TI Programmable 58/59

Surveying

Using the power of your *Solid State Software*™ module

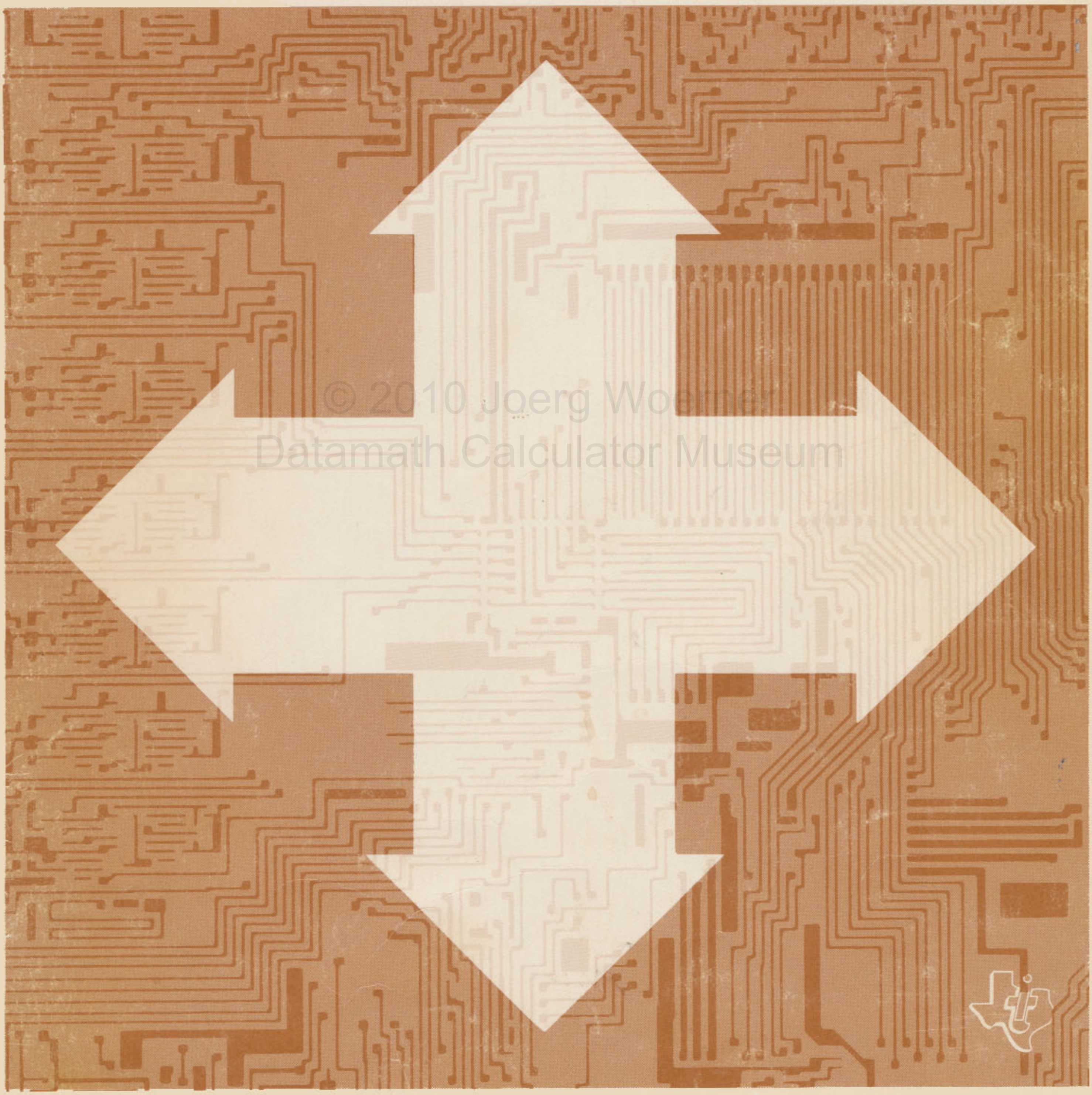

TABLE OF CONTENTS

INTRODUCTION

The Surveying Module places a library of surveying programs at your fingertips. Within seconds, you can install this *Solid State Software** module which tailors your calculator to solve problems related specifically to this professional field. Your self-contained *Solid State Software* library module provides easy-to-use calculating power both in the field and in the office.

USING THIS MANUAL

Following this brief introduction, you will find the description, principal equations, user instructions, and example problems for each of the 25 programs in the Surveying Library. Each program is easily identified by the "SY" number in the upper corner of the page. This number corresponds with the call number you use to tell the calculator which program in the *Solid State Software* module you wish to use.

The primary reference point in this manual for each program is the User Instructions. These user instructions are also available for you in the handy pocket guide furnished with the library. The program description and sample problems should be used when you first run a program, to help you understand its full capabilities and limitations. Nonmagnetic label cards to identify the user-defined keys are also included in the library. Carefully remove the cards from the sheet and insert them in the card carrying case for convenient storage. Note that a special holder has been built into the case for storage of the library module.

When using the *Solid State Software* programs as subroutines to your own programs, you will also want to check Register Contents for the program and check Program Reference Data provided in Appendix A.

USING THE OPTIONAL PRINTER

If you have the optional PC-100A printer*, a printed record of entries and results is automatic. The User Instructions and example problems are marked to show exactly which values are printed in addition to being displayed.

Use the Calculator Mounting procedure in the PC-100A Owner's Manual to mount your calculator on the PC-100A. The switch called out in step 2 should be to "OTHER" for your calculator. Always turn the calculator and printer off before mounting or unmounting the calculator.

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*Note: The TI Programmable 58 and TI Programmable 59 will not operate on the PC-100 print cradle.

INTRODUCTION

TIPS FOR RUNNING PROGRAMS

Before you begin using the *Solid State Software* programs on your own, here are a few things to keep clearly in mind until you become familiar with your calculator.

1. Press [CLR] before running a program if you are not sure of the status of the calculator. (To be completely sure of calculator status, turn it off and on again — but remember that this will clear the program memory.)

2. Some programs will leave the calculator in fix-decimal format (See Appendix A). In that event, you should press [INV] [2nd] [fix] before running another program if this format is not desired.

3. There is no visual indication of which *Solid State Software* program has been called. If you have any doubts, the safest method is to call the desired program with [2nd] [Pgm] mm, where mm is the two-digit program number. The calculator will remain at this program number until another program is called, [RST] is pressed or the calculator is turned off.

4. A flashing display normally indicates an improper key sequence or that a numerical limit has been exceeded. When this occurs, always repeat the program sequence and check that each step is performed as directed by the User Instructions. Any unusual limits of a program are given in the User Instructions or related notes. The In Case of Difficulty portion of Appendix A in the Owner's Manual may be helpful in isolating a problem.

5. Some of the *Solid State Software* programs may run for several minutes depending on input data. If you desire to halt a running program, press the [RST] key. This is considered as an emergency halt operation which returns control to the main memory. A program must be recalled to be run again.

USING SOLID STATE SOFTWARE PROGRAMS AS SUBROUTINES

Any of the *Solid State Software* programs may be called as a subroutine to your own program in the main memory. Either of two program sequences may be used: 1) [2nd] [Pgm] mm (User Defined Key) or 2) [2nd] [Pgm] mm [SBR] (Common Label). Both will send the program control to program mm, run the subroutine sequence, and then automatically return to the main program without interruption. Following [2nd] [Pgm] mm with anything other than [SBR] or a user-defined key is not a valid key sequence and can cause unwanted results.

It is very important to consider the Program Reference Data in Appendix A for any program called as a subroutine. You must plan and write your own program such that the data registers, flags, subroutine levels, parentheses levels, T-register, angular mode, etc., used by the called subroutine are allowed for in your program. In addition, a Register Contents section of each program description provides a guide to determine where data is or must be located to run the program. A sample program that calls a *Solid State Software* program as a subroutine is provided in the PROGRAMMING CONSIDERATIONS section of the Owner's Manual.

If you need to examine and study the content of a *Solid State Software* program, you can download as described in the following paragraphs.

DOWNLOADING *SOLID STATE SOFTWARE* PROGRAMS

If you need to examine a *Solid State Software* program, it can be downloaded into the main program memory.* This will allow you to single step through a program in or out of the learn mode. It also allows using the program list or trace features of the optional printer. The only requirement for downloading a *Solid State Software* program is that the memory partition be set so there is sufficient space in the main program memory to receive the downloaded program. The key sequence to download a program is [2nd] [Pgm] mm [2nd] [Op] 09, where mm is the program number to be downloaded. This procedure places the requested program into program memory beginning at program location 000. The downloaded program writes over any instructions previously stored in that part of program memory. Remember to press [RST] before running or tracing the downloaded program.

Please note that SY-20 cannot be downloaded in the TI Programmable 58 due to the length of this program. Also, the partition must be reset from the power-up condition in the TI Programmable 58 for program SY-25. The key sequence to repartition the main memory for this program is 2 [2nd] [Op] 17 which must be performed before the downloading sequence.

The partition must be changed from the power-up condition in the TI Programmable 59 for the SY-20 program. The key sequence to repartition the main memory for this program is 5 [2nd] [Op] 17.

REMOVING AND INSTALLING MODULES

The Surveying Module can easily be installed in the calculator or replaced with another. It is a good idea to leave the module in place in the calculator except when replacing it with another module. Be sure to follow these instructions when you need to remove or replace a module.

CAUTION

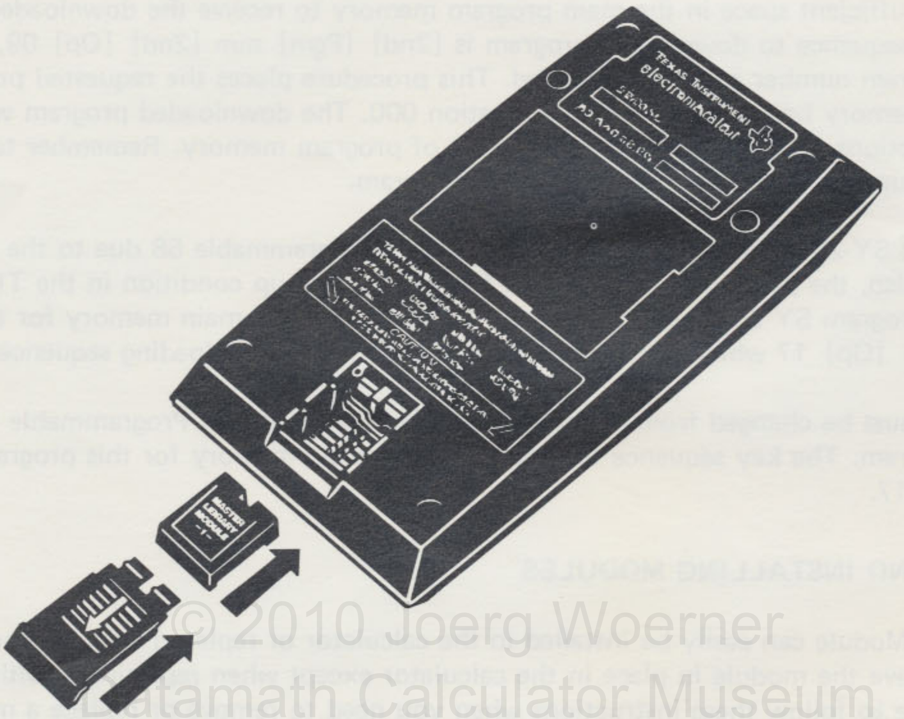
Be sure to touch some metal object before handling a module to prevent possible damage by static electricity.

1. **Turn the calculator OFF.** Loading or unloading the module with the calculator ON may cause the keyboard or display to lock out. Also, shorting the contacts can damage the module or calculator.
2. Slide out the small panel covering the module compartment at the bottom of the back of the calculator. (See Diagram on following page.)
3. Remove the module. You may turn the calculator over and let the module fall out into your hand.

*Unless the library is a protected special-purpose library.

4. Insert the module, notched end first with the labeled side up into the compartment. The module should slip into place effortlessly.

5. Replace the cover panel, securing the module against the contacts.



Don't touch the contacts inside the module compartment as damage can result.

CONVENTIONS USED IN THIS MANUAL

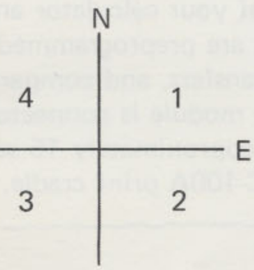
Some confusion might exist as to the term "station" as used in this manual. A station designated as 25 + 14 *must* be entered as 2514. The key sequence 25 [+] 14 *does not work.* It causes 14 to be entered with the operation pending, and incorrect values will result.

The term "station" or "Sta" throughout denotes the point defined by the station value, or the decimal value (usually in feet) of that station. The term "station number" or "Sta #" denotes the integer designation of the station by the calculator in the order of calculation. For instance, the first station in a series of calculations is "station number 1", regardless of the actual value in stations. A "station number" is never entered, but is displayed to help keep track of one's position in the series.

Angles are generally entered and displayed in the DDD.MMSSss format. To the left of the decimal, DDD denotes whole degrees. To the right, MM denotes minutes, SS seconds, and ss decimal parts of seconds. For instance, 118°27'38.93" is entered and displayed as 118.273893. See the User Instructions for each program to determine the format used in that program.

Each example is assumed to start just after the calculator has been turned on. Where, for instance, an initialize command is listed as returning 0. in the display, and a fix 3 display format still exists due to a program previously run (if the calculator has not been turned off), the display will show 0.000. In this case, press [INV] [2nd] [fix] or [2nd] [fix] [9] and continue.

In the case of conversion from bearing/quadrant to azimuth or vice versa, a 0° or 90° bearing is ambiguous as to quadrant. In these cases, either of the two adjoining quadrants may be entered or displayed. The quadrant designation is:



SURVEYING LIBRARY DIAGNOSTIC

This program performs the following functions separately.

1. Diagnostic/Library Module Check
2. Linear Regression Initialization

Diagnostic/Library Module Check

This routine checks the operation of your calculator and most of its functions, including conversion and statistics functions that are preprogrammed in the calculator, trigonometric functions, data register operations, program transfers, and comparisons. It also uses other Surveying Library programs to verify that the module is connected and operating correctly. If this diagnostic routine runs successfully, in approximately 15 seconds the numeral 4. will be displayed. If the calculator is attached to a PC-100A print cradle, the following will be printed:

```
SURVEYING
       4.
```


If there is a malfunction in the calculator or the *Solid State Software* module, a flashing number will be displayed. Refer to Appendix A of the Owner's Manual for an explanation of the various procedures to be followed when you have difficulties.

When you simply want to know which of your *Solid State Software* modules is in the calculator without physically looking at it, you can call the Library Module check portion of the routine directly. If the Surveying Library Module is in the calculator, the number 4. will be displayed. This number is unique to the Surveying Library (other optional libraries use other identifying digits).

Linear Regression Initialization

This routine initializes the calculator for linear regression by clearing data registers R_{01} through R_{06} and the T-register. It should be used whenever linear regression or other built-in statistics functions are to be started. You can also use the routine at any time to clear these registers selectively without disturbing any other registers.

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SURVEYING LIBRARY DIAGNOSTIC SY-01

DIAGNOSTIC: SBR =

LINEAR REGRESSION INITIALIZATION: SBR CLR

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	Diagnostic/Module Check			
A1	Select Program		[2nd] [Pgm] 01	
A2	Run Diagnostic		[SBR] [=]	4.[1, 2]
	or			
A3	Library Module Check		[SBR] [2nd] [R/S]	4.[2]
	Initialize Linear Regression			
B1	Select Program		[2nd] [Pgm] 01	
B2	Initialize Linear Regression		[SBR] [CLR]	0.

NOTES: 1. This output is obtained if the calculator is operating properly.
2. The number 4 indicates the Surveying Library.

Example 1: Diagnostic

PRESS	DISPLAY	OPTIONAL PRINTOUT
[2nd] [Pgm] 01		
[SBR] [=]	1.	SURVEYING 4.

Example 2: Library Module Check

PRESS	DISPLAY	OPTIONAL PRINTOUT
[2nd] [Pgm] 01		
[SBR] [2nd] [R/S]	1.	SURVEYING 4.

Example 3: Initialize Linear Regression

PRESS	DISPLAY
[2nd] [Pgm] 01	
[SBR] [CLR]	0.

TRAVERSE PROGRAMS

These four programs calculate the unknown elements of a traverse leg, as well as total horizontal distance for use in closure determination, and intermediate calculations for an overall closed-traverse area. Each program deals with a certain type of traverse, but the programs may be used interdependently as demonstrated in the Example, as well as in conjunction with the Closure and Balance programs. Each program is discussed separately.

Remarks: The key to interdependent use of these programs is the [E] keystroke. Basically, this arranges the data present in the storage registers for use in calculating the next leg of a traverse. While only the total horizontal distance is displayed following [E], several other things also happen that are quite difficult to correct once completed. Therefore, be certain that all data for that leg is correct before pressing [E].

For the first leg, select the proper program (usually Azimuth/Bearing or Field Angle), initialize, and enter the reference data. This should be the *only* time you need to enter this data. The [E] command will do it otherwise. Once the (closed) traverse is complete, it is best to go to the Closure program, although Inverse Traverse will also work for closure. Then the Balance programs will distribute closure error in proportion to leg length.

In the first three programs, if an error occurs before [E], it may be corrected by doing that leg again; but the Circle Arc program is somewhat different. See the User Instructions, Note 4.

Register Contents (SY-02 through SY-05)

R_{00} Used	R_{05} C∠	R_{10} A_{part}	R_{15} $\Sigma\|Dp\|$
R_{01} N	R_{06}	R_{11} Ref Az	R_{16} Brg ***
R_{02} E	R_{07} Dist	R_{12} next Az	R_{17} Σ A_{sect} *
R_{03} next N	R_{08} Arc Dist *	R_{13} Ω **	R_{18} Lt
R_{04} next E	R_{09} Σ Hz Dist	R_{14} $\Sigma\|Lt\|$	R_{19} Dp
			R_{20} Used

*Circle Arc only.
**Except Circle Arc.
***Azimuth/Bearing and Inverse only.

AZIMUTH/BEARING TRAVERSE

Given the starting coordinates, the azimuth or bearing and quadrant, and the distance to the next station, this program calculates the end coordinates, latitude, and departure. The distance input may be horizontal distance, or, if this is not known, slope distance and zenith or vertical angle (from which the horizontal distance is calculated).

If the leg calculated is not a sideshot, then a single keystroke ([E]) transfers the calculated coordinates to the proper registers for use as the next starting coordinates, and sums the horizontal distance, latitude, and departure with all previous distance, latitudes, and departures for later use. It also causes an intermediate calculation for the area of a closed traverse. See Closure (SY-06) for an explanation of this feature.

The following formulas are used:

$$\text{Hz Dist} = \text{SDist} \cos V\angle = \text{SDist} \cos (90 - Z\angle)$$

$$\text{Lt} = \text{HzDist} \cos \text{Az} \qquad N = \text{Ref } N + \text{Lt}$$

$$\text{Dp} = \text{HzDist} \sin \text{Az} \qquad E = \text{Ref } E + \text{Dp}$$

where

HzDist = horizontal distance of leg
SDist = slope distance
$V\angle$ = vertical angle
$Z\angle$ = zenith angle
Az = azimuth
Lt = latitude
Dp = departure

Ref N = starting North
Ref E = starting East
N = next North
E = next East

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TRAVERSE (AZ/BRG)				SY-02
Ref N;E	Q;→Az	Z∠→HzD		[Init]→
Az;→Brg; Q	Brg	D; V∠→HzD	→Dp;Lt;N;E	Occupy→ΣD

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 02	
	Select degree mode		[2nd] [Deg]	
2[1]	Initialize		[2nd] [E′]	0.000000
3[1]	Enter Reference North	Ref N	[2nd] [A′]	Ref N†
4[1]	Enter Reference East	Ref E	[R/S]	Ref E†
	Do Step 5 OR Step 6			
5a	Enter Azimuth (DDD.MMSS)[2]	Az	[A]	Az†
5b	Compute Bearing (DD.MMSS)		[R/S]	Brg†
5c	Compute Quadrant		[R/S]	Q†
6a	Enter Bearing (DD.MMSS)	Brg	[B]	Brg†
6b	Enter Quadrant	Q	[2nd] [B′]	Q†
6c	Compute Azimuth (DDD.MMSS)		[R/S]	Az†
7	Enter distance[3]	Dist	[C]	Dist†
	Do Step 8a, OR 8b, OR 8c			
8a	If Dist in 7 is horizontal	0†	[R/S]	Hz Dist†
8b	If slope Dist and vertical angle known, enter vertical angle (DD.MMSS)[4]	V∠†	[R/S]	Hz Dist†
8c	If slope Dist and zenith angle known, enter zenith angle (DD.MMSS)	Z∠†	[2nd] [C′]	Hz Dist†
9	Compute Departure		[D]	Dp†
10	Compute Latitude		[R/S]	Lt†
11	Compute next North		[R/S]	N†
12	Compute next East		[R/S]	E†
13[5]	Occupy next station and compute total distance		[E]	ΣHz Dist†

NOTES:

1. Do Steps 2, 3, and 4 *only if* this is the first leg of a traverse.
2. All angles are entered and displayed in DDD.MMSS format.
3. Distance may be entered in any unit, as long as this is consistent throughout the traverse. Note that this must be the same unit as that used in the reference coordinate expression.
4. Vertical angle is positive above the horizon, negative below.
5. Step 13 is omitted if the leg was a sideshot. Pressing [E] sums latitude, departure, and horizontal distance into the accumulating registers, and occupies the next station by storing the calculated N and E coordinates in registers designated for starting coordinates. Therefore, be certain that all previous calculations are correct before performing this step.
6. Program leaves calculator in fix 6 display format.
7. Steps 8a and 8b print an intermediate step, zenith angle.
8. Does not run in ENG.

