HEWLETT PACKARD

HP-65

SURVEYING PAC 1

SEPTEMBER, 1974

HEWLETT PACKARD

Sales and service from 172 offices in 65 countries.
19310 Pruneridge Avenue, Cupertino, CA 95014

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INTRODUCTION

Programs for your HP-65 Surveying Pac I have been selected to provide solutions for many of the day-to-day problems you encounter.*

In general, the programs are grouped into common problem areas of traversing, curves, triangles and intersections, field reductions, predetermined area and earthwork.

Included in Surveying Pac I are 34 prerecorded magnetic cards, a card case, 20 pocket instruction cards, and this instruction booklet with program descriptions, formulas, example problems, user instructions and program listings.

We are confident that you will find this pac useful, and we welcome any comments or suggestions you may have.

*This pac is written using North American surveying conventions.

FORMAT OF USER INSTRUCTIONS

The following is an example of a set of user instructions (from Field Angle Check – *Surveying 1-25A*):

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	Input Ref Az away from pt	Ref Az	A		
3	If angle right	Ang Rt	B		
4	If angle left	Ang Lt	CHS	B	
5	If deflection right	Defl Rt	C		
6	If deflection left	Defl Lt	CHS	C	
7	Optional: Compute course brg		D		Brg
8	Optional: Compute quad code		R/S		Quad
9	Optional: Compute azimuth		R/S		Az
	(Repeat lines 3-9 for each				
	course)				
10	Compute angular error		E		Ang Error
11			R/S		Ang Corr

If checking traverse between two points, the closing reference azimuth is entered via key A; angular error is then obtained at line 10.

To run another problem, press [f^{-1}] [SF1] then return to line 2.

The instructions read from left to right starting with line 1; follow any indicated operations in this order. Lines having no numbers contain special notes to the user and are in parentheses under the INSTRUCTIONS column. An example is the comment between lines 9 and 10.

Always move sequentially from line to line unless a comment in the INSTRUCTIONS column indicates otherwise. Thus, the comment after line 9, "Repeat lines 3-9 for each course", means to return to line 3 following the instructions indicated until all necessary data has been entered. If there were no more courses, the user would proceed to line 10 for further instructions.

Information under the DATA column will be the instruction to enter a number or value, even though in many cases there is not a comment given in the INSTRUCTIONS column.

Generally, where an instruction is designated as "Optional", the results have already been computed and stored. Thus, skipping optional path may save time by not displaying results but does not affect calculations.

The DISPLAY column indicates results where applicable. In some cases, the calculator display may show a value which is an intermediate factor used in final calculations and may be ignored.

The function keys A through E are used for entering data and displaying solutions. Keys to the left are used for data entry and those to the right for solutions. Solution keys are always indicated by "SOLN". Data is entered by entering the value and pressing the appropriate function key. Solutions are obtained by first pressing the appropriate function key and then, if the particular solution consists of multiple values, pressing the R/S key successively until all the values have been displayed. The R/S key is never used for data entry.

POINTS TO REMEMBER

Turning the calculator off clears all storage registers, the operational stack, and program memory. Neither the storage registers nor the operational stack is disturbed when a program is loaded into the calculator.

When running successive problems with one program without turning the calculator off, clear the storage registers by pressing [f] [REG] . To insure that the program restarts execution properly, press [RTN] after [f] [REG] . The same rules apply when running one program after another unless data is utilized which was stored by a previous program. Failure to perform these steps may result in incorrect solutions.

When working with problems which involve the display of degrees, minutes, and seconds as output, set the decimal at four places (press [DSP] [•] [4]) to enable full display of minutes and seconds.

Input degrees, minutes, seconds in the form DDD.MMSS, i.e., 60 degrees, 05 minutes and 12 seconds is displayed as 60.0512.

[CLX] may not be used as an equivalent to an input of zero.

Do not perform manual calculations between program execution steps. In many cases the stack contains values necessary for program execution.

Quadrant codes for bearings are as follows: NE is 1, SE is 2, SW is 3, and NW is 4.

ENTERING A PROGRAM

From the card case supplied with this application pac, select a program card.

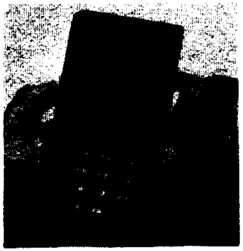
Set W/PRGM-RUN switch to RUN.

Turn the calculator ON. You should see 0.00

Gently insert the card (printed side up) in the right, lower slot as shown. When the card is part way in, the motor engages it and passes it out the left side of the calculator. Sometimes the motor engages but does not pull the card in. If this happens, push the card a little farther into the machine. Do not impede or force the card; let it move freely. (The display will flash if the card reads improperly. In this case, press [CLX] and reinsert the card.)

When the motor stops, remove the card from the left side of the calculator and insert it in the upper "window slot" on the right side of the calculator.

The program is now stored in the calculator. It remains stored until another program is entered or the calculator is turned off.



FIELD ANGLE TRAVERSE

FIELD ANGLE TRAVERSE			SURV 1-01B	
BEG N-E -REF AZ	ANGLE LT-RT	DEFL LT-RT	DIST-ZNTH ANG	N-E-AREA SOLN

his program will accept angles right, angles left, deflections right nd deflections left as well as horizontal or slope distances. The oordinates of the next point are calculated, and area in square feet nd acres are available upon completion of the traverse. Traversing etween two known points is accomplished through a second rogram in which the coordinates of the closing point are entered. his same secondary program, Closure for Field Angle and Bearing raverses (*Surveying 1-3A*), also computes area, closure for bearing nd distance, total distance traversed and precision ratio.

lope angles are assumed to be entered as zenith angles. To change he program to use vertical angles, the following sequence must be ollowed:

1. Enter program
2. Press GTO D
3. Switch to program mode (W/PRGM)–14 should appear in the display
4. Press SST (single step) three times–09 should appear in the display
5. Press 9 DEL (delete)–09 should appear in the display
7. Press SST eleven times–04 should appear in the display
7. Press 9 DEL –31 should appear in the display
8. Press 5 –05 should appear in the display
9. Record changed program by inserting blank card in reader
10. Switch back to run mode
11. Enter changed program and test

Formulas used:

H Dist = S Dist sin (Znth ang)

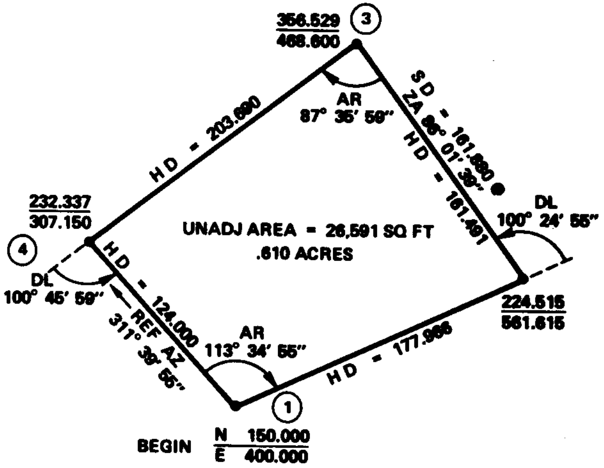
$N_{i+1} = N_i + \text{H Dist} \cos Az$

$E_{i+1} = E_i + \text{H Dist} \sin Az$

$\text{Area} = \frac{1}{2}[(N_2 + N_1)(E_2 - E_1) + (N_3 + N_2)(E_3 - E_2) + \ldots + (N_n + N_1)(E_1 - E_n)]$

Where: N, E = Northing, easting of a point
Subscript i refers to current point
Subscript n refers to next to last point
Numeric subscript refers to point number
Az = Azimuth of a course
H Dist = Horizontal distance
S Dist = Slope distance
Znth ang = Zenith angle

Example:



Calculated Ending Coordinates $\frac{N\ =\ 149.905}{E\ =\ 399.783}$

In this example, the Field Angle Traverse program is used until the calculated ending coordinates are established. The Closure for Field Angle and Bearing Traverse program is then loaded and the closing coordinates are entered (N = 150.00 and E = 400.00). From there, the remaining closure information can be obtained—see instructions for the Closure program (*Surveying 1-3A*).

Closure distance = 0.237
Error bearing = S 66° 19′ 43″ W
Distance traversed = 667.147
Precision = 2814

NOTE: If registers for the Closure for Field Angle and Bearing Traverse program (*Surveying 1-3A*) have been manually loaded, variations in the above may occur due to rounding.

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Begin N	A		Begin N
3		Begin E	A		Begin E
4	Input ref az away from pt	Ref Az	A		
5	If angle right	AR	B		
6	If angle left	AL	CHS	B	
7	If deflection right	DR	C		
8	If deflection left	DL	CHS	C	
9	Input distance (SD or HD)	Dist	D		
10	If horizontal distance		D		H Dist
11	If slope distance	Zn Ang	D		H Dist
12	Compute Coords		E		N
13			R/S		E
	(Repeat lines 5-13 for successive				
	courses. Lines 14 & 15 should				
	be executed only after comple-				
	tion of polygon traverse.)				
14	Optional: Compute sq ft		R/S		Sq Ft
15	Optional: Compute acres		R/S		Acres

For closure information and/or traverse between two points, proceed to program **Closure for Field Angle & Bearing Traverse** (*Surveying 1-3A*).
To repeat field angle traverse go to line 2

BEARING TRAVERSE

This program uses bearings and horizontal or slope distances to calculate coordinates.

Traversing between two known points is accomplished through a second program in which the coordinates of the closing point are entered. This same secondary program, Closure for Field Angle and Bearing Traverse (*Surveying 1-3A*), also supplies area, closure bearing and distance, total distance traverses and precision ratio.

Slope angles are assumed to be entered as zenith angles. To change the program to use vertical angles, the following sequence must be followed:

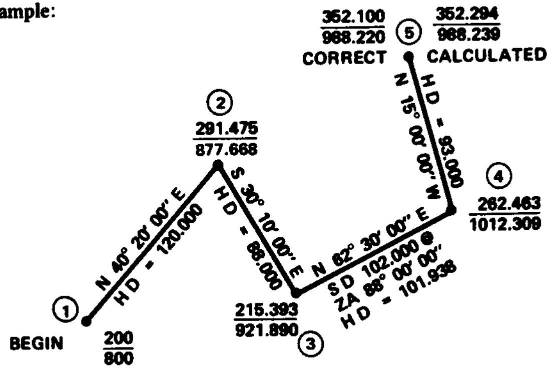
1. Enter program
2. Press GTO D
3. Switch to program mode (W/PRGM)–14 should appear in the display
4. Press SST (single step) three times–09 should appear in the display
5. Press 9 DEL (delete)–09 should appear in the display
6. Press SST 10 times–04 should appear in the display
7. Press 9 DEL –31 should appear in the display
8. Press 5 –05 should appear in the display
9. Record changed program by inserting blank card in reader slot
10. Switch back to run mode
11. Enter changed program and test

Formulas used:

$$\text{H Dist} = \text{S Dist} \sin(\text{Znth ang})$$
$$N_{i+1} = N_i + \text{H Dist} \cos \text{Az}$$
$$E_{i+1} = E_i + \text{H Dist} \sin \text{Az}$$
$$\text{Area} = \tfrac{1}{2}[(N_2+N_1)(E_2-E_1) + (N_3+N_2)(E_3-E_2) + \ldots + (N_n+N_1)(E_1-E_n)]$$

Where: N, E = Northing, easting of a point
Subscript i refers to current point
Subscript n refers to next to last point
Numeric subscript refers to point number
Az = Azimuth of a course
H Dist = Horizontal distance
S Dist = Slope distance
Znth ang = Zenith angle

Example:



In this example, the Bearing Traverse program is used until the calculated ending coordinates are established. The Closure for Field Angle & Bearing Traverse program is then loaded and the closing coordinates are entered (N = 352.100 and E = 988.220). From there, the remaining closure information can be obtained -- see instructions for the Closure program (*Surveying 1-3A*).

Closure distance = 0.195
Error bearing = N 5° 41′ 31″ E
Distance traversed = 402.938
Precision = 2068

NOTE: If registers for the Closure for Field Angle and Bearing Traverse program (*Surveying 1-3A*) have been manually loaded, variations in the above may occur due to rounding.

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Begin N	A		Begin N
3		Begin E	A		Begin E
4	Input bearing	Brg	B		
5	Input quadrant code	Quad	C		
6	Input distance (SD or HD)	Dist	D		
7	If horizontal distance		D		H Dist
8	If slope distance	Zn Ang	D		H Dist
9	Compute coords		E		N
10			R/S		E
	(Repeat lines 4-10 for successive				
	courses. Lines 11 & 12 should				
	be executed only after comple-				
	tion of polygon traverse.)				
11	Optional: Compute sq ft		R/S		Sq Ft
12	Optional: Compute acres		R/S		Acres

For closure information and/or traverse between two points, proceed to program Closure for Field Angle & Bearing Traverse (*Surveying 1-3A*).
To restart this program after an error or for new data press [illegible] then f REG and go to line 2.

Notes

CLOSURE FOR FIELD ANGLE AND BEARING TRAVERSES

CLOSURE FOR FIELD ANGLE AND BEARING TRAVERSES — SURV 1-03A

CLOSING N-E	AREA SOLN	DIST-BRG SOLN	TOT DIST SOLN	PRCSN SOLN

This program, used in conjunction with either the Field Angle Traverse program (*Surveying 1-1B*) or the Bearing Traverse program (*Surveying 1-2A*), computes area, closure bearing and distance, total distance traversed, and precision ratio.

Key **A** is used only for entering the closing coordinates in the case of a traverse between two points (i.e., not a polygon).

If this program is not used immediately after the Field Angle Traverse program (*Surveying 1-1B*) or the Bearing Traverse program (*Surveying 1-2A*), or if the storage registers have been altered, or if the calculator power has been turned off since either of the traverse programs were run, enter the following data into the specified storage registers (this is done by entering the data in the display and pressing STO followed by the register number for each of the five parameters):

REGISTER	PARAMETERS TO BE STORED
2	Total distance traversed
4	2 X area (sq. ft.)
5	Correct closing easting
6	Correct closing northing
7	Calculated ending easting
8	Calculated ending northing

Formulas used:

$$\text{Closure distance} = \sqrt{(N_C - N_L)^2 + (E_C - E_L)^2}$$

$$\text{Precision ratio} = \Sigma\ \text{Dist/Closure distance}$$

$$\text{Error bearing} = \tan^{-1}\frac{E_C - E_L}{N_C - N_L}$$

Where: N_C, E_C = Correct closing northing and easting

N_L, E_L = Calculated closing northing and easting

Σ Dist = Total length of traverse

Example:

Values stored in the registers given below are those stored by the Field Angle Traverse (*Surveying 1-1B*) example.

REGISTER	VALUE	
2	667.147	Total distance traversed
4	53182.000	Area x 2 (sq ft)
5	400.000	Correct closing easting
6	150.000	Correct closing northing
7	399.783	Calculated ending easting
8	149.905	Calculated ending northing

Using these values, the closure information is calculated.

Area = 26,591 sq ft = 0.610 Acres
Closure distance = 0.237 feet
Error bearing = S 66° 19′ 43″ W*
Total distance traversed = 667.147 feet
Precision = 2814*

*These values will not be exact if values are stored manually. This is because of rounding of the input values.

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
	(Skip lines 2-3 if registers loaded				
	manually)				
2	Input correct closing N	Close N	A		Close N
3	Input correct closing E	Close E	A		Close E
4	Optional: If polygon recall				
	area		B		Sq Ft
5	Optional		R/S		Acres
6	Compute closure dist		C		Dist
7	Compute error brg		R/S		Brg
8	Compute quad code		R/S		Quad
9	Compute total dist traversed		D		Tot Dist
10	Compute precision ratio*		E		Prcsn

*Flashing zeros indicate perfect closure

INVERSE FROM COORDINATES

INVERSE FROM COORDINATES			SURV 1-04A	
BEG N-E	NEXT N-E	DIST SOLN	BRG-QUAD SOLN	AREA-TOT DIST-SOLN

This program uses coordinates to calculate distance and bearing between points of a traverse. The area in square feet and acres, plus a summation of distance inversed are also computed.

Formulas used:

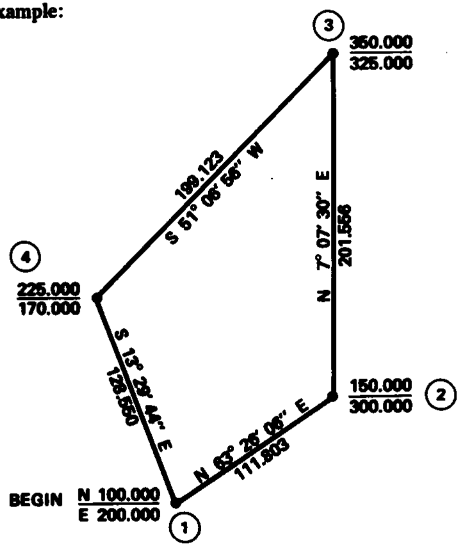
$$\text{H Dist} = \sqrt{(N_i - N_{i-1})^2 + (E_i - E_{i-1})^2}$$

$$\text{Az} = \tan^{-1} \frac{E_i - E_{i-1}}{N_i - N_{i-1}}$$

$$\text{Area} = \tfrac{1}{2}[(N_2 + N_1)(E_2 - E_1) + (N_3 + N_2)(E_3 - E_2) + \ldots (N_n + N_1)(E_1 - E_n)]$$

Where: N, E = Northing, easting of a point
Subscript i refers to current point
Subscript n refers to next to last point
Numeric subscript refers to point number
H Dist = Horizontal distance
Az = Azimuth of a course

Example:



AREA = 20,938 SQ. FT.

0.481 ACRES

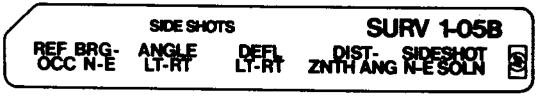
TOTAL DISTANCE INVERSED = 641.033

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Beg N	A		Begin N
3		Beg E	A		Begin E
4		Next N	B		Lat.
5		Next E	B		Dep.
6	Compute distance		C		Dist
7	Compute bearing		D		Brg
8			R/S		Quad
	(Repeat lines 4-8 for successive				
	courses.)				
9	Optional: Compute area		E		Sq. Ft.
10	Optional:		R/S		Acres
11	Optional: total dist inversed		R/S		Tot Dist

To compute area correctly, lines 4-8 must be executed for each leg.
To repeat Inverse From Coordinates go to line 2.

