71 feet and a zenith angle of 89°13′54″. The point is located from the theodolite by a angle right from the reference of 75°14′09″ with a zenith angle of 90°48′38″. The distance meter measures a slope distance to the point of 157.36 feet. The height of the reflector is 5.66 feet. What are the coordinates and elevation of the point?



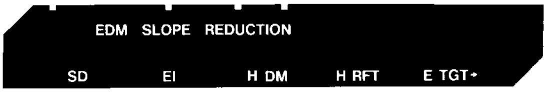


Keystrokes:	Outputs:	
Load side 1 and side 2		
E ⟶	0.0000*	(Print/Pause is off.)
100 ENTER↑ 150 f A ⟶	100.0000	NT
3476.5 f B ⟶	3476.5000	ELT
4.45 f C ⟶	4.4500	HIT
107.4522 f D ⟶	107.7561	AZ
65.2718 A ⟶	65.4550	AR DM
10.71 ENTER↑ 89.1354 B ⟶	89.2317	ZA
75.1409 A ⟶	75.2358	AR P
157.36 ENTER↑ 90.4838 B ⟶	90.8106	ZA
5.66 C ⟶	5.6600	HIP
D ⟶	167.8827 ***	HD
	182.5931 ***	AZ (D.MS)
	−67.6539 ***	NP
	141.2373 ***	EP
	3472.9148 ***	ELP

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	If you want your inputs shown			
	by print/pause, press E.			
	A 1.0000 indicates print/pause			
	is on.			
	A 0.0000 indicates print/pause			
	is off.*		E	0.0000/1.0000
	*If you don't get the output			
	shown, repeat the step.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
3	Input coordinates of theodolite	NT	ENTER↑	
		ET	f A	NT
4	Input elevation of theodolite	ELT	f B	ELT
5	Input height of instrument for			
	theodolite	HIT	f C	HIT
6	Input reference azimuth	AZ(D.MS)	f D	AZ(D.d)
	or reference bearing	BRG(D.MS)	ENTER↑	
	and quadrant	QD	f E	
7	Input angle right from reference			
	azimuth to distance meter	AR DM(D.MS)	A	AR DM(D.d)
8	Input slope distance and zenith			
	or vertical angle from theodolite			
	to distance meter.	SD DM	ENTER↑	
		VA/ZA(D.MS)	B	VA/ZA(D.d)
9	Input angle right from reference			
	azimuth to unknown point.	AR P(D.MS)	A	AR P(D.d)
10	Input slope distance from			
	distance meter to point.	SDP	ENTER↑	
	and vertical or zenith angle			
	from theodolite to point.	VA/ZA(D.MS)	B	VA/ZA(D.d)
11	Input height of instrument for			
	reflector at point.	HIP	C	HIP
12	Compute horizontal distance			
	and azimuth from theodolite			
	to point; plus coordinates and			
	elevation of point.		D	HD,AZ(D.MS);
				NP,EP,ELP

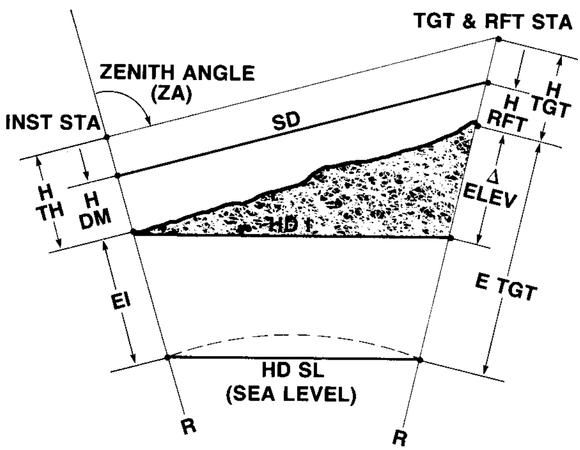
EDM SLOPE REDUCTION



This program is designed for reducing slope distances measured with an Electronic Distance Meter to a horizontal distance at sea level (HD SL) and a horizontal distance at the instrument station elevation (HD I). Corrections are made for curvature of the earth and for refraction of light (coefficient of refraction 0.071). A radius of 20,906,000 feet is used for the earth.

Example:

SD = 10000.0000
EI = 5000.0000
H DM = 5.12
H RFT = 5.75
H TH = 5.96
H TGT = 5.34
ZA = 85°30′20″



Using the information given above, reduce the slope distance to a horizontal distance.

Keystrokes:	Outputs:	
Load side 1 and sie 2.		
f A ⟶	0.0000*	
(Print/pause is off)		
10000 A ⟶	10000.0000	SD
5000 B ⟶	5000.0000	EI
5.12 C ⟶	5.1200	H DM
5.75 D ⟶	5.7500	H RFT
5.96 f C ⟶	5.9600	H TH
5.34 f D ⟶	5.3400	H TGT
85.3020 f E ⟶	786.2840 ***	ΔELEV
	5786.2840 ***	E TGT
	9966.4190 ***	HD SL
	9968.8026 ***	HD I

Instead of using zenith angle, height of theodolite and height of target, the elevation at the target station could have been input:

5786.284 E ⟶	786.2840	ΔELEV
	5786.2840	E TGT
	9966.4166	HD SL
	9968.8002	HD I

HD SL and HD I calculated here are slightly different from those calculated one step earlier. This results from inputting E TGT rounded to 7 places instead of 10 places.

*If output is 1.0000, press f A again.
***Shown by PRINT on HP-97 and by PAUSE on HP-67.

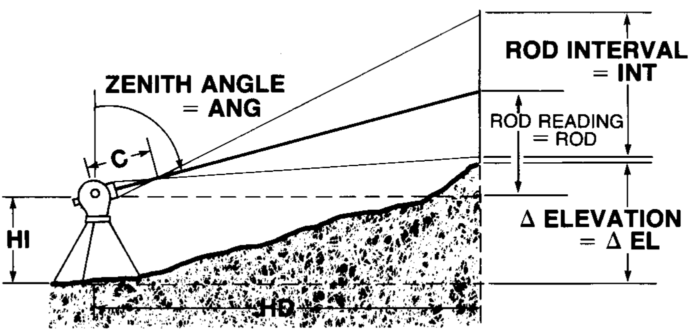
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	If you want your inputs shown			
	by print/pause press f A.			
	A 1.0000 indicates print/pause			
	is on.			
	A 0.0000 indicates print/pause			
	is off.*		f A	1.0000/0.0000
3	Input slope distance.	SD	A	SD
4	Input elevation at instrument			
	station.	EI	B	EI
5	Input height of distance meter.	H DM	C	H DM
6	Input height of reflector.	H RFT	D	H RFT
7	If zenith or vertical angle is			
	known, go to step 8. If elevation			
	at target station is known, go to			
	step 12.			
8	Input height of theodolite.	H TH	f C	H TH
9	Input height of target.	H TGT	f D	H TGT
10	Input zenith or vertical angle.	ZA/VA(D.MS)	f E	ΔELEV,
				E TGT,
				HD SL,
				HD I
11	Go to step 3 for next reduction.			
12	Input elevation at target station.	E TGT	E	ΔELEV,
				E TGT,
				HD SL,
				HD I
13	Go to step 3 for next reduction.			
	*If pressing f A gives undesired			
	output, press f A again.			

STADIA RED./3-WIRE LEVEL

This card contains two independent programs, 1) Stadia Reduction and 2) Three Wire Leveling.

Stadia Reduction

This program is designed to compute the elevation (ΔEL) and horizontal distance (HD) for points located by stadia observations. The required information consists of station elevation (EL) height of instrument (HI), rod reading (ROD) if different from HI, vertical or zenith angle (ANG), and rod interval (INT). Stadia constants are contained in the program and may be changed as desired.



Example:

EL = 491.0 HI = 5.2

ROD	ANG	INT
5.2	75°50′00″	1.31
8.1	93°18′00″	3.32
8.8	90°00′00″	4.06

Reduce the stadia observations given above to elevation and distance for each point.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
A ⟶	0.0000

491 ENTER↑ 5.2 B →	491.0000 *** EL
	5.2000 *** HI
75.5 D 1.31 E →	5.2000 *** ROD
	75.5000 *** ANG
	1.3100 *** INT
	123.1532 *** HD
	522.0863 *** ΔEL
8.1 C →	8.1000 ROD
93.18 D 3.32 E →	8.1000 *** ROD
	93.1800 *** ANG
	3.3200 *** INT
	330.8999 *** HD
	469.0204 *** EL
8.8 C →	8.8000 ROD
90 D 4.06 E →	8.8000 *** ROD
	90.0000 *** ANG
	4.0600 *** INT
	406.0000 *** HD
	487.4000 *** ΔEL

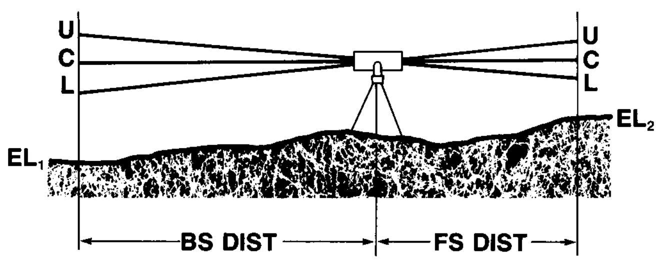
***Shown by PRINT on HP-97 and by PAUSE on H-67.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Press start.		A	0.0000
3	Change the stored constants			
	as desired:			
	stadia interval factor (100)	K	STO 5	
	stadia constant (0)	C	STO 6	
4	Input elevation	EL	ENTER↑	
	and height of instrument	HI	B	EL, HI
5	Input rod reading if different			
	from HI.	ROD	C	ROD
6	Input vertical or zenith angle.	ANG	D	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
7	Input rod interval and compute			
	distance and elevation.	INT	E	ROD, ANG,
				INT, HD,
				ΔEL
8	Go to step 4. Skip step 4, 5 or			
	6 if any of those inputs have not			
	changed.			

Three Wire Leveling

This program is designed to compute elevations for a line of wire levels. The required information consists of upper (U), center (C) and lower (L) stadia hair readings for the backsight (BS) and foresight (FS). The elevation is computed by averaging these and the difference between the half stadia intervals is output as a check. The backsight and foresight distances are accumulated and can be output if desired. The program contains a stadia constant which may be changed as desired.



Example:

EL = 5280.0

Station	BS U, C, L	FS U, C, L
1	8.266	3.491
	8.105	3.320
	7.940	3.152
2	8.119	5.221
	7.329	4.435
	6.535	3.654

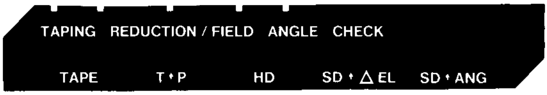
Compute the elevations using the stadia data given above.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
A →	0.0000
5280 f B →	5280.0000 *** EL_1
8.266 ENTER↑ 8.105 ENTER↑	
7.94 f C →	8.2660 *** U
	8.1050 *** C
	7.9400 *** L
	0.0040 *** CHECK
3.491 ENTER↑ 3.32 ENTER↑	
3.152 f D →	3.4910 *** U
	3.3200 *** C
	3.1520 *** L
	0.0030 *** CHECK
	5284.7827 *** EL_2
8.119 ENTER↑ 7.329 ENTER↑	
6.535 f C →	8.1190 *** U
	7.3290 *** C
	6.5350 *** L
	0.0040 *** CHECK
5.221 ENTER↑ 4.435 ENTER↑	
3.654 f D →	5.2210 *** U
	4.4350 *** C
	3.6540 *** L
	0.0050 *** CHECK
	5287.6737 *** EL_2
f E →	0.0000 ***
	191.0000 *** BS DIST
	190.6000 *** FS DIST
	381.6000 *** TOT DIST

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Press start.		A	0.0000
3	Change stored constant if			
	desired:			
	stadia constant (1.00)	K	STO 5	
4	Input beginning elevation.	EL_1	f B	EL_1
5	Input backsight rod readings:			
	upper reading	U	ENTER↑	
	center reading	C	ENTER↑	
	lower reading	L	f C	U, C, L,
				CHECK
6	Input foresight rod readings:			
	upper reading	U	ENTER↑	
	center reading	C	ENTER↑	
	lower reading	L	f D	U, C, L,
				CHECK,
				EL_2
7	Go to step 5 for next station.			
8	Compute backsight distance,			
	foresight distance and total			
	distance.		f E	0, BS DIST,
				FS DIST,
				TOT DIST

TAPING REDUCTION/FIELD ANGLE CHECK



This card contains two independent programs, 1) Taping Reduction and 2) Field Angle Check.

Taping Reduction

This program corrects taped distances for temperature, pull (tension), sag and index. The program contains a series of constants, but these may be changed as desired. Slope distances can also be reduced to horizontal distances with correction. The slope can be indicated either by an elevation difference or by a vertical or zenith angle.

Example:

Using the stored constants and a temperature of 88°F and tension of 20 lbs., reduce the following taped measurements:

1) HD = 100.0000
2) SD = 100.0000 ΔEL = −3.7500

Then change the stored standard tension to 35 lbs. and reduce

3) SD = 77.4580 ZA = 88°05′43″

Keystrokes:	**Outputs:**		
Load side 1 and side 2.			
A →	0.0150		W
88 ENTER↑ 20 B →	88.0000	***	T
	20.0000	***	P
100 C →	0.0000	***	
	100.0000	***	HD
	99.9895	***	HDC
	99.9895	***	Σ HDC
100 ENTER↑ 3.75 CHS D →	−3.7500	***	ΔEL
	100.0000	***	SD
	99.9191	***	HDC
	199.9086	***	Σ HDC
35 STO 0 →	35.0000		P

77.458 ENTER↑ 88.0543 E ⟶ 88.0543 *** ANG
77.4580 *** SD
77.4143 *** HDC
277.3229 *** Σ HDC

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select Taping Reduction			
	program.		A	W
3	Change any stored constants			
	(shown in parenthesis) as			
	desired:			
	standard tension (20 lbs.)	P_0	STO 0	
	cross section area (.009 in^2)	A	STO 1	
	modulus of elasticity			
	(30×10^7 psi)	E	STO 2	
	standard temperature (68°F)	T_0	STO 3	
	coefficient of thermal			
	expansion (6.45×10^{-6}/°F)	CT	STO 4	
	weight (.015 lbs./ft.)	W	STO 5	
	index correction (0.0)	CI	STO 6	
4	Input temperature	T	ENTER↑	
	and pull	P	B	T, P
5	Input horizontal distance	HD	C	0, HD, HDC,
				ΣHDC
	or slope distance	SD	ENTER↑	
	and elevation difference	ΔEL	D	ΔEL, SD,
				HDC, ΣHDC
	or slope distance	SD	ENTER↑	
	and angle.	ANG	E	ANG, SD,
				HDC, ΣHDC
6	Repeat steps 4 & 5 for next			
	reduction. If T and P do not			
	change, skip step 4.			

Field Angle Check

This program is designed to reduce field angle data. One direct and one reverse pointing to the backsight and one direct and one reverse pointing to the foresight are input for each position. The average angle for each position is computed. Data for any number of positions can be averaged to get a final average angle.

Example:

The following data is available for observations of three positions.

Position	BD	BR	FD	FR
1	0°00′07″	10″	86°01′37″	39″
2	11°00′21″	26″	97°01′55″	57″
3	22°01′03″	04″	108°02′33″	29″

Note:

BD = backsight direct, BR = backsight reverse, FD = foresight direct, FR = foresight reverse.

Compute the average for each position and overall average.

Keystrokes:	Outputs:
Load side 1 and side 2.	
f A →	0.0000
0.0007 ENTER↑ 10 f B →	0.0007 *** BD
	10.0000 *** BR
86.0137 ENTER↑ 39 f C →	86.0137 *** FD
	39.0000 *** FR
	86.0130 *** ANG
11.0021 ENTER↑ 26 f B →	11.0021 *** BD
	26.0000 *** BR
97.0155 ENTER↑ 57 f C →	97.0155 *** FD
	57.0000 *** FR
	86.0133 *** ANG
22.0103 ENTER↑ 4 f B →	22.0103 *** BD
	4.0000 *** BR
108.0233 ENTER↑ 29 f C →	108.0233 *** FD
	29.0000 *** FR
	86.0127 *** ANG
f D →	86.0130 *** ANG

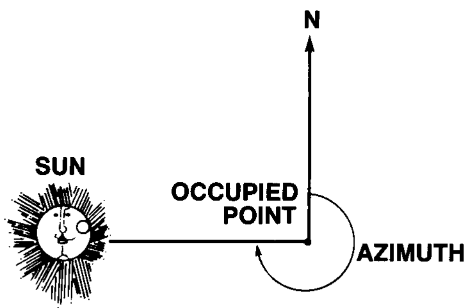
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Select Field Angle Check			
	program.		f A	0.0000
3	Input direction to backsight	BD (D.MS)	ENTER↑	
	and the seconds portion of			
	the reverse pointing to the			
	backsight.	BR (S)	f B	BD, BR
4	Input direction to foresight	FD (D.MS)	ENTER↑	
	and the seconds portion of			
	the reverse pointing to the			
	foresight and compute the			
	average.	FR (S)	f C	FD, FR,
				ANG (D.MS)
5	Go to step 3 for next position at			
	same setup. When all observed			
	data has been input, go to			
	step 6.			
6	Compute average angle.		f D	ANG (D.MS)
7	Go to step 2 for next check.			

AZIMUTH OF THE SUN

This program was designed to compute the azimuth of the sun and reference mark from a solar observation. Required information consists of observer's latitude, time zone, watch correction, temperature, pressure, time of observation, horizontal angle clockwise from reference mark to sun, and vertical or zenith angle. Declination and hour difference in declination are also required and may be obtained from an ephemeris. If declination is on the increase, the hour difference will have a positive value, if on the decrease, the hour difference will be negative.

Example:

date—August 14, 1976
latitude—37°49′.5
time zone—5 hrs.
watch correction— −2′49″
temperature—66°F
pressure—28.58″ Hg
declination—14°23′.6 Oh UTC
hour difference—−0′.76



Direction	Horizontal Angle	Time	Zenith angle
direct	77°53′33″	16h33m30s	62°12′37″
reverse	258°17′01″	16h35m46s	297°21′16″
direct	78°33′44″	16h37m30s	62°59′20″
reverse	258°50′02″	16h39m05s	296°42′14″

Keystrokes:	Outputs:
Load side 1 and side 2	
3749.5 f A →	3749.5000 *** LAT (DM.m)
5 ENTER↑ .0249 CHS f B →	5.0000 *** TZ
	−.0249 *** COR (H.MS)
66 ENTER↑ 28.58 f C →	66.0000 *** T
	28.5800 *** P
1423.6 ENTER↑ .76 CHS A →	1423.6000 *** DEC (DM.m)
	−0.7600 *** DIF (M.m)
77.5333 B →	77.5333 *** HA D
16.3330 D →	16.3330 *** TIME

62.1237 CHS E →	−62.1237 *** ZA
	266.3447 *** Sun's AZ
	188.4114 *** REF AZ
258.1701 C →	258.1701 *** HA R
16.3546 D →	16.3546 *** TIME
297.2116 CHS E →	−297.2116 *** ZA
	266.5551 *** Sun's AZ
	188.3850 *** REF AZ
78.3344 B →	78.3344 *** HA D
16.3730 D →	16.3730 *** TIME
62.5920 CHS E →	−62.5920 *** ZA
	267.1224 *** Sun's AZ
	188.3840 *** REF AZ
258.5002 C →	258.5002 *** HA R
16.3905 D →	16.3905 *** TIME
296.4214 CHS E →	−296.4214 *** ZA
	267.2709 *** Sun's AZ
	188.3707 *** REF AZ
f E →	267.0232 *** Sun's AZ
	188.3857 *** REF AZ

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Input latitude.	LAT(DM.m)*	f A	LAT(DM.m)
3	Input time zone and	TZ	ENTER↑	
	watch correction.	COR(H.MS)	f B	TZ,COR(H.MS)
4	Input temperature	T(°F)	ENTER↑	
	and pressure.	P(in. Hg.)	f C	T, P
5	Input declination at Oh. UTC	DEC (DM.m)*	ENTER↑	
	and hour difference,	DIF (M.m)**	A	DEC, DIF.
	or, if declination is decreasing,			
	input negative hour difference	DIF (M.m)**	CHS A	DEC, DIF.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
6	Input horizontal angle clock-			
	wise from reference to sun for			
	direct reading	HA D(D.MS)	B	HA D(D.MS)
	or for reverse reading	HA R(D.MS)	C	HA R(D.MS)
7	Input local zone time of			
	observation	TIME(H.MS)	D	TIME(H.MS)
8	Input vertical angle	VA(D.MS)	E	VA(D.MS)
	or zenith angle	ZA(D.MS)	CHS E	−ZA(D.MS),
				Sun's AZ(D.MS),
				REF AZ(D.MS)
9	For next sight in same group,			
	go to step 6.			
10	Compute average of sights		f E	Sun's AZ(D.MS)
				REF AZ(D.MS)
11	For a new group of sights,			
	press f D to clear. If any of			
	the inputs on steps 2-5 has			
	changed, input the new value			
	at the appropriate step and			
	then go to step 6.			
	*DM.m = key in degrees, then			
	minutes, (2 digits), then decimal			
	point, then tenths of			
	minutes.			
	**M.m = key in minutes, then			
	decimal point, then tenths of			
	minutes.			

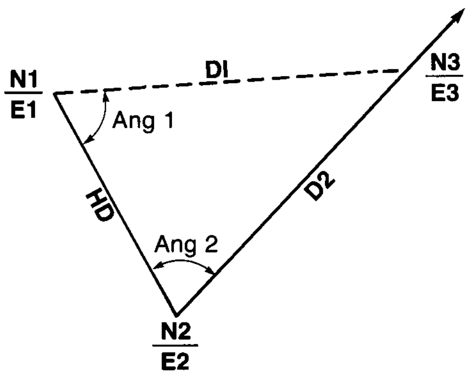
PREDETERMINED AREA

This program is designed to solve two cases of specifying the area of a land parcel, 1) by hinging one side of a triangle, and 2) by sliding one side of a trapezoid parallel to another.

Line Through a Point

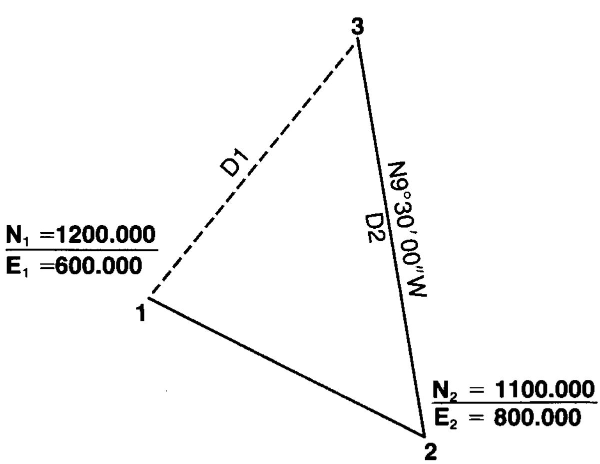
The area of the land parcel must be divided so that a triangle of desired area can be solved by hinging one side.

The required information consists of the coordinates of points 1 and 2 and the bearing (azimuth) of the line from point 2 toward point 3. Alternatively, the distance between points 1 and 2 and the angle at point 2 can be given. The program outputs the angles at points 1 and 2 and the distances from points 1 and 2 to point 3. If coordinates for points 1 and 2 were given, the coordinates for point 3 are also output.



Example:

The area of the land parcel shown below is to be 27,000 square meters.



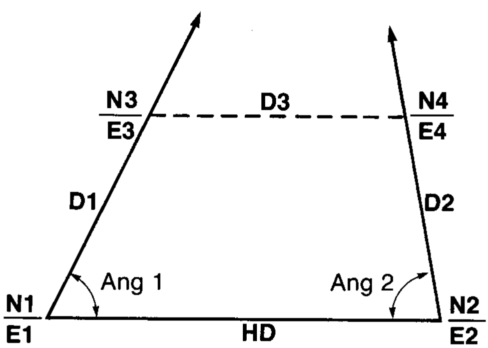
Keystrokes:		**Outputs:**
Load side 1 and side 2.		
1200 ENTER↑ 600 A	→	1.0000 *** Pt. no.
		1200.0000 *** N1
		600.0000 *** E1
1100 ENTER↑ 800 B	→	2.0000 *** Pt. no.
		1100.0000 *** N2
		800.0000 *** E2
9.3 ENTER↑ 4 C	→	350.3000 *** AZ2
27000 E	→	27000.0000 *** AREA
		78.4911 T ANG 1
		246.1671 Z D1
		-53.5606 Y ANG 2
		298.7513 X D2
		3.0000 *** Pt. no.
		1394.6541 *** N3
		750.6918 *** E3

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	If the coordinates of points 1			
	and 2 are known, go to step 3.			
	If the distance between the			
	points and the angle are known,			
	go to step 8.			
3	Input the coordinates of point 1.	N1	ENTER↑	
		E1	A	1, N1, E1
4	Input the coordinates of point 2.	N2	ENTER↑	
		E2	B	2, N2, E2
5	Input the direction of the line			
	from point 2 towards point 3:			
	bearing	BRG(D.MS)	ENTER↑	
	and quadrant	QD	C	AZ(D.MS)
	or azimuth	AZ(D.MS)	D	AZ(D.MS)

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
6	Input the desired area.	AREA	E	AREA,
				ANG 1 (D.MS),
				D1,
				ANG 2, (D.MS),
				D2;
				3, N3, E3
7	Go to step 2 for next calculation.			
8	Input angle at point 2.	ANG 2(D.MS)	f B	
9	Input distance between points			
	1 and 2.	HD	f C	
10	Input the desired area.	AREA	E	AREA,
				ANG 1 (D.MS),
				D1,
				ANG 2 (D.MS),
				D2
11	Go to step 2 for next calculation.			

Two Sides Parallel

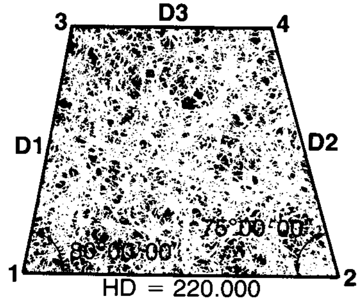
The area of a land parcel must be divided so that a trapezoid of desired area can be solved by sliding one of the parallel sides.



