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PUBLICATION SERIES

5

COMPUTER PROGRAMS (HP-65 DOCUMENTATION)

by
CHARLES C. CAMPBELL, L.S.

PUBLICATION
sponsored by
INDIANA SOCIETY OF PROFESSIONAL LAND SURVEYORS, INC.

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Charles C. Campbell, L.S.
(with contributions by others)

sponsored by

Indiana Society of Professional Land Surveyors, Inc.

January 1976

PREFACE

There have been many aids developed in the past for the surveyor to help him with his computations, eg: logs, slide rules, mechanical calculators, electronic calculators, scientific calculators, each one considered the ultimate, but now we have the HP-65 manufactured by the Hewlett-Packard Company, which probably is still not the ultimate, but close to it.

There has been much discussion on whether the 65 is a calculator or a computer. Actually it is both, but a computer first and a calculator second. Its power can be compared with the first digital computers developed, those which would take a building the size of a five room house to contain its electronic components and enviromental control equipment. This is because trig. functions, logs, square root, conversions, etc., are programmed into the hardware of the 65, which eliminates the need for large memories to store software routines.

Several of the programs by the author were considered to be needed once every 5 years, but were used the "next day". The programs have evolved from the authors past 20 years of experience and represents what he considers the best way to solve the problems. Some-time days were spent just to find a formula for a particular problem.

This manual is hereby dedicated to the memory of John H. Kantner, who was taken from us before his time and who first described to me, the HP-35 which Hewlett-Packard Company was about to place upon the market, at which time, was the only time during my long association with him, that I thought he was "telling me a story". It is further dedicated to Vincent J. Schneider, who programs the "big ones" and leaves the "little ones" to me.

ACKNOWLEDGEMENTS

This publication was sponsored by the Indiana Society of Professional Land Surveyors, Inc.

Acknowledgement is made to Richard H. Cassera, John A. Gilbert, M.S.E., Grant J. Munsey for their fine program contributions; to M. Neil Franklin, LS, PE for his help with the Manning's formula; to Ursell W. Cox for the drawings and special characters; to Gordon Martain for his fine cartoons, and to my wife Laura D. for her many hours of typing. Special acknowledgement is made to Prof. Kenneth S. Curtis, LS and Dr. John G. McEntyre, LS, authors of ISPLS Manuals 1 through 4, for their inspiration and encouragement and for allowing me to attempt to "bridge the gap between the academics and practical field use", if indeed such a gap exist, and to Thomas H. Murphy, LS, for many ideas for programs and testing them in the field.

Indianapolis, In., Jan. 1976 Charles C. Campbell

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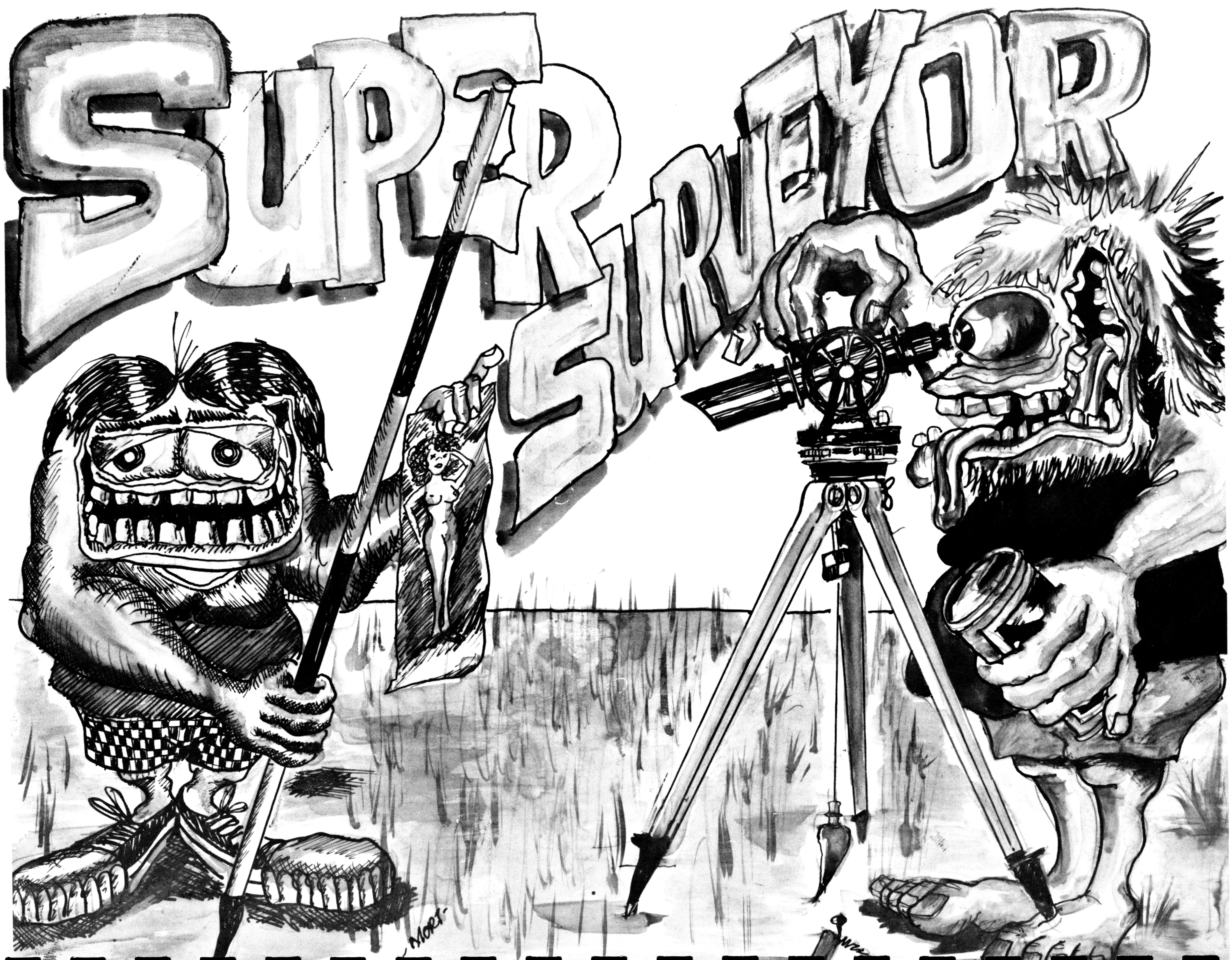