Notes

SIDESHOTS



This program may be used alone or in conjunction with one of the traverse programs *(Surveying 1-1B) or Surveying 1-2A)*. Used as a stand-alone program, the reference bearing from a backsight is entered along with the coordinates of the occupied point. If used with a traverse program, these steps are omitted and data stored by a traverse program is used. In either case, the stored data is not destroyed, and the traverse operation may be carried out from the point occupied.

Slope angles are assumed to be entered as zenith angles. To change the program to use vertical angles, the following sequence must be followed:

1. Enter program
2. Press GTO D
3. Switch to program mode (W/PRGM) - 14 should appear in the display
4. Press SST (single step) four times - 03 should appear in the display
5. Press 9 DEL (delete) - 44 should appear in the display
6. Press SST 15 times–04 should appear in the display
7. Press 9 DEL –31 should appear in the display
8. Press 5 –05 should appear in the display
9. Record changed program by inserting blank card in reader slot.
10. Switch back to run mode
11. Enter changed program and test

Formulas used:

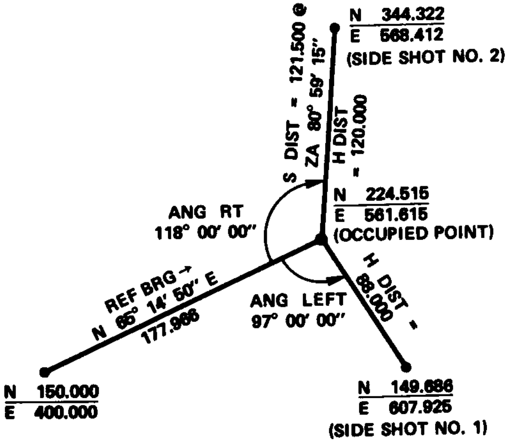
H Dist = S Dist sin (Znth ang)

$N = N_1 + \text{H Dist} \cos Az$

$E = E_1 + \text{H Dist} \sin Az$

Where:
- N, E = Northing, easting of sideshot
- N_1, E_1 = Northing, easting of occupied point
- H Dist = Horizontal distance
- S Dist = Slope distance
- Znth ang = Zenith angle
- Az = Azimuth to side shot

Example:



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
	(Skip lines 2-5 if using in con-				
	junction with a traverse program)				
2	Input Ref Brg into occ pt	Ref Brg	A		
3		Quad	A		
4		Occ N	A		
5		Occ E	A		
6	If angle right	Ang Rt	B		
7	If angle left	Ang Lt	CHS	B	
8	If deflection right	Defl Rt	C		
9	If deflection left	Defl Lt	CHS	C	
10		Dist	D		
11	If horizontal distance		D		H Dist
12	If slope distance	Zn Ang	D		H Dist
13	Compute sideshot coordinates		E		N
			R/S		E

To execute another side shot from the same point go to line 6, for a different point go to line 2.

Notes

COORDINATE TRANSFORMATION

COORDINATE TRANSFORMATION			SURV 1-06A	
OLD N-E NEW N-E	ROTATION ANGLE	SCALE FACTOR	NEXT N-E	TRNSFRMD N-E SOLN

This program translates, rotates, and rescales coordinates. Traverse rotation angle is entered as a positive value for counterclockwise rotation and negative for clockwise rotation. The translation factors are calculated by entering old and new grid system coordinates for the same point; rotation is also about this point.

Formulas used:

$$Az_R = \phi + \tan^{-1} \frac{E_i - E_P}{N_i - N_P}$$

$$H\ Dist_S = S \sqrt{(N_i - N_P)^2 + (E_i - E_P)^2}$$

$$N = N_P + H\ Dist_S \cos(Az_R) + T_N$$

$$E = E_P + H\ Dist_S \sin(Az_R) + T_E$$

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

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

Where:

Az_R = Rotated azimuth
ϕ = Rotation angle
N_i, E_i = Northing, easting of current point before transformation
N_P, E_P = Original northing, easting of pivot point
$H\ Dist_S$ = 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

Example:

Coordinates before transformation are those computed by Compass Rule Adjustment (*Surveying 1-7A*).

COORDINATES IN OLD SYSTEM	COORDINATES IN NEW SYSTEM
N 150.000*	N 100.000*
E 400.000	E 350.000
N 224.540	N 165.977
E 561.673	E 515.353
N 356.577	N 302.698
E 468.710	E 429.427
N 232.414	N 187.151
E 307.327	E 261.767

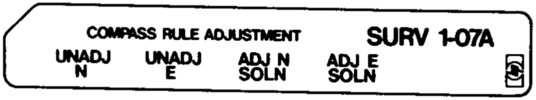
* Rotated about this point

Rotation Angle = −3° 00′ 00″
Scale Factor = 1.00

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
	(Skip lines 4-5 if no translation				
	is desired.)				
2	Input N in old system	Old N	A		
3	Input E in old system	Old E	A		
4	Input N in new system	New N	A		
5	Input E in new system	New E	A		
6	Optional: Input rotation angle	Angle	B		
7	Input scale factor	Scale	C		
8		Next N	D		
9		Next E	D		
10	Compute transformed coord		E		N
11			R/S		E

Return to line 8 for next N,E. For new case start at line 2.

COMPASS RULE ADJUSTMENT*



This program adjusts a traverse by the compass rule. It is intended to follow the program Closure For Field Angle and Bearing Traverses (*Surveying 1-3A*). However, if the correct coordinates of the last point, the computed coordinates of the last point, and the total distance traversed are known, these parameters can be used in lieu of executing the closure program.

If this program is not used immediately after Closure for Field Angle and Bearing Traverse (*Surveying 1-3A*) or the storage registers have been altered or the calculator turned off since the closure program was run, enter the following data into the specified storage registers. (This is done by entering the data in the display and pressing [STO] followed by the register number for each of the five parameters).

REGISTER	PARAMETERS TO BE STORED
2	Total distance traversed
5	Correct closing easting
6	Correct closing northing
7	Calculated ending easting
8	Calculated ending northing

The Inverse From Coordinates program (*Surveying 1-4A*) may be used to obtain adjusted bearings, distances and area.

*This is also know as the Bowditch adjustment

To adjust a traverse between two points (non-polygon), run the Closure program (*Surveying 1-3A*) as usual. Then upon entering the Compass Rule Adjustment program:

Press [A]
Enter starting northing, press [STO] [2], [STO] [6]
Enter starting easting, press [STO] [1] [STO] [5]
Proceed to line 2 of the operating instructions.

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

Formulas used:

$$C_L = \frac{(\Delta N)\,(\text{Dist})}{\Sigma\ \text{Dist}} \qquad C_D = \frac{(\Delta E)\,(\text{Dist})}{\Sigma\ \text{Dist}}$$

Where:

C_L	=	Correction to latitude of a course
C_D	=	Correction to departure of a course
ΔN	=	Closing latitude
ΔE	=	Closing departure
Dist	=	Length of course to be corrected
Σ Dist	=	Total length of traverse

Example:

Values stored in the registers given below are those stored by the Field Angle Traverse (*Surveying 1-1B*) example.

REGISTER	VALUE	
2	667.147	Total distance traversed
5	400.000	Correct closing easting
6	150.000	Correct closing northing
7	399.783	Calculated ending easting
8	149.905	Calculated ending northing

Using these values, the compass rule method of adjustment yields the following results:

POINT NO.	UNADJUSTED COORDINATES	ADJUSTED COORDINATES
2	N = 224.515 E = 561.615	N = 224.540 E = 561.673
3	N = 356.529 E = 468.600	N = 356.577 E = 468.710
4	N = 232.337 E = 307.150	N = 232.414 E = 307.327
Ending & Beginning	N = 149.905 E = 399.783	N = 150.000 E = 400.000

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Unadj N	A		
3		Unadj E	B		
4	Compute adjusted coordinates		C		Adj N
5			D		Adj E

Return to line 2 for next point.

TRANSIT RULE ADJUSTMENT

TRANSIT RULE ADJUSTMENT				SURV 1-08A
START	UNADJ N	UNADJ E	PRE-ADJUST	ADJ N-E SOLN

This program adjusts a traverse by the transit rule method. It is intended to follow the program Closure for Field Angle or Bearing Traverses (*Surveying 1-3A*).

Because of storage register limitation and requirements of the transit rule method, it is necessary to enter the unadjusted coordinates twice.

If the storage registers have been altered in any way since one of the traverse programs or the closure program was run, store the following data in the specified registers (this is done by entering the data in the display and pressing STO followed by the register number for each of the parameters).

REGISTER	PARAMETER TO BE STORED
5	Correct closing easting
6	Correct closing northing
7	Calculated ending easting
8	Calculated ending northing

The Inverse from Coordinates program (*Surveying 1-4A*) may be used to obtain bearings, distances and area from the adjusted coordinates. The starting and closing coordinates must be the same.

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

Formulas used:

$$C_L = \Delta N \mid L \mid / \Sigma \mid L \mid$$
$$C_D = \Delta E \mid D \mid / \Sigma \mid D \mid$$

Where: C_L = Correction to latitude of a course
C_D = Correction to departure of a course
ΔN = Closing latitude
ΔE = Closing departure
L = Latitude of a course
D = Departure of a course

Example:

Values stored in the registers given below are those stored by the Field Angle Traverse (*Surveying 1-1B*) example.

REGISTER	VALUE	
5	400.000	Correct closing easting
6	150.000	Correct closing northing
7	399.783	Calculated ending easting
8	149.905	Calculated ending northing

Using these values, the transit rule method of adjustment yields the following results:

POINT NO.	UNADJUSTED COORDINATES	ADJUSTED COORDINATES
2	N = 224.515	N = 224.532
	E = 561.615	E = 561.684
3	N = 356.529	N = 356.576
	E = 468.600	E = 468.709
4	N = 232.337	N = 232.413
	E = 307.150	E = 307.327
Ending & Beginning	N = 149.905	N = 150.000
	E = 399.783	E = 400.000

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Compute closing lat, dep (start)		A		Closing Lat
3	Optional: Display closing				
	departure		g	x⇄y	Closing Dep
4		Unadj N	B		
5		Unadj E	C		
6	Compute sum of absolute values				
	of latitudes and departures		D		
	(pre-adjust). (Repeat lines 4–6				
	until last point has been pro-				
	cessed, then proceed to line 7.)				
7		Unadj N	B		
8		Unadj E	C		
9	Compute adjusted coords		E		Adj N
			R/S		Adj E

Repeat lines 7–9 until all coordinates have been entered and adjusted.

TWO INSTRUMENT RADIAL SURVEY

TWO INSTRUMENT RADIAL SURVEY				SURV 1-09A
POINT 1 N-E	POINT 2 N-E	POINT 1 BRG-DIST	POINT 2 BRG-DIST	N-E SOLN

This program determines the coordinates of a point using a two instrument radial survey technique. The coordinates of the two instrument locations are entered. The bearing and distance to the target point are measured from each of the instrument locations. The solution makes two independent calculations of the coordinates of the target point and outputs the average coordinates of the target point. As an optional check, the program outputs the distance between the two calculated locations of the target point.

Formulas used:

$$N = [(N_1 + HD_1 \cos Az_1) + (N_2 + HD_2 \cos Az_2)]/2$$
$$E = [(E_1 + HD_1 \sin Az_1) + (E_2 + HD_2 \sin Az_2)]/2$$

Where: N, E = Northing, easting of target point

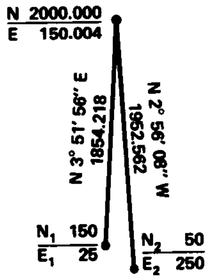
N_1, E_1 = Northing, easting of first instrument point

N_2, E_2 = Northing, easting of second instrument point

HD_i = Horizontal distance–point of origin is designated by subscript.

Az_i = Azimuth (converted from bearing)–point of origin is designated by subscript.

Example:



Data at Pt 1
- Bearing 3° 51' 56"
- Quad 1
- Distance 1854.218

Data at Pt 2
- Bearing 2° 56' 08"
- Quad 4
- Distance 1952.562

Distance between target point solutions = 0.001

LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		N_1	A	
3		E_1	A	
4		N_2	B	
5		E_2	B	
6		Brg 1	C	
7		Quad 1	C	
8		Dist 1	C	
9		Brg 2	D	
10		Quad 2	D	
11		Dist 2	D	
12	Compute coordinates		E	N
13			R/S	E
14	Optional: (straight line distance			
	between the two target point			
	solutions)		R/S	Distance

For successive points measured from the same instrument locations, return to line 6. For new case go to line 2.

CURVE SOLUTION – GIVEN Δ & R OR Δ & T

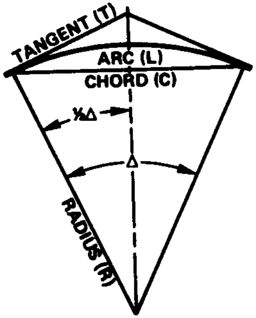
Given the central angle and either the radius or tangent distance, this program computes four remaining parameters plus the sector, segment and fillet areas.

Formulas used:

$T = R \tan(\frac{1}{2}\Delta)$
$C = 2T \cos(\frac{1}{2}\Delta)$
$R = T/\tan(\frac{1}{2}\Delta) = C/(2 \sin(\frac{1}{2}\Delta))$
$L = \Delta \pi R/180$
Sector area = $LR/2$
Segment area = Sector area $- \frac{1}{2} CR \cos(\frac{1}{2}\Delta)$
Fillet area = $T R -$ Sector area

Where: T = Tangent distance
C = Chord length
L = Arc length
R = Radius
Δ = Central angle

Example:



R = 223.181
Δ = 45° 30' 23"
½Δ = 22° 45' 11"
C = 172.636
T = 93.602
L = 177.258
Sector area (▽) = 19,780
Segment area (⌓) = 2,015
Fillet area (⌒) = 1,110

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Δ	A		
3	If radius known*	R	B		
4	If tangent known*	T	C		
5	Optional: Compute area		D		Sec Area
6	Optional		R/S		Seg Area
7	Optional		R/S		Fil Area
8	Compute curve solution		E		R
9			R/S		Δ
10			R/S		½Δ
11			R/S		C
12			R/S		T
13			R/S		L

*Input radius or tangent, not both.
Lines 5-7 can be executed at any time after initial parameters have been input.
For new case go to line 2.

CURVE SOLUTION – GIVEN R & T OR R & L

Given the radius and either the tangent or arc length, this program computes four remaining parameters plus the sector, segment and fillet areas.

Formulas used:

$½\Delta = \tan^{-1}(T/R) = \sin^{-1}(½\, C/R) = 90L/\pi R$

$T = R \tan ½\Delta$

$C = 2\,T \cos(½\Delta)$

$L = \Delta\, \pi\, R / 180$

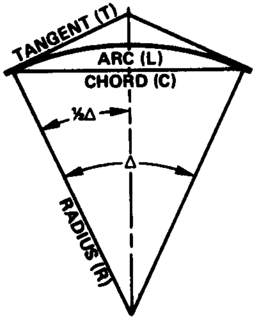
Sector area = $LR/2$

Segment area = Sector area – $½\, C\, R \cos(½\Delta)$

Fillet area = $T\,R$ – Sector area

Where: T = Tangent Distance
C = Chord length
L = Arc length
R = Radius
Δ = Central angle

Example:

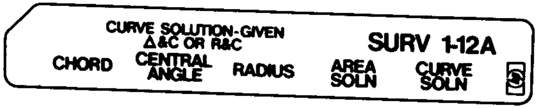


R = 223.181
Δ = 45° 30' 23"
½Δ = 22° 45' 11"
C = 172.636
T = 93.602
L = 177.258
Sector area (▽) = 19,780
Segment area (⌓) = 2,015
Fillet area (⌒) = 1,110

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Radius	A		
3	If tangent known*	T	B		
4	If arc length known*	L	C		
5	Optional: Compute area		D		Sec Area
6	Optional		R/S		Seg Area
7	Optional		R/S		Fil Area
8	Compute curve solution		E		R
9			R/S		Δ
10			R/S		½ Δ
11			R/S		C
12			R/S		T
13			R/S		L

*Input tangent or arc length, not both.
Lines 5-7 can be executed any time after initial parameters are entered.
For new case go to line 2.

CURVE SOLUTION – GIVEN Δ & C OR R & C



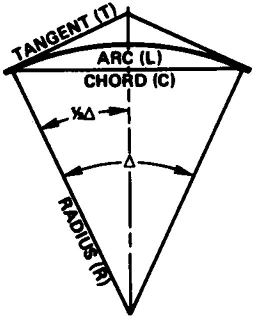
Given the chord length and either the central angle or radius, this program computes four remaining parameters plus the sector, segment and fillet areas.

Formulas used:

$R = C/(2 \sin(\frac{1}{2}\Delta))$
$\Delta = 2 \sin^{-1}(\frac{1}{2} C/R)$
$T = R \tan(\frac{1}{2}\Delta)$
$L = \Delta \pi R/180$
Sector area = $LR/2$
Segment area = Sector area – $\frac{1}{2}$ C R cos ($\frac{1}{2}\Delta$)
Fillet area = T R–Sector area

Where:
- T = Tangent distance
- C = Chord length
- L = Arc length
- R = Radius
- Δ = Central angle

Example:

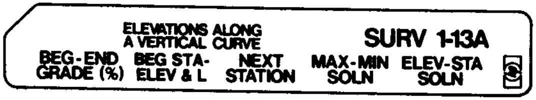


R = 223.181
Δ = 45° 30' 23"
½Δ = 22° 45' 11"
C = 172.636
T = 93.602
L = 177.258
Sector area (▽) = 19,780
Segment area (⌓) = 2,015
Fillet area (⌃) = 1,110

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		C	A		
3	If central angle known*	Δ	B		
4	If radius known*	R	C		
5	Optional: Compute area		D		Sec Area
6	Optional		R/S		Seg Area
7	Optional		R/S		Fil Area
8	Compute curve solution		E		R
9			R/S		Δ
10			R/S		½Δ
11			R/S		C
12			R/S		T
13			R/S		L

*Input central angle or radius, not both.
Lines 5-7 can be executed any time after initial parameters are entered.
For new case go to line 2.

ELEVATIONS ALONG A VERTICAL CURVE



This program computes elevation at any specified station along a vertical curve as well as the elevation at the highest or lowest point on the curve and the station at that point. Program inputs are beginning and ending grades, length of curve, the station and elevation at the beginning of the curve and station at which elevation is desired.