† These values are automatically printed if the PC-100A is connected.

INVERSE TRAVERSE

Given the start and end coordinates of a traverse leg, this program calculates the latitude, departure, azimuth, bearing and quadrant, and horizontal distance of the leg. This has several uses: 1) calculating closure bearing and distance, 2) calculating corrected results from the adjusted coordinates output by the Balance programs, and 3) finding omitted measurements, etc. . . .

Like the other traverse programs, the keystroke [E] instructs the calculator to occupy the next station, preserving continuity through the traverse. Note that Step 12 is unique in this program set. If this program is used for closure, then the total area bounded by the traverse is calculated.

The following formulas are used:

$$Lt = N - Ref\ N \qquad Dp = E - Ref\ E$$

$$Hz\ Dist = \sqrt{Lt^2 + Dp^2}$$

$$Brg = \arctan \left| \frac{Dp}{Lt} \right|$$

where

Ref N = starting North
Ref E = starting East
Lt = latitude
Dp = departure
Hz Dist = horizontal distance
N = next North
E = next East
Brg = bearing

Solid State Software			TI ©1977	
TRAVERSE (INVERSE)				SY-03
Ref N; E				[Init]→
N	E	→HzD	→Brg; Q; Az	Occupy→ΣD

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program Select degree mode		[2nd] [Pgm] 03 [2nd] [Deg]	
2[1]	Initialize		[2nd] [E']	0.000000
3[1]	Enter Reference North	Ref N	[2nd] [A']	Ref N†
4[1]	Enter Reference East	Ref E	[R/S]	Ref E†
5	Enter next North, compute Lt	N†	[A]	Lt†
6	Enter next East, compute Dp	E†	[B]	Dp†
7	Compute horizontal distance		[C]	Hz Dist†
8[2]	Compute bearing		[D]	Brg†
9	Compute quadrant		[R/S]	Q†
10	Compute azimuth		[R/S]	Az†
11[3]	Occupy next station and compute total Hz Dist thus far		[E]	ΣHz Dist†
	For another leg, go to Step 5.			
12	Compute traverse area (only if program used for closure)		[RCL] [1] [7] [+] [( ] [RCL] [1] [0] [÷] [2] [=]	Area

NOTES:

1. Do Steps 2, 3, and 4 *only if* this is starting leg of a traverse.
2. All angles must be entered, and are displayed, in DDD.MMSS format. Distances are displayed in the same units as the coordinates used.
3. Do this step *only if* the traverse leg just calculated is not a sideshot. (See Note 5 under the Azimuth/Bearing Traverse User Instructions.) Be certain that all other calculations are correct before pressing [E].
4. Program leaves calculator in fix 6 display format.
5. Does not run in ENG.

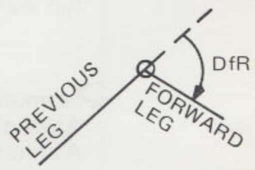
† These values are automatically printed if the PC-100A is connected.

FIELD ANGLE TRAVERSE

Given the starting coordinates, field angle (see below), and distance, this program calculates the azimuth, bearing and quadrant, departure, latitude, and end coordinates of a traverse leg.

The keystroke [E] acts just as it does in the preceding programs. See Azimuth/Bearing Traverse (SY-02) for formulas used.

Field Angle Conventions – The field angle is an angle measured between one leg of a traverse and the suceeding leg. It is always referenced to an azimuth of the previous leg (or a reference azimuth for the first point) *into* the occupied point. Field angles are categorized as shown in the following illustrations.

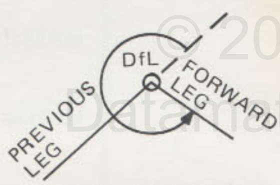


DEFLECTION RIGHT

MEASURED CLOCKWISE FROM PROJECTION OF AZIMUTH OF PREVIOUS LEG THROUGH OCCUPIED POINT ⊙ TO FORWARD LEG

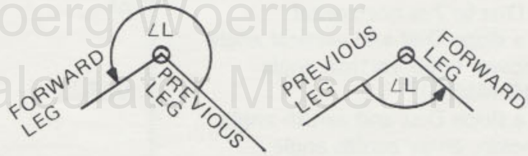
ANGLE RIGHT

MEASURED CLOCKWISE FROM BACK AZIMUTH OF PREVIOUS LEG TO FORWARD LEG



DEFLECTION LEFT

SAME AS DEFLECTION RIGHT, EXCEPT MEASURED IN A COUNTERCLOCKWISE DIRECTION



ANGLE LEFT

SAME AS ANGLE RIGHT, EXCEPT MEASURED IN A COUNTERCLOCKWISE DIRECTION

Solid State Software				TI ©1977
TRAVERSE (FIELD ANGLE)				SY-04
Ref N; E; Az		Z∠→HzD		
∠R+:∠L−	DfR+: DfL−	D; V∠→HzD	→Dp; Lt; N; E	Occupy→ΣD

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 04	
	Select degree mode		[2nd] [Deg]	
2[1]	Enter Reference North	Ref N	[2nd] [A′]	Ref N†
3[1]	Enter Reference East	Ref E	[R/S]	Ref E†
4[1]	Enter Reference azimuth	Ref Az	[R/S]	Ref Az†
	Do Step 5a OR 5b OR 5c OR 5d			
5a[2]	Enter angle right (DD.MMSS)	∠R†	[A]	Azimuth†
5b	Enter angle left	∠L†	[+/−] [A]	Azimuth†
5c	Enter deflection right	DfR†	[B]	Azimuth†
5d	Enter deflection left	DfL†	[+/−] [B]	Azimuth†
6	Compute bearing		[R/S]	Brg†
7	Compute quadrant		[R/S]	Q†
8	Enter distance	Dist	[C]	Dist†
	Do Step 9a OR 9b OR 9c			
9a	If Dist in 7 is horizontal	0†	[R/S]	Hz Dist†
9b	If a slope Dist and vertical angle known, enter vertical angle (DD.MMSS)[3]	V∠†	[R/S]	Hz Dist†
9c	If a slope Dist and zenith angle known, enter zenith angle (DD.MMSS)	Z∠†	[2nd] [C′]	Hz Dist†
10	Compute departure		[D]	Dp†
11	Compute latitude		[R/S]	Lt†
12	Compute next North		[R/S]	N†
13	Compute next East		[R/S]	E†
14[4]	Occupy next station and compute total distance thus far		[E]	Σ Hz Dist†

NOTES:

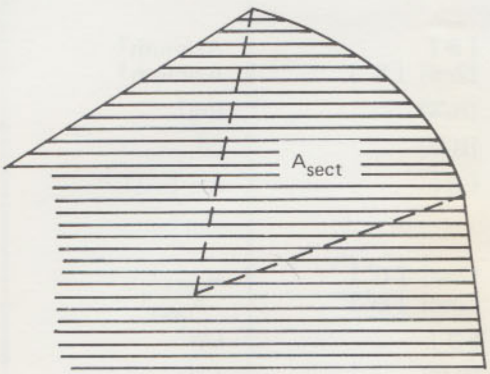
1. Do Steps 2, 3, and 4 *only if* this is the first leg. The Reference Azimuth is that azimuth from which the field angle is measured (usually the azimuth of the previous leg).
2. All angles are entered and displayed in DDD. MMSS format. All distance units must be identical with those used for reference coordinates.
3. Vertical angle is positive above horizon, negative below.
4. Do this step only if the leg just computed is not a sideshot. (See Note 5 under the Azimuth/Bearing Traverse User Instructions.) Be certain that results are correct before doing this step.
5. Program leaves calculator in fix 6 display format.
6. Steps 5a and 5b print intermediate steps DfR and DfL, respectively.
7. Steps 9a and 9b print intermediate step, zenith angle.
8. Does not run in ENG.

† These values are automatically printed if the PC-100A is connected.

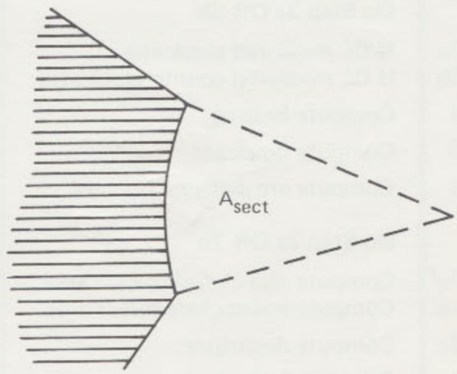
CIRCLE ARC TRAVERSE

This program must be preceded by either the Azimuth/Bearing, Inverse, or Field Angle Traverse program to establish the center coordinates, radius, and reference azimuth (of the known radial) of the arc. Then, given the central angle, this program calculates the azimuth, bearing and quadrant, latitude, departure, and end coordinates of the unknown radial. In addition, the arc distance is calculated and summed into the total distance register, while the previously calculated and summed leg distance is subtracted from that register, thus bounding the traverse by the arc rather than its radials.

Note that the program assumes that the *closed traverse is bounded by the arc.* Two cases become apparent here:



Case 1



Case 2

In **Case 1**, the sector area must be included in the traverse, since the program otherwise calculates only the area inside the irregular polygon (bounded by the radials). Do Step 7a (press [2nd] [C']. In **Case 2**, the sector area will already be included, so the program must be instructed to subtract (exclude) A_{sect}. Do Step 7b (press [2nd] [D']). See Example for further illustration.

The following formulas are used:

$$\text{Arc Dist} = \frac{\pi R C\angle}{180} \qquad A_{sect} = \frac{R \text{ Arc Dist}}{2}$$

where

Arc Dist = arc distance
R = radius (found by traverse to center and saved from previous program)
$C\angle$ = central angle
A_{sect} = sector area

Solid State Software			TI ©1977	
TRAVERSE (CIRCLE ARC)				SY-05
°	CCW→Az	Inc Asect	Exc Asect	
C∠	CW→Az	→Arc D	→Dp; Lt; N; E	Occupy→ΣD

USER INSTRUCTIONS

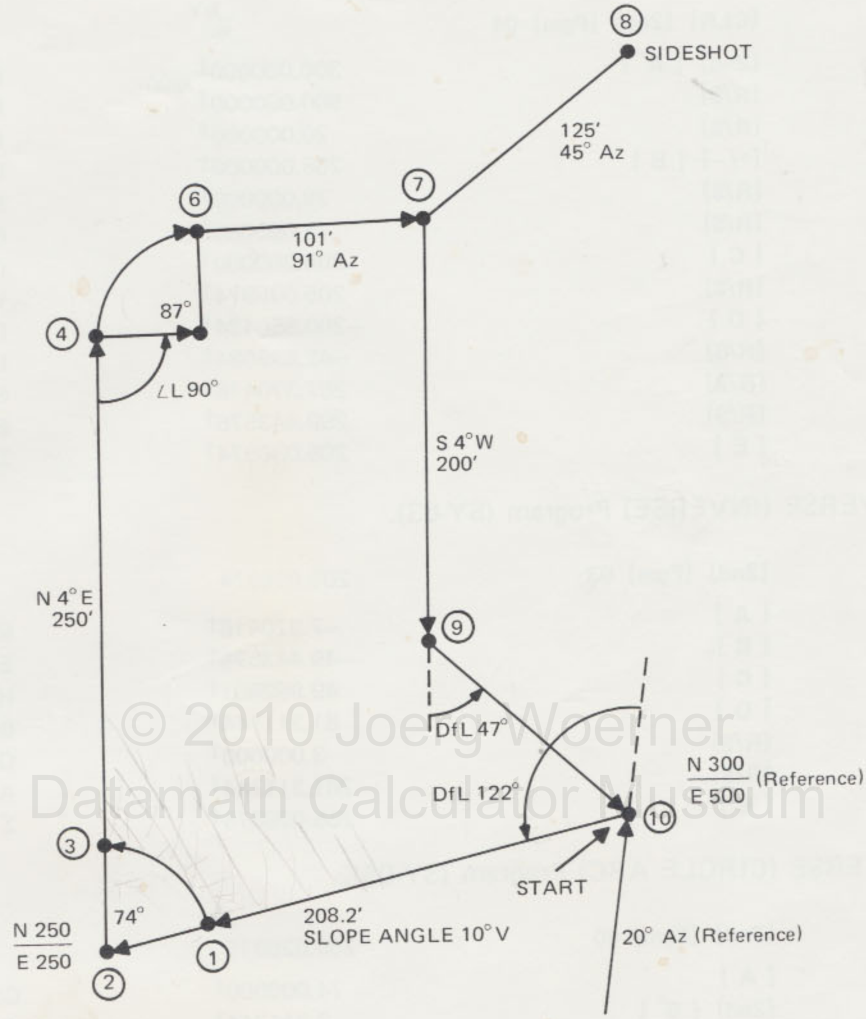
STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1[1]	Select Program Select degree mode		[2nd] [Pgm] 05 [2nd] [Deg]	
2[2]	Enter central angle (DDD.MMSS)	C∠	[A]	C∠†
	Do Step 3a OR 3b			
3a	If C∠ measured clockwise		[B]	Azimuth†
3b	If C∠ measured counterclockwise		[2nd] [B′]	Azimuth†
4	Compute bearing		[R/S]	Brg†
5	Compute quadrant		[R/S]	Q†
6	Compute arc distance		[C]	Arc Dist†
	Do Step 7a OR 7b			
7a[3]	Compute and *include* sector area		[2nd] [C′]	A_{sect}†
7b	Compute and *exclude* sector area		[2nd] [D′]	$-A_{sect}$†
8	Compute departure		[D]	Dp†
9	Compute latitude		[R/S]	Lt†
10	Compute next North		[R/S]	N†
11	Compute next East		[R/S]	E†
12[4]	Occupy next station and compute total distance thus far		[E]	Σ Hz Dist†

NOTES:

1. Either the Azimuth/Bearing, Inverse, or Field Angle Traverse programs *must* have been used immediately before running this program to establish the center coordinates, reference azimuth, and radius of the arc.
2. All angles are entered and displayed in DDD.MMSS format.
3. Step 7 includes or excludes the sector area from the total traverse area found in the Closure and Inverse Traverse programs. (see text)
4. See Note 5 under the Azimuth/Bearing Traverse User Instructions. Be certain that the results obtained through Step 11 are correct before pressing [E]. To recover from an error noticed after **Step 6,** press [RCL] [0] [8] [–] [RCL] [0] [7] [=] [INV] [SUM] [0] [9]. To recover after **Step 7a,** press the above plus [2nd] [D′]. To recover after **Step 7b,** do the above for Step 6 plus [2nd] [C′].
5. Program leaves calculator in fix 6 display format.
6. Does not run in ENG.

† These values are automatically printed if the PC-100A is connected.

Example: This is intended as a demonstration of the various programs available for traverse, including closure and balance.



Select TRAVERSE (FIELD ANGLE) Program (SY-04).

ENTER	PRESS	DISPLAY	COMMENT
	[CLR] [2nd] [Pgm] 04	0.	
300	[2nd] [A′]	300.000000†	Ref N
500	[R/S]	500.000000†	Ref E
20	[R/S]	20.000000†	Ref Az
122†	[+/–] [B]	258.000000†	DfL → Az
	[R/S]	78.000000†	Brg
	[R/S]	3.000000†	Q
208.2	[C]	208.200000†	Dist (slope)
10†	[R/S]	205.036974†	V∠ → Hz Dist
	[D]	–200.556424†	Dp
	[R/S]	–42.629584†	Lt
	[R/S]	257.370416†	N
	[R/S]	299.443576†	E
	[E]	205.036974†	Σ Hz Dist

Select TRAVERSE (INVERSE) Program (SY-03).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 03	205.036974	
250†	[A]	–7.370416†	N → Lt
250†	[B]	–49.443576†	E → Dp
	[C]	49.989901†	Hz Dist
	[D]	81.311744†	Brg
	[R/S]	3.000000†	Q
	[R/S]	261.311744†	Az
	[E]	255.026875†	Σ Hz Dist

Select TRAVERSE (CIRCLE ARC) Program (SY-05).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 05	255.026875	
74	[A]	74.000000†	C∠
	[2nd] [B′]	7.311744†	Az
	[R/S]	7.311744†	Brg
	[R/S]	1.000000†	Q
	[C]	64.564139†	Arc Dist
	[2nd] [D′]	–1613.777461†	Excluded Area
	[D]	6.543598†	Dp
	[R/S]	49.559777†	Lt
	[R/S]	299.559777†	N
	[R/S]	256.543598†	E
	[E]	269.601113†	Σ Hz Dist

† These values are printed if the PC-100A is connected.

Select TRAVERSE (AZ/BRG) Program (SY-02).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 02	269.601113	
4	[B]	4.000000†	Brg
1	[2nd] [B′]	1.000000†	Q
	[R/S]	4.000000†	Az
250	[C]	250.000000†	Dist
0†	[R/S]	250.000000†	Hz Dist
	[D]	17.439118†	Dp
	[R/S]	249.391013†	Lt
	[R/S]	548.950790†	N
	[R/S]	273.982716†	E
	[E]	519.601113†	Σ Hz Dist

Select TRAVERSE (FIELD ANGLE) Program (SY-04).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 04	519.601113	
90†	[+/−] [A]	94.000000†	∠L → Az
	[R/S]	86.000000†	Brg
	[R/S]	2.000000†	Q
50	[C]	50.000000†	Dist
0†	[R/S]	50.000000†	Hz Dist
	[D]	49.878203†	Dp
	[R/S]	−3.487824†	Lt
	[R/S]	545.462966†	N
	[R/S]	323.860919†	E
	[E]	569.601113†	Σ Hz Dist

Select TRAVERSE (CIRCLE ARC) Program (SY-05).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 05	569.601113	
87	[A]	87.000000†	C∠
	[B]	1.000000†	Az
	[R/S]	1.000000†	Brg
	[R/S]	1.000000†	Q
	[C]	75.921822†	Arc Dist
	[2nd] [C′]	1898.045562†	Included Area
	[D]	0.872620†	Dp
	[R/S]	49.992385†	Lt
	[R/S]	595.455351†	N
	[R/S]	324.733539†	E
	[E]	595.522936†	Σ Hz Dist

† These values are printed if the PC-100A is connected.