SUPER SURVEYOR

INTRODUCTION

Although computers won't make "Super Surveyors" out of us, they will relieve us from the drudgery of endless calculations so that our time can be devoted to worthier purposes and allows us to stake projects in the field using methods which would not have been considered before computers and electronic distance measuring equipment.

Although there are other "pocket computers" currently being developed, the HP-65 has features that should be considered necessary, such as: merged store and recall codes, degree-minute-second arithmetic, absolute value, integers, exchange x and y registers, plus software support. There are now approximately 4000 programs available for the 65. If more than 100 steps are needed in a program merely use another magnetic card. The author feels that all in all the "reversed polish notation" method is easier to master and use than the "algebraic" method.

The hardware of the HP-65 is not set out herein, since it is well covered in the "Owners Handbook". The magnetic cards may be purchased separately from Hewlett-Packard Co. and the program steps listed can be quickly keyed into the HP-65 and recorded onto the cards.

As general rules for CCC programs, (1) If one data item is entered with a function key: the data is keyed into the 65 then the function key is pushed. If more than one data item is entered: the function key is pushed first and data is entered with the R/S key. Exceptions include those programs requiring longitude and latitude in which both data items are entered with the same function key. (2) For most programs: distrubing the stack by using the HP-65 as a calculator during stops for intermediate answers does not affect the normal resumption of the program. Warnings are given for each program where the stack should not be distrubed. In any event, studying the program will yield the dos and don'ts.

In the future it is hoped that a supplemental manual of programs may be published. Anyone who has programs or ideas and formulas for programs, who may wish to contribute to CCC and is considered worthy of publication, will be rewarded with a free copy of the supplement.

Program Description I

Program Title ANGLES TO AZIMUTH

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

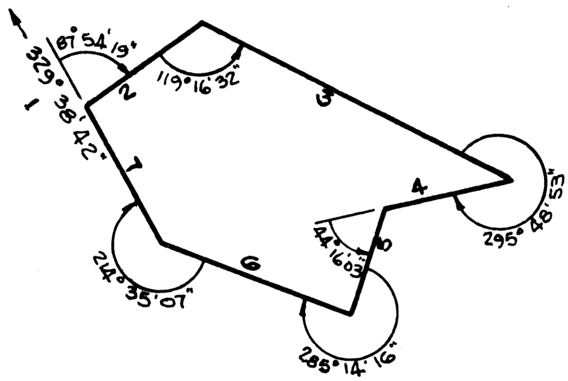
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes azimuths of the survey lines, given beginning azimuth and left deflection angle, right deflection angle, interior angle, or exterior angle or any combination thereof. Angle left(D key) means interior or exterior angle measured on the left side of line as we "walk" the traverse toward the point and conversly angle right(E key) means that the angle is on the right side.

All angles are converted to a right deflection angle then added to the last azimuth entered or computed.

Operating Limits and Warnings South or north azimuths may be computed. Angles and azimuths have I/O format of DDD.MMSS

Program Description II



Sample Problem(s) Compute azimuths for the lines in the above sketch.