In the program, stations are entered in the form xxxx.xx for station xx + xx.xx. For example, 20 + 10.00 is entered as 2010.00.

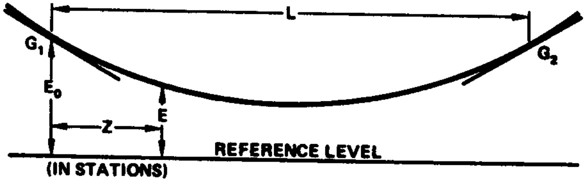
Formulas used:

Elevation at any station $= \frac{1}{2} AZ^2 + G_1 Z + E_0$

Distance in stations from beginning station to station of lowest elevation $= -G_1/A$

Where: E_0 = Elevation at beginning of curve
Z = Distance in 100 foot stations - measured from beginning of curve
G_1 = Grade in % at beginning of curve
G_2 = Grade in % at end of curve
$A = 100\,(G_2 - G_1)/L$
L = Length of curve in feet

Example:



G_1 (Beginning Grade) = –1.065%
G_2 (Ending Grade) = 1.600%
L (Length of Curve) = 340 ft.
E_0 (Elevation at G_1) = 614 ft.
Beginning station = 17 + 00.00

STATION	ELEVATION (E)
18 + 00.00	613.327
19 + 00.00	613.438
20 + 00.00	614.332
20 + 40.00	614.910

Station of lowest elevation = 18 + 35.87
Lowest elevation = 613.276

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	Input begin grade in %	Grade 1	A		
3	Input end grade in %	Grade 2	A		
4	Input beginning station	Beg Sta	B		
5	Input beginning elevation	E_0	B		
6	Input curve length	L	B		
7	Input station	Sta	C		
8	If seeking max or min elev		D		
9	Compute elev solution		E		Elev
10			R/S		Sta

Lines 7-10 may be repeated if there are no changes in data entered in lines 2-6.
Lines 8-10 may be executed any time after initial curve data is entered.
For a new case go to line 2.

HORIZONTAL CURVE LAYOUT

HORIZONTAL CURVE LAYOUT SURV 1-14A

RADIUS | PC STA | NEXT STATION | DEFL ANG SOLN | CHORD SOLN

Given the curve radius, the point of curvature station (P C) and the station on the curve, this program computes deflection angles from the tangent and long chord lengths from the point of curvature.

If regular stationing intervals are used, the short chord will remain constant, thus eliminating calculation of the chord for all but odd interval stations.

In the program, stations are entered in the form xxxx.xx for station xx + xx.xx. For example, 20 + 10.00 is entered as 2010.00.

Formulas used:

Deflection/ft. = $90/\pi R$

Deflection angle = L (Deflection/ft.)

Short chord = 2 R sin (Deflection angle)

Where: R = Radius

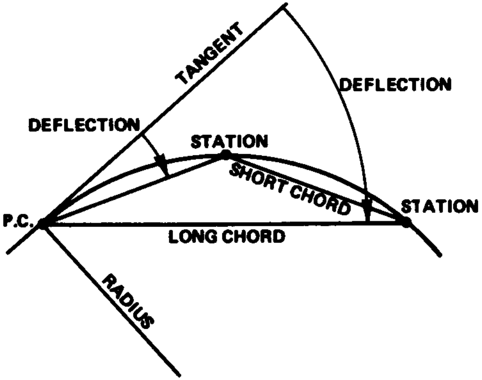
L = Arc length

Example:

Radius = 900.00 Ft.

Station	Arc Length	Deflection	Long Chord
12 + 57.000	(Point of Curvature, PC)		
12 + 75.00	18.00	00° 34' 22"	18.00
12 + 88.50	31.50	01° 00' 10"	31.50
13 + 00.00	43.00	01° 22' 07"	43.00
13 + 25.00	68.00	02° 09' 52"	67.98
13 + 50.00	93.00	02° 57' 37"	92.96

Arc length = Difference in stations



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		R	A		
3		PC Sta	B		
4		Sta	C		
5	Compute deflection angle		D		Defl Ang
6	Compute chord length		E		Chord

Repeat lines 4-6 for successive stations. PC Sta may be changed any time by executing line 3. For new case start at line 2.

TRIANGLE SOLUTION – GIVEN SSS OR SAS

This program computes the area and the unknown sides and interior angles of two cases of triangles--one which requires three sides to be known and the other which requires two sides and the included angle to be known.

If one case is to be solved immediately after the other, the known parameters must be reentered.

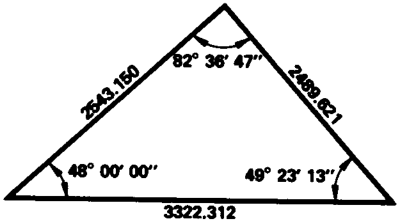
Formulas used:

Area = ½ B C sin c

$A^2 = B^2 + C^2 - 2\,B\,C\,\cos a$

Where:
- A = Length of side A
- B = Length of side B
- C = Length of side C
- a = Angle opposite side A
- c = Angle opposite side C

Example:



AREA = 3,139,466

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Side	A		
3	If side angle side	Angle	B		
4		Side	A		
5	If side side side	Side	A		
6	If side side side soln desired		C		Side
7	If side angle side soln desired		D		Side
8			R/S		Opp Ang
9			R/S		Side
10			R/S		Opp Ang
11			R/S		Side
12			R/S		Opp Ang
13	Compute area		E		Area

For new case start at line 2.

TRIANGLE SOLUTION – GIVEN SSA

This program computes the area and the unknown sides and interior angles of a triangle in which two sides and a non-included angle are the known parameters. Both possible solutions are calculated without reentering the known parameters.

Formulas used:

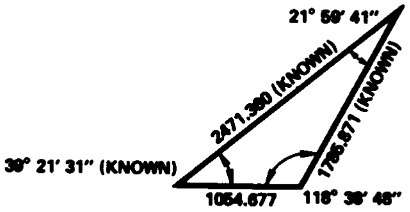
Area = ½ BC sin c

$A^2 = B^2 + C^2 - 2\ BC \cos a$

Where:
- A = Length of side A
- B = Length of side B
- C = Length of side C
- a = Angle opposite side A
- b = Angle opposite side B
- c = Angle opposite side C

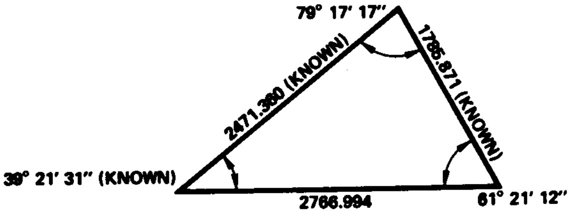
Example:

Solution A



AREA = 826,481

Solution B



AREA = 2,168,310

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	*	Side	A		
3		Side	A		
4	Input ang opposite 2nd side	Angle	B		
5	If soln A desired		C		Side
6	If soln B desired		D		Side
7			R/S		Opp Ang
8			R/S		Side
9			R/S		Opp Ang
10			R/S		Side
11			R/S		Opp Ang
12	Optional: Compute area		E		Area

If alternate solution desired, go to line 5 or 6.

*For oblique triangles input longest side first.

For new case start at line 2.

TRIANGLE SOLUTION—GIVEN ASA OR AAS

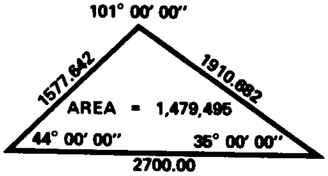
This program computes the area and the unknown sides and interior angles of two cases of triangles--one which requires two angles and the included side and the other which requires two angles and a non-included side.

If one case is to be solved immediately after the other, the known parameters must be reentered.

Formulas used:

Area = ½ B C sin a
A/sin a = B/sin b = C/sin c
Where: A = Length of side A
B = Length of side B
C = Length of side C
a = Angle opposite side A
b = Angle opposite side B
c = Angle opposite side C

Example:



LINE	INSTRUCTIONS	DATA	KEYS	DISPLAY
1	Enter program			
2		Angle	B	
3	If angle side angle	Side	A	
4		Angle	B	
5	If angle angle side input side			
	opposite second angle	Side	A	
6	If angle side angle soln desired		C	Side
7	If angle angle side soln desired		D	Side
8			R/S	Opp Ang
9			R/S	Side
10			R/S	Opp Ang
11			R/S	Side
12			R/S	Opp Ang
13	Compute area		E	Area

For new case start at line 2.

BEARING-BEARING INTERSECT

BEARING-BEARING INTERSECT				SURV 1-18A
POINT 1 N-E	POINT 2 N-E	LINE 1 BRG-QUAD	LINE 2 BRG-QUAD	N-E SOLN

This program computes the point of intersection coordinates of two lines for which the bearing of each line is known and the coordinates of a point on each line are known.

Formulas used:

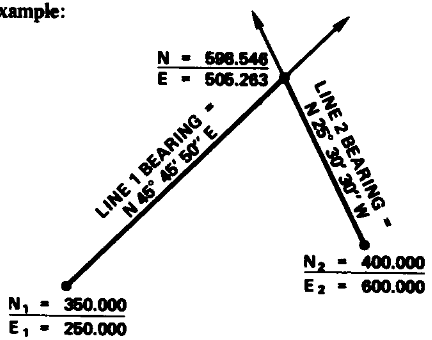
$$N = ((E_1 - N_1 \tan Az_1) - (E_2 - N_2 \tan Az_2)) / (\tan Az_2 - \tan Az_1)$$

$$E = E_1 - N_1 \tan Az_1 + N \tan Az_1$$

Where: Az_1 = Azimuth of line 1
Az_2 = Azimuth of line 2
N_1, E_1 = Northing, easting of point 1
N_2, E_2 = Northing, easting of point 2
N, E = Northing, easting of intersect point

NOTE: Program will not give a solution if one of the bearings is due east or west

Example:



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		N_1	A		
3		E_1	A		
4		N_2	B		
5		E_2	B		
6		Brg 1	C		
7		Quad 1	C		
8		Brg 2	D		
9		Quad 2	D		
10	Compute intersect coord		E		N
			R/S		E

For new case start at line 2.

BEARING-DISTANCE INTERSECT

BEARING-DISTANCE INTERSECT SURV 1-19A

POINT 1 N-E	POINT 2 N-E	LINE 1 BRG-QUAD	LINE 2 DIST	N-E SOLN

This program calculates the coordinates of the point of intersection of two lines--one of known bearing through known coordinates and the other of known length from a point of known coordinates. Both solutions are computed.

The far solution is obtained by entering the bearing from point 1, and the near solution by entering the bearing into point 1.

Formulas used:

$$Az_{12} = \tan^{-1} \frac{E_2 - E_1}{N_2 - N_1}$$

$$h = Dist_{12} \sin \phi$$

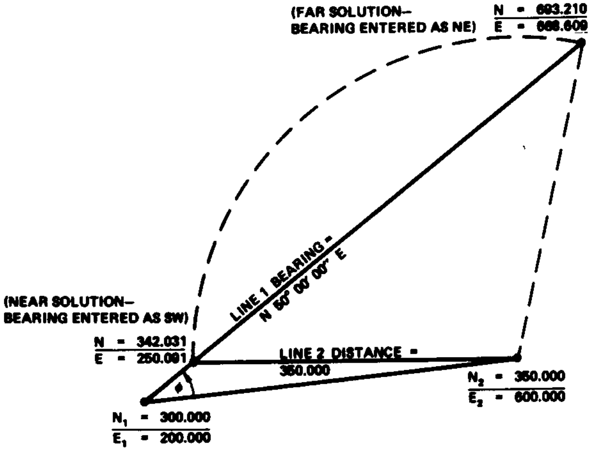
$$b = \sqrt{Dist_2^2 - h^2}$$

$$N = N_1 + ((Dist_{12} \cos \phi) + b) \cos (Az_1)$$

$$E = E_1 + ((Dist_{12} \cos \phi) + b) \sin (Az_1)$$

Where:
- Az_{12} = Azimuth of line from point 1 to point 2
- Az_1 = Azimuth of line 1
- ϕ = Angle between line 1 and line from point 1 to point 2
- h = Perpendicular distance from point 2 to line 1
- b = Distance from point of intersection to the point where the perpendicular (h) intersects line 1
- $Dist_2$ = Length of line 2 (the known distance)
- N_1, E_1 = Northing, easting of point 1
- N_2, E_2 = Northing, easting of point 2
- $Dist_{12}$ = Distance from point 1 to point 2

Example:



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		N_1	A		
3		E_1	A		
4		N_2	B		
5		E_2	B		
6		Brg 1	C		
7		Quad 1*	C		
8		Dist 2	D		
9	Compute intersect coord		E		N
10			R/S		E

*There can be two solutions. To obtain the 'near' solution, enter the bearing as into point 1; for the 'far' solution, enter the bearing as away from point 1.

For new case start at line 2.

DISTANCE-DISTANCE INTERSECT

DISTANCE-DISTANCE INTERSECT			SURV 1-20A	
POINT 1 N-E	POINT 2 N-E	LINE 1 DIST	LINE 2 DIST	N-E SOLN

iven two lines, each of known length and originating from two nown points, this program computes the intersection coordinates. here are two possible solutions; this program calculates the one ound by proceeding in a clockwise direction from the first known oint to the second known point. The other solution is found by eversing the entry of the known point coordinates.

ormulas used:

$$= \cos^{-1}\frac{Dist_{12}^2 + Dist_1^2 - Dist_2^2}{2\,(Dist_1)\,(Dist_{12})}$$

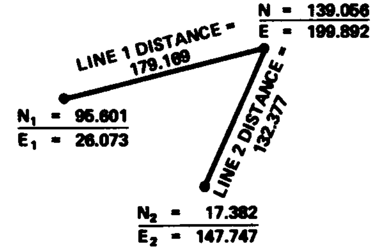
$$z = \tan^{-1}\frac{E_2 - E_1}{N_2 - N_1}$$

$$= N_1 + Dist_1 \cos(Az - \phi)$$

$$= E_1 + Dist_1 \sin(Az - \phi)$$

here: ϕ = Angle between line 1 and line 1→2
$Dist_{12}$ = Distance from point 1 to point 2
$Dist_1$ = Known distance along line 1
$Dist_2$ = Known distance along line 2
N_1, E_1 = Northing, easting of point 1
N,E = Northing, easting of intersection point
Az = Azimuth of line from point 1 to point 2

Example:

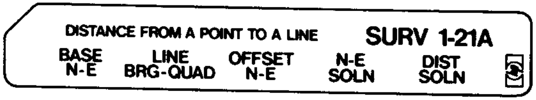


NOTE: Computed solution is always clockwise from point 1 to 2. For alternate solution, start at Point 2.

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		N_1	A		
3		E_1	A		
4		N_2	B		
5		E_2	B		
6		Dist 1	C		
7		Dist 2	D		
8	Compute intersect coord		E		N
9			R/S		E

For new case start at line 2.

DISTANCE FROM A POINT TO A LINE



Given a point of known coordinates with a line of known bearing passing through it and a second point of known coordinates, this program calculates the offset distance from the second point to the line, the distance from the intersection to the first known point, and the coordinates of the intersection.

Formulas used:

$$\text{Dist}_{BO} = \sqrt{(N_O - N_B)^2 + (E_O - E_B)^2}$$

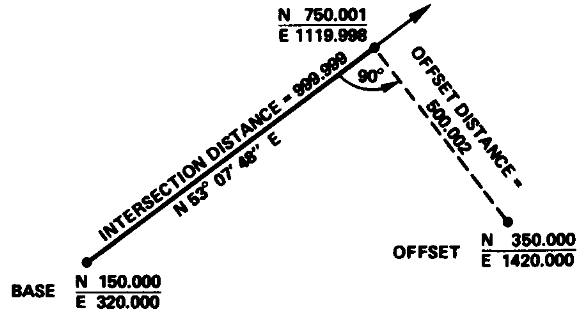
$$\text{Dist}_{BI} = \sqrt{(N_O - N_I)^2 + (E_O - E_I)^2}$$

$$N_1 = \frac{E_O - E_B + N_O \operatorname{ctn}(Az_{BI}) + N_B \tan(Az_{BI})}{\operatorname{ctn}(Az_{BI}) + \tan(Az_{BI})}$$

$$E_1 = E_B + (N_I - N_B)\tan(Az_{BI})$$

Where:
- Dist_{BO} = Distance from base point to offset point
- Dist_{BI} = Distance from base point to intersection point
- Dist_{IO} = Distance from intersection point to offset point
- N_O, E_O = Northing, easting of offset point
- N_B, E_B = Northing, easting of base point
- N_I, E_I = Northing, easting of intersection point
- Az_{BI} = Known az from base point to intersection point

Example:



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Base N	A		
3		Base E	A		
4		Brg	B		
5		Quad	B		
6		Offst N	C		
7		Offst E	C		
8	Compute intersect coord		D		N
9			R/S		E
10	Compute distances		E		Off Dist
11			R/S		Int Dist

For new case start at line 2.

TAPING CORRECTIONS

TAPING CORRECTIONS			SURV 1-22A	
LBS PULL	TEMP	SLOPE DIST	ZNTH ANG SOLN	ΔELEV SOLN

This program will apply corrections for tension, temperature, slope, correction index and sag to yield a corrected horizontal distance as measured with a steel tape. Inputs are slope distance and either zenith angle or difference in elevation for each unsupported successive length. Tape constants are stored in the program; however, the program can be customized for any tape by changing the constants stored in the program.

The specified tape constants stored are:

Tape Standardization Tension 20 lbs.
Tape Standardization Temperature 68°F
Tape Correction Index 0.000 ft/100 ft
Tape Unit Weight 0.014 lbs/ft
Tape Coefficient of Thermal Expansion $6.45 \times 10^{-6}\ \frac{1}{°F}$
Tape Area x Modulus of Elasticity 3.0×10^5 lbs.