The required information consists of the coordinates of points 1 and 2 and the bearings (azimuths) of the lines 1-3 and 2-4. Alternatively, the distance between points 1 and 2 and the angles at points 1 and 2 can be given. The program outputs the angles at points 1 and 2 and the distances between points 1 and 3, points 2 and 4 and points 3 and 4. If coordinates for points 1 and 2 are given, coordinates for points 3 and 4 are also output.

Example 1:

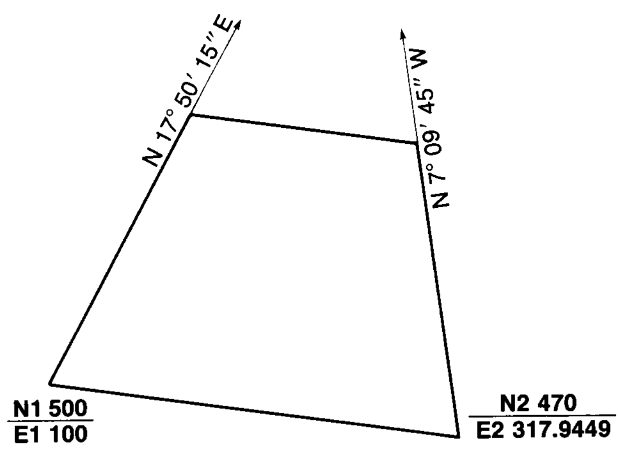
The area of the land parcel shown below is to be 36,000 square feet.



Keystrokes:	**Outputs:**
Load side 1 and side 2	
80 f A →	80.0000 *** ANG 1
75 f B →	75.0000 *** ANG 2
220 f C →	220.0000 *** HD
36000 f E →	36000.0000 *** AREA
	80.0000 T ANG 1
	210.0220 Z D1
	75.0000 Y ANG 2
	214.1275 X D2
	128.1098 *** D3

Example 2:

The area of the land parcel shown below is to be 36,000 square feet.



Keystrokes:	**Outputs:**
500 ENTER↑ 100 A →	1.0000 *** Pt. no.
	500.0000 *** N1
	100.0000 *** E1
17.5015 ENTER↑ 1 C →	17.5015 *** AZ1
470 ENTER↑ 317.9449 B →	2.0000 *** Pt. no.
	470.0000 *** N2
	317.9449 *** E2
7.0945 ENTER↑ 4 C →	352.5015 *** AZ2
36000 f E →	36000.0000 *** AREA
	79.5960 T ANG 1
	210.0221 Z D1
	75.0000 Y ANG 2
	214.1276 X D2
	3.0000 T Pt. no.
	699.9261 Z N3
	164.3336 Y E3
	0.0000 X
	0.0000 T
	4.0000 Z Pt. no.
	682.4566 Y N4
	291.2466 X E4
	128.1097 *** D3

*Internal rounding causes 80°00′00″ to be displayed as 79°59′60″.
***Shown by PRINT on HP-97 and by PAUSE on HP-67.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	If coordinates of points 1 and			
	2 and bearings (azimuths) of			
	lines 1–3 and 2–4 are known,			
	go to step 3. If the distance			
	between points 1 and 2 and the			
	angles are known, go to step 9.			
3	Input coordinates of point 1.	N1	ENTER↑	
		E1	A	1, N1, E1

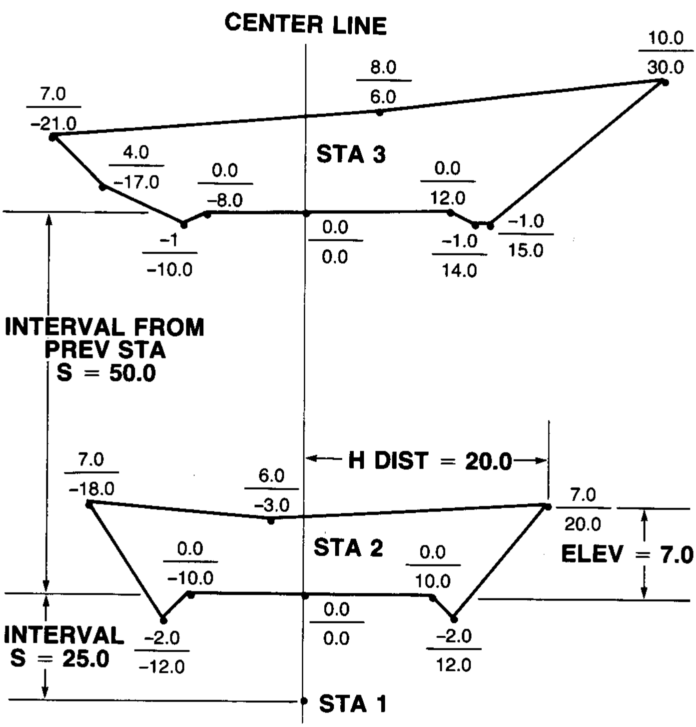
STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
4	Input the direction of the			
	line 1–3:			
	bearing	BRG(D.MS)	ENTER↑	
	and quadrant	QD	C	AZ
	or azimuth.	AZ(D.MS)	D	AZ
5	Input coordinates of point 2.	N2	ENTER↑	
		E2	B	2, N2, E2
6	Input the direction of line 2–4:			
	bearing	BRG(D.MS)	ENTER↑	
	and quadrant	QD	C	AZ
	or azimuth.	AZ(D.MS)	D	AZ
7	Input the desired area.	AREA	f E	AREA,
				ANG 1(D.MS),
				D1,
				ANG 2(D.MS),
				D2;
				3, N3, E3, 0;
				0, 4, N4, E4;
				D3
8	Go to step 2 for next calculation.			
9	Input angle at point 1.	ANG 1(D.MS)	f A	ANG 1(D.MS)
10	Input angle at point 2.	ANG 2(D.MS)	f B	ANG 2(D.MS)
11	Input distance between			
	points 1 and 2.	HD	f C	HD
12	Input desired area.	AREA	f E	AREA,
				ANG 1(D.MS),
				D1,
				ANG 2(D.MS),
				D2,
				D3
13	Go to step 2 for next calculation.			

EARTHWORK

This program is designed for two types of earthwork calculations, 1) volume by average end area and 2) volume of a borrow pit. For volume by average end area, the required information is the elevation and offset distance for each point on the cross-section and the interval between cross-sections. The required information for volume of a borrow pit is width and length of a rectangular section or base and height of a triangular section and the elevation at each corner of the section. Volume for each section is computed as well as total accumulated volume. For volume by average end area, the cross-section area is also computed.

Two options are available, 1) you can choose to have inputs shown by print/pause, 2) you can choose to have volumes computed in cubic yards or cubic feet.

Example 1:



Compute the volumes in cubic yards between the staions shown above. Note that station 1 has zero area.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
f A →	0.00*
Inputs will not be shown with print/pause.	
f B →	1.00*
Volumes will be computed in cubic yards.	
C →	0.00
0 B →	1.00 *** STA
	0.00 ***
	0.00 ***
	0.00 ***
	0.00 ***
0 ENTER↑ 0 A 0 ENTER↑ 10 A	
2 CHS ENTER↑ 12 A 7 ENTER↑	
20 A 6 ENTER↑ 3 CHS A 7 ENTER↑	
18 CHS A 2 CHS ENTER↑	
12 CHS A 0 ENTER↑ 10 CHS A	
0 ENTER↑ 0 A 25 B →	2.00 *** STA
	25.00 *** INT
	216.00 *** AREA
	100.00 *** VOL
	100.00 *** TOT VOL
0 ENTER↑ 0 A 0 ENTER↑ 12 A	
1 CHS ENTER↑ 14 A 1 CHS ENTER↑	
15 A 10 ENTER↑ 30 A 8 ENTER↑	
6 A 7 ENTER↑ 21 CHS A 4 ENTER↑	
17 CHS A 1 CHS ENTER↑ 10 CHS	
A 0 ENTER↑ 8 CHS A 0 ENTER↑	
0 A 50 B →	3.00 *** STA
	50.00 *** INT
	321.50 *** AREA
	497.69 *** VOL
	597.69 *** TOT VOL

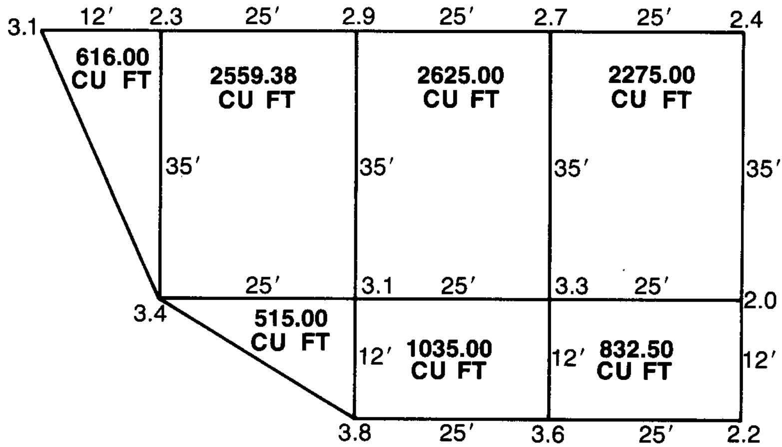
Note that it makes no difference what point you start with on the cross-section,

*If pressing keys gives different output, press keys again.

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

and the elevations and distances may be measured from any base lines as long as the same lines are used for the whole section. Also, you may work around the section clockwise (CW) or counterclockwise (CCW).

Example 2:



Compute the volumes in cubic feet for the sections of the borrow pit shown above.

Keystrokes:	**Outputs:**
Load side 1 and side 2.	
f A ⟶	0.00*
Inputs will not be shown with print/pause.	
f B ⟶	0.00*
Volumes will be computed in cubic feet.	
C ⟶	0.00
12 ENTER↑ 35 f D 3.1 E 2.3 E 3.4 E f E ⟶	1.00 *** SECTION 616.00 *** VOL 616.00 *** TOT VOL
35 ENTER↑ 25 D 3.4 E 2.3 E 2.9 E 3.1 E f E ⟶	2.00 *** SECTION 2559.38 *** VOL 3175.38 *** TOT VOL
2.9 E 3.1 E 2.7 E 3.3 E f E ⟶	3.00 *** SECTION 2625.00 *** VOL 5800.38 *** TOT VOL

*If pressing keys gives different output, press keys again.

The volumes of the remaining sections are computed in a similar manner. The final total volume will be 10,457.88 cubic feet.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	If you want your inputs shown by			
	print/pause, press f A.			
	A 1.00 indicates print/pause			
	is on; a 0.00 indicates			
	print/pause is off.*		f A	1.00/0.00
3	To have volumes output in			
	cubic yards instead of cubic			
	feet, press f B.			
	A 1.00 indicates cubic yards			
	and a 0.00 indicates cubic			
	feet.*		f B	1.00/0.00
4	For volume by average end			
	area, go to step 5. For volume			
	of a borrow pit, go to step 11.			
5	Press "start".		C	0.00
6	If station has zero end area, go			
	to step 9.			
7	Input elevation	EL	ENTER↑	
	and horizontal or offset			
	distance.	D	A	
8	Repeat step 7 working around			
	the section (CW or CCW)			
	until the first EL and D has			
	been reinput.			
	*If pressing keys gives undesired			
	output, press keys again.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
9	Input interval from previous			
	station, and compute area			
	and volumes.	INT	B	Station No.,
	NOTE: Input 0 interval			INT, AREA,
	for first station.			VOL,
				TOT VOL
10	Go to step 6 for next station.			
11	Press "start".		C	0.00
12	For rectangular area,			
	go to step 13.			
	For triangular area,			
	go to step 14.			
13	Input:			
	rectangle's width	W	ENTER↑	
	and length	L	D	
14	Input triangle's base	B	ENTER↑	
	and height	H	f D	
15	Input elevations at corners			
	(rectangles and triangles),			
	pressing E after each.	EL	E	
16	When all 3 or 4 corners have			
	been input, compute volume.		f E	Section No.,
				VOL,
				TOT VOL
17	Go to step 15 for another			
	section of the same type and			
	dimensions. Go to step 12 for			
	a new section.			

COORDINATE TRANSFORMATION

This program is designed to transform coordinates from one system to a second system that has been scaled, rotated, and translated with respect to the first. The transformation parameters can be input if they are known. If coordinates of at least two points are known in both systems, the transformation parameters can be computed by a least squares method. Once the parameters are known, it is possible to convert from system 1 to system 2 or from system 2 to system 1.

Example:

Coordinates of points in two systems are given below:

POINT	OLD SYSTEM NO. 1		NEW SYSTEM NO. 2	
	N	E	N	E
1	150.000	400.000	100.000	350.000
2	224.540	561.673	165.977	515.353

Compute the transformation from these points and then find the missing coordinates for the points given below:

POINT	OLD SYSTEM NO. 1		NEW SYSTEM NO. 2	
	N	E	N	E
3	356.577	468.710	?	?
4	?	?	187.151	261.767

Keystrokes:	Outputs:	
Load side 1 and side 2.		
[f] [E] →	0.000	
[E] →	0.000*	
(Print/pause is off.)		
150 [ENTER↑] 400 [A] →	1.000	Pt. no.
100 [ENTER↑] 350 [A] →	1.000	Pt. no.
224.54 [ENTER↑] 561.673 [A] →	2.000	Pt. no.
165.977 [ENTER↑] 515.353 [A] →	2.000	Pt. no.
[B] [E] →	1.000*	

*If you don't get the output shown, repeat this step.

(Print/pause is on.)

356.577 ENTER↑ 468.71 A →	356.577 *** N1
	468.710 *** E1
	302.699 *** N2
	429.427 *** E2
187.151 ENTER↑ 261.767 f A →	187.151 *** N2
	261.767 *** E2
	232.414 *** N1
	307.327 *** E1

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load side 1 and side 2.			
2	Press "START".		f E	
3	If transformation parameters			
	are known, go to step 4. If			
	coordinates of two or more			
	points are known for both			
	systems, go to step 7.			
4	Input scale factor and rotation			
	angle.	S	ENTER↑	
		ϕ (D.MS)	C	
5	Input northing translation	TN	ENTER↑	
	and easting translation.	TE	D	
6	Go to step 12.			
7	If you want your inputs shown			
	by print/pause, press E.			
	A 1.000 indicates print/pause			
	is on.			
	A 0.000 indicates print/pause is			
	off.*		E	1.000/0.000
8	Input coordinates of point in			
	system 1.	N1	ENTER↑	
		E1	A	Pt. no.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
9	Input coordinates of point in			
	system 2.	N2	ENTER↑	
		E2	A	Pt. no.
10	Repeat steps 8 & 9 for all points			
	known in both systems.			
11	After all points have been input,			
	compute transformation.		B	
12	If you want your inputs shown			
	by print/pause, press E.			
	A 1.000 indicates print/pause			
	is on.			
	A 0.000 indicates print/pause			
	is off.*		E	1.000/0.000
13	Input coordinates of point in			
	system 1 and compute			
	coordinates in system 2,	N1	ENTER↑	
		E1	A	N2, E2
	or input coordinates of point			
	in system 2 and compute			
	coordinates in system 1.	N2	ENTER↑	
		E2	f A	N1, E1
	Repeat step 13 for additional			
	points.			
	*If pressing E does not give			
	desired output, press E again.			

STATE PLANE COORDINATES—LAMBERT

This two card program is designed to convert geographic coordinates (latitude and longitude) to and from state plane coordinates for regions using Lambert conformal conic projections. These regions are listed in table 1 with a set of constants for each region that are required by the conversion program. Using the values in table 1 and the supplied data card, data cards for any of the regions listed can be made. The data card supplied with the program is set up for Alaska zone 10 for use with the example.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load data card side 1 and			
	side 2.			
2	If geographic coordinates (ϕ			
	and λ) are known, go to step 3.			
	If state plane coordinates (x and			
	y) are known, go to step 8.			
3	Load Geographic to Lambert			
	program side 1 and side 2.			
4	Input latitude and longitude.*	ϕ (D.MS)	A	ϕ (D.MS)
		λ (D.MS)	B	λ (D.MS)
	*In Alaska zone 10 for stations			
	in east longitude, input the			
	longitude as negative by using			
	CHS before B.			
5	Compute state plane			
	coordinates.		C	x, y

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
6	Compute scale factor (k) and			
	convergence (θ).		D	k, θ(D.MS)
7	Go to step 4 for next			
	calculation.			
8	Load Lambert to Geographic			
	program side 1 and side 2.			
9	Input state plane coordinates.	x	A	x
		y	B	y
10	Compute geographic			
	coordinates.		C	ϕ (D.MS),
				λ (D.MS)
11	Compute scale factor (k) and			
	convergence (θ).		D	k, θ(D.MS)
12	Go to step 9 for next			
	calculation.			

Example:

Compute the state plane coordinates of the point in Alaska zone 10 given below:

Latitude = ϕ = 54°27′30″N
Longitude = λ = 164°02′30″W

Keystrokes: **Outputs:**

Load data card side 1 and side 2.

Load Geographic to Lambert program side 1 and side 2.

Keystrokes	Outputs
54.273 A →	54.2730 *** ϕ (D.MS)
164.023 B →	164.0230 *** λ (D.MS)
C →	5533424.385 *** x
	1473805.130 *** y
D →	1.0003 *** k
	9.3148 *** θ (D.MS)

Compute the geographic coordinates for the state plane coordinates just computed.

Keystrokes: **Outputs:**

Load Lambert to Geographic program side 1 and side 2.

5533424.385 **A**	——→	5533424.385 *** x
1473805.13 **B**	——→	1473805.130 *** y
C	——→	54.2730 *** ϕ (D.MS)
		164.0230 *** λ (D.MS)
D	——→	1.0003 *** k
		9.3148 *** θ (D.MS)

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

Making Data Cards:

Additional data cards can be made using the instructions given below. The supplied data card must be used to make new data cards since constants common to all regions must also be on the cards.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load data card side 1			
	and side 2			
2	Input constants from table 1:	L1	STO 0	
		L2	STO 1	
		L3	STO 2	
		L4	STO 3	
		L5	STO 4	
		L6	STO 5	
		L7	STO 6	
		L8	STO 7	
		L9	STO 8	
		L10	STO 9	
		L11	STO A	
3	Press W/DATA and load side 1			
	and side 2 of a blank			
	unprotected card.			
4	Mark the card and clip the			
	corners to protect the data			
	stored on it.			

Table 1
CONSTANTS FOR LAMBERT PROJECTION

	ALASKA	ARKANSAS	ARKANSAS	CALIFORNIA
ZONE CODE	10 5010	North 0301	South 0302	I 0401
L_1	3,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	633,600.00	331,200.00	331,200.00	439,200.00
L_3	15,893,950.36	29,277,593.61	31,014,039.23	24,245,358.05
L_4	16,564,628.77	29,732,882.87	31,511,724.20	24,792,436.23
L_5	.99984 80641	.99993 59370	.99991 84698	.99989 46358
L_6	.79692 23940	.58189 91407	.55969 06871	.65388 43192
L_7	3161.	2126.	2033.	2441.
L_8	47.87068	46.35656	56.94711	26.75847
L_9	3.79919	3.81452	3.81550	3.80992
L_{10}	5.91550	3.26432	3.08256	3.93575
L_{11}	44.	0	0	0

	CALIFORNIA	CALIFORNIA	CALIFORNIA	CALIFORNIA
ZONE CODE	II 0402	III 0403	IV 0404	V 0405
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	439,200.00	433,800.00	428,400.00	424,800.00
L_3	25,795,850.31	27,057,475.85	28,182,405.33	30,194,145.54
L_4	26,312,257.65	27,512,992.04	28,652,931.96	30,649,424.27
L_5	.99991 46793	.99992 91792	.99994 07628	.99992 21277
L_6	.63046 79732	.61223 20427	.59658 71443	.57001 19219
L_7	2336.	2256.	2189.	2076.
L_8	30.81964	35.52018	10.35494	52.10305
L_8	3.81147	3.81265	3.81362	3.81523
L_{10}	3.70114	3.52998	3.39020	3.16593
L_{11}	0	0	0	0

	CALIFORNIA	CALIFORNIA	COLORADO	COLORADO
ZONE CODE	VI 0406	VII 0407	North 0501	Central 0502
L_1	2,000,000.00	4,186,692.58	2,000,000.00	2,000,000.00
L_2	418,500.00	426,000.00	379,800.00	379,800.00
L_3	31,846,570.92	30,891,382.10	24,751,897.68	25,781,376.91
L_4	32,271,267.72	35,055,396.31	25,086,068.20	26,243,052.74
L_5	.99995 41438	.99998 85350	.99995 68475	.99993 59117
L_6	.54951 75982	.56124 32071	.64613 34829	.63068 95773
L_7	1992.	2040.	2406.	2337.
L_8	00.16335	22.88096	24.62308	29.65162
L_9	3.81642	3.81572	3.81044	3.81146
L_{10}	3.00292	3.09520	3.85610	3.70326
L_{11}	0	0	0	0

ZONE CODE	COLORADO South 0503	CONNECTICUT 0600	FLORIDA North 0903	IOWA North 1401
L_1	2,000,000.00	600,000.00	2,000,000.00	2,000,000.00
L_2	379,800.00	261,900.00	304,200.00	336,600.00
L_3	26,977,133.89	23,659,233.56	36,030,443.05	22,736,950.34
L_4	27,402,231.82	23,914,389.02	36,454,924.53	23,162,461.59
L_5	.99994 53995	.99998 31405	.99994 84343	.99994 53686
L_6	.61337 80528	.66305 94147	.50252 59000	.67774 45518
L_7	2261.	2483.	1802.	2551.
L_8	34.26662	19.67980	26.11701	20.02265
L_9	3.81257	3.80929	3.81898	3.80827
L_{10}	3.54046	4.03278	2.65643	4.19479
L_{11}	0	0	0	0

ZONE CODE	IOWA South 1402	KANSAS North 1501	KANSAS South 1502	KENTUCKY North 1601
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	336,600.00	352,800.00	354,600.00	303,300.00
L_3	23,936,585.11	25,644,959.12	26,896,024.48	26,371,820.68
L_4	24,374,096.67	25,979,068.57	27,351,521.50	26,724,051.82
L_5	.99994 83705	.99995 68556	.99993 59200	.99996 20817
L_6	.65870 10213	.63271 48646	.61452 81068	.62206 72671
L_7	2463.	2346.	2266.	2299.
L_8	22.59905	27.97215	34.41020	30.63364
L_9	3.80959	3.81133	3.81250	3.81202
L_{10}	3.98630	3.72376	3.55102	3.62113
L_{11}	0	0	0	0

ZONE CODE	KENTUCKY South 1602	LOUISIANA North 1701	LOUISIANA South 1702	LOUISIANA Offshore 1703
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	308,700.00	333,000.00	328,800.00	328,800.00
L_3	27,467,860.75	33,624,568.36	36,271,389.35	41,091,749.54
L_4	27,832,235.64	34,079,629.33	36,756,553.45	41,576,762.39
L_5	.99994 53808	.99991 47417	.99992 57458	.99989 47956
L_6	.60646 23718	.52870 06734	.50001 26971	.45400 68519
L_7	2231.	1907.	1792.	1612.
L_8	36.57874	12.68515	28.55026	59.30342
L_9	3.81301	3.81758	3.81911	3.82138
L_{10}	3.47771	2.84511	2.63885	2.27436
L_{11}	0	0	0	25.

ZONE CODE	MARYLAND 1900	MASSACHUSETTS Mainland 2001	MASSACHUSETTS Island 2002	MICHIGAN North 2111
L_1	800,000.00	600,000.00	200,000.00	2,000,000.00
L_2	277,200.00	257,400.00	253,800.00	313,200.00
L_3	25,989,474.99	23,111,975.14	23,784,678.44	20,041,716.18
L_4	26,369,112.76	23,549,477.32	23,924,398.02	20,589,420.09
L_5	.99994 98485	.99996 45506	.99999 84844	.99994 10344
L_6	.62763 41196	.67172 86561	.66109 53994	.72278 99381
L_7	2323.	2523.	2474.	2768.
L_8	59.69369	19.53138	19.47463	22.25085
L_9	3.81166	3.80870	3.80943	3.80501
L_{10}	3.67392	4.12738	4.01174	4.68430
L_{11}	0	0	0	36.