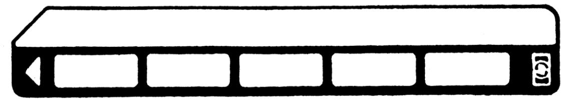
Steps: 329.3842A, 87.5419C, 119.1632E, 295.4853D, 44.1603B, 285.1416D, 214.3507 R/S.

Solution(s)

1. 329-38-42= beginning azimuth
2. 57-33-01
3. 118-16-29
4. 234-05-22
5. 189-49-19
6. 295-03-35
7. 329-38-42

Reference(s) None

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Load Program				
2.	Optional (See flag)		RTN	R/S	1.5
3.	Input Bgn. Az.	DDD.MMSS	A		
4.	Input Defl. Left	DDD.MMSS	B		Az.
4.	or Defl. Right	DDD.MMSS	C		Az.
4.	or Angle Left	DDD.MMSS	D		Az.
4.	or Angle Right	DDD.MMSS	E		Az.
5.	If next angle is same type, enter angle, push R/S.				
5.	Or return to step 4 for next angle				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
DSP	21	
•	83	
1	01	
1	01	
•	83	
5	05	Flag
R/S	84	Inp. Bgn. Azimuth
LBL	23	
A	11	
g	35	
DSZ	83	
GTO	22	
0	00	
g↓	3508	
RCL1	3401	
f	31	
D.MS+	02	
0	00	
gx>y	3524	
CLX	44	
RCL2	3402	
f	31	
D.MS+	02	
RCL2	3402	
gx>y	3524	
CLX	44	
0	00	
f-1	32	
D.MS+	02	
STO1	3301	
RTN	24	
LBL	23	Defl. left
B	12	
CHS	42	
1	01	
STO8	3308	
A	11	
R/S	84	New azimuth
GTO	22	
B	12	
LBL	23	Defl. right
C	13	
1	01	
STO8	3308	
A	11	
R/S	84	New azimuth
GTO	22	
C	13	
LBL	23	Angle left
D	14	

KEY ENTRY	CODE SHOWN	COMMENTS
RCL	3403	
f-1	32	
D.MS+	02	
1	01	
STO8	3308	
A	11	
R/S	84	New azimuth
GTO	22	
D	14	
LBL	23	
E	15	Angle right
RCL3	3403	
gx⇄y	3507	
f-1	32	
D.MS+	02	
1	01	
STO8	3308	
A	11	
R/S	84	New azimuth
GTO	22	
E	15	
LBL	23	
0	00	
DSP	21	
•	83	
4	04	
3	03	
6	06	
0	00	
STO2	3302	
2	02	
÷	81	
STO3	3303	
g↓	3508	
STO 1	3301	Begin azimuth
RTN	24	

REGISTERS	
R_1	Bgn. Az.
R_2	360 180
R_3	180
R_4	
R_5	
R_6	
R_7	
R_8	used DSZ
R_9	used tests

LABELS	
A	Bgn.Az.
B	Def.L
C	Def.R
D	△L
E	△R
0	used
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title AZIMUTH TRAVERSE/INVERSE

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Uses north azimuths to compute the unknowns by traversing or inversing from same point or from point to point. Additionally the last azimuth traversed or inversed may be used in the traverse routine as is or rotated any amount left or right.

TRAVERSE:

$$N2 = N1 + \cos \text{azimuth} \times \text{distance}$$
$$E2 = E1 + \sin \text{azimuth} \times \text{distance}$$

INVERSE:

$$\text{azimuth} = \tan^{-1} \frac{E2 - E1}{N2 - N1}$$

$$\text{distance} = \sqrt{(N2-N1)^2 + (E2-E1)^2}$$

WHERE:

N1 = North coord. point 1

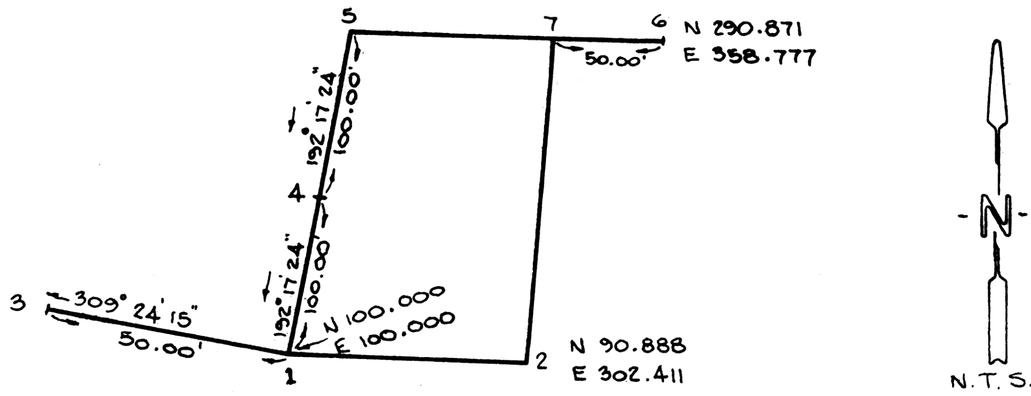
E1 = East coord. point 1

N2 = North coord. point 2

E2 = East coord. point 2

Operating Limits and Warnings None

Program Description II



Sample Problem(s) Solve for the unknowns in the above sketch, entering the known data as shown one time, except for coord. of point 2:

