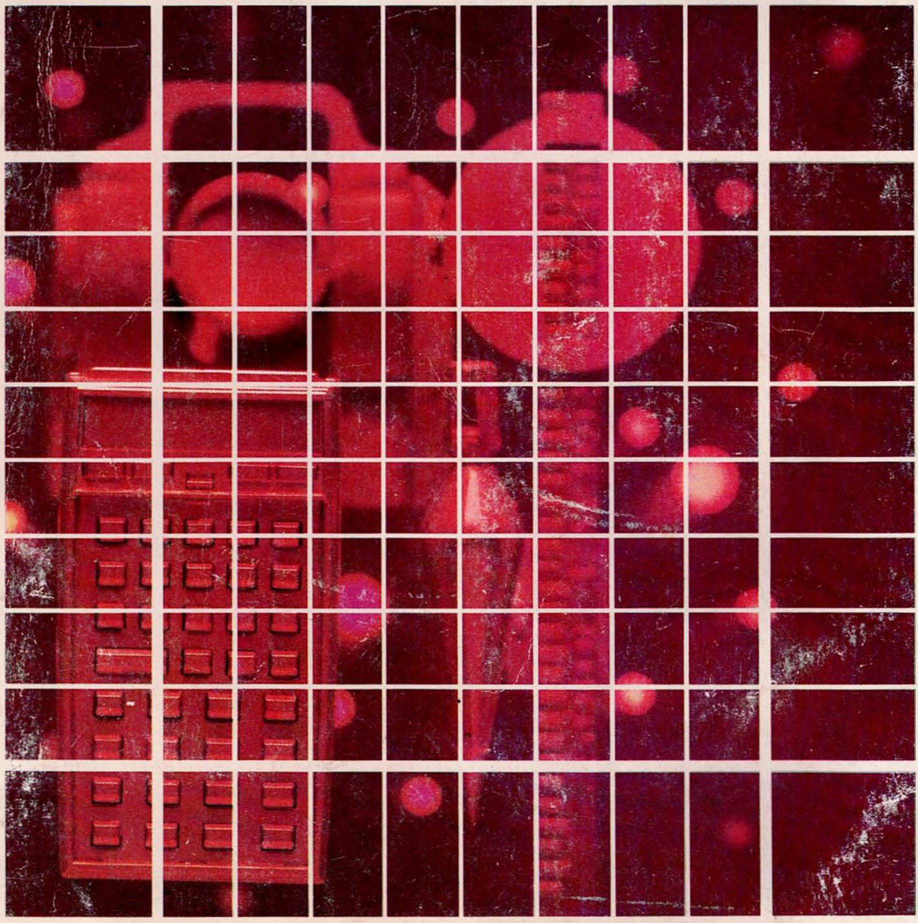
HEWLETT-PACKARD

HP-41C

SURVEYING PAC



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NOTICE

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INTRODUCTION

The programs in this Surveying Pac have been chosen to aid survetors in calculations for many of their often encountered problems. Each program in this pac represents a program in the Application Module and a section in this manual. The manual provides a description of the program with relevant equations, a set of instructions for using the program, and one or more example problems, each of which includes a list of the keystrokes required for its solution.

Before plugging in your Application Module, **turn the calculator off,** and be sure you understand the section Inserting and Removing Application Modules. And before using a particular program, take a few minutes to read Format of User Instructions and A Word About Program Usage.

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 program's prompting or the mnemonics on the overlays should provide the necessary instructions, including which variables are to be input, which keys are to be pressed, and which values will be output. A quick-reference card with a brief description of each program's operating instructions has been provided for your convenience.

We hope the Surveying Pac will assist you in the solution of numerous problems in your discipline. If you have technical problems with this Pac, refer to your HP-41 owner's handbook for information on Hewlett-Packard "technical support" or "programming assistance."

Note: Application modules are designed to be used in all HP-41 model calculators. The term "HP-41C" is used throughout the rest of this manual, unless otherwise specified, to refer to all HP-41 calculators.

CONTENTS

INSERTING AND REMOVING APPLICATION MODULES

Before you insert an application module for the first time, familiarize yourself with the following information.

Up to four application modules can be plugged into the ports on the HP-41C. While plugged in, the names of all programs contained in the module can be displayed by pressing ▢ CATALOG 2.

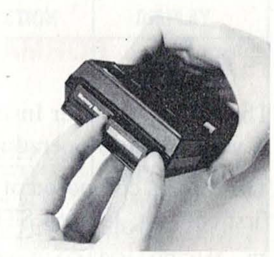
> **CAUTION**
>
> Always turn the HP-41C off before inserting or removing any plug-in extensions or accessories. Failure to turn the HP-41C off could damage both the calculator and the accessory.

Here is how you should insert application modules:

1. Turn the HP-41C off! Failure to turn the calculator off could damage both the module and the calculator.

2. Remove the port covers. Remember to save the port covers, they should be inserted into the empty ports when no extensions are inserted.

3. With the application module label facing downward as shown, insert the application module into any port **after** the last memory module presently inserted.



4. If you have additional application modules to insert, plug them into any port after the last memory module. For example, if you have a memory module inserted in port 1, you can insert application modules in any of ports 2, 3, or 4. **Never insert an application module into a lower numbered port than a memory module.** Be sure to place port covers over unused ports.
5. Turn the calculator on and follow the instructions given in this book for the desired application functions.

To remove application modules:

1. Turn the HP-41C off! Failure to do so could damage both the calculator and the module.
2. Grasp the desired module handle and pull it out as shown.

3. Place a port cap into the empty ports.

Mixing Memory Modules and Application Modules

Any time you wish to insert other extensions (such as the HP-82104A Card Reader, or the HP-82143 Printer) the HP-41C has been designed so that the memory modules are in lower numbered ports.

So, when you are using both memory modules and application modules, the memory modules must always be inserted into the lower numbered ports and the application module into any port after the last memory module. When mixing memory and application modules, the HP-41C allows you to leave gaps in the port sequence. For example, you can plug a memory module into port 1 and an application module into port 4, leaving ports 2 and 3 empty.

FORMAT OF USER INSTRUCTIONS

The completed User Instruction Form—which accompanies each program—is your guide to operating the programs in this Pac.

The form is composed of five labeled columns. Reading from left to right, the first column, labeled STEP, gives the instruction step number.

The INSTRUCTIONS column gives instructions and comments concerning the operations to be performed.

The INPUT column specifies the input data, the units of data if applicable, or the appropriate alpha response to a prompted question. Data Input keys consist of 0 to 9 and the decimal point (the numeric keys), [EEX] (enter exponent), and [CHS] (change sign).

The FUNCTION column specifies the keys to be pressed after keying in the corresponding input data.

Whenever a statement in the INPUT or FUNCTION column is printed in gold, the [ALPHA] key must be pressed before the statement can be keyed in. After the statement is keyed in, press [ALPHA] again to return the calculator to its normal operating mode, or to begin program execution. For example, [XEQ] CURVE means press the following keys: [XEQ] [ALPHA] CURVE [ALPHA].

The DISPLAY column specifies prompts and intermediate and final answers and their units, where applicable.

Above the DISPLAY column is a box, SIZE XXX, which specifies the minimum number of registers necessary to execute the program. Refer to pages 73 and 117 in the Owner's Handbook for a complete description of how to size calculator memory.

The following illustrates the User Instruction Form for *Resection*.

STEP	INSTRUCTIONS	INPUT	FUNCTION	SIZE: 016 DISPLAY
1	Begin Resection program		[XEQ] RESECT	COORDS?
2	If coordinates of the three points are known, answer: Y and input coordinates of the three points. Then go to step 4.	Y N1 E1 N2 E2 N3 E3	[R/S] [R/S] [R/S] [R/S] [R/S] [R/S] [R/S]	N1=? E1=? N2=? E2=? N3=? E3=? ∡A=?

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	OR			
3	If coordinates of the three points are not known, answer: N and input distance between points 1 and 2, distance between points 2 and 3 and angle C.	N L1 L2 ∡C(D.MS)	[R/S] [R/S] [R/S] [R/S]	DIST1=? DIST2=? ∡C=? ∡A=?
4	Input angle A and angle B	∡A(D.MS) ∡B(D.MS)	[R/S] [R/S] [R/S]†	∡B=? ∡D= ∡E=
5	If coordinates of the three points were input calculate coordinates of point P.		[R/S]† [R/S]†	NP= EP=
6	In either case, distances 1 through 5 may be calculated.		[R/S]† [R/S]† [R/S]† [R/S]† [R/S]†	DIST1= DIST2= DIST3= DIST4= DIST5=
7	For a new case go to step 1.			

† This [R/S] not necessary when calculator is operated with printer.

The user should first allocate (at least) 16 data storage registers (**SIZE:** 016) for use during program execution. To do this the keys [XEQ] [ALPHA] SIZE [ALPHA] 016 are pressed.

Program execution is begun by pressing [XEQ] [ALPHA] RESECT [ALPHA]. The calculator display shows ***COORDS?***, asking whether or not the coordinates of the 3 points are known. If the coordinates are known the user replies by pressing Y [R/S]. The calculator then prompts for coordinate input, beginning with the display ***N1=?***. The user then keys in the northing of the first point, presses [R/S], sees the display ***E1=?***, and inputs the easting of the first point, etc. until all coordinates have been input. The display then requests input for ∡ A and ∡ B (which are keyed in in D.MS mode). Following these inputs the calculator calculates and displays the values of angles D and E, the coordinates of the unknown point, P, and the distances 1 through 5. When the calculator is not attached to a printer the user presses [R/S] after each output to go on to the next. If a printer is attached and turned on the results are printed automatically, with no need to press the [R/S] key.

If the coordinates of the three points are not known, the user replies to ***COORDS?*** by pressing N [R/S] and then follows the prompting ***DIST 1=?*** by inputting the distance from point 1 to point 2. Following further prompts the ditance from point 2 to point 3, and the angles C, A and B are input. Outputs are obtained in the manner described above.

A WORD ABOUT PROGRAM USAGE

Catalog

When an Application Module is plugged into a port of the HP-41C, the contents of the Module can be reviewed by pressing [gold] [CATALOG] 2 (the Extension Catalog). Executing the [CATALOG] function lists the name of each global label in the module, as well as functions of any other extensions which might be plugged in.

Overlays

Overlays have been included for some of the programs in this pac. To run the program, choose the appropriate overlay, and place it on the calculator.

The mnemonics on the overlay are provided to help you run the program. The program's name is given vertically on the left side. Blue mnemonics are associated with the key they are directly below when the overlay is in place and the calculator is in USER mode. Gold mnemonics are similar to blue mnemonics, except that they are above the appropriate key and the shift (gold) key must be pressed before the re-defined key. Once again, USER mode must be set.

ALPHA and USER Mode Notation

This manual uses a special notation to signify ALPHA mode. Whenever a statement on the User Instruction Form is printed in gold, the [ALPHA] key must be pressed before the statement can be keyed in. After the statement is input, press [ALPHA] again to return the calculator to its normal operating mode, or to begin program execution. For example, [XEQ] CURVE means press the following keys: [XEQ] [ALPHA] CURVE [ALPHA]. Refer to the back of the calculator for a full description of the Alpha keyboard and placement of the various symbols.

In USER mode, when referring to the top two rows of keys (the keys having been redefined), this manual will use the symbols [A] [J] and [gold] [A] [gold] [E] on the User Instruction Form and in the keystroke solutions to sample problems.

Units

All angular inputs in the Surveying Pac are accepted and output in Degrees. Minutes Seconds (D.MS) mode, unless otherwise noted. Lenghts may be entered in any convenient unit, except for the programs ACRES, ENDVOL, and PIT where they must be in feet.

Using Optional Printer

When the optional printer is plugged into the HP-41C along with the Surveying Pac Applications Module, all results will be printed automatically.

You 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 the corresponding keystrokes will be listed on the printer, thus providing a record of the entire operation of the program.

Using Programs As Subroutines

Some programs in the Surveying Pac may be called as subroutines for user programs in the HP-41C's program memory. Refer to appendix B for information regarding use of these subroutines.

Downloading Module Programs

If you wish to trace execution, to modify, to record on magnetic cards, or to print a program in this Application Module, it must first be copied into the HP-41C's program memory. For information concerning the HP-41C COPY function, see the Owner's Handbook. It is *not* necessary to copy a program in order to run it.

Program Interruption

These programs have been designed to operate properly when run from beginning to end, without turning the calculator off (remember, the calculator may turn itself off). If the HP-41C is turned off, it may be necessary to set flag 21 (SF 21) to continue proper execution.

Use of Labels

The user should be aware of possible problems when writing programs into calculator memory using Alpha labels identical with those in an Application Module. In order to avoid conflicts the user should take care to choose labels which are not *identical* with those in Application Modules.

Several labels used in the Surveying Application Module are also used in other modules. If you have this module and another plugged into your calculator, you should make sure that the module containing the program you want to use is in the lower numbered port.

You will find a list of all the global labels used in this application pac at the back of this manual in appendix D, Program Labels. The names of modules or accessories where duplicate labels occur are also listed. Before plugging in two or more modules, check that listing for duplicate label conflicts.

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, or it is easy to switch from one to another as required. Two additional routines are included to supplement the major routines: 5) Closure for Traverses and 6) Curved Sides for Traverses. Each of these routines is described with separate user instructions.

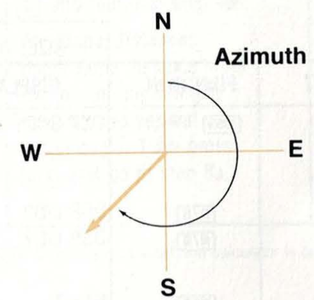
Upon beginning the program the user chooses the desired angular output (azimuths or bearings) and whether or not latitudes and departures for each leg will be displayed (default mode displays azimuths and does not display latitudes and departures).

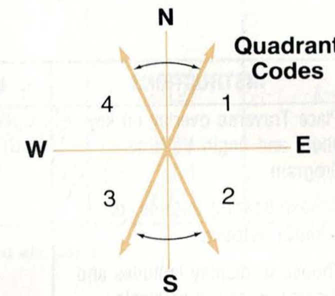
The user may switch from bearing/azimuth data to field angle data at will, simply by using the proper input keys for the type of angle (see the user instructions and the keyboard overlay).