To customize the program for any tape, use the following sequence to change the stored tape constants:

1. Enter program
2. Switch to program mode (W/PRGM)–00 00 should be displayed
3. Press [SST] five times–00 should be displayed
4. Press [9] [DEL] two times–33 03 should be displayed
5. Press keys to enter tape standardization tension e.g., [1] [8] (lbs.)
6. Press [SST] four times–05 should be displayed
7. Press [9] [DEL] three times–51 should be displayed
8. Press keys to enter tape area x modulus of elasticity e.g., [3] [2] [EEX] [4] (32×10^4 lbs.)
9. Press [SST] five times–00 should be displayed

10. Press [9] [DEL] four times–81 should be displayed
11. Press keys to enter correction index per 100 ft e.g., [•] [0] [1] [2] [CHS] (–0.012 ft/100 ft)
12. Press [SST] eleven times–08 should be displayed
13. Press [9] [DEL] two times - 12 should be displayed
14. Press keys to enter tape standardization temperature e.g. [6] [9] (69° F)
15. Press [SST] seven times - 08 should be displayed
16. Press [9] [DEL] six times - 51 should be displayed
17. Press keys to enter coefficient of thermal expansion e.g. [6] [6] [9] [EEX] [CHS] [8] (669×10^{-8}/ °ft)
18. Press [SST] twelve times - 04 should be displayed
19. Press [9] [DEL] four times - 33 06 should be displayed
20. Press keys to enter unit weight of tape e.g. [•] [0] [1] [8] (.018 lbs/ft)
21. Record changed program by inserting blank card in reader slot
22. Switch to run mode
23. Enter changed program and test

NOTE: The total number of keys pressed to enter tape constants must not exceed 30. The above examples show 23.

To change program to accept vertical angles instead of zenith angles, use the following sequence:

1. Enter program
2. Press [GTO] [D]
3. Switch to program mode (W/PRGM) - 14 should be displayed.
4. Press [SST] four times–04 should be displayed
5. Press [9] [DEL] one time–31 should be displayed
6. Press [5]
7. Record changed program by entering blank card in reader slot
8. Switch to run mode
9. Enter changed program and test

Formulas used:

$C_C = C_I\, L/100$

$C_P = L(P - P_o)/AE$

$C_T = C_X L (T - T_o)$

$C_S = W^2 L^3/24 P^2$

$\text{Corrected S Dist} = \text{S Dist} + C_C + C_P + C_T + C_S$

$\text{H Dist} = (\text{Corrected S Dist}) \sin (\text{Znth ang})$

$\text{H Dist} = \sqrt{(\text{Corrected S Dist})^2 - (\Delta\,\text{Elev})^2}$

Where: P = Tension on tape in pounds (pull)

P_o = Standard tension in pounds

A = Cross section area of tape in square inches

E = Modulus of elasticity for the tape material

C_X = Coefficient of thermal expansion for the tape

T = Temperature at time of reading in °F

T_o = Standard temperature in °F

W = Weight of tape per foot in pounds

L = Distance between supports in feet

C_C = Index correction

C_P = Correction for tension

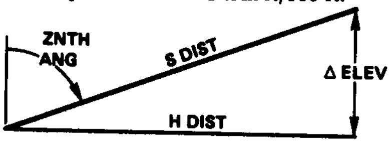
C_T = Correction for temperature

C_S = Correction for sag

Znth ang = Zenith angle

C_I = Tape correction index in ft/100 ft.

Example:



ZNTH ANG KNOWN

Pull = 25 lbs
Temp = 88°F
S Dist = 100′
Znth Ang = 88° 00′ 00″
H Dist = 99.941
S Dist = 75.35
Znth Ang = 90° 00′ 00″
H Dist = 75.355
Σ H Dist = 175.296

Δ ELEV KNOWN

Pull = 25 lbs
Temp = 88°F
S Dist = 100′
Δ Elev = 3.49
H Dist = 99.941
S Dist = 75.35
Δ Elev = 0
H Dist = 75.355
Σ H Dist = 175.296

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	Optional after first entry	Pull	A		
3	Optional after first entry	Temp	B		
4		S Dist	C		
5	If zenith angle known	Zn Ang	D		H Dist
6	Optional (after line 5)		R/S		Σ H Dist
7	If elevation diff known	Δ Elev	E		H Dist
8	Optional (after line 7)		R/S		Σ H Dist

Return to line 2, 3, or 4 for next length.

For new case, press f REG and start at line 2.

EDM SLOPE REDUCTION GIVEN ZENITH ANGLE

EDM SLOPE REDUCTION-GIVEN ZENITH ANGLE SURV 1-23A

S DIST | ZNTH ANG | HI DM-HT RFT | HI INST-HT TGT | H DIST-ΔEL SOLN

This program reduces slope distance to horizontal distance at the instrument elevation and at sea level and gives the difference in elevation between two stations. The program will correct for the differences between the heights of the instruments and the heights of the targets. Corrections due to the curvature of the earth and the refraction of light are obtained by multiplying a derived constant times the horizontal distance. The value used for the coefficient of refraction is 0.071.

Formulas used:

$$Z_1 = Z - c + r + \sin^{-1}\left[\frac{\Delta \sin(Z - 2c + r)}{\text{S Dist}}\right]$$

$$\text{H Dist} = \frac{\text{S Dist}}{\cos c}\sin(Z_1 - c)\left[\frac{R}{R+E}\right]$$

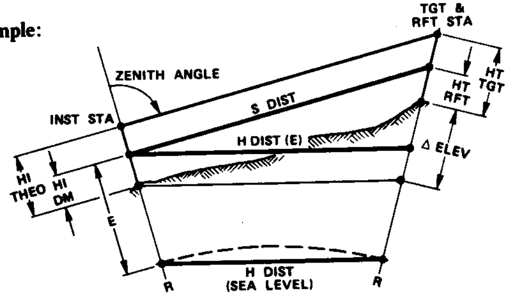
$$\Delta\,\text{Elev} = \frac{\text{S Dist}}{\cos c}\cos Z_1 + (\text{HI DM} - \text{HT Rft})$$

$$c = 14 \times 10^{-7}\ \text{S Dist}\sin Z \quad \text{from} \quad \frac{\text{S Dist}\sin Z}{2R}\,\frac{180}{\pi}$$

$$r = 2 \times 10^{-7}\ \text{S Dist}\sin Z \quad \text{from} \quad \frac{0.071\ \text{S Dist}\sin Z}{R}\,\frac{180}{\pi}$$

Where:
- S Dist = Slope Distance
- Z = Zenith angle
- Z_1 = Zenith angle corrected for c & r and Δ
- H Dist = Horizontal distance
- Δ Elev = Difference in elevation
- c = Zenith correction due to earth's curvature in degrees
- r = Correction due to refraction in degrees
- R = 20,906,000 ft. (radius of earth)
- E = Elevation of instrument
- Δ = Height of DM–Height of Reflector–Height of Theodolite + Height of Target

Example:

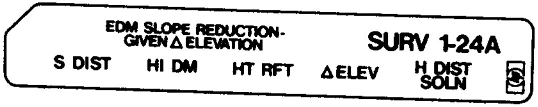


Slope Distance	S Dist	= 10,000 ft.
Elev at Instrument	E	= 5,000 ft.
Zenith Angle	Znth ang	= 75° 00' 00"
Height of DM	HI DM	= 5.12
Height of Reflector	HT Rft	= 5.75
Height of Theodolite	HT Theo	= 5.96
Height of Target	HT Tgt	= 5.34
Horizontal Distance (E)	H Dist	= 9657.810
Horizontal Distance (SL)	H Dist	= 9655.501
Elevation Difference	Δ Elev	= 2590.681

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		S Dist	A		
3		E	A		
4		Zn Ang	B		
5		HI DM	C		
6		HT Rft	C		
7		HT Theo	D		
8		HT Tgt	D		
9	Compute horizontal distance		E		H Dist (E)
10	Compute H Dist (sea level)		R/S		H Dist (SL)
11	Compute elevation difference		R/S		Δ Elev

For new case go to line 2.

EDM SLOPE REDUCTION GIVEN Δ ELEVATION



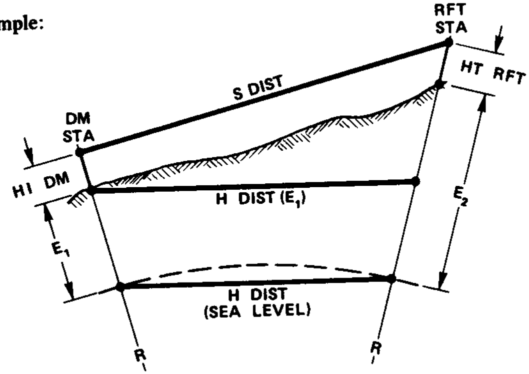
Taking into consideration the curvature of the earth, this program reduces slope distance to horizontal distance at the instrument station elevation. The program assumes the slope distance between two points having known elevations was measured using an Electronic Distance Measuring Instrument. As options, the program will reduce the slope distance to a horizontal distance at sea level, and to a horizontal distance at any specified elevation. The value used for the radius of the earth is 20,906,000 feet.

Formulas used:

$$\text{H Dist} = \left[\sqrt{\frac{(\text{S Dist})^2 - (E_2 + \text{HT Rft} - E_1 - \text{HI DM})^2}{(R + E_1 + \text{HI DM})(R + E_2 + \text{HT Rft})}}\right]\left[R + E\right]$$

Where:
- S Dist = Slope Distance
- E_1 = Elevation of Instrument Station
- HI DM = Height of Instrument
- E_2 = Elevation of Reflector Station
- Ht Rft = Height of Reflector
- R = Radius of the Earth (20,906,000 ft.)
- E = Elevation of Horizontal Distance
- H Dist = Horizontal Distance

Example:



Slope Distance	S Dist	= 10,000 ft.
Height of DM	HI DM	= 5.12
Height of Reflector	HT Rft	= 5.75
Elev at DM Station	E_1	= 1000.00
Elev at Reflector Station	E_2	= 3590.63
Specified Elevation	E_S	= 2000
Horizontal Distance (E_1)	H Dist	= 9657.834
Horizontal Distance (Sea Level)	H Dist	= 9657.372
Horizontal Distance (E_S)	H Dist	= 9658.296

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter Program				
2		S Dist	A		
3		HI DM	B		
4		HT Rft	C		
5	Input elevation at DM station	E_1	D		
6	Input elevation at Rft station	E_2	D		
7	Optional	E_S	D		
8	Compute horizontal distance		E		H Dist(E_1)
9	Optional		R/S		H Dist(SL)
10	Optional		R/S		H Dist(E_S)

For new case go to line 2.

FIELD ANGLE CHECK

FIELD ANGLE CHECK			SURV 1-25A	
REF AZ	ANGLE LT-RT	DEFL LT-RT	BEARING SOLN	ANG COR SOLN

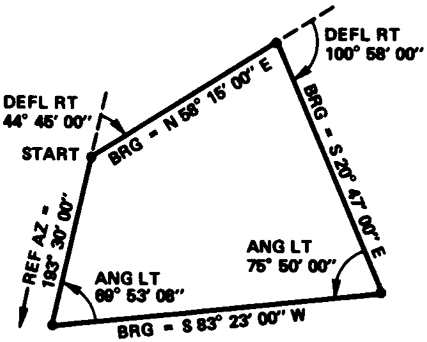
This program accepts a reference azimuth and field angles at each point in a traverse. The field angles are converted to bearings for each leg. At closing, the final leg is compared to the reference azimuth and the angular error of closure computed. The program can also handle traverses between two points.

Formulas used:

Angular error = (Reference azimuth – 180) – Last course azimuth

Angular correction = – Angular error/Number of angles

Example:



Reference Azimuth = 193° 30' 00"
Last Course Azimuth = 13° 29' 52"
Angular Error = 00° 00' 08"
Angular Correction (to be applied to interior angles) = –00° 00' 02"

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	Input Ref Az away from pt	Ref Az	A		
3	If angle right	Ang Rt	B		
4	If angle left	Ang Lt	CHS	B	
5	If deflection right	Defl Rt	C		
6	If deflection left	Defl Lt	CHS	C	
7	Optional: Compute course brg		D		Brg
8	Optional: Compute quad code		R/S		Quad
9	Optional: Compute azimuth		R/S		Az
	(Repeat lines 3-9 for each				
	course)				
10	Compute angular error		E		Ang Error
11			R/S		Ang Corr

If checking traverse between two points, the closing reference azimuth is entered via key A; angular error is then obtained at line 10.

To run another problem, press f⁻¹ SF1 then return to line 2.

STADIA REDUCTIONS

STADIA REDUCTIONS SURV 1-26A

STATION ELEV-HI | ZENITH ANGLE | ROD INTERVAL | ROD READING | DIST-ELEV SOLN

This program computes the elevation of and horizontal distance to points from an instrument station using stadia methods. Required inputs are the height of instrument, the zenith angle, the rod reading, and the rod stadia interval.

The program assumes stadia constant = 0, and stadia interval factor (K) = 100.

Slope angles are assumed to be entered as zenith angles. To change the program to use vertical angles, the following sequence must be followed:

1. Enter program
2. Press GTO B
3. Switch to program mode (W/PRGM) - 12 should appear in the display
4. Press SST (single step) 6 times - 51 should appear in the display
5. Press 9 DEL - 35 07 should appear in the display
6. Press SST four times - 03 should appear in the display
7. Press 9 DEL twice - 35 00 should appear in the display
8. Record changed program by inserting blank card in reader slot
9. Switch back to run mode
10. Enter changed program and test

Formulas used:

$H\ Dist = K\ s\ \cos^2 (V\ ANG)$

$V = \frac{1}{2} K\ s\ \sin 2\ (V\ ANG)$

Pt Elev = HI + V – Rod reading + occupied station elevation

Vert Ang = 90 – Znth Ang

Where: K = Stadia interval

s = Rod interval

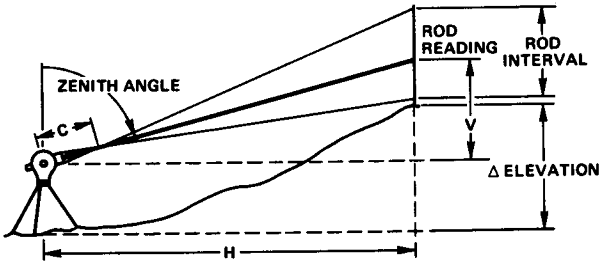
Vert Ang = Vertical angle of line of sight (0° is horizontal)

H Dist = Horizontal distance

V = Vertical distance

HI = Height of instrument

Example:



POINT NO.	HI	ZENITH ANGLE	ROD INTERVAL	ROD READING	HORIZONTAL DISTANCE	ELEVATION
Occ Sta.	5.2					491.0
1		93°18′	3.28	7.4	326.91	469.95
2		93°18′	3.32	8.1	330.90	469.02
3		90°00′	4.06	8.8	406.00	487.40
4		91°06′	4.51	5.2	450.83	482.34
5		86°15′	1.29	5.2	128.45	499.42
6		73°40′	1.20	8.2	110.51	520.39
7		75°50′	1.31	5.2	123.15	522.09

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Sta El	A		
3		HI	A		
4		Zn Ang	B		
5		Intv	C		
6	If rod reading ≠ HI	Reading	D		
7	Compute distance and elevation		E		H Dist
8	Optional		R/S		Pt Elev

For additional points from same instrument station, repeat lines 4-8.
For new case start at line 2.

Notes

THREE WIRE LEVELING

THREE WIRE LEVELING				SURV 1-27A
STARTING ELEV-K	BACK SIGHT	FORE SIGHT	U,C,L READING	SOLN

After the initial entry of the starting elevation and stadia interval factor (if it is not 100), this program uses the upper stadia hair, crosshair, and lower stadia hair readings to provide the elevation difference, elevation of final point, backsight distances and foresight distances.

If no stadia interval constant, K, is entered, the value used by the calculator is 100.

Formulas used:

$$\text{Elev 2} = \text{Elev 1} + \left[\frac{U+C+L}{3}\right]_{BS} - \left[\frac{U+C+L}{3}\right]_{FS}$$

$$\text{Dist} = K\,[\Sigma\ \text{BS ½ stadia intv} + \Sigma\ \text{FS ½ stadia intv}]$$

$$\text{Check} = 2C - U - L$$

Where:
- U = Upper reading
- C = Center reading
- L = Lower reading
- BS = Backsight
- FS = Foresight
- K = Stadia constant

Example:

NO OF STATION	U,C,L READING BACKSIGHT	½ STADIA INTERVAL BACKSIGHT	U,C,L READING FORESIGHT	½ STADIA INTERVAL FORESIGHT	ELEV OF STATION
ELEV 5280.000					
1	8.266 8.105 7.940	.161 .165	3.491 3.320 3.152	.171 .168	5284.783
2	8.119 7.329 6.535	.790 .794	5.221 4.435 3.654	.786 .781	5287.674
3	6.593 6.021 5.444	.572 .577	3.172 2.631 2.085	.541 .546	5291.064
		Σ = 3.059		Σ = 2.993	

Elevation Difference from Sum of Means is 11.064

Final Elevation 5291.064

Backsight Distance 305.9

Foresight Distance 299.3

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	Input starting elevation	Elev	A		
3	Optional: Input stadia interval				
	factor	K	A		
4	If backsight		B		
5	If foresight		C		
6	Input upper reading	Upper	D		
7	Input center reading	Center	D		
8	Input lower reading	Lower	D		Check*
	(Repeat lines 4-8 for each set of				
	backsight and foresight readings)				
9	Optional: Read elev difference		E		Δ Elev
10	Optional: Read final elev		R/S		Sta Elev
11	Optional: Read sum of BS				
	distances		R/S		BS Dist
12	Optional: Read sum of FS				
	distances		R/S		FS Dist
	(Repeat lines 4-12 for successive				
	stations)				

* Difference between upper and lower stadia interval is displayed. Allows a check on accuracy of reading

For a new case press f REG and start at line 2.

SLOPE STAKING – GIVEN CENTERLINE TERRAIN ELEVATION

Using a previously located center line and the design cross section to provide center line terrain and hinge point elevations, this program helps in the setting of slope stakes. The program produces a distance for the rod man to move from his present trial point to a new trial point which should be very close to the catch point.

The trial point may be entered by either of two methods--slope distance and vertical angle or horizontal distance and elevation difference. All input data is measured with reference to the center line and its terrain elevation.

Slope is entered as a ratio to 1. For example, a 1½:1 slope is entered as 1.5. Cut slopes are entered as positive and fill slopes as negative.