STEPS: RTN, R/S, 100R/S, R/S, D, E, 90.888R/S, 302.411R/S, R/S, A, 309.2415R/S, 50R/S, R/S, C, A, 192.1724R/S, B, 180CHS, R/S, 100R/S, R/S, B, R/S, 100R/S, R/S,E, 290.871R/S, 358.777R/S, R/S, B, 180R/S, 50R/S, R/S, E, 90.888R/S, 302.411R/S, R/S.

Solution(s)

LINE	AZIMUTH	DISTANCE	POINT	N	E
1-2	92-34-39	202.616	3	131.739	61.366
5-6	91-12-16	216.253	4	197.708	121.286
7-2	181-49-01	201.135	5	295.417	142.572
			7	291.922	308.788

Reference(s) Any surveying textbook.

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input starting coordinate (Note 1)		RTN	R/S	1.00
	Starting Northing	N1	R/S		
	Starting Easting	E1	R/S		
3	Traverse point to point (Note 2)		C	A	
3	Or traverse from same point (Note 2)		D	A	
4	Input azimuth	A	R/S		
5	Input distance (see north coordinate)	d	R/S		Nn
6	(See east coordinate)		R/S		En
	Repeat steps 4,5,&6 or go to steps 2,3,7, or 11				
7	Inverse point to point (Note 2)		C	E	
7	Or inverse from same point (Note 2)		D	E	
8	Input next north coordinate	Nn	R/S		
9	Input next east coordinate (See azimuth)	En	R/S		azimuth
10	(See distance)		R/S		distance
	Repeat steps 8,9, & 10 or go to steps 2,3,7,11				
11	Recall last azimuth and rotate (Note 3)		B		
12	No rotation		R/S		
12	Rotate xx°xx'xx" right (Note 4)	dd.mmss	R/S		
12	Rotate xx°xx'xx" left	dd.mmss	CHS	R/S	
	Continue at step 5				
	NOTE 1: Point 2 from intersection programs by the contributor, is in starting coordinate position.				
	NOTE 2: C or D key does not have to be pressed, if it was pressed during prior computation.				
	NOTE 3: Last azimuth travered or inversed.				
	NOTE 4: OK if azimuth is negative or exceeds 360 degrees.				
	NOTE 5: When traversing with south azimuths, the user may input the south azimuth, (without 180 degree rotation), then input the distance as a negative value, which has the effect of rotating the azimuth 180 degrees.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
1	01	Flag
R/S	84	Input N1
STO1	3301	
R/S	84	Input E1
STO2	3302	
R/S	84	
LBL	23	
C	13	Point to point
f-1	32	
SF 1	51	
LBL	23	
A	11	Traverse
DSP	21	
•	83	
3	03	
R/S	84	Input az. (See En)
f-1	32	
→D.MS	03	
LBL	23	Return point from B
1	01	
STO3	3303	
R/S	84	Input distance
RCL3	3403	
gx⇄y	3507	
f-1	32	
R→P	01	
RCL1	3401	
+	61	
f-1	32	
TF 1	61	
STO1	3301	
gnop	3501	
R/S	84	See Nn
gx⇄y	3507	
RCL2	3402	
+	61	
f-1	32	
TF 1	61	
STO2	3302	
gnop	3501	
GTO	22	
A	11	
LBL	23	Last azimuth
B	12	
0	00	
R/S	84	Input rotation
f-1	32	
→D.MS	03	
RCL 3	3403	
+	61	

KEY ENTRY	CODE SHOWN	COMMENTS
GTO	22	
1	01	
LBL	23	
D	14	From same point
f	31	
SF 1	51	
LBL	23	
E	15	Inverse
DSP	21	
•	83	
3	03	
R/S	84	Input N2(See dist.)
STO5	3305	
R/S	84	Input E2
STO6	3306	
RCL2	3402	
-	51	
RCL5	3405	
RCL1	3401	
-	51	
f	31	
R→P	01	
STO4	3304	
gx⇄y	3507	
0	00	
gx≥y	3524	
3	03	
6	06	
0	00	
+	61	
+	61	
STO3	3303	
f	31	
→D.MS	03	
DSP	21	
•	83	
4	04	
R/S	84	See azimuth
RCL4	3404	
f	31	
TF 1	61	
GTO	22	
E	15	
RCL5	3405	
STO1	3301	
RCL6	3406	
STO2	3302	
RCL4	3404	
GTO	22	
E	15	

REGISTERS	
R_1	N1
	Nn
R_2	E1
	En
R_3	azimuth
R_4	distance inversed
R_5	N2
R_6	E2
R_7	
R_8	
R_9	

LABELS	
A	TRA.
B	last az.
C	PT.- PT.
D	from PT
E	INV.
0	
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	used
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title AZIMUTH-AZIMUTH INTERSECT

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc.