Sideshots may be made at anytime by changing to sideshot mode.

Bearing/Azimuth Traverse

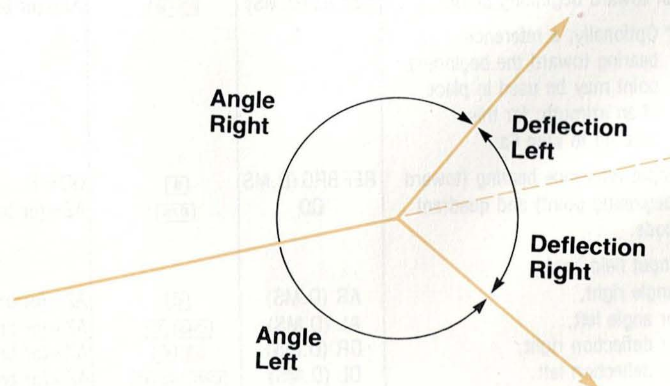
This routine uses quadrant bearings or azimuths and horizontal distances to compute the coordinates of successive points in a traverse. The routines for Slope Distance Reduction and Curved Sides for Traverses can be used where slope distances or curves are encountered. At the end of the traverse, Closure 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:





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:



A reference azimuth toward or a back azimuth away from the point of beginning or a reference bearing toward the point of beginning must be input. Back azimuths are converted and displayed as azimuths toward the point. When switching from bearing/azimuths to field angles, the bearing or azimuth input of the last leg becomes the reference direction from which the field angles are turned.

Slope Distance Reduction

This routine calculates the horizontal distance, 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°.

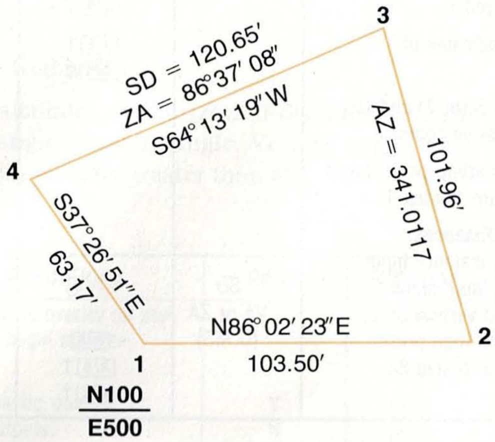
				SIZE: 016
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Place Traverse overlay on keyboard and begin traverse Program.		[XEQ] TRAV	DSP BRG?
2	Choose bearing outputs, or azimuth outputs.	Y N	[R/S] [R/S]	DSP L/D? DSP L/D?
3	Choose to display latitudes and departures or not to display latitudes and departures	Y N	[R/S] [R/S]	N1=? N1=?
4	Input coordinates of the point of beginning.	N1 E1	[R/S] [R/S]	E1=? N1**
5	**For bearing or azimuth traverse:** Input the bearing and quadrant code or azimuth, then go to step 8.	 BRG (D.MS) QD AZ (D.MS)	 [B] [R/S] ■ [B]	 QD=? AZ=(or brg.) AZ=(or brg.)
6	**For field angle traverse:** Input reference azimuth: away from beginning point, (back azimuth) or toward beginning point.*	 REF AZ (D.MS) REF AZ (D.MS)	 [H] ■ [B]	 AZ=(or brg.) AZ=(or brg.)
	* Optionally, a reference bearing toward the beginning point may be used in place of an azimuth; for this case go to step 6a:			
6a	Input reference bearing (toward beginning point) and quadrant code.	REF BRG (D.MS) QD	[B] [R/S]	QD=? AZ=(or brg.)
7	Input field angle: angle right, or angle left, or deflection right, or deflection left.	 AR (D.MS) AL (D.MS) DR (D.MS) DL (D.MS)	 [C] [CHS] [C] ■ [C] [CHS] ■ [C]	 AZ=(or brg.) AZ=(or brg.) AZ=(or brg.) AZ=(or brg.)

** N1 and E1 will automatically be printed at this point when the calculator is operated with printer.

STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
8	Input horizontal distance.	HD	[D]	HD=
8a	(If latitudes and departures are to be displayed.)		[R/S]† [R/S]†	L= D=
	Display coordinates of next point.		[R/S]† [R/S]†	N#= E#=
9	Repeat step 5 (or 7) and step 8 for successive courses.			
10	For a new starting point, press [A] and return to step 4.		[A]	N1=?
11	**For Slope Distances:** Begin slope distance input routine and input slope distance and vertical or zenith angle. Then press [R/S] and go to step 8a.	SD VA or ZA (D.MS)	■ [D] [R/S] [R/S]† [R/S]†	∡=? HD= N#= E#=

† This [R/S] is not required when the calculator is operated with printer.

BEARING TRAVERSE



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

Keystrokes:	Display:	
XEQ ALPHA SIZE ALPHA 016	*SIZE 016*	
XEQ ALPHA TRAV ALPHA	*DSP BRG?*	
Y R/S	*DSP L/D?*	
N R/S	*N1=?*	
100 R/S	*E1=?*	
500 R/S	*100.0000*	
86.0223 B	*QD=?*	
1 R/S	*N 86.0223 E*	
103.5 D	*HD=103.5000*	
R/S	*N2=107.1482*	
R/S	*E2=603.2529*	
341.0117 B	*N 18.5843 W*	(Azimuth input)
101.96 D	*HD=101.9600*	
R/S	*N3=203.5657*	
R/S	*E3=570.0939*	

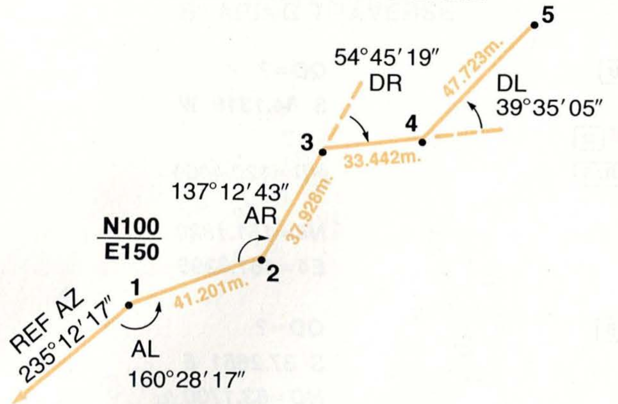
Keystrokes:	Display:
64.1319 B	*QD=?*
3 R/S	*S 64.1319 W*
120.65 D	*∡=?*
86.3708 R/S	*HD=120.4400*
R/S	*N4=151.1880*
R/S	*E4=461.6395*
37.2651 B	*QD=?*
2 R/S	*S 37.2651 E*
63.17 D	*HD=63.1700*
R/S	*N5=101.0366*
R/S	*E5=500.0490*

To avoid reworking this example you might wish to work next the Closure for Traverse example on page 25.

Note:

For purposes of illustration only one slope distance is shown in the traverse. In actual instances 2 or more slope distances would be included to close at the starting elevation.

FIELD ANGLE TRAVERSE



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

Keystrokes:	Display:	
[XEQ] [ALPHA] SIZE [ALPHA] 016	*SIZE 016*	
[XEQ] [ALPHA] TRAV [ALPHA]	*DSP BRG?*	
N [R/S]	*DSP L/D?*	
N [R/S]	*N1=?*	
100 [R/S]	*E1=?*	
150 [R/S]	*100.0000*	
235.1217 [H]	*AZ=55.1217*	(Ref. AZ)
160.2817 [CHS] [C]	*AZ=74.4360*	(Note 74.4360 = 74°44′00″)
41.201 [D]	*HD=41.2010*	
[R/S]	*N2=110.8487*	
[R/S]	*E2=189.7470*	
137.1243 [C]	*AZ=31.5643*	
37.928 [D]	*HD=37.9280*	
[R/S]	*N3=143.0327*	
[R/S]	*E3=209.8151*	
54.4519 [■] [C]	*AZ=86.4202*	
33.442 [D]	*HD=33.4420*	
[R/S]	*N4=144.9574*	
[R/S]	*E4=243.2017*	

Keystrokes:	Display:
39.3505 [CHS] [■] [C]	*AZ=47.0657*
47.723 [D]	*HD=47.7230*
[R/S]	*N5=177.4338*
[R/S]	*E5=278.1698*

Inverse

This routine calculates the distance and direction 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 routine, Curved Sides for Traverses, may be used where curves are encountered. At the end of a traverse, Closure for Traverses can be used to get the total distance traversed and area. Note that you may employ the inverse routine at any time during a traverse by going to step 5 of these User Instructions.

				SIZE: 016
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	To perform inverse place Traverse overlay on keyboard and begin traverse program.		[XEQ] TRAV	DSP BRG?
2	Choose bearing outputs, or azimuth outputs.	Y N	[R/S] [R/S]	DSP L/D? DSP L/D?
3	Choose to display latitudes and departures or not to display latitudes and departures	Y N	[R/S] [R/S]	N1=? N1=?
4	Input coordinate of the point of beginning.	N1 E1	[R/S] [R/S]	E1=? N1**
5	Input coordinates of next point and calculate and display azimuth (or bearing) and horizontal distance.	N E	[ENTER♦] [■] [A] [R/S]†	AZ=(or brg.) HD=
5a	(If latitudes and departures are to be displayed.)		[R/S]† [R/S]†	L= D=
6	Display coordinates (this step is not optional.)		[R/S]† [R/S]†	N#= E#=
7	Repeat steps 5 and 6 for successive courses.			
8	For a new starting point, press [A] and go to step 4.		[A]	N1=?

** N1 and E1 will automatically be printed at this point when the calculator is operated with printer.

† This [R/S] is not required when the calculator is operated with printer.

Example:

Work the Field Angle Traverse example as an inverse. Input the coordinates of the points and calculate the bearing and distance of the line joining each pair of points. Also display the latitude and departure of each leg.

Keystrokes:	Display:	
[XEQ] [ALPHA] SIZE [ALPHA] 016	*SIZE 016*	
[XEQ] [ALPHA] TRAV [ALPHA]	*DSP BRG?*	
Y [R/S]	*DSP L/D?*	
Y [R/S]	*N1=?*	
100 [R/S]	*E1=?*	
150 [R/S]	*100.0000*	
110.8487 [ENTER↑]		
189.7470 [A]	*N 74.4360 E*	(N74.4400E)
[R/S]	*HD=41.2010*	
[R/S]	*L=10.8487*	
[R/S]	*D=39.7470*	
[R/S]	*N2=110.8487*	
[R/S]	*E2=189.7470*	
143.0327 [ENTER↑]		
209.8151 [A]	*N 31.5643 E*	
[R/S]	*HD=37.9281**	
[R/S]	*L=32.1840*	
[R/S]	*D=20.0681*	
[R/S]	*N3=143.0327*	
[R/S]	*E3=209.8151*	
144.9574 [ENTER↑]		
243.2017 [A]	*N 86.4202 E*	
[R/S]	*HD=33.4420*	
[R/S]	*L=1.9247*	
[R/S]	*D=33.3866*	

* HD varies slightly from value in Field Angle Traverse due to input of coordinates as 4 decimal place number (rounding to 4 places). These points were calculated to 10 decimal places when running the Field Angle Traverse example.

Keystrokes:	Display:
[R/S]	*N4=144.9574*
[R/S]	*E4=243.2017*
177.4338 [ENTER↑]	
278.1698 [A]	*N 47.0657 E*
[R/S]	*HD=47.7230*
[R/S]	*L=32.4764*
[R/S]	*D=34.9681*
[R/S]	*N5=177.4338*
[R/S]	*E5=278.1698*

Sideshots

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

This routine may be used in conjunction with a traverse or as a stand-alone routine. When used with a traverse one may switch back and forth at will. Stored data is used by either, but not destroyed so long as a new occupied point is not input, and the traverse operation may be continued from the occupied point.

As with a traverse, the user may use either bearing/azimuth or field angle inputs at will.

SIZE: 016

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	To perform sideshots:			
1	Place Traverse overlay on keyboard and begin traverse Program.		[XEQ] TRAV	DSP BRG?
2	Choose bearing outputs, or azimuth outputs.	Y N	[R/S] [R/S]	DSP L/D? DSP L/D?
3	Choose to display latitudes and departures or not to display latitudes and departures	Y N	[R/S] [R/S]	N1=? N1=?
4	Input coordinates of the point of beginning.	N1 E1	[R/S] [R/S]	E1=? N1**
5	After completion of step 4 set sideshot mode by pressing [J].		[J]	SS
6	**For bearing or azimuth traverse:** input the bearing and quadrant code or azimuth, then go to step 8.	BRG (D.MS) QD AZ (D.MS)	[B] [R/S] ■ [B]	QD=? AZ=(or brg.) AZ=(or brg.)
7	**For field angle traverse:** Input reference azimuth: away (back azimuth) from beginning point, (or hub), or toward beginning point (or hub).* * Optionally, a reference bearing toward the beginning point (or hub) may be used in place of an azimuth; for this case go to step 7a:	REF AZ (D.MS) REF AZ (D.MS)	[H] ■ [B]	AZ=(or brg.) AZ=(or brg.)
7a	Input reference bearing (toward beginning point or hub) and quadrant code.	REF BRG (D.MS) QD	[B] [R/S]	QD=? AZ=(or brg.)
8	Input field angle: angle right, or angle left, or deflection right, or deflection left.	AR (D.MS) AL (D.MS) DR (D.MS) DL (D.MS)	[C] [CHS] [C] ■ [C] [CHS] ■ [C]	AZ=(or brg.) AZ=(or brg.) AZ=(or brg.) AZ=(or brg.)
9	Input horizontal distance.	HD	[D]	HD=
9a	(If latitudes and departures are to be displayed.)		[R/S]† [R/S]†	L= D=
	Display coordinates of next point.		[R/S]† [R/S]†	N#= E#=
10	Repeat step 6 (or 8) for successive sideshots.			
11	For a new starting point, press [A] and return to step 4.		[A]	N1=?