Formulas used:

E = HG Dist + Slope (T Elev–HG Elev + Δh) – H Dist;

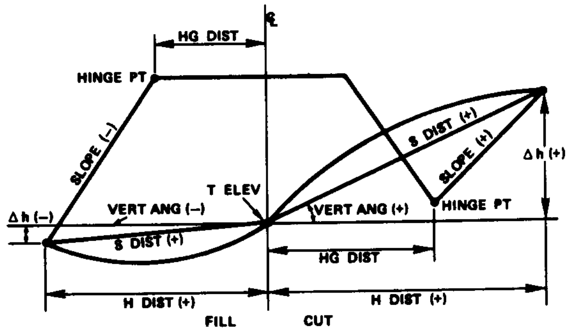
H Dist_{i+1} = H Dist_i + E (until E $\leqslant$ 0.1)

Δh = S Dist sin (V ANG)

H Dist = S Dist cos (V ANG)

Where:
- HG Dist = Distance from centerline to hinge point
- T Elev = Terrain elevation at centerline
- HG Elev = Elevation at hinge point
- Δh = Elevation difference from T Elev to trial point
- H Dist_i = Horizontal distance from centerline to trial point; it is varied until tolerance is reached.
- E = Error term
- S Dist_i = Slope distance from centerline to trial point.
- V ANG = Vertical Angle

Example:



INPUT		FILL	CUT
Horizontal distance to hinge pt.	HG Dist	+12	+18
Slope (ratio of horizontal distance to 1)	Slope	-1.5	+1
Centerline terrain elevation	℄ T Elev	5280.00	5280.00
Hinge pt. elevation	HG Elev	5286.00	5282.00
TRIAL PT LOCATION (DATA FOR CATCH PT GIVEN)			
Slope distance from centerline to trial pt.	S Dist	+24.0	+33.1
Vertical angle between horizontal and slope distance line	Vert Ang	-4° 46'	+25°01'
Horizontal distance from centerline to trial pt.	H Dist	+24.0	+30.0
Elevation difference between centerline terrain elevation and trial pt. elevation	Δh	-2.0	+14.0

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		HG Dist	A		
3	Ratio to 1; fill (-), cut (+)	Slope	A		
4		℄ T Elev	B		
5		HG Elev	B		
6	If S Dist & V Ang known	S Dist	C		
7	If S Dist & V Ang known	V Ang	C		
8	If H Dist & Δh known	H Dist	D		
9	If H Dist & Δh known	Δh	D		
10	Compute move required to reach				
	catch pt (+ move away from ℄;				
	- move toward ℄)		E		Catch Dist
11	Optional: Compute H Dist to ℄		R/S		Dist to ℄

For new case start at line 2.

Notes

SLOPE STAKING – GIVEN CENTERLINE CUT/FILL

Using a previously located center line and the design cross section to provide cut or fill at center line and vertical drop from center line elevation to hinge point elevation, this program helps in the setting of slope stakes. The program produces a distance for the rod man to move from his present trial point to a new trial point which should be very close to the catch point.

The trial point may be entered by either of two methods--slope distance and vertical angle or horizontal distance and elevation difference. All data is measured in reference to the center line and its terrain elevation.

Slope is entered as a ratio to 1. For example, a 1½:1 slope is entered as 1.5. Cut slopes are entered as positive and fill slopes as negative.

Formulas used:

$$E = \text{HG Dist} + \text{Slope}\,((\text{cut or fill}) + \text{V drop} + \Delta h) - \text{H Dist}_i$$

$$\text{H Dist}_{i+1} = \text{H Dist}_i + E \ (\text{until } E < 0.1)$$

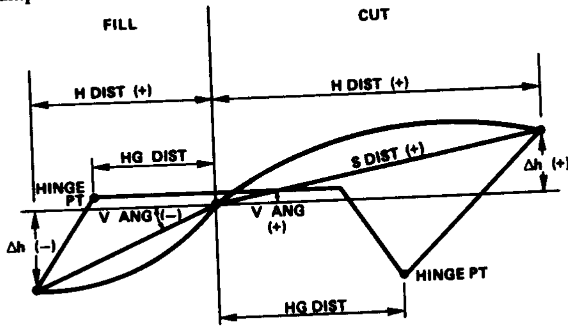
$$\Delta h = \text{S Dist} \sin(\text{V ANG})$$

$$\text{H Dist} = \text{S Dist} \cos(\text{V ANG})$$

Where:

HG Dist	=	Distance from centerline to hinge point
Cut or fill	=	Depth to final grade at centerline; fill designated by negative sign
V Drop	=	Vertical drop from centerline elevation to hinge point
Δh	=	Elevation difference from centerline elevation to trial point
Vert ang	=	Vertical angle from centerline elevation to trial point
H Dist_i	=	Horizontal distance from centerline to trial point
S Dist_i	=	Slope distance from centerline to trial point.
V ANG	=	Vertical Angle

Example:



INPUT		FILL	CUT
Horizontal distance to hinge pt.	HG Dist	12	18
Slope (ratio to 1)	Slope	-1.5	1
Centerline cut (+) or fill (–)	℄ C or F	-3.75	-3.75
Vertical drop from ℄	V Drop	+0.25	+4.25
CATCH PT. LOCATION			
Slope distance from centerline to trial pt.	S Dist	24.42	34.73
Vertical Angle between horizontal and slope distance line	Vert Ang	-10° 37'	22° 52'
Horizontal distance from centerline to trial pt.	H Dist	24.0	+32.0
Elevation difference between centerline and trial pt.	Δh	-4.5	13.5

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		HG Dist	A		
3	Ratio to 1, fill (-), cut (+)	Slope	A		
4		℄ C or F	B		
5		V Drop	B		
6	If S Dist & Vert Ang known	S Dist	C		
7	If S Dist & Vert Ang known	V Ang	C		
8	If H Dist & Δh known	H Dist	D		
9	If H Dist & Δh known	Δh	D		
10	Compute move required to				
	reach catch pt (+ move away				
	from ℄; - move toward ℄)		E		D to Catch
11	Optional: Compute H Dist to ℄		R/S		Dist to ℄

For new case start at line 2.

Notes

AZIMUTH OF THE SUN

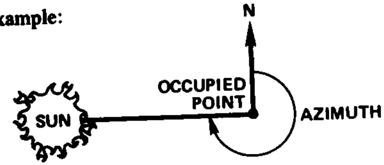
This program will yield azimuth of the sun from solar observations. Data which are entered here are assumed to be mean values with appropriate corrections made where necessary prior to operation of the program. Since the result is the sun's azimuth from north, it is left to the observer to add or subtract the angle turned to a backsite to determine the azimuth between two points.

Formulas used:

$$Az = \cos^{-1}\left[\frac{\sin\delta - \sin\phi \sin(\text{V ANG})}{\cos\phi \cos(\text{V ANG})}\right]$$

Where: Az = Azimuth from north
δ = Hr diff (Time + T Zone) + Declination
ϕ = Latitude of observer's position
Vert ang = Vertical angle to sun

Example:



Date: 18 July 1973
Time of observation: 15 hrs 38 min 37 sec (EST)
Longitude of standard meridian (time zone): 5 hrs
Declination at 0 hrs. (ephemeris): 21° 05' 36"
Hour difference in declination (ephemeris) -00° 00' 26.4"
Latitude (ϕ): 43° 00' 34" N
Mean corrected vertical angle to sun: 33° 34' 49"
Calculated north azimuth of sun: 268° 07' 54"

Input all angles as degrees, minutes and seconds in the form DDD.MMSS. Times are based on a 24 hour clock and are input as HH.MMSS (4 pm becomes 16 hours).

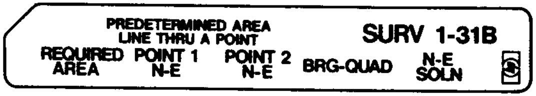
If the declination is North–it will have a positive value, and if the declination is South–it will be negative.

If the declination is on the increase, the hour difference will have a positive value, and if the declination is on the decrease, the hour difference will be negative.

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	Input local std. time	Time	A		
3		T Zone	A		
4		Declin	B		
5		Hr diff	B		
6		Lat	C		
7		V Ang	D		
8	Compute north Azimuth of sun		E		Sun Az

For new case start at line 2.

PREDETERMINED AREA – LINE THRU A POINT



This program solves one of the two cases of specifying the area of a land parcel, namely, that of hinging a side. First, the user breaks the area into a triangle and then uses this program to hinge the side to force the area to a predetermined value. Required inputs are the coordinates of the two known points, the bearing of the second side and the desired area. Outputs are coordinates of the unknown point.

In the example below, the coordinates of point 3 are unknown. A line passing through point 1 (the hinge point) will intersect at only one place on the line 2→3 which satisfies the area requirements.

Formulas used:

$$\text{Area} = \tfrac{1}{2}(b)(h)$$

$$h = a \sin\theta$$

$$\text{Area} = \tfrac{1}{2}(b)(a \sin\theta)$$

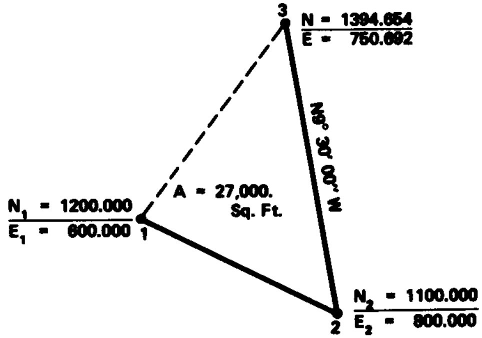
$$a = \frac{2\,\text{Area}}{b \sin\theta}$$

$$N = N_2 + a \cos(Az)$$

$$E = E_2 + a \sin(Az)$$

Where: b = Length of line 1→2
h = Height of the triangle
a = Length of line 2→3
θ = Angle 123
Az = Azimuth of line 2→3

Example:



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Area	A		
3		N_1	B		
4		E_1	B		
5		N_2	C		
6		E_2	C		
7		Brg	D		
8		Quad	D		
9	Compute solution		E		N
			R/S		E

For new case start at line 2.

PREDETERMINED AREA – TWO SIDES PARALLEL

PREDETERMINED AREA TWO SIDES PARALLEL				SURV 1-32A
REQUIRED AREA	BASE 1 LENGTH	ANGLE TO SIDE 1	ANGLE TO SIDE 2	SOLN

This program solves one of the two cases of specifying the area of a land parcel, namely, that of sliding a side along a fixed bearing. First, the user breaks the area into a trapezoid and then uses this program to slide the side to force the area to a predetermined value. Computed values include the lengths of the non-parallel sides, the length of the second parallel base and the angles formed by the intersection of each non-parallel side with the second base (angles 3 and 4 in diagram).

In the diagram, base 2 (side 4-3) is the side being moved.

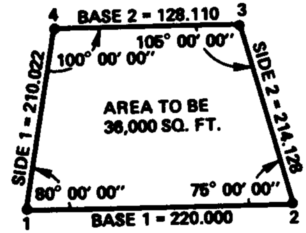
Formulas used:

$$\text{Area} = \tfrac{1}{2}(b_1 h + b_2 h)$$
$$b_2 = b_1 - h(\text{ctn}\,\theta + \text{ctn}\,\phi)$$
$$\text{Area} = \tfrac{1}{2}(b_1 h + (b_1 - h(\text{ctn}\,\theta + \text{ctn}\,\phi))h)$$
$$\text{Area} = b_1 h - \tfrac{1}{2}(\text{ctn}\,\theta + \text{ctn}\,\phi)h^2$$
$$h = \frac{b_1 - \sqrt{b_1^2 - 2A(\text{ctn}\,\theta + \text{ctn}\,\phi)}}{\text{ctn}\,\theta + \text{ctn}\,\phi}$$
$$r_1 = h/\sin\theta$$
$$r_2 = h/\sin\phi$$
$$\theta' = 180 - \theta$$
$$\phi' = 180 - \phi$$

Where:
- A = Area
- b_1 = Length of base 1
- b_2 = Length of base 2
- h = Altitude of trapezoid
- θ = Angle between base 1 and side 1 (Angle 1)

- ϕ = Angle between base 1 and side 2 (Angle 2)
- r_1 = Length of side 1
- r_2 = Length of side 2
- θ' = Angle between base 2 and side 1 (Angle 4)
- ϕ' = Angle between base 2 and side 2 (Angle 3)

Example:



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2		Area	A		
3		Base 1	B		
4		Ang 1	C		
5		Ang 2	D		
6	Compute length of 2nd base		E		Base 2
7	Compute non-parallel side 1		R/S		Side 1
8	Compute non-parallel side 2		R/S		Side 2
9	Compute 2nd angle to side 1		R/S		Angle 4
10	Compute 2nd angle to side 2		R/S		Angle 3

NOTE: This program will not solve a parallelogram.
(i.e. sides 1 and 2 parallel)
For new case start at line 2.

VOLUME BY AVERAGE END AREA

This program computes end area for any station, volume from previous station, and accumulated volume to the present station. Inputs are the elevations and distances from the centerline for all points of a cross section and the interval from the previous station.

When entering elevations and distances from center line for a particular station, start with center point (0,0). The storage registers must be cleared between successive problems.

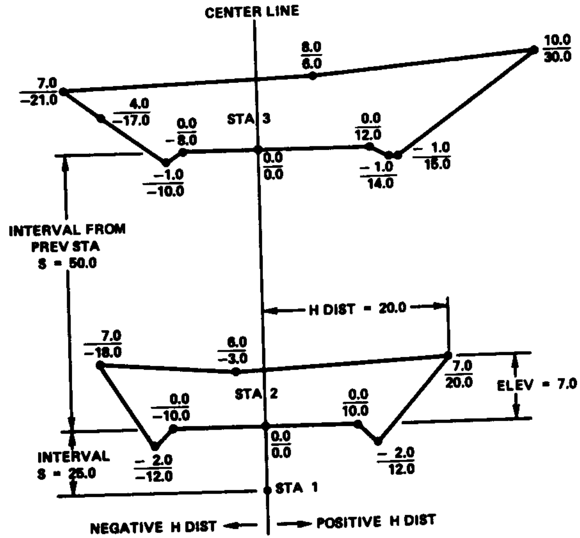
Formulas used:

$$V\ avg = (Area_i + Area_{i-1})\ I/2$$

$$Area = \tfrac{1}{2}\big[Elev_1\,(H\ Dist_2 - H\ Dist_n) + Elev_2\,(H\ Dist_3 - H\ Dist_1) + \ldots + Elev_n\,(H\ Dist_1 - H\ Dist_{n-1})\big]$$

Where:
- V avg = Average volume between two stations
- Area = Cross sectional area at a station
- H Dist = Horizontal distance from centerline at cross section
- Elev = Elevation at a point on the cross section
- I = Interval between stations
- Subscript i refers to current point
- Subscript n refers to last point
- Numeric subscript refers to point number

Example:



STA	AREA	INTERVAL (Ft)	VOLUME (cubic feet)	Σ VOLUME (cubic yards)
1	0			
2	216	25	2,700	100
3	321.5	50	13,437.5	597.7

NOTE: Traverse sections in clockwise direction to insure positive areas and volumes.

LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program				
2	If station has zero area	0	A		
3	If station has zero area go to				
	line 6				
4	First and last point input				
	must be 0 elev at 0 dist	Elev	A		
5		Dist	B		
	(Return to line 4 for next pt.				
	Continue to line 6 when cross				
	section complete)				
6	Compute station end area		C		End Area
	(If station is first station in				
	problem, go to line 4 and input				
	data for second station)				
7		Interval	D		
8	Optional: Volume from				
	previous station		E		Sta Vol
9	Optional: Accumulated volume		R/S		Cu Ft
10	Optional: Accumulated volume		R/S		Cu Yds

For new case, press f REG, and start at line 2.

Notes

VOLUME OF BORROW PIT

This program calculates volume of fill which can be taken from a borrow pit given grid dimensions and elevations at the grid intersections. Volume is available for each grid section and also as an accumulative volume for all previous sections.

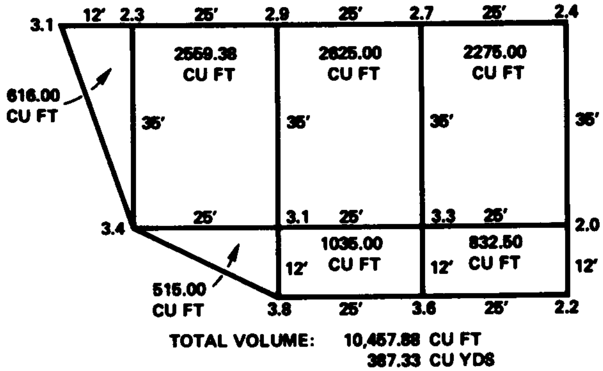
If several grid blocks have the same horizontal dimensions, the sum of the volumes of all these blocks can be calculated at once. This is done by entering all of the elevations using the "C" key before pressing the "D" key to compute the volume. For example, if three rectangular blocks have the same dimensions, the 12 elevations are entered before pressing the "D" key.

Formulas used:

$$Vol_{\triangle} = \tfrac{1}{2}\,(\text{Base})\,(\text{Ht})\,(\text{Elev})$$
$$Vol_{\square} = (\text{Width})\,(\text{Length})\,(\text{Elev})$$

Where:
- $Vol_{\triangle}$ = Volume of triangular grid section
- Base = Base of triangle
- Ht = Height of triangle
- Elev = Elevation of grid section (depth of cut)
- $Vol_{\square}$ = Volume of rectangular grid section
- Width = Width of rectangle
- Length = Length of rectangle

Example:



LINE	INSTRUCTIONS	DATA	KEYS		DISPLAY
1	Enter program		RTN	R/S	
2	If triangular area	Base	A		
3	If triangular area	Height	A		
4	If rectangular area	Width	B		
5	If rectangular area	Length	B		
6		Elev	C		
	(Input as many elevations as				
	needed to describe each corner				
	pressing C after each				
	entry)				
7	Compute grid section volume		D		Cu Ft
8	Compute accumulated volume		E		Cu Ft
9	Optional		R/S		Cu Yds

For next grid section, return to line 2.

For new case, press [illegible] [illegible] and start at line 2.