Given two known north azimuths from two known coordinated points, the program computes the two unknown distances and the coordinate of the intersecting point. The computed coordinates are stored for use as the starting coordinates with the "AZIMUTH TRAVERSE/INVERSE" program.

$$\text{distance a (pt. 1 to 2)} = \frac{(N3-N1)\sin B-(E3-E1)\cos B}{\sin(B-A)}$$

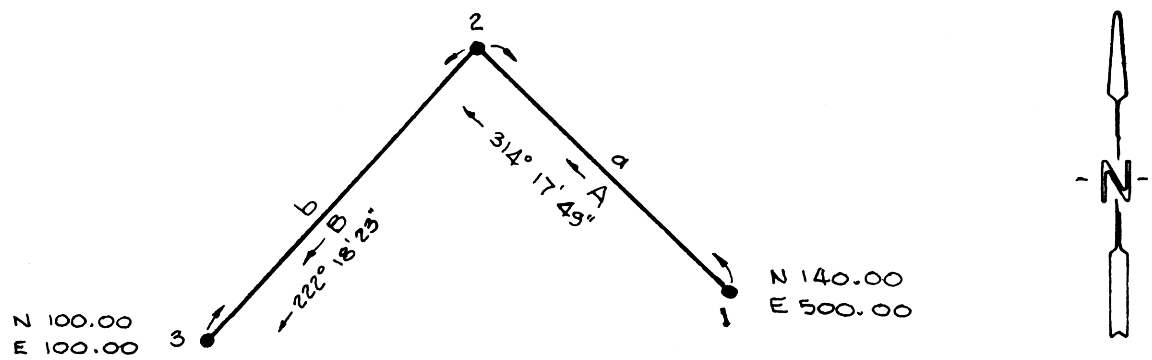
$$\text{distance b (pt. 2 to 3)} = \frac{(N3-N1)\sin A-(E3-E1)\cos A}{\sin(B-A)}$$

$$N2 = N1 + a\cos A \qquad E2 = E1 + a\sin A$$

Operating Limits and Warnings

Flashing 0 indicates that the problem is ambiguous: eg the two lines will not intersect.

Program Description II



Sample Problem(s) Solve for the unknowns in the above sketch:

STEPS: A, 140R/S, 500R/S, 314.1749R/S, 222.1823R/S, 100R/S, R/S, R/S, R/S, R/S.

Solution(s)

a = 269.061
b = 308.166
N2 = 327.906
E2 = 307.425

Reference(s) Welch, Harold J., <u>Traverse Tips,</u> out of print.

User Instructions

AZ.-AZ. INTERSECT

Start

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter Program			
2	Start (See flag)		A	2.00
3	Input north coordinate of point 1	N1	R/S	
4	Input east coordinate of point 1	E1	R/S	
5	Input azimuth of line 1-2	A	R/S	
6	Input azimuth of line 2-3	B	R/S	
7	Input north coordinate of point 3	N3	R/S	
8	Input east coordinate of point 3	E3	R/S	dist. a
9			R/S	dist. b
10	See north coordinate of point 2		R/S	N2
11	See east coordinate of point 2		R/S	E2
12	Return to step 2 for next intersection			
	NOTES:			
1	a = distance line 1-2			
2	b = distance line 2-3			
3	Coordinate of point 2, the intersection point, is			
	stored for use as the starting coordinate with			
	"Azimuth Traverse/Inverse" program.			
4	Flashing 0 indicates the problem is ambiguous. Lines			
	will never intersect.			
5	Azimuths have I-0 format of DDD.MMSS			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
DSP	21	
.	83	
3	03	
2	02	Flag
RTN	24	Input N1
STO1	3301	
R/S	84	Input E1
STO2	3302	
R/S	84	Input azimuth A
f-1	32	
→D.MS	03	
STO3	3303	
DSP	21	
.	83	
4	04	
gLSTx	3500	
R/S	84	Input azimuth B
f-1	32	
→D.MS	03	
STO4	3304	
gLSTx	3500	
R/S	84	Input N3
RCL 1	3401	
-	51	
STO5	3305	
DSP	21	
.	83	
3	03	
gLSTx	3500	
+	61	
R/S	84	Input E3
RCL 2	3402	
-	51	
RCL 4	3404	
RCL 4	3404	
RCL 3	3403	
-	51	
f	31	
SIN	04	
STO6	3306	
g↓	3508	
E	15	
STO7	3307	
R/S	84	See a
g↓	3508	
RCL 3	3403	
E	15	
R/S	84	See b