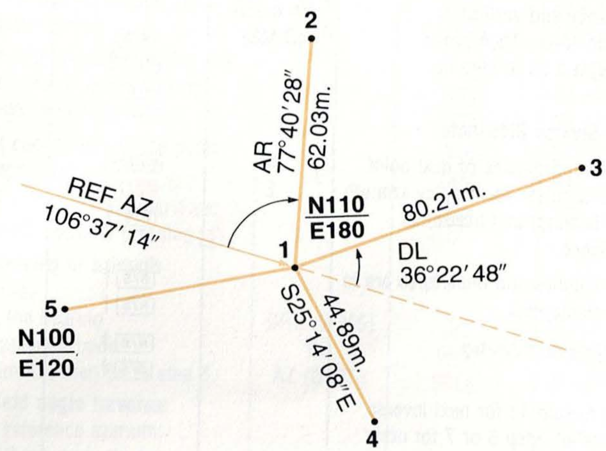
** N1 and E1 will automatically be printed at this point when the calculator is operated with printer.

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
12	**For Slope Distances:** Begin slope distance input routine and input slope distance and vertical or zenith angle. Then press [R/S] and go to step 9a.	SD VA or ZA (D.MS)	■ [D] [R/S] [R/S]† [R/S]†	∠=? HD= N#= E#=
	For Inverse Sideshots:			
13	Input coordinates of next point and calculate and display azimuth (or bearing) and horizontal distance.	N E	[ENTER↑] ■ [A] [R/S]†	AZ=(or brg.) HD=
13a	(If latitudes and departures are to be displayed.)		[R/S]† [R/S]†	L= D=
14	Display coordinates.		[R/S]† [R/S]†	N#= E#=
15	Go to step 13 for next inverse sideshot, step 6 or 7 for other sideshots.			
16	For a new set of sideshots press [A] and go to step 4. (Step 5 may be omitted.)		[A]	N1=?
	To Convert From Sideshots to Traverse:			
17	User may convert from sideshot made to traverse mode at any time after executing step 4. To begin new traverse press [I] and go to step 10, page 13. To continue former traverse press [I] and continue.		[I]	TRAV
	To Convert From Traverse to Sideshots:			
18	User may convert from traverse to sideshots at any time after completion of step 4 or step 8 of traverse instructions by pressing [J].		[J]	SS
19	After sideshots have been made user may continue former traverse from the last occupied point (hub), by pressing [I].		[I]	TRAV

† This [R/S] is not required when the calculator is operated with printer.

SIDESHOTS

Example:



Starting from point 1 with coordinates N110, E180, calculate the sideshots shown in the figure above displaying azimuths and latitudes and departures.

Keystrokes:	Display:	
[XEQ] [ALPHA] SIZE [ALPHA] 016	*SIZE 016*	
[XEQ] [ALPHA] TRAV [ALPHA]	*DSP BRG?*	
N [R/S]	*DSP L/D?*	
Y [R/S]	*N1=?*	
110 [R/S]	*E1=?*	
180 [R/S]	*110.0000*	
[J]	*SS*	(Set for sideshots)
106.3714 [B]	*AZ=106.3714*	(Ref. AZ)
77.4028 [C]	*AZ=4.1742*	
62.03 [D]	*HD=62.0300*	
[R/S]	*L=61.8558*	
[R/S]	*D=4.6455*	
[R/S]	*N2=171.8558*	
[R/S]	*E2=184.6455*	

Keystrokes:	Display:
36.2248 [CHS] [C]	*AZ=70.1426*
80.21 [D]	*HD=80.2100*
[R/S]	*L=27.1167*
[R/S]	*D=75.4873*
[R/S]	*N3=137.1167*
[R/S]	*E3=255.4873*
25.1408 [B]	*QD=?*
2 [R/S]	*AZ=154.4552*
44.89 [D]	*HD=44.8900*
[R/S]	*L=-40.6058*
[R/S]	*D=19.1384*
[R/S]	*N4=69.3942*
[R/S]	*E4=199.1384*
100 [ENTER↑]	
120 [A]	*AZ=260.3216*
[R/S]	*HD=60.8276*
[R/S]	*L=-10.0000*
[R/S]	*D=-60.0000*
[R/S]	*N5=100.0000*
[R/S]	*E5=120.0000*

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 distanced traversed (ΣHD), area, closure azimuth, and closure distance. The traverse can be closed exactly by inversing from the last point calculated to the correct closing coordinates.

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY (SIZE: 016)
1	At completion of a closed traverse, initiate closure routine. Display the sum of the total distance traversed, (ΣHD), and the area.*		[E] [R/S]†	ΣHD= AREA=
2	Input the correct closing coordinates and calculate the error azimuth and distance.	 N CORR E CORR	[R/S]† [R/S] [R/S] [R/S]† [R/S]† [R/S]† [R/S]†	N CORR=? E CORR=? CLOSURE AZ=(or brg.) HD=(closing HD) N#= E#=
3	(optional) To include the error course in the traverse and adjust the area: inverse to the correct closing coordinates.	N CORR E CORR	[ENTER↑] [■] [A] [R/S]† [R/S]† [R/S]†	 AZ=(or brg.) HD= N#= E#=
4	(optional) Go to step 1 to recalculate the ΣHD and area. NOTE: Steps 3 and 4 are optional. Step 3 may be performed before steps 1 and 2 and step 4 may then be omitted. * The area will be displayed in square units of the distance, i.e., feet² if HD is in feet, meters² if HD is in meters, etc.			
5	For area in acres: (Use only if distances were entered in feet.)		[XEQ] ACRES	AREA=(acres)

† This [R/S] not necessary when calculator is operated with a printer.

Example:

Rework the bearing traverse example and perform closure.

Keystrokes:	Display:
The last coordinates calculated were:	***N5=101.0366*** ***E5=500.0490***
[E]	***ΣHD=389.0700***
[R/S]	***AREA=8,855.4914***
[R/S]	***N CORR=?***
100 [R/S]	***E CORR=?***
500 [R/S]	***CLOSURE***
[R/S]	***S 2.4221 W***
[R/S]	***HD=1.0378***
[R/S]	***N6=100.0000***
[R/S]	***E6=500.0000***

Now include the error course in the traverse, to adjust the area, by inversing to the correct closing coordinates. (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.)

100 [ENTER↑]	
500 [■] [A]	***S 2.4221 W***
[R/S]	***HD=1.0378***
[R/S]	***N7=100.0000***
[R/S]	***E7=500.0000***
[E]	***ΣHD=390.1078***
[R/S]	***AREA=8,855.4660***

The adjusted area is only about 0.025 square feet different.

To obtain the final area in acres:

[XEQ] [ALPHA] ACRES [ALPHA]	***AREA=0.2033***

Curved Sides for Traverses

This routine is designed to be used with the Traverse or Inverse routines to include circular curved sides.

Traverse to the beginning point of the curve (PC) and input the bearing (or azimuth) or field angle to the end point of the curve. Then begin the Curved Sides routine and input the central angle and radius. The Curved Sides routine calculates the segment area and arc length for use in the Closure for Traverses routine to calculate distance traversed and area.

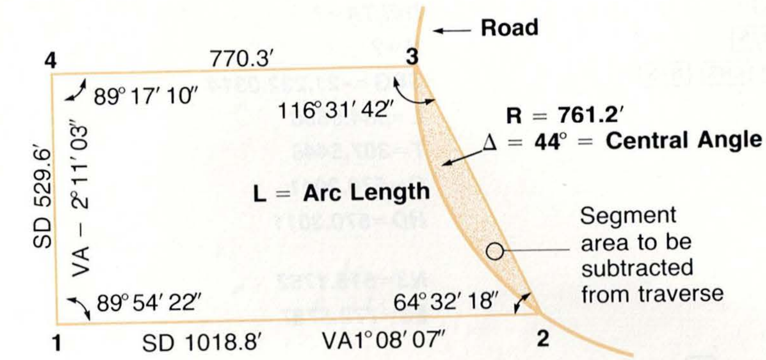
To include a curved side when inversing, inverse to the PC, execute the Curved Sides routine and then continue the inverse to the point at the end of the curve, (PT).

If the central angle and radius of the curve are not known they may be calculated from the other curve parameters using the Curve Solutions program *before beginning* the traverse.

STEP	INSTRUCTIONS	INPUT	FUNCTION	SIZE: 016 DISPLAY
1	Traverse to the point at which the curve begins (PC). (Follow Traverse Instructions, steps 1 through 11, or instructions for inverse.)			
2	Input the azimuth, bearing or field angle to the next point of the traverse. (See steps 5 or 7 of Traverse Instructions.)			AZ=(or brg.)
3	Initiate the curved sides routine and input the central angle, (Δ), and the radius. (Positive if the segment area is to be added to the traverse, negative if the segment area is to be subtracted from the traverse.) The segment area will be displayed.	Δ (D.MS) R	■ [E] [R/S] [R/S]	DELTA=? R=? SEG=
4	Calculate the arc length (L) the tangent (T) and the chord (C).		[R/S]† [R/S]† [R/S]†	L= T= C=
5	Press [D] to use the chord as the horizontal distance to the next point of the traverse and calculate coordinates of the next point. OR,		[D] [R/S]† [R/S]†	HD=(chord) N#= E#=
5a	If inversing, input coordinates of PT.	N(PT) E(PT)	[ENTER↑] ■ [A]	(inverse outputs)
6	Continue the traverse.			

† This [R/S] not necessary when calculator is operated with printer.

Curved Sides for Traverses



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:	Display:
[XEQ] [ALPHA] SIZE [ALPHA] 016	*SIZE 016*
[XEQ] [ALPHA] TRAV [ALPHA]	*DSP BRG?*
N [R/S]	*DSP L/D?*
N [R/S]	*N1=?*

Arbitrarily make point 1 N=0, E=0

0 [R/S]	*E1=?*
0 [R/S]	*0.0000*

And use reference azimuth away from point 1 of 0°:

0 [H]	*AZ=180.000*
89.5422 [C]	*AZ=89.5422*
1018.8 ■ [D]	*∠=?*
1.0807 [R/S]	*HD=1018.6000*
[R/S]	*N2=1.6691*
[R/S]	*E2=1,018.5986*

Keystrokes:	**Display:**
64.3218 [C]	*AZ=334.2640*
■ [E]	*DELTA=?*
44 [R/S]	*R=?*
761.2 [CHS] [R/S]	*SEG=-21,232.0314*
[R/S]	*L=584.5596*
[R/S]	*T=307.5448*
[R/S]	*C=570.3011*
[D]	*HD=570.3011*
[R/S]	*N3=516.1762*
[R/S]	*E3=772.5787*
116.3142 [C]	*AZ=270.5822*
770.3 [D]	*HD=770.3000*
[R/S]	*N4=529.2539*
[R/S]	*E4=2.3897*
89.1710 [C]	*AZ=180.1532*
529.6 ■ [D]	*∡=?*
2.1103 [CHS] [R/S]	*HD=529.2152*
[R/S]	*N5=0.0440*
[R/S]	*E5=-0.0015*
[E]	*ΣHD=2,902.6749*
[R/S]	*AREA=444,840.2084*
[R/S]	*N CORR=?*
0 [R/S]	*E CORR=?*
0 [R/S]	*CLOSURE*
[R/S]	*AZ=178.0226*
[R/S]	*HD=0.0441*
[R/S]	*N6=1.0000E-11*
[R/S]	*E6=3.4000E-11*
[XEQ] [ALPHA] ACRES [ALPHA]	*AREA=10.2121*

Notes

COMPASS RULE ADJUSTMENT

This program adjusts a traverse using the compass or Bowditch rule. The data to be adjusted consists of the coordinates of the points for each leg of the traverse.

If the *Traverse* program has just been run, and step 3 of the Closure for Traverses *has not* been executed, the storage registers will be set to start the adjustment. Otherwise, the total horizontal distance traversed and the calculated coordinates of the last point as well as the beginning coordinates must be input. Then for each pair of coordinates, the adjusted values can be calculated.

The Inverse routine of the *Traverse* program may be used to obtain bearings, distances and area from the adjusted coordinates.

Note:

Coordinates must be entered in the same sequence as originally traversed, starting at the second point.

SIZE 016

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Begin Compass Rule program.		XEQ COMP	DATA IN?
2	If data is already stored in calculator (as from running TRAVERSE program) answer Y and go to step 4,	Y	R/S	OPEN?
	OR, if data is not stored in calculator answer N and go to step 3.	N	R/S	N BEG=?
3	Input data: coordinates of point of beginning,	N BEG E BEG	R/S R/S	E BEG=? Σ HD=?
	sum of the horizontal distance traversed, and calculated coordinates of the end point of the traverse. Then go to step 4.	Σ HD N END E END	R/S R/S R/S	N END=? E END=? OPEN?
4	If traverse is open* answer Y and input correct coordinates of the end point, then go to step 5,	Y N CORR E CORR	R/S R/S R/S	N CORR=? E CORR=? N2=?
	OR, If traverse is closed* answer N and go to step 5.	N	R/S	N2=?

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
5	Beginning with the first point to be adjusted, input the unadjusted coordinates and obtain the adjusted coordinates.	N2 E2	R/S R/S R/S†	E2=? N ADJ= E ADJ=
6	Press R/S and repeat step 5 for the rest of the coordinates. NOTE: the coordinates must be entered sequentially. * A closed traverse is one that, neglecting closure error, ends at the same point at which it began, an open traverse does not.		R/S†	N3=?

† This R/S not necessary when calculator is operated with printer.

Example:

Adjust the coordinates of the bearing/azimuth traverse calculated in the example on page 14 by use of the compass rule. The calculated coordinates are shown:

PT#	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

The total horizontal distance traversed was 389.0700

Keystrokes:	Display:
XEQ ALPHA SIZE ALPHA 016	*SIZE 016*
XEQ ALPHA COMP ALPHA	*DATA IN?*
N R/S	*N BEG=?*
100 R/S	*E BEG=?*
500 R/S	*ΣHD=?*
389.07 R/S	*N END=?*
101.0366 R/S	*E END=?*
500.049 R/S	*OPEN?*
N R/S	*N2=?*
107.1482 R/S	*E2=?*
603.2529 R/S	*N ADJ=106.8724*
R/S	*E ADJ=603.2399*
R/S	*N3=?*

If the traverse program has just been run and step 3 of Closure for Traverses has not been executed, answer 'Y' to the question "DATA IN?" and skip this portion of data entry.