ZONE CODE	MICHIGAN Central 2112	MICHIGAN South 2113	MINNESOTA North 2201	MINNESOTA Central 2202
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	303,600.00	303,600.00	335,160.00	339,300.00
L_3	21,001,715.22	22,564,848.51	18,984,319.62	20,006,679.72
L_4	21,594,768.40	23,069,597.22	19,471,398.75	20,493,457.15
L_5	.99995 09058	.99994 50783	.99990 28166	.99992 20223
L_6	.70640 74100	.68052 92633	.74121 96637	.72338 80702
L_7	2687.	2564.	2861.	2771.
L_8	50.76661	22.23938	24.63011	20.89747
L_9	3.80622	3.80808	3.80362	3.80497
L_{10}	4.46875	4.15706	5.01609	4.76197
L_{11}	35.	33.	0	0

ZONE CODE	MINNESOTA South 2203	MONTANA North 2501	MONTANA Central 2502	MONTANA South 2503
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	338,400.00	394,200.00	394,200.00	394,200.00
L_3	21,327,006.06	18,689,498.40	19,432,939.76	20,500,650.51
L_4	21,874,349.14	19,157,874.26	19,919,806.36	21,096,820.93
L_5	.99992 20448	.99997 14855	.99992 20151	.99991 07701
L_6	.70092 77824	.74645 18080	.73335 38278	.71490 12442
L_7	2661.	2888.	2821.	2729.
L_8	20.12517	20.21285	21.96779	21.15820
L_9	3.80662	3.80322	3.80422	3.80560
L_{10}	4.46959	5.09490	4.90135	4.64814
L_{11}	0	0	0	0

ZONE CODE	NEBRASKA North 2601	NEBRASKA South 2602	NEW YORK Long Island 3104	NORTH CAROLINA 3200
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	360,000.00	358,200.00	266,400.00	284,400.00
L_3	23,004,346.29	24,104,561.06	24,235,000.80	29,637,059.47
L_4	23,368,977.46	24,590,781.86	24,462,545.30	30,183,611.25
L_5	.99996 45501	.99992 20725	.99999 49000	.99987 25510
L_6	.67345 07906	.65607 64003	.65408 20950	.57717 07700
L_7	2531.	2451.	2442.	2106.
L_8	19.30504	24.68139	20.64240	51.60353
L_9	3.80858	3.80977	3.80990	3.81480
L_{10}	4.14653	3.95865	3.93780	3.22483
L_{11}	0	0	0	0

ZONE CODE	North Dakota North 3301	North Dakota South 3302	Ohio North 3401	Ohio South 3402
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	361,800.00	361,800.00	297,000.00	297,000.00
L_3	18,819,849.05	19,661,027.79	24,048,738.51	25,522,875.81
L_4	19,215,516.01	20,086,977.18	24,559,158.47	26,027,071.12
L_5	.99993 58426	.99993 58523	.99993 91411	.99993 59346
L_6	.74413 33961	.72938 26040	.65695 03193	.63451 95439
L_7	2876.	2801.	2455.	2354.
L_8	22.57950	20.45445	23.48125	28.63705
L_9	3.80339	3.80452	3.80971	3.81121
L_{10}	5.05972	4.84504	3.96783	3.74048
L_{11}	0	0	0	0

ZONE CODE	OKLAHOMA North 3501	OKLAHOMA South 3502	OREGON North 3601	OREGON South 3602
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	352,800.00	352,800.00	433,800.00	433,800.00
L_3	28,657,871.66	30,382,831.06	20,836,250.94	22,341,309.43
L_4	29,082,831.70	30,838,032.96	21,383,852.48	22,888,667.15
L_5	.99994 54101	.99993 59432	.99989 45810	.99989 46058
L_6	.59014 70744	.56761 66827	.70918 60222	.68414 73833
L_7	2161.	2066.	2701.	2581.
L_8	42.56887	52.48935	22.08858	22.74104
L_9	3.81402	3.81537	3.80602	3.80782
L_{10}	3.33440	3.14645	4.57382	4.26823
L_{11}	0	0	0	0

ZONE CODE	PENNSYLVANIA North 3701	PENNSYLVANIA South 3702	SOUTH CAROLINA North 3901	SOUTH CAROLINA South 3902
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	279,900.00	279,900.00	291,600.00	291,600.00
L_3	23,755,351.27	24,577,800.67	30,630,125.53	32,252,126.30
L_4	24,211,050.37	24,984,826.43	31,127,724.75	32,676,887.65
L_5	.99995 68410	.99995 95012	.99994 54207	.99993 26284
L_6	.66153 97363	.64879 31668	.56449 73800	.54465 15700
L_7	2476.	2418.	2053.	1972.
L_8	21.57953	23.87979	53.44099	3.57839
L_9	3.80940	3.81026	3.81555	3.81669
L_{10}	4.01753	3.88319	3.12127	2.94381
L_{11}	0	0	0	0

ZONE CODE	SOUTH DAKOTA North 4001	SOUTH DAKOTA South 4002	TENNESSEE 4100	TEXAS North 4201
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	360,000.00	361,200.00	309,600.00	365,400.00
L_3	20,922,704.09	21,993,575.61	29,010,231.09	29,456,907.29
L_4	21,366,697.03	22,461,937.05	29,535,149.91	29,972,959.94
L_5	.99993 91116	.99990 68931	.99994 84030	.99991 08771
L_6	.70773 81841	.68985 19579	.58543 97296	.57953 58654
L_7	2694.	2608.	2141.	2116.
L_8	18.93392	21.54370	44.28313	48.58548
L_9	3.80612	3.80742	3.81431	3.81466
L_{10}	4.55529	4.33519	3.29422	3.24452
L_{11}	0	0	0	0

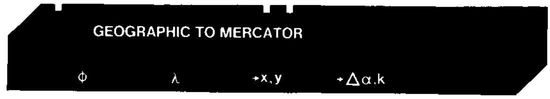
ZONE CODE	TEXAS North Central 4202	TEXAS Central 4203	TEXAS South Central 4204	TEXAS South 4205
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	351,000.00	361,200.00	356,400.00	354,600.00
L_3	32,187,809.58	34,851,703.46	37,261,509.20	41,091,749.54
L_4	32,691,654.54	35,337,121.23	37,807,440.38	41,576,762.39
L_5	.99987 26224	.99988 17443	.99986 32433	.99989 47956
L_6	.54539 44146	.51505 88857	.48991 26408	.45400 68519
L_7	1975.	1852.	1752.	1612.
L_8	5.95074	21.62181	37.19059	59.30342
L_9	3.81665	3.81832	3.81962	3.82138
L_{10}	2.97107	2.74550	2.56899	2.33094
L_{11}	0	0	0	0

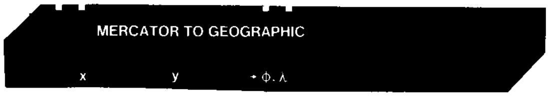
ZONE CODE	UTAH North 4301	UTAH Central 4302	UTAH South 4303	VIRGINIA North 4501
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	401,400.00	401,400.00	401,400.00	282,600.00
L_3	23,894,872.45	25,117,176.75	27,025,955.35	26,230,200.09
L_4	24,229,110.29	25,664,114.42	27,432,812.88	26,576,444.45
L_5	.99995 68422	.99989 88207	.99995 12939	.99994 83859
L_6	.65935 54910	.64057 85926	.61268 73424	.62411 78597
L_7	2466.	2381.	2258.	2308.
L_8	21.96231	29.30066	34.16878	30.78682
L_9	3.80955	3.81081	3.81262	3.81189
L_{10}	3.99323	3.80024	3.53414	3.64047
L_{11}	0	0	0	0

ZONE CODE	VIRGINIA South 4502	WASHINGTON North 4601	WASHINGTON South 4602	WEST VIRGINIA North 4701
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	282,600.00	435,000.00	433,800.00	286,200.00
L_3	27,434,800.06	18,798,081.67	19,832,653.52	25,305,029.12
L_4	27,811,312.71	19,205,863.43	20,289,119.60	25,715,126.55
L_5	.99994 54027	.99994 22551	.99991 45875	.99994 07460
L_6	.60692 48249	.74452 03390	.72639 57947	.63777 29696
L_7	2233.	2878.	2786.	2368.
L_8	36.41072	22.15711	21.72121	57.52979
L_9	3.81298	3.80336	3.80474	3.81099
L_{10}	3.48187	5.06556	4.80336	3.77244
L_{11}	0	0	0	0

ZONE CODE	WEST VIRGINIA South 4702	WISCONSIN North 4801	WISCONSIN Central 4802	WISCONSIN South 4803
L_1	2,000,000.00	2,000,000.00	2,000,000.00	2,000,000.00
L_2	291,600.00	324,000.00	324,000.00	324,000.00
L_3	26,639,323.45	20,124,133.05	21,050,746.99	22,161,432.25
L_4	27,070,620.78	20,489,179.67	21,430,913.91	22,672,134.66
L_5	.99992 56928	.99994 53461	.99994 07059	.99993 25474
L_6	.61819 53936	.72137 07913	.70557 66312	.68710 32423
L_7	2282.	2761.	2683.	2595.
L_8	33.82207	19.04034	48.81363	20.01691
L_9	3.81227	3.80511	3.80628	3.80761
L_{10}	3.58491	4.73451	4.52782	4.30274
L_{11}	0	0	0	0

STATE PLANE COORDINATES—TRANSVERSE MERCATOR





This two card program is designed to convert geographic coordinates (latitude and longitude) to and from state plane coordinates for regions using transverse Mercator projections. These regions are listed in table 2 with a set of constants for each region that are required by the conversion program. Using the values in table 2 and the supplied data card, data cards for any of the regions listed can be made. The data card supplied with the program is set up for the west zone of Idaho for use with the example.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load data card side 1 and			
	side 2.			
2	If geographic coordinates (ϕ			
	and λ) are known, go to step 8.			
	If state plane coordinates (x			
	and y) are known, go to step 3.			
3	Load Mercator to Geographic			
	side 1 and side 2.			
4	Input state plane coordinates.	x	A	x
		y	B	y
5	Compute geographic			
	coordinates.		C	ϕ(D.MS),
				λ(D.MS)
6	To compute convergence			
	($\Delta\alpha$) and scale factor, continue			
	with step 8, but skip step 9.			
7	Go to step 4 for next calculation.			

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
8	Load Geographic to Mecator			
	side 1 and side 2.			
9	Input latitude	ϕ (D.MS)	A	ϕ (D.MS)
	and longitude.	λ (D.MS)	B	λ (D.MS)
10	Compute state plane			
	coordinates.		C	x, y
11	Compute convergence ($\Delta\alpha$)			
	and scale factor (k).		D	$\Delta\alpha$ (D.MS), k
12	Go to step 9 for next calculation			
	of state plane coordinates.			

Example:

Compute the state plane coordinates of triangulation station Indian 1947 in the west zone of Idaho.

$$\text{LATITUDE} = \phi = 48°07'50''.941$$

$$\text{LONGITUDE} = \lambda = 116°22'02''.592$$

Keystrokes: **Outputs:**

Load data card side 1 and side 2.

Load Geographic to Mercator program side 1 and side 2.

48.0750941 A ⟶ 48.0751 *** ϕ (D.MS)

116.2202592 B ⟶ 116.2203 *** λ (D.MS)

C ⟶ 349231.2941 *** x
2357247.284 *** y

D ⟶ −0.2735 *** $\Delta\alpha$ (D.MS)
1.0000 *** k

Compute the geographic coordinates for the state plane coordinates just computed.

Keystrokes: **Outputs:**

Load Mercator to Geographic program side 1 and side 2.

349231.2941 A ⟶ 349231.2941 *** x

2357247.284 **B** →	2357247.284 ***	y
C →	48.0751 ***	ϕ (D.MS)
	116.2203 ***	λ (D.MS)

Load Geographic to Mercator Program side 1 and side 2.

C →	349231.2940 ***	x
	2357247.272 ***	y
D →	−0.2735 ***	$\Delta\alpha$ (D.MS)
	1.0000 ***	k

Note that the state plane coordinates must be recomputed if $\Delta\alpha$ and k are desired when converting from state plane coordinates to geographic coordinates. The accuracy of the program is not sufficient with 10 digit precision to compute exactly the same values for x and y as originally input, but $\Delta\alpha$ and k will be close enough in spite of this.

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

Making Data Cards:

Additional data cards can be made using the instructions given below. The supplied data card must be used to make new data cards since constants common to all regions must also be on the cards.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load data card side 1			
	and side 2.			
2	Input constants from table 2:	T1	STO 0	
		T2	STO 1	
		T3	STO 2	
		T4	STO 3	
		T5	STO 4	
		T6	STO 5	
3	Press W/DATA and load side 1			
	and side 2 of a blank			
	unprotected card.			
4	Mark the card and clip the			
	corners to protect the data			
	stored on it.			

Table 2
CONSTANTS FOR TRANSVERSE MERCATOR PROJECTION

	ALABAMA	ALABAMA	ARIZONA	ARIZONA
ZONE CODE	East 0101	West 0102	East 0201	Central 0202
T_1	500,000.00	500,000.00	500,000.00	500,000.00
T_2	309,000.00	315,000.00	396,600.00	402,900.00
T_3	1822.	1792.	1852.	1852.
T_4	21.00903	25.53386	16.62358	16.62358
T_5	.99996 00000	.99993 33333	.99990 00000	.99990 00000
T_6	.38170 65	.38174 77	.38164 85	.38164 85

	ARIZONA	DELAWARE	FLORIDA	FLORIDA
ZONE CODE	West 0203	0700	East 0901	West 0902
T_1	500,000.00	500,000.00	500,000.00	500,000.00
T_2	409,500.00	271,500.00	291,600.00	295,200.00
T_3	1852.	2271.	1453.	1453.
T_4	16.62358	30.53702	26.09287	26.09287
T_5	.99993 33333	.99999 50281	.99994 11765	.99994 11765
T_6	.38159 48	.38114 54	.38210 90	.38210 90

	GEORGIA	GEORGIA	HAWAII	HAWAII
ZONE CODE	East 1001	West 1002	1 5101	2 5102
T_1	500,000.00	500,000.00	500,000.00	500,000.00
T_2	295,800.00	303,000.00	559,800.00	564,000.00
T_3	1792.	1792.	1124.	1214.
T_4	25.53386	25.53386	39.52714	18.21554
T_5	.99990 00000	.99990 00000	.99996 66667	.99996 66667
T_6	.38175 93	.38175 93	.38264 96	.38257 62

	HAWAII	HAWAII	HAWAII	IDAHO
ZONE CODE	3 5103	4 5104	5 5105	East 1101
T_1	500,000.00	500,000.00	500,000.00	500,000.00
T_2	568,800.00	574,200.00	576,600.00	403,800.00
T_3	1264.	1303.	1294.	2491.
T_4	6.77497	57.83623	0.05280	18.35156
T_5	.99999 00000	.99999 00000	.99999 99999	.99994 73684
T_6	.38251 76	.38248 12	.38248 67	.38076 24

ZONE CODE	IDAHO Central 1102	IDAHO West 1103	ILLINOIS East 1201	ILLINOIS West 1202
T_1 T_2	500,000.00 410,400.00	500,000.00 416,700.00	500,000.00 318,000.00	500,000.00 324,600.00
T_3 T_4	2491. 18.35156	2491. 18.35156	2191. 37.04639	2191. 37.04639
T_5 T_6	.99994 73684 .38076 24	.99993 33333 .38062 27	.99997 50000 .38110 74	.99994 11765 .38113 32

ZONE CODE	INDIANA East 1301	INDIANA West 1302	MAINE East 1801	MAINE West 1802
T_1 T_2	500,000.00 308,400.00	500,000.00 313,500.00	500,000.00 246,600.00	500,000.00 252,600.00
T_3 T_4	2241. 32.84965	2241. 32.84965	2621. 15.15187	2561. 16.25668
T_5 T_6	.99996 66667 .38110 64	.99996 66667 .38110 64	.99990 00000 .38061 80	.99996 66667 .38065 75

ZONE CODE	MICHIGAN East 2101	MICHIGAN Central 2102	MICHIGAN West 2103	MISSISSIPPI East 2301
T_1 T_2	500,000.00 301,200.00	500,000.00 308,700.00	500,000.00 319,500.00	500,000.00 319,800.00
T_3 T_4	2481. 18.72150	2481. 18.72150	2481. 18.72150	1772. 28.62716
T_5 T_6	.99994 28571 .38072 83	.99990 90909 .38075 41	.99990 90909 .38053 61	.99996 00000 .38172 57

ZONE CODE	MISSISSIPPI West 2302	MISSOURI East 2401	MISSOURI Central 2402	MISSOURI West 2403
T_1 T_2	500,000.00 325,200.00	500,000.00 325,800.00	500,000.00 333,000.00	500,000.00 340,200.00
T_3 T_4	1822. 21.00903	2141. 41.66790	2141. 41.66790	2161. 39.76857
T_5 T_6	.99994 11765 .38169 86	.99993 33333 .38126 43	.99993 33333 .38124 22	.99994 11765 .38123 62

	NEVADA	NEVADA	NEVADA	NEW HAMPSHIRE
ZONE CODE	East 2701	Central 2702	West 2703	2800
T_1	500,000.00	500,000.00	500,000.00	500,000.00
T_2	416,100.00	420,000.00	426,900.00	258,000.00
T_3	2076.	2076.	2076.	2541.
T_4	48.30429	48.30429	48.30429	16.76677
T_5	.99990 00000	.99990 00000	.99990 00000	.99996 66667
T_6	.38123 11	.38123 11	.38123 11	.38073 27

	NEW JERSEY	NEW MEXICO	NEW MEXICO	NEW MEXICO
ZONE CODE	2900	East 3001	Central 3002	West 3003
T_1	2,000,000.00	500,000.00	500,000.00	500,000.00
T_2	268,800.00	375,600.00	382,500.00	388,200.00
T_3	2321.	1852.	1852.	1852.
T_4	27.02745	16.62358	16.62358	16.62358
T_5	.99997 50295	.99990 90909	.99990 00000	.99991 66667
T_6	.38108 45	.38161 35	.38162 04	.38162 88

	NEW YORK	NEW YORK	NEW YORK	RHODE ISLAND
ZONE CODE	East 3101	Central 3102	West 3103	3800
T_1	500,000.00	500,000.00	500,000.00	500,000.00
T_2	267,600.00	275,700.00	282,900.00	257,400.00
T_3	2391.	2391.	2391.	2456.
T_4	22.84247	22.84247	22.84247	19.72344
T_5	.99996 66667	.99993 75000	.99993 75000	.99999 37500
T_6	.38083 77	.38084 50	.38087 50	.38092 20

	VERMONT	WYOMING	WYOMING	WYOMING
ZONE CODE	4400	East 4901	East Central 4902	West Central 4903
T_1	500,000.00	500,000.00	500,000.00	500,000.00
T_2	261,000.00	378,600.00	386,400.00	391,500.00
T_3	2541.	2431.	2431.	2431.
T_4	16.76677	20.83533	20.83533	20.83533
T_5	.99996 42857	.99994 11765	.99994 11765	.99994 11765
T_6	.38074 20	.38084 22	.38084 22	.38084 22

WYOMING

ZONE CODE	West 4904			
T_1 T_2	500,000.00 396,300.00			
T_3 T_4	2431. 20.83533			
T_5 T_6	.99994 11765 .38084 22			

STATE PLANE COORDINATES—ALASKA ZONES 2-9

This two card program is designed to convert geographic coordinates (latitude and longitude) to and from state plane coordinates for zones 2-9 in Alaska. A data card is required for each program, but the two data cards supplied can be used for all zones.

Example:

Compute the state plane coordinates for a point in zone 6 having geographic coordinates of

$$\text{Latitude} = \phi = 71°00'00''$$
$$\text{Longitude} = \lambda = 155°00'00''$$

Keystrokes:	**Outputs:**
Load data card Geo to Alaska 2-9 side 1 and side 2.	
Load Geographic to Alaska 2-9 program side 1 and side 2.	
6 A 71 B ⟶	71.0000 *** ϕ
155 C ⟶	155.0000 *** λ
D ⟶	857636.1683 *** x
	6224356.322 *** y
E ⟶	2.5013 *** $\Delta\alpha$ (D.MS)
	1.0000 *** k

Compute the geographic coordinates of the state plane coordinates just computed.

Keystrokes:	**Outputs:**
Load data card Alaska 2-9 to Geo side 1 and side 2.	
Load Alaska 2-9 to Geographic program side 1 and side 2.	
6 **A** 857636.1683 **B** ⟶	857636.1683 *** x
6224356.322 **C** ⟶	6224356.322 *** y
D ⟶	71.0000 *** ϕ (D.MS)
	155.0000 *** λ (D.MS)
Load Geographic to Alaska 2-9 program side 1 and side 2.	
E ⟶	2.5013 *** $\Delta\alpha$ (D.MS)
	1.0000 *** k

***Shown by PRINT on HP-97 and by PAUSE on HP-67.

GEOGRAPHIC TO ALASKA 2-9

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load data card Geo to Alaska			
	2–9 side 1 and side 2.			
2	Load Geographic to Alaska 2–9			
	program side 1 and side 2.			
3	Input zone number.	Z	**A**	
4	Input latitude.	ϕ (D.MS)	**B**	ϕ (D.MS)
5	Input longitude.	λ (D.MS)	**C**	λ (D.MS)
6	Compute state plane			
	coordinates.		**D**	x, y
7	Compute convergence ($\Delta\alpha$)			
	and scale factor (k).		**E**	$\Delta\alpha$ (D.MS),
				k
8	Go to step 3 for next			
	calculation.			

ALASKA 2-9 TO GEOGRAPHIC

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Load data card Alaska 2–9 to			
	Geo side 1 and side 2.			
2	Load Alaska 2–9 to Geographic			
	program side 1 and side 2.			
3	Input zone number.	Z	A	
4	Input coordinates.	x	B	x
		y	C	y
5	Compute geographic			
	coordinates.		D	ϕ (D.MS),
				λ (D.MS)
6	Go to step 3 for next			
	calculation, or to compute			
	convergence and scale factor			
	go to step 7.			
7	Load Geographic to Alaska 2–9			
	program side 1 and side 2.			
8	Compute convergence ($\Delta\alpha$)			
	and scale factor (k).		E	$\Delta\alpha$ (D.MS)
				k
9	Go to step 2 for next			
	calculation.			

PROGRAM LISTINGS

Traverse, Inverse, and Sideshots

Step	Key	Comment
001	*LBLA	BEG N, E input
002	CLRG	
003	1	
004	STOI	Initialize pt. no.
005	SPC	
006	PRTX	
007	R↓	
008	STO8	BEG E
009	X⇄Y	
010	PRTX	
011	STO7	BEG N
012	X⇄Y	
013	PRTX	
014	1	
015	8	
016	0	180
017	STO9	
018	R/S	
019	*LBLB	AR, AL, BRG input
020	F0?	Was bearing input?
021	GTO0	
022	RCL9	180
023	HMS+	DR = AR + 180, DL = 180 − AL
024	*LBLC	DR, DL, AZ input
025	HMS→	Was azimuth input?
026	F0?	
027	GTO1	
028	RCL0	AZ
029	+	AZ + DR, AZ − DL
030	GTO1	
031	*LBL0	BRG to AZ
032	X⇄Y	BRG
033	HMS→	
034	X⇄Y	QD
035	ENT↑	
036	ENT↑	
037	2	
038	÷	
039	INT	INT (QD/2)
040	RCL9	
041	×	180 INT (QD/2)
042	X⇄Y	QD
043	RCL9	
044	×	
045	COS	
046	R↑	Cos (180 QD)
047	×	
048	−	BRG cos (180 QD)
049	*LBL1	AZ
050	1	
051	→R	
052	*LBL8	
053	→P	
054	X⇄Y	AZ
055	X>0?	AZ positive?
056	GTO7	

Step	Key	Comment
057	3	
058	6	
059	0	
060	+	360 + AZ
061	*LBL7	
062	F1?	Is traverse on?
063	STO0	
064	STOA	
065	→HMS	
066	SPC	
067	PRTX	AZ
068	RTN	
069	*LBLD	SD to HD
070	SPC	
071	PRTX	Slope angle
072	HMS→	
073	X⇄Y	
074	PRTX	SD
075	→R	
076	X≤Y?	X = short side?
077	X⇄Y	
078	R/S	
079	*LBLd	CLOSE
080	RCL6	ΣHD
081	SPC	
082	SPC	
083	PRTX	
084	R↓	
085	RCL4	AREA
086	ABS	
087	RCL5	Curve Area
088	+	
089	PRTX	
090	R↓	
091	CF1	Sideshot on
092	GSBc	Inverse to close
093	SF1	Traverse on
094	R↓	
095	R↓	
096	R/S	
097	*LBLc	INVERSE
098	RCL8	BEG E
099	−	
100	RCL3	DEP
101	−	E − BEG E − DEP
102	X⇄Y	
103	RCL7	BEG N
104	−	
105	RCL2	LAT
106	−	N − BEG N − LAT
107	GSB8	Output AZ
108	HMS→	
109	X⇄Y	HD
110	GSB4	Output HD, N, E
111	R↑	
112	RCL1	HD

REGISTERS

0	1	2	3	4	5	6	7	8	9
AZ	HD	LAT	DEP	AREA	Curve Area	ΣHD	BEG N	BEG E	180

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
AZ, R	Δ	$\pi\Delta/180$			Point No.