ABBREVIATIONS

AAS	(Triangle) – Angle–Angle–Side
ACC	Accumulated
ADJ	Adjusted
AL, Ang Lt	Angle left
ANG	Angle
AR, Ang Rt	Angle right
ASA	(Triangle) – Angle–Side–Angle
AZ	Azimuth
BEG	Beginning
BRG	Bearing
BS	Backsight
C	Center stadia reading on level rod; also cut or chord length
℄	Centerline
COORD	Coordinate
CORR	Correction
DECLIN	Declination
DEFL	Deflection
DEP	Departure
DIFF	Difference
DIST	Distance
DL	Deflection left
DM	Distance Meter
DR	Deflection right
E	Easting
EL	Elevation
ELEV	Elevation
F	Fill
FIL	Fillet
FS	Foresight
H	Height
H DIST, HD	Horizontal distance
HI	Height of instrument
HG DIST	Horizontal distance from centerline to hinge point

HG ELEV	Hinge point elevation
HR	Hour
HT	Height of target; also height
INST	Instrument (Theodolite or Transit only)
INT	Intersection
INTV	Interval
K	Stadia interval factor
L	Length; also lower stadia reading on level rod or arc length
LAT	Latitude
LBS	Pounds
LT	Left
MAX	Maximum
MIN	Minimum
N	Northing
OCC	Occupied
OFFSET, OFF	Offset distance
PC	Point of curvature
PRCSN	Precision ratio
PT	Point
QUAD	Quadrant code
R	Radius
REF	Reference
RFT	Reflector
RT	Right
SAS	(Triangle) – Side–Angle–Side
SEC	Section, also sector
SEG	Segment
S DIST, SD	Slope distance
SOLN	Solution
SSA	(Triangle) – Side–Side–Angle
SSS	(Triangle) – Side–Side–Side
STA	Station
T	(Curve) Tangent distance; also terrain
T ZONE	Time zone
TGT	Target
TEMP	Temperature

TOT	Total
TRNSFRMD	Transformed
U	Upper stadia reading on level rod
UNADJ	Unadjusted
V	Vertical
VERT	Vertical
VOL	Volume
W	Width
ZA	Zenith angle
ZNTH, ZN	Zenith
Δ	Difference or change in quantity or measurement; also triangle or central angle
▭	Rectangle

PROGRAM LISTINGS

FIELD ANGLE TRAVERSE

CODE	KEYS
23	LBL
11	A
31	f
43	REG
33 08	STO 8
33 06	STO 6
33 03	STO 3
24	RTN
23	LBL
11	A
33 07	STO 7
33 05	STO 5
24	RTN
23	LBL
11	A
23	LBL
12	B
01	1
08	8
00	0
31	f
02	D.MS+
23	LBL
13	C
32	f^{-1}
03	→D.MS
34 01	RCL 1
61	+
33 01	STO 1
24	RTN
23	LBL
14	D
33	STO
09	9
09	9

CODE	KEYS
00	0
24	RTN
23	LBL
14	D
34	RCL
09	9
35 07	g x⇄y
32	f^{-1}
03	→D.MS
31	f
04	SIN
71	x
24	RTN
23	LBL
15	E
33	STO
61	+
02	2
34 01	RCL 1
35 07	g x⇄y
32	f^{-1}
01	R→P
33	STO
61	+
08	8
35 07	g x⇄y
33	STO
61	+
07	7
34 03	RCL 3
34 08	RCL 8
84	R/S
33 03	STO 3
61	+
71	x

CODE	KEYS
33	STO
61	+
04	4
34 07	RCL 7
84	R/S
34 04	RCL 4
02	2
81	÷
35	g
06	ABS
84	R/S
04	4
03	3
05	5
06	6
00	0
81	÷
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Azimuth	R_4 Area Factor	R_7 Current E
R_2 ΣH Dist	R_5 Beg E	R_8 Current N
R_3 Previous N	R_6 Beg N	R_9 Used

BEARING TRAVERSE

CODE	KEYS
23	LBL
11	A
33 08	STO 8
33 06	STO 6
33 03	STO 3
24	RTN
23	LBL
11	A
33 07	STO 7
33 05	STO 5
24	RTN
23	LBL
12	B
32	f^{-1}
03	→D.MS
24	RTN
23	LBL
13	C
02	2
81	÷
41	↑
31	f
83	INT
35 21	g x ≠ y
22	GTO
01	1
35 09	g R↑
35 09	g R↑
42	CHS
35 09	g R↑
35 09	g R↑
23	LBL
01	1
35 08	g R↓
31	f

CODE	KEYS
83	INT
01	1
08	8
00	0
71	x
61	+
33 01	STO 1
24	RTN
23	LBL
14	D
33	STO
09	9
09	9
00	0
24	RTN
23	LBL
14	D
34	RCL
09	9
35 07	g x⇄y
12	B
31	f
04	SIN
71	x
24	RTN
23	LBL
15	E
33	STO
61	+
02	2
34 01	RCL 1
35 07	g x⇄y
32	f^{-1}
01	R→P
33	STO

CODE	KEYS
61	+
08	8
35 07	g x⇄y
33	STO
61	+
07	7
34 03	RCL 3
34 08	RCL 8
84	R/S
33 03	STO 3
61	+
71	x
33	STO
61	+
04	4
34 07	RCL 7
84	R/S
34 04	RCL 4
02	2
81	÷
35	g
06	ABS
84	R/S
04	4
03	3
05	5
06	6
00	0
81	÷
24	RTN

R_1 Azimuth	R_4 Area Factor	R_7 Current E
R_2 ΣH Dist	R_5 Beg E	R_8 Current N
R_3 Previous N	R_6 Beg N	R_9 Used

CLOSURE FOR FIELD ANGLE AND BEARING TRAVERSES

CODE	KEYS
23	LBL
11	A
33 06	STO 6
24	RTN
23	LBL
11	A
33 05	STO 5
24	RTN
23	LBL
12	B
34 04	RCL 4
02	2
81	÷
35	g
06	ABS
84	R/S
04	4
03	3
05	5
06	6
00	0
81	÷
24	RTN
23	LBL
13	C
34 07	RCL 7
34 05	RCL 5
51	–
34 08	RCL 8
34 06	RCL 6
51	–
31	f
01	R→P
84	R/S
33 03	STO 3

CODE	KEYS
44	CLX
35 24	g x>y
03	3
06	6
00	0
61	+
41	↑
41	↑
09	9
00	0
81	÷
01	1
61	+
31	f
83	INT
33	STO
09	9
02	2
81	÷
31	f
83	INT
01	1
08	8
00	0
71	x
51	–
35	g
06	ABS
31	f
03	→D.MS
84	R/S
34	RCL
09	9
24	RTN
23	LBL

CODE	KEYS
14	D
34 02	RCL 2
24	RTN
23	LBL
15	E
34 02	RCL 2
34 03	RCL 3
81	÷
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Current Az	R_4 Area	R_7 Current E
R_2 ΣH Dist	R_5 Beg E	R_8 Current N
R_3 Closure Dist	R_6 Beg N	R_9 Used

INVERSE FROM COORDINATES

CODE	KEYS
23	LBL
11	A
31	f
43	REG
33 05	STO 5
33 03	STO 3
24	RTN
23	LBL
11	A
33 06	STO 6
24	RTN
23	LBL
12	B
34 05	RCL 5
51	–
33	STO
61	+
05	5
24	RTN
23	LBL
12	B
34 06	RCL 6
51	–
33	STO
61	+
06	6
33 01	STO 1
24	RTN
23	LBL
13	C
35 07	g x⇄y
31	f
01	R→P
33	STO
61	+

CODE	KEYS
02	2
24	RTN
23	LBL
14	D
44	CLX
35 24	g x>y
03	3
06	6
00	0
61	+
41	↑
41	↑
09	9
00	0
81	÷
01	1
61	+
31	f
83	INT
33 08	STO 8
02	2
81	÷
31	f
83	INT
01	1
08	8
00	0
71	x
51	–
35	g
06	ABS
31	f
03	→D.MS
33 07	STO 7
34 03	RCL 3

CODE	KEYS
34 05	RCL 5
33 03	STO 3
61	+
34 01	RCL 1
71	x
33	STO
61	+
04	4
34 07	RCL 7
84	R/S
34 08	RCL 8
24	RTN
23	LBL
15	E
34 04	RCL 4
02	2
81	÷
35	g
06	ABS
84	R/S
04	4
03	3
05	5
06	6
00	0
81	÷
84	R/S
34 02	RCL 2
24	RTN
35 01	g NOP

R_1 Current dep	R_4 Area Factor	R_7 BRG
R_2 Σ H Dist	R_5 Beg N	R_8 QUAD
R_3 Previous N	R_6 Beg E	R_9 Used

SIDESHOTS

CODE	KEYS
23	LBL
11	A
32	f^{-1}
03	→D.MS
24	RTN
23	LBL
11	A
02	2
81	÷
41	↑
31	f
83	INT
35 21	g x≠y
22	GTO
01	1
35 09	g R↑
35 09	g R↑
42	CHS
35 09	g R↑
35 09	g R↑
23	LBL
01	1
35 08	g R↓
31	f
83	INT
01	1
08	8
00	0
71	x
61	+
33 01	STO 1
24	RTN
23	LBL
11	A
33 08	STO 8

CODE	KEYS
24	RTN
23	LBL
11	A
33 07	STO 7
24	RTN
23	LBL
12	B
01	1
08	8
00	0
31	f
02	D.MS+
23	LBL
13	C
32	f^{-1}
03	→D.MS
34 01	RCL 1
61	+
24	RTN
23	LBL
14	D
33	STO
09	9
44	CLX
03	3
00	0
41	↑
41	↑
61	+
61	+
24	RTN
23	LBL
14	D
34	RCL
09	9

CODE	KEYS
35 07	g x⇄y
32	f^{-1}
03	→D.MS
31	f
04	SIN
71	x
24	RTN
23	LBL
15	E
35 09	g R↑
35 07	g x⇄y
32	f^{-1}
01	R→P
34 08	RCL 8
61	+
84	R/S
35 07	g x⇄y
34 07	RCL 7
61	+
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Current Az.	R_4 Area Factor	R_7 Current E
R_2 ΣH Dist	R_5 Beg E	R_8 Current N
R_3 Previous N	R_6 Beg N	R_9 Used

COORDINATE TRANSFORMATION

CODE	KEYS
23	LBL
11	A
33 01	STO 1
24	RTN
23	LBL
11	A
33 02	STO 2
35 07	g x⇄y
24	RTN
23	LBL
11	A
51	−
33 03	STO 3
35 07	g x⇄y
24	RTN
23	LBL
11	A
51	−
33 04	STO 4
01	1
24	RTN
23	LBL
12	B
32	f^{-1}
03	→D.MS
33 05	STO 5
01	1
24	RTN
23	LBL
13	C
33 06	STO 6
24	RTN
23	LBL
14	D
34 01	RCL 1

CODE	KEYS
51	−
24	RTN
23	LBL
14	D
34 02	RCL 2
51	−
35 07	g x⇄y
31	f
01	R→P
34 06	RCL 6
71	x
35 07	g x⇄y
34 05	RCL 5
51	−
35 07	g x⇄y
32	f^{-1}
01	R→P
34 01	RCL 1
61	+
34 03	RCL 3
51	−
33 07	STO 7
35 07	g x⇄y
34 02	RCL 2
61	+
34 04	RCL 4
51	−
33 08	STO 8
44	CLX
24	RTN
23	LBL
15	E
34 07	RCL 7
84	R/S
34 08	RCL 8

CODE	KEYS
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 N_P	R_4 T_E	R_7 New N
R_2 E_P	R_5 ϕ	R_8 New E
R_3 T_N	R_6 Scale Factor	R_9 Used

COMPASS RULE ADJUSTMENT

CODE	KEYS
23	LBL
11	A
33	STO
09	9
31	f
61	TF 1
84	R/S
84	R/S
34 05	RCL 5
33 01	STO 1
34 07	RCL 7
51	−
34 02	RCL 2
81	÷
33 03	STO 3
34 06	RCL 6
34 08	RCL 8
51	−
34 02	RCL 2
81	÷
33 04	STO 4
34 06	RCL 6
33 02	STO 2
31	f
51	SF 1
84	R/S
23	LBL
12	B
33 07	STO 7
34	RCL
09	9
33 08	STO 8
34 06	RCL 6
51	−
33	STO
61	+
02	2
35 07	g x⇄y
34 05	RCL 5
51	−
33	STO
61	+
01	1
31	f
01	R→P
33	STO
09	9
34 03	RCL 3
71	x
33	STO
61	+
01	1
34	RCL
09	9
34 04	RCL 4
71	x
33	STO
61	+
02	2
34 08	RCL 8
33 06	STO 6
34 07	RCL 7
33 05	STO 5
84	R/S
23	LBL
13	C
34 02	RCL 2
24	RTN
23	LBL
14	D
34 01	RCL 1
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Adj E	R_4 ΔN/Σ Dist	R_7 Closing E
R_2 Adj N	R_5 Beg E	R_8 Closing N
R_3 ΔE/Σ Dist	R_6 Beg N	R_9 Used

TRANSIT RULE ADJUSTMENT

CODE	KEYS
23	LBL
11	A
44	CLX
33 01	STO 1
33 02	STO 2
34 07	RCL 7
34 05	RCL 5
33 07	STO 7
51	−
33 03	STO 3
34 08	RCL 8
34 06	RCL 6
33 08	STO 8
51	−
33 04	STO 4
24	RTN
23	LBL
12	B
24	RTN
23	LBL
13	C
24	RTN
23	LBL
14	D
34 07	RCL 7
51	−
33	STO
61	+
07	7
35	g
06	ABS
33	STO
61	+
01	1
35 07	g x⇄y
34 08	RCL 8
51	−
33	STO
61	+
08	8
35	g
06	ABS
33	STO
61	+
02	2
24	RTN
23	LBL
15	E
34 05	RCL 5
32	f^{-1}
61	TF1
33 07	STO 7
35 01	g NOP
51	−
41	↑
33	STO
61	+
05	5
35	g
06	ABS
34 01	RCL 1
81	÷
34 03	RCL 3
71	x
51	−
33	STO
61	+
07	7
35 07	g x⇄y
34 06	RCL 6
32	f^{-1}
61	TF 1
33 08	STO 8
35 01	g NOP
51	−
41	↑
33	STO
61	+
06	6
35	g
06	ABS
34 02	RCL 2
81	÷
34 04	RCL 4
71	x
51	−
33	STO
61	+
08	8
31	f
51	SF 1
34 08	RCL 8
84	R/S
34 07	RCL 7
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Σ|Dep|	R_4 Closing Lat	R_7 Adj Easting
R_2 Σ|Lat|	R_5 Beg Easting	R_8 Adj Northing
R_3 Closing Dep	R_6 Beg Northing	R_9

TWO INSTRUMENT RADIAL SURVEY

CODE	KEYS
23	LBL
12	B
32	f^{-1}
51	SF 1
02	2
81	÷
41	↑
31	f
83	INT
35 21	g x≠y
31	f
51	SF 1
01	1
08	8
00	0
71	x
35 09	g R↑
32	f^{-1}
03	→D.MS
32	f^{-1}
61	TF 1
42	CHS
35 01	g NOP
61	+
24	RTN
23	LBL
11	A
33 01	STO 1
24	RTN
23	LBL
11	A
33 02	STO 2
24	RTN
23	LBL
12	B

CODE	KEYS
33 03	STO 3
24	RTN
23	LBL
12	B
33 04	STO 4
24	RTN
23	LBL
13	C
24	RTN
23	LBL
13	C
12	B
24	RTN
23	LBL
13	C
32	f^{-1}
01	R→P
34 01	RCL 1
61	+
33 05	STO 5
35 08	g R↓
34 02	RCL 2
61	+
33 06	STO 6
24	RTN
23	LBL
14	D
24	RTN
23	LBL
14	D
12	B
24	RTN
23	LBL
14	D
32	f^{-1}

CODE	KEYS
01	R→P
24	RTN
23	LBL
15	E
34 03	RCL 3
61	+
34 05	RCL 5
61	+
02	2
81	÷
84	R/S
34 05	RCL 5
51	−
35 07	g x⇄y
34 04	RCL 4
61	+
34 06	RCL 6
61	+
02	2
81	÷
84	R/S
34 06	RCL 6
51	−
31	f
01	R→P
02	2
71	x
24	RTN
35 01	g NOP
35 01	g NOP

R_1 Point 1 N	R_4 Point 2 E	R_7
R_2 Point 1 E	R_5 First Calc N	R_8
R_3 Point 2 N	R_6 First Calc E	R_9 Used

CURVE SOLUTION — GIVEN Δ & R OR Δ & T

CODE	KEYS
23	LBL
11	A
33 02	STO 2
32	f^{-1}
03	→D.MS
02	2
81	÷
33 06	STO 6
84	R/S
23	LBL
12	B
35 07	g x⇄y
31	f
06	TAN
71	x
34 06	RCL 6
35 07	g x⇄y
23	LBL
13	C
33 04	STO 4
35 07	g x⇄y
31	f
05	COS
71	x
33 03	STO 3
33	STO
61	+
03	3
34 06	RCL 6
31	f
04	SIN
81	÷
33 01	STO 1
35	g
02	π

CODE	KEYS
71	x
34 06	RCL 6
71	x
09	9
00	0
81	÷
33 05	STO 5
24	RTN
23	LBL
14	D
34 05	RCL 5
34 01	RCL 1
71	x
02	2
81	÷
33 07	STO 7
84	R/S
34 06	RCL 6
31	f
05	COS
34 01	RCL 1
71	x
34 03	RCL 3
71	x
02	2
81	÷
51	−
84	R/S
34 04	RCL 4
34 01	RCL 1
71	x
34 07	RCL 7
51	−
24	RTN
23	LBL

CODE	KEYS
15	E
34 01	RCL 1
84	R/S
34 02	RCL 2
84	R/S
34 06	RCL 6
31	f
03	→D.MS
84	R/S
34 03	RCL 3
84	R/S
34 04	RCL 4
84	R/S
34 05	RCL 5
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 R	R_4 T	R_7 Sector Area
R_2 Δ	R_5 L	R_8
R_3 C	R_6 ½Δ	R_9 Used

CURVE SOLUTION – GIVEN R & T OR R & L

CODE	KEYS
23	LBL
11	A
33 01	STO 1
24	RTN
23	LBL
12	B
35 07	g x⇄y
81	÷
32	f^{-1}
06	TAN
09	9
00	0
81	÷
35	g
02	π
71	x
34 01	RCL 1
71	x
34 01	RCL 1
35 07	g x⇄y
23	LBL
13	C
33 05	STO 5
09	9
00	0
71	x
35	g
02	π
81	÷
35 07	g x⇄y
81	÷
33 06	STO 6
31	f
06	TAN
34 01	RCL 1

CODE	KEYS
71	x
33 04	STO 4
34 06	RCL 6
31	f
05	COS
71	x
02	2
71	x
33 03	STO 3
24	RTN
23	LBL
14	D
34 05	RCL 5
34 01	RCL 1
71	x
02	2
81	÷
33 07	STO 7
84	R/S
34 06	RCL 6
31	f
05	COS
34 01	RCL 1
71	x
34 03	RCL 3
71	x
02	2
81	÷
51	–
84	R/S
34 04	RCL 4
34 01	RCL 1
71	x
34 07	RCL 7
51	–