Select TRAVERSE (AZ/BRG) Program (SY-02).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 02	595.522936	
91	[A]	91.000000†	Az
	[R/S]	89.000000†	Brg
	[R/S]	2.000000†	Q
101	[C]	101.000000†	Dist
0†	[R/S]	101.000000†	Hz Dist
	[D]	100.984617†	Dp
	[R/S]	−1.762693†	Lt
	[R/S]	593.692658†	N
	[R/S]	425.718156†	E
	[E]	696.522936†	Σ Hz Dist
45	[A]	45.000000†	Az
	[R/S]	45.000000†	Brg
	[R/S]	1.000000†	Q
125	[C]	125.000000†	Dist
0†	[R/S]	125.000000†	Hz Dist
	[D]	88.388348†	Dp
	[R/S]	88.388348†	Lt
	[R/S]	682.081006†	N
	[R/S]	514.106504†	E
4	[B]	4.000000†	Brg
3	[2nd] [B′]	3.000000†	Q
	[R/S]	184.000000†	Az
200	[C]	200.000000†	Dist
0†	[R/S]	200.000000†	Hz Dist
	[D]	−13.951295†	Dp
	[R/S]	−199.512810†	Lt
	[R/S]	394.179848†	N
	[R/S]	411.766862†	E
	[E]	896.522936†	Σ Hz Dist

Select TRAVERSE (FIELD ANGLE) Program (SY-04).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 04	896.522936	
47†	[+/−] [B]	137.000000†	DfL → Az
	[R/S]	43.000000†	Brg
	[R/S]	2.000000†	Q
127	[C]	127.000000†	Dist
0†	[R/S]	127.000000†	Hz Dist
	[D]	86.613792†	Dp
	[R/S]	−92.881920†	Lt
	[R/S]	301.297928†	N
	[R/S]	498.380653†	E
	[E]	1023.522936†	Σ Hz Dist

† These values are printed if the PC-100A is connected.

Select CLOSURE Program (SY-06).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 06	1023.522936	
300	[B]	300.000000†	N_{corr}
500	[B]	500.000000†	E_{corr}
	[C]	2.075307†	C Dist
	[D]	51.171451†	Err Brg
	[E]	2.000000†	Q
	[2nd] [A′]	52594.84896†	Area
	[2nd] [B′]	0.002028†	Prec (ratio)

Select BALANCE (COMPASS RULE) Program (SY-07).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 07	0.002028	
300	[A]	300.000000†	N_s
500	[A]	500.000000†	E_s
257.370	[B]	257.370000†	N (unadj)
299.444	[B]	299.444000†	E (unadj)
	[C]	257.109993†	N_{adj}
	[D]	299.768395†	E_{adj}
	[E]	0.000000†	new points
250	[B]	250.000000†	N
250	[B]	250.000000†	E
	[C]	249.676601†	N_{adj}
	[D]	250.403486†	E_{adj}
	[E]	0.000000†	new points
299.560	[B]	299.560000†	N
256.544	[B]	256.544000†	E
	[C]	299.173208†	N_{adj}
	[D]	257.026577†	E_{adj}
	[E]	0.000000†	new points
⋮	⋮	⋮	⋮

Continue in like manner for all coordinates. See Summary for results.

Summary*

	LEG NO. 1	LEG NO. 2	LEG NO. 3	LEG NO. 4	LEG NO. 5	LEG NO. 6	LEG NO. 7	LEG NO. 8	LEG NO. 9	LEG NO. 10
Az	258	261.311744	7.311744	4	94	1	91	45	184	137
Brg	78	81.311744	7.311744	4	86	1	89	45	4	43
Q	3	3	1	1	2	1	2	1	3	2
Hz Dist	205.037	49.990	64.564	250.000	50.000	75.922	101.000	125.000	200.000	127.000
Lt	−42.630	−7.370	49.560	249.391	−3.488	49.992	−1.763	88.388	−199.513	−92.882
Dp	−200.556	−49.444	6.544	17.439	49.878	0.873	100.985	88.388	−13.951	86.614
N	257.370	250.000	299.560	548.951	545.463	595.455	593.693	682.081	394.180	301.298
E	299.444	250.000	256.544	273.983	323.861	324.734	425.718	514.107	411.767	498.381
N (adj)	257.110	249.677	299.173	548.247	544.696	594.624	592.734	–	392.968	299.925
E (adj)	299.768	250.403	257.027	274.861	324.818	325.770	426.914	–	413.280	500.094

*Values in table have been rounded off to 3 decimal places.
†These values are printed if the PC-100A is connected.

CLOSURE

The closure of a traverse is that line which will exactly close the traverse. Given the calculated and the correct endpoints, this program will compute the closure distance (horizontal), bearing (error bearing) and quadrant, latitude, departure, and precision ratio.

When used in conjunction with the traverse programs, a routine is included to complete calculation of the area of a closed traverse. The following formula is used:*

$$2A = N_1(E_2 - E_n) + N_2(E_3 - E_1) + \ldots + N_{n-1}(E_n - E_{n-2}) + N_n(E_1 - E_{n-1})$$

from which:

$$\text{Area} = \left|\tfrac{1}{2}(N_2 E_1 - N_1 E_2 + N_3 E_2 - N_2 E_3 + \ldots + N_n E_{n-1} - N_{n-1} E_n)\right|$$

Two things must be mentioned in connection with the area calculations. First, a part of the final equation (that is, $N_n E_{n-1} - N_{n-1} E_n$) is performed by each traverse program and summed into register 10. Then the Closure program calculates the part of the equation due to the closure leg, adds to R_{10}, divides by 2, adds the sector area preserved in R_{17}, and displays the area. Thus, to use the Closure program to calculate area, but not immediately following the Traverse programs, the contents of registers 10 and 17 *must* be saved after the last Traverse program is run, and restored for the Closure program. (see User Instructions)

Second, the calculated area is that area bounded by the irregular polygon with vertices at the *calculated* coordinates. If the area is desired for the *balanced* coordinates, find these using one of the Balance programs, and then use the Inverse Traverse program to calculate the bounded area.

The example problem for this program is included under the Traverse section.

*Reference: *Surveying,* Bouchard and Moffit, International Textbook Co., Scranton, Pa., 1965, p. 228.

Solid State Software			TI ©1977	
CLOSURE			SY-06	
→Area	→Prec	ΣDist	$Area_{part}$	
N_{calc}, E_{calc}	N_{corr}, E_{corr}	→C Dist	→Err Brg	→Q

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program Select degree mode		[2nd] [Pgm] 06 [2nd] [Deg]	
	If done immediately after a Traverse program, go to Step 7.[1]			
2	Enter total distance traversed	Σ Hz Dist	[2nd] [C′]	Σ Hz Dist†
3[2]	Enter partial area (from R_{10})	A_{part}	[2nd] [D′]	A_{part}†
4[2]	Enter sector area (from R_{17})	A_{sect}	[STO] [1] [7]	A_{sect}†
5	Enter calculated North	N_{calc}	[A]	N_{calc}†
6	Enter calculated East	E_{calc}	[A]	E_{calc}†
7	Enter correct North	N_{corr}	[B]	N_{corr}†
8	Enter correct East	E_{corr}	[B]	E_{corr}†
9	Compute closure distance		[C]	C Dist†
10	Compute error bearing (DD.MMSSss)		[D]	Err Brg†
11	Compute quadrant		[E]	Q†
12[2]	Compute Area		[2nd] [A′]	Area†
13[3]	Compute precision ratio		[2nd] [B′]	Prec†

NOTES:
1. Provided that memories are intact.
2. See text for explanation.
3. $\frac{\text{C Dist}}{\Sigma \text{ Hz Dist}}$
4. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} Lt_c	R_{10} Area	R_{15}
R_{01} N_{calc}	R_{06} Dp_c	R_{11}	R_{16} Err Brg
R_{02} E_{calc}	R_{07} C Dist	R_{12}	R_{17} ΣA_{sect}
R_{03} N_{corr}	R_{08}	R_{13} Q	R_{18} Lt_c
R_{04} E_{corr}	R_{09} Σ Hz Dist *	R_{14}	R_{19} Dp_c

*Excludes C Dist.

BALANCE

This is a two program set which provides a means of balancing a closed traverse by either compass or transit rule. They are designed for use either with Closure (SY-06) or alone.

Balance — Compass Rule (SY-07)

Given the total distance traversed, the end coordinates of the closure, and the end coordinates of a traverse leg, this program calculates the adjusted (balanced) coordinates. The compass rule, which assumes roughly equivalent precision in both angular and distance measurements, implies the following formulas:

$$N_{adj} = N + C_L \qquad C_L = Lt_c \left(\frac{\text{Hz Dist}}{\Sigma \text{ Hz Dist}}\right)$$

$$E_{adj} = E + C_D \qquad C_D = Dp_c \left(\frac{\text{Hz Dist}}{\Sigma \text{ Hz Dist}}\right)$$

where

- N, E = unadjusted coordinates
- N_{adj}, E_{adj} = adjusted coordinates
- C_L = correction to latitude
- C_D = correction to departure
- Lt_c = closure latitude
- Dp_c = closure departure
- Hz Dist = horizontal distance of unadjusted leg
- Σ Hz Dist = total horizontal distance traversed

The example problem for this program is included under the Traverse section.

Balance — Transit Rule (SY-08)

Given the sums of the latitudes and departures, regardless of sign, the end coordinates of the closure, and the end coordinates of a traverse leg, this program calculates the adjusted (balanced) coordinates. The transit rule, which assumes that angular precision is generally higher than distancing precision, implies the following formulas:

$$N_{adj} = N + C_L \qquad C_L = Lt_c \left(\frac{Lt}{\Sigma |Lt|}\right)$$

$$E_{adj} = E + C_D \qquad C_D = Dp_c \left(\frac{Dp}{\Sigma |Dp|}\right)$$

where

- Lt = latitude of traverse leg
- Dp = departure of traverse leg
- $\Sigma|Lt|$ = sum of the absolute values of all latitudes
- $\Sigma|Dp|$ = sum of the absolute values of all departures

all others as in "Compass Rule."

Solid State Software				TI ©1977
BALANCE (COMPASS RULE)				SY-07
Ncalc, Ecalc	Ncorr, Ecorr	ΣDist	[calc/store]→	[Init]→
Ns, Es	N,E (unadj)	→Nadj	→Eadj	[new pts]→

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 07	
	If done immediately after Closure, go to Step 9.			
2	Initialize		[2nd] [E′]	0.000000
3[1]	Enter last calculated North	N_{calc}	[2nd] [A′]	N_{calc} †
4	Enter last calculated East	E_{calc}	[2nd] [A′]	E_{calc} †
5	Enter correct North	N_{corr}	[2nd] [B′]	N_{corr} †
6	Enter correct East	E_{corr}	[2nd] [B′]	E_{corr} †
7[2]	Enter total distance traversed	Σ Hz Dist	[2nd] [C′]	Σ Hz Dist†
8	Compute and store closing latitude and departure		[2nd] [D′]	0.†
9[3]	Enter starting North	N_s	[A]	N_s †
10	Enter starting East	E_s	[A]	E_s †
11	Enter unadjusted North	N	[B]	N†
12	Enter unadjusted East	E	[B]	E†
13	Compute adjusted North	N_{adj}	[C]	N_{adj} †
14	Compute adjusted East	E_{adj}	[D]	E_{adj} †
15	If more points then go to Step 11.		[E]	0.†

NOTES:

1. Steps 3-6 enter the end coordinates of the closure.
2. Does not include the closure distance.
3. Enter coordinates in the same order as traversed.
4. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Register Contents (SY-07, SY-08)

R_{00}	R_{05} Lt_c	R_{10}	R_{15} Σ|Dp| **
R_{01} N	R_{06} Dp_c	R_{11} N_{adj}	R_{16}
R_{02} E	R_{07} Dist *	R_{12} E_{adj}	R_{17}
R_{03} next N	R_{08}	R_{13}	R_{18} Lt
R_{04} next E	R_{09} Σ Hz Dist*	R_{14} Σ|Lt|**	R_{19} Dp

*(unadjusted) Used by Compass Rule only.
**Transit Rule only.

Solid State Software				TI ©1977
BALANCE (TRANSIT RULE)				SY-08
N_s, E_s	N, E (next)	[calc Σ]→	[calc/store]→	[Init]→
N_s, E_s	N, E (unadj)	→N_{adj}	→E_{adj}	[new pts]→

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 08	
	If done immediately following Closure, go to Step 9.			
2	Initialize		[2nd] [E′]	0.000000
3	Enter starting North	N_s	[2nd] [A′]	N_s†
4	Enter starting East	E_s	[2nd] [A′]	E_s†
5[1]	Enter next North	N	[2nd] [B′]	N†
6	Enter next East	E	[2nd] [B′]	E†
7	Compute $\Sigma\|Lt\|$ and $\Sigma\|Dp\|$		[2nd] [C′]	0.†
	For next leg, go to Step 5[2].			
8	Compute closure latitude and departure		[2nd] [D′]	0.†
9	Enter starting North	N_s	[A]	N_s†
10	Enter starting East	E_s	[A]	E_s†
11[1]	Enter unadjusted North	N	[B]	N†
12	Enter unadjusted East	E	[B]	E†
13	Compute adjusted North		[C]	N_{adj}†
14	Compute adjusted East		[D]	E_{adj}†
15	If more points go to step 11[2].		[E]	0.†
16	Stop.			

NOTES:
1. Enter coordinates in the same order as they were traversed.
2. Do not do Steps 5-7 or 11-15 for the closure. If no more legs, go to Steps 8 and 16 respectively.
3. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

ADDENDUM

The following corrections should be made in the Surveying Library manual.

Page 26

The User Instructions for Program SY-08 should be changed as follows:

1) The display column for Steps 7, 8, and 15 should read 0.000000†.
2) Replace Step 8 with the following:

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
8	Compute closure latitude and departure	N_s	[2nd] [B′]	N_s
		E_s	[2nd] [B′]	E_s
			[2nd] [D′]	0.000000†

These changes should be made in the Quick Reference Guide.

VERTICAL CURVE DESIGN

This program computes the stationing and elevation of stations along a vertical curve, given the starting and ending grades, and the curve length (or the rate of change of grade (Δg) per station). Also computed are the rate of change of grade per station (or the curve length) and the stationing and elevation of the maximum or minimum elevation point. The following formulas are used:

$$r = \frac{g_2 - g_1}{L} \qquad y = \frac{r}{2} x^2 + g_1 x + \text{elevation of B.V.C.}$$

where

g_1 = starting grade, in percent

g_2 = ending grade, in percent

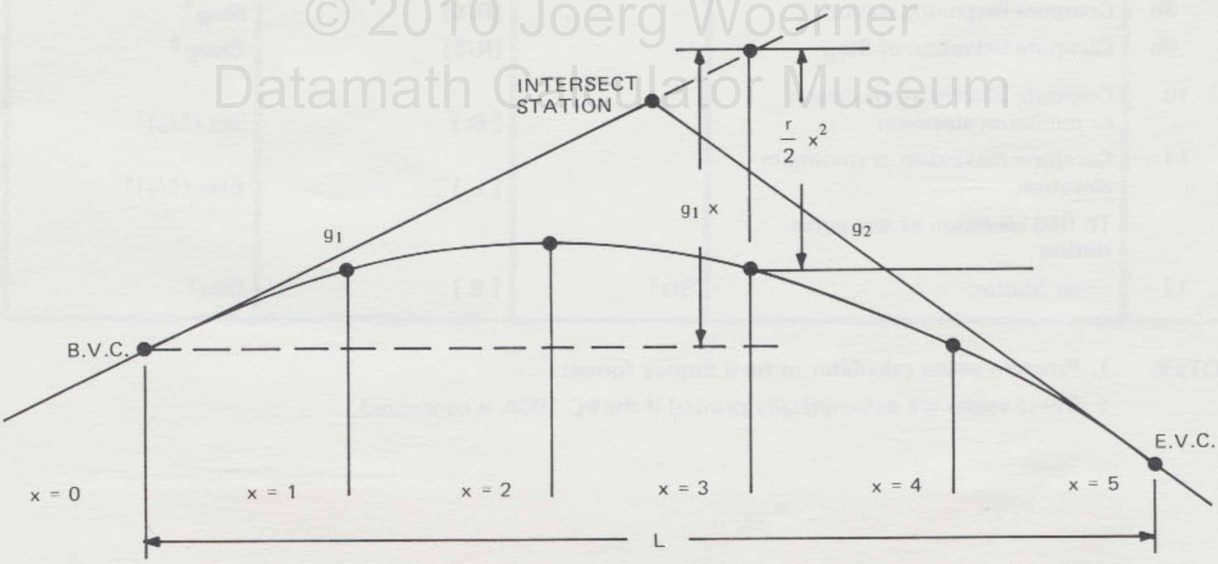
L = length of curve (horizontal distance)

y = elevation of a point on the curve

x = distance in stations from the B.V.C.

B.V.C. = beginning of the vertical curve

E.V.C. = end of the vertical curve



Reference: *Surveying (Fifth Edition),* H. Bouchard and F.H. Moffit, International Textbook Company, Scranton, PA., 1965.

Solid State Software		TI ©1977		
VERTICAL CURVE DESIGN				SY-09
	Δg→L	[Int→Beg]		[Init]→
g_1, g_2	L→Δg	[Beg→Int]	→Sta (↑/↓)	Sta→Elev

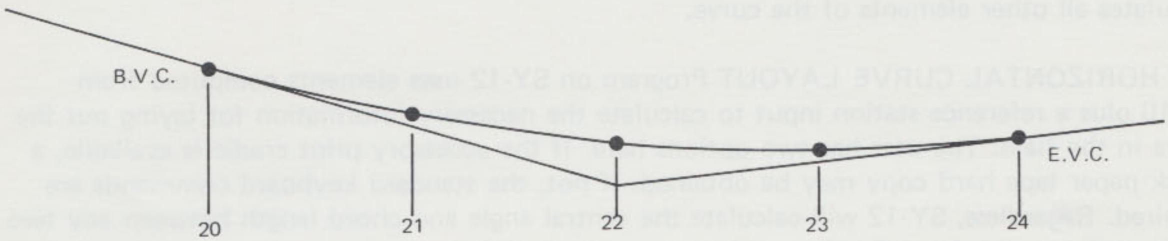
USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 09	
2	Initialize		[2nd] [E′]	0.000000
3a	Enter starting grade	g_1	[A]	g_1 †
3b	Enter ending grade	g_2	[A]	g_2 †
4a	Enter curve length	L†	[B]	Δg†
4b	or change of grade per station	Δg†	[2nd] [B′]	L†
	Do Steps 6–9a OR Steps 6–9b.			
6a	Enter Beginning station	Sta_B	[C]	Sta_B †
7a	Enter Elevation of Sta_B	$Elev_B$	[C]	$Elev_B$ †
8a	Compute Intersect station		[R/S]	Sta_I †
9a	Compute Elevation of Sta_I		[R/S]	$Elev_I$ †
	OR			
6b	Enter Intersect station	Sta_I	[2nd] [C′]	Sta_I †
7b	Enter Elevation of Sta_I	$Elev_I$	[2nd] [C′]	$Elev_I$ †
8b	Compute Beginning station		[R/S]	Sta_B †
9b	Compute Elevation of Sta_B		[R/S]	$Elev_B$ †
10	Compute Station at maximum or minimum elevation		[D]	Sta (↑/↓)†
11	Compute maximum or minimum elevation		[E]	Elev (↑/↓)†
	To find elevation of any curve station			
12	Enter Station	Sta†	[E]	Elev†

NOTES: 1. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example: Two grade lines intersect at station 22 where the elevation is 239.5 ft. The starting grade is –6 percent and the ending grade is 2 percent. The length of the curve is 400 ft. Compute the stations and elevations of the B.V.C. and E.V.C., and elevations of all full stations on the curve.



ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 09		
	[2nd] [E′]	0.000000	Initialize
6	[+/–] [A]	–6.000000†	g_1
2	[A]	2.000000†	g_2
400†	[B]	2.000000†	$L \rightarrow \Delta g$
2200	[2nd] [C′]	2200.000000†	Sta_I
239.5	[2nd] [C′]	239.500000†	$Elev_I$
	[R/S]	2000.000000†	Sta_B
	[R/S]	251.500000†	$Elev_B$
	[D]	2300.000000†	Sta (min)
	[E]	242.500000†	Elev (min)
2100†	[E]	246.500000†	Sta → Elev
2200†	[E]	243.500000†	Sta → Elev
2400†	[E]	243.500000†	Sta → Elev

† These values are printed if the PC-100A is connected.