Step	Key	Comment
113	RTN	
114	*LBLE	HD
115	RCL0	AZ for traverse
116	X⇄Y	
117	F1?	
118	GTO4	Is traverse on?
119	RCLA	AZ for sideshot
120	X⇄Y	
121	*LBL4	HD
122	F1?	Is traverse on?
123	ST+6	
124	STO1	
125	PRTX	
126	→R	LAT
127	F1?	Is traverse on?
128	GTO2	
129	X⇄Y	DEP
130	RCL3	DEP
131	+	
132	RCL6	BEG E
133	+	E = BEG E + DEP
134	X⇄Y	LAT
135	RCL2	LAT
136	+	
137	RCL7	BEG N
138	+	N = BEG N + LAT
139	RCLA	AZ
140	GTO3	
141	*LBL2	
142	ST+2	LAT
143	X⇄Y	
144	ST+3	DEP
145	2	
146	÷	
147	RCL3	
148	-	DEP – DEP/2
149	x	
150	ST+4	LAT(DEP – DEP/2)
151	RCL3	
152	RCL8	
153	+	E
154	RCL2	
155	RCL7	
156	+	N
157	RCL0	AZ
158	*LBL3	Output point, N, E
159	→HMS	
160	ISZI	Increment point no.
161	RCLI	
162	SPC	
163	SPC	
164	PRTX	Point no.
165	R↓	
166	R↓	
167	PRTX	N
168	X⇄Y	
169	PRTX	E
170	RTN	
171	*LBLe	CURVE
172	CF2	Clear curve sign
173	STOA	Radius
174	X>0?	Radius positive?
175	SF2	
176	X⇄Y	Δ
177	HMS→	
178	STOB	
179	SIN	Sin (Δ)
180	RCLB	Δ
181	D→R	
182	STOC	Δ Pi/180
183	-	Sin (Δ) –Δ Pi/180
184	F2?	Radius positive?
185	CHS	
186	RCLA	
187	X²	R^2
188	x	
189	2	
190	÷	
191	ST+5	Segment area ⌓
192	SPC	
193	PRTX	
194	RCL1	HD or chord
195	ST-6	
196	RCLC	
197	RCLA	
198	x	Arc length
199	ABS	
200	ST+6	
201	RCLB	Δ
202	→HMS	
203	RCLA	Radius
204	PRST	
205	R/S	
206	*LBLa	FA/BRG
207	1	
208	F0?	Bearing on?
209	0	
210	SF0	Bearing on
211	X=0?	
212	CF0	Field angle on
213	R/S	
214	*LBLb	SS/TRA
215	1	
216	F1?	Traverse on?
217	0	
218	SF1	Traverse on
219	X=0?	
220	CF1	Sideshot on

LABELS					FLAGS
A BEG N↑E	B AR, AL, BRG	C DR, DL, AZ	D SD↑ANG	E HD↔N, E	0 FA/BRG
a FA/BRG?	b SS/TRA?	c INV	d CLOSE	e Δ↑R	1 SS/TRA
0 QD BRG→AZ	1 AZ	2 Used	3 Out N, E	4 Used	2 Curve Sign
5	6	7 Used	8 Used	9	3

SET STATUS				
FLAGS	ON	OFF	TRIG	DISP
0	☒	☐	DEG ☒	FIX ☒
1	☒	☐	GRAD ☐	SCI ☐
2	☐	☒	RAD ☐	ENG ☐
3	☐	☒		n 4

Traverse Adjustment

Step	Key	Comment	Step	Key	Comment
001	*LBLB	L, D input	057	X=0?	Compass rule?
002	SF0	L, D were input	058	GTO3	
003	*LBLA	N, E input	059	R↓	D
004	ISZI	Increment pt. no.	060	→P	HD
005	F1?	Print/pause?	061	STO9	
006	GTO0		062	RCL4	L
007	RCLI	Pt. no.	063	X²	
008	SPC		064	RCL9	HD
009	PRTX		065	÷	L^2/HD
010	R↓		066	RCLA	A
011	X⇄Y	N(L)	067	×	AL^2/HD
012	PRTX		068	ST+0	L correction
013	X⇄Y	E(D)	069	RCL5	D
014	PRTX		070	X²	
015	*LBL0		071	RCL9	HD
016	F0?	L, D input?	072	÷	
017	GTO1		073	RCLB	B
018	RCL8	BEG E	074	×	BD^2/HD
019	-	E- BEG E	075	ST+1	D correction
020	RCL3	ΣD	076	RCLA	A
021	-	D	077	RCL4	L
022	ST+3		078	RCL5	D
023	ST+1		079	×	
024	X⇄Y		080	RCL9	HD
025	RCL7	BEG N	081	÷	
026	-	N- BEG N	082	×	ALD/HD
027	RCL2	ΣL	083	ST+1	D correction
028	-	L	084	LSTX	
029	ST+2		085	RCLB	B
030	ST+0		086	×	BLD/HD
031	X⇄Y		087	ST+0	L correction
032	*LBL1		088	GTO5	
033	F0?	L, D input?	089	*LBL3	Compass rule
034	STO1	D	090	R↓	D
035	STO5		091	→P	HD
036	X⇄Y		092	STO9	
037	F0?	L, D input?	093	RCLC	
038	STO0	L	094	×	
039	STO4		095	ST-0	L correction
040	X⇄Y		096	RCL9	
041	F2?	Compute?	097	RCLD	
042	GTO2		098	×	
043	→P	HD	099	ST-1	D correction
044	√X		100	*LBL5	
045	RCL5	D	101	RCL1	D
046	X⇄Y		102	RCL0	L
047	÷	D/$\sqrt{HD}$	103	F0?	L, D input?
048	RCL4		104	GTO2	
049	LSTX	L	105	RCL7	BEG N
050	÷	L/$\sqrt{HD}$	106	+	N
051	Σ+		107	X⇄Y	D
052	RCLI	Pt. no.	108	RCL8	BEG E
053	R/S		109	+	E
054	*LBL2	Compute	110	X⇄Y	
055	SF2		111	*LBL2	
056	RCLE	0/1	112	SPC	

REGISTERS

0	1	2	3	4	5	6	7	8	9
Cor ΣL	Cor ΣD	ΣL	ΣD	L	D	ΣHD	BEG N	BEG E	HD

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
		ER L	ER D	Σ|L|	Σ(L^2/HD)	Σ|D|	Σ(D^2/HD)	Σ(LD/HD)	n

A	B	C	D	E	I
A	B	ERL/ΣHD	ERD/ΣHD	0/1	Pt. no.

Step	Key	Comment
113	PRTX	
114	X⇄Y	
115	PRTX	
116	RCLI	Pt. no.
117	R/S	
118	*LBLb	Crandall's rule
119	GSBa	
120	1	
121	STOE	
122	R/S	
123	*LBLa	Compass rule
124	CF0	
125	CF2	
126	RCL2	ER L
127	RCL3	ER D
128	P⇄S	
129	CLRG	
130	STO3	ER D
131	X⇄Y	
132	STO2	ER L
133	P⇄S	
134	1	
135	STOI	Pt. no.
136	GSB4	Clear sums
137	RTN	
138	*LBLc	Print/pause
139	0	
140	F1?	Off?
141	1	
142	CF1	Turn on
143	X=0?	
144	SF1	Turn off
145	R/S	
146	*LBLC	BEG N, E input
147	STO8	BEG E
148	X⇄Y	
149	STO7	BEG N
150	F1?	Print/pause?
151	GTO0	
152	PRTX	
153	R↓	
154	PRTX	
155	X⇄Y	
156	PRTX	
157	*LBL0	
158	RCLI	Pt. no.
159	R/S	
160	*LBLD	ER L, ER D input
161	P⇄S	
162	STO3	ER D
163	X⇄Y	
164	STO2	ER L
165	P⇄S	
166	R/S	
167	*LBLE	Compute
168	1	
169	STOI	Pt. no.
170	GSB4	Clear sums
171	SF2	Compute on
172	P⇄S	
173	RCLE	0/1
174	X=0?	Compass rule?
175	GTO3	
176	RCL2	ER L
177	RCL8	Σ(LD/HD)
178	×	
179	RCL3	ER D
180	RCL5	$\Sigma(L^2/HD)$
181	×	
182	-	
183	RCL7	$\Sigma(D^2/HD)$
184	RCL5	$\Sigma(L^2/HD)$
185	×	
186	RCL8	Σ(LD/HD)
187	X²	
188	-	
189	÷	B
190	STOB	
191	LSTX	
192	RCL3	ER D
193	RCL8	Σ(LD/HD)
194	×	
195	RCL2	ER L
196	RCL7	$\Sigma(D^2/HD)$
197	×	
198	-	
199	X⇄Y	
200	÷	A
201	STOA	
202	P⇄S	
203	RCLI	Pt. no.
204	R/S	
205	*LBL3	Compass rule
206	RCL2	ER L
207	RCL3	ER D
208	P⇄S	
209	RCL6	ΣHD
210	÷	ER D/ΣHD
211	STOD	
212	X⇄Y	ER L
213	RCL6	ΣHD
214	÷	ER L/ΣHD
215	STOC	
216	RCLI	Pt. no.
217	R/S	
218	*LBL4	Clear
219	0	
220	STO0	
221	STO1	
222	STO2	
223	STO3	
224	RTN	

LABELS

A N↑E	B L↑D	C BEG N↑E	D ER L↑D	E COMPUTE
a COMPASS	b CRANDALL	c P?	d	e
0 NO PRINT	1 L, D	2 COMPUTE	3 COMPASS	4 CLEAR
5 OUTPUT	6	7	8	9

FLAGS

0	N,E/L,D
1	P?
2	COMPUTE
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☐
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	4

Intersections

001	*LBLA	N1, E1 input	057	RCL6	AZ2
002	STO1	E1	058	RCL2	AZ1
003	X⇄Y		059	-	ϕ
004	STO0	N1	060	SIN	Sin ϕ
005	R/S		061	÷	D1
006	*LBLB	N2, E2 input	062	STO3	
007	STO5	E2	063	GTO2	
008	X⇄Y		064	*LBLd	Offset
009	STO4	N2	065	SF2	
010	R/S		066	GSB0	D12, AZ12
011	*LBLC	Brg, Qd input	067	RCL6	AZ1
012	X⇄Y	Brg	068	RCLD	AZ12
013	HMS→		069	-	α
014	X⇄Y	Qd	070	SIN	Sin α
015	ENT↑		071	RCLC	D12
016	ENT↑		072	x	
017	2		073	STO7	D2
018	÷		074	*LBLb	B–D
019	INT	INT (Qd/2)	075	GSB0	D12, AZ12
020	1		076	RCL7	D2
021	8		077	X²	
022	0		078	RCL6	AZ1
023	x	180 INT (Qd/2)	079	STO2	
024	X⇄Y	Qd	080	RCLD	AZ12
025	LSTX		081	-	AZ1 – AZ12
026	x		082	RCLC	D12
027	COS	Cos (180 Qd)	083	→R	D12 cos α
028	R↑	Brg	084	F2?	
029	x		085	GTO4	D12 sin α
030	-		086	R↓	
031	1		087	X²	
032	→R		088	-	$D2^2 - (D12 \sin\alpha)^2$
033	GSB3	To polar	089	√X	
034	GTO1		090	R↑	D12 cos α
035	*LBLD	AZ input	091	X⇄Y	
036	HMS→		092	-	D1
037	*LBL1		093	STOE	
038	RCL6	AZ1	094	LSTX	
039	STO2		095	R↑	
040	R↓		096	+	D1
041	STO6	AZ2	097	*LBL5	
042	R/S		098	STO3	
043	*LBLE	D input	099	GSB2	First solution
044	RCL7		100	F2?	Offset?
045	STO3	D1	101	R/S	
046	R↓		102	RCLE	
047	STO7	D2	103	RCL3	
048	R/S		104	STOE	
049	*LBLa	B–B	105	R↓	
050	GSB0	D12, AZ12	106	STO3	D1
051	RCL6	AZ2	107	GTO2	2^{nd} solution
052	RCLD	AZ12	108	*LBLc	D–D
053	-	θ	109	GSB0	D12, AZ12
054	SIN	Sin θ	110	RCL3	D1
055	RCLC	D12	111	→P	
056	x		112	X²	$D1^2 + D12^2$

REGISTERS

0	1	2	3	4	5	6	7	8	9
N1	E1	AZ1	D1	N2	E2	AZ2	D2	N3	E3
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
		D12	AZ12	AZ 1	

Step	Key	Comment
113	RCL7	D12
114	X²	
115	-	D1
116	RCLC	
117	÷	
118	RCL3	
119	÷	α
120	2	AZ12
121	÷	
122	COS⁻¹	AZ12−α = AZ1₁
123	RCLD	AZ1₁
124	X⇄Y	α
125	-	AZ12
126	STOE	AZ12+α = AZ1₂
127	LSTX	AZ1₂
128	RCLD	1st solution
129	+	AZ1₁
130	STO2	AZ1₂
131	GSB2	
132	RCLE	
133	RCL2	2nd solution:
134	STOE	Output
135	R↓	AZ1
136	STO2	D1
137	*LBL2	
138	RCL2	To polar
139	RCL3	AZ1
140	→R	N1
141	GSB3	E1
142	→HMS	
143	RCL0	
144	RCL1	
145	R↓	AZ1
146	R↓	D1
147	PRST	
148	RCL2	N1
149	RCL3	N3
150	→R	
151	RCL0	
152	+	E1
153	STO8	E3
154	X⇄Y	
155	RCL1	E2
156	+	
157	STO9	
158	RCL5	N2
159	-	
160	X⇄Y	To polar
161	RCL4	
162	-	N2
163	GSB3	E2
164	→HMS	
165	RCL4	
166	RCL5	
167	R↓	N3
168	R↓	
169	PRST	E3
170	RCL8	
171	PRTX	
172	RCL9	D12, AZ12
173	PRTX	E2
174	RTN	E1
175	*LBL0	
176	RCL5	N2
177	RCL1	N1
178	-	
179	RCL4	To polar
180	RCL0	AZ12
181	-	
182	GSB3	D12
183	STOD	
184	X⇄Y	To polar
185	STOC	
186	RTN	
187	*LBL3	Positive AZ?
188	→P	
189	X⇄Y	
190	X>0?	
191	RTN	
192	3	AZ + 360
193	6	
194	0	
195	+	
196	RTN	
197	*LBL4	
198	SF2	
199	GTO5	
200	R/S	

LABELS

A N1↑E1	B N2↑E2	C BRG↑QD	D AZ	E D
a B–B	b B–D	c D–D	d OFF	e
0 D12, AZ12	1 AZ	2 OUTPUT	3	4 →P
5	6	7	8	9

FLAGS

0	
1	
2	OFFSET
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	4

Curve Solutions

Step	Key	Comment
001	*LBLA	R or –D input
002	X>0?	Was R input?
003	GTO9	
004	CHS	
005	HMS→	
006	EEX	
007	2	
008	X⇄Y	
009	÷	100/D
010	R→D	R = 18000/(π D)
011	*LBL9	
012	STOA	R
013	SF0	
014	R/S	
015	*LBLB	Δ input
016	HMS→	
017	2	
018	÷	Δ/2
019	STOB	
020	CF0	
021	R/S	
022	*LBLC	L input
023	R→D	180 L/π
024	F0?	Was R input?
025	GTO1	
026	RCLB	Δ/2
027	2	
028	x	
029	÷	R = 180 L/(π Δ)
030	STOA	
031	R/S	
032	*LBL1	
033	RCLA	R
034	÷	
035	2	
036	÷	Δ/2 = 90 L/(π R)
037	STOB	
038	R/S	
039	*LBLD	C input
040	2	
041	÷	C/2
042	F0?	Was R input?
043	GTO2	
044	RCLB	
045	SIN	
046	÷	R = C/(2 sin (Δ/2))
047	STOA	
048	R/S	
049	*LBL2	
050	RCLA	R
051	÷	
052	SIN⁻¹	$\Delta/2 = \sin^{-1}$ (C/2R)
053	STOB	
054	R/S	
055	*LBLb	E input
056	F0?	Was R input?
057	GTO5	
058	RCLB	Δ/2
059	2	
060	÷	
061	TAN	
062	÷	T = E/tan (Δ/4)
063	GTOE	
064	*LBL5	
065	RCLA	R
066	÷	
067	1	
068	+	1 + E/R
069	1/X	
070	COS⁻¹	$\Delta/2 = \cos^{-1} (1 + E/R)^{-1}$
071	STOB	
072	R/S	
073	*LBLE	T input
074	F0?	Was R input?
075	GTO3	
076	RCLB	Δ/2
077	TAN	
078	÷	R = T/tan (Δ/2)
079	STOA	
080	R/S	
081	*LBL3	
082	RCLA	R
083	÷	
084	TAN⁻¹	$\Delta/2 = \tan^{-1}$ (T/R)
085	STOB	
086	R/S	
087	*LBLa	M input
088	F0?	Was R input?
089	GTO4	
090	1	
091	RCLB	Δ/2
092	COS	
093	-	1 – cos (Δ/2)
094	÷	R = M/(1 – cos (Δ/2))
095	STOA	
096	R/S	
097	*LBL4	
098	RCLA	R
099	÷	
100	1	
101	X⇄Y	
102	-	1 – M/R
103	COS⁻¹	$\Delta/2 = \cos^{-1}$ (1 – M/R)
104	STOB	
105	R/S	
106	*LBLc	Output R, D, Δ, L
107	EEX	
108	2	
109	RCLA	R
110	÷	100/R
111	R→D	D = 18000/π R
112	→HMS	

REGISTERS

0	1	2	3	4	5	6	7	8	9
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
R	Δ/2	L	C	T	

113	RCLB	Δ/2
114	2	
115	x	Δ
116	→HMS	
117	LSTX	Δ
118	RCLA	R
119	x	
120	D→R	L = πRΔ/180
121	STOC	
122	RCLA	R
123	R↓	
124	PRST	
125	R/S	
126	*LBLd	Output T, C, M, E
127	RCLB	Δ/2
128	TAN	
129	RCLA	
130	x	T = R tan (Δ/2)
131	STOE	
132	RCLB	Δ/2
133	SIN	
134	RCLA	
135	x	
136	2	
137	x	C = 2R sin (Δ/2)
138	STOD	
139	1	
140	RCLB	Δ/2
141	COS	
142	-	
143	RCLA	
144	x	M = R (1−cos(Δ/2))
145	RCLB	Δ/2
146	2	
147	÷	
148	TAN	
149	RCLE	
150	x	E = T tan (Δ/4)
151	RCLE	T
152	R↓	
153	PRST	
154	R/S	
155	*LBLe	Output ∇, ⌓, A
156	RCLA	R
157	X²	
158	RCLB	Δ/2
159	x	
160	D→R	∇ = R²πΔ/360
161	ENT↑	
162	ENT↑	
163	RCLB	Δ/2
164	RCLA	R
165	→R	
166	x	R² sin (Δ/2) cos (Δ/2)
167	-	⌓ = ∇ − R² sin(Δ/2) cos(Δ/2)
168	RCLB	Δ/2
169	TAN	
170	RCLA	R
171	X²	
172	x	R² tan (Δ/2)
173	R↑	
174	-	A = R² tan (Δ/2) − ∇
175	0	0
176	R↓	
177	PRST	
178	R/S	

LABELS

A R (−D)	B Δ	C L	D C/	E T
a M	b E	c →R,D,Δ,L	d →T,C,M,E	e ∇, ⌓, A
0	1 R & L	2 R & C	3 R & T	4 R & M
5 R & E	6	7	8	9

FLAGS

0	Δ or R?
1	
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	4

Horizontal Curve Layout

Step	Key	Comment
001	*LBLA	PC input
002	STO1	
003	STO2	Current station
004	SF2	PC was input
005	R/S	
006	*LBLa	PI input
007	STO6	
008	CF2	PI was input
009	R/S	
010	*LBLb	R or D input
011	X>0?	Was R input?
012	GTO7	
013	CHS	D
014	HMS→	
015	EEX	
016	2	
017	X⇄Y	
018	÷	
019	R→D	R = 18000/π D)
020	*LBL7	
021	STOA	R
022	D→R	πR/180
023	2	
024	x	
025	STO0	FT/DEF
026	R/S	
027	*LBLc	Δ input
028	2	
029	0	
030	0	
031	RCL0	
032	÷	D
033	→HMS	
034	X⇄Y	Δ
035	ENT↑	
036	HMS+	
037	2	
038	÷	
039	STOB	Δ/2
040	RCL0	
041	x	
042	STOC	L
043	RCLA	R
044	R↓	
045	PRST	
046	RCLB	Δ/2
047	TAN	
048	RCLA	
049	x	
050	STOE	T = Rtan (Δ/2)
051	RCL1	PC
052	F2?	Was PC input?
053	GTO7	
054	RCL6	PI
055	RCLE	T
056	-	
057	STO1	PC = PI − T
058	STO2	Current station
059	*LBL7	
060	RCLC	L
061	+	
062	STO3	PT = PC + L
063	RCL1	
064	RCLE	
065	+	
066	STO6	PI = PC + T
067	RCL1	PC
068	0	
069	R↓	
070	CF3	Clear input flag
071	PRST	
072	R/S	
073	*LBLB	PC DEF
074	3	Code for PC DEF
075	GTO1	
076	*LBLD	TN OFF
077	4	Code for TN OFF
078	GTO1	
079	*LBLE	CD OFF
080	5	Code for CD OFF
081	GTO1	
082	*LBLC	PI DEF
083	6	Code for PI DEF
084	*LBL1	
085	STOI	Code
086	R↓	STA
087	RCL2	Current station
088	-	
089	F3?	Was STA input?
090	GTO0	
091	*LBL8	AUTO stationing
092	RCL3	PT
093	RCL2	Current station
094	-	
095	RCL4	INT
096	X≤Y?	
097	GTO9	
098	X⇄Y	PT − cur. sta.
099	*LBL0	
100	SF0	AUTO-H is on
101	*LBL9	
102	ST+2	New STA
103	GSB2	SC
104	RCL2	STA
105	RCL1	PC
106	-	
107	GSB2	
108	RCL5	LC
109	GTOi	ANG
110	*LBL2	Arc length to chord
111	RCL0	π R/90
112	÷	

REGISTERS

0	1	2	3	4	5	6	7	8	9
FT/DEF	PC	STA	PT	INT	ANG	PI			
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
R	Δ/2	L		T	ROUTINE

Step	Key	Comments
113	ST05	ANG
114	SIN	
115	RCLA	
116	x	
117	2	
118	x	C = 2Rsin(ANG)
119	RTN	
120	*LBL3	ANG
121	→HMS	
122	RCL2	STA
123	GT09	
124	*LBL6	PI DEF
125	X⇄Y	LC
126	→R	TD = X, TO = Y
127	CHS	
128	RCLE	T
129	+	T – TD
130	→P	DIST
131	X⇄Y	ANG
132	→HMS	
133	GT07	
134	*LBL5	CD OFF
135	RCLB	Δ/2
136	X⇄Y	ANG
137	–	
138	*LBL4	TN OFF
139	X⇄Y	LC
140	→R	X = Dist, Y = Offset
141	*LBL7	
142	RCL2	STA
143	0	
144	R↓	
145	*LBL9	
146	CF3	Clear input flag
147	PRST	
148	F0?	Halt?
149	R/S	
150	GT08	Next station
151	*LBLe	
152	SF0	AUTO-H is on
153	GT07	
154	*LBLd	
155	CF0	AUTO-P is on
156	*LBL7	
157	F3?	INT input?
158	ST04	
159	RCL4	
160	R/S	
161	P⇄S	Spiral constants for spiral
162	3	curve layout program.
163	ST01	
164	1	
165	0	
166	CHS	
167	ST02	
168	4	
169	2	
170	CHS	
171	ST03	
172	2	
173	1	
174	6	
175	ST04	
176	1	
177	3	
178	2	
179	0	
180	ST05	
181	9	
182	3	
183	6	
184	0	
185	CHS	
186	ST06	
187	7	
188	5	
189	6	
190	0	
191	0	
192	CHS	
193	ST07	
194	6	
195	8	
196	5	
197	4	
198	4	
199	0	
200	ST08	
201	6	
202	8	
203	9	
204	4	
205	7	
206	2	
207	0	
208	ST09	
209	P⇄S	
210	R/S	

LABELS					FLAGS
A PC	B →PC DEF	C →PI DEF	D →TN OFF	E →CD OFF	0 H/P
a PI	b R (–D)	c Δ	d AUTO-P	e AUTO-H	1
0 Used	1 Used	2 L→C	3 PC DEF	4 TN OFF	2 PC/PI
5 CD OFF	6 PI DEF	7 Used	8 LOOP	9 Used	3 Input?

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Spiral Curve Layout

*LBLA	PS input
STO1	
STO2	
SF1	PS was input
R/S	
*LBLa	PI, T_Δ input
HMS→	
2	
÷	
STO5	$T_\Delta/2$
X⇄Y	
STO6	PI
CF1	PI was input
R/S	
*LBLB	R (−D) input
X>0?	Was R input?
GTO6	
HMS→	
CHS	D
1/X	
R→D	$180/(D\ \pi)$
EEX	
2	
x	$R = 18000/(D\ \pi)$
*LBL6	
STOA	R
R/S	
*LBLb	L_s input
STOC	
ENT↑	
ST+2	$PSC = PS + L_s$
RCLA	R
÷	
2	
÷	
STO0	$\theta_s = L_s/2R$
R→D	
STOD	$S = 180\ L_s/(\pi\ 2R)$
→HMS	
EEX	
2	
RCLA	
÷	100/R
R→D	$D = 18000/(\pi\ R)$
→HMS	
RCLA	R
PRST	
F1?	Was PS input?
GTO5	
0	
STO1	
RCLC	L_s
STO2	
GSB9	Compute Y_s & X_s
RCLD	S
RCLA	R
→R	R cos (S)
R↓	R sin (S)
−	Y_s − Rsin (S)
R↓	
+	X_s + Rcos (S)
RCL5	$T_\Delta/2$
TAN	
x	
R↑	
+	T_s
STOE	
RCL6	PI
X⇄Y	
−	
STO1	PS
ST+2	
RCL5	$T_\Delta/2$
RCLD	S
−	
2	
x	$T_\Delta - 2S$
STOB	Δ
D→R	$\pi\ \Delta/180$
RCLA	R
x	L of cir. curv.
RCLC	L_s
2	
x	
+	Total curve L_t
+	$PT = PS + L_t$
STO7	
RCL6	PI
RCL1	PS
0	
R↓	
PRST	
*LBL5	PS, SPI, PSC
GSB9	Compute Y & X
X⇄Y	X
RCLD	S
TAN	
÷	
−	$U = Y_s - X_s$ cot (S)
F2?	Exit spiral?
CHS	
STOE	U
0	
RCL1	PS
RCLC	L_s
+	$PSC = PS + L_s$
STO3	
RCL1	PS
RCLE	U
+	SPI = PS + U
RCL1	PS
PRST	

REGISTERS

0 θ_s, θ	1 PS, PT	2 STA	3 PSC, PCS	4 INT	5 $T_\Delta/2$	6 PI	7 PT, PS	8 Y	9 X
S0	S1 3	S2 −10	S3 −42	S4 216	S5 1320	S6 −9360	S7 −75600	S8 685440	S9 6894720

A R	B Δ	C $L_s, -L_s$	D S	E T_s, U	I

Step	Key	Comment
113	R/S	
114	*LBLE	Exit spiral
115	RCL7	PT
116	RCL1	PS
117	STO7	
118	X⇄Y	
119	STO1	
120	RCLC	L_s
121	CHS	
122	STOC	$-L_s$
123	+	
124	STO2	PT − L_s
125	SF2	Exit spiral
126	GTO5	Compute SPI, PCS
127	*LBLd	AUTO–H
128	SF0	AUTO–H is on
129	GTO8	
130	*LBLc	AUTO–P
131	CF0	AUTO–P is on
132	*LBL6	
133	F3?	INT input?
134	STO4	INT
135	RCL4	
136	R/S	
137	*LBLC	PS DEF
138	CF1	
139	GTO1	
140	*LBLD	TN OFF
141	SF1	
142	*LBL1	
143	RCL2	Previous STA
144	−	
145	F3?	STA input?
146	GTO0	
147	RCL4	INT
148	CF2	
149	X<0?	INT negative?
150	SF2	Exit spiral
151	ABS	
152	RCL3	PSC
153	RCL2	STA
154	−	
155	ABS	
156	X≤Y?	End of spiral?
157	GTO0	
158	X⇄Y	INT
159	GTO7	
160	*LBL0	STA was input
161	SF0	AUTO–H
162	*LBL7	AUTO station
163	F2?	Exit spiral?
164	CHS	
165	ST+2	
166	RCL2	STA
167	RCL1	PS
168	−	ℓ_s
169	RCLC	L_s
170	÷	
171	X²	$(\ell_s/L_s)^2$
172	RCLD	S
173	D→R	
174	×	
175	STO0	$\theta = (\ell_s/L_s)^2\,[(\pi\,S)/180]$
176	GSB9	Compute Y & X
177	F1?	TN OFF?
178	GTO4	
179	→P	CD
180	X⇄Y	ANG
181	→HMS	
182	*LBL4	
183	RCL2	STA
184	0	
185	R↓	
186	PRST	
187	F0?	AUTO–H
188	R/S	
189	GTO1	AUTO–P
190	*LBL9	Compute Y & X
191	CF3	Clear input flag
192	9	
193	STOI	9 terms
194	0	
195	STO8	
196	STO9	
197	*LBL2	Loop point
198	RCL0	θ
199	RCLI	n
200	Yˣ	
201	P⇄S	Constants
202	RCL i	
203	÷	θ^n/c_i
204	P⇄S	
205	RCL8	Switch
206	RCL9	
207	STO8	
208	R↓	
209	+	Add term
210	STO9	
211	DSZI	Next term
212	GTO2	
213	RCL9	X/1
214	RCL2	
215	RCL1	
216	−	= STA–PS
217	ABS	
218	×	X
219	LSTx	1
220	RCL8	
221	1	
222	+	Y/1
223	×	Y
224	RTN	