Keystrokes:	Display:
203.5657 [R/S]	*E3=?*
570.0939 [R/S]	***N ADJ=203.0183***
[R/S]	***E ADJ=570.0680***
[R/S]	*N4=?*
151.188 [R/S]	*E4=?*
461.6395 [R/S]	***N ADJ=150.3197***
[R/S]	***E ADJ=461.5985***
[R/S]	*N5=?*
101.0366 [R/S]	*E5=?*
500.049 [R/S]	***N ADJ=100.0000***
[R/S]	***E ADJ=500.0000***

Notes

TRANSIT RULE ADJUSTMENT

This program adjusts a traverse by the transit rule method. The data to be adjusted consists of the coordinates of the points for each leg of the traverse.

If the *Traverse* program has just been run, and step 3 of the Closure for Traverses *has not* been executed, the storage registers will be set to start the adjustment.

Otherwise the calculated coordinates of the last point and the beginning coordinates must be input. In addition the user must then enter all the unadjusted coordinates of the traverse to calculate the adjustment data.

The Inverse routine of the *Traverse* program may be used to obtain bearings, distances and area from the adjusted coordinates.

Note:

Coordinates must be entered in the same sequence as originally traversed, starting at the second point.

				SIZE: 016
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Begin Transit Rule program.		XEQ TRANSIT	DATA IN?
2	If data is already stored in calculator (as from running TRAVERSE program) answer Y and go to step 4	Y	R/S	OPEN?
	OR,			
	If data is not stored in calculator answer N and go to step 3	N	R/S	N BEG=?
3	Input coordinates of point of beginning.	N BEG E BEG	R/S R/S	E BEG=? N END=?
	Input calculated coordinates of the end point of the traverse. Then go to step 4.	N END E END	R/S R/S	E END=? OPEN?
4	If traverse is open* answer Y and input correct coordinates of the end point,	Y N CORR E CORR	R/S R/S R/S	N CORR=? E CORR=? N2=?
	OR,			
	If traverse is closed* answer N	N	R/S	N2=?
5	If data was already stored when Transit Adjustment program was begun, go to step 7, otherwise input the coordinates of the traverse points in order, starting with the second point. Continue until all points have been input.	 N2 E2	 R/S R/S	N2=? E2=? E3=?

STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
6	After last point has been input, go to Adjustment routine		XEQ ADJUST	N2=?
7	Beginning with the first point to be adjusted, input the unadjusted coordinates and obtain the adjusted coordinates.	N2 E2	R/S R/S R/S†	E2=? N ADJ= E ADJ=
8	Press R/S and repeat step 7 for the rest of the coordinates. NOTE: the coordinates must be entered sequentially. * A closed traverse is one that, neglecting closure error, ends at the same point at which it began, an open traverse does not.		R/S†	N3=?

† This R/S not necessary when calculator is operated with printer.

Adjust the coordinates of the following open traverse according to the transit rule:

PT#	N	E
1	200.0000	800.0000
2	291.4750	877.6680
3	215.3931	921.8895
4	262.4628	1012.3096
5	352.2939	988.2394

Correct Ending Coordinates

N	E
352.1000	988.2200

Keystrokes:	**Display:**
XEQ ALPHA SIZE ALPHA 016	*SIZE 016*
XEQ ALPHA TRANSIT ALPHA	*DATA IN?*
N R/S	*N BEG=?*
200 R/S	*E BEG=?*
800 R/S	*N END=?*
352.2939 R/S	*E END=?*
988.2394 R/S	*OPEN?*
Y R/S	*N CORR=?*
352.1 R/S	*E CORR=?*
988.22 R/S	*N2=?*
291.475 R/S	*E2=?*
877.668 R/S	*N3=?*
215.3931 R/S	*E3=?*
921.8895 R/S	*N4=?*

If the traverses program has just been run and step 3 of Closure for Traverses has not been executed, answer 'Y' to the question "DATA IN". and skip this portion of data entry.

Keystrokes:	**Display:**
262.4628 [R/S]	*E4=?*
1012.3096 [R/S]	*N5=?*
352.2939 [R/S]	*E5=?*
988.2394 [R/S]	*N6=?*
[XEQ] [ALPHA] ADJUST [ALPHA]	*N2=?*
291.475 [R/S]	*E2=?*
877.668 [R/S]	***N ADJ=291.4167***
[R/S]	***E ADJ=877.6616***
[R/S]	*N3=?*
215.3931 [R/S]	*E3=?*
921.8895 [R/S]	***N ADJ=215.2864***
[R/S]	***E ADJ=921.8795***
[R/S]	*N4=?*
262.4628 [R/S]	*E4=?*
1012.3096 [R/S]	***N ADJ=262.3261***
[R/S]	***E ADJ=1,012.2922***
[R/S]	*N5=?*
352.2939 [R/S]	*E5=?*
988.2394 [R/S]	***N ADJ=352.1000***
[R/S]	***E ADJ=988.2200***

Notes

INTERSECTIONS

This program calculates information for the point of intersection of two lines. Given the coordinates of two points the required information is:

A. For a bearing-bearing intersection: the bearings (or azimuths) of the lines through the points.

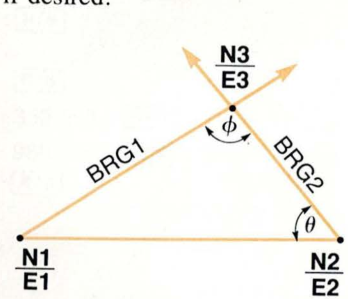
B. For a bearing-distance intersection: the bearing from one point and the distance from the second point.

C. For a distance-distance intersection: the distances from each of the points.

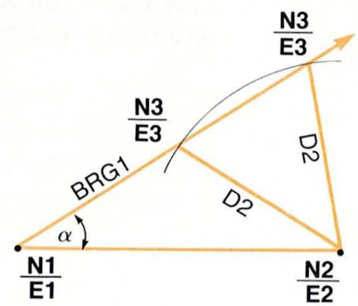
D. For offsets from a point to a line: the bearing from the base point to the intersection.

Two solutions are possible for bearing-distance and distance-distance intersections and both solutions are calculated.

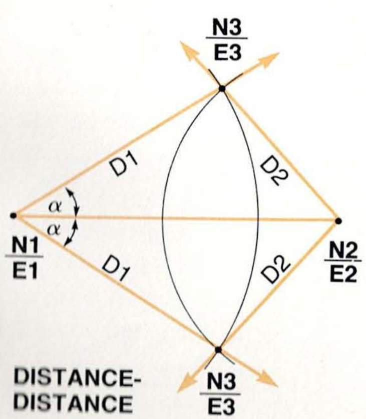
Calculated data includes the bearing and distance from each point to the intersection and the coordinate of the point of intersection. In addition, the bearing and distance from the first to the second point may be displayed, if desired.



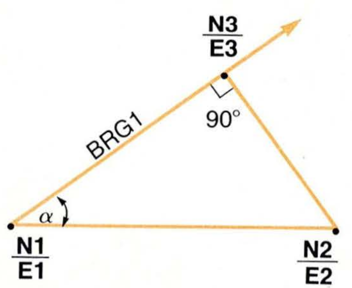
BEARING-BEARING



BEARING-DISTANCE



DISTANCE-DISTANCE



OFFSET FROM A POINT TO A LINE

SIZE: 015

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Begin intersection program		[XEQ] INTER	BB BD DD OFS
2	Choose the type of intersection to be calculated: Bearing-Bearing (BB) Bearing-Distance (BD) Distance-Distance (DD) Offset from Point to Line (OFS).		 [A] [B] [C] [D]	 N1=? N1=? N1=? N1=?
3	Input coordinates of point 1 and point 2 Northing of point 1 Easting of point 1 Northing of point 2 Easting of point 2.	 N1 E1 N2 E2	 [R/S] [R/S] [R/S] [R/S]	 N1=? E1=? N2=? E2=?
3a	For Bearing-Bearing go to step 4. For Bearing-Distance go to step 5. For Distance-Distance go to step 6. For Offset go to step 7.			
4	Bearing-Bearing Intersection: Input bearing and quadrant from point 1. Input bearing and quadrant from point 2. Go to step 8.	 BRG 1 QD BRG 2 QD	 [R/S] [R/S] [R/S] [R/S]	BRG1=? QD=? BRG2=? QD=?
5	Bearing-Distance Intersection: Input bearing and quadrant from point 1. Input distance from point 2. Go to step 8.	 BRG 1 QD DIST 2	 [R/S] [R/S] [R/S]	BRG1=? QD=? DIST2=?
6	Distance-Distance Intersection: Input distance from point 1. Input distance from point 2. Go to step 8.	 DIST 1 DIST 2	 [R/S] [R/S]	DIST1=? DIST2=?
7	Offset from Point to a Line: Input bearing and quadrant from point 1. Go to step 8.	 BRG 1 QD	 [R/S] [R/S]	BRG1=? QD=?
8	Results are calculated and displayed as follows: Bearing from point 1 Distance from point 1 Bearing from point 2 Distance from point 2 Northing of point of intersection Easting of point of intersection.		 [R/S]† [R/S]† [R/S]† [R/S]† [R/S]†	 (Bearing 1) DIST1= (Bearing 2) DIST2= N3= E3=

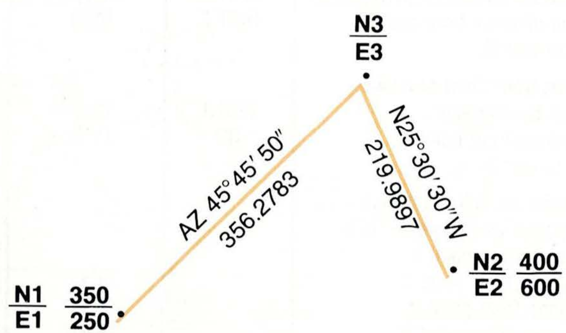
† This [R/S] not necessary when calculator is operated with printer.

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
8a	For second solution (if it exists): Press [R/S]. If second solution exists results are output as in step 8. If second solution does not exist program execution stops.			
9	(Optional) To display bearing and distance from point 1 to point 2:		[R/S] [R/S]† [R/S]†	(Bearing 1-2) DIST1-2=
10	For a new intersection, press [E] and go to step 2.		[E]	BB BD DD OFS
	NOTE: If you desire to input azimuths rather than bearing/quadrants: Input azimuth Then quadrant=1	AZ 1	[R/S] [R/S]	BRG=? QD=?

† This [R/S] not necessary when calculator is operated with printer.

Example 1:

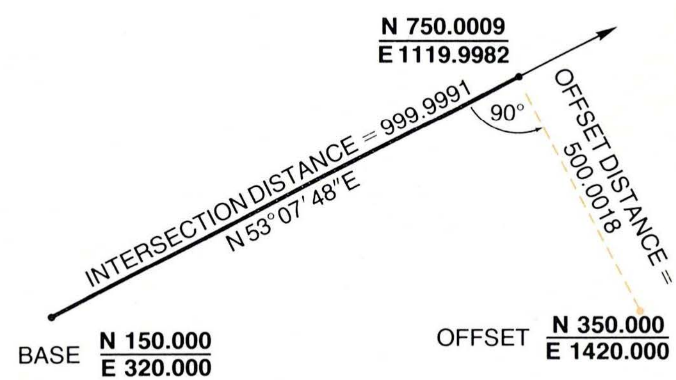
Calculate Bearing-Bearing Intersection for the following problem:



Keystrokes:	Display:	
XEQ [ALPHA] SIZE [ALPHA] 015	*SIZE 015*	
[XEQ] [ALPHA] INTER [ALPHA]	*BB BD DD OFS*	
[A]	*N1=?*	
350 [R/S]	*E1=?*	
250 [R/S]	*N2=?*	
400 [R/S]	*E2=?*	
600 [R/S]	*BRG1=?*	
45.455 [R/S]	*QD=?*	
1 [R/S]	*BRG2=?*	
25.303 [R/S]	*QD=?*	
4 [R/S]	*N 45.4550 E*	(Brg. pt. 1→3)
[R/S]	*DIST1=356.2783*	(Dist. pt. 1→3)
[R/S]	*N 25.3030 W*	(Brg. pt. 2→3)
[R/S]	*DIST2=219.9897*	(Dist. pt. 2→3)
[R/S]	*N3=598.5457*	
[R/S]	*E3=505.2631*	
[R/S] [R/S]	*N 81.5212 E*	(Brg. pt. 1→2)
[R/S]	*DIST1-2=353.5534*	(Dist. pt. 1→2)

Example 2:

Solve the following offset problem:

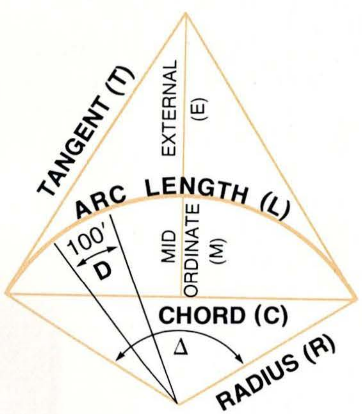


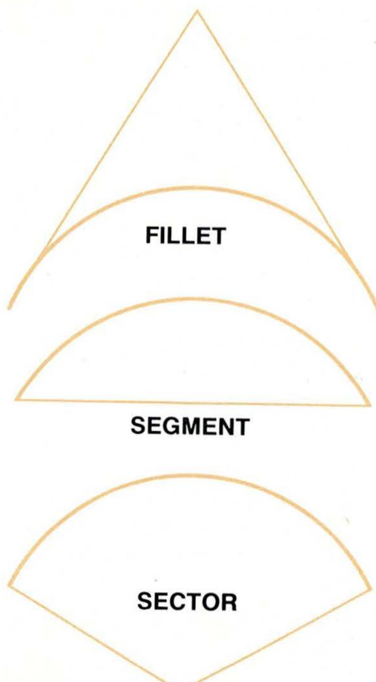
Keystrokes:	Display:	
[E]	*BB BD DD OFS*	
[D]	*N1=?*	
150 [R/S]	*E1=?*	
320 [R/S]	*N2=?*	
350 [R/S]	*E2=?*	
1420 [R/S]	*BRG1=?*	
53.0748 [R/S]	*QD=?*	
1 [R/S]	*N 53.0748 E*	(Brg. pt. 1→3)
[R/S]	*DIST1=999.9991*	(Dist. pt. 1→3)
[R/S]	*N 36.5212 W*	(Brg. pt. 2→3)
[R/S]	*DIST2=500.0018*	(Dist. pt. 2→3)
[R/S]	*N3=750.0009*	
[R/S]	*E3=1,119.9982*	
[R/S] [R/S]	*N 79.4143 E*	(Brg. pt. 1→2)
[R/S]	*DIST1-2=1,118.0340*	(Dist. pt. 1→2)

Notes

CURVE SOLUTIONS

This program is designed to calculate 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 calculated, as well as the areas of the fillet, segment and sector.