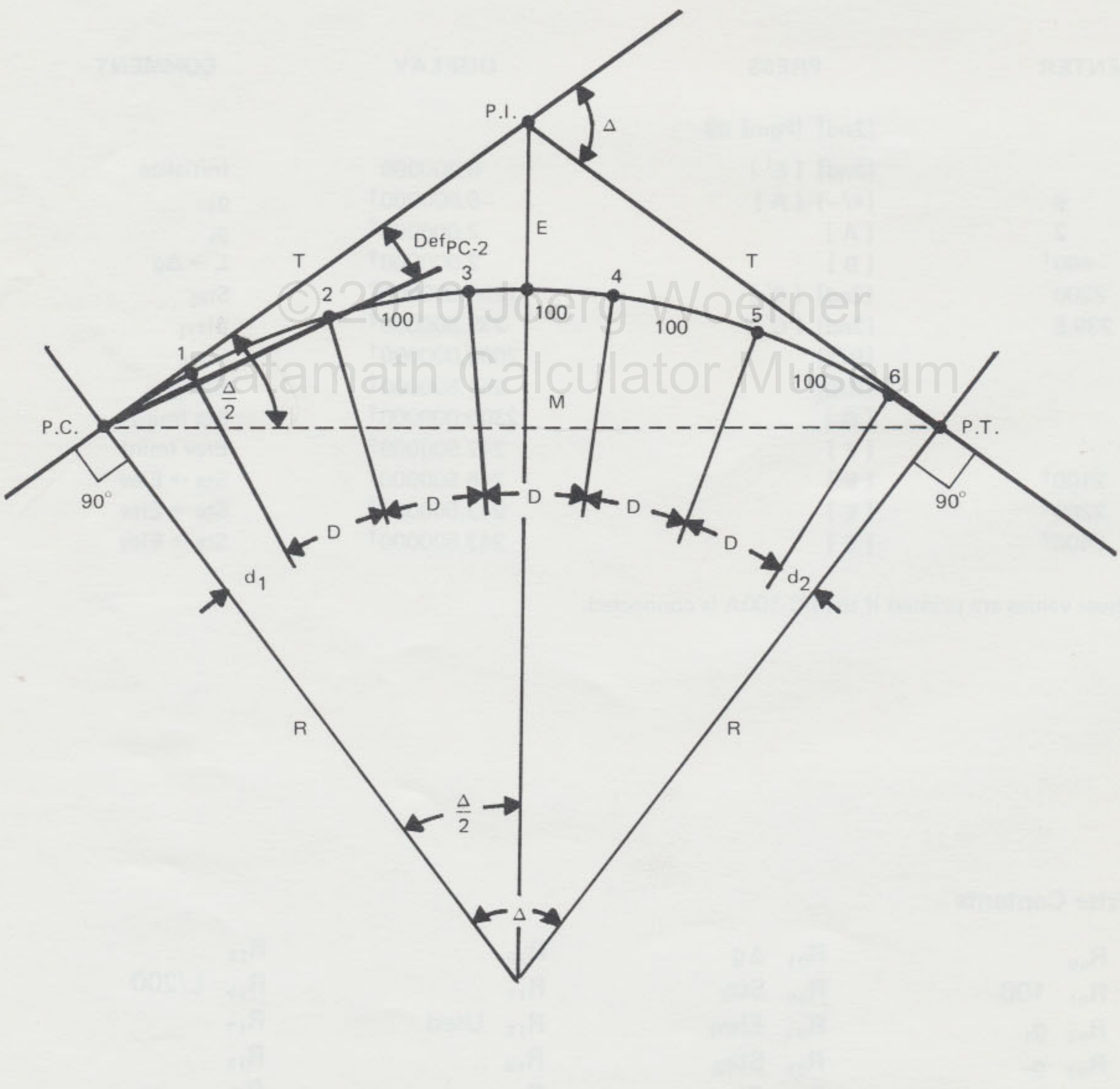
Register Contents

R_{00}	R_{05} Δg	R_{10}	R_{15}
R_{01} 100	R_{06} Sta_I	R_{11}	R_{16} L/200
R_{02} g_1	R_{07} $Elev_I$	R_{12} Used	R_{17}
R_{03} g_2	R_{08} Sta_B	R_{13}	R_{18}
R_{04} L	R_{09} $Elev_B$	R_{14}	R_{19}

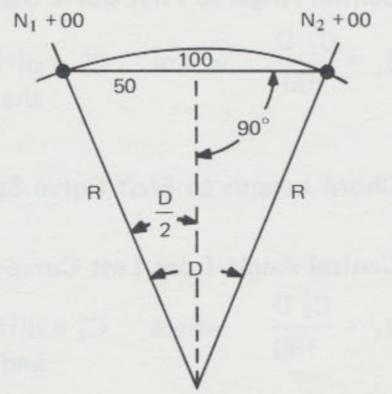
HORIZONTAL CURVE DESIGN

This three-program set implements the computations for designing and laying out a circular horizontal curve. Knowing the angle of intersection of two lines (central angle of curve), and one other key element, SY-10 calculates the remaining key elements, while SY-11 calculates all other elements of the curve.

The HORIZONTAL CURVE LAYOUT Program on SY-12 uses elements computed from SY-10 plus a reference station input to calculate the necessary information for laying out the curve in the field. The user has two options here. If the accessory print cradle is available, a quick paper tape hard copy may be obtained. If not, the standard keyboard commands are required. Regardless, SY-12 will calculate the central angle and chord length between any two curve stations, and the deflection angle to any curve station.



ELEMENTS OF A CIRCULAR CURVE



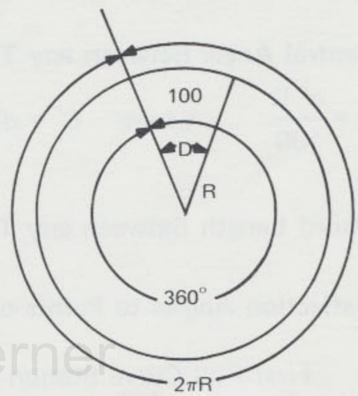
1) D (Degree of Curve)

a. By Chord Definition (station interval measured along chord)

$$D = 2 \arcsin \frac{50}{R} \quad \text{where } R = \text{radius}, \; D = \text{degrees}$$

b. By Arc Definition (station interval measured along arc)

$$\frac{100}{D} = \frac{2\pi R}{360} \quad \text{from which} \quad D = \frac{5729.58}{R}$$



2) R (Radius of Curve)

a. By Chord Definition $R = \dfrac{50}{\sin \dfrac{D}{2}}$

b. By Arc Definition $R = \dfrac{5729.58}{D}$

3) T (Tangent Distance) $T = R \tan \dfrac{\Delta}{2}$

4) E (External Distance) $E = R \left| \left(\sec \dfrac{\Delta}{2}\right) - 1 \right|$

5) L (Curve Length) $L = 100 \dfrac{\Delta}{D}$

6) M (Middle Ordinate) $M = R \left(1 - \cos \dfrac{\Delta}{2}\right)$

7) C (Chord from P.C. to P.T. $C = 2R \sin \dfrac{\Delta}{2}$

8) Point-of-Curvature (P.C.) Station P.C. = P.I. – T

9) Point-of-Tangency (P.T.) Station P.T. = P.C. + L

NOTE: These equations assume that the minimum curve radius is 50, and that the distance between adjacent full stations is 100.

10) Central Angle to First Curve Station (from P.C.)

$d_1 = \frac{C_1' D}{100}$ where C_1' = difference in stationing between P.C. and first station on the curve

11) Chord Length to First Curve Station (from P.C.) $C_1 = 2R \sin \frac{d_1}{2}$

12) Central Angle from Last Curve Station to P.T.

$d_2 = \frac{C_2' D}{100}$ where C_2' = difference in stationing between the last station on the curve and the P.T.

13) Chord Length from Last Curve Station to P.T. $C_2 = 2R \sin \frac{d_2}{2}$

14) Central Angle Between any Two Curve Points

$d = \frac{c' D}{100}$ where C' = difference in stationing between any two points on the curve.

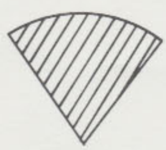
15) Chord Length Between any Two Curve Points $C_n = 2R \sin \frac{d}{2}$

16) Deflection Angles to Points on the Curve (from P.C.)

a. First Full Curve Station $\angle_{def} = \frac{d_1}{2}$

b. Second Full Curve Station $\angle_{def} = \frac{d_1 + D}{2}$

c. nth Full Curve Station $\angle_{def} = \frac{d_1}{2} + (n - 1)\frac{D}{2}$

17) a. Sector area  $A_{sect} = \frac{\Delta}{360} \pi R^2$

b. Segment area  $A_{seg} = A_{sect} - ½ RC \cos \frac{\Delta}{2}$

c. Fillet area  $A_{fil} = R^2 \tan \frac{\Delta}{2} - A_{sect}$

Reference: *Surveying (Fifth Edition)*, H. Bouchard and F.H. Moffitt, International Textbook Co., Scranton, Pa., 1965.

Solid State Software TI ©1977

HORIZ. CURVE DESIGN (1)				SY-10
Δ	[Arc def.]→			[Init]→
Radius	Tan Dist	Ext Dist	⌒Degree	⌒Length

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 10	
2	Initialize		[2nd] [E']	0.000000
3	Enter Central Angle (DDD.MMSSss)	Δ	[2nd] [A']	Δ† (DDD.MMSSss)
4a	If by Chord Definition, go to Step 5			
4b	If by Arc Definition		[2nd] [B']	Δ†
5a	Enter Radius	R	[A]	R†
5b	or Tangent Distance	T†	[B]	R†
5c	or External Distance	E†	[C]	R†
5d	or Degree of Curve	D†	[D]	R†
5e	or Curve Length	L†	[E]	R†
6	Compute Tangent Distance		[R/S]	T†
7	Compute External Distance		[R/S]	E†
8	Compute Degree of Curve		[R/S]	D† (DDD.MMSSss)
9	Compute Curve Length		[R/S]	L†

NOTES: 1. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Solid State Software				TI ©1977
HORIZ. CURVE DESIGN (2)				SY-11
Δ	[Arc def.]→			[Init]→
Radius	Tan Dist	Ext Dist	⌒Degree	⌒Length

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program **If run immediately after SY-10, go to Step 4.**		[2nd] [Pgm] 11	
2	Initialize		[2nd] [E′]	0.000000
3	Enter Central Angle (DDD.MMSS)	Δ	[2nd] [A′]	Δ† (DDD.MMSSss)
4a	If by Chord Definition, go to Step 5			
4b	If by Arc Definition		[2nd] [B′]	Δ†
5a	Enter Radius	R	[A]	R†
5b	or Tangent Distance	T†	[B]	R†
5c	or External Distance	E†	[C]	R†
5d	or Degree of Curve	D†	[D]	R†
5e	or Curve Length	L†	[E]	R†
6	Compute Chord Length (P.C. to P.T.)		[R/S]	C†
7	Compute Middle Ordinate		[R/S]	M†
8	Compute Sector Area		[R/S]	A_{sect}†
9	Compute Segment Area		[R/S]	A_{seg}†
10	Compute Fillet Area		[R/S]	A_{fil}†

NOTES: 1. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Solid State Software			TI ©1977	
HORIZ. CURVE LAYOUT				SY-12
PI→PC	PC→PT	[prt]→	→PC	
Sta	→C∠IJ	→CIJ	DefPC-J	→PT

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Execute SY-10 through Step 9[1]			
2	Select Program		[2nd] [Pgm] 12	
3a	Enter P.I.	P.I.	[2nd] [A′]	P.C.
3b	or P.C.	P.C.	[2nd] [B′]	P.T.
	If printer is not available, go to Step 5.			
4	Compute and print the following: P.C. (then for each station on the curve)[2] Current Station Central angle from previous station Chord length from previous station Deflection angle from P.C.		[2nd] [C′]	
5	Enter Station I	Sta I	[A]	Sta I
6	Enter Station J[3]	Sta J	[A]	Sta J
7	Compute Central angle (I to J)		[B]	$C\angle_{I-J}$
8	Compute Chord length (I to J)		[C]	C_{I-J}
9	Compute Deflection Angle (PC to J)		[D]	Def_{PC-J}
	Optional:[4]			
10	Display P.C.		[2nd] [D′]	P.C.
11	Display P.T.		[E]	P.T.

NOTES:
1. SY-10 or other intervening calculations may be executed, but R_{02}-R_{08} must remain intact.
2. This step calculates these values for each full curve station and P.T. If any other station is desired, go to Step 5. Note that any result may be printed by manual command (i.e. – [prt].
3. If the current Station J is to become the new Station I, only Step 6 needs be done.
4. Steps 10 and 11 may be done any time after Step 4.
5. Program leaves calculator in fix 6 display format.

Example: The following data is available for a curve to be staked out on the ground: 1) a central angle of 23°18′, 2) a degree of curve of 4°00′ by chord definition, and 3) the point of intersection station is 5053.87.

Select HORIZONTAL CURVE DESIGN (1) Program.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 10		
	[2nd] [E′]	0.000000	Initialize
23.18	[2nd] [A′]	23.180000†	Δ
4†	[D]	1432.685417†	D → Radius
	[R/S]	295.391249†	Tangent distance
	[R/S]	30.134973†	External distance
	[R/S]	4.000000†	Degree of curve
	[R/S]	582.500000†	Length of curve

Select HORISONTAL CURVE DESIGN (2) Program. (If [CLR] has not been pressed while loading, L will be in the display. In this case, simply press [E] and continue. If [CLR] has been pressed, one of the key elements above must be entered, such as the following:)

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 11		
582.5†	[E]	1432.685417†	L → Radius
	[R/S]	578.612027†	C
	[R/S]	29.514175†	Middle ordinate
	[R/S]	417354.3783†	A_{sect}
	[R/S]	11408.50011†	A_{seg}
	[R/S]	5848.357138†	A_{fil}

† These values are printed if the PC-100A is connected.

Select HORIZONTAL CURVE LAYOUT Program. Assume printer is available.

ENTER	PRESS	DISPLAY	COMMENT	PRINT†
	[2nd] [Pgm] 12			
5053.87	[2nd] [A′]	4758.478751	P.I. → P.C.	
	[2nd] [C′]	— —	P.C.	4758.478751
		— —	Station 1	4800.000000
		— —	$C\angle_{PC-1}$	1.393906
		— —	C_{PC-1}	41.528229
		— —	Def_{PC-1}	0.494953
		— —	Sta 2	4900.000000
		— —	$C\angle_{1-2}$	4.000000
		— —	C_{1-2}	100.000000
		— —	Def_{PC-2}	2.494953
		— —	Sta 3	5000.000000
		— —	$C\angle_{2-3}$	4.000000
		— —	C_{2-3}	100.000000
		— —	Def_{PC-3}	4.494953
		— —	Sta 4	5100.000000
		— —	$C\angle_{3-4}$	4.000000
		— —	C_{3-4}	100.000000
		— —	Def_{PC-4}	6.494953
		— —	Sta 5	5200.000000
		— —	$C\angle_{4-5}$	4.000000
		— —	C_{4-5}	100.000000
		— —	Def_{PC-5}	8.494953
		— —	Sta 6	5300.000000
		— —	$C\angle_{5-6}$	4.000000
		— —	C_{5-6}	100.000000
		— —	Def_{PC-6}	10.494953
		— —	P.T.	5340.978751
		— —	$C\angle_{6-PT}$	1.382094
		— —	C_{6-PT}	40.985676
		11.390000	$Def_{PC-PT}\left(\frac{\Delta}{2}\right)$	11.390000

† All values in print column are printed if the PC-100A is connected.

If printer is not available, do the following:

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 12		
5053.87	[2nd] [A′]	4758.478751	P.I. → P.C.
	[A]	4758.478751	P.C.
4800	[A]	4800.000000	Sta 1
	[B]	1.393906	$C\angle_{PC-1}$
	[C]	41.528229	C_{PC-1}
	[D]	0.494953	Def_{PC-1}
4900	[A]	4900.000000	Sta 2
	[B]	4.000000	$C\angle_{1-2}$
	[C]	100.000000	C_{1-2}
	[D]	2.494953	Def_{PC-2}
5000	[A]	5000.000000	Sta 3
	[B]	4.000000	$C\angle_{2-3}$
	[C]	100.000000	C_{2-3}
	[D]	4.494953	Def_{PC-3}
5100	[A]	5100.000000	Sta 4
	[B]	4.000000	$C\angle_{3-4}$
	[C]	100.000000	C_{3-4}
	[D]	6.494953	Def_{PC-4}
5200	[A]	5200.000000	Sta 5
	[B]	4.000000	$C\angle_{4-5}$
	[C]	100.000000	C_{4-5}
	[D]	8.494953	Def_{PC-5}
5300	[A]	5300.000000	Sta 6
	[B]	4.000000	$C\angle_{5-6}$
	[C]	100.000000	C_{5-6}
	[D]	10.494953	Def_{PC-6}
	[E]	5340.978751	P.T.
	[A]	5340.978751	P.T.
	[B]	1.382094	$C\angle_{6\text{-}P.T.}$
	[C]	40.985676	$C_{6\text{-}PT}$
	[D]	11.390000	$Def_{PC\text{-}PT}\left(\frac{\Delta}{2}\right)$

Register Contents (SY-10 and SY-11)

R_{00}		R_{05}	R	R_{10}	C*	R_{15}	
R_{01}	50	R_{06}	T	R_{11}	Δ/2	R_{16}	
R_{02}	100	R_{07}	E	R_{12}	A_{sect}*	R_{17}	
R_{03}	Δ	R_{08}	L	R_{13}		R_{18}	
R_{04}	D	R_{09}	M*	R_{14}		R_{19}	

*SY-11 only.

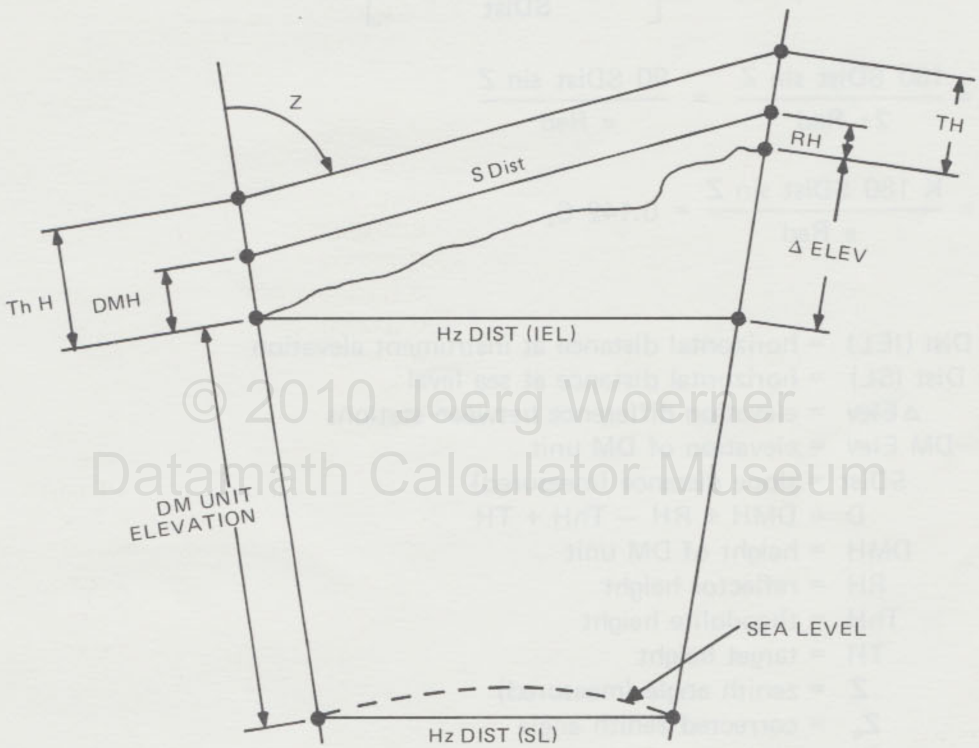
Register Contents (SY-12)

R_{00}		R_{05}	R	R_{10}		R_{15}	curr Sta
R_{01}		R_{06}	T	R_{11}		R_{16}	d
R_{02}	100	R_{07}	E	R_{12}	P.I.	R_{17}	P.T.
R_{03}	Δ	R_{08}	L	R_{13}	P.C.	R_{18}	next Sta
R_{04}	D	R_{09}		R_{14}	prev Sta	R_{19}	

EDM SLOPE REDUCTION – (SLOPE ANGLE)

This program converts slope distance measured by an electronic distance measuring (EDM or DM) unit to horizontal distance at sea level and at the elevation of the EDM unit. Given the slope angle as an input parameter, the difference in elevation between the two stations is calculated, and may then be used in SY-14 to calculate the horizontal distance at any specified elevation. Included are corrections for:

EDM unit height	Target height
EDM reflector height	Earth curvature
Theodolite height	Refraction of light



The following formulas are used:

$$\text{Hz Dist (IEL)} = \frac{\text{SDist} \sin (Z_c - C_z)}{\cos C_z}$$

$$\text{Hz Dist (SL)} = \frac{\text{SDist} \sin (Z_c - C_z)}{\cos C_z} \left[\frac{\text{Rad}}{\text{Rad} + \text{DM Elev}} \right] = \text{Hz Dist (IEL)} \left[\frac{\text{Rad}}{\text{Rad} + \text{DM Elev}} \right]$$

$$\Delta \text{Elev} = \frac{\text{SDist} \cos Z_c}{\cos C_z} + \text{DMH} - \text{RH}$$

$$Z_c = Z - C_z + C_r + \arcsin \left[\frac{D \sin (Z + 2\,C_z + C_r)}{\text{SDist}} \right]$$

$$C_z = \frac{180 \text{ SDist} \sin Z}{2\pi \text{ Rad}} = \frac{90 \text{ SDist} \sin Z}{\pi \text{ Rad}}$$

$$C_r = \frac{K\, 180 \text{ SDist} \sin Z}{\pi \text{ Rad}} = 0.142\, C_z$$

where

Hz Dist (IEL) = horizontal distance at instrument elevation
Hz Dist (SL) = horizontal distance at sea level
ΔElev = elevation difference between stations
DM Elev = elevation of DM unit
SDist = slope distance (measured)
D = DMH + RH − ThH + TH
DMH = height of DM unit
RH = reflector height
ThH = theodolite height
TH = target height
Z = zenith angle (measured)
Z_c = corrected zenith angle
C_z = correction factor due to earth curvature (degrees)
C_r = correction factor due to refraction of light (degrees)
Rad = radius of earth*
K = coefficient of refraction (0.071)

*Radius of the earth is taken to be 20,902,227.28 feet which is the mean radius of the Clarke Spheroid of 1866, as given in *American Practical Navigator,* Vol. 2, N. Bowditch, Defense Mapping Agency Hydrographic Service, 1975, p. 641. A different radius may be used if desired. (see User Instructions).