LABELS

A PS	B R (−D)	C →PS DEF	D →TN OFF	E Exit SP
a PI↑TΔ	b L	c AUTO–P	d AUTO–H	e
0 STA INPUT	1 NEXT STA	2 LOOP	3 PS DEF	4 TN OFF
5 Entrance	6 R INPUT	7 AUTO STA	8 AUTO–H	9 Y, X

FLAGS

0	H/P
1	Used
2	PS/PT
3	INPUT

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	X		DEG	x	FIX	x
1		X	GRAD		SCI	
2		X	RAD		ENG	
3		X			n	4

Vertical Curves and Grades

Step	Key	Comment
001	*LBLA	Grade
002	SF1	Grade is on
003	0	Prepare for print
004	PRST	
005	GTO3	
006	*LBLB	Vertical curve
007	CF1	Curve is on
008	PRST	
009	*LBL3	
010	CF3	Clear input flag
011	R↑	PC or −PI
012	CF2	PI was input
013	X>0?	Was PC input?
014	SF2	PC was input
015	ABS	
016	STO7	PC or PI
017	STO0	
018	CLX	
019	EEX	
020	2	100
021	÷	Gn/100
022	STO3	
023	X⇄Y	
024	LSTX	
025	÷	G1/100
026	STO2	
027	R↑	
028	STO1	EL1 or ELI
029	R/S	
030	*LBLb	STA, EL input
031	RCL1	EL1
032	−	EL−EL1 or EL−ELI
033	X⇄Y	
034	RCL0	
035	−	STA−PC or STA−PI
036	STO8	
037	RCL8	
038	RCL2	G1/100
039	×	G1 (STA−PC)/100
040	R↑	EL−EL1
041	−	
042	RCL2	G1/100
043	RCL3	Gn/100
044	−	
045	÷	
046	2	
047	×	
048	F2?	Was PC input?
049	GTO6	
050	−	
051	RCL8	STA−PC
052	X²	
053	4	
054	1/X	1/4
055	SF2	Set return flag
056	GSB4	Compute L
057	X<0?	negative root?
058	X⇄Y	L
059	GTOC	
060	*LBL6	
061	÷	
062	×	
063	GTO1	L
064	*LBLa	Hi/Lo EL$_o$ input
065	RCL1	EL1 or ELI
066	X⇄Y	
067	−	EL1−EL$_o$ or ELI−EL$_o$
068	2	
069	×	2 (EL1−EL$_o$)
070	RCL3	
071	RCL2	
072	−	(Gn−G1)/100
073	×	
074	RCL2	G1/100
075	X²	
076	÷	
077	F2?	Was PC input?
078	GTO1	
079	RCL2	G1/100
080	×	
081	RCL3	Gn/100
082	÷	
083	*LBLC	L input
084	STO5	L
085	F2?	Was PC input?
086	GTO1	
087	2	
088	÷	L/2
089	RCL0	PI
090	X⇄Y	
091	−	PC = PI−L/2
092	STO0	
093	STO7	
094	LSTX	L/2
095	RCL2	G1/100
096	×	
097	ST−1	ELI
098	RCL5	L
099	*LBL1	
100	RCL3	
101	RCL2	
102	−	(Gn−G1)/100
103	X⇄Y	L
104	STO5	
105	÷	
106	STO6	(Gn−G1)/100L
107	SPC	
108	RCL0	
109	PRTX	PC
110	RCL1	
111	PRTX	EL1
112	X⇄Y	

REGISTERS

0	1	2	3	4	5	6	7	8	9
Used	EL1, ELI	G1/100	Gn/100	INT	L	Used	STA	Used	EL
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I

Step	Key	Comment
113	CF3	Clear input flag
114	R/S	
115	*LBLc	Compute Hi/Lo STA
116	RCL0	PC
117	RCL2	G1
118	RCL6	(Gn−G1)/100L
119	÷	
120	−	Hi/Lo STA
121	SF3	Input flag on
122	GTOE	Compute EL
123	*LBLe	Auto-halt
124	SF0	Auto-halt is on
125	GTO0	
126	*LBLd	Auto-pause
127	CF0	Auto-pause is on
128	*LBL0	
129	F3?	INT input?
130	STO4	
131	*LBLE	STA to EL
132	F3?	STA input?
133	GTO2	
134	RCL4	INT
135	RCL7	STA
136	+	Current station
137	F1?	Grade?
138	GTO5	
139	RCL5	L
140	RCL0	PC
141	+	PT = PC + L
142	X≤Y?	End of curve?
143	GTO2	
144	X⇄Y	
145	GTO5	
146	*LBL2	
147	SF0	Auto-halt is on
148	*LBL5	
149	STO7	STA
150	RCL0	PC or PI or STA1
151	−	STA−PC or STA−PI
152	ENT↑	
153	ENT↑	
154	RCL6	(Gn−G1)/100L
155	F1?	Grade?
156	CLX	No 2nd order term
157	x	
158	2	
159	÷	ax
160	RCL2	G1/100
161	+	ax + b
162	x	$ax^2 + bx$
163	RCL1	
164	+	$ax^2 + bx + c = EL$
165	RCL7	STA
166	SPC	
167	PRTX	
168	X⇄Y	EL
169	PRTX	
170	PSE	
171	F0?	Auto-halt?
172	R/S	
173	GTOE	Loop to next STA
174	*LBLD	EL to STA
175	SPC	
176	PRTX	EL
177	STO9	
178	RCL1	EL1
179	−	
180	F1?	Grade?
181	GTO7	
182	CHS	EL1−EL
183	RCL6	(Gn−G1)/100L
184	2	
185	RCL2	G1/100
186	R↓	
187	÷	(Gn−G2)/200L
188	*LBL4	Quadratic sol'n
189	÷	c/a
190	X⇄Y	
191	LSTX	
192	÷	b/a
193	2	
194	÷	b/2a
195	CHS	
196	ENT↑	
197	ENT↑	
198	X^2	$b^2/4a^2$
199	R↑	c/a
200	−	
201	√X	
202	−	root
203	LSTX	
204	R↑	
205	+	root
206	F2?	Was L just calc.?
207	RTN	
208	RCL0	PC
209	+	STA
210	PRTX	
211	X⇄Y	
212	RCL0	PC
213	+	STA
214	PRTX	
215	R/S	
216	*LBL7	
217	RCL2	G1/100
218	÷	100 (EL−EL1)/G1
219	RCL0	STA1
220	+	STA
221	STO7	
222	PRTX	
223	R/S	

LABELS

A GRADE	B CURVE	C L	D EL→STA	E STA→EL
a HI/LO EL_o	b STA↑EL	c →STA_o,EL_o	d AUTO-P	e AUTO-H
0 AUTO H/P	1 L & PC	2 STA INPUT	3 INPUTS	4 QUAD EQ
5 AUTO STA	6 PC→L	7 EL→STA	8	9

FLAGS

Flag	Name
0	AUTO H/P
1	CURV/GRD
2	PI/PC
3	INPUT

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	2

Resection

Step	Key	Comment	Step	Key	Comment
001	*LBLA	N1, E1 input	057	F0?	Lengths input?
002	CF0	Coordinates input	058	GTO0	
003	X⇄Y	N1	059	RCL1	E1
004	STO0		060	RCL3	E2
005	SPC		061	-	
006	PRTX		062	RCL0	N1
007	X⇄Y	E1	063	RCL2	N2
008	STO1		064	-	
009	PRTX		065	→P	L1
010	R/S		066	STO6	
011	*LBLB	N2, E2 input	067	X⇄Y	$\theta 1$
012	X⇄Y		068	STO8	
013	STO2	N2	069	RCL5	E3
014	SPC		070	RCL3	E2
015	PRTX		071	-	
016	X⇄Y	E2	072	RCL4	N3
017	STO3		073	RCL2	N2
018	PRTX		074	-	
019	R/S		075	→P	L2
020	*LBLC	N3, E3 input	076	STO7	
021	X⇄Y	N3	077	X⇄Y	$\theta 2$
022	STO4		078	RCL8	$\theta 1$
023	SPC		079	-	
024	PRTX		080	RCLA	A
025	X⇄Y	E3	081	-	
026	STO5		082	RCLB	B
027	PRTX		083	-	
028	R/S		084	STOE	D + E
029	*LBLD	A, B input	085	*LBL1	
030	X⇄Y	A	086	2	
031	SPC		087	÷	(D + E)/2
032	PRTX		088	ENT↑	
033	HMS→		089	TAN	tan ((D + E)/2)
034	STOA		090	RCL7	L2
035	X⇄Y	B	091	RCL6	L1
036	PRTX		092	÷	
037	HMS→		093	RCLA	A
038	STOB		094	SIN	
039	R/S		095	×	L2 sin (A)/L1
040	*LBLa	L1, L2 input	096	RCLB	B
041	SF0	Lengths input	097	SIN	
042	X⇄Y	L1	098	÷	L2 sin (A)/L1 sin (B)
043	STO6		099	1	
044	SPC		100	-	K−1
045	PRTX		101	×	(K−1) tan ( )
046	X⇄Y		102	LSTX	K−1
047	STO7	L2	103	2	
048	PRTX		104	+	K + 1
049	R/S		105	→P	
050	*LBLb	C input	106	R↓	$\tan^{-1}$ ( ) = (D−E)/2
051	SPC		107	+	D
052	PRTX		108	STO9	
053	HMS→		109	1	
054	STOC		110	8	
055	R/S		111	0	
056	*LBLE	Compute	112	X⇄Y	

REGISTERS

0	1	2	3	4	5	6	7	8	9
N1	E1	N2	E2	N3	E3	L1	L2	θ	Used

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
A	B	C	D	D + E, E	

Step	Key	Comment
113	X<0?	
114	+	D + E
115	STOD	E
116	→HMS	
117	SPC	
118	PRTX	
119	RCL9	
120	CHS	Lengths input
121	RCLE	
122	+	
123	1	360
124	8	A
125	0	
126	X⇄Y	B
127	X<0?	
128	+	C
129	STOE	
130	→HMS	D + E
131	PRTX	
132	R/S	NP, EP output
133	*LBL0	D
134	3	θ1
135	6	A
136	0	
137	RCLA	
138	-	
139	RCLB	
140	-	
141	RCLC	
142	-	D + θ1 + A − 180
143	STOE	D
144	GTO1	
145	*LBLe	L1
146	RCLD	L1 sin (D)
147	RCL8	
148	RCLA	
149	1	L1 sin (D)/sin (A)
150	8	
151	0	N2
152	-	NP
153	+	
154	+	
155	R↑	
156	SIN	E2
157	RCL6	EP
158	×	
159	RCLA	
160	SIN	Output lengths
161	÷	L1
162	→R	
163	RCL2	
164	+	L2
165	SPC	
166	PRTX	L1
167	X⇄Y	A
168	RCL3	L1/sin (A)

Step	Key	Comment
169	+	
170	PRTX	
171	R/S	180
172	*LBLd	A
173	RCL6	
174	SPC	D
175	PRTX	
176	RCL7	Sin (180 − A − D)
177	PRTX	L1/sin (A)
178	X⇄Y	L3
179	RCLA	
180	SIN	L1/sin (A)
181	÷	D
182	1	
183	8	Sin (D) L1/sin (A)
184	0	L4
185	RCLA	L2
186	-	B
187	RCLD	
188	-	L2/sin (B)
189	SIN	
190	X⇄Y	
191	×	180
192	PRTX	B
193	LSTX	
194	RCLD	E
195	SIN	
196	×	Sin (180 − B − E)
197	PRTX	L5
198	RCL7	
199	RCLB	
200	SIN	
201	÷	
202	1	
203	8	
204	0	
205	RCLB	
206	-	
207	RCLE	
208	-	
209	SIN	
210	×	
211	PRTX	

LABELS

A N1↑E1	B N2↑E2	C N3↑E3	D A↑B	E COMPUTE
a L1↑L2	b C	c	d →L1–L5	e →NP, EP
0 Used	1 Used	2	3	4
5	6	7	8	9

FLAGS

0	L/N, E
1	
2	
3	

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Two Instrument Radial Survey

Instruction	Comment
*LBLa	NT, ET input
F1?	No P?
GTO0	
X⇄Y	NT
SPC	
PRTX	
X⇄Y	ET
PRTX	
*LBL6	
STO1	
X⇄Y	
STO0	
R/S	
*LBLb	ELT input
STO2	
F1?	No P?
R/S	
PRTX	
R/S	
*LBLc	HIT input
STO3	
F1?	No P?
R/S	
PRTX	
R/S	
*LBLe	BRG, QD input
X⇄Y	BRG
HMS→	
X⇄Y	QD
ENT↑	Change to AZ
ENT↑	
2	
÷	
INT	
1	
8	
0	
x	
X⇄Y	
LSTX	
x	
COS	
R↑	
x	
-	AZ
→HMS	
*LBLd	REF AZ input
F1?	No P?
GTO0	
SPC	
PRTX	
*LBL0	
HMS→	
STO4	
R/S	
*LBLA	AR input
F1?	No P?
GTO0	
SPC	
PRTX	
*LBL0	
HMS→	
RCL8	AR DM
STO5	
R↓	
STO8	AR P
R/S	
*LBLB	SD, ANG input
F1?	No P?
GTO0	
X⇄Y	
PRTX	
X⇄Y	
PRTX	
*LBL0	
HMS→	ANG
X⇄Y	
→R	
X>Y?	Vertical angle?
X⇄Y	
→P	
RCLA	SD DM
STO7	
R↓	
STOA	SD P
X⇄Y	Zenith angle
RCL9	ZA DM
STO6	
R↓	
STO9	ZA P
R/S	
*LBLC	HIP input
STOB	
F1?	No P?
R/S	
PRTX	
R/S	
*LBLD	Compute
RCL5	AR DM
RCL6	ZA DM
SIN	
→R	
RCL8	AR P
RCL9	ZA P
SIN	
→R	
X⇄Y	
R↑	
x	
R↓	
x	
R↑	

REGISTERS

0	1	2	3	4	5	6	7	8	9
NT	ET	ELT	HIT	REF AZ	AR DM	ZA DM	SD DM	AR P	# ZA P

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
SD P	HIP	$\cos\theta$	HD	ΔEL	

113	+		169	→P	
114	RCL6	ZA DM	170	R↓	VA P
115	COS		171	TAN	
116	RCL9	ZA P	172	RCLD	HD
117	COS		173	x	ΔEL
118	x		174	RCL2	ELT
119	+		175	+	
120	STOC	Cos θ	176	RCL3	HIT
121	RCL7	SD DM	177	+	
122	x		178	RCLB	HIP
123	ENT↑		179	-	
124	X^2		180	PRTX	ELP
125	RCL7	SD DM	181	R/S	
126	X^2		182	*LBLE	P?
127	-		183	0	
128	RCLA	SD P	184	F1?	P off?
129	X^2		185	1	
130	+		186	CF1	P on
131	√X		187	X=0?	
132	+		188	SF1	P off
133	RCL9	ZA P	189	R/S	
134	SIN				
135	x				
136	STOD	HD			
137	SPC				
138	PRTX				
139	RCL8	AR P			
140	RCL4	REF AZ			
141	+	AZ P			
142	1				
143	→R				
144	→P				
145	R↓				
146	3				
147	6				
148	0				
149	X⇄Y				
150	X<0?				
151	+				
152	→HMS				
153	PRTX	AZ P			
154	LSTX				
155	RCLD	HD			
156	→R				
157	RCL0	NT			
158	+	NP			
159	SPC				
160	PRTX				
161	X⇄Y				
162	RCL1	ET			
163	+	EP			
164	PRTX				
165	RCL9	ZA P			
166	1				
167	→R				
168	X⇄Y				

LABELS					FLAGS
A AR	B SD↑ANG	C HIP	D COMPUTE	E P?	0
a NT↑ET	b ELT	c HIT	d REF AZ	e BRG↑QD	1 P?
0 No P	1	2	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

EDM Slope Reduction

001	*LBLA	SD input	057	÷	
002	STO0		058	2	
003	F1?		059	÷	
004	SPC		060	SIN⁻¹	Curvature cor.
005	F1?		061	STO8	c
006	PRTX		062	RCL7	SD sin (ZA)
007	R/S		063	1	
008	*LBLB	EI input	064	9	
009	STO1		065	EEX	
010	F1?		066	CHS	
011	PRTX		067	8	
012	R/S		068	x	
013	*LBLC	H DM input	069	STO7	Refraction cor.
014	STO2		070	RCL8	r
015	F1?		071	2	
016	PRTX		072	x	2c
017	R/S		073	-	r−2c
018	*LBLD	H RFT input	074	RCL6	ZA
019	STO3		075	+	
020	F1?		076	SIN	sin (ZA + r − 2c)
021	PRTX		077	RCL2	H DM
022	R/S		078	RCL3	H RFT
023	*LBLa	P?	079	-	
024	1		080	RCL5	H TH
025	F1?	Is P off?	081	-	
026	0		082	RCL4	H TGT
027	SF1	P is off	083	+	
028	X=0?		084	x	
029	CF1	P is on	085	RCL0	SD
030	R/S		086	÷	
031	*LBLc	H TH input	087	SIN⁻¹	
032	STO5		088	RCL8	c
033	F1?		089	-	
034	PRTX		090	RCL7	r
035	R/S		091	+	
036	*LBLd	H TGT input	092	RCL6	ZA
037	STO4		093	+	
038	F1?		094	STO9	ZA′ (corrected)
039	PRTX		095	RCL8	c
040	R/S		096	-	
041	*LBLe	VA (ZA) input	097	SIN	Sin (ZA′ − c)
042	F1?		098	RCL0	SD
043	PRTX		099	x	
044	HMS→		100	RCL8	c
045	1		101	COS	
046	→R		102	÷	
047	X>Y?	VA?	103	STOB	HD at instrument
048	X⇄Y		104	RCLA	R
049	→P		105	x	
050	R↓	ZA	106	RCLA	R
051	STO6		107	RCL1	EI
052	SIN		108	+	
053	RCL0	SD	109	÷	HD at sea level
054	x	SD sin (ZA)	110	RCL9	ZA′
055	STO7		111	COS	
056	GSB1	R of earth	112	RCL8	SD

REGISTERS

0 SD	1 EI	2 H DM	3 H RFT	4 H TGT	5 H TH	6 ZA, ETGT	7 r	8 c	9 ZA′
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A R	B HD I	C	D	E	I

113	x	SD cos (ZA')
114	RCL8	c
115	COS	
116	÷	
117	RCL2	H DM
118	RCL3	H RFT
119	-	
120	+	ΔELEV
121	RCL1	EI
122	X⇄Y	
123	+	E TGT
124	LSTX	ΔELEV
125	X⇄Y	
126	*LBL2	
127	RCLB	HD at instrument
128	R↓	
129	R↓	
130	R↓	
131	X⇄Y	
132	PRST	
133	R/S	
134	*LBLE	E TGT input
135	STO6	
136	RCL0	SD
137	X²	
138	X⇄Y	E TGT
139	RCL3	H RFT
140	+	
141	RCL1	EI
142	-	
143	RCL2	H DM
144	-	
145	X²	
146	-	
147	GSB1	R of earth
148	RCL1	EI
149	+	
150	RCL2	H DM
151	+	
152	÷	
153	RCLA	R
154	RCL6	E TGT
155	+	
156	RCL3	H RFT
157	+	
158	÷	
159	√X	
160	RCLA	R
161	RCL1	EI
162	+	
163	x	
164	STOB	HD at instrument
165	RCLA	R
166	x	
167	RCLA	R
168	RCL1	EI
169	+	
170	÷	HD at sea level
171	RCL6	E TGT
172	RCL1	EI
173	-	ΔELEV
174	RCL6	E TGT
175	GTO2	
176	*LBL1	R of earth
177	2	
178	0	
179	9	
180	0	
181	6	
182	EEX	
183	3	20906000
184	STOA	
185	RTN	

LABELS					FLAGS
A SD	B EI	C H DM	D H RFT	E E TGT	0
a P?	b	c H TH	d H TGT	e VA/ZA	1 P?
0	1 R	2 OUTPUT	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☒	☐	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Stadia Reduction/3-Wire Level

001	*LBLA	Start	057	+	ΔEL
002	EEX		058	RCL1	HI
003	2		059	+	
004	ST05	K = 100	060	RCL2	ROD
005	0		061	SPC	
006	ST06	C = 0, clear sum	062	PRTX	
007	ST07	Clear sum	063	-	
008	R/S		064	RCL0	EL
009	*LBLB	EL, HI input	065	+	New EL
010	X⇄Y	EL	066	RCL7	ANG
011	ST00		067	PRTX	
012	SPC		068	RCL4	INT
013	PRTX		069	PRTX	
014	X⇄Y	HI	070	SPC	
015	ST01		071	R↑	HD
016	ST02	ROD = HI	072	PRTX	
017	PRTX		073	R↑	EL
018	R/S		074	PRTX	
019	*LBLC	ROD input	075	R/S	
020	ST02		076	*LBLb	EL input
021	R/S		077	ST00	
022	*LBLD	ANG input	078	SPC	
023	ST07		079	PRTX	
024	HMS→		080	R/S	
025	1	Change to vertial angle	081	*LBLc	BS inputs
026	→R		082	0	
027	X≤Y?		083	ST04	
028	X⇄Y		084	GSB0	
029	→P		085	RCL1	U
030	R↓	Vertical angle	086	RCL3	L
031	ST03		087	-	U–L
032	R/S		088	ST+6	BS stadia
033	*LBLE	INT input	089	R/S	
034	ST04		090	*LBLd	FS inputs
035	RCL3	ANG	091	1	
036	RCL6	C	092	CHS	
037	→R	C cos (ANG)	093	ST×4	
038	RCL3	ANG	094	GSB0	
039	COS		095	RCL1	U
040	X²	Cos^2 (ANG)	096	RCL3	L
041	RCL5	K	097	-	U–L
042	×		098	ST+7	FS stadia
043	RCL4	INT	099	RCL0	EL
044	×		100	RCL4	U + C + L
045	+	HD	101	3	
046	X⇄Y	C sin (ANG)	102	÷	
047	RCL3	ANG	103	-	EL
048	2		104	PRTX	
049	×		105	ST00	
050	SIN	Sin(2 ANG)	106	R/S	
051	2		107	*LBL0	Stadia compute
052	÷		108	R↓	L
053	RCL5	K	109	ST03	
054	×		110	ST+4	
055	RCL4	INT	111	R↓	C
056	×		112	ST02	

REGISTERS

0	1	2	3	4	5	6	7	8	9
EL	HI/U	ROD/C	ANG/L	INT/U+C+L	K	$C/\Sigma(U-L)_B$	$A/Z(U-L)_F$		
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
A	B	C	D	E	I				

113	ST+4	
114	R↓	U
115	STO1	
116	ST+4	U + C + L
117	RCL2	C
118	-	U–C
119	RCL2	C
120	RCL3	L
121	-	C–L
122	-	Check
123	RCL1	U
124	RCL2	C
125	RCL3	L
126	R↑	Check
127	ABS	
128	PRST	
129	RTN	
130	*LBLe	DIST output
131	RCL6	BS stadia
132	RCL5	K
133	x	BS DIST
134	ENT↑	
135	ENT↑	
136	RCL7	FS stadia
137	RCL5	K
138	x	FS DIST
139	+	TOT DIST
140	LSTX	FS DIST
141	X⇄Y	
142	6	
143	R↓	
144	PRST	
145	R/S	

LABELS					FLAGS
A START	B EL↑HI	C ROD	D ANG	E INT	0
a	b EL	c BS	d FS	e DIST	1
0 Used	1	2	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Taping Reduction/Field Angle Check

001	*LBLA	Start	057	÷	
002	CLRG		058	RCL7	P
003	2		059	PRTX	
004	0		060	X²	
005	STO0	P_o	061	÷	
006	.		062	STOA	Sag corr.
007	0		063	R/S	
008	6		064	*LBLC	HD input
009	9		065	CF2	No return
010	STO1	A	066	STOB	HD
011	3		067	0	
012	EEX		068	STOC	No ANG/ΔEL
013	7		069	*LBL0	
014	STO2	E	070	RCLB	SD
015	6		071	ENT↑	
016	8		072	ENT↑	
017	STO3	T_o	073	ENT↑	
018	6		074	x	
019	4		075	x	SD^3
020	5		076	RCLA	
021	EEX		077	x	Sag corr.
022	CHS		078	X⇄Y	SD
023	8		079	RCL8	
024	STO4	CT	080	x	T, P, CI corr.
025	.		081	-	
026	0		082	-	Corr. SD
027	1		083	F2?	
028	5		084	RTN	
029	STO5	W	085	*LBL1	
030	R/S		086	ST+9	ΣHD
031	*LBLB	T, P input	087	RCLC	ANG/ΔE1
032	STO7	P	088	F0?	ANG?
033	RCL0	P_o	089	→HMS	
034	-		090	RCLB	SD
035	RCL1	A	091	RCL9	ΣHD
036	÷		092	R↑	HD
037	RCL2	E	093	X⇄Y	
038	÷	$(P-P_o)/AE$	094	PRST	
039	STO8	Tension corr.	095	R/S	
040	X⇄Y	T	096	*LBLD	SD, ΔEL input
041	SPC		097	CF0	ΔEL
042	PRTX		098	STOC	
043	RCL3	T_o	099	X⇄Y	
044	-		100	STOB	SD
045	RCL4	CT	101	SF2	Return
046	x	$(T-T_o)$ CT	102	GSB0	Correct SD
047	ST+8	Temperature corr.	103	X²	
048	RCL6	CI	104	RCLC	
049	EEX		105	X²	
050	2		106	-	
051	÷	CI/100	107	√X	
052	ST+8	Index corr.	108	GTO1	HD
053	RCL5	W	109	*LBLE	SD, ANG input
054	X²		110	SF0	ANG
055	2		111	HMS→	
056	4		112	STOC	