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

In normal operational mode the program accepts D (the degree of curve) by arc definition. An optional mode allows setting of program to accept D by chord definition.

				SIZE: 005
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Place Curve overlay on keyboard and begin Curve Solutions program.		XEQ CURVE	=?
2	Input the radius, (R), if known, and go to step 4, or, if the radius is not known, press R/S for the next prompt.	R –	R/S R/S	DELTA=? D=?
3	Input the degree of curve, (D), if it is known, or, if D is not known press R/S for the next prompt.	D (D.MS) –	R/S R/S	DELTA=? DELTA=?
4	Input the central angle, Delta, if it is known. If Delta is not known, press R/S.	DELTA (D.MS)	R/S R/S	(see 4a) (see 4a)
4a	If either R or D, and Delta were input, go to step 6.			R=(radius)
4b	If only one of the above was input see the following display and go to step 5.			L T C M E
5	Input one of the following: Arc length Tangent Chord Midordinate External NOTE: To review function prompts press R/S after inputting data, then press appropriate key.	 L T C M E	 A B C D E	
6	Results of calculation are displayed as follows:		 R/S† R/S†	R=(radius) D=(D.MS) DELTA=(D.MS)

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
7	Continue display of results.*		[ ] [B] [R/S]† [R/S]† [R/S]† [R/S]†	L=(arc) T=(tan.) C=(chord) M=(midordinate) E=(external)
8	Display sector, segment and fillet areas.* * NOTE: These groups of results may be called at any time by pressing [ ] [B] or [ ] [C] as indicated.		[ ] [C] [R/S]† [R/S]†	SEC=(area) SEG=(area) FIL=(area)
9	This program assumes that the degree of curvature, D, is by arc definition. If you desire to use chord definition, set to proper mode before inputting data.		[ ] [E] [R/S]	D-CHD R=?
9a	To reset to arc definition, press [ ] [A]. Then go to step 2.		[ ] [A]	R=?
10	For a new case, press [ ] [A]. Then go to step 2.		[ ] [A]	R=?

† This [R/S] not necessary when calculator is operated with printer.

Example 1:

Given a curve with a radius of 100 feet and an arc length of 150 feet, calculate D, and sector, segment and fillet areas.

Keystrokes:	Display:	
[XEQ] [ALPHA] SIZE [ALPHA] 005	*SIZE 005*	
[XEQ] [ALPHA] CURVE [ALPHA]	*R=?*	
100 [R/S]	*DELTA=?*	
[R/S]	*L T C M E*	
150 [A]	*R=100.0000*	
[R/S]	*D=57.1745*	(D.MS)
[R/S]	*DELTA=85.5637*	(D.MS)
[ ] [C]	*SEC=7,500.0000*	
[R/S]	*SEG=2,512.5251*	
[R/S]	*FIL=1,815.9646*	

Example 2:

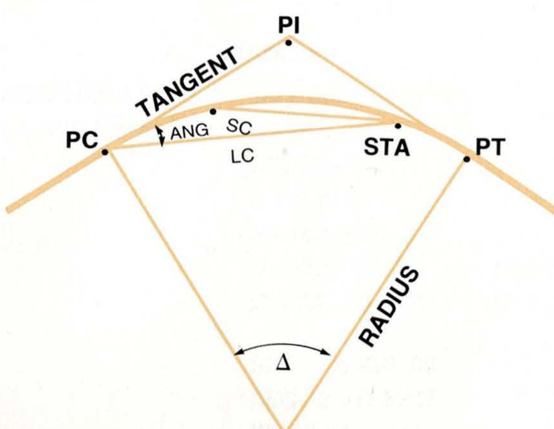
A curve with a central angle of 35° 32′ 25″ has a tangent of 53 feet. Find the degree of curvature (chord definition) and the arc length.

Keystrokes:	Display:	
[ ] [A]	*R=?*	
[ ] [E]	*D-CHD*	
[R/S]	*R=?*	
[R/S]	*D=?*	
[R/S]	*DELTA=?*	
35.3225 [R/S]	*L T C M E*	
53 [B]	*R=165.3717*	
[R/S]	*D=35.1151*	(D.MS)
[R/S]	*DELTA=35.3225*	(D.MS)
[ ] [B]	*L=102.5792*	

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

The *Curve Solutions* program is used to calculate and input the necessary parameters for this program. It may also be used to calculate the other curve parameters after this program has been run.



Field data output for PC deflections consist of:

STA—current station

ANG—deflection angle from tangent to long chord

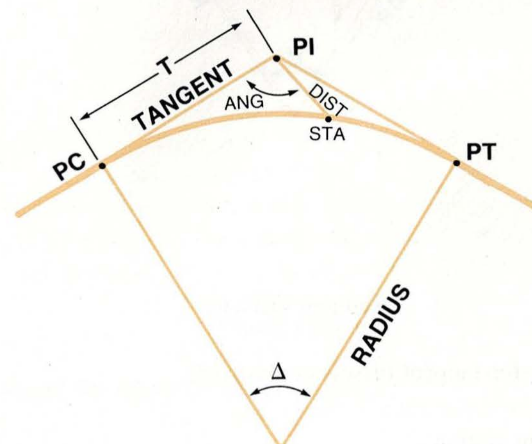
LC—long chord from PC to current station

SC—short chord from previous station to current station

Δ—central angle

PI—point of intersection of tangents

PC, PT—ends of curve



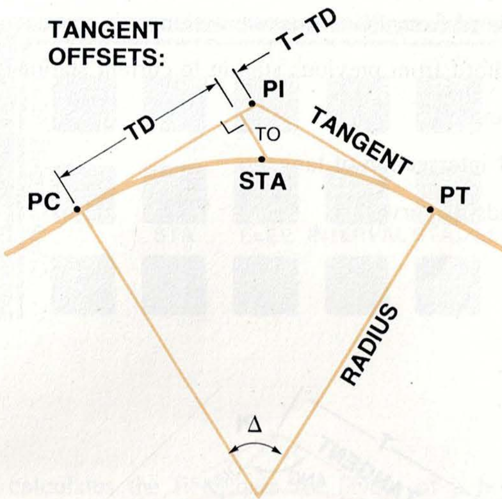
PI Deflections:

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:

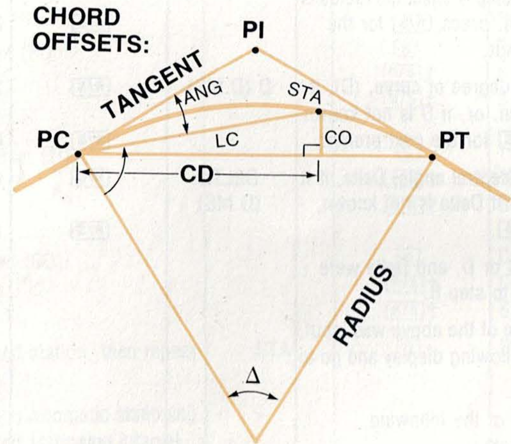
Field data output for tangent offsets consists of:

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	FUNCTION	DISPLAY (SIZE: 014)
1	Place the Horiz overlay on the keyboard and begin the Horizontal Curve Layout program.		[XEQ] HORIZ	R=?
2	Input the radius, (R), if known, and go to step 4, or, if the radius is not known, press [R/S] for the next prompt.	R –	[R/S] [R/S]	DELTA=? D=?
3	Input the degree of curve, (D), if it is known, or, if D is not known press [R/S] for the next prompt.	D (D.MS) –	[R/S] [R/S]	DELTA=? DELTA=?
4	Input the central angle, Delta, if it is known. If Delta is not known, press [R/S].	DELTA (D.MS)	[R/S] [R/S]	(see 4a) (see 4a)
4a	If either R or D, and Delta were input, go to step 6.			R=(radius)
4b	If only one of the above was input, see the following display and go to step 5.			L T C M E
5	Input one of the following: Arc length Tangent Chord Midordinate External (Optional, to reprompt: press [R/S] after inputting data. See alpha display, then press appropriate key.	 L T C M E	 [A] [B] [C] [D] [E]	
6	Curve parameters are calculated and displayed.		 [R/S]† [R/S]† [R/S]†	R=(radius) D=(D.MS) DELTA=(D.MS) L=(arc)
7	Call prompt for horizontal curve data.		[R/S]†	PC=?
8a	Input PC, or	PC	[R/S]	PT=
8b	Prompt for and input PI. PT, PI, and PC are calculated.	 PI	[R/S] [R/S] [R/S]† [R/S]†	PI=? PT= PI= PC=
9	Input current (or starting) station and display labelling of top row keys for type of layout method.	STA	[G]	PC PI TO CO

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
10	Select type of layout method and calculate field data: PC deflection (PC) or PI deflection (PI) or Tangent Offset (TO) or Chord Offset (CO)		 [A] [R/S]† [R/S]† [R/S]† [B] [R/S]† [R/S]† [C] [R/S]† [R/S]† [D] [R/S]† [R/S]†	 SC= LC= ∡= STA= DIST= ∡= STA= TO= TD= STA= CO= CD= STA=
11a	Input desired station, then repeat step 9, or	STA	[G]	PC PI TO CO
11b	If you desire automatic stationing input desired stationing interval and select type of layout as in step 9. Program will begin calculating field data from the current station. After each set of calculations press [R/S] to continue automatically to the next station. Calculation will finally halt at the PT of the curve.	INT	[I]	PC PI TO CO

† This [R/S] is not necessary when calculator is operated with printer.

Example 1:

Calculate field data for PC deflections for a curve with a central angle of 35°30′ and a degree of curve of 12°30′ (arc definition). 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:	Display:
[XEQ] [ALPHA] SIZE [ALPHA] 014	*SIZE 014*
[XEQ] [ALPHA] HORIZ [ALPHA]	*R=?*
[R/S]	*D=?*
12.3 [R/S]	*DELTA=?*
35.3 [R/S]	*R=458.3662*
[R/S]	*D=12.3000*
[R/S]	*DELTA=35.3000*

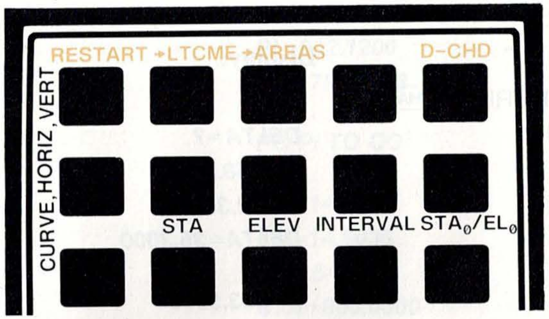
Keystrokes:	Display:
[R/S]	*L=284.0000*
[R/S]	*PC=?*
[R/S]	*PI=?*
932.12 [R/S]	*PT=1,069.3958*
[R/S]	*PI=932.1200*
[R/S]	*PC=785.3958*
800 [G]	*PC PI TO CO*
[A]	*SC=14.6036*
[R/S]	*LC=14.6036*
[R/S]	*∡=0.5446*
[R/S]	*STA=800.0000*
100 [I]	*PC PI TO CO*
[A]	*SC=99.8018*
[R/S]	*LC=114.3059*
[R/S]	*∡=7.0946*
[R/S]	*STA=900.0000*
[R/S]	*SC=99.8018*
[R/S]	*LC=212.6495*
[R/S]	*∡=13.2446*
[R/S]	*STA=1,000.0000*
[R/S]	*SC=69.3296*
[R/S]	*LC=279.4790*
[R/S]	*∡=17.4500*
[R/S]	*PT=1,069.3958*

Example 2:

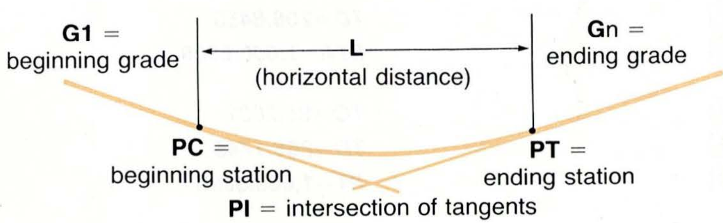
Calculate field data for tangent offsets for a curve with a central angle of 35°30′ and a radius of 458.366 feet. Start at station 8+00 and use a stationing interval of 100 feet up to and including the station at the PT. The station at the PC is 7+85.4.

Keystrokes:	Display:
[XEQ] [ALPHA] HORIZ [ALPHA]	*R=?*
458.366 [R/S]	*DELTA=?*
35.3 [R/S]	*R=458.3660*
[R/S]	*D=12.3000*
[R/S]	*DELTA=35.3000*
[R/S]	*L=283.9999*
[R/S]	*PC=?*
785.4 [R/S]	*PT=1,069.3999*
[R/S]	*PI=932.1241*
[R/S]	*PC=785.4000*
800 [G]	*PC PI TO CO*
[C]	*TO=0.2325*
[R/S]	*TD=14.5975*
[R/S]	*STA=800.0000*
100 [I]	*PC PI TO CO*
[C]	*TO=14.2516*
[R/S]	*TD=113.4098*
[R/S]	*STA=900.0000*
[R/S]	*TO=49.3253*
[R/S]	*TD=206.8455*
[R/S]	*STA=1,000.0000*
[R/S]	*TO=85.2031*
[R/S]	*TD=266.1745*
[R/S]	*PT=1,069.3999*

VERTICAL CURVES AND GRADES



This program calculates 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 calculated as well as elevations at specified stations. If a stationing interval is given, elevations at successive stations are calculated automatically.