Solid State Software			TI ©1977	
EDM SLOPE REDUCT'N (S∠)				SY-13
→HzDist (IEL)	→HzDist (SL)	→Δ Elev		[Init]→
SDist	Z∠	DMH; RH	ThH; TH	DMElev

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 13	
	Select degree mode		[2nd] [Deg]	
2	Initialize		[2nd] [E']	earth Radius[1] †
3	Enter slope distance[2]	S Dist	[A]	S Dist†
4	Enter zenith angle[3]	Z∠	[B]	Z∠†
5	Enter height of DM unit	DMH	[C]	DMH†
6	Enter reflector height	RH	[R/S]	RH†
7	Enter theodolite height	ThH	[D]	ThH†
8	Enter target height	TH	[R/S]	TH†
9	Enter DM unit elevation	DM Elev	[E]	DM Elev†
10	Compute Hz Dist (IEL)		[2nd] [A']	Hz Dist (IEL)†
11	Compute Hz Dist (SL)		[2nd] [B']	Hz Dist (SL)†
12	Compute Δ Elev		[2nd] [C']	Δ Elev†

NOTES:

1. A different value may be used by entering it at this point (after pressing [2nd] [E']). Key in the desired value and press [STO] [0] [1], then continue.
2. All distances entered and displayed in feet unless Rad is altered to another unit.
3. Angle must be entered in decimal degrees. If angle is known in DD.MMSS, key in angle and press [2nd] [D.MS] [B] to enter in decimal degrees.
4. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example: You have measured a slope distance of 5000 feet at a zenith angle of 80°. You know that the DM unit elevation is 1000 ft., that the unit is 5 ft. above the surface, the reflector height is 4 ft., and both the theodolite and target heights are 6 ft. Find the horizontal distance at DM Elev and at sea level, and the difference in elevation between stations.

Select Program (SY-13).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 13		
	[2nd] [E′]	20902227.28*†	Initialize
5000	[A]	5000.000000†	S Dist
80	[B]	80.000000†	Z∠
5	[C]	5.000000†	DMH
4	[R/S]	4.000000†	RH
6	[D]	6.000000†	ThH
6	[R/S]	6.000000†	TH
1000	[E]	1000.000000†	DM Elev
	[2nd] [A′]	4924.019788†	Hz Dist (IEL)
	[2nd] [B′]	4923.784225†	Hz Dist (SL)
	[2nd] [C′]	868.768713†	Δ Elev

*Display shows earth radius constant in use. To use another constant, key in the desired value at this point (*after* pressing [2nd] [E′]) and press [STO] [0] [1], then continue.

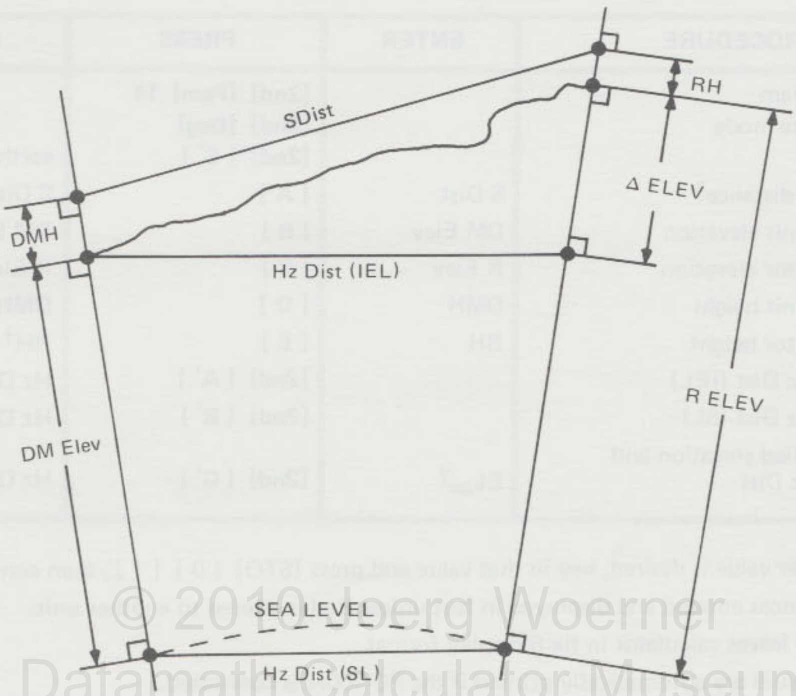
†These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} DMH	R_{10} C_r	R_{15} D
R_{01} Radius	R_{06} RH	R_{11} Z_c	R_{16}
R_{02} S Dist	R_{07} ThH	R_{12}	R_{17} Hz Dist (IEL)
R_{03} DM Elev	R_{08} TH	R_{13}	R_{18}
R_{04} Z∠	R_{09} C_z	R_{14}	R_{19}

EDM SLOPE REDUCTION – (Δ ELEVATION)

This program converts slope distance measured by an electronic distance measuring (EDM or DM) unit to horizontal distance at sea level, at the EDM unit elevation, and at any specified elevation, given the difference in elevation (Δ Elev) of the two stations. Included are corrections for EDM unit height and reflector height. The following formulas are used:



$$\text{Hz Dist} = \left[\frac{\text{SDist}^2 - (\text{R Elev} + \text{RH} - \text{DM Elev} - \text{DMH})^2}{(\text{Rad} + \text{DM Elev} + \text{DMH})\,(\text{Rad} + \text{R Elev} + \text{RH})}\right]^{1/2} (\text{Rad} + \text{HE})$$

where

Hz Dist = horizontal distance at HE
HE = DM Elev, *or* EL_{sp} *or* 0 (sea level)
DM Elev = elevation of DM unit
EL_{sp} = any specified elevation
R Elev = elevation of reflector
DMH = height of DM unit
RH = height of reflector
S Dist = slope distance (measured)
Rad = radius of earth*

*Radius of the earth is taken to be 20,902,227.28 ft. which is the mean radius of the Clarke Spheriod of 1866, as given in *American Practical Navigator,* Vol. 2, N. Bowditch, Defense Mapping Agency Hydrographic Service, 1975, p. 641. A different value may be used if desired. (see User Instructions)

Solid State Software			TI ©1977	
EDM SLOPE REDUCT'N (ΔElev)				SY-14
→HzDist (IEL)	→HzDist (SL)	EL_{sp}→HzDist		[Init]→
SDist	DMElev	RElev	DMH	RH

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 14	
	Select degree mode		[2nd] [Deg]	
2	Initialize		[2nd] [E']	earth Radius[1] †
3	Enter slope distance[2]	S Dist	[A]	S Dist†
4	Enter DM unit elevation	DM Elev	[B]	DM Elev†
5	Enter reflector elevation	R Elev	[C]	R Elev†
6	Enter DM unit height	DMH	[D]	DMH†
7	Enter reflector height	RH	[E]	RH†
8	Compute Hz Dist (IEL)		[2nd] [A']	Hz Dist (IEL)†
9	Compute Hz Dist (SL)		[2nd] [B']	Hz Dist (ISL)†
10	Enter specified elevation and compute Hz Dist	EL_{sp}†	[2nd] [C']	Hz $Dist_{sp}$†

NOTES:

1. If another value is desired, key in that value and press [STO] [0] [1], then continue.
2. All distances entered and displayed in feet unless Rad is altered to another unit.
3. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example: Given a measured slope distance of 5000 ft., a DM unit elevation of 1000 ft., a reflector elevation of 1868.769 ft., a DM height of 5 ft., and a reflector height of 4 ft., calculate the horizontal distance at an elevation of 2000 ft.

Select Program (SY-14).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 14		
	[2nd] [E']	20902227.28*†	Initialize
5000	[A]	5000.000000†	S Dist
1000	[B]	1000.000000†	DM Elev
1868.769	[C]	1868.769000†	R Elev
5	[D]	5.000000†	DMH
4	[E]	4.000000†	RH
	[2nd] [A']	4924.018565†	Hz Dist (IEL)
	[2nd] [B']	4923.783002†	Hz Dist (SL)
2000†	[2nd] [C']	4924.254127†	Hz Dist @ 2000 ft.

*Earth radius constant in use. To use another constant, key in at this point (*after* [2nd] [E']), press [STO] [0] [1], then continue.

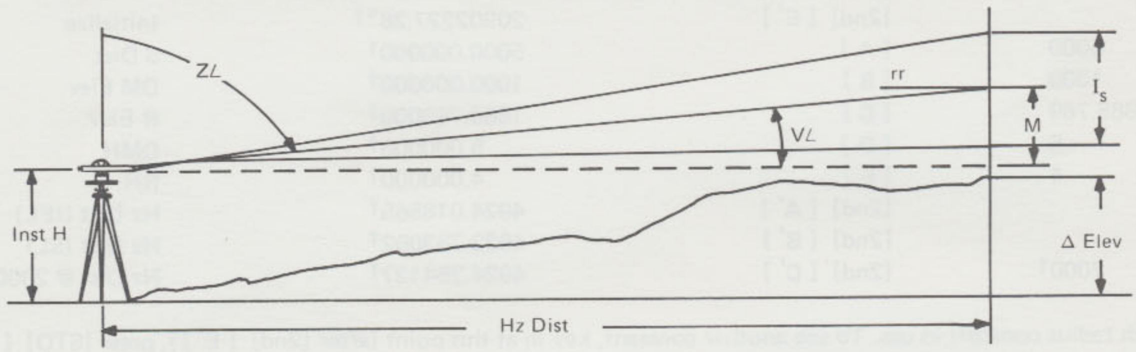
†These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} DMH	R_{10}	R_{15}
R_{01} Radius	R_{06} RH	R_{11}	R_{16}
R_{02} S Dist	R_{07}	R_{12} Hz Dist (SL)	R_{17} Hz Dist (IEL)
R_{03} DM Elev	R_{08}	R_{13}	R_{18} R Elev
R_{04}	R_{09}	R_{14}	R_{19}

STADIA REDUCTIONS AND TRAVERSE

This program calculates horizontal distance to and elevation at the rod station using stadia methods, given the instrument elevation and height, readings, and angle. The program may be used to detail a fixed station, or to perform a traverse. In the case of a traverse, the program keeps track of station numbers, and transfers the calculated elevation at the rod to the proper registers for use as the base elevation of the next leg, and the elevation closure error is determined and balanced at each station. The following equations are used:



Horizontal Measurement – $\text{Hz Dist} = KI_s + C$

Inclined Measurement – $\text{Hz Dist} = KI_s \cos^2 V\angle + C \cos V\angle$

$$M = \frac{KI_s}{2} \sin 2\,V\angle + C \sin V\angle \qquad \text{Elev}_c = \text{Ref Elev} + CE\left(\frac{\text{Hz Dist}}{\Sigma\,\text{Hz Dist}}\right)$$

$$\Delta\,\text{Elev} = M + \text{Inst H} - rr \qquad \text{Elev} = \text{Ref Elev} + \Delta\,\text{Elev}$$

where

Hz Dist = horizontal distance between stations

$*K$ = stadia interval factor = $\frac{\text{instrument focal length}}{\text{stadia hair spacing}}$ (assumed to be 100)

I_s = stadia interval (difference between upper and lower crosshair readings)

$*C$ = stadia constant (distance from instrument axis to principal focus) (assumed to be 1)

V∠ = vertical angle to line of sight (= 90 – Z∠)

Z∠ = zenith angle to line of sight

M = difference in elevation between instrument axis and middle crosshair reading

Δ Elev = difference in elevation between stations

rr = rod reading at middle crosshair

Elev = elevation of rod station

Ref Elev = reference elevation, or elevation of instrument station

Elev_c = corrected elevation (balanced)

CE = closure error

ΣHz Dist = sum of horizontal distance for entire traverse

*Both K and C may be changed if desired. (see User Instructions)

Solid State Software			TI ©1977	
STADIA REDUCT'N/TRAVERSE				SY-15
→Hz Dist	→ΔEL; EL	→Sta #	EL; HzD→EL$_c$	[Init]→
Ref Elev	Inst H	Intv'l	Vert ∠	rod read'g

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program Select degree mode		[2nd] [Pgm] 15 [2nd] [Deg]	
2	Initialize[1]		[2nd] [E']	0.000000
3	Enter reference elevation[2]	Ref Elev	[A]	Ref Elev†
4	Enter instrument height	Inst H	[B]	Inst H†
5	Enter stadia interval	Intv'l	[C]	Intv'l†
6a 6b	**Enter** vertical angle[2] **OR** zenith angle[2]	Vert ∠ 90 Z∠	[D] [–] [=] [D]	Vert ∠† 90. Vert ∠†
7	Enter rod reading[3]	rod read'g	[E]	Rod Read'g†
8	Compute horizontal distance		[2nd] [A']	Hz Dist†
9	Compute change in elevation		[2nd] [B']	Δ Elev†
10	Compute elevation of next station **For another reduction from the same point, go to Step 5. For a traverse, continue.**		[R/S]	Elev†
11	Display current station # and occupy next station[3]		[2nd] [C']	Sta #†
12	**Do Steps 4–11 for next station. Otherwise, go to Step 13 to distribute closure error.**			
13	Enter computed elevation of station[4]	Elev	[2nd] [D']	Elev†
14	Enter Hz Dist *to* station and compute corrected elevation (Repeat Steps 13 and 14 for each leg in the same order as traversed.)	Hz Dist	[R/S]	Elev$_c$†

NOTES:
1. Program assumes K = 100 and C = 1. Different values may be entered immediately after Step 2 by:
   Entering K, pressing [STO] [0] [1]
   Entering C, pressing [STO] [0] [2].
2. Distance may be entered in any unit. Angles must be entered in DD.MMSS format.
3. An entry error in Steps 4–7 may be corrected by repeating that step and continuing. If [2nd] [C'] has been pressed:
   Enter the previous elevation and press [STO] [1] [0]
   Enter the previous station # and press [STO] [1] [1]
   Enter the sum of the previously calculated horizontal distances and press [STO] [1] [4]
   Then go to the erroneous step, correct, and continue
4. If an error is made in Steps 13 and 14, do the following:
   Press [2nd] [B'], ignore display, then
   Go to Step 13 and begin again.
5. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example 1: The following inputs were measured from a fixed point with elevation 236 and an instrument height of 5.1. Find the horizontal distance to, change in elevation, and elevation at each rod station.

	Interval	Vertical Angle	Rod Reading
Station # 1	4.22	–2°37′	7.2
2	3.98	–3°06′	3.7
3	4.56	–4°45′	4.6

Select Program (SY-15).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 15		
	[2nd] [E′]	0.000000	Initialize
236	[A]	236.000000†	Ref Elev
5.1	[B]	5.100000†	Inst H
(Station #1)			
4.22	[C]	4.220000†	Intv'l
2.37	[+/–] [D]	–2.370000†	Vert ∠
7.2	[E]	7.200000†	rod read'g
	[2nd] [A′]	422.119404†	Hz Dist
	[2nd] [B′]	–21.391374†	Δ Elev
	[R/S]	214.608626†	Elev
(Station #2)			
3.98	[C]	3.980000†	Intv'l
3.06	[+/–] [D]	–3.060000†	Vert ∠
3.7	[E]	3.700000†	rod read'g
	[2nd] [A′]	397.834579†	Hz Dist
	[2nd] [B′]	–20.145951†	Δ Elev
	[R/S]	215.854049†	Elev
(Station #3)			
4.56	[C]	4.560000†	Intv'l
4.45	[+/–] [D]	–4.450000†	Vert ∠
4.6	[E]	4.600000†	rod read'g
	[2nd] [A′]	453.869683†	Hz Dist
	[2nd] [B′]	–37.213662†	Δ Elev
	[R/S]	198.786338†	Elev

† These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} rod reading	R_{10} pres Sta Elev	R_{15} Used
R_{01} K	R_{06} Inst H	R_{11} Sta counter	R_{16} Used
R_{02} C	R_{07} Ref Elev	R_{12}	R_{17} Used
R_{03} I_S	R_{08} Hz Dist	R_{13} Elev corr/ft	R_{18} Adj Elev
R_{04} V∠	R_{09}	R_{14} Σ Hz Dist	R_{19}

Example 2: Having performed a closed traverse, the following information is available. Reference elevation is 234.0 at Station #1. Complete the calculations, including closure, to find the corrected elevation.

	Instrument Ht.	Interval	Vertical Angle	Rod Reading
at Station #1	5.1	2.1	1°23′	5.4
2	5.1	2.34	–2°56′	5.6
3	5.0	2.3	2°32′	4.6

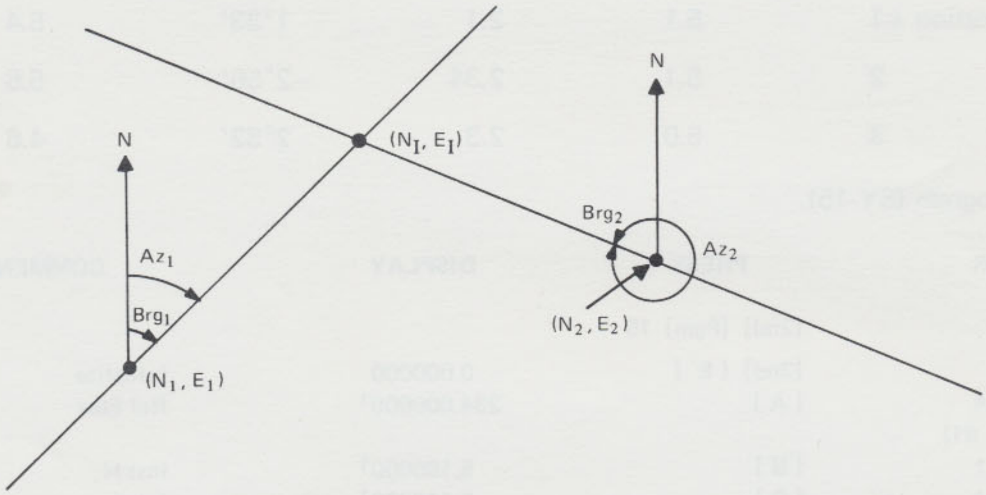
Select Program (SY-15).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 15		
	[2nd] [E′]	0.000000	Initialize
234	[A]	234.000000†	Ref Elev
(at Station #1)			
5.1	[B]	5.100000†	Inst H
2.1	[C]	2.100000†	Intv'l
1.23	[D]	1.226000*†	Vert ∠
5.4	[E]	5.400000†	rod read'g
	[2nd] [A′]	210.877319†	Hz Dist to #2
	[2nd] [B′]	4.792353†	Δ Elev to #2
	[R/S]	238.792353†	Elev at #2
	[2nd] [C′]	1.000000†	→ Sta #, occupy next Sta
(at Station #2)			
2.34	[C]	2.340000†	Intv'l
2.56	[+/–] [D]	–2.556000*†	Vert ∠
5.6	[E]	5.600000†	rod read'g
	[2nd] [A′]	234.385897†	Hz Dist to #3
	[2nd] [B′]	–12.510191†	Δ Elev
	[R/S]	226.282161†	Elev at #3
	[2nd] [C′]	2.000000†	→ Sta #, occupy next Sta
(at Station #3)			
5	[B]	5.000000†	Inst H
2.3	[C]	2.300000†	Intv'l
2.32	[D]	2.316000*†	Vert ∠
4.6	[E]	4.600000†	rod read'g
	[2nd] [A′]	230.549673†	Hz Dist to #1
	[2nd] [B′]	10.600404†	Δ Elev
	[R/S]	236.882565†	Elev at #1
	[2nd] [C′]	3.000000†	→ Sta #, occupy next Sta
238.792	[2nd] [D′]	238.792000†	Elev (at Sta #2)
210.877†	[R/S]	237.892540†	Hz Dist → $Elev_c$
226.282	[2nd] [D′]	226.282000†	Elev (at Sta #3)
234.386†	[R/S]	224.382806†	Hz Dist → $Elev_c$
236.883	[2nd] [D′]	236.883000†	Elev (at Sta #1)
230.55†	[R/S]	234.000435†	Hz Dist → $Elev_c$

*Interpret 6 as 60″ (for example, 1.226000 = 1°22′60″ = 1°23′).
†These values are printed if the PC-100A is connected.