REGISTERS

0	1	2	3	4	5	6	7	8	9
P_o/D	A/M	E/S	T_o/S	CT/ANG	W/ΣANG	CI/n	P	Cor	Σ HDC
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
Cor	SD	ANG/ΔEL			

Step	Key	Comment	Step	Key	Register
113	X⇄Y	SD	169	x	
114	STOB		170	ENT↑	
115	SF2	Return	171	INT	
116	GSB0	Correct SD	172	STO1	M
117	RCLC	ANG	173	-	
118	X⇄Y		174	EEX	
119	→R	HD	175	2	
120	X≤Y?		176	x	
121	X⇄Y	HD	177	STO2	S
122	GTO1		178	RCL3	S
123	*LBLa	Start	179	PRTX	
124	0		180	-	
125	STO5		181	ENT↑	
126	STO6		182	ABS	
127	R/S		183	3	
128	*LBLb	B D, R input	184	0	
129	GSB2	Average ANG	185	X⇄Y	
130	STO4	ANG	186	X≤Y?	
131	R/S		187	GTO3	
132	*LBLc	F D, R input	188	R↓	
133	GSB2	Average ANG	189	R↓	
134	RCL4	B ANG	190	6	
135	-		191	0	
136	3		192	X⇄Y	
137	6		193	÷	
138	0		194	LSTX	
139	X⇄Y		195	ABS	
140	X<0?		196	x	
141	+		197	ST+2	
142	ST+5	ΣANG	198	*LBL3	
143	1		199	RCL2	S
144	ST+6	n	200	RCL3	S
145	X⇄Y		201	+	
146	→HMS		202	1	
147	SPC		203	2	
148	PRTX		204	0	
149	R/S		205	÷	S
150	*LBLd	AVE	206	RCL1	M
151	RCL5	ΣANG	207	+	
152	RCL6	n	208	6	
153	÷	Average ANG	209	0	
154	→HMS		210	÷	
155	SPC		211	RCL0	D
156	PRTX		212	+	
157	R/S		213	RTN	
158	*LBL2	Average ANG			
159	STO3	S			
160	X⇄Y				
161	SPC				
162	PRTX				
163	ENT↑				
164	INT				
165	STO0	D			
166	-				
167	EEX				
168	2				

LABELS					FLAGS
A TAPE	B T↑P	C HD	D SD↑ΔEL	E SD↑ANG	0 ANGLE?
a FA CK	b B D↑R	c F D↑R	d AVE	e	1
0	1	2	3	4	2 RETURN?
5	6	7	8	9	3

SET STATUS		
FLAGS (ON / OFF)	TRIG	DISP
0 ☒ ☐	DEG ☒	FIX ☒
1 ☐ ☒	GRAD ☐	SCI ☐
2 ☐ ☒	RAD ☐	ENG ☐
3 ☐ ☒		n 4

Azimuth of the Sun

001	*LBLa	LAT input	057	X⇄Y	DEC
002	SPC		058	PRTX	
003	PRTX		059	X⇄Y	DIF
004	→HMS		060	PRTX	
005	EEX	Change to D.MS	061	6	
006	2		062	0	
007	÷		063	÷	DIF in hours
008	HMS→		064	STO5	
009	STO0		065	X⇄Y	DEC
010	*LBLd	Clear for AVE	066	→HMS	
011	P⇄S		067	EEX	Change to D.MS
012	CLRG		068	2	
013	P⇄S		069	÷	
014	0		070	HMS→	
015	R/S		071	STO4	
016	*LBLb	TZ, COR input	072	R/S	
017	X⇄Y	TZ	073	*LBLC	HA R input
018	PRTX		074	SPC	
019	X⇄Y	COR	075	PRTX	
020	PRTX		076	SF2	Reverse input
021	HMS→		077	1	
022	+	TZ + COR	078	8	
023	STO1		079	0	
024	R/S		080	CHS	
025	*LBLc	T, P input	081	HMS+	HA D
026	X⇄Y	T	082	GTO3	
027	PRTX		083	*LBLB	HA D input
028	X⇄Y	P	084	CF2	Direct input
029	PRTX		085	SPC	
030	2		086	PRTX	
031	.		087	*LBL3	
032	9		088	HMS→	
033	8		089	1	Normalize
034	3	Std. press.x10^{-1}	090	→R	
035	÷		091	→P	
036	5		092	R↓	
037	1	Std. temp.x10^{-1}	093	3	
038	x		094	6	
039	X⇄Y		095	0	
040	4		096	X⇄Y	
041	6		097	X<0?	
042	0		098	+	
043	+		099	STO3	
044	÷	T, P cor. factor	100	R/S	
045	STO2		101	*LBLD	TIME input
046	R/S		102	PRTX	
047	*LBLe	Average AZ	103	HMS→	
048	x̄		104	STO6	
049	→HMS	Sun's AZ	105	R/S	
050	SPC		106	*LBLE	VA (−ZA) input
051	PRTX	Ref. AZ	107	PRTX	
052	X⇄Y		108	HMS→	
053	→HMS		109	X>0?	VA?
054	PRTX		110	GTO0	
055	R/S		111	ABS	Change −ZA to VA
056	*LBLA	DEC, DIF input	112	1	

REGISTERS

0	1	2	3	4	5	6	7	8	9
LAT	TZ + COR	T, P COR	HA	DEC	DIF	TIME	VA	SUN AZ	

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
				Used	Used	Used	Used	Used	Used

A	B	C	D	E	I

Step	Key	Comment
113	→R	
114	X⇄Y	
115	→P	
116	R↓	
117	*LBL0	VA
118	1	
119	8	
120	0	
121	X⇄Y	
122	F2?	Reverse?
123	-	
124	STO7	
125	RCL7	
126	RCL7	
127	3	
128	+	
129	1	
130	2	
131	x	
132	TAN⁻¹	
133	-	
134	TAN	
135	.	
136	9	
137	7	
138	x	
139	6	
140	0	
141	÷	Refrac. cor.
142	RCL2	T, P cor. factor
143	x	
144	+	VA–correction
145	R↑	VA
146	COS	
147	2	
148	5	
149	EEX	
150	CHS	
151	4	
152	x	Parallax cor.
153	+	VA + par. cor.
154	1	
155	→R	Cos (VA)
156	RCL1	TZ + COR
157	RCL6	TIME
158	+	
159	RCL5	DIF
160	x	DEC correction
161	RCL4	DEC
162	+	DEC + cor.
163	SIN	
164	RCL0	LAT
165	SIN	
166	R↑	Sin (VA)
167	x	Sin (VA) sin (LAT)
168		Sin (DEC) – ( )
169	X⇄Y	Cos (VA)
170	RCL0	LAT
171	COS	
172	x	Cos (LAT) cos (VA)
173	÷	
174	COS⁻¹	Sun's AZ
175	RCL6	TIME
176	1	
177	2	
178	X≤Y?	P.M.?
179	GTO2	
180	R↓	
181	R↓	
182	*LBL1	A.M.
183	STO8	Sun's AZ
184	RCL3	HA D
185	-	Ref. ZA
186	RCL8	Sun's AZ
187	Σ+	Accumulate
188	LSTX	
189	→HMS	Sun's AZ
190	SPC	
191	PRTX	
192	X⇄Y	Ref. AZ
193	→HMS	
194	PRTX	
195	R/S	
196	*LBL2	P.M. adjust
197	R↓	
198	R↓	
199	CHS	
200	3	
201	6	
202	0	
203	+	360–AZ
204	GTO1	

LABELS					FLAGS
A DEC↑DIF	B HA D	C HA R	D TIME	E VA (–ZA)	0
a LAT	b TZ↑COR	c T↑P	d CLEAR	e AVE	1
0 VA	1 A.M.	2 P.M.	3 HA R	4	2 REV/DIR
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Predetermined Area

Step	Instruction	Comment	Step	Instruction	Comment
001	*LBLE	AREA input	057	PRTX	
002	STO8		058	F0?	
003	PRTX		059	GTO2	
004	F0?		060	GSB1	No coords?
005	GTO2	No coords?	061	RCL5	
006	GSB1		062	-	HD, AZ pt. 2 to pt. 1
007	RCL5	HD, AZ pt. 2 to pt. 1	063	COS	AZ2
008	-	AZ2	064	COS⁻¹	
009	STO5		065	STOC	
010	*LBL2	ANG2	066	1	
011	RCL8		067	8	ANG2
012	RCL5	AREA	068	0	
013	SIN	ANG2	069	RCL7	
014	ABS		070	RCL2	
015	RCL6	Sin(ANG2)	071	-	AZ
016	x	HD	072	COS	AZ1
017	÷	Height	073	COS⁻¹	
018	2		074	-	
019	x		075	STOB	
020	STO9	Base = D2	076	*LBL2	
021	RCL5		077	RCL6	ANG1
022	RCL6	ANG2	078	RCL6	
023	→R	HD	079	X²	HD
024	RCL9		080	RCLB	
025	-	D2	081	TAN	
026	CHS		082	1/X	ANG1
027	→P		083	RCLC	
028	X⇄Y	D1	084	TAN	
029	RCL5	ANG3	085	1/X	Cot(ANG1)
030	+		086	+	ANG2
031	COS		087	STOA	
032	CHS		088	RCL8	Cot(ANG2)
033	COS⁻¹		089	x	
034	→HMS		090	2	
035	X⇄Y	ANG1	091	x	AREA
036	RCL5		092	-	
037	→HMS	D1	093	√X	
038	RCL9	ANG2	094	-	
039	PRST		095	RCLA	
040	F0?	D2	096	÷	
041	R/S		097	STO9	
042	RCL7	No coords?	098	RCLB	
043	RCL5		099	SIN	
044	-	AZ	100	÷	Height
045	RCL9	ANG2	101	RCLB	ANG1
046	→R		102	→HMS	
047	RCL3	D2	103	X⇄Y	D1
048	+		104	RCL9	ANG1
049	X⇄Y	N2	105	RCLC	
050	RCL4	N3	106	SIN	D1
051	+		107	÷	Height
052	X⇄Y	E2	108	RCLC	ANG2
053	3	E3	109	→HMS	
054	GTO0		110	X⇄Y	D2
055	*LBLe	Pt. no.	111	PRST	ANG2
056	STO8		112	F0?	
		AREA input			D2

REGISTERS

0	1	2	3	4	5	6	7	8	9
N1	E1	AZ1	N2	E2	ANG2 AZ2	HD	AZ	AREA	D2
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
$\cot\theta + \cot\phi$	Trap. ANG1	Trap. ANG2			

Step	Key	Comment
113	GTO3	
114	RCL2	No coords?
115	R↑	
116	→R	AZ1
117	ST+0	
118	X⇄Y	
119	ST+1	
120	RCL5	
121	R↑	
122	→R	AZ2
123	ST+3	
124	X⇄Y	
125	ST+4	
126	3	
127	RCL0	
128	RCL1	Point no.
129	0	N3
130	PRST	E3
131	4	
132	RCL3	Output
133	RCL4	Point no.
134	PRST	N4
135	*LBL3	E4
136	RCL6	
137	RCLA	
138	RCL9	
139	x	E4
140	-	N2
141	PRTX	Height
142	RTN	N4
143	*LBLB	D3
144	STO4	
145	X⇄Y	N2, E2 input
146	STO3	E2
147	2	
148	GTO0	N2
149	*LBLA	Pt. no.
150	CF0	Output
151	STO1	N1, E1 input
152	X⇄Y	Coords input
153	STO0	E1
154	1	
155	*LBL0	N1
156	SPC	Pt. no.
157	PRTX	
158	R↓	
159	PRTX	
160	X⇄Y	
161	PRTX	
162	RTN	
163	*LBLC	
164	X⇄Y	
165	HMS→	BRG, QD input
166	X⇄Y	BRG
167	ENT↑	
168	ENT↑	QD Change to AZ

Step	Key	Comment
169	2	
170	÷	
171	INT	
172	1	
173	8	
174	0	
175	x	
176	X⇄Y	
177	LSTX	
178	x	
179	COS	
180	R↑	
181	x	
182	-	
183	→HMS	
184	*LBLD	AZ
185	PRTX	AZ input
186	HMS→	
187	RCL5	
188	STO2	
189	R↓	AZ1
190	STO5	
191	R/S	AZ2
192	*LBLb	
193	PRTX	ANG2 input
194	HMS→	
195	STO5	
196	STOC	
197	R/S	
198	*LBLa	ANG1 input
199	PRTX	
200	HMS→	
201	STOB	
202	R/S	
203	*LBLc	
204	SF0	HD input
205	STO6	No coords input
206	PRTX	
207	R/S	
208	*LBL1	
209	3	N, E to HD, AZ
210	6	
211	0	
212	RCL1	360
213	RCL4	E1
214	-	E2
215	RCL0	
216	RCL3	N1
217	-	N2
218	→P	
219	STO6	
220	R↓	HD
221	X<0?	
222	+	
223	STO7	
224	RTN	AZ

LABELS

A	B	C	D	E
N1↑E1	N2↑E2	BRG↑QD	AZ	

a	b	c	d	e
ANG1	ANG2	HD		

0	1	2	3	4
OUTPUT	→HD, AZ	No coord's	D3	

5	6	7	8	9

FLAGS

Flag	
0	Coord's
1	
2	
3	

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	4

Earthwork

Step	Instruction	Comment
001	*LBLA	E1, D input
002	F1?	No print?
003	GTO1	
004	X<>Y	E1
005	SPC	
006	PRTX	
007	X<>Y	D
008	PRTX	
009	*LBL1	
010	ST×1	Previous D
011	RCL1	
012	ST-2	Current D
013	R↓	E1
014	X<>Y	Previous E1
015	ST×0	
016	RCL0	Current E1
017	ST+2	DMD
018	R↓	
019	STO1	
020	R↓	
021	STO0	D/2 – DMD
022	RCL2	
023	2	Area
024	÷	
025	STO3	
026	R/S	
027	*LBLB	INT input
028	ISZI	
029	RCLI	Section no.
030	SPC	
031	PRTX	
032	R↓	
033	RCL4	Previous area
034	RCL3	Current area
035	ABS	
036	STO4	
037	X<>Y	
038	RCL4	
039	+	
040	2	
041	÷	Average area
042	R↑	Int
043	x	
044	F0?	Cu. ft.?
045	GTO0	
046	2	
047	7	
048	÷	
049	*LBL0	
050	ST+5	VOL
051	RCL5	TOT VOL
052	PRST	
053	0	
054	STO3	Clear area
055	STO2	
056	STO1	
057	STO0	
058	R/S	
059	*LBLC	Start
060	0	
061	CLRG	
062	R/S	
063	*LBLd	B, H input
064	SF2	Triangular
065	GTO3	
066	*LBLD	W, L input
067	CF2	
068	*LBL3	
069	F1?	No print?
070	GTO1	
071	X<>Y	B or W
072	SPC	
073	PRTX	
074	X<>Y	L or H
075	PRTX	
076	SPC	
077	*LBL1	
078	x	Area
079	6	
080	÷	
081	F2?	Triangular?
082	GTO2	
083	1	
084	.	
085	5	
086	x	
087	*LBL2	
088	STO3	Area/(4 or 6)
089	R/S	
090	*LBLE	E1 input
091	ST+2	
092	F1?	No print?
093	R/S	
094	PRTX	
095	R/S	
096	*LBLe	Output
097	ISZI	
098	RCLI	Section no.
099	SPC	
100	SPC	
101	PRTX	
102	RCL3	Area/(4 or 6)
103	RCL2	ΣE1
104	x	VOL
105	ABS	
106	F0?	Cu. ft.?
107	GTO0	
108	2	
109	7	
110	÷	
111	*LBL0	
112	ST+5	VOL

REGISTERS

0	1	2	3	4	5	6	7	8	9
EL	D	DMD	AREA	AREA	VOL				

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9

A	B	C	D	E	I
					SECTION

Step	Key	Comment
113	PRTX	
114	RCL5	TOT VOL
115	PRTX	
116	0	
117	STO2	Clear ΣE1
118	SPC	
119	R/S	
120	*LBLa	Print?
121	0	
122	F1?	No print on?
123	1	
124	CF1	Print on
125	X=0?	
126	SF1	Print off
127	R/S	
128	*LBLb	Cu. yd.?
129	0	
130	F0?	Cu. ft. on?
131	1	
132	CF0	Cu. yd. on
133	X=0?	
134	SF0	Cu. ft. on
135	R/S	

LABELS					FLAGS
A EL↑D	B INT→OUTPUT	C START	D W↑L	E EL	0 Cu. ft.?
a PRINT?	b Cu. Yd.?	c	d B↑H	e →OUTPUT	1 No print?
0 Skip Cu.Yd.	1 Skip print	2 Used	3	4	2 Triangle
5	6	7	8	9	3

SET STATUS				
FLAGS	ON	OFF	TRIG	DISP
0	☐	☒	DEG ☒	FIX ☒
1	☐	☒	GRAD ☐	SCI ☐
2	☐	☒	RAD ☐	ENG ☐
3	☐	☒		n 2

Coordinate Transformation

Step	Key	Comment	Step	Key	Comment
001	*LBLD	TN, TE input	057	RCL7	$\Sigma E1^2$
002	CF0	Parameters input	058	+	
003	STO5		059	RCL4	ΣN1
004	X⇄Y		060	X^2	
005	STO4		061	RCL6	ΣE1
006	R/S		062	X^2	
007	*LBLC	s, φ input	063	+	
008	CF0	Parameters input	064	RCL9	n
009	HMS→		065	÷	
010	X⇄Y		066	−	
011	→R		067	÷	
012	STOA		068	STOA	a
013	X⇄Y		069	LSTX	
014	STOB		070	RCL6	ΣE1
015	R/S		071	RCL0	ΣN2
016	*LBLe	START	072	×	
017	CLRG		073	RCL4	ΣN1
018	P⇄S		074	RCL1	ΣE2
019	CLRG		075	×	
020	0		076	−	
021	SF0	Compute params.	077	RCL9	n
022	R/S		078	÷	
023	*LBLE	P?	079	RCL3	ΣN2E1 − N1E2
024	0		080	X⇄Y	
025	F1?	P off?	081	−	
026	1		082	X⇄Y	
027	CF1	P on	083	÷	
028	X=0?		084	STOB	b
029	SF1	P off	085	RCL0	ΣN2
030	R/S		086	RCL4	ΣN1
031	*LBLB	Compute params.	087	RCLA	a
032	CF0		088	×	
033	RCL6	ΣN2	089	−	
034	RCL7	ΣE2	090	RCL6	ΣE1
035	RCL8	ΣN1N2 + E1E2	091	RCLB	b
036	RCL9	ΣN2E1 − N1E2	092	×	
037	P⇄S		093	−	
038	STO3		094	RCL9	n
039	R↓		095	÷	TN
040	STO2		096	RCL1	ΣE2
041	R↓		097	RCL6	ΣE1
042	STO1		098	RCLA	a
043	R↓		099	×	
044	STO0		100	−	
045	RCL2	ΣN1N2 + E1E2	101	RCL4	ΣN1
046	RCL4	ΣN1	102	RCLB	b
047	RCL0	ΣN2	103	×	
048	×		104	+	
049	RCL1	ΣE2	105	RCL9	n
050	RCL6	ΣE1	106	÷	TE
051	×		107	P⇄S	
052	+		108	STO5	TE
053	RCL9	n	109	X⇄Y	
054	÷		110	STO4	TN
055	−		111	R/S	
056	RCL5	$\Sigma N1^2$	112	*LBLa	N2, E2→N1, E1

REGISTERS

0	1	2	3	4	5	6	7	8	9
N1	E1	N2	E2	TN	TE	ΣN2	ΣE2	Σ	Σ

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
ΣN2	ΣE2	Σ	Σ	ΣN1	$\Sigma N1^2$	ΣE1	$\Sigma E1^2$	ΣE1N1	n

A	B	C	D	E	I
a	b			0, 1	

113	SF2	Compute N1, E1	169	RCL2	N2
114	*LBLA	N, E input	170	RCL1	E1
115	F1?	P?	171	x	
116	GTO0		172	RCL3	E2
117	X⇄Y		173	RCL0	N1
118	SPC		174	x	
119	PRTX		175	-	N2E1 − E2N1
120	X⇄Y		176	ST+9	
121	PRTX		177	P⇄S	
122	*LBL0		178	RCL9	n
123	F2?	Compute N1, E1?	179	P⇄S	
124	GTO1		180	R/S	
125	F0?	Input N, E?	181	*LBL3	N1, E1 input
126	GTO2		182	1	
127	STO1	E1	183	STOE	
128	RCLB	b	184	R↓	
129	x		185	R↓	
130	X⇄Y		186	STO1	E1
131	STO0	N1	187	X⇄Y	
132	RCLA	a	188	STO0	N1
133	x		189	Σ+	
134	+	aN1 + bE1	190	R/S	
135	RCL4	TN	191	*LBL1	Compute N1, E1
136	+	N2	192	STO3	E2
137	SPC		193	RCL5	TE
138	PRTX		194	-	
139	RCL1	E1	195	RCLA	a
140	RCLA	a	196	x	
141	x		197	X⇄Y	
142	RCL0	N1	198	STO2	N2
143	RCLB	b	199	RCL4	TN
144	x		200	-	
145	-	aE1 − bN1	201	RCLB	b
146	RCL5	TE	202	x	
147	+	E2	203	+	
148	PRTX		204	RCLA	a
149	R/S		205	X²	
150	*LBL2	N, E input	206	RCLB	b
151	RCLE	0, 1	207	X²	
152	X=0?	N1, E1 input?	208	+	
153	GTO3		209	÷	
154	0		210	STO1	E1
155	STOE		211	RCLB	b
156	R↓		212	x	
157	R↓		213	RCL4	TN
158	ST+7		214	+	
159	STO3	E2	215	RCL2	N2
160	RCL1	E1	216	X⇄Y	
161	x		217	-	
162	X⇄Y		218	RCLA	a
163	ST+6		219	÷	N1
164	STO2	N2	220	SPC	
165	RCL0	N1	221	PRTX	
166	x		222	RCL1	E1
167	+		223	PRTX	
168	ST+8	N1E1 + N2E2	224	R/S	

LABELS					FLAGS
A N↑E	B COMPUTE	C STϕ	D TN↑TE	E P?	0 Comp. par.?
a P2→P1	b	c	d	e START	1 P?
0 No Print	1 P2→P1	2 N2, E2	3 N1, E1	4	2 P2→P1?
5	6	7	8	9	3

SET STATUS				
FLAGS	ON	OFF	TRIG	DISP
0	☐	☒	DEG ☒	FIX ☒
1	☐	☒	GRAD ☐	SCI ☐
2	☐	☒	RAD ☐	ENG ☐
3	☐	☒		n 4

Geographic to Lambert

Step	Key	Comment
001	*LBLA	ϕ input
002	SPC	
003	PRTX	
004	HMS→	
005	STOB	
006	R/S	
007	*LBLB	λ input
008	PRTX	
009	HMS→	
010	STOC	
011	3	
012	6	
013	0	
014	0	
015	STOD	3600
016	x	
017	6	
018	6	
019	2	
020	4	
021	0	
022	0	
023	X⇄Y	
024	X>0?	
025	RCL1	L2
026	ABS	
027	-	
028	CHS	
029	RCL5	L6
030	x	
031	RCLD	3600
032	÷	
033	STOI	θ
034	R/S	
035	*LBLC	Compute
036	RCLB	ϕ
037	1	
038	→R	Cos (ϕ)
039	x	Cos (ϕ) sin (ϕ)
040	LSTX	Cos (ϕ)
041	X²	
042	ENT↑	
043	P⇄S	
044	RCL0	C1
045	x	
046	RCL1	C2
047	-	
048	x	
049	RCL2	C3
050	P⇄S	
051	+	
052	x	
053	RCL7	L8
054	+	
055	RCLB	ϕ
056	6	
057	0	
058	STOD	60
059	x	
060	ENT↑	
061	INT	
062	-	ϕ''
063	LSTX	ϕ'
064	RCL6	L7
065	-	
066	+	
067	RCLD	60
068	x	
069	-	
070	P⇄S	
071	RCL3	C4
072	P⇄S	
073	x	
074	STOE	s
075	EEX	
076	8	
077	÷	
078	ENT↑	
079	ENT↑	
080	ENT↑	
081	RCLA	
082	x	L11
083	RCL9	L10
084	-	
085	x	
086	RCL8	L9
087	+	
088	x	
089	x	
090	1	
091	+	
092	RCL4	L5
093	x	
094	RCLE	s
095	x	
096	RCL2	L3
097	+	
098	STOE	R
099	RCLI	θ
100	X⇄Y	
101	→R	Rcos (θ)
102	X⇄Y	Rsin (θ)
103	RCL0	L1
104	+	x
105	SPC	
106	PRTX	
107	X⇄Y	
108	RCL3	L4
109	X⇄Y	
110	-	y
111	PRTX	
112	R/S	

REGISTERS

0: L1	1: L2	2: L3	3: L4	4: L5	5: L6	6: L7	7: L8	8: L9	9: L10
S0: C1	S1: C2	S2: C3	S3: C4	S4: C5	S5: C6	S6: C7	S7: C8	S8: C9	S9: C10

A: L11	B: ϕ	C: λ	D: 3600	E: s, R	I: θ

113	*LBLD	k, θ output
114	1	
115	RCLB	ϕ
116	SIN	
117	X²	
118	P⇄S	
119	RCL4	C5
120	P⇄S	
121	×	
122	-	
123	√X	
124	RCLE	R
125	×	
126	RCL5	L6
127	×	
128	P⇄S	
129	RCL5	C6
130	P⇄S	
131	÷	
132	RCLB	ϕ
133	COS	
134	÷	k
135	SPC	
136	PRTX	
137	RCLI	θ
138	→HMS	
139	PRTX	
140	R/S	