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

SIZE: 014

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Place Vert overlay on calculator and begin Vertical Curves and Grades.		XEQ VERT	CURVE?
2	If calculating a vertical curve, input Y. Then go to step 3.	Y	R/S	PC=?
2a	If calculating a grade, input N. Then call prompting and input beginning station, beginning elevation, and grade, then go to step 7.	N STA1 EL1 GRADE%	R/S R/S R/S R/S R/S	GRADE STA1=? EL1=? GRADE%=?
3	Input PC, the beginning station. If PC is not known, press R/S and then input PI (the station at the intersection of the tangents).	PC PI	R/S R/S R/S	EL=? PI=? EL=?
4	Input elevation at PC or PI (whichever was input above) and beginning and ending grades.	EL GRADE BEG% GRADE END%	R/S R/S R/S	GRADE BEG%=? GRADE END%=? L=?
5	Input horizontal length of curve, if known. Or, if unknown, press R/S and input elevation of high or low point, if known. Or, if unknown, press R/S and input a station and elevation through which the curve passes.	L — EL0 — STA EL	R/S R/S R/S R/S R/S R/S	PC= EL0=? PC= STA=? EL=? PC=
6	The beginning station, PC, and its elevation are displayed.		R/S †	PC= EL=
7	To calculate stations at specified elevations, go to step 8. To calculate elevations at specified stations, go to step 9. To calculate the low or high point of a vertical curve, go to step 11.			
8	Input elevation and calculate station. (Two stations will be output for a vertical curve, "DATA ERROR" will be displayed if no point with the specified elevation exists on the curve.) Repeat step 8 for the next elevation.	EL	H R/S † R/S †	EL= STA= STA=
9	Input station and calculate its elevation. Repeat step 9 for next station or, go to step 10 for automatic stationing.	STA	G R/S †	STA= EL=

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
10	Input stationing interval and automatically calculate successive stations and elevations along the curve beginning from the current station. Press [R/S]† to proceed to next station.	INT	[I] [R/S]† [R/S]† [R/S]† etc.	STA= EL= STA= EL=
10a	For a vertical curve, execution will halt at the PT.		[R/S]† [R/S]†	PT= EL=
11	To calculate the high or low point of a vertical curve.		[J] [R/S]†	STA0= EL0=
12	For a new curve or grade, go to step 1.			

† This [R/S] not necessary when calculator is operated with printer.

Example:

Calculate 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:	Display:
[XEQ] [ALPHA] SIZE [ALPHA] 014	***SIZE 014***
[XEQ] [ALPHA] VERT [ALPHA]	***CURVE?***
Y [R/S]	***PC=?***
[R/S]	***PI=?***
1424.08 [R/S]	***EL=?***
104.77 [R/S]	***GRADE BEG%=?***
5.1 [CHS] [R/S]	***GRADE END%=?***
2.4 [R/S]	***L=?***
400 [R/S]	***PC=1,224.0800***
[R/S]	***EL=114.9700***
1,300 [G]	***STA=1,300.0000***
[R/S]	***EL=111.6384***
100 [I]	***STA=1,400.0000***
[R/S]	***EL=108.8994***
[R/S]	***STA=1,500.0000***
[R/S]	***EL=108.0354***

Keystrokes:	Display:
[R/S]	***STA=1,600.0000***
[R/S]	***EL=109.0464***
[R/S]	***PT=1,624.0800*** (End of Curve)
[R/S]	***EL=109.5700***

What is the station and elevation of the low point?

[J]	***STA0=1496.0800***
[R/S]	***EL0=108.0340***

What stations would have an elevation of 109.00 feet?

109 [H]	***EL=109.0000***
[R/S]	***STA=1,597.5886***
[R/S]	***STA=1,394.5714***

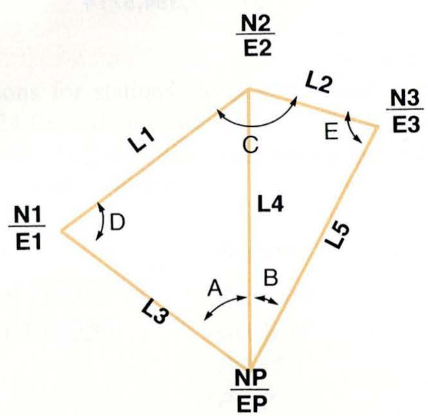
RESECTION

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 is the distances between pints 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 calculated and the five distances between the points can also be calculated. If coordinates for the three points were input, coordinates of point P can also be obtained.

There are three possible cases depending on the spatial relationship of the points.

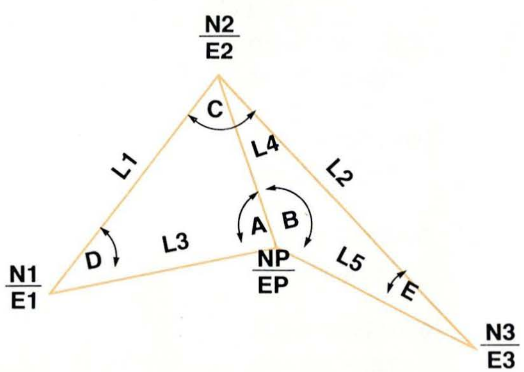
Case 1

Point P is outside the triangle formed by points 1, 2 and 3 and opposite point 2.



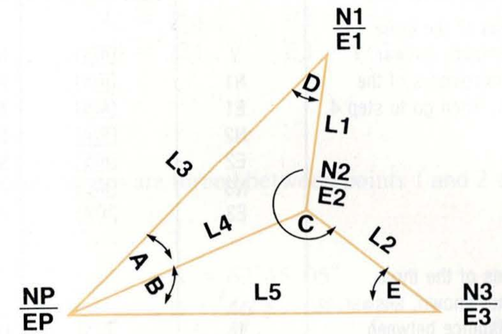
Case 2

Point P is within the triangle formed by points 1, 2 and 3.



Case 3

Point P is outside the triangle formed by points 1, 2 and 3 and on the same side as point 2.



Note:

Be sure that the points are arranged 1, 2, 3, P in clockwise order for all three cases.

				SIZE: 016
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Begin Resection program		XEQ RESECT	COORDS?
2	If coordinates of the three points are known, answer: Y and input coordinates of the three points. Then go to step 4.	Y	R/S	N1=?
		N1	R/S	E1=?
		E1	R/S	N2=?
		N2	R/S	E2=?
		E2	R/S	N3=?
		N3	R/S	E3=?
		E3	R/S	∡A=?
	OR			
3	If coordinates of the three points are not known, answer: N and input distance between points 1 and 2, distance between points 2 and 3 and angle C.	N	R/S	DIST1=?
		L1	R/S	DIST2=?
		L2	R/S	∡C=?
		∡C(D.MS)	R/S	∡A=?
4	Input angle A and angle B.	∡A(D.MS)	R/S	∡B=?
		∡B(D.MS)	R/S	∡D=
			R/S†	∡E=
5	If coordinates of the three points were input calculate coordinates of point P.		R/S†	NP=
			R/S†	EP=
6	In either case, distances 1 through 5 may be calculated.		R/S†	DIST1=
			R/S†	DIST2=
			R/S†	DIST3=
			R/S†	DIST4=
			R/S†	DIST5=
7	For a new case go to step 1.			

† This R/S not necessary when calculator is operated with printer.

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:	**Display:**
XEQ ALPHA SIZE ALPHA 016	*SIZE 016*
XEQ ALPHA RESECT ALPHA	*COORDS?*
Y R/S	*N1=?*
232 R/S	*E1=?*
307 R/S	*N2=?*
356 R/S	*E2=?*
468 R/S	*N3=?*
224 R/S	*E3=?*
561 R/S	*∡A=?*
62.4505 R/S	*∡B=?*
46.5100 R/S	*∡D=75.1900*
R/S	*∡E=87.3106*
R/S	*NP=138.5604*
R/S	*EP=427.8368*
R/S	*DIST1=203.2166*
R/S	*DIST2=161.4714*
R/S	*DIST3=152.7498*
R/S	*DIST4=221.1178*
R/S	*DIST5=158.2162*

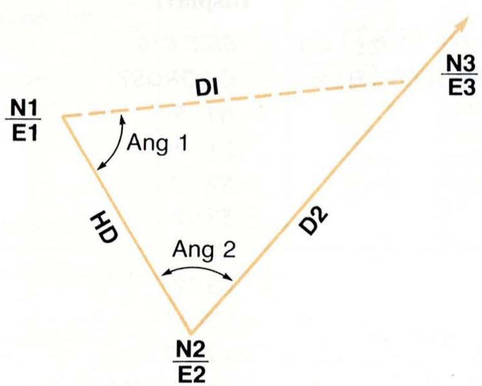
PREDETERMINED AREA

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

Line Through a Point (Triangular Parcel)

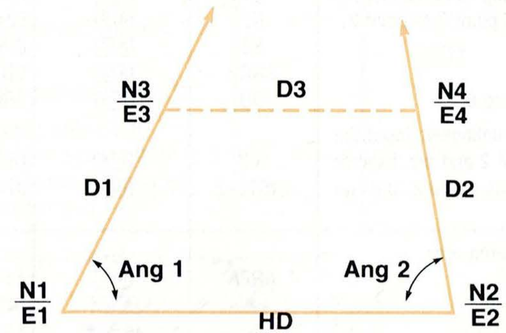
The area of the land parcel must be divided so that a triangle of desired area can be solved by hinging one side.

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.



Two Sides Parallel (Trapezoidal Parcel)

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.

				SIZE: 015
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Begin Predetermined Area.		[XEQ] PREAREA	TRI∡?
2	If land parcel is triangular: answer Y and go to step 3 OR If land parcel is trapezoidal: answer N and go to step 9.	Y N	[R/S] [R/S]	TRI∡ TRAPZ
3	**For Triangular Parcel:** If coordinates points 1 and 2 are known answer Y and go to step 4. OR If coordinates are not known answer N and go to step 5.	 Y N	[R/S] [R/S] [R/S]	COORDS? N1=? ∡2=?

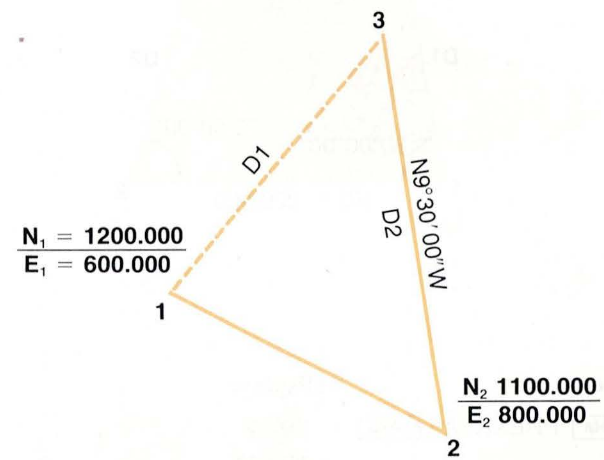
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
		Y	R/S	CORDS ?
4	**Coordinates known:** Input the coordinates of points 1 and 2 and the bearing* and quadrant of the line from point 2 to point 3,			N1=?
		N1	R/S	E1=?
		E1 BRG1	R/S	N2=? BRG1
		N2	R/S	E2=?
		E2	R/S	BRG2=?
		BRG2	R/S	QD=?
	then go to step 6.	QD	R/S	AREA=?
5	**Coordinates unknown:** Input the angle at point 2 and the distance between points 1 and 2, then go to step 6.			∡2=?
		∡2	R/S	DIST1-2=?
		DIST1-2	R/S	AREA=?
6	Input the desired area.	AREA	R/S	∡1=
			R/S†	DIST1-3=
			R/S†	∡2=
				DIST2-3=
7	If coordinates were input at step 4, display calculated coordinates of point 3.		R/S†	N3=
			R/S†	E3=
8	For a new case go to step 1.			
9	**For a Trapezoidal Parcel:**			TRAPZ
	If the coordinates of points 1 and 2 are known, answer Y and go to step 10.		R/S	COORDS?
		Y	R/S	N1=?
	OR If coordinates are not known, answer N and go to step 11.	N	R/S	∡1=?
10	**Coordinates known:** Input coordinates of point 1 and the bearing* and quadrant of the line from point 1 to point 3. Then input the coordinates of point 2 and the bearing* and quadrant of the line from point 2 to point 4, then go to step 12.			N1=?
		N1	R/S	E1=?
		E1	R/S	BRG1=?
		BRG1	R/S	QD=?
		QD	R/S	N2=?
		N2	R/S	E2=?
		E2	R/S	BRG2=?
		BRG2	R/S	QD=?
		QD	R/S	AREA=?
11	**Coordinates unknown:** Input the angle at point 1, the angle at point 2 and the distance between points 1 and 2, then go to step 12.			∡1=?
		∡1	R/S	∡2=?
		∡2	R/S	DIST1-2=?
		DIST1-2	R/S	AREA=?
12	Input the desired area.	AREA	R/S	∡1=
			R/S†	DIST1-3=
			R/S†	∡2=
			R/S†	DIST2-4=

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
13	If coordinates were input at step 10, display calculated coordinates of points 3 and 4.		R/S†	N3=
			R/S†	E3=
			R/S†	N4=
			R/S†	E4=
14	Display distance from point 3 to point 4.		R/S†	DIST3-4=
15	For a new case go to step 1. * If azimuths rather than bearings are known, input azimuth in place of bearing with quadrant=1.			

† This R/S not necessary when calculator is operated with printer.

Example 1:

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

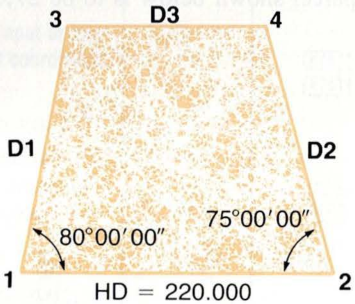


Keystrokes:	Display:
XEQ ALPHA SIZE ALPHA 015	*SIZE 015*
XEQ ALPHA PREAREA ALPHA	*TRI∡?*
Y R/S	*TRI∡*
R/S	*COORDS?*
Y R/S	*N1=?*
1200 R/S	*E1=?*
600 R/S	*N2=?*
1100 R/S	*E2=?*

Keystrokes:	Display:
800 [R/S]	*BRG2=?*
9.3 [R/S]	*QD=?*
4 [R/S]	*AREA=?*
27000 [R/S]	***∡1=78.4911***
[R/S]	***DIST1-3=246.1671***
[R/S]	***∡2=53.5606***
[R/S]	***DIST2-3=298.7513***
[R/S]	***N3=1,394.6541***
[R/S]	***E3=750.6918***

Example 2:

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



Keystrokes:	Display:
[XEQ] [ALPHA] PREAREA [ALPHA]	*TRI∡?*
N [R/S]	*TRAPZ*
[R/S]	*COORDS?*
N [R/S]	*∡1=?*
80 [R/S]	*∡2=?*
75 [R/S]	*DIST1-2=?*
220 [R/S]	*AREA=?*
36000 [R/S]	***∡1=80.0000***
[R/S]	***DIST1-3=210.0220***
[R/S]	***∡2=75.0000***
[R/S]	***DIST2-4=214.1275***
[R/S]	***DIST3-4=128.1098***

Notes

VOLUME BY AVERAGE END AREA

This program calculates volumes of earth by the method of average end area. The required information is the elevation and offset or horizontal distance for each point on the cross-section and the interval between cross-sections.