CODE	KEYS
24	RTN
23	LBL
15	E
34 01	RCL 1
84	R/S
34 06	RCL 6
02	2
71	x
31	f
03	→D.MS
84	R/S
34 06	RCL 6
31	f
03	→D.MS
84	R/S
34 03	RCL 3
84	R/S
34 04	RCL 4
84	R/S
34 05	RCL 5
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 R	R_4 T	R_7 Sector Area
R_2	R_5 L	R_8
R_3 C	R_6 ½Δ	R_9 Used

CURVE SOLUTION – GIVEN Δ & C OR R & C

CODE	KEYS
23	LBL
11	A
33 03	STO 3
24	RTN
23	LBL
12	B
33 02	STO 2
32	f^{-1}
03	→D.MS
02	2
81	÷
33 06	STO 6
31	f
04	SIN
81	÷
02	2
81	÷
33 01	STO 1
34 06	RCL 6
31	f
06	TAN
71	x
33 04	STO 4
34 06	RCL 6
09	9
00	0
81	÷
35	g
02	π
71	x
34 01	RCL 1
71	x
33 05	STO 5
44	CLX
24	RTN

CODE	KEYS
23	LBL
13	C
02	2
71	x
81	÷
32	f^{-1}
04	SIN
02	2
71	x
31	f
03	→D.MS
34 03	RCL 3
35 07	g x⇄y
12	B
84	R/S
23	LBL
14	D
34 05	RCL 5
34 01	RCL 1
71	x
02	2
81	÷
33 07	STO 7
84	R/S
34 06	RCL 6
31	f
05	COS
34 01	RCL 1
71	x
34 03	RCL 3
71	x
02	2
81	÷
51	–
84	R/S

CODE	KEYS
34 04	RCL 4
34 01	RCL 1
71	x
34 07	RCL 7
51	–
24	RTN
23	LBL
15	E
34 01	RCL 1
84	R/S
34 02	RCL 2
84	R/S
34 06	RCL 6
31	f
03	→D.MS
84	R/S
34 03	RCL 3
84	R/S
34 04	RCL 4
84	R/S
34 05	RCL 5
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 R	R_4 T	R_7 Sector Area
R_2 Δ	R_5 L	R_8
R_3 C	R_6 ½Δ	R_9 Used

ELEVATIONS ALONG A VERTICAL CURVE

CODE	KEYS
23	LBL
11	A
41	↑
33 01	STO 1
24	RTN
23	LBL
11	A
35 07	g x⇄y
51	−
05	5
00	0
71	x
33 03	STO 3
44	CLX
24	RTN
23	LBL
12	B
33 06	STO 6
24	RTN
23	LBL
12	B
33 02	STO 2
24	RTN
23	LBL
12	B
33	STO
81	÷
03	3
24	RTN
23	LBL
13	C
34 06	RCL 6
51	−
43	EEX
02	2

CODE	KEYS
81	÷
23	LBL
01	1
33 04	STO 4
41	↑
32	f^{-1}
09	$\sqrt{x}$
34 03	RCL 3
71	x
35 07	g x⇄y
34 01	RCL 1
71	x
61	+
34 02	RCL 2
61	+
33 05	STO 5
44	CLX
84	R/S
23	LBL
14	D
34 01	RCL 1
42	CHS
02	2
81	÷
34 03	RCL 3
81	÷
22	GTO
01	1
23	LBL
15	E
34 05	RCL 5
84	R/S
34 04	RCL 4
43	EEX
02	2

CODE	KEYS
71	x
34 06	RCL 6
61	+
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Grade 1	R_4 No of Stations	R_7
R_2 Beg Elevation	R_5 Elev at Sta	R_8
R_3 A/2	R_6 Beg Sta	R_9

HORIZONTAL CURVE LAYOUT

CODE	KEYS
23	LBL
11	A
33 01	STO 1
35	g
02	π
71	x
35	g
04	1/x
09	9
00	0
71	x
33 02	STO 2
24	RTN
23	LBL
12	B
33 03	STO 3
24	RTN
23	LBL
13	C
34 03	RCL 3
51	−
34 02	RCL 2
71	x
33 04	STO 4
31	f
04	SIN
34 01	RCL 1
71	x
02	2
71	x
33 05	STO 5
44	CLX
24	RTN
23	LBL
14	D

CODE	KEYS
34 04	RCL 4
31	f
03	→D.MS
24	RTN
23	LBL
15	E
34 05	RCL 5
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

CODE	KEYS
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Radius	R_4 Defl Ang	R_7
R_2 Defl/Ft	R_5 Chord	R_8
R_3 PC Sta	R_6	R_9 Used

TRIANGLE SOLUTION – GIVEN SSS OR SAS

CODE	KEYS
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
12	B
32	f^{-1}
03	→D.MS
33 06	STO 6
84	R/S
23	LBL
11	A
33 02	STO 2
84	R/S
23	LBL
11	A
33 03	STO 3
84	R/S
23	LBL
14	D
34 01	RCL 1
34 02	RCL 2
31	f
01	R→P
32	f^{-1}
09	$\sqrt{x}$
34 01	RCL 1
34 02	RCL 2
02	2
71	x
71	x
34 06	RCL 6
31	f
05	COS
71	x

CODE	KEYS
51	–
31	f
09	$\sqrt{x}$
33 03	STO 3
23	LBL
13	C
34 02	RCL 2
34 03	RCL 3
31	f
01	R→P
32	f^{-1}
09	$\sqrt{x}$
34 01	RCL 1
84	R/S
32	f^{-1}
09	$\sqrt{x}$
51	–
34 02	RCL 2
34 03	RCL 3
02	2
71	x
71	x
81	÷
32	f^{-1}
05	COS
31	f
03	→D.MS
24	RTN
33 04	STO 4
34 03	RCL 3
34 01	RCL 1
33 03	STO 3
35 07	g x⇄y
33 01	STO 1
13	C

CODE	KEYS
84	R/S
33 05	STO 5
34 02	RCL 2
34 01	RCL 1
33 02	STO 2
35 07	g x⇄y
33 01	STO 1
13	C
33 06	STO 6
84	R/S
23	LBL
15	E
34 02	RCL 2
34 03	RCL 3
71	x
02	2
81	÷
34 06	RCL 6
32	f^{-1}
03	→D.MS
31	f
04	SIN
71	x
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Side 3	R_4 Angle	R_7
R_2 Side 2	R_5 Angle	R_8
R_3 Side 1	R_6 Angle	R_9 Used

TRIANGLE SOLUTION – GIVEN SSA

CODE	KEYS
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
11	A
33 02	STO 2
84	R/S
23	LBL
12	B
33 05	STO 5
84	R/S
23	LBL
13	C
31	f
51	SF 1
22	GTO
01	1
23	LBL
14	D
32	f^{-1}
51	SF 1
23	LBL
01	1
34 02	RCL 2
32	f^{-1}
09	$\sqrt{x}$
34 05	RCL 5
32	f^{-1}
03	→D.MS
34 01	RCL 1
32	f^{-1}
01	R→P
35 08	g R↓
32	f^{-1}

CODE	KEYS
09	$\sqrt{x}$
51	–
31	f
09	$\sqrt{x}$
31	f
61	TF 1
35 01	gNOP
42	CHS
35 09	g R↑
61	+
33 03	STO 3
34 02	RCL 2
31	f
01	R→P
32	f^{-1}
09	$\sqrt{x}$
34 01	RCL 1
84	R/S
32	f^{-1}
09	$\sqrt{x}$
51	–
34 02	RCL 2
34 03	RCL 3
71	x
81	÷
02	2
81	÷
32	f^{-1}
05	COS
31	f
03	→D.MS
84	R/S
34 02	RCL 2
84	R/S
44	CLX

CODE	KEYS
34 05	RCL 5
84	R/S
31	f
02	D.MS +
34 03	RCL 3
84	R/S
44	CLX
01	1
08	8
00	0
35 07	g x⇄y
32	f^{-1}
02	D.MS +
84	R/S
23	LBL
15	E
34 01	RCL 1
34 03	RCL 3
34 05	RCL 5
32	f^{-1}
03	→D.MS
31	f
04	SIN
71	x
71	x
02	2
81	÷
84	R/S
35 01	g NOP
35 01	g NOP

R_1 Side 1	R_4	R_7
R_2 Side 2	R_5 Angle 2	R_8
R_3 Side 3	R_6	R_9 Used

TRIANGLE SOLUTION – GIVEN ASA OR AAS

CODE	KEYS
23	LBL
12	B
33 04	STO 4
84	R/S
23	LBL
12	B
33 06	STO 6
84	R/S
23	LBL
11	A
33 03	STO 3
84	R/S
23	LBL
12	B
33 05	STO 5
84	R/S
23	LBL
14	D
01	1
08	8
00	0
34 04	RCL 4
32	f^{-1}
02	D.MS+
34 06	RCL 6
32	f^{-1}
02	D.MS+
33 05	STO 5
23	LBL
13	C
01	1
08	8
00	0
34 04	RCL 4
32	f^{-1}

CODE	KEYS
02	D.MS +
34 05	RCL 5
32	f^{-1}
02	D.MS +
33 06	STO 6
32	f^{-1}
03	→D.MS
31	f
04	SIN
34 03	RCL 3
35 07	g x⇄y
81	÷
33 07	STO 7
34 04	RCL 4
32	f^{-1}
03	→D.MS
31	f
04	SIN
71	x
84	R/S
33 01	STO 1
34 04	RCL 4
84	R/S
34 07	RCL 7
34 05	RCL 5
32	f^{-1}
03	→D.MS
31	f
04	SIN
33 07	STO 7
71	x
84	R/S
34 05	RCL 5
84	R/S
34 03	RCL 3

CODE	KEYS
84	R/S
34 06	RCL 6
84	R/S
23	LBL
15	E
34 01	RCL 1
34 03	RCL 3
34 07	RCL 7
71	x
71	x
02	2
81	÷
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Side 1	R_4 Angle 1	R_7 Used
R_2	R_5 Angle 2	R_8
R_3 Side 3	R_6 Angle 3	R_9 Used

BEARING – BEARING INTERSECT

CODE	KEYS
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
11	A
33 02	STO 2
84	R/S
23	LBL
12	B
33 03	STO 3
84	R/S
23	LBL
12	B
33 04	STO 4
84	R/S
23	LBL
13	C
32	f^{-1}
03	→D.MS
31	f
06	TAN
33 05	STO 5
35 00	g LST X
84	R/S
23	LBL
13	C
41	↑
01	1
35 23	g x = y
22	GTO
01	1
44	CLX
03	3
35 23	g x = y

CODE	KEYS
22	GTO
01	1
34 05	RCL 5
42	CHS
33 05	STO 5
23	LBL
01	1
84	R/S
23	LBL
14	D
32	f^{-1}
03	→D.MS
31	f
06	TAN
33 06	STO 6
35 00	g LST X
84	R/S
23	LBL
14	D
41	↑
01	1
35 23	g x = y
22	GTO
02	2
44	CLX
03	3
35 23	g x = y
22	GTO
02	2
34 06	RCL 6
42	CHS
33 06	STO 6
23	LBL
02	2
84	R/S

CODE	KEYS
23	LBL
15	E
34 04	RCL 4
34 03	RCL 3
34 06	RCL 6
71	x
51	–
34 02	RCL 2
34 01	RCL 1
34 05	RCL 5
71	x
51	–
33 07	STO 7
51	–
34 05	RCL 5
34 06	RCL 6
51	–
81	÷
84	R/S
34 05	RCL 5
71	x
34 07	RCL 7
61	+
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Point 1N	R_4 Point 2E	R_7 Used
R_2 Point 1E	R_5 Line 1 TAN (AZ)	R_8
R_3 Point 2N	R_6 Line 2 TAN (AZ)	R_9 Used

BEARING – DISTANCE INTERSECT

CODE	KEYS
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
11	A
33 02	STO 2
84	R/S
23	LBL
12	B
33 03	STO 3
84	R/S
23	LBL
12	B
33 04	STO 4
84	R/S
23	LBL
13	C
32	f^{-1}
03	→D.MS
84	R/S
23	LBL
13	C
02	2
81	÷
41	↑
31	f
83	INT
35 07	g x⇄y
35 21	g x≠y
22	GTO
01	1
35 09	g R↑
35 09	g R↑
42	CHS

CODE	KEYS
35 09	g R↑
35 09	g R↑
23	LBL
01	1
44	CLX
01	1
08	8
00	0
71	x
61	+
33 05	STO 5
84	R/S
23	LBL
14	D
33 06	STO 6
84	R/S
23	LBL
15	E
34 04	RCL 4
34 02	RCL 2
51	–
34 03	RCL 3
34 01	RCL 1
51	–
31	f
01	R→P
33 07	STO 7
44	CLX
35 24	g x>y
03	3
06	6
00	0
61	+
34 05	RCL 5
51	–

CODE	KEYS
34 07	RCL 7
32	f^{-1}
01	R→P
35 07	g x⇄y
32	f^{-1}
09	$\sqrt{x}$
34 06	RCL 6
32	f^{-1}
09	$\sqrt{x}$
35 07	g x⇄y
51	–
31	f
09	$\sqrt{x}$
61	+
34 05	RCL 5
35 07	g x⇄y
32	f^{-1}
01	R→P
34 01	RCL 1
61	+
84	R/S
35 07	g x⇄y
34 02	RCL 2
61	+
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Point 1N	R_4 Point 2E	R_7 Dist 1→2
R_2 Point 1E	R_5 Line 1Az	R_8
R_3 Point 2N	R_6 Line 2-Dist	R_9 Used

DISTANCE – DISTANCE INTERSECT

CODE	KEYS
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
11	A
33 02	STO 2
84	R/S
23	LBL
12	B
33 03	STO 3
84	R/S
23	LBL
12	B
33 04	STO 4
84	R/S
23	LBL
13	C
33 05	STO 5
84	R/S
23	LBL
14	D
33 06	STO 6
84	R/S
23	LBL
15	E
34 04	RCL 4
34 02	RCL 2
51	–
34 03	RCL 3
34 01	RCL 1
51	–
31	f
01	R→P
33 07	STO 7

CODE	KEYS
32	f^{-1}
09	$\sqrt{x}$
34 05	RCL 5
32	f^{-1}
09	$\sqrt{x}$
61	+
34 06	RCL 6
32	f^{-1}
09	$\sqrt{x}$
51	–
02	2
81	÷
34 07	RCL 7
34 05	RCL 5
71	x
81	÷
32	f^{-1}
05	COS
51	–
34 05	RCL 5
32	f^{-1}
01	R→P
34 01	RCL 1
61	+
84	R/S
35 07	g x⇄y
34 02	RCL 2
61	+
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

CODE	KEYS
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Point 1 N	R_4 Point 2 E	R_7 Dist 1→2
R_2 Point 1 E	R_5 Dist 1	R_8
R_3 Point 2 N	R_6 Dist 2	R_9 Used

DISTANCE FROM A POINT TO A LINE

CODE	KEYS
23	LBL
11	A
31	f
43	REG
33 01	STO 1
84	R/S
23	LBL
11	A
33 02	STO 2
84	R/S
23	LBL
12	B
32	f^{-1}
03	→D.MS
31	f
06	TAN
33 03	STO 3
84	R/S
23	LBL
12	B
02	2
81	÷
32	f^{-1}
83	INT
83	•
04	4
35 22	g x≤y
22	GTO
01	1
34 03	RCL 3
42	CHS
33 03	STO 3
23	LBL
01	1
84	R/S

CODE	KEYS
23	LBL
13	C
33 04	STO 4
84	R/S
23	LBL
13	C
33 05	STO 5
84	R/S
23	LBL
14	D
34 02	RCL 2
34 01	RCL 1
34 03	RCL 3
71	x
51	–
33 07	STO 7
34 05	RCL 5
34 04	RCL 4
34 03	RCL 3
81	÷
61	+
51	–
34 03	RCL 3
41	↑
35	g
04	$^1/_x$
61	+
42	CHS
81	÷
33 08	STO 8
84	R/S
34 03	RCL 3
71	x
34 07	RCL 7
61	+

CODE	KEYS
33 03	STO 3
84	R/S
23	LBL
15	E
34 04	RCL 4
34 08	RCL 8
51	–
34 05	RCL 5
34 03	RCL 3
51	–
31	f
01	R→P
84	R/S
34 01	RCL 1
34 08	RCL 8
51	–
34 02	RCL 2
34 03	RCL 3
51	–
31	f
01	R→P
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1	Point 1 N	R_4	Point 2 N	R_7	Used
R_2	Point 1 E	R_5	Point 2 E	R_8	Point 3 N
R_3	Point 3 E	R_6		R_9	Used

TAPING CORRECTIONS

CODE	KEYS
23	LBL
11	A
33 03	STO 3
02	2
00	0
51	–
03	3
43	EEX
05	5
81	÷
83	•
00	0
00	0
00	0
41	↑
43	EEX
02	2
81	÷
61	+
33 01	STO 1
84	R/S
23	LBL
12	B
06	6
08	8
51	–
06	6
04	4
05	5
43	EEX
42	CHS
08	8
71	x
34 01	RCL 1
61	+

CODE	KEYS
33 02	STO 2
84	R/S
23	LBL
13	C
33 06	STO 6
83	•
00	0
01	1
04	4
71	x
34 03	RCL 3
81	÷
41	↑
71	x
02	2
04	4
81	÷
42	CHS
34 02	RCL 2
01	1
61	+
61	+
34 06	RCL 6
71	x
33 06	STO 6
44	CLX
84	R/S
23	LBL
14	D
32	f^{-1}
03	→D.MS
31	f
04	SIN
34 06	RCL 6
71	x

CODE	KEYS
22	GTO
01	1
23	LBL
15	E
41	↑
71	x
42	CHS
34 06	RCL 6
41	↑
71	x
61	+
31	f
09	$\sqrt{x}$
23	LBL
01	1
33	STO
61	+
05	5
84	R/S
34 05	RCL 5
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1	Used	R_4		R_7	
R_2	Used	R_5	Σ H Dist	R_8	
R_3	Lbs Pull	R_6	S Dist	R_9	