KEY ENTRY	CODE SHOWN	COMMENTS
RCL 3	3403	
RCL 7	3407	
f-1	32	
R→P	01	
RCL 1	3401	
+	61	
STO1	3301	
gx⇄y	3507	
RCL 2	3402	
+	61	
STO2	3302	
RCL 1	3401	
R/S	84	See N2
RCL 2	3402	
R/S	84	See E2
GTO	22	
A	11	
LBL	23	
E	15	
1	01	
f-1	32	
R→P	01	
g↑	3509	
x	71	
gx⇄y	3507	
RCL 5	3405	
x	71	
-	51	
RCL 6	3406	
÷	81	
g	35	
ABS	06	
RTN	24	

REGISTERS	
R_1	N1 N2
R_2	E1 E2
R_3	A
R_4	B
R_5	used
R_6	Sin B-A
R_7	a
R_8	
R_9	

LABELS	
A	start
B	
C	
D	
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title AZIMUTH-DISTANCE INTERSECT

Contributor's Name Charles C. Cabpbell, LS

Address 9841 E 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Given a known north azimuth from one coordinated point and a known distance from another coordinated point. The program computes the unknown azimuth, distance, and the coordinates of the intersecting point, short or long solution. The computed coordinates are stored for use as the starting coordinates with the "AZIMUTH TRAVERSE/INVERSE" program. Let 1st course contain known azimuth and 2nd course contain known distance.

$$\text{Sin}(B-A) \pm 180 = \frac{(N3-N1)\,\text{Sin}A - (E3-E1)\,\text{Cos}\,A}{b}$$

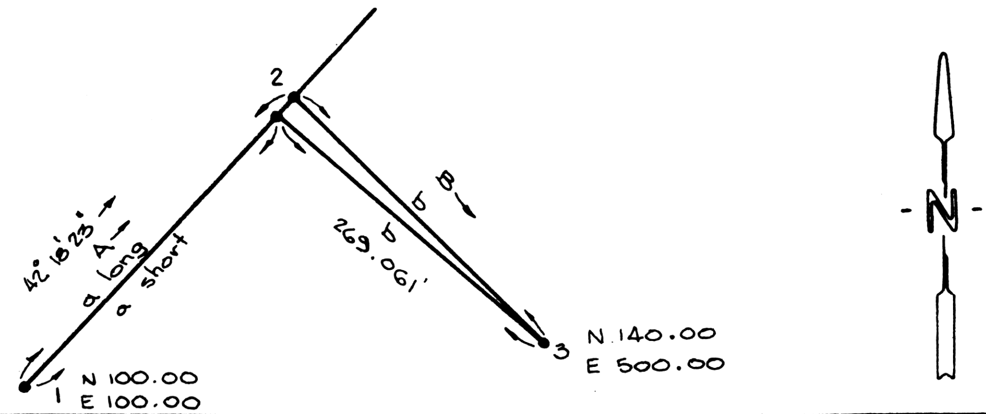
$$a = \frac{(N3-N1)\,\text{Sin}B-(E3-E1)\,\text{Cos}\,B}{\text{Sin}\,(B-A)}$$

$$N2 = N1 + a\text{Cos}A$$

$$E2 = E1 + a\,\text{Sin}A$$

Operating Limits and Warnings Flashing 0 indicates that the problem is ambiguous; eg: the two lines will not intersect.

Program Description II



Sample Problem(s) NO. 1 Solve for the knowns (long solution) in the above sketch:

STEPS: A, 100R/S, R/S, 42.1823R/S, 269.061R/S, 140R/S, 500R/S, R/S, R/S, R/S

NO. 2 Solve same for short solution:

STEPS: Same as No. 1 except push B instead of A.

Solution(s)

		LONG		SHORT
No. 1	a	308.167	No. 2	a = 289.474
	B	134-17-49		B = 130-18-56
	N2	327.906		N2 = 314.082
	E 2	307.425		E2 = 294.843

Reference(s) Welch, Harold J., Traverse Tips, out of print.