The volume for each section is calculated, as well as the total accumulated volume. The cross-section area is also calculated.

The cross-sections must either be all cut or all fill. The user may choose to have volumes output in cubic yards or cubic feet, all areas are in square feet.

You may start at any point on the cross-section and the elevations and distances may be measured from any base lines as long as the same lines are used for the whole section. In addition, you may work around the section clockwise (CW) or counterclockwise (CCW).

Note:

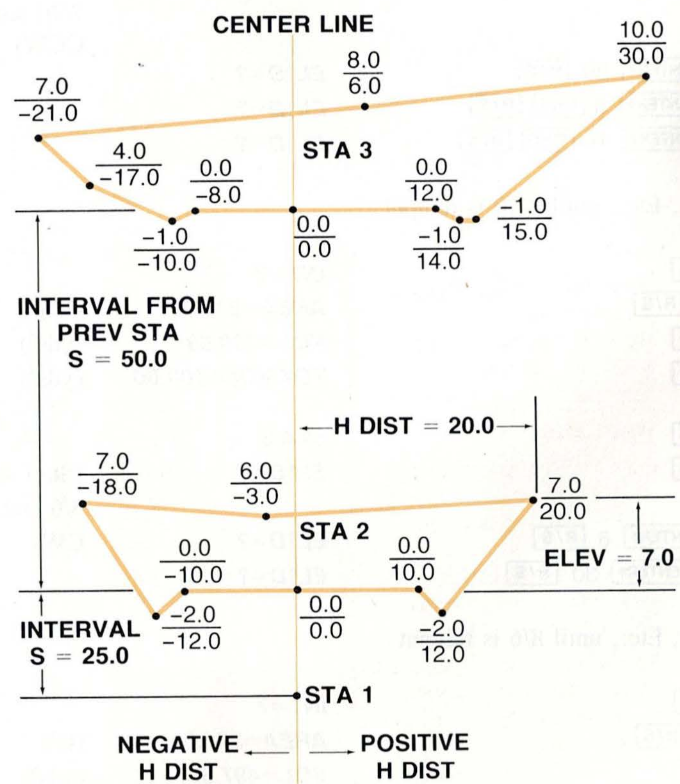
Execution of this program clears all storage registers.

				SIZE: 014
STEP	**INSTRUCTIONS**	**INPUT**	**FUNCTION**	**DISPLAY**
1	Begin Volume by Average End Area.		XEQ ENDVOL	CU YDS?
2	If you wish volumes displayed in cubic yards: or, if you wish volumes displayed in cubic feet:	Y N	R/S R/S	CU YDS CU FT
3	Call station number and input prompts.	– –	R/S † R/S †	STA(#) EL↑D=?
4	Input elevation and horizontal or offset distance. (You may start at any point on the section) Note: If a section has zero end area, skip steps 4 and 5 and go directly to step 6 by pressing R/S without prior data enter.	EL D	ENTER↑ R/S †	 EL↑D=?
5	Repeat step 4, working around the section (clockwise or counterclockwise) until the first EL and D have been reinput.			

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
6	To signal end of EL and D inputs press R/S, without prior data entry. Input interval from previous station and calculate area and volumes. (Note: Input 0 interval for first station.)	– INT	R/S R/S R/S † R/S †	INT=? AREA= VOL= TOT VOL=
7	Return to step 3 to input next section.	–	R/S †	STA(#)
8	For a new problem press E and go to step 2.		E	CU YDS?

† This R/S not necessary if calculator is operated with printer.

Example:



Calculate the volumes in cubic yards between the station shown above. (Note: Station 1 has zero area.)

Keystrokes:	Display:	
[XEQ] [ALPHA] SIZE [ALPHA] 014	*SIZE 014*	
[XEQ] [ALPHA] ENDVOL [ALPHA]	*CU YDS?*	
Y [R/S]	*CU YDS*	
[R/S]	*STA 1*	
[R/S]	*EL D=?*	(No entry, end area is zero)
[R/S]	*INT=?*	(Enter 0; first station)
0 [R/S]	*AREA=0.00*	
[R/S]	*VOL=0.00*	
[R/S]	*TOT VOL=0.00*	
[R/S]	*STA 2*	
[R/S]	*EL↑D=?*	(Start with point 7/20 and proceed CCW)
7 [ENTER↑] 20 [R/S]	*EL↑D=?*	
6 [ENTER↑] 3 [CHS] [R/S]	*EL↑D=?*	
7 [ENTER↑] 18 [CHS] [R/S]	*EL↑D=?*	

Etc., Etc., until 7/20 is reinput

[R/S]	*INT=?*	
25 [R/S]	*AREA=216.00*	(ft^2)
[R/S]	*VOL=100.00*	(yds^3)
[R/S]	*TOT VOL=100.00*	(yds^3)
[R/S]	*STA 3*	
[R/S]	*EL↑D=?*	(Start with point 8/6 and proceed CW)
8 [ENTER↑] 6 [R/S]	*EL↑D=?*	
10 [ENTER↑] 30 [R/S]	*EL↑D=?*	

Etc., Etc., until 8/6 is reinput

[R/S]	*INT=?*	
50 [R/S]	*AREA=321.50*	(ft^2)
[R/S]	*VOL=497.69*	(yds^3)
[R/S]	*TOT VOL=597.69*	(yds^3)

Notes

VOLUME OF A BORROW PIT

The volume of a borrow pit may be calculated with this program. The required information is the width and length of a rectangular section or base and height of a triangular section and the elevation at each corner of the section.

The volume of each section is calculated, as well as the total accumulated volume. You may choose to have volumes calculated in cubic yards or cubic feet.

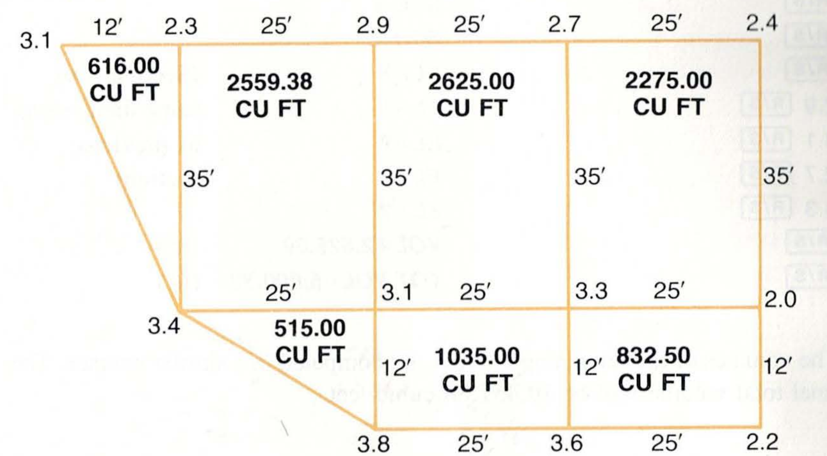
Note:

Execution of this program clears all storage registers.

STEP	INSTRUCTIONS	INPUT	FUNCTION	SIZE: 014 DISPLAY
1	Begin Borrow Pit program		[XEQ] PIT	CU YDS?
2	If you wish volumes displayed in cubic yards:	Y	[R/S]	CU YDS
	or, if you wish volumes displayed in cubic feet:	N	[R/S]	CU FT
3	Call station number and input prompts	– –	[R/S]† [R/S]†	STA(#) B↑H=?
4	Input the base and height of the triangular section or the length and width of the rectangular section	B(orL) H(orW)	[ENTER↑] [R/S]	 EL=?
5	Input the elevation of each corner of the section (3 inputs for triangles, 4 inputs for rectangles)	EL EL EL	[R/S] [R/S] [R/S]	EL=? EL=? EL=?
6	When all 3 or 4 corners have been input, calculate the volume by pressing [R/S], without prior data entry	–	[R/S] [R/S]†	VOL= TOT VOL=
7	Return to step 3 and input data for next section		[R/S]†	STA(#)
8	For a new problem press [ ] [E] and go to step 2.		[ ] [E]	CU YDS?

† This [R/S] not necessary when calculator is operated with printer.

Example:



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

Keystrokes:	Display:	
[XEQ] [ALPHA] SIZE [ALPHA] 014	*SIZE 014*	
[XEQ] [ALPHA] PIT [ALPHA]	*CU YDS?*	
N [R/S]	*CU FT*	
[R/S]	*STA 1*	
[R/S]	*B↑H=?*	
12 [ENTER↑] 35 [R/S]	*EL=?*	
3.1 [R/S]	*EL=?*	
2.3 [R/S]	*EL=?*	
3.4 [R/S]	*EL=?*	
[R/S]	*VOL=616.00*	(ft^3)
[R/S]	*TOT VOL=616.00*	(ft^3)
[R/S]	*STA 2*	
[R/S]	*B↑H=?*	
25 [ENTER↑] 35 [R/S]	*EL=?*	
3.4 [R/S]	*EL=?*	
2.3 [R/S]	*EL=?*	
2.9 [R/S]	*EL=?*	
3.1 [R/S]	*EL=?*	
[R/S]	*VOL=2,559.38*	(ft^3)
[R/S]	*TOT VOL=3,175.38*	(ft^3)

Keystrokes:	Display:	
[R/S]	*STA 3*	
[R/S]	*B↑H=?*	
[R/S]	*EL=?*	(Section is of
2.9 [R/S]	*EL=?*	same dimensions
3.1 [R/S]	*EL=?*	as previous
2.7 [R/S]	*EL=?*	section)
3.3 [R/S]	*EL=?*	
[R/S]	*VOL=2,625.00*	(ft^3)
[R/S]	*TOT VOL=5,800.38*	(ft^3)

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

Notes

COORDINATE TRANSFORMATION

This program translates, rotates and rescales coordinates. Required data are the rotation angle and a pivot point in the old and new coordinate systems. The rotation angle is entered as a negative value for clockwise rotation or as a positive value for counterclockwise rotation. If a new scale factor (other than unity) is desired, it may be entered.

Alternatively, if the coordinates of two points are known in both systems the transformation parameters may be automatically calculated and the coordinate transformation performed.

SIZE: 014

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Begin Coordinate Transformation program. Then go to step 2 or step 6.		[XEQ] COORD	ROT. ∡=?
	If rotation angle is known:			
2	Input rotation angle (positive if counter-clockwise, negative if clockwise).	ROT.∡(D.MS)	[R/S]	SCALE FACT.=?
3a	If new scale factor, (other than 1) is desired: input scale factor OR,	SCALE FACT.	[R/S]	N1 OLD=?
3b	If scale factor is unchanged (i.e., equal to 1) press [R/S] without prior data entry.		[R/S]	N1 OLD=?
4	Input coordinates of point in old system.	N1 OLD E1 OLD	[R/S] [R/S]	E1 OLD=? N1 NEW=?
5	Input coordinates of point in new system. Then go to step 9 or 10.	N1 NEW E1 NEW	[R/S] [R/S]	E1 NEW=?
	If two points in each system are known:			
6	Following step 1, immediately press [R/S] without prior data entry.		[R/S]	ROT. ∡=? N1 OLD=?
7	Input coordinates of point 1 and 2 in the old system.	N1 OLD E1 OLD N2 OLD E2 OLD	[R/S] [R/S] [R/S] [R/S]	E1 OLD=? N2 OLD=? E2 OLD=? N1 NEW=?
8	Input coordinates of points 1 and 2 in the new system. Then go to step 9 or 10.	N1 NEW E1 NEW N2 NEW E2 NEW	[R/S] [R/S] [R/S] [R/S]	E1 NEW=? N2 NEW=? E2 NEW=?

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
	To transform coordinates from old system to new system:			
9	Input coordinates of the point in the old system.	N OLD E OLD	[ENTER↑] [A] [R/S]†	 N NEW= E NEW=
	To transform coordinates from new system to old system:			
10	Input coordinates of the point in the new system.	N NEW E NEW	[ENTER↑] [B] [R/S]†	 N OLD= E OLD=
11	Repeat steps 9 and 10 as desired.			
12	For a new case; press [E] and go to step 2.		[E]	ROT. ∡=?

† This [R/S] not necessary when calculator is operated with printer.

Example 1:

Coordinates of points in two systems are given below:

Point	Old System N	Old System E	New System N	New System E
1	999.063	1932.096	1932.000	1000.000
2	1011.164	2810.942	2811.000	1011.000
3	1712.901	3775.734	–	–
4	1566.005	2507.720	–	–
5	–	–	2600.000	1500.000

Calculate the coordinates of points 3 and 4 in the new system. What are the coordinates of point 5 in the old system?

Keystrokes:	Display:
[XEQ] [ALPHA] SIZE [ALPHA] 014	***SIZE 014***
[XEQ] [ALPHA] COORD [ALPHA]	***ROT. ∡=?***
[R/S]	***N1 OLD=?***
999.063 [R/S]	***E1 OLD=?***

Keystrokes:	Display:	
1932.096 [R/S]	N2 OLD=?	
1011.164 [R/S]	E2 OLD=?	
2810.942 [R/S]	N1 NEW=?	
1932 [R/S]	E1 NEW=?	
1000 [R/S]	N2 NEW=?	
2811 [R/S]	E2 NEW=?	
1011 [R/S]	0.7170	(ignore)
1712.901 [ENTER↑]		
3775.734 [A]	N NEW=3,794.0557	
[R/S]	E NEW=334.7517	
1566.005 [ENTER↑]		
12507.72 [A]	N NEW=2,522.4175	
[R/S]	E NEW=448.2930	
2600 [ENTER↑]		
1500 [B]	N OLD=516.8665	
[R/S]	E OLD=2,612.8967	

Example 2:

A set of coordinates is to be rotated clockwise 3 degrees and translated such that the new coordinates of point 1 are N=100/E=350. The scale factor is 1. Calculate the new coordinates for points 2 and 3. Calculate the old coordinates for points 4 and 5.