EDM SLOPE REDUCTION – GIVEN ZENITH ANGLE

CODE	KEYS
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
11	A
02	2
00	0
09	9
00	0
06	6
43	EEX
03	3
61	+
35 00	g LST X
81	÷
33 05	STO 5
24	RTN
23	LBL
12	B
32	f^{-1}
03	→D.MS
41	↑
31	f
04	SIN
34 01	RCL 1
71	X
33 06	STO 6
01	1
04	4
43	EEX
42	CHS
07	7
71	X
33 04	STO 4

CODE	KEYS
51	–
34 06	RCL 6
02	2
43	EEX
42	CHS
07	7
71	X
61	+
33 02	STO 2
24	RTN
23	LBL
13	C
84	R/S
23	LBL
13	C
51	–
33 06	STO 6
84	R/S
23	LBL
14	D
51	–
84	R/S
23	LBL
14	D
61	+
34 01	RCL 1
81	÷
34 02	RCL 2
34 04	RCL 4
51	–
31	f
04	SIN
71	X
32	f^{-1}
04	SIN

CODE	KEYS
33	STO
61	+
02	2
24	RTN
23	LBL
15	E
34 01	RCL 1
34 04	RCL 4
31	f
05	COS
81	÷
33 01	STO 1
34 02	RCL 2
34 04	RCL 4
51	–
31	f
04	SIN
71	X
84	R/S
34 05	RCL 5
81	÷
84	R/S
34 01	RCL 1
34 02	RCL 2
31	f
05	COS
71	X
34 06	RCL 6
61	+
84	R/S

R_1 S Dist/used	R_4 c	R_7
R_2 Z_1/used	R_5 (R + E) /R	R_8
R_3	R_6 Used	R_9 Used

EDM SLOPE REDUCTION – GIVEN Δ ELEVATION

CODE	KEYS
23	LBL
11	A
33 01	STO 1
02	2
00	0
09	9
00	0
06	6
00	0
00	0
00	0
33 05	STO 5
24	RTN
23	LBL
12	B
33 02	STO 2
24	RTN
23	LBL
13	C
33 03	STO 3
24	RTN
23	LBL
14	D
33	STO
61	+
02	2
33 07	STO 7
84	R/S
23	LBL
14	D
33	STO
61	+
03	3
84	R/S
23	LBL

CODE	KEYS
14	D
33 04	STO 4
24	RTN
23	LBL
15	E
34 01	RCL 1
32	f^{-1}
09	$\sqrt{X}$
34 03	RCL 3
34 02	RCL 2
51	–
32	f^{-1}
09	$\sqrt{X}$
51	–
34 05	RCL 5
34 02	RCL 2
61	+
81	÷
34 05	RCL 5
34 03	RCL 3
61	+
81	÷
31	f
09	$\sqrt{X}$
33 06	STO 6
34 05	RCL 5
34 07	RCL 7
61	+
71	X
84	R/S
34 06	RCL 6
34 05	RCL 5
71	X
84	R/S
34 06	RCL 6

CODE	KEYS
34 04	RCL 4
34 05	RCL 5
61	+
71	X
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 S Dist	R_4 E_S	R_7 E_1
R_2 HI DM + E_1	R_5 R	R_8
R_3 HT Rft + E_2	R_6 Used	R_9

FIELD ANGLE CHECK

CODE	KEYS
23	LBL
11	A
32	f^{-1}
03	→D.MS
01	1
08	8
00	0
51	–
31	f
61	TF 1
22	GTO
01	1
31	f
43	REG
33 02	STO 2
23	LBL
01	1
33 01	STO 1
31	f
51	SF 1
24	RTN
23	LBL
12	B
01	1
08	8
00	0
31	f
02	D.MS +
23	LBL
13	C
32	f^{-1}
03	→D.MS
34 02	RCL 2
61	+
35	g

CODE	KEYS
83	DS Z
01	1
32	f^{-1}
01	R→P
31	f
01	R→P
44	CLX
35 24	g x>y
03	3
06	6
00	0
61	+
33 02	STO 2
09	9
00	0
81	÷
01	1
61	+
31	f
83	INT
33 03	STO 3
02	2
81	÷
31	f
83	INT
01	1
08	8
00	0
71	x
34 02	RCL 2
51	–
35	g
06	ABS
33 04	STO 4
44	CLX

CODE	KEYS
24	RTN
23	LBL
14	D
34 04	RCL 4
31	f
03	→D.MS
84	R/S
34 03	RCL 3
84	R/S
34 02	RCL 2
31	f
03	→D.MS
84	R/S
23	LBL
15	E
34 01	RCL 1
34 02	RCL 2
51	–
31	f
03	→D.MS
84	R/S
32	f^{-1}
03	→D.MS
34 08	RCL 8
81	÷
31	f
03	→D.MS
32	f^{-1}
51	SF 1
24	RTN

R_1 Ref Az –180	R_4 Bearing	R_7
R_2 Current Az	R_5	R_8 Counter
R_3 Quad Code	R_6	R_9 Used

STADIA REDUCTIONS

CODE	KEYS
23	LBL
11	A
33 05	STO 5
84	R/S
23	LBL
11	A
33 01	STO 1
33 04	STO 4
84	R/S
23	LBL
12	B
32	f^{-1}
03	→D.MS
09	9
00	0
35 07	g x≠y
51	–
33 02	STO 2
35 00	g LST X
31	f
03	→D.MS
84	R/S
23	LBL
13	C
33 03	STO 3
84	R/S
23	LBL
14	D
33 04	STO 4
84	R/S
23	LBL
15	E
34 02	RCL 2
31	f
05	COS

CODE	KEYS
32	f^{-1}
09	$\sqrt{x}$
34 03	RCL 3
71	x
01	1
00	0
00	0
71	x
84	R/S
34 02	RCL 2
02	2
71	x
31	f
04	SIN
05	5
00	0
71	x
34 03	RCL 3
71	x
34 04	RCL 4
51	–
34 01	RCL 1
33 04	STO 4
61	+
34 05	RCL 5
61	+
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

CODE	KEYS
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Ht Instrument	R_4 Rod Reading	R_7
R_2 Vertical Angle	R_5 Sta Elev	R_8
R_3 Rod Inter	R_6	R_9 Used

THREE WIRE LEVELING

CODE	KEYS
23	LBL
11	A
33 01	STO 1
01	1
00	0
00	0
33 08	STO 8
84	R/S
23	LBL
11	A
33 08	STO 8
84	R/S
23	LBL
12	B
31	f
51	SF 1
84	R/S
23	LBL
13	C
32	f^{-1}
51	SF 1
84	R/S
23	LBL
14	D
33 07	STO 7
84	R/S
23	LBL
14	D
33	STO
61	+
07	7
51	−
35 00	g LST X
84	R/S
23	LBL

CODE	KEYS
14	D
33	STO
61	+
07	7
51	−
61	+
35 00	g LST X
02	2
71	x
35 07	g x⇄y
51	−
35 00	g LST X
34 07	RCL 7
03	3
81	÷
31	f
61	TF 1
22	GTO
01	1
33	STO
61	+
05	5
35 08	g R↓
33	STO
61	+
06	6
35 08	g R↓
84	R/S
23	LBL
01	1
33	STO
61	+
02	2
35 08	g R↓
33	STO

CODE	KEYS
61	+
03	3
35 08	g R↓
84	R/S
23	LBL
15	E
34 02	RCL 2
34 05	RCL 5
51	−
84	R/S
34 01	RCL 1
61	+
84	R/S
34 03	RCL 3
34 08	RCL 8
71	x
84	R/S
34 06	RCL 6
34 08	RCL 8
71	x
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Elev	R_4	R_7 Used
R_2 Σ BS Means	R_5 Σ FS Means	R_8 Stadia Intr K
R_3 Σ BS Intervals	R_6 Σ FS Intervals	R_9

SLOPE STAKING – GIVEN CENTERLINE TERRAIN ELEVATION

CODE	KEYS
23	LBL
11	A
84	R/S
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
12	B
84	R/S
23	LBL
12	B
51	−
71	x
61	+
33 02	STO 2
84	R/S
23	LBL
13	C
84	R/S
23	LBL
13	C
32	f^{-1}
03	→D.MS
31	f
05	COS
35 00	g LST X
31	f
06	TAN
34 01	RCL 1
71	x
01	1
51	−
33 03	STO 3
35 08	g R↓

CODE	KEYS
71	x
33 04	STO 4
33 05	STO 5
22	GTO
01	1
23	LBL
14	D
33 04	STO 4
33 05	STO 5
84	R/S
23	LBL
14	D
35 07	g x⇄y
81	÷
34 01	RCL 1
71	x
01	1
51	−
33 03	STO 3
23	LBL
01	1
34 02	RCL 2
34 03	RCL 3
34 05	RCL 5
71	x
61	+
33	STO
61	+
05	5
35	g
06	ABS
83	•
01	1
35 22	g x≤y
22	GTO

CODE	KEYS
01	1
84	R/S
23	LBL
15	E
34 05	RCL 5
34 04	RCL 4
51	−
84	R/S
34 05	RCL 5
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Slope	R_4 H Dist	R_7
R_2 Used	R_5 H Dist	R_8
R_3 Used	R_6	R_9 Used

SLOPE STAKING – GIVEN CENTERLINE CUT/FILL

CODE	KEYS
23	LBL
11	A
84	R/S
23	LBL
11	A
33 01	STO 1
84	R/S
23	LBL
12	B
84	R/S
23	LBL
12	B
61	+
71	x
61	+
33 02	STO 2
84	R/S
23	LBL
13	C
84	R/S
23	LBL
13	C
32	f^{-1}
03	→D.MS
31	f
05	COS
35 00	gLST X
31	f
06	TAN
34 01	RCL 1
71	x
01	1
51	–
33 03	STO 3
35 08	g R↓

CODE	KEYS
71	x
33 04	STO 4
33 05	STO 5
22	GTO
01	1
23	LBL
14	D
33 04	STO 4
33 05	STO 5
84	R/S
23	LBL
14	D
35 07	g x⇄y
81	÷
34 01	RCL 1
71	x
01	1
51	–
33 03	STO 3
23	LBL
01	1
34 02	RCL 2
34 03	RCL 3
34 05	RCL 5
71	x
61	+
33	STO
61	+
05	5
35	g
06	ABS
83	•
01	1
35 22	g x≤y
22	GTO

CODE	KEYS
01	1
84	R/S
23	LBL
15	E
34 05	RCL 5
34 04	RCL 4
51	–
84	R/S
34 05	RCL 5
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Slope	R_4 H Dist	R_7
R_2 Used	R_5 H Dist	R_8
R_3 Used	R_6	R_9 Used

AZIMUTH OF THE SUN

CODE	KEYS
23	LBL
11	A
33 04	STO 4
24	RTN
23	LBL
11	A
31	f
02	D.MS+
32	f^{-1}
03	→D.MS
24	RTN
23	LBL
12	B
32	f^{-1}
03	→D.MS
35 07	g x⇄y
24	RTN
23	LBL
12	B
32	f^{-1}
03	→D.MS
71	x
61	+
33 01	STO 1
24	RTN
23	LBL
13	C
32	f^{-1}
03	→D.MS
33 02	STO 2
24	RTN
23	LBL
14	D
32	f^{-1}
03	→D.MS

CODE	KEYS
33 03	STO 3
34 01	RCL 1
31	f
04	SIN
34 02	RCL 2
31	f
04	SIN
34 03	RCL 3
31	f
04	SIN
71	x
51	–
34 02	RCL 2
31	f
05	COS
34 03	RCL 3
31	f
05	COS
71	x
81	÷
24	RTN
23	LBL
15	E
32	f^{-1}
05	COS
34 04	RCL 4
01	1
02	2
35 22	g x≤y
22	GTO
01	1
35 08	g R↓
35 08	g R↓
31	f
03	→D.MS

CODE	KEYS
24	RTN
23	LBL
01	1
35 08	g R↓
35 08	g R↓
42	CHS
41	↑
03	3
06	6
00	0
61	+
31	f
03	→D.MS
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Declination (δ)	R_4 Local time	R_7
R_2 Latitude (ϕ)	R_5	R_8
R_3 Vert ang (h)	R_6	R_9 Used

PREDETERMINED AREA – LINE THRU A POINT

CODE	KEYS
23	LBL
11	A
02	2
71	x
33 01	STO 1
24	RTN
23	LBL
12	B
24	RTN
23	LBL
12	B
24	RTN
23	LBL
13	C
33 06	STO 6
35 07	g x⇄y
24	RTN
23	LBL
13	C
33 05	STO 5
51	–
35 08	g R↓
51	–
35 09	g R↑
35 07	g x⇄y
31	f
01	R→P
34 01	RCL 1
35 07	g x⇄y
81	÷
33 02	STO 2
44	CLX
35 24	g x>y
03	3
06	6

CODE	KEYS
00	0
61	+
33 03	STO 3
24	RTN
23	LBL
14	D
32	f^{-1}
03	→D.MS
24	RTN
23	LBL
14	D
41	↑
02	2
81	÷
41	↑
31	f
83	INT
35 21	g x≠y
22	GTO
01	1
35 09	g R↑
35 09	g R↑
42	CHS
35 09	g R↑
35 09	g R↑
23	LBL
01	1
35 08	g R↓
31	f
83	INT
01	1
08	8
00	0
71	x
61	+

CODE	KEYS
33 04	STO 4
34 03	RCL 3
51	–
31	f
04	SIN
35	g
06	ABS
34 02	RCL 2
35 07	g x⇄y
81	÷
33 02	STO 2
24	RTN
23	LBL
15	E
34 04	RCL 4
31	f
05	COS
71	x
34 06	RCL 6
61	+
84	R/S
34 02	RCL 2
34 04	RCL 4
31	f
04	SIN
71	x
34 05	RCL 5
61	+
84	R/S
35 01	g NOP

R_1 2 x Area (2A)	R_4 Az 2→3	R_7
R_2 2A/Base	R_5 Point 2 E	R_8
R_3 Az 2→1	R_6 Point 2 N	R_9 Used

PREDETERMINED AREA – TWO SIDES PARALLEL

CODE	KEYS
23	LBL
11	A
33 01	STO 1
24	RTN
23	LBL
12	B
33 02	STO 2
24	RTN
23	LBL
13	C
33 06	STO 6
32	f^{-1}
03	→D.MS
41	↑
31	f
04	SIN
33 03	STO 3
35 07	g x⇄y
31	f
06	TAN
35	g
04	1/x
33 05	STO 5
24	RTN
23	LBL
14	D
33 08	STO 8
32	f^{-1}
03	→D.MS
41	↑
31	f
04	SIN
33 04	STO 4
35 07	g x⇄y
31	f

CODE	KEYS
06	TAN
35	g
04	1/x
33	STO
61	+
05	5
34 02	RCL 2
41	↑
32	f^{-1}
09	$\sqrt{x}$
34 01	RCL 1
02	2
71	x
34 05	RCL 5
71	x
51	–
31	f
09	$\sqrt{x}$
51	–
34 05	RCL 5
81	÷
33	STO
09	9
34 05	RCL 5
71	x
34 02	RCL 2
35 07	g x⇄y
51	–
33 07	STO 7
34	RCL
09	9
34 03	RCL 3
33 01	STO 1
81	÷
33 03	STO 3

CODE	KEYS
34	RCL
09	9
34 04	RCL 4
33 02	STO 2
81	÷
33 04	STO 4
44	CLX
24	RTN
23	LBL
15	E
34 07	RCL 7
84	R/S
34 03	RCL 3
84	R/S
34 04	RCL 4
84	R/S
34 06	RCL 6
23	LBL
01	1
42	CHS
01	1
08	8
00	0
31	f
02	D.MS +
84	R/S
34 08	RCL 8
22	GTO
01	1
35 01	g NOP

R_1 Area/SIN ∢1	R_4 SIN ∢2/Side 2	R_7 Base 2
R_2 Base 1/SIN ∢2	R_5 CTN ∢1 + CTN ∢2	R_8 ϕ
R_3 SIN ∢1/Side 1	R_6 θ	R_9 Used

VOLUME BY AVERAGE END AREA

CODE	KEYS
23	LBL
11	A
34 06	RCL 6
33 07	STO 7
44	CLX
33 06	STO 6
84	R/S
23	LBL
12	B
33 01	STO 1
84	R/S
23	LBL
11	A
33 02	STO 2
84	R/S
23	LBL
12	B
33 03	STO 3
84	R/S
23	LBL
11	A
33 04	STO 4
84	R/S
23	LBL
12	B
33 05	STO 5
23	LBL
01	1
34 02	RCL 2
34 05	RCL 5
34 01	RCL 1
51	−
71	x
02	2
81	÷

CODE	KEYS
33	STO
61	+
06	6
34 03	RCL 3
33 01	STO 1
34 04	RCL 4
33 02	STO 2
34 05	RCL 5
33 03	STO 3
84	R/S
23	LBL
11	A
33 04	STO 4
84	R/S
23	LBL
12	B
33 05	STO 5
22	GTO
01	1
23	LBL
13	C
34 06	RCL 6
35	g
06	ABS
33 06	STO 6
84	R/S
23	LBL
14	D
34 06	RCL 6
34 07	RCL 7
61	+
71	x
02	2
81	÷
33	STO

CODE	KEYS
61	+
08	8
33	STO
09	9
44	CLX
84	R/S
23	LBL
15	E
34	RCL
09	9
84	R/S
34 08	RCL 8
84	R/S
02	2
07	7
81	÷
24	RTN
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1 Used	R_4 Used	R_7 Last Area
R_2 Used	R_5 Used	R_8 Σ Volume
R_3 Used	R_6 Area	R_9 Used

VOLUME OF BORROW PIT

CODE	KEYS
31	f
43	REG
84	R/S
23	LBL
11	A
84	R/S
23	LBL
11	A
71	x
06	6
81	÷
33 03	STO 3
22	GTO
01	1
23	LBL
12	B
84	R/S
23	LBL
12	B
71	x
04	4
81	÷
33 03	STO 3
23	LBL
01	1
44	CLX
41	↑
84	R/S
23	LBL
13	C
61	+
84	R/S
23	LBL
14	D
34 03	RCL 3

CODE	KEYS
71	x
33	STO
61	+
02	2
84	R/S
23	LBL
15	E
34 02	RCL 2
84	R/S
02	2
07	7
81	÷
84	R/S
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

CODE	KEYS
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP
35 01	g NOP

R_1	R_4	R_7
R_2 Σ Vol.	R_5	R_8
R_3 Grid Area	R_6	R_9