LABELS					FLAGS
A ϕ	B λ	C →x, y	D →k, θ	E	0
a	b	c	d	e	1
0	1	2	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Lambert to Geographic

001	*LBLA	x input	057	+	w
002	STOB		058	RCLD	60
003	SPC		059	÷	w
004	PRTX		060	STOD	
005	R/S		061	1	
006	*LBLB	y input	062	→R	Cos (w)
007	STOC		063	x	Cos (w) sin (w)
008	PRTX		064	LSTX	Cos (w)
009	R/S		065	X²	
010	*LBLC	Compute	066	ENT↑	
011	RCLB	x	067	P⇄S	
012	RCL0	L1	068	RCL7	C8
013	-		069	x	
014	RCL3	L4	070	RCL8	C9
015	RCLC	y	071	+	
016	-		072	x	
017	→P		073	RCL9	C10
018	R↓	θ	074	P⇄S	
019	STOI		075	+	
020	COS		076	x	
021	1/X		077	3	
022	RCL3	L4	078	6	
023	RCLC	y	079	0	
024	-		080	0	3600
025	x		081	÷	
026	STOE		082	RCLD	w
027	RCL2	L3	083	+	φ
028	-		084	STOD	
029	RCL4	L5	085	SPC	
030	÷	s1	086	→HMS	
031	STOD		087	PRTX	
032	GSB0	s2	088	RCL1	L2
033	GSB0	s3	089	3	
034	GSB0	s	090	6	
035	P⇄S		091	0	
036	RCL6	C7	092	0	3600
037	P⇄S		093	÷	
038	x		094	RCLI	θ
039	RCL7	L8	095	RCL5	L6
040	X⇄Y		096	÷	
041	-		097	-	
042	3		098	1	
043	6		099	→R	
044	0		100	→P	
045	0		101	R↓	λ
046	0	36000	102	→HMS	
047	+	w″	103	PRTX	
048	6		104	R/S	
049	0	60	105	*LBL0	Compute s
050	STOD		106	EEX	
051	÷		107	8	
052	RCL6	L7	108	÷	
053	6		109	ENT↑	
054	0		110	ENT↑	
055	0	600	111	ENT↑	
056	-	w′	112	RCLA	L11

REGISTERS

0	1	2	3	4	5	6	7	8	9
L1	L2	L3	L4	L5	L6	L7	L8	L9	L10

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10

A	B	C	D	E	I
L11	x	y	60, s, φ, w′	R	θ

Step	Key Entry	Comments
113	x	
114	RCL9	L10
115	-	
116	x	
117	RCL8	L9
118	+	
119	x	
120	x	
121	1	
122	+	
123	1/X	
124	RCLD	s
125	x	New s
126	RTN	
127	*LBLD	k, θ output
128	1	
129	RCLD	φ
130	SIN	
131	X²	
132	P⇄S	
133	RCL4	C5
134	P⇄S	
135	x	
136	-	
137	√X	
138	RCLE	R
139	x	
140	RCL5	L6
141	x	
142	P⇄S	
143	RCL5	C6
144	P⇄S	
145	÷	
146	RCLD	φ
147	COS	
148	÷	k
149	SPC	
150	PRTX	
151	RCL1	θ
152	→HMS	
153	PRTX	
154	R/S	

LABELS

A	B	C	D	E
x	y	→φ, λ	→k, θ	
a	b	c	d	e

REGISTERS

0	1	2	3	4	5	6	7	8	9
s									

FLAGS: 0, 1, 2, 3 (no labels)

SET STATUS

FLAGS	ON	OFF
0	☐	☒
1	☐	☒
2	☐	☒
3	☐	☒

TRIG	
DEG	☒
GRAD	☐
RAD	☐

DISP	
FIX	☒
SCI	☐
ENG	☐
n	4

Lambert Data

Primary Registers

	PREG
3000000.000	0
633600.0000	1
15893950.36	2
16564628.77	3
0.999848064	4
0.796922394	5
3161.000000	6
47.87068000	7
3.799190000	8
5.915500000	9
44.00000600	A
0.000000000	B
0.000000000	C
0.000000000	D
0.000000000	E
0.000000000	I

Secondary Registers

P⇄S

	PREG
0.023520000	0
4.483344000	1
1052.893882	2
101.2794065	3
0.006768658	4
20925832.16	5
0.009873676	6
0.050912000	7
6.192760000	8
1047.546710	9
44.00000000	A
0.000000000	B
0.000000000	C
0.000000000	D
0.000000000	E
0.000000000	I

Geographic to Transverse Mercator

Step	Key	Comment
001	*LBLA	ϕ input
002	SPC	
003	PRTX	
004	HMS→	
005	STO6	
006	R/S	
007	*LBLB	λ input
008	PRTX	
009	HMS→	
010	STO7	
011	R/S	
012	*LBLC	Compute
013	RCL1	T2
014	RCL7	λ
015	3	
016	6	
017	0	
018	0	3600
019	STOC	
020	×	
021	-	
022	GSB1	
023	P⇄S	
024	RCL0	C1
025	×	
026	-	
027	RCL1	C2
028	P⇄S	
029	×	
030	RCL6	ϕ
031	COS	
032	×	
033	1	
034	RCL6	ϕ
035	SIN	
036	X²	
037	P⇄S	
038	RCL2	C3
039	P⇄S	
040	×	
041	-	
042	√X	
043	÷	
044	GSB1	
045	4	
046	.	
047	0	
048	8	
049	3	
050	1	
051	×	
052	+	Sm
053	STOA	
054	RCL4	T5
055	×	
056	P⇄S	
057	RCL9	C10
058	P⇄S	
059	×	
060	GSB1	
061	RCL5	T6
062	×	
063	+	
064	RCL0	T1
065	+	x
066	SPC	
067	PRTX	
068	STO8	
069	RCL6	ϕ
070	GSB0	$\phi 1$
071	GSB0	$\phi 2$
072	STOD	
073	1	
074	→R	Cos ($\phi 2$)
075	×	
076	LSTX	Cos ($\phi 2$)
077	X²	
078	ENT↑	
079	ENT↑	
080	.	
081	0	
082	2	
083	3	
084	5	
085	2	
086	×	
087	P⇄S	
088	RCL3	C4
089	-	
090	×	
091	RCL6	C7
092	P⇄S	
093	+	
094	×	
095	RCL3	T4
096	+	
097	RCLD	$\phi 2$
098	6	
099	0	
100	×	
101	ENT↑	
102	INT	
103	-	$\phi 2''$
104	LSTX	$\phi 2'$
105	RCL2	T3
106	-	
107	+	
108	6	
109	0	
110	×	
111	X⇄Y	
112	-	

REGISTERS

0	1	2	3	4	5	6	7	8	9
T1	T2	T3	T4	T5	T6	ϕ	λ	x	
S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
C1	C2	C3	C4	C5	C6	C7	C8	C9	C10

A	B	C	D	E	I
Sm		3600	ϕ_2	λ - T2	

Step	Key	Comment	Step	Key	Comment
113	RCL4	T5	169	RCL7	λ
114	x		170	RCLC	3600
115	P⇄S		171	x	
116	RCL5	C6	172	RCL1	T2
117	P⇄S		173	-	
118	x	y	174	STOE	
119	PRTX		175	X²	
120	R/S		176	x	
121	*LBL1		177	x	
122	ENT↑		178	1	
123	ENT↑		179	.	
124	EEX		180	9	
125	5	10^5	181	5	
126	÷		182	8	
127	3		183	7	
128	Y^x		184	EEX	
129	RTN		185	CHS	
130	*LBL0	φ	186	1	
131	TAN		187	2	
132	LSTX		188	x	
133	SIN	Sin (φ)	189	-	
134	X²		190	RCLE	λ - T2
135	P⇄S		191	x	
136	RCL2	C3	192	CHS	
137	P⇄S		193	RCLC	3600
138	x		194	÷	Δα
139	1		195	→HMS	
140	X⇄Y		196	SPC	
141	-		197	PRTX	
142	X²		198	RCL8	x
143	x		199	RCL0	T1
144	RCLA	Sm	200	-	
145	X²		201	EEX	
146	x		202	6	
147	P⇄S		203	÷	
148	RCL4	C5	204	RCL4	T5
149	P⇄S		205	÷	
150	x		206	RCL6	φ
151	EEX		207	COS	
152	1		208	X²	
153	0		209	P⇄S	
154	÷		210	RCL7	C8
155	RCLC	3600	211	x	
156	÷		212	1	
157	RCL6	φ	213	+	
158	+	New φ	214	x	
159	RTN		215	X²	
160	*LBLD	Δα, k output	216	RCL8	C9
161	RCL6	φ	217	÷	
162	RCLD	φ2	218	P⇄S	
163	+		219	1	
164	2		220	+	
165	÷		221	RCL4	T5
166	1		222	x	k
167	→R		223	PRTX	
168	X²		224	R/S	

LABELS					FLAGS
A φ	B λ	C →x, y	D →Δα, k	E	0
a	b	c	d	e	1
0 φ	1 Used	2	3	4	2
5	6	7	8	9	3

SET STATUS				
FLAGS	ON	OFF	TRIG	DISP
0	☐	☒	DEG ☒	FIX ☒
1	☐	☒	GRAD ☐	SCI ☐
2	☐	☒	RAD ☐	ENG ☐
3	☐	☒		n 4

Transverse Mercator to Geographic

Step	Key	Comment
001	*LBLA	x input
002	SPC	
003	PRTX	
004	STO8	
005	R/S	
006	*LBLB	y input
007	PRTX	
008	STO9	
009	R/S	
010	*LBLC	Compute
011	RCL8	x
012	RCL0	T1
013	-	
014	GSB0	Sg1
015	GSB0	
016	RCL4	
017	÷	
018	.	
019	3	
020	0	
021	4	
022	8	
023	0	
024	0	
025	6	
026	0	
027	9	
028	9	
029	x	Sm
030	STOA	
031	RCL9	y
032	.	
033	0	
034	0	
035	9	
036	8	
037	7	
038	3	
039	6	
040	7	
041	5	
042	5	
043	5	
044	3	
045	x	
046	RCL4	T5
047	÷	
048	RCL3	T4
049	+	
050	STOE	w''
051	6	
052	0	
053	STOC	60
054	÷	
055	RCL2	T3
056	+	w'
057	RCLC	60
058	÷	w
059	1	
060	→R	Cos (w)
061	x	
062	LSTX	Cos (w)
063	X²	
064	ENT↑	
065	ENT↑	
066	.	
067	0	
068	5	
069	0	
070	9	
071	1	
072	2	
073	x	
074	6	
075	.	
076	1	
077	9	
078	2	
079	7	
080	6	
081	+	
082	x	
083	1	
084	0	
085	4	
086	7	
087	.	
088	5	
089	4	
090	6	
091	7	
092	1	
093	+	
094	x	
095	RCLE	w
096	+	
097	STOE	(φ')'
098	RCLC	60
099	÷	
100	RCL2	T3
101	+	
102	RCLC	60
103	÷	φ'
104	TAN	
105	LSTX	
106	GSB2	
107	X²	
108	x	
109	RCLA	Sm
110	EEX	
111	5	
112	÷	

REGISTERS

0 T1	1 T2	2 T3	3 T4	4 T5	5 T6	6 φ	7	8 x	9 y
S0 C1	S1 C2	S2 C3	S3 C4	S4 C5	S5 C6	S6 C7	S7 C8	S8 C9	S9 C10
A Sm	B Used	C 60	D	E w'', (φ')'	I				

113	X²	
114	x	
115	P⇄S	
116	RCL4	C5
117	P⇄S	
118	x	
119	RCLE	(φ')'
120	X⇄Y	
121	-	φ''
122	RCLC	60
123	÷	
124	RCL2	T3
125	+	
126	RCLC	60
127	÷	
128	STO6	φ
129	→HMS	
130	SPC	
131	PRTX	
132	4	
133	.	
134	8	
135	8	
136	3	
137	1	
138	STOB	
139	RCLA	Sm
140	RCLA	
141	RCLA	
142	GSB1	Sa
143	GSB1	S1
144	RCL6	φ
145	GSB2	
146	√X	
147	x	
148	P⇄S	
149	RCL1	C2
150	P⇄S	
151	÷	
152	RCL6	φ
153	COS	
154	÷	Δλ1
155	ENT↑	
156	ENT↑	
157	ENT↑	
158	P⇄S	
159	RCL0	C1
160	P⇄S	
161	CHS	
162	STOB	
163	R↓	
164	GSB1	Δλa
165	RCL1	T2
166	X⇄Y	
167	-	λ''
168	RCLC	60
169	÷	
170	RCLC	60
171	÷	
172	STO7	λ
173	→HMS	
174	PRTX	
175	R/S	
176	*LBL0	S
177	EEX	
178	5	
179	÷	
180	3	
181	Yˣ	
182	RCL5	T6
183	x	
184	RCL8	x
185	RCL0	T1
186	-	
187	X⇄Y	
188	-	
189	RTN	New S
190	*LBL1	
191	EEX	
192	5	
193	÷	
194	3	
195	Yˣ	
196	RCLB	
197	x	
198	-	
199	RTN	
200	*LBL2	
201	SIN	
202	X²	
203	P⇄S	
204	RCL2	C3
205	P⇄S	
206	x	
207	1	
208	X⇄Y	
209	-	
210	RTN	

LABELS					FLAGS
A x	B y	C →φ, λ	D	E	0
a	b	c	d	e	1
0 S	1 Used	2 Used	3	4	2
5	6	7	8	9	3

SET STATUS		
FLAGS (ON / OFF)	TRIG	DISP
0 ☐ ☒	DEG ☒	FIX ☒
1 ☐ ☒	GRAD ☐	SCI ☐
2 ☐ ☒	RAD ☐	ENG ☐
3 ☐ ☒		n 4

Mecator Data

Primary Registers

```
               PREG

500000.0000    0
416700.0000    1
2491.000000    2
18.35150000    3
0.999933333    4
0.380622700    5
0.000000000    6
0.000000000    7
0.000000000    8
0.000000000    9
0.000000000    A
0.000000000    B
0.000000000    C
0.000000000    D
0.000000000    E
0.000000000    I
```

Secondary Registers

```
               P⇄S
               PREG

3917.400000    0
30.92241724    1
0.006768658    2
4.483344000    3
25.52381000    4
101.2794065    5
1052.893882    6
0.006814785    7
881.7491620    8
3.280833330    9
```

Geographic to Alaska 2-9

001	*LBLA	z input	057	x	
002	STOC		058	RCL2	C2
003	4		059	x	
004	x		060	STOI	
005	1		061	2	
006	3		062	CHS	
007	4		063	RCL3	C3
008	+		064	0	
009	STOE	CM	065	GSB1	
010	9		066	RCL4	C4
011	RCLC		067	x	
012	X≠Y?	Not zone 9?	068	RCLI	
013	GTO0		069	+	
014	6		070	RCLE	$((CM - \lambda)/10^4)^2$
015	GTO1		071	x	
016	*LBL0		072	1	
017	7		073	+	
018	X=Y?	Zone 7?	074	RCLE	
019	GTO1		075	√X	$(CM - \lambda)/10^4$
020	5		076	x	
021	*LBL1		077	RCLD	$\text{Cos}^2(\phi)$
022	EEX		078	1/X	
023	5		079	RCL3	C3
024	x		080	−	
025	STOC	C	081	√X	
026	R/S		082	÷	
027	*LBLB	ϕ input	083	RCL5	C5
028	PRTX		084	x	
029	HMS→		085	RCLC	C
030	STOA		086	+	
031	R/S		087	STOI	x
032	*LBLC	λ input	088	SPC	
033	PRTX		089	PRTX	
034	HMS→		090	P⇄S	
035	STOB		091	6	
036	R/S		092	CHS	
037	*LBLD	Compute x, y	093	RCL1	C11
038	RCLA	ϕ	094	RCL0	C10
039	COS		095	GSB1	
040	X²		096	RCLE	$((CM - \lambda)/10^4)^2$
041	STOD	$\text{Cos}^2(\phi)$	097	x	
042	2		098	RCL2	C12
043	0		099	x	
044	CHS		100	1	
045	RCL1	C1	101	+	
046	RCL0	C0	102	RCLE	$((CM - \lambda)/10^4)^2$
047	GSB1		103	x	
048	RCLE	CM	104	RCLD	$\text{Cos}^2(\phi)$
049	RCLB	λ	105	1/X	
050	−		106	RCL3	C13
051	.		107	+	
052	3		108	√X	
053	6		109	÷	
054	x		110	RCL4	C14
055	X²		111	x	
056	STOE	$((CM - \lambda)/10^4)^2$	112	RCLA	ϕ

REGISTERS

0	1	2	3	4	5	6	7	8	9
C0	C1	C2	C3	C4	C5	C6	C7	C8	C9

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
C10	C11	C12	C13	C14	C15	C16	C17	C18	C19

A	B	C	D	E	I
ϕ	λ	C	$\cos^2\phi$	Used	x

Step	Key	Comments
113	SIN	
114	x	
115	STOB	
116	RCL6	C16
117	RCL5	C15
118	0	
119	GSB1	
120	RCL7	C17
121	+	
122	RCLA	ϕ
123	1	
124	→R	
125	x	
126	x	
127	RCL8	C18
128	-	
129	RCLA	ϕ
130	3	
131	6	
132	0	
133	0	
134	x	
135	+	
136	RCL9	C19
137	x	
138	RCLB	
139	+	y
140	PRTX	
141	P⇄S	
142	R/S	
143	*LBLE	Compute $\Delta\alpha$, k
144	RCLD	$\text{Cos}^2\ (\phi)$
145	X^2	
146	3	
147	x	
148	RCLD	$\text{Cos}^2\ (\phi)$
149	-	
150	RCLE	$((\text{CM} - \lambda)/10^4)^2$
151	x	
152	RCL6	C6
153	x	
154	STOB	
155	1	
156	RCL7	C7
157	9	
158	EEX	
159	CHS	
160	4	
161	GSB1	
162	1	
163	-	
164	RCL8	C8
165	x	
166	RCLB	
167	+	
168	RCLE	$((\text{CM} - \lambda)/10^4)^2$
169	x	
170	EEX	
171	4	
172	+	
173	RCLE	$((\text{CM} - \lambda)/10^4)^2$
174	√X	
175	x	
176	RCLA	ϕ
177	SIN	
178	x	
179	3	
180	6	
181	0	
182	0	
183	÷	$\Delta\alpha$
184	→HMS	
185	SPC	
186	PRTX	
187	RCLI	x
188	RCLC	C
189	-	
190	EEX	
191	6	
192	÷	
193	X^2	
194	RCL9	C9
195	÷	
196	1	
197	RCLD	$\text{Cos}^2\ (\phi)$
198	RCL3	C3
199	x	
200	-	
201	X^2	
202	x	
203	1	
204	+	
205	.	
206	9	
207	9	
208	9	
209	9	
210	x	k
211	PRTX	
212	R/S	
213	*LBL1	
214	RCLD	$\text{Cos}^2\ (\phi)$
215	x	
216	+	
217	RCLD	$\text{Cos}^2\ (\phi)$
218	x	
219	+	
220	RCLD	$\text{Cos}^2\ (\phi)$
221	x	
222	1	
223	+	
224	RTN	

LABELS					FLAGS
A Z	B ϕ	C λ	D →x, y	E →$\Delta\alpha$, k	0
a	b	c	d	e	1
0 Used	1 Used	2	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Data Card—Geo to Alaska 2-9

Primary Registers

	PREG
0.490700000	0
23.60470000	1
0.000000046	2
-0.006814785	3
-0.000391741	4
1017862.150	5
0.003683000	6
0.020440000	7
7.834810000	8
881.5728210	9
71.00000000	A
8855.241726	B
500000.0000	C
0.105994623	D
1.166400000	E
857636.1683	I

Secondary Registers

P⇄S

	PREG
-0.000185770	0
-0.006133306	1
-0.000195870	2
0.006814785	3
24673.67480	4
-0.023559000	5
4.483386000	6
-1053.893943	7
193900.0544	8
101.2692765	9
71.00000000	A
8855.241726	B
500000.0000	C
0.105994623	D
1.166400000	E
857636.1683	I

Alaska 2-9 to Geographic

Step	Key	Comment
001	*LBLA	z input
002	4	
003	x	
004	1	
005	3	
006	4	
007	+	
008	STOE	CM
009	9	
010	RCLC	
011	X≠Y?	Not zone 9?
012	GTO0	
013	6	
014	GTO1	
015	*LBL0	
016	7	
017	X=Y?	Zone 7?
018	GTO1	
019	5	
020	*LBL1	
021	EEX	
022	5	
023	x	
024	STOC	C
025	R/S	
026	*LBLB	x input
027	SPC	
028	PRTX	
029	STOI	
030	R/S	
031	*LBLC	y input
032	PRTX	
033	STOB	
034	R/S	
035	*LBLD	Compute ϕ, λ
036	P⇄S	
037	RCLB	y
038	RCL0	C10
039	x	
040	RCL1	C11
041	+	
042	STOA	w''
043	3	
044	6	
045	0	
046	0	
047	÷	
048	1	
049	→R	
050	x	
051	LSTX	Cos (w)
052	X^2	
053	ENT↑	
054	ENT↑	
055	RCL2	C12
056	x	
057	RCL3	C13
058	+	
059	x	
060	RCL4	C14
061	+	
062	x	
063	RCLA	w''
064	+	$(\phi')''$
065	ENT↑	
066	ENT↑	
067	3	
068	6	
069	0	
070	0	
071	÷	ϕ'
072	COS	
073	X^2	
074	STOD	$\cos^2(\phi')$
075	2	
076	.	
077	7	
078	9	
079	EEX	
080	CHS	
081	4	
082	x	
083	RCL5	C15
084	+	
085	RCLD	$\cos^2(\phi')$
086	x	
087	3	
088	RCLD	$\cos^2(\phi')$
089	÷	
090	+	
091	RCL6	C16
092	+	
093	RCL7	C17
094	x	
095	RCLI	x
096	RCLC	C
097	-	
098	EEX	
099	6	
100	÷	
101	X^2	
102	STOB	$((x - C)/10^6)^2$
103	x	
104	1	
105	+	
106	RCLB	$((x - C)/10^6)^2$
107	x	
108	RCL9	C19
109	x	
110	RCLD	$\cos^2(\phi')$
111	RCL8	C18
112	x	

REGISTERS

0	1	2	3	4	5	6	7	8	9
C0	C1	C2	C3	C4	C5	C6	C7	C8	C9

S0	S1	S2	S3	S4	S5	S6	S7	S8	S9
C10	C11	C12	C13	C14	C15	C16	C17	C18	C19

A	B	C	D	E	I
w'', ϕ	Used	C	$\cos^2(\phi')$	CM	x

113	1	
114	+	
115	X²	
116	x	
117	RCLD	$\cos^2(\phi')$
118	1/X	
119	1	
120	-	
121	√X	
122	x	
123	+	
124	3	
125	6	
126	0	
127	0	
128	÷	ϕ
129	STOA	
130	→HMS	
131	SPC	
132	PRTX	
133	P⇄S	
134	2	
135	4	
136	RCLD	$\cos^2(\phi')$
137	÷	
138	2	
139	0	
140	-	
141	RCLD	$\cos^2(\phi')$
142	÷	
143	RCL0	C0
144	RCLD	$\cos^2(\phi')$
145	x	
146	+	
147	RCL1	C1
148	+	
149	RCLB	$((x - C)/10^6)^2$
150	x	
151	1	
152	RCLD	$\cos^2(\phi')$
153	RCL3	C3
154	x	
155	-	
156	X²	
157	x	
158	RCL2	C2
159	x	
160	RCL3	C3
161	RCLD	$\cos^2(\phi')$
162	CHS	
163	x	
164	1	
165	-	
166	2	
167	RCLD	$\cos^2(\phi')$
168	÷	
169	+	$\cos(\phi')$
170	RCLD	C3
171	RCL3	
172	CHS	
173	x	
174	1	
175	+	
176	x	
177	RCL4	C4
178	x	
179	+	
180	RCLB	$((x - C)/10^6)^2$
181	x	
182	1	
183	+	
184	RCLD	$\cos^2(\phi')$
185	1/X	
186	RCL3	C3
187	-	
188	RCLB	$((x - C)/10^6)^2$
189	x	
190	√X	
191	x	
192	RCL5	C5
193	x	
194	3	
195	6	
196	0	
197	0	
198	÷	
199	RCLE	CM
200	+	
201	→HMS	λ
202	PRTX	
203	LSTX	
204	RCLE	CM
205	X⇄Y	
206	-	
207	.	
208	3	
209	6	
210	x	
211	X²	
212	STOE	$((CM - \lambda)/10^4)^2$
213	RCLA	ϕ
214	COS	
215	X²	$\cos^2(\phi)$
216	STOD	
217	R/S	

LABELS					FLAGS
A Z	B x	C y	D →φ, λ	E	0
a	b	c	d	e	1
0 Used	1 Used	2	3	4	2
5	6	7	8	9	3

SET STATUS

FLAGS	ON	OFF	TRIG		DISP	
0	☐	☒	DEG	☒	FIX	☒
1	☐	☒	GRAD	☐	SCI	☐
2	☐	☒	RAD	☐	ENG	☐
3	☐	☒			n	4

Data Card—Alaska 2-9 to Geo

Primary Registers		Secondary Registers	
			P⇄S
	PREG		PREG
-0.013600000	0	0.009874663	0
1.054000000	1	193900.0544	1
0.000000043	2	0.050699000	2
-0.006814785	3	6.193011000	3
-0.000378112	4	1047.546690	4
-9824.513072	5	0.081359000	5
0.003683000	6	1.959111300	6
0.020440000	7	-0.000189056	7
7.834810000	8	0.006814785	8
881.5728210	9	-233.9736450	9
0.000000000	A	0.000000000	A
0.000000000	B	0.000000000	B
0.000000000	C	0.000000000	C
0.000000000	D	0.000000000	D
0.000000000	E	0.000000000	E
0.000000000	I	0.000000000	I

Appendix A

MAGNETIC CARD SYMBOLS AND CONVENTIONS

SYMBOL OR CONVENTION	INDICATED MEANING
White mnemonic: x A	White mnemonics are associated with the user definable key they are above when the card is inserted in the calculator's window slot. In this case the value of x could be input by keying it in and pressing A.
Gold mnemonic: y x f E	Gold mnemonics are similar to white mnemonics except that the gold f key must be pressed before the user definable key. In this case y could be input by pressing f E.
x↑y A	↑ is the symbol for ENTER↑. In this case ENTER↑ is used to separate the input variables x and y. To input both x and y you would key in x, press ENTER↑, key in y and press A.
$\boxed{x}$ A	The box around the variable x indicates input by pressing STO A.
(x) A	Parentheses indicate an option. In this case, x is not a required input but could be input in special cases.
→x A	→ is the symbol for calculate. This indicates that you may calculate x by pressing key A.
→x, y, z A	This indicates that x, y, and z are calculated by pressing A once. The values would be printed in x, y, z order.
→x; y; z A	The semi-colons indicate that after x has been calculated using A, y and z may be calculated by pressing R/S.
→"x," y A	The quote marks indicate that the x value will be "paused" or held in the display for one second. The pause will be followed by the display of y.
⟷ x A	The two-way arrow ⟷ indicates that x may be either output or input when the associated user definable key is pressed. If numeric keys have been pressed between user-definable keys, x is stored. If numeric keys have not been pressed, the program will calculate x.