Point	Old System		New System	
	N	E	N	E
1	150.000	400.000	100.000	350.000
2	224.540	561.673	–	–
3	356.577	468.710	–	–
4	–	–	187.151	261.767
5	–	–	285.120	397.850

Keystrokes:	Display:	
[E]	ROT.∠=?	
3 [CHS] [R/S]	SCALE FACT.=?	
[R/S]	N1 OLD=?	
150 [R/S]	E1 OLD=?	
400 [R/S]	N1 NEW=?	
100 [R/S]	E1 NEW=?	
350 [R/S]	100.0000	(ignore)

Keystrokes:	Display:
224.54 [ENTER↑]	
561.673 [A]	N NEW=165.9765
[R/S]	E NEW=515.3526
356.577 [ENTER↑]	
468.71 [A]	N NEW=302.6979
[R/S]	E NEW=429.4272
187.151 [ENTER↑]	
261.767 [B]	N OLD=232.4138
[R/S]	E OLD=307.3268
285.12 [ENTER↑]	
397.85 [B]	N OLD=337.3706
[R/S]	E OLD=438.0960

PROGRAM DATA

Program	# Regs. to Copy	Data Registers	Flags	Display Format	Angular Mode
Traverse, Inverse and Sideshots	69	00-15	00-05,10,21, 22,24,27,29	FIX 4	DEG
Compass Rule Adjustment Transit Rule Adjustment	47	00-08,10,13,15	00-03,10,21, 22,24,27,29	FIX 4	DEG
Intersections	45	00-14	00,10,21,22, 24,27,29	FIX 4	DEG
Curve Solutions	57	00-04	00,02,05,10, 21,22,24,27, 29	FIX 4	DEG
Horizontal Curve Layout	45	00-13	00,02,05,10, 21,22,24,27, 29	FIX 4	DEG
Vertical Curves and Grades	66	00-09,12,13	00-04,10,21, 22,24,27,29	FIX 4	DEG
Resection	42	00-15	00,10,21,22, 24,27,29	FIX 4	DEG
Predetermined Area	56	00-14	00,01,10,21, 22,24,27,29	FIX 4	DEG
Volume by Average End Area Volume of a Borrow Pit	43	00-07,13	00-02,10,21, 22,24,27,29	FIX 2	DEG
Coordinate Transformation	33	00-05,11-13	10,21,22,24, 27,29	FIX 4	DEG
Utility Subroutines (Label ⁂ IN)	49	—	10,21,24,27, 29	FIX 4	DEG

SUBROUTINES

This table provides information necessary to use various portions of the Surveying Application Module as subroutines. When using the subroutines be sure the calculator status is set as follows:

FIX 4
DEG
SF 21 (optional: for display or print)

Clear registers before inputting data for first execution of TS or INVERSE routines.

Subroutine	Label	Initial Registers	Initial Stack	Flag Status	Final Registers	Final Stack	Display	Remarks
Traverse (Size: 016)	TS	00 AZ(D.d) 02 0.0 03 0.0 07 N Beg. 08 E Beg. 13 0.9	X HD	SF 01 CF 10	00 AZ(D.d) 01 HD 02 Σ LAT 03 Σ DEP 13 1.9	Y N2 X E2	HD= N2= E2=	Some or all of the contents of registers 00 thru 15 will be altered by running this subroutine.
Sideshot (Size: 016)	TS	02 0.0 03 0.0 07 N Beg. 08 E Beg. 10 AZ(D.d) 13 0.9	X HD	CF 01 CF 10	01 HD 10 AZ(D.d) 13 1.9	Y N2 X E2	HD= N2= E2=	

Inverse Traverse (Size: 016)	INVERSE	02 0.00 03 0.00 07 N Beg. 08 E Beg. 13 0.9	Y Nnew X Enew	SF 01 CF 10	00 AZ(D.d) 01 HD 02 ΣLAT 03 ΣDEP 07 N Beg. 08 E Beg. 13 1.9	Y Nnew X Enew	AZ= (or brg.) HD= N2= E2=	Some or all of the contents of registers 00 thru 15 will be altered by running this subroutine.
Inverse Sideshots (Size: 016)	INVERSE	02 0.0 03 0.0 07 N Beg. 08 E Beg. 13 0.9	Y Nnew X Enew	CF 01 CF 10	01 HD 10 AZ(D.d) 13 1.9	Y Nnew X Enew	AZ= (or brg.) HD= N2= E2=	
Circular Curve Components (Size: 005)	CIR	00 Radius 01 $\Delta/2$(D.d)	N.A.	CF 05	00 Radius 01 $\Delta/2$(D.d) 02 Arc 03 Tangent 04 Chord	Z C Y M X E	L= T= C= M= E=	After E is displayed, continue pressing R/S to obtain balance of results and return to main program.
Convert Azimuth to Bearing	BRG	N.A.	(Input prompt) AZ(D.MS)	SF 10	N.A.	Y BRG(D.MS) X QD		XEQ *AVIEW* for Alphanumeric display of bearing

Convert Bearing & Quadrant to Azimuth	AZ	N.A.	(Input prompt) BRG(D.MS) QD code	SF 10 (OR) CF 10	N.A. N.A.	X AZ(D.d) X AZ(D.MS)	Az(D.d) XEQ *AVIEW* for AZ= (D.MS) display
Coordinate Input Prompting	NE	13 PT# or Alpha	N.A.	SF 10	13 unchanged	N.A.	Prompts for N#=? E#=?
Coordinate Outputs	NE	13 PT# or Alpha	Y N X E	CF 10	13 unchanged	Y N X E	XEQ *AVIEW* for display of N#= E#=

Appendix C

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, Intext Educational Publishers, New York, 1975.

Traverse, Inverse and Sideshots

1. $HD = SD \sin(\text{zenith angle})$
2. $HD = SD \cos(\text{vertical angle})$
3. $\text{Latitude}_k = LAT_k = N_{k+1} - N_k$
   For instance: $LAT_1 = N_2 - N_1$
4. $\text{Departure}_k = DEP_k = E_{k+1} - E_k$
   For instance: $DEP_4 = E_5 - E_4$
5. $$\text{Area} = \sum_{k=1}^{n} LAT_k \left(\frac{1}{2} DEP_k + \sum_{j=1}^{k-1} DEP_j\right)$$

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 =

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

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

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

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

6. $\text{Segment area} = \frac{R^2}{2}\left(\frac{\Delta\pi}{180} - \sin\Delta\right)$
7. $\text{Arc length: } L = \frac{R\Delta\pi}{180}$
8. $\text{Tangent: } T = R \tan\left(\frac{\Delta}{2}\right)$
9. $\text{Chord: } C = 2\,R \sin\left(\frac{\Delta}{2}\right)$

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.

Compass Rule

See reference 1, pp 458-463.

Compass Rule for latitude and departure course correction:

1. $\text{Corrected latitude}_1 = L_1 + \ _1 = L_1 + \frac{(HD)_1(ER\ L)}{\Sigma(HD)}$
2. $\text{Corrected departure}_1 = D_1 + d_1 = D_1 + \frac{(HD)_1(ER\ D)}{\Sigma(HD)}$

Transit Rule

Transit Rule for latitude and departure course correction:

3. $\text{Corrected latitude} = L_1 + \ _1 = L_1 + \frac{(ER\ L)(|L|)}{\Sigma|L|}$
4. $\text{Corrected departure} = D_1 + d_1 = D_1 + \frac{(ER\ D)(|D|)}{\Sigma|D|}$

where: (for both Compass and Transit Rules:)

L_1 = Uncorrected latitude of any course

D_1 = Uncorrected departure of any course

ER L = Total error in latitude (closing latitude)

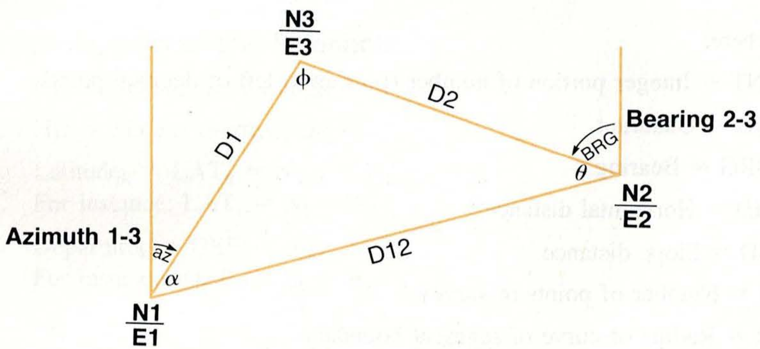
ER D = Total error in departure (closing departure)

HD = Uncorrected horizontal distance of any course

$_1$ = Correction to be applied to the uncorrected latitude of the course

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

Intersections



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

1. $\dfrac{D2}{\sin \alpha} = \dfrac{D12}{\sin \phi} = \dfrac{D1}{\sin \theta}$

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

Representative equations for solving the four intersection problems:

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

4. $\sin AZ13 = \dfrac{E3 - E1}{D1}$

5. $\cos AZ\,13 = \dfrac{N3 - N1}{D1}$

6. $\sin BRG23 = \dfrac{E2 - E3}{D2}$

7. $\cos BRG23 = \dfrac{N2 - N3}{D2}$

For bearing-bearing case:

8. $D1 = \dfrac{(D12)\sin \theta}{\sin \phi}$

For bearing-distance case:

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

For distance-distance case:

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

11. $\cos \alpha = \dfrac{(D12)^2 + (D1)^2 - (D2)^2}{2(D12)(D1)}$ (law of cosines)

For offset from a point to a line:

12. D2 = (D12) sin α, then use 9.

Curve Solutions

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

2. $D = \dfrac{18000}{R\pi}$ (by arc definition), or,

$D = 2\sin^{-1}\dfrac{50}{R}$ (by chord definition)

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

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

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

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

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

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

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

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

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

11. Fillet area $= RT -$ Sector area

where:

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

Horizontal Curve Layout

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

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

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

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

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

6. $D = \dfrac{18{,}000}{\pi R} = \dfrac{200}{\text{ft./defl.}}$ (by arc definition), or,

$D = 2 \sin^{-1} \dfrac{50}{R}$ (by chord definition)

7. LC $= 2$ R sin (defl. ang.)

8. TO $=$ LC sin (defl. ang.)

9. TD $=$ LC cos (defl. ang.)

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

11. PI ang. $= \tan^{-2} \left(\dfrac{TO}{T - TD} \right)$

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

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

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, measured in degrees, subtending arc of 100 ft. (by arc definition) or chord of 100 ft. (by chord definition).

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.

Vertical Curves and Grades

Grades:

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

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:

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

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

3. $PC = PI - \dfrac{L}{2}$ (Substitute in eq. 2)

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

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

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

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

Curve to pass through specified point:

PC known:

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

PI known:

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

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

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

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

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.

Resection

1. $\dfrac{\sin a}{A} = \dfrac{\sin b}{B} = \dfrac{\sin c}{C}$ (law of sines)

2. $K = \dfrac{L2 \sin A}{L1 \sin B}$

3. $A + B + C + D + E = 360°$

4. $\tan \theta 1 = \dfrac{E2 - E1}{N2 - N1}$

5. $\tan \theta 2 = \dfrac{E3 - E2}{N3 - N2}$

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

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 diagrams in program description.

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

N_1, E_1, N_2, E_2, N_3, E_3 = 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.

Predetermined Area

Line Through a Point

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

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

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

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

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

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

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

7. $D3 = \sqrt{(HD)^2 - 2A\left[\cot(\text{ANG}1) + \cot(\text{ANG}2)\right]}$

8. $h = 2A/(HD + D3)$

9. $D1 = \dfrac{h}{\sin(\text{ANG } 1)}$

10. $D2 = \dfrac{h}{\sin(\text{ANG } 2)}$

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.

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.

Volume by Average End Area

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

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

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.

numberic subscript: refers to point or station number.

Volume of a Borrow Pit

1. $VOL_{\Delta} = \dfrac{BH}{2}(EL)$

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

where:

VOL_{Δ} = Volume of triangular grid section.

B = Base of triangle.

H = Height of triangle.

EL = Elevation of grid section or depth of cut (average depth of vertices).

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

W = Width of rectangle.

L = Length of rectangle.

Coordinate Transformation

$$AZ_R = \o + \tan^{-1}\frac{E_i—E_p}{N_i—N_p}$$

$$HD_S = S\sqrt{(N_i—N_p)^2 + (E_i—E_p)^2}$$

$$N = N_p + H\ Dist_s \cos(AZ_R) + T_N$$

$$E = E_p + H\ Dist_S \sin(AZ_R) + T_E$$

$$T_N = N_{T_1} - E_p$$

$$T_E = E_{T_1} - E_p$$

where:

AZ_R = Rotated azimuth.

ø = Rotation angle.

N_i, E_i = Northing, easting of current point before transformation.

N_p, E_p = Original northing, easting of pivot point.

HD_S = Scaled horizontal distance.

S = Scale factor.

N, E = Northing, easting after transformation.

N_{T_1}, E_{T_1} = Northing, easting of pivot point after transformation.

Bearing—Azimuth Conversions

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

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

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

Appendix D

PROGRAM LABELS

Label	Duplicate Labels In
COMP	Petroleum Fluids Pac
COORD	Machine Design Pac
*H	Home Management Pac, Clinical Lab Pac
*IN	Navigation Pac, Machine Design Pac, Clinical Lab Pac
*YN	Clinical Lab Pac
*∡ ACRES INVERSE *AO ADJUST NE *A1 AZ PREAREA *BR BRG PIT *B1 CIR RESECT *DL CURVE TRANSIT *DS ENDVOL TRAV *EL HORIZ TS *S INTER VERT	(no Label Conflicts)

The labels in this list are not in the same order as they appear in the catalog listing for the module.

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