INTERSECTION – (BEARING/BEARING)

This program calculates the coordinates of the point of intersection of two lines given the bearing and quadrant of each line, and the coordinates of two points, one on each line. The following formulas are used:



$$N_I = \frac{(E_1 - N_1 \tan Az_1) - (E_2 - N_2 \tan Az_2)}{\tan Az_2 - \tan Az_1}$$

$$E_I = E_1 + (N_I - N_1) \tan Az_1$$

where

- N_I = North coordinate of intersection
- E_I = East coordinate of intersection
- N_1 = North coordinate of point 1
- E_1 = East coordinate of point 1
- N_2 = North coordinate of point 2
- E_2 = East coordinate of point 2
- Az_1 = Azimuth of line 1
- Az_2 = Azimuth of line 2

Limitations: Due to the nature of Euclidean space, do not attempt to find the intersection of two parallel lines.

Solid State Software			TI ©1977	
INTERSECTION (BRG-BRG)				SY-16
→ E_I				[Init]→
N_1, E_1	N_2, E_2	Brg_1, Q_1	Brg_2, Q_2	→ N_I

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 16	
	Select degree mode		[2nd] [Deg]	
2	Initialize		[2nd] [E′]	0.000000
3	Enter N_1	N_1	[A]	N_1 †
4[1]	Enter E_1	E_1	[A]	E_1 †
5	Enter N_2	N_2	[B]	N_2 †
6[1]	Enter E_2	E_2	[B]	E_2 †
7	Enter $Bearing_1$ (DD.MMSS)	Brg_1	[C]	Brg_1 †
8[1]	Enter $Quadrant_1$	Q_1	[C]	Q_1 †
9	Enter $Bearing_2$ (DD.MMSS)	Brg_2	[D]	Brg_2 †
10[1]	Enter $Quadrant_2$	Q_2	[D]	Q_2 †
11	Compute N_I		[E]	N_I †
12	Compute E_I		[2nd] [A′]	E_I †

NOTES:
1. To correct an entry error in Steps 4, 6, 8, or 10, go back to the preceding step.
2. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example: Given

N_1 = 300	N_2 = 350
E_1 = 200	E_2 = 550
Brg_1 = 35°45′40″	Brg_2 = 22°35′10″
Q_1 = 1	Q_2 = 4

Find the coordinates of the intersection.

Select Program (SY-16).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 16		
	[2nd] [E′]	0.000000	Initialize
300	[A]	300.000000†	N_1
200	[A]	200.000000†	E_1
350	[B]	350.000000†	N_2
550	[B]	550.000000†	E_2
35.454	[C]	35.454000†	Brg_1
1	[C]	1.000000†	Q_1
22.351	[D]	22.351000†	Brg_2
4	[D]	4.000000†	Q_2
	[E]	626.359421†	N_I
	[2nd] [A′]	435.041267†	E_I

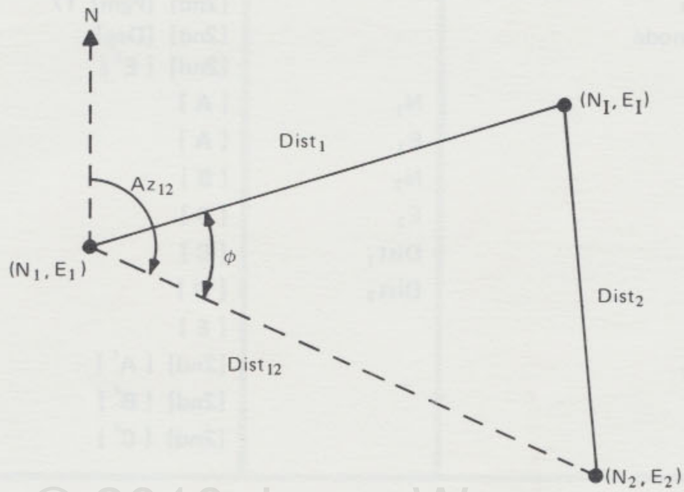
† These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} Brg_1	R_{10} N_I	R_{15}
R_{01} N_1	R_{06} Q_1	R_{11} E_I	R_{16}
R_{02} E_1	R_{07} Brg_2	R_{12} tan Az_1	R_{17}
R_{03} N_2	R_{08} Q_2	R_{13} tan Az_2	R_{18}
R_{04} E_2	R_{09}	R_{14}	R_{19}

INTERSECTION – (DISTANCE/DISTANCE)

This program calculates the coordinates of the point of intersection of two lines given the length of each line segment from a known point on that line to the point of intersection. Two solutions are possible. One is found by designating one line and its corresponding point and distance as $line_1$, $point_1$, and $distance_1$, and the other as $line_2$, etc. . . . The other solution is found by reversing the designations and resolving the problem. The following formulas are used:



$$N_I = N_1 + Dist_1 \cos (Az_{12} - \phi)$$

$$E_I = E_1 + Dist_1 \sin (Az_{12} - \phi)$$

$$Az_{12} = \arctan \left[\frac{E_2 - E_1}{N_2 - N_1} \right]$$

$$\phi = \arccos \left[\frac{Dist_{12}^2 + Dist_1^2 - Dist_2^2}{2\ Dist_1\ Dist_{12}} \right]$$

where

N_I, E_I = North and East coordinates of point of intersection
N_1, E_1 = coordinates of point 1
N_2, E_2 = coordinates of point 2
$Dist_1$ = distance from point 1 to intersection
$Dist_2$ = distance from point 2 to intersection
$Dist_{12}$ = distance from point 1 to point 2
Az_{12} = azimuth of line from point 1 to point 2
ϕ = angle between line 1 and the line including point 1 and point 2

Limitations: No solution exists for $Dist_1 + Dist_2 < Dist_{12}$.

Solid State Software			TI ©1977	
INTERSECTION (DIST-DIST)				SY-17
→Az_{12}	→N_I	→E_I		[Init]→
N_1, E_1	N_2, E_2	$Dist_1$	$Dist_2$	→ϕ

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 17	
	Select degree mode		[2nd] [Deg]	
2	Initialize		[2nd] [E']	0.000000
3	Enter N_1	N_1	[A]	N_1 †
4[1]	Enter E_1	E_1	[A]	E_1 †
5	Enter N_2	N_2	[B]	N_2 †
6[1]	Enter E_2	E_2	[B]	E_2 †
7	Enter $Dist_1$	$Dist_1$	[C]	$Dist_1$ †
8	Enter $Dist_2$	$Dist_2$	[D]	$Dist_2$ †
9[2]	Compute ϕ		[E]	ϕ †
10	Compute Az_{12}		[2nd] [A']	Az_{12} †
11[2]	Compute N_I		[2nd] [B']	N_I †
12[2]	Compute E_I		[2nd] [C']	E_I †

NOTES:
1. To correct an entry in Steps 4 or 6, go back to the preceding step.
2. The computed solution is always clockwise from point 1 to 2.
3. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example: Given

$N_1 = 85.213$ $\quad N_2 = 16.824$
$E_1 = 21.089$ $\quad E_2 = 137.182$
$Dist_1 = 169.274$ $\quad Dist_2 = 122.144$

Select Program (SY-17).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 17		
	[2nd] [E′]	0.000000	Initialize
85.213	[A]	85.213000†	N_1
21.089	[A]	21.089000†	E_1
16.824	[B]	16.824000†	N_2
137.182	[B]	137.182000†	E_2
169.274	[C]	169.274000†	$Dist_1$
122.144	[D]	122.144000†	$Dist_2$
	[E]	45.384728†	ϕ
	[2nd] [A′]	120.300659†	Az_{12}
	[2nd] [B′]	129.436950†	N_I
	[2nd] [C′]	184.484010†	E_I

Note that the second solution is:

$\phi = 82.165719$
$Az_{12} = 300.300659$
$N_I = -79.138283$
$E_I = 61.614831$

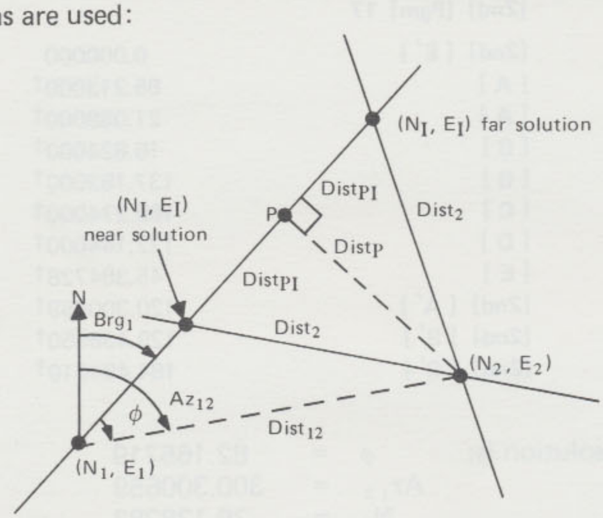
† These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} $Dist_1$	R_{10} $(E_2 - E_1)^2$	R_{15}
R_{01} N_1	R_{06} $Dist_2$	R_{11} $Dist_{12}$	R_{16}
R_{02} E_1	R_{07} $N_2 - N_1$	R_{12} ϕ	R_{17}
R_{03} N_2	R_{08} $E_2 - E_1$	R_{13} Az_{12}	R_{18}
R_{04} E_2	R_{09} $(N_2 - N_1)^2$	R_{14}	R_{19}
			R_{20} Used

INTERSECTION – (BEARING/DISTANCE)

Given two intersecting lines and knowing a point on each, plus the bearing and quadrant of one line and the distance from the point on the other line to the point of intersection, this program calculates: 1) the distance between the two known points, 2) the azimuth from the first to the second known point, and 3) the coordinates of the point of intersection. Two solutions are possible for the point of intersection. The second is found by entering the quadrant 180° opposed to the first (see User Instructions). This effectively changes the azimuth of line 1 by 180°. The following formulas are used:



$$Dist_{12} = \sqrt{(N_2 - N_1)^2 + (E_2 - E_1)^2}$$

$$\phi = Az_1 - Az_{12} \qquad Az_{12} = \arctan\left[\frac{E_2 - E_1}{N_2 - N_1}\right]$$

$$Dist_P = Dist_{12} \sin\phi \qquad Dist_{PI} = \sqrt{Dist_2^2 - Dist_P^2}$$

$$N_I = N_1 + (Dist_{12} \cos\phi + Dist_{PI}) \cos Az_1$$

$$E_I = E_1 + (Dist_{12} \cos\phi + Dist_{PI}) \sin Az_1$$

where

- N_1, E_1 = coordinates of point 1 (known)
- N_2, E_2 = coordinates of point 2 (known)
- N_I, E_I = coordinates of point of intersection
- ϕ = angle between line 1 and line from point 1 to point 2 (line 12)
- Az_1 = azimuth of line 1 (known bearing)
- Az_{12} = azimuth of line 12
- $Dist_2$ = length of line 2 (known)
- $Dist_{12}$ = length of line 12
- $Dist_P$ = length of the perpendicular from point 2 to line 1
- $Dist_{PI}$ = distance from point of intersection of line 1 and line 2 to point of intersection of line 1 and perpendicular from point 2.

Limitations: No solution exists for $Dist_2 < Dist_P$.

Solid State Software				TI ©1977
INTERSECTION (BRG-DIST)				SY-18
→ $Dist_{12}$	→ Az_{12}	→ N_I	→ E_I	[Init] →
N_1, E_1	N_2, E_2	Brg_1	Q_1	$Dist_2$

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program Select degree mode		[2nd] [Pgm] 18 [2nd] [Deg]	
2	Initialize		[2nd] [E′]	0.000000
3	Enter N_1	N_1	[A]	N_1 †
4	Enter E_1 [1]	E_1	[A]	E_1 †
5	Enter N_2	N_2	[B]	N_2 †
6	Enter E_2 [1]	E_2	[B]	E_2 †
7	Enter bearing of line 1 (DD.MMSS)	Brg_1	[C]	Brg_1 †
8	Enter quadrant of Brg_1 [2]	Q_1	[D]	Q_1 †
9	Enter $Dist_2$	$Dist_2$	[E]	$Dist_2$ †
10	Compute distance from point 1 to point 2		[2nd] [A′]	$Dist_{12}$ †
11	Compute azimuth from point 1 to point 2		[2nd] [B′]	Az_{12} †
12	Compute N_I		[2nd] [C′]	N_I †
13	Compute E_I		[2nd] [D′]	E_I †

NOTES:

1. To correct an entry error in Steps 4 and 6, go back to the previous step.
2. For the solution nearest point 1, enter the bearing *into* point 1 (from intersection). For the solution farthest from point 1, enter the bearing *out of* point 1. Only the quadrant will differ, so for the second solution, do Steps 8, 10–13.
3. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example: Given

N_1 = 250	N_2 = 300
E_1 = 150	E_2 = 550
Brg_1 = 50°	$Dist_2$ = 350
Q_1 = 1 or 3	

Select Program SY-18.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 18		
	[2nd] [E']	0.000000	Initialize
250	[A]	250.000000†	N_1
150	[A]	150.000000†	E_1
300	[B]	300.000000†	N_2
550	[B]	550.000000†	E_2
50	[C]	50.000000†	Brg_1
1	[D]	1.000000†	Q_1 (far solution)
350	[E]	350.000000†	$Dist_2$
	[2nd] [A']	403.112887†	$Dist_{12}$
	[2nd] [B']	82.522994†	Az_{12}
	[2nd] [C']	643.209579†	N_I (far)
	[2nd] [D']	618.608928†	E_I (far)
3	[D]	3.000000†	Q_1 (near solution)
	[2nd] [A']	403.112887†	$Dist_{12}$
	[2nd] [B']	82.522994†	Az_{12}
	[2nd] [C']	292.031114†	N_I (near)
	[2nd] [D']	200.090731†	E_I (near)

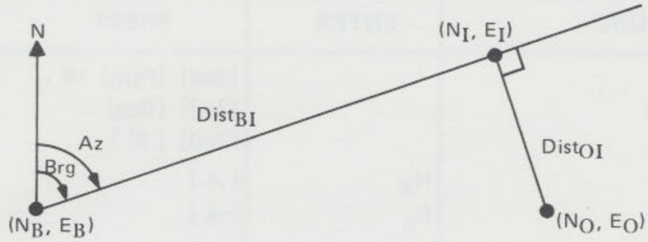
† These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} Brg_1	R_{10} $E_2 - E_1$	R_{15}
R_{01} N_1	R_{06} Q_1	R_{11} $Dist_{12}$	R_{16}
R_{02} E_1	R_{07} $Dist_2$	R_{12} Az_{12}	R_{17}
R_{03} N_2	R_{08} Az_1	R_{13} ϕ	R_{18}
R_{04} E_2	R_{09} $N_2 - N_1$	R_{14} Used	R_{19}
			R_{20} Used

INTERSECTION OF A PERPENDICULAR FROM A POINT TO A LINE

Given a base line defined by a point (base point), a bearing and quadrant, and an offset point, this program will calculate the point of intersection of the perpendicular from the offset point to the line, the distance along the perpendicular, and the distance from the base point to the intersection. The following formulas are used:



$$N_I = \frac{E_O - E_B + N_O \cot Az + N_B \tan Az}{\cot Az + \tan Az}$$

$$E_I = E_B + (N_I - N_B) \tan Az$$

$$Dist_{OI} = \sqrt{(N_O - N_I)^2 + (E_O - E_I)^2} \qquad Dist_{BI} = \sqrt{(N_B - N_I)^2 + (E_B - E_I)^2}$$

where

N_B, E_B = coordinates of base point
N_O, E_O = coordinates of offset point
N_I, E_I = coordinates of intersection
Az = azimuth of base line
$Dist_{OI}$ = distance from offset point to intersection
$Dist_{BI}$ = distance from base point to intersection

Limitations: Program will not accept bearings of 0° or 90°. Bearings of 0.000001 or 89.999999 yield very close approximations.

Solid State Software TI ©1977

INTERSECTION (BRG IF ⊾)				SY-19
→ $Dist_{OI}$	→ $Dist_{BI}$			[Init] →
N_B, E_B	N_O, E_O	Brg, Q	→ N_I	→ E_I

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program Select degree mode		[2nd] [Pgm] 19 [2nd] [Deg]	
2	Initialize		[2nd] [E′]	0.000000
3	Enter N_B	N_B	[A]	N_B †
4	Enter E_B[1]	E_B	[A]	E_B †
5	Enter N_O	N_O	[B]	N_O †
6	Enter E_O[1]	E_O	[B]	E_O †
7	Enter Bearing (DD.MMSS)	Brg	[C]	Brg †
8	Enter Quadrant[1]	Q	[C]	Q †
9	Compute N_I		[D]	N_I †
10	Compute E_I		[E]	E_I †
11	Compute $Dist_{OI}$		[2nd] [A′]	$Dist_{OI}$ †
12	Compute $Dist_{BI}$		[2nd] [B′]	$Dist_{BI}$ †

NOTES:

1. To correct an entry error in Steps 4, 6 or 8, go back to the previous step.
2. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example: Given N_B = 100 N_O = 300
E_B = 270 E_O = 1370
Brg = 54°09′48″
Q = 1

Select Program SY-19.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 19		
	[2nd] [E′]	0.000000	Initialize
100	[A]	100.000000†	N_B
270	[A]	270.000000†	E_B
300	[B]	300.000000†	N_O
1370	[B]	1370.000000†	E_O
54.0948	[C]	54.094800†	Brg
1	[C]	1.000000†	Q
	[D]	690.660149†	N_I
	[E]	1087.866791†	E_I
	[2nd] [A′]	481.886397†	$Dist_{OI}$
	[2nd] [B′]	1008.853557†	$Dist_{BI}$

† These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{05} Brg	R_{10} N_I	R_{15}
R_{01} N_B	R_{06} Q	R_{11} E_I	R_{16}
R_{02} E_B	R_{07} tan Az	R_{12} Az	R_{17}
R_{03} N_O	R_{08} cot Az	R_{13}	R_{18}
R_{04} E_O	R_{09} (R_{07} + R_{08})	R_{14}	R_{19}

THREE-POINT RESECTION

This program solves the three-point resection problem in which the location of an unknown point (P) is determined with respect to three known control points (A, B, and C) by measuring the angles at point P from A to B (angle APB) and from A to C (angle APC), and then using these angles and the coordinates of the control points to compute the desired information.

Three cases are handled by the program, as illustrated in Figure 1. These are distinguished by the fact that in Case 1, the points A and P are on opposite sides of a line connecting points B and C; in Case 2, point P lies between point A and a line connecting points B and C; in Case 3 point A lies between point P and a line connecting points B and C.