User Instructions

AZ.-DIST. INTERSECT

Long | Short

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	Choose long intersection		A		
2	Or short intersection		B		
3	Input North coordinate of point 1	N1	R/S		
4	Input East coordinate of point 1	E1	R/S		
5	Input azimuth of line 1-2	A	R/S		
6	Input distance of line 2-3	b	R/S		
7	Input North coordinate of point 3	N3	R/S		
8	Input East coordinate of point 3	E3	R/S		dist. a
9			R/S		B
10	See North coordinate of point 2		R/S		N2
11	See East coordinate of point 2		R/S		E2
12	Return to step 2 for next intersection				
	NOTES:				
1	a = distance line 1-2				
2	B = azimuth line 2-3				
3	Coordinate of Point 2, the intersection point, is				
	stored for use as the starting coordinate with				
	"Azimuth Traverse/Inverse" program.				
4	Flashing 0 indicates the problem is ambiguous. Lines				
	will never intersect.				
5	Azimuths have I/0 format at DDD.MMSS				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
f-1	32	Long
SF 1	51	Off
LBL	23	
3	03	
DSP	21	
•	83	
3	03	
RTN	24	Input N1
STO1	3301	
R/S	84	Input E1
STO2	3302	
R/S	84	Input A
f-1	32	
→D.MS	03	
STO7	3307	
f	31	
TF 1	61	
1	01	
8	08	
0	00	
+	61	
STO3	3303	
RCL 7	3407	
R/S	84	Input b
STO4	3304	
R/S	84	Input N3
RCL 1	3401	
-	51	
STO5	3305	
gLSTx	3500	
+	61	
R/S	84	Input E3
RCL 2	3402	
-	51	
RCL 3	3403	
E	15	
f-1	32	
SIN	04	
RCL 3	3403	
+	61	
1	01	
8	08	
0	00	
gx > y	3524	
CHS	42	
gnop	3501	
-	51	
STO6	3306	
E	15	
g	35	

KEY ENTRY	CODE SHOWN	COMMENTS
ABS	06	
STO4	3304	
R/S	84	See a
RCL 6	3406	
f	31	
→D.MS	03	
DSP	21	
•	83	
4	04	
R/S	84	See B
RCL 7	3407	
RCL 4	3404	
f-1	32	
R → P	01	
RCL 1	3401	
+	61	
STO1	3301	
gx⇄y	3507	
RCL 2	3402	
+	61	
STO2	3302	
RCL 1	3401	
DSP	21	
•	83	
3	03	
R/S	84	See N2
RCL 2	3402	
R/S	84	See E2
LBL	23	
E	15	
1	01	
f-1	32	
R → P	01	
gx⇄y	3507	
RCL 5	3405	
x	71	
gx⇄y	3507	
g↓	3509	
x	71	
-	51	
RCL 4	3404	
÷	81	
STO4	3304	
RTN	24	
LBL	23	
B	12	Short
f	31	
SF 1	51	On
GTO	22	
3	03	

REGISTERS	
R_1	N1 / N2
R_2	E1 / E2
R_3	A or A+ 180
R_4	b Sin B-A / a
R_5	N3-N1
R_6	B
R_7	A
R_8	
R_9	

LABELS	
A	long
B	short
C	
D	
E	used
0	
1	
2	
3	used
4	
5	
6	
7	
8	
9	

FLAGS	
1	used
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title DISTANCE - DISTANCE INTERSECT

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Given two known distances from two known coordinated points, the program computes the two unknown north azimuths and the coordinates of the intersecting point. The computed coordinates are stored for use as the starting coordinates with the "AZIMUTH TRAVERSE/INVERSE" program. "Traverse" in a "clockwise" direction. For opposite solution "traverse" from point 3 to 1.

USES COSINE LAW:

$$A = \text{azimuth } (1-3) - \text{Cos}^{-1} \frac{c}{a}$$

$$B = \text{azimuth } (1-3) + \text{Cos}^{-1} \frac{d-c}{b}$$

Where: $d = \sqrt{(E3-E1)^2 + (N3-N1)^2}$ Azimuth $(1-3) = \tan^{-1} \dfrac{E3-E1}{N3-N1}$

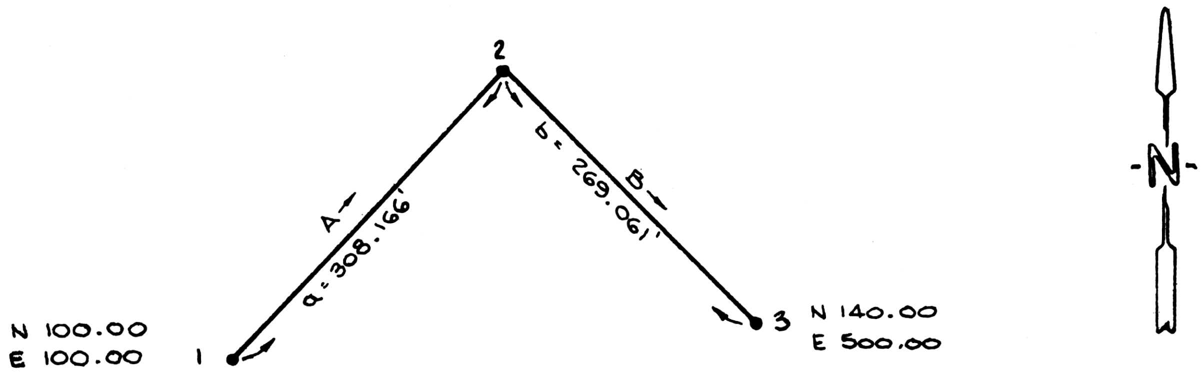
$$c = \frac{d^2 + a^2 - b^2}{2d}$$

$$N2 = N1 + a\text{Cos } A$$

$$E2 = E1 + a\text{Sin } A$$

Operating Limits and Warnings Flashing 0 indicates that the problem is ambiguous; eg: the sum of the two lines is to small to intersect.