MAGNETIC CARD SYMBOLS AND CONVENTIONS (continued)

SYMBOL OR CONVENTION	INDICATED MEANING
P? A	The question mark indicates that this is a mode setting, while the mnemonic indicates the type of mode being set. In this case a print mode is controlled. Mode settings typically have a 1.00 or 0.00 indicator displayed after they are executed. If 1.00 is displayed, the mode is on. If 0.00 is displayed, it is off.
START A	The word START is an example of a command. The start function should be performed to begin or start a program. It is included when initialization is necessary.
DEL A	This special command indicates that the last value or set of values input may be deleted by pressing A.

Appendix B-1
FORMULAS AND REFERENCES

GENERAL REFERENCES:

1. Surveying, Theory and Practice, Fifth Edition, Raymond E. Davis, Francis S. Foote, Joe W. Kelly, McGraw Hill Book Company, New York, 1966.

2. Surveying, Sixth Edition, Francis H. Moffitt and Harry Bouchard, Intex Educational Publishers, New York, 1975.

Program 1—Traverse, Inverse and Sideshots

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

2. $\text{HD} = \text{SD} \sin (\text{zenith angle})$

3. $\text{HD} = \text{SD} \cos (\text{vertical angle})$

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 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 =

$$k = 1: \text{LAT}_1\left(\frac{1}{2}\text{DEP}_1\right)$$

$$k = 2: \text{LAT}_2\left(\frac{1}{2}\text{DEP}_2 + \text{DEP}_1\right)$$

$$k = 3: \text{LAT}_3\left(\frac{1}{2}\text{DEP}_3 + \text{DEP}_1 + \text{DEP}_2\right)$$

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

7. Segment area $= \dfrac{R^2}{2}\left(\dfrac{\Delta\pi}{100} - \sin\Delta\right)$

8. Arc length: $L = \dfrac{R\Delta\pi}{180}$

where:

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

QD = Quadrant.

BRG = Bearing.

HD = Horizontal distance.

SD = Slope distance.

n = Number of points in survey.

R = Radius of curve of segment boundary.

Δ = Central angle of curve of segment boundary.

Program 2—Traverse Adjustment

See reference 1, pp 458-463

Compass Rule for latitude and departure course correction:

9. Corrected latitude$_1 = L_1 + \ell_1 = L_1 + \dfrac{(HD)_1(ER\ L)}{\Sigma(HD)}$

10. Corrected departure$_1 = D_1 + d_1 = D_1 + \dfrac{(HD)_1(ER\ L)}{\Sigma\ (HD)}$

Crandall Rule for latitude and departure course correction:

11. $$A = \frac{(ER\ D)\left[\Sigma\dfrac{(L)(D)}{(HD)}\right] - (ER\ L)\left[\Sigma\dfrac{D^2}{(HD)}\right]}{\left[\Sigma\dfrac{D^2}{(HD)}\right]\left[\Sigma\dfrac{L^2}{(HD)}\right] - \left[\Sigma\dfrac{(L)(D)}{(HD)}\right]^2}$$

12. $$B = \frac{(ER\ L)\left[\Sigma\dfrac{(L)(D)}{(HD)}\right] - (ER\ D)\left[\Sigma\dfrac{L^2}{(HD)}\right]}{\left[\Sigma\dfrac{D^2}{(HD)}\right]\left[\Sigma\dfrac{L^2}{(HD)}\right] - \left[\Sigma\dfrac{(L)(D)}{(HD)}\right]^2}$$

13. $(hd)_1 = (L_1)(A) + (D_1)(B)$

14. $(hd)_2 = (L_2)(A) + (D_2)(B)$

etc.

15. $\ell_1 = (hd)_1 \left[\frac{L_1}{(HD)_1}\right] = A\left[\frac{L_1^2}{(HD)_1}\right] + B\left[\frac{L_1D_1}{(HD)_1}\right]$

etc.

16. $d_1 = (hd)_1 \left[\frac{D_1}{(HD)_1}\right] = A\left[\frac{D_1L_1}{(HD)_1}\right] + B\left[\frac{D_1^2}{(HD)_1}\right]$

etc.

17. Corrected latitude$_1 = L_1 + \ell_1$

etc.

18. Corrected departure$_1 = D_1 + d_1$

etc.

where:

A and B are intermediate values used in the calculations.

(ER D) = Total error in departure.

(ER L) = Total error in latitude.

L = Uncorrected latitude of any course.

D = Uncorrected departure of any course.

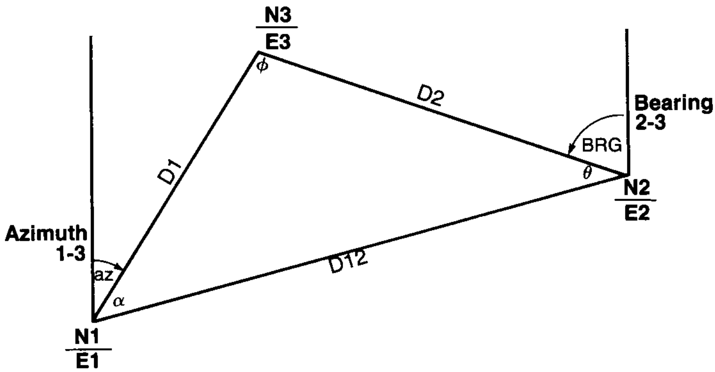
(HD) = Uncorrected horizontal distance of any course.

$(hd)_1$ = Correction to be applied to the uncorrected horizontal distance of the first course.

ℓ_1 = Correction to be applied to the uncorrected latitude of the first course.

d_1 = Correction to be applied to the uncorrected departure of the first course.

Program 3—Intersections



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

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

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

Representative equations for solving the four intersection problems:

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

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

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

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

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

For bearing-bearing case:

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

For bearing-distance case:

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

For distance-distance case:

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

29. $\cos \alpha = \dfrac{(D12)^2 + (D1)^2 - (D2)^2}{2(D12)(D1)}$

For offset from a point to a line:

30. $D2 = (D12) \sin \alpha$, then use 27.

Program 4—Curve Solutions

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

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

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

34. $T = R \tan\left(\dfrac{\Delta}{2}\right)$

35. $R = \dfrac{C}{2 \sin (\Delta/2)}$

36. $E = T \tan\left(\dfrac{\Delta}{4}\right)$

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

38. Sector area $= \dfrac{\pi R^2 \Delta}{360} = \dfrac{LR}{2}$

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

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

40. Fillet area = RT − Sector area

where:

L = Arc length
R = Radius
Δ = Central angle
C = Chord
T = Tangent
E = External
M = Mid ordinate

Program 5—Horizontal Curve Layout

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

42. Deflection angle $= \frac{\Delta}{2}$

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

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

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

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

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

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

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

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

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

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

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

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.

Program 6—Spiral Curve Layout

Reference: "Standard Highway Spiral," Oregon State Highway Division Technical Bulletin No. 20—Revised, Oregion Department of Transportation, August 1973, by H.W. Libby and E.M. Booth.

54. $R = \dfrac{18{,}000}{\pi D}$

55. $S = \dfrac{90L}{\pi R}$

56. $\theta_S = \dfrac{S\pi}{180} = \dfrac{L}{2R}$

57. $\theta = \left(\dfrac{\ell_S}{L}\right)^2 \left(\dfrac{\pi S}{180}\right)$

58. $X = TO = \ell_S \left[\dfrac{\theta}{3} - \dfrac{\theta^3}{42} + \dfrac{\theta^5}{1320} - \dfrac{\theta^7}{75{,}600} + \dfrac{\theta^9}{6{,}894{,}720}\right]$

59. $Y = TD = \ell_S \left[1 - \dfrac{\theta^2}{10} + \dfrac{\theta^4}{216} - \dfrac{\theta^6}{9360} + \dfrac{\theta^8}{685{,}440}\right]$

60. $U = Y_S - X_S \cot S$

61. $p = X_S - R\,(1 - \cos S)$

62. $q = Y_S - R \sin S$

63. $T_S = q + (R + p)\tan\dfrac{T_\Delta}{2}$

64. $CD = \sqrt{X^2 + Y^2}$

65. $ANG = \tan^{-1}\dfrac{X}{Y}$

where:

NOTE: See figures in program description to clarify definitions.

R = Radius of central curve.

D = Degree of curve of central curve.

S = Central angle of each spiral.

L = Length of each spiral (distance along curve).

θ_S = S expressed in radians.

θ = Central angle of spiral curve section between PS and station on spiral (between beginning station of spiral and any other station on spiral).

ℓ_S = Length of spiral, measured along curve, between PS and any station on spiral.

X = TO = Tangent offset = Perpendicular from tangent to station on curve, where tangent is line which is tangent to curve at PS.

Y = TD = Tangent distance = distance along tangent from PS to right angle intersection of tangent and tangent offset X.

U = Distance along tangent from PS to PSI where PSI is intersection of spiral tangents; i.e., intersection of tangents from PS and PSC.

Y_S = Y for station at PSC.

X_S = X for station at PSC.

p = The offset from the PS tangent to the point where the tangent to the circular curve (extended backward or forward) becomes parallel to the main tangent.

q = The distance along the tangent from the PS to the offset p.

T_S = Distance along tangent from PS to PI, where PI is the intersection of the main tangents from PS and PT.

T_Δ = Total angle, equal to $\Delta + 2S$, the central angle of the circular curve plus the central angles of both equal spirals.

CD = Length of chord from PS to any station on spiral curve.

ANG = Deflection angle from main tangent to chord CD.

Program 7—Vertical Curves and Grades

Grades:

66. $$EL = (STA - STA1)\frac{G1}{100} + EL1$$

where:

EL = Elevation at station STA.

STA = Station with elevation EL.

STA1 = Beginning station.

G1 = Grade (in percent).

EL1 = Beginning elevation.

Vertical Curves

Length and beginning station (L and PC) known:

67. $$\left(\frac{Gn - G1}{200L}\right)(STA - PC)^2 + \left(\frac{G1}{100}\right)(STA - PC) + (EL1 - EL) = 0$$

$(ax^2 + bx + c = 0)$

Length and intersection of tangents station (L and PI) known:

68. $$PC = PI - \frac{L}{2} \text{ (Substitute in eq. 67)}$$

High or low point elevation and beginning station (EL_0 and PC) known:

69. $$L = 200(EL1 - EL_0)(Gn - G1)\left(\frac{1}{G1^2}\right)$$

High or low point elevation and point of tangent intersection (EL_0 and PI) known:

70. $$L = 200(EL1 - EL_0)(Gn - G1)\left(\frac{1}{GnG1}\right)$$

Curve to pass through specified point:

PC known:

71. $$L = \left[\frac{(STA - PC)^2}{\frac{G1}{100}(STA - PC) - (EL - EL1)}\right]\left[\frac{200}{G1 - Gn}\right]$$

PI known:

72. $$\left(\frac{1}{4}\right)L^2 + \left[(STA - PI) - \frac{200}{G1 - Gn}\left\{\frac{G1}{100}(STA - PI) - (EL - ELI)\right\}\right]L + (STA - PI)^2 = 0$$

$(aL^2 + bL + c = 0)$

73. $$EL1 = ELI - \left(\frac{G1}{100}\right)\left(\frac{L}{2}\right)$$

Roots of quadratic equation $ax^2 + bx + c = 0$:

74. $$x = \frac{-b \pm \sqrt{b - 4ac}}{2a}$$

where:

Gn = Ending grade (in percent).

G1 = Beginning grade (in percent).

L = Length of curve measured along horizontal.

STA = Station along horizontal with curve elevation EL.

PC = Beginning station (point of curve).

EL1 = Beginning elevation.

EL = Elevation of curve at station STA.

$ax^2 + bx + c$ = General form of quadratic equation.

PI = Station of tangent intersection point (intersection of lines tangent to curve at beginning and ending of curve).

EL_0 = Elevation of high or low power of curve.

ELI = Elevation of curve at station PI.

Program 8—Resection

75. $$\frac{\sin a}{A} = \frac{\sin b}{B} = \frac{\sin c}{C} \text{ (law of sines)}$$

76. $$K = \frac{L2 \sin A}{L1 \sin B}$$

77. $$A + B + C + D + E = 360°$$

78. $$\tan \theta 1 = \frac{E2 - E1}{N2 - N1}$$

79. $$\tan \theta 2 = \frac{E3 - E2}{N3 - N2}$$

80. $$\tan\left(\frac{D - E}{2}\right) = \frac{\left[\frac{L2 \sin A}{L1 \sin B} - 1\right] \tan\left(\frac{D + E}{2}\right)}{\frac{L2 \sin A}{L1 \sin B} + 1}$$

where:

A, B, C = Sides of any plane triangle.

a, b, c = Opposite angles.

K = Expression used in comments associated with program listing.

A, B, C, D, E = The 5 angles shown in resection diagram in program description.

$\theta 1$, $\theta 2$ = Auxiliary angles used in resection solution.

E2, E1, N2, N1, E3, E2, N3, N2 = Coordinates of 3 points in resection diagram.

L1 = Distance between points 1 and 2 in resection diagram.

L2 = Distance between points 2 and 3 in resection diagram.

Program 9—Two Instrument Radial Survey

81. $\cos \alpha = \sin (\text{AR DM}) \sin (\text{ZA DM})$

82. $\cos \beta = \cos (\text{AR DM}) \sin (\text{ZA DM})$

83. $\cos \gamma = \cos (\text{ZA DM})$

84. $\text{SD DM} = \dfrac{\text{HD DM}}{\sin (\text{ZA DM})}$

85. $\cos \theta = \cos \alpha \sin (\text{AR P}) \sin (\text{ZA P}) + \cos \beta \cos (\text{AR P}) \sin (\text{ZA P}) + \cos \gamma \cos (\text{ZA P})$

86. HD P =

$$\left[(\text{SD DM}) \cos \theta + \sqrt{(\text{SD P})^2 - (\text{SD DM})^2 + (\text{SD DM})^2 \cos^2 \theta}\right] \sin (\text{ZA P})$$

where:

$\cos \alpha, \cos \beta, \cos \gamma$ = Direction cosines of line from theodolite to distance meter.

AR DM = Angle right from backsight to distance meter.

ZA DM = Zenith angle to distance meter.

SD DM = Slope distance from theodolite to distance meter.

HD DM = Horizontal distance from theodolite to distance meter.

θ = Angle at theodolite between line to distance meter and line to point.

AR P = Angle right from backsight to point.

ZA P = Zenith angle to point.

HD P = Horizontal distance from theodolite station to point.

SD P = Slope distance from distance meter to prism.

Program 10—EDM Slope Reduction

87. $\text{ZA}' = \text{ZA} - \text{c} + \text{r} + \sin^{-1} \left[\dfrac{\Delta \sin (\text{ZA} - 2\text{c} + \text{r})}{\text{SD}}\right]$

88. $$\text{HD I} = \left(\frac{\text{SD}}{\cos c}\right) \sin(\text{ZA}' - c)$$

89. $$\text{HD SL} = \left(\frac{\text{SD}}{\cos c}\right) \sin(\text{ZA}' - c) \left[\frac{\text{R}}{\text{R} + \text{EI}}\right]$$

90. $$\Delta\text{ELEV} = \left(\frac{\text{SD}}{\cos c}\right) \cos(\text{ZA}') + (\text{H DM} - \text{H RFT})$$

91. $$c = \sin^{-1}\left(\frac{(\text{SD}) \sin(\text{ZA})}{2\text{R}}\right)$$

92. $$r = (19 \times 10^{-8})(\text{SD}) \sin(\text{ZA})$$

93. $$\text{HD I} = \left[\frac{(\text{SD})^2 - [(\text{E TGT}) + (\text{H RFT}) - \text{EI} - (\text{H DM})]^2}{[\text{R} + \text{EI} + (\text{H DM})][\text{R} + (\text{E TGT}) + (\text{H RFT})]}\right]^{1/2} (\text{R} + \text{EI})$$

94. $$\text{HD SL} = (\text{HD I}) \left[\frac{\text{R}}{\text{R} + \text{EI}}\right]$$

where:

ZA′ = Zenith angle corrected for c, r, and Δ.

ZA = Uncorrected zenith angle.

c = Zenith angle correction due to earth's curvature in degrees.

r = Zenith angle correction due to refraction in degrees.

Δ = Height of distance meter − height of reflector − height of theodolite + height of target.

SD = Slope distance, distance meter to reflector.

HD I = Horizontal distance at distance meter station elevation.

HD SL = Horizontal distance at sea level.

R = Radius of earth = 20,906,000 ft.

EI = Elevation of instrument station.

ΔELEV = Difference in elevation between distance meter station and target station.

H DM = Height of distance meter above ground.

H RFT = Height of reflector above ground.

E TGT = Elevation of target station.

Program 11—Stadia Reduction/3-Wire Level

Stadia Reduction

95. $HD = K\,(INT)\cos^2(VA) + C\cos(VA)$

96. $\Delta EL = \dfrac{K\,(INT)}{2}\sin\left[2(VA)\right] + C\sin(VA)$

where:

HD = Horizontal distance

K = Stadia interval factor

INT = Rod interval

VA = Vertical angle of line of sight (0° is horizontal).

C = Stadia constant.

ΔEL = Change in elevation.

3-Wire Level

97. $EL2 = EL1 + \dfrac{(U + C + L)BS}{3} - \dfrac{(U + C + L)FS}{3}$

98. $Check = (U - C) - (C - L)$

99. $\Sigma\, BS = K\left[\Sigma\,(U - L)\,BS\right]$

100. $\Sigma\, FS = K\left[\Sigma\,(U - L)\,FS\right]$

101. $\text{Total distance} = \Sigma\, BS + \Sigma FS$

where:

EL2 = Foresight elevation.

EL1 = Backsight elevation.

U, C, L = Upper, center and lower stadia hair readings.

BS, FS = Backsight, foresight readings.

Σ BS, Σ FS = Sum of backsight, foresight readings.

Σ (U − L) = Sum of differences between upper and lower stadia hair readings.

Program 12—Taping Reduction/Field Angle Check

Taping Reduction

102. Correction for tension $= \dfrac{L}{AE}(P - P_0)$

103. Correction for temperature $= L\,(CT)\,(T - T_0)$

104. Correction for sag $= \dfrac{W^2L^3}{24\,P^2}$

105. Index correction $= \dfrac{L\,(CI)}{100}$

106. $HD_c = (SD_c)\sin(ZA) = (SD_c)\cos(VA)$

107. $HD_c = \sqrt{(SD_c)^2 - (\Delta EL)^2}$

where:

L = Distance between supports in feet.

A = Cross section of tape in square inches.

E = Modulus of elasticity for the tape material.

P = Tension on tape in pounds (pull).

P_0 = Standard tension in pounds.

CT = Coefficient of thermal expansion for the tape.

T = Temperature at time of reading in °F.

T_0 = Standard temperature in °F.

W = Weight of tape per foot in pounds.

CI = Tape correction.

HD_c = Horizontal distance (corrected).

SD_c = Slope distance (corrected).

ZA = Zenith angle.

VA = Vertical angle.

ΔEL = Change in elevation.

Field Angle Check

The method of solution is described in the program description.

Program 13—Azimuth of the Sun

108. $\cos(AZ) = \dfrac{\sin(DEC_c) - \cos(ZA_c)\sin(LAT)}{\sin(ZA_c)\cos(LAT)}$

109. $DEC_c = DEC + \Delta DEC\ (TIME + COR + TZ)$

110. $ZA_c = ZA + \text{refraction} - \text{parallax}$

111. $\text{Refraction} = \dfrac{45 \times 10^{-4}\ P}{273 + T} \tan(ZA)$

112. $\text{Parallax} = 25 \times 10^{-4} \sin(ZA)$

where:

AZ = Azimuth of sun.

DEC_c = Corrected declination.

ZA_c = Corrected zenith angle.

LAT = Latitude.

DEC = Declination at 0^{hr} GCT.

ΔDEC = Change in declination per hour.

TIME = Local zone time of observation.

COR = Watch correction.

TZ = Time zone.

ZA = Observed zenith angle.

P = Pressure in millibars.

T = Temperature in °C.

NOTE: The program accepts temperature in degrees Fahrenheit and pressure in inches of mercury.

Program 14—Predetermined Area

Line Through a Point

113. $\text{Area} = \dfrac{h}{2}\ (HD)$

114. $h = (D2) \sin(ANG\ 2)$

115. $\text{Area} = \left(\frac{HD}{2}\right)(D2)\sin(\text{ANG } 2)$

116. $D2 = \frac{2\,(\text{area})}{(HD)\sin(\text{ANG } 2)}$

117. $N_3 = N_2 + (D2)\cos(AZ)$

118. $E_3 = E_2 + (D2)\sin(AZ)$

where:

h = Height of triangle.

HD = Horizontal distance between points 2 and 1.

D2 = Distance between points 2 and 3.

ANG 2 = Angle at point 2 between lines 2-1 and 2-3.

N_3, E_3 = Coordinates of point 3.

N_2, E_2 = Coordinates of point 2.

AZ = Azimuth of line 2-3.

Two Sides Parallel

119. $A = \frac{h}{2}(HD + D3)$

120. $D3 = HD - h\left[\cot(\text{ANG } 1) + \cot(\text{ANG } 2)\right]$

121. $A = (HD)\,h - \frac{h^2}{2}\left[\cot(\text{ANG } 1) + \cot(\text{ANG } 2\right]$

122. $h = \frac{HD - \sqrt{(HD)^2 - ZA\left[\cot(\text{ANG } 1) + \cot(\text{ANG } 2)\right]}}{\cot(\text{ANG } 1) + \cot(\text{ANG } 2)}$

123. $D1 = \frac{h}{\sin(\text{ANG } 1)}$

124. $D2 = \frac{h}{\sin(\text{ANG } 2)}$

where:

A = Area of trapezoid.

h = Altitude of trapezoid.

HD = Horizontal distance of fixed base of trapezoid (side 1-2).

D3 = Distance between points 3 and 4 (length of movable base).

ANG 1 = Internal angle at point 1, between sides 1-2 and 1-3.

ANG 2 = Internal angle at point 2, between sides 2-1 and 2-4.

Program 15—Earthwork

Volume by Average End Area

125. $VOL = (AREA_i + AREA_{i-1})\frac{INT}{2}$

126. $AREA = \frac{1}{2}\left[EL_1(D_2 - D_n) + \ldots + EL_n(D_1 - D_{n-1})\right]$

where:

VOL = Average volume between two stations.

AREA = Cross sectional area at a station.

INT = Interval between stations.

EL = Elevation at a point on a cross section.

D = Horizontal distance (offset) from centerline at cross section.

i = Subscript referring to current point or station.

n = Subscript referring to last point or station.

numeric subscript: refers to point or station number.

Volume of a Borrow Pit

127. $VOL_{\Delta} = \frac{BH}{2}\,(EL)$

128. $VOL_{\square} = WL\,(EL)$

where:

VOL_{Δ} = Volume of triangular grid section.

B = Base of triangle.

H = Height of triangle.

EL = Elevation of grid section (depth of cut).

$VOL_{\square}$ = Volume of rectangular grid section.

W = Width of rectangle.

L = Length of rectangle.

Program 16—Coordinate Transformation

129. $N_2 = a\,N_1 + b\,E_1 + TN$

130. $E_2 = a\,E_1 - b\,N_1 + TE$

131. $a = S\cos\phi$

132. $b = S\sin\phi$

133. $$a = \frac{\Sigma(N_1N_2 + E_1E_2) - \frac{1}{n}(\Sigma N_1 \Sigma N_2 + \Sigma E_1 \Sigma E_2)}{\Sigma(N_1^2 + E_1^2) - \frac{1}{n}\left[(\Sigma N_1)^2 + (\Sigma E_1)^2\right]}$$

134. $$b = \frac{\Sigma(E_1N_2 - N_1E_2) - \frac{1}{n}(\Sigma E_1 \Sigma N_2 - \Sigma N_1 \Sigma E_2)}{\Sigma(N_1^2 + E_1^2) - \frac{1}{n}\left[(\Sigma N_1)^2 + (\Sigma E_1)^2\right]}$$

135. $TN = \frac{1}{n}(\Sigma N_2 - a\Sigma N_1 - b\Sigma E_1)$

136. $TE = \frac{1}{n}(\Sigma E_2 - a\Sigma E_1 + b\Sigma N_1)$

where:

Subscript 1: Refers to the first coordinate system.

Subscript 2: Refers to the second coordinate system.

N = Northings.

E = Eastings.

a = Symbol for expression defined by above equation.

b = Symbol for expression defined by above equation.

TN = Northing translation.

TE = Easting translation.

S = Scale factor.

ϕ = Rotation.

n = Number of points in each coordinate system whose N, E values have been entered.

Programs 17, 18 and 19—State Plane Coordinates (Lambert, Transverse Mercator, Alaska Zones 2-9).

All equations used in these programs to convert from geographic to state plane coordinates and visa versa are those contained in the following publication:

"State Plane Coordinates by Automatic Data Processing", Charles N. Claire, U.S. Dept. of Commerce, Environmental Sciences Administration, Coast and Geodetic Survey.

Publication 62-4.

Available at many libraries and also for 45 cents (subject to change without notice) from:

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