Solid State Software			TI ©1977	
THREE POINT RESECTION				SY-20
→ Az_{AP}, D_{AP}	→ Az_{BP}, D_{BP}	Az_{CP}, D_{CP}	→ P_N, P_E	Case No.
A_N, A_E	B_N, Az_{BA}, D_{BA}	C_N, Az_{CA}, D_{CA}	P1	/ P2

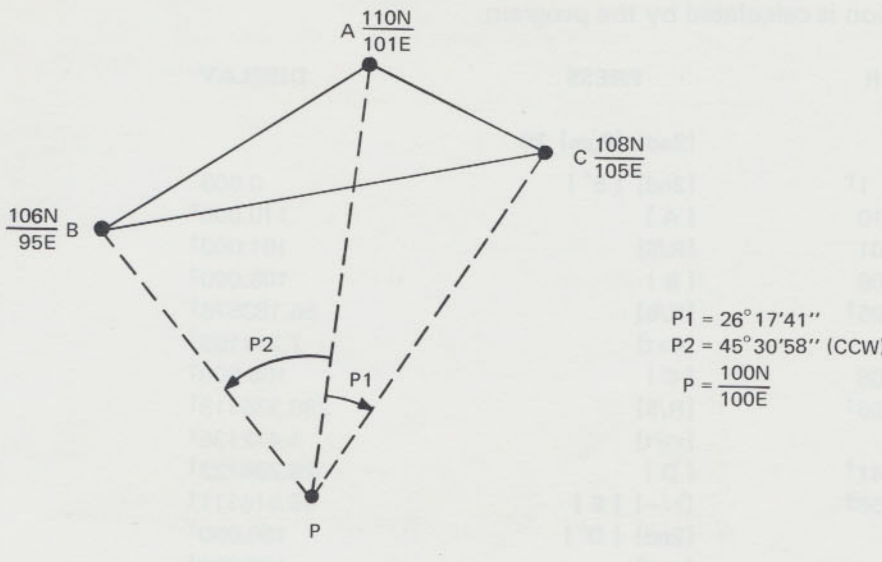
USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select program 20		[2nd] [Pgm] 20	
2	Enter appropriate case number (see Figure 1)	CASE NO. (1-3)	[2nd] [E']	0.000
3	Enter north coordinate of point A	A NORTH	[A]	A_N†
4	Enter east coordinate of point A	A EAST	[R/S]	A_E†
5	Enter north coordinate of point B	B NORTH	[B]	B_N†
6	Enter east coordinate of point B	B EAST†	[R/S]	Azimuth BA†
7	Display distance BA		[x⪴t]	Dist BA†
8	Enter north coordinate of point C	C NORTH†	[C]	C_N†
9	Enter east coordinate of point C	C EAST†	[R/S]	Azimuth CA†
10	Display distance CA		[x⪴t]	Dist CA†
11	Enter angle P1 (DDD.MMSS)	P1 (DDD.MMSS)†	[D]	P1 (decimal)†
12	Enter angle P2 (DDD.MMSS) **Clockwise P2 is positive. Counter-clockwise P2 is negative.**	P2 (DDD.MMSS)†	[E]	|P2| (decimal)†
13	Calculate P_N, P_E		[2nd] [D'] [x⪴t]	P_N† P_E†
14	Calculate azimuth AP and distance AP		[2nd] [A'] [x⪴t]	Azimuth AP† Dist AP†
15	Calculate azimuth BP and distance BP		[2nd] [B'] [x⪴t]	Azimuth BP† Dist BP†
16	Calculate azimuth CP and distance CP		[2nd] [C'] [x⪴t]	Azimuth CP† Dist CP†

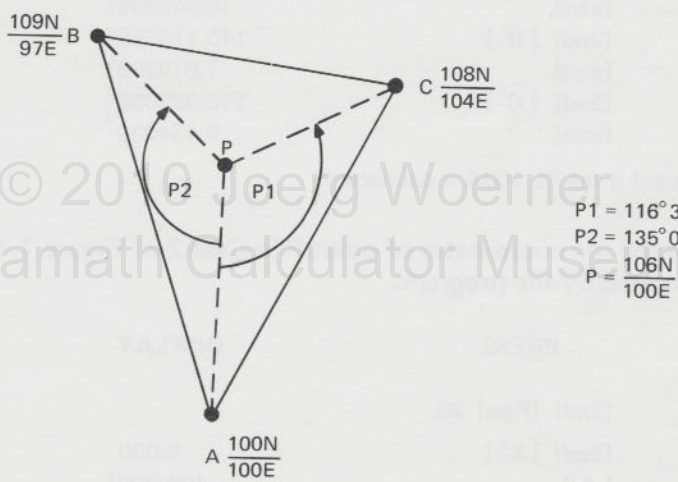
NOTES:

1. Azimuths are printed in the format DDD.MMSS.
2. $0 < P1 < 180$, $0 < P2 < 180$
3. Program leaves calculator in fix 3 or fix 6 display format.
4. Does not run in ENG.

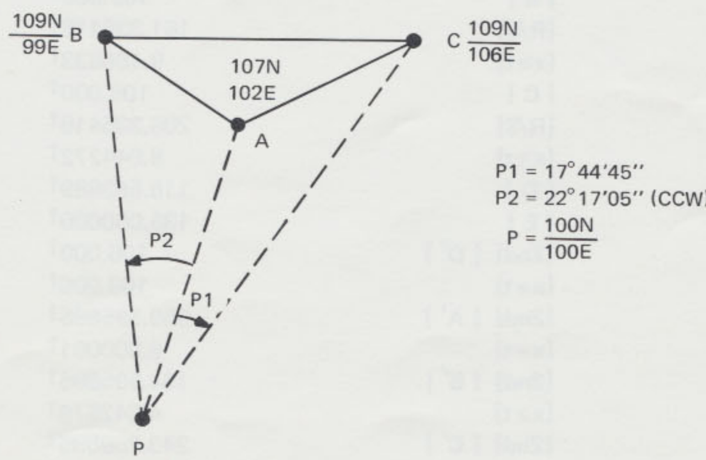
† These values are automatically printed if the PC-100A is connected.



CASE 1



CASE 2



CASE 3

Example 1: Determine the coordinates of point P in Case 1 of Figure 1. Notice that additional information is calculated by the program.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 20		
1†	[2nd] [E′]	0.000	Select Case No.
110	[A]	110.000†	A_N
101	[R/S]	101.000†	A_E
106	[B]	106.000†	B_N
95†	[R/S]	56.183576†	Az BA
	[x≷t]	7.211103†	Dist BA
108	[C]	108.000†	C_N
105†	[R/S]	296.335418†	Az CA
	[x≷t]	4.472136†	Dist CA
26.1741†	[D]	26.294722†	$P1_{dec}$
45.3058†	[+/−] [E]	45.516111†	$\|P2\|_{dec}$
	[2nd] [D′]	100.000†	P_N
	[x≷t]	100.000†	P_E
	[2nd] [A′]	185.423966†	Az AP
	[x≷t]	10.049894†	Dist AP
	[2nd] [B′]	140.114166†	Az BP
	[x≷t]	7.810209†	Dist BP
	[2nd] [C′]	212.002066†	Az CP
	[x≷t]	9.434030†	Dist CP

† These values are printed if the PC-100A is connected.

Example 2: Determine the coordinates of point P in Case 2 of Figure 1. Notice that additional information is calculated by the program.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 20		
2†	[2nd] [E′]	0.000	Select Case No.
100	[A]	100.000†	A_N
100	[R/S]	100.000†	A_E
109	[B]	109.000†	B_N
97†	[R/S]	161.335418†	Az BA
	[x≷t]	9.486833†	Dist BA
108	[C]	108.000†	C_N
104†	[R/S]	206.335418†	Az CA
	[x≷t]	8.944272†	Dist CA
116.3350†	[D]	116.563889†	$P1_{dec}$
135.0000†	[E]	135.000000†	$P2_{dec}$
	[2nd] [D′]	106.000†	P_N
	[x≷t]	100.000†	P_E
	[2nd] [A′]	359.595895†	Az AP
	[x≷t]	6.000061†	Dist AP
	[2nd] [B′]	134.595895†	Az BP
	[x≷t]	4.242576†	Dist BP
	[2nd] [C′]	243.260895†	Az CP
	[x≷t]	4.472136†	Dist CP

† These values are printed if the PC-100A is connected.

Example 3: Determine the coordinates of point P in Case 3 of Figure 1. Notice that additional information is calculated by the program.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 20		
3†	[2nd] [E′]	0.000	Initialize
107	[A]	107.000†	A_N
102	[R/S]	102.000†	A_E
109	[B]	109.000†	B_N
99†	[R/S]	123.412424†	Az BA
	[x≷t]	3.605551†	Dist BA
109	[C]	109.000†	C_N
106†	[R/S]	243.260582†	Az CA
	[x≷t]	4.472136†	Dist CA
17.4445†	[D]	17.745833†	$P1_{dec}$
22.1705†	[+/−] [E]	22.284722†	$\|P2\|_{dec}$
	[2nd] [D′]	100.000†	P_N
	[x≷t]	100.000†	P_E
	[2nd] [A′]	195.563161†	Az AP
	[x≷t]	7.280120†	Dist AP
	[2nd] [B′]	173.392661†	Az BP
	[x≷t]	9.055553†	Dist BP
	[2nd] [C′]	213.411661†	Az CP
	[x≷t]	10.816537†	Dist CP

† These values are printed if the PC-100A is connected.

Register Contents

R_{00}	R_{06} Used	R_{12} Az CA (dec)	R_{18} ∠PAB (dec)
R_{01} Case No.	R_{07} Used	R_{13} Dist CA	R_{19} Az AP (dec)
R_{02} A_N (temp)/P_N	R_{08} Used	R_{14} ∠A (dec)	R_{20} B_N
R_{03} A_E (temp)/P_E	R_{09} Used	R_{15} ∠ P1 (dec)	R_{21} B_E
R_{04} Used	R_{10} Az BA (dec)	R_{16} ∠ P2 (dec)	R_{22} C_N
R_{05} Used	R_{11} Dist BA	R_{17} Dist AP	R_{23} C_E

BORROW PIT VOLUME

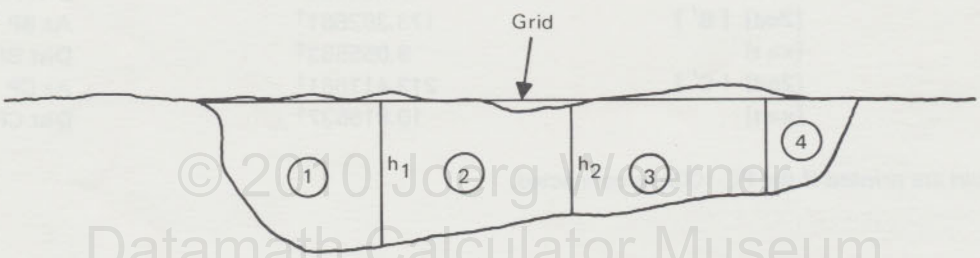
This program computes the amount of fill that can be taken from a borrow pit where the pit is described by a grid of triangles and rectangles, with the grid dimensions and the depth at grid intersections providing the information to compute the volume available in each grid section and the accumulated volume from a succession of sections. The following formula is used for each prism:

$$V = A \frac{h_1 + h_2 \ . \ . \ . + h_n}{n}$$

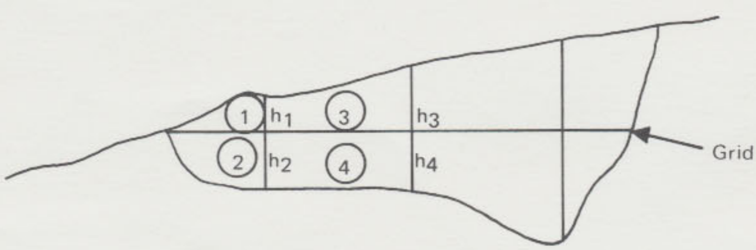
where

- V = volume of a truncated prism
- A = horizontal area of the prism
- h_i = depth (elevation) of corner i of the prism
- n = number of corners of the prism

Alternate Methods: The program assumes the grid layout to be on a fairly level surface.



But in the case where neither the pit floor nor the original surface are level, the grid may be 'placed' as shown in the following vertical cross-section to better approximate the volume.



Treat the volumes above and below the grid as separate prisms, each with its own corner elevations. For instance, prism 3 with elevations h_1 and h_3, and prism 4 with elevations h_2 and h_4 would be entered separately.

Reference: *Surveying (Fifth Edition)*, Bouchard, H. and Moffitt, F.H., International Textbook Co., Scranton, Pa., 1965, pp. 535-6.

Solid State Software				TI ©1977
BORROW PIT VOLUME				SY-21
→ALT : L	→Base : W	→ΣVol	→Sect Vol	[Init]→
ALT : L	Base : W	Tri △	Rect ▭	Depth

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 21	
2	Initialize		[2nd] [E′]	0.
	For each prism			
3	Enter altitude or length[1]	ALT:L	[A]	ALT:L†
4	Enter base or width[1]	Base: W	[B]	Base: W†
5	Identify section as triangle OR rectangle		[C] [D]	3.† 4.†
6	Enter corner depth (repeat for each corner)[2]	Corner depth†	[E]	# of corner entries left
	Optional — Display for current section			
7	Altitude or length		[2nd] [A′]	Alt:L†
8	Base or width		[2nd] [B′]	Base: W†
9	Cumulative volume so far		[2nd] [C′]	Σ Vol†
10	Section volume		[2nd] [D′]	Sect Vol†
11	Go to Step 3 for next prism			

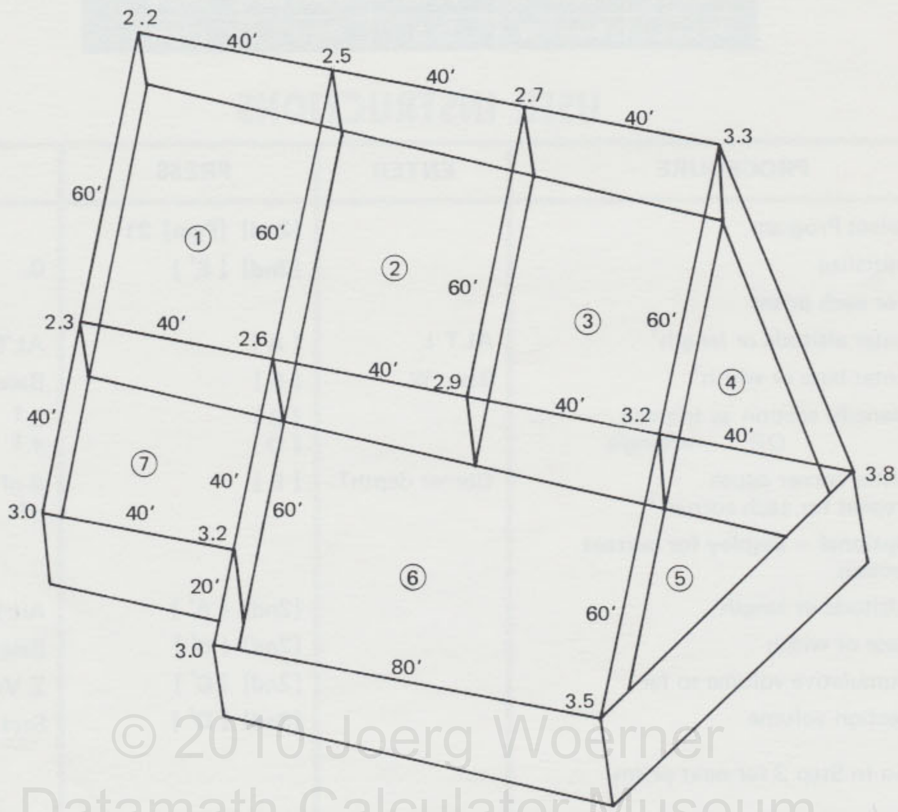
NOTES:
1. Do Steps 3 and 4 as needed. (See Example)
2. To recover from a mistake before the last corner depth is entered, go to Step 3; otherwise, begin again.

† These values are automatically printed if the PC-100A is connected.

Register Contents

R_{00} Counter	R_{05} Sect Vol	R_{10}	R_{15}
R_{01} Alt:L	R_{06} Σ Vol	R_{11}	R_{16}
R_{02} Base:W	R_{07} Depth	R_{12}	R_{17}
R_{03} Σ Depth	R_{08}	R_{13}	R_{18}
R_{04}	R_{09}	R_{14}	R_{19}

Example: A borrow pit has been divided into triangles and rectangles as shown below. Dimensions are shown along the sides of each plane figure with the numbers at each intersection representing the depth of cut (or fill) at that point. Find the volume of the pit.



ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 21		
	[2nd] [E′]	0.	Initialize
(Prism 1)			
60	[A]	60.†	L
40	[B]	40.†	W
	[D]	4.†	Rectangle
2.2†	[E]	3.	h_1
2.5†	[E]	2.	h_2
2.6†	[E]	1.	h_3
2.3†	[E]	0.	h_4
	[2nd] [D′]	5760.†	Prism Vol

Note that the entered dimensions of the next 4 prisms are the same as the first. These values need not be reentered.

ENTER	PRESS	DISPLAY	COMMENT
(Prism 2)			
	[2nd] [A′]	60.†	Display L
	[2nd] [B′]	40.†	Display W
	[D]	4.†	Rect.
2.5†	[E]	3.	h_1
2.7†	[E]	2.	h_2
2.9†	[E]	1.	h_3
2.6†	[E]	0.	h_4
	[2nd] [D′]	6420.†	Prism Vol.
	[2nd] [C′]	12180.†	Σ Vol

† These values are printed if the PC-100A is connected.

ENTER	PRESS	DISPLAY	COMMENT
(Prism 3)			
	[D]	4.†	Rect.
2.7†	[E]	3.	h_1
3.3†	[E]	2.	h_2
3.2†	[E]	1.	h_3
2.9†	[E]	0.	h_4
	[2nd] [C′]	19440.†	Σ Vol
(Prism 4)			
	[C]	3.†	Triangle
3.3†	[E]	2.	h_1
2.8†	[E]	1.	h_2
3.2†	[E]	0.	h_3
(Prism 5)			
	[C]	3.†	Triangle
3.2†	[E]	2.	h_1
3.8†	[E]	1.	h_2
3.5†	[E]	0.	h_3
(Prism 6)			
80	[A]	80.†	L
60	[B]	60.†	W
	[D]	4.†	Rect.
2.6†	[E]	3.	h_1
3.2†	[E]	2.	h_2
3.5†	[E]	1.	h_3
3†	[E]	0.	h_4
	[2nd] [D′]	14760.†	Prism Vol
	[2nd] [C′]	42520.†	Σ Vol
(Prism 7)			
40	[A]	40.†	L
40	[B]	40.†	W
	[D]	4.†	Rect.
2.3†	[E]	3.	h_1
2.6†	[E]	2.	h_2
3.2†	[E]	1.	h_3
3†	[E]	0.	h_4
	[2nd] [C′]	46960.†	Σ Vol

† These values are printed if the PC-100A is connected.

EARTHWORK VOLUME
(BY AVERAGE END AREA)

This program computes the volume of materials to be excavated or embanked on an engineering project. At each cross section station, the elevation and distance from the centerline of each point (corner) of the cross-sectional figure is entered, along with the interval from the last station; and the end area, incremental volume, and cumulative volume are computed. Although not exact, this method is the most often used since errors tend to be on the high side. The following formulas are used:

Area of a Cross Section = $\frac{1}{2}[x_1(y_2 - y_n) + x_2(y_3 - y_1) + x_3(y_4 - y_2) + \ldots + x_n(y_1 - y_{n-1})]$

where

x_i = horizontal distance of a point i in the cross section from the center line of the cross section

y_i = elevation at a point i in the cross section

Volume between Cross Sections = $\frac{1}{2}(A_n + A_{n+1})\,L$

where

A_n = cross sectional area at Station n

A_{n+1} = cross sectional area at Station n+1

L = length of interval between the two stations

Reference: *Surveying (5th edition),* H. Bouchard and F. Moffitt, International Textbook Co., Scranton, PA., 1965, p. 520 ff.

Solid State Software			TI ©1977	
EARTHWORK VOLUME				SY-22
→Sta Area	→Sta Vol	→Σ Vol	→Nxt Sta	[Init]→
Elev	Dist	Intv'l	[calc]→	

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 22	
2	Initialize		[2nd] [E']	1.
	For each point[1]			
3a	Enter elevation	Elev	[A]	Elev†
3b	Enter distance from centerline	Dist	[B]	Dist†
	For each station			
4	Enter interval from previous station (zero for 1st station)	Intv'l	[C]	Intv'l†
5	Calculate[2]		[D]	Next Station #†
	Optional — Display results			
6	Display station area		[2nd] [A']	Sta Area†
7	Display station volume		[2nd] [B']	Sta Vol†
8	Display cumulative volume		[2nd] [C']	Σ Vol†
9	Display next station number		[2nd] [D']	Next Sta #†

NOTES:

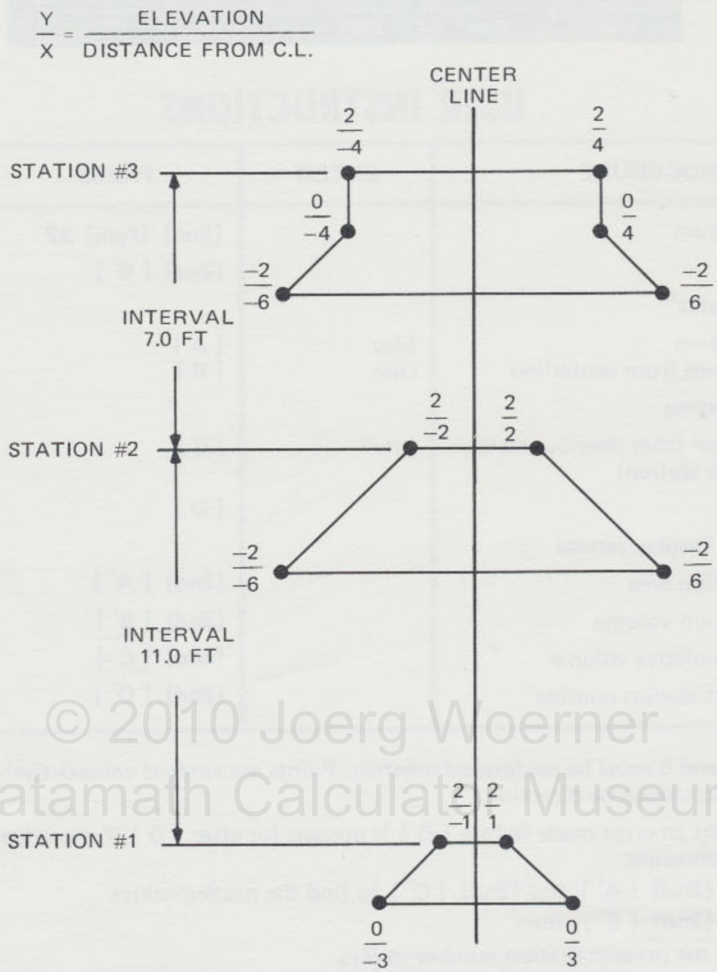
1. Step 3a and b must be performed together. Points are entered consecutively in either a clockwise or counterclockwise direction.
2. To correct an error made before [D] is pressed (or after [D] if the values below are known), do the following:
   Press [2nd] [A'] and [2nd] [C'] to find the needed values
   Press [2nd] [E'], then
   Store the present Station number in R_{10}
   Store the previous Station Area in R_{07}
   Store the previous Σ Volume in R_{12}
   Then go to Step 3 and continue.

† These values are automatically printed if the PC-100A is connected.

Register Contents

R_{00}		R_{05}	Used	R_{10}	Sta #	R_{15}	
R_{01}	Used	R_{06}	Used	R_{11}	Sta Vol	R_{16}	
R_{02}	Used	R_{07}	Sta Area	R_{12}	Σ Vol	R_{17}	
R_{03}	Used	R_{08}	Used	R_{13}		R_{18}	
R_{04}	Used	R_{09}	Interval	R_{14}		R_{19}	

Example: Given the embankment described by the following cross sections, compute the area of each cross section, the incremental volume and the accumulated volume.



Select EARTHWORK VOLUME Program (SY-22).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 22		
	[2nd] [E′]	1.	Initialize
(Station #1)			
2	[A]	2.†	Elevation
1	[+/−] [B]	−1.†	Distance
2	[A]	2.†	Elev
1	[B]	1.†	Dist
0	[A]	0.†	Elev
3	[B]	3.†	Dist
0	[A]	0.†	Elev
3	[+/−] [B]	−3.†	Dist
0	[C]	0.†	Interval
	[D]	2.†	calculate
	[2nd] [A′]	8.†	Sta Area
	[2nd] [D′]	2.†	Next Sta #
(Station #2)			
2	[A]	2.†	Elev
2	[+/−] [B]	−2.†	Dist
2	[A]	2.†	Elev
2	[B]	2.†	Dist
2	[+/−] [A]	−2.†	Elev
6	[B]	6.†	Dist
2	[+/−] [A]	−2.†	Elev
6	[+/−] [B]	−6.†	Dist
11	[C]	11.†	Intv'l
	[D]	3.†	calculate
	[2nd] [A′]	32.†	Sta Area
	[2nd] [B′]	220.†	Sta Vol
(Station #3)			
2	[A]	2.†	Elev
4	[+/−] [B]	−4.†	Dist
2	[A]	2.†	Elev
4	[B]	4.†	Dist
0	[A]	0.†	Elev
4	[B]	4.†	Dist
2	[+/−] [A]	−2.†	Elev
6	[B]	6.†	Dist
2	[+/−] [A]	−2.†	Elev
6	[+/−] [B]	−6.†	Dist
0	[A]	0.†	Elev
4	[+/−] [B]	−4.†	Dist
7	[C]	7.†	Intv'l
	[D]	4.†	calculate
	[2nd] [A′]	36.†	Sta Area
	[2nd] [B′]	238.†	Sta Vol
	[2nd] [C′]	458.†	Σ Vol

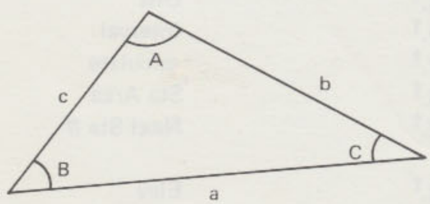
† These values are printed if the PC-100A is connected.

TRIANGLE SOLUTION (1 & 2)

Knowing certain combinations of attributes (sides or angles) of a triangle, the unknown attributes and the area can be calculated. These programs perform the following:

SY-23: Knowing SSS (sides a, b, c), compute angles A, B, C.
Knowing SS$\angle$ (sides a, b, $\angle$A), compute side c, $\angle$B, $\angle$C.
Knowing S$\angle$S (sides a, b, $\angle$C), compute c, $\angle$A, $\angle$B.

SY-24: Knowing $\angle$S$\angle$ (side a, $\angle$B, $\angle$C), compute b, c, $\angle$A.
Knowing S$\angle\angle$ (side a, $\angle$A, $\angle$C), compute b, c, $\angle$B.
Knowing 3 sides, compute the area of the triangle.



$$A + B + C = 180^\circ \text{ (or equivalent)}$$

$$c = \sqrt{a^2 + b^2 - 2\,ab\cos C}$$

$$\text{Area} = \sqrt{s\,(s-a)\,(s-b)\,(s-c)}\,, \quad \text{where } s = \frac{a+b+c}{2}$$

Remarks:

1) All angles must be entered in the same units, either degrees, grads, or radians, and the angular mode must be set accordingly.

2) The sum of entered angles must be less than 180°, π radians, or 200 grads.

3) The resulting solution to any particular problem may not be that problem's unique solution. The display will flash if no solution exists.

4) $\angle$'s are entered as DD

Solid State Software			TI ©1977	
TRIANGLE SOLUTION (1)				SY-23
[SSS]→∠A	[SS∠]→c	[S∠S]→c		
a	b	c :∠A :∠C	→∠B	→∠A :∠C

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1a	Select Program		[2nd] [Pgm] 23	
1b	Select angular mode			
	Knowing SSS			
2	Enter a	a	[A]	a†
3	Enter b	b	[B]	b†
4	Enter c	c	[C]	c†
5	Calculate ∠A		[2nd] [A′]	∠A†
6	Calculate ∠B		[D]	∠B†
7	Calculate ∠C		[E]	∠C†
	Knowing SS∠			
8	Enter a	a	[A]	a†
9	Enter b	b	[B]	b†
10	Enter ∠A	∠A	[C]	∠A†
11	Calculate c		[2nd] [B′]	c†
12	Calculate ∠B		[D]	∠B†
13	Calculate ∠C		[E]	∠C†
	Knowing S∠S			
14	Enter a	a	[A]	a†
15	Enter b	b	[B]	b†
16	Enter ∠C	∠C	[C]	∠C†
17	Calculate c		[2nd] [C′]	c†
18	Calculate ∠B		[D]	∠B†
19	Calculate ∠A		[E]	∠A†
	To Calculate Area			
20	Select Program		[2nd] [Pgm] 24	
21	Calculate Area		[2nd] [C′]	Area†

NOTES:

1. Does not run in ENG.
2. Cannot recalculate values without first reentering data.

† These values are automatically printed if the PC-100A is connected.

Solid State Software			TI ©1977	
TRIANGLE SOLUTION (2)				SY-24
[∠S∠]→∠A	[S∠∠]→∠B	→Area		
a	∠A : ∠B	∠C	→b	→c

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1a	Select Program		[2nd] [Pgm] 24	
1b	Select angular mode			
	Knowing ∠S∠			
2	Enter a	a	[A]	a†
3	Enter ∠B	∠B	[B]	∠B†
4	Enter ∠C	∠C	[C]	∠C†
5	Calculate ∠A		[2nd] [A′]	∠A†
6	Calculate b		[D]	b†
7	Calculate c		[E]	c†
	Knowing S∠∠			
8	Enter a	a	[A]	a†
9	Enter ∠A	∠A	[B]	∠A†
10	Enter ∠C	∠C	[C]	∠C†
11	Calculate ∠B		[2nd] [B′]	∠B†
12	Calculate b		[D]	b†
13	Calculate c		[E]	c†
14[1]	Calculate Area		[2nd] [C′]	Area†

NOTES:
1. a, b, c are stored in R_{00-02} by solving a triangle. They may be stored from the keyboard, if desired.
2. Cannot recalculate values without first reentering data.

† These values are automatically printed if the PC-100A is connected.

Example 1: Given a = 4.1, b = 2.7, c = 1.6, calculate the angles.

Select TRIANGLE SOLUTION (1) Program (SY-23).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 23		
	[2nd] [Deg]		
4.1	[A]	4.1†	a
2.7	[B]	2.7†	b
1.6	[C]	1.6†	c
	[2nd] [A′]	143.6639425†	∠A (degrees)
	[D]	22.96671197†	∠B
	[E]	13.36934555†	∠C

Example 2: Given a = 38.4, b = 16.8, ∠A = 42°, calculate c, ∠B, ∠C, and the area.

Select TRIANGLE SOLUTION (1) Program (SY-23).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 23		
	[2nd] [Deg]		
38.4	[A]	34.8†	a
16.8	[B]	16.8†	b
42	[C]	42.†	∠A
	[2nd] [B′]	49.20255436†	c
	[D]	17.02234529†	∠B
	[E]	120.9776547†	∠C
Select TRIANGLE SOLUTION (2) Program (SY-24).			
	[2nd] [C′]	276.5526543†	Area

Example 3: Given a = 2, b = $\sqrt{3}$, ∠C = .5235987756 radians, calculate c, ∠B, ∠A.

Load TRIANGLE SOLUTION (1) Program (SY-23).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 23		
	[2nd] [Rad]		
2	[A]	2.†	a
3	[√x] [B]	1.732050808†	b
.5235987756	[C]	.5235987756†	∠C
	[2nd] [C′]	1.†	c
	[D]	1.047197551†	∠B
	[E]	1.570796327†	∠A

† These values are printed if the PC-100A is connected.

Example 4: Given a = 15, ∠B = 80 grad, ∠C = 40 grad, calculate b, c, ∠A.

Select TRIANGLE SOLUTION (2) Program (SY-24).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 24		
	[2nd] [Grd]		
15	[A]	15.†	a
80	[B]	80.†	∠B
40	[C]	40.†	∠C
	[2nd] [A′]	80.†	∠A
	[D]	15.†	b
	[E]	9.270509831†	c

Example 5: Given a = 26.6, ∠A = 50° 12′, ∠C = 95° 23′58″, find the area.

Select TRIANGLE SOLUTION (2) Program (SY-24).

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 24		
	[2nd] [Deg]		
26.6	[A]	26.6†	a
50.12	[2nd] [D.MS] [B]	50.2†	∠A
95.2358	[2nd] [D.MS] [C]	95.39944444†	∠C
	[2nd] [B′]	34.40055556†	∠B
	[D]	19.56092333†	b
	[E]	34.46901009†	c
	[2nd] [C′]	259.0059172†	Area

† These values are printed if the PC-100A is connected.

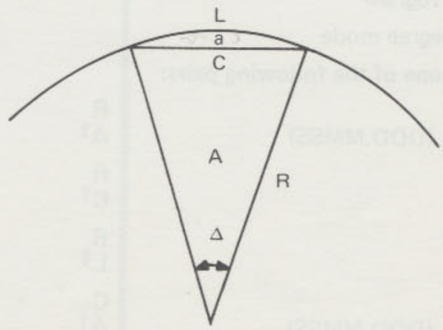
Register Contents (SY-23 and SY-24)

R_{00} a	R_{05} Used	R_{10}	R_{15}
R_{01} b	R_{06} Used	R_{11}	R_{16}
R_{02} c	R_{07}	R_{12}	R_{17}
R_{03} Used	R_{08}	R_{13}	R_{18}
R_{04} Used	R_{09}	R_{14}	R_{19}

CURVE SOLUTION

For an arc of a circle, this program calculates the remaining parameters when certain pairs are given. One of the following pairs of parameters must be supplied as input:

- R, Δ
- R, C
- R, L
- C, Δ
- Δ, L



Central angle, Δ (<180°)

Radius, R

Arc length, $L = \frac{\pi R \Delta}{180}$

Chord length, $C = 2\,R \sin \frac{\Delta}{2}$

Sector area, $A = \frac{LR}{2}$

Segment area, $a = A - \frac{CR}{2}\left[\cos \frac{\Delta}{2}\right]$

Reference: *Standard Math Tables,* Chemical Rubber Publishing Co., 1960.

Solid State Software			TI ©1977	
CURVE SOLUTION				SY-25
→Δ; R	→L; C	→A; a		
R; Δ	R; C	R; L	C; Δ	Δ; L

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Select Program		[2nd] [Pgm] 25	
2	Select degree mode		[2nd] [Deg]	
	Do any one of the following pairs:			
3a	Enter R	R	[A]	R†
4a	Enter Δ (DDD.MMSS)	Δ†	[R/S]	L†
3b	Enter R	R	[B]	R†
4b	Enter C	C†	[R/S]	L†
3c	Enter R	R	[C]	R†
4c	Enter L	L†	[R/S]	C†
3d	Enter C	C	[D]	C†
4d	Enter Δ (DDD.MMSS)	Δ†	[R/S]	L†
3e	Enter Δ (DDD.MMSS)	Δ	[E]	Δ (DDD.dddddd)†
4e	Enter L	L†	[R/S]	C†
	Do Steps 5–7 as needed			
5a	Calculate Δ and		[2nd] [A′]	Δ (DDD.MMSSss)†
5b	R		[R/S]	R†
6a	Calculate L and		[2nd] [B′]	L†
6b	C		[R/S]	C†
7a	Calculate A and		[2nd] [C′]	A†
7b	a		[R/S]	a†

NOTES:
1. Δ must be less than 180°.
2. Program leaves calculator in fix 6 display format.

† These values are automatically printed if the PC-100A is connected.

Example 1: Given R = 2, Δ = 30°20′17″, calculate all other elements.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 25		
2	[A]	2.000000†	R
30.2017†	[R/S]	1.058998†	L
	[2nd] [B′]	1.058998†	L
	[R/S]	1.046670†	C
	[2nd] [C′]	1.058998†	A
	[R/S]	0.048796†	a

Example 2: C = 2, Δ = 5.2°.

ENTER	PRESS	DISPLAY	COMMENT
	[2nd] [Pgm] 25		
2	[D]	2.000000†	C
5†	[R/S]	2.000635†	L
	[2nd] [A′]	5.000000†	Δ
	[R/S]	22.925586†	R
	[2nd] [C′]	22.932862†	A
	[R/S]	0.029096†	a

† These values are printed if the PC-100A is connected.

Register Contents

R_{00} Δ	R_{05}	R_{10}	R_{15}
R_{01} R	R_{06}	R_{11}	R_{16}
R_{02} L	R_{07}	R_{12}	R_{17}
R_{03} C	R_{08}	R_{13}	R_{18}
R_{04} A	R_{09}	R_{14}	R_{19}

APPENDIX A: PROGRAM REFERENCE DATA

Program Number	Title	No. of Steps	Data Reg. Used	Flags Used	SBR. Levels	Paren. Levels	Calls Pgms.	Special Functions Used	x ≷ t	ABS. Address.	Fix Decimal	EE*
01	Diagnostic	111	1-6, 11		1	4	11	N/A	CP	X	9	
02	Traverse (Az/Brg)	202	1-5, 7, 9-16, 18, 19, 20		2	4	4,5	DMS P/R	X	X	6	X
03	Traverse (Inverse)	189	0-5, 7, 9-16, 18, 19, 20		1	2	2	DMS P/R	X	X	6	X
04	Traverse (Field Angle)	170	0-5, 7, 9-15, 18, 19, 20		3	5	2,5	DMS P/R	X		6	X
05	Traverse (Circle Arc)	189	1-5, 7-12, 14, 15, 17-19, 20		2	4	2,3,4	DMS P/R	X	X	6	X
06	Closure	182	1-7, 9, 10, 13, 16-19		1	3	7	DMS	CP	X	6	
07	Balance (Compass Rule)	150	1-7, 9, 11, 12, 18, 19		2	3	8			X	6	
08	Balance (Transit Rule)	124	1-6, 11, 12, 14, 15, 18, 19		1	2	7				6	
09	Vertical Curve Design	222	1-9, 12, 16		0	3					6	
10	Horizontal Curve Design (1)	155	1-8, 11	1	2	5	11	DMS		X	6	
11	Horizontal Curve Design (2)	201	1-12	1	1	4	10	DMS		X	6	
12	Horizontal Curve Layout	183	2-8, 12-18	1	2	3		DMS	CP	X	6	
13	EDM Slope Reduction (Slope Angle)	205	1-11, 15, 17		0	3					6	
14	EDM Slope Reduction (Δ Elevation)	138	1-3, 5, 6, 12, 17, 18		1	3	13				6	
15	Stadia Reductions and Traverse	196	1-8, 10, 11, 13-18		1	4		DMS			6	
16	Intersection (Brg – Brg)	191	1-8, 10-13	7	1	4	6	DMS		X	6	
17	Intersection (Dist – Dist)	166	1-13, 20		1	3	2,6,16	DMS P/R	X	X	6	
18	Intersection (Brg – Dist)	195	1-14, 20		1	4	2,6,16	DMS P/R	X	X	6	
19	Intersection (Brg If ⊥)	176	1-12		2	4	6,16	DMS	CP	X	6	
20	3-Pt. Resection	521	1-23		2	4		DMS P/R	X	X	3,6	X
21	Borrow Pit Volume	135	0-3, 5-7	1	0	1			CP	X	9	
22	Earthwork Volume	207	1-12	1-3	1	3			CP	X	9	
23	Triangle Solution (1)	204	0-6	0-3	1	2	22			X	9	X
24	Triangle Solution (2)	163	0-6	0	0	2				X	9	
25	Curve Solution	249	0-4		2	6		DMS	CP	X	6	
	Pointers and Counters	176										

*Does not run in ENG.

ADDENDUM

The following corrections should be made in the Surveying Library manual.

Page 26

The User Instructions for Program SY-08 should be changed as follows:

1) The display column for Steps 7, 8, and 15 should read 0.000000†.
2) Replace Step 8 with the following:

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
8	Compute closure latitude and departure	N_s	[2nd] [B′]	N_s
		E_s	[2nd] [B′]	E_s
			[2nd] [D′]	0.000000†

These changes should be made in the Quick Reference Guide.

use with 1014984-4
1015755-4

1019307-1

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