Program Description II



Sample Problem(s) Solve for the unknowns in the above sketch:

STEPS: A, 100R/S, R/S, 308.166R/S, 269.061R/S, 140R/S, 500R/S, R/S, R/S, R/S.

Solution(s)

A= 42-18-23
B=134-17-49
N2 = 327.906
E2 = 307.425

Reference(s) Welch, Harold J., Traverse Tips, out of print.

User Instructions

DIST.-DIST. INTERSECT

Start				

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter Program			
2	Start (See flag)			3.000
3	Input north coordinate of point 1	N1	R/S	
4	Input east coordinate of point 1	E1	R/S	
5	Input distance of line 1-2	a	R/S	
6	Input distance of line 2-3	b	R/S	
7	Input north coordinate of point 3	N3	R/S	
8	Input east coordinate of point 3	E3	R/S	A
9			R/S	B
10	See north coordinate of point 2		R/S	N2
11	See east coordinate of point 2		R/S	E2
12	Return to step 2 for next intersection			
	NOTES:			
1	A = azimuth line 1-2			
2	B = azimuth line 2-3			
3	Coordinate of point 2, the intersection point, is			
	stored for use as the starting coordinate with			
	"Azimuth Traverse/Inverse" program.			
4	Flashing 0 indicates the problem is ambiguous. Lines			
	will not intersect.			
5	Azimuths have I-O format of DDD.MMSS			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
DSP	21	Start
.	83	
3	03	
3	03	flag
RTN	24	Input N1
STO1	3301	
R/S	84	Input E1
STO2	3302	
R/S	84	Input a
STO3	3303	
R/S	84	Input b
STO4	3304	
R/S	84	Input N3
STO5	3305	
R/S	84	Input E3
RCL 2	3402	
-	51	
RCL 5	3405	
RCL 1	3401	
-	51	
f	31	
R → P	01	
STO5	3305	
gx⇄y	3507	
E	15	
gx⇄y	3507	
f-1	32	
√x	09	
RCL 3	3403	
f-1	32	
√x	09	
+	61	
RCL 4	3404	
f-1	32	
√x	09	
-	51	
RCL 5	3405	
2	02	
x	71	
÷	81	=c
STO6	3306	
RCL 3	3403	
÷	81	
f-1	32	
COS	05	
-	51	
E	15	
STO7	3307	
DSP	21	
.	83	

KEY ENTRY	CODE SHOWN	COMMENTS
4	04	
f	31	
→D.MS	03	
R/S	84	See A
CLX	44	
RCL 5	3405	
RCL 6	3406	
-	51	
RCL 4	3404	
÷	81	
f-1	32	
COS	05	
+	61	Sub.360 if necessary
3	03	
6	06	
0	00	
gx > y	3524	
CLX	44	
0	00	
-	51	
f	31	
→D.MS	03	
R/S	84	See B
DSP	21	
.	83	
3	03	
RCL 7	3407	
RCL 3	3403	
f-1	32	
R → P	01	
RCL 1	3401	
+	61	
STO 1	3301	
R/S	84	See N2
gx⇄y	3507	
RCL 2	3402	
+	61	
STO 2	3302	
R/S	84	See E2
LBL	23	if negative, add 360
E	15	
0	00	
gx > y	3524	
3	03	
6	06	
0	00	
+	61	
+	61	
RTN	24	

REGISTERS	
R_1	N1
	N2
R_2	E1
	E2
R_3	a
R_4	b
R_5	N3
	d
R_6	c
R_7	A
R_8	
R_9	

LABELS	
A	start
B	
C	
D	
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title STA. /OFFSET CALC.

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes stationing along a line and right angle offset, left or right of the line, given beginning coordinates of a point on the line and the north azimuth of the line, and the coordinates of the second point. Also computes the coordinates of the second point given stationing and offset. Positive offset is right of line and negative offset is left of line. Positive stationing is along the line and negative stationing is along the opposite extension of the line. Let N1 & E1 represent the rectangular coordinates of point 1 and N2 & E2 the rectangular coordinates of point 2:

STA=stationing = d COS B OFF=offset = d SIN B

N2 = N1+ STA Cos A+OFF Cos(A+90)

E2 = E1+STA Sin A+ OFF Sin(A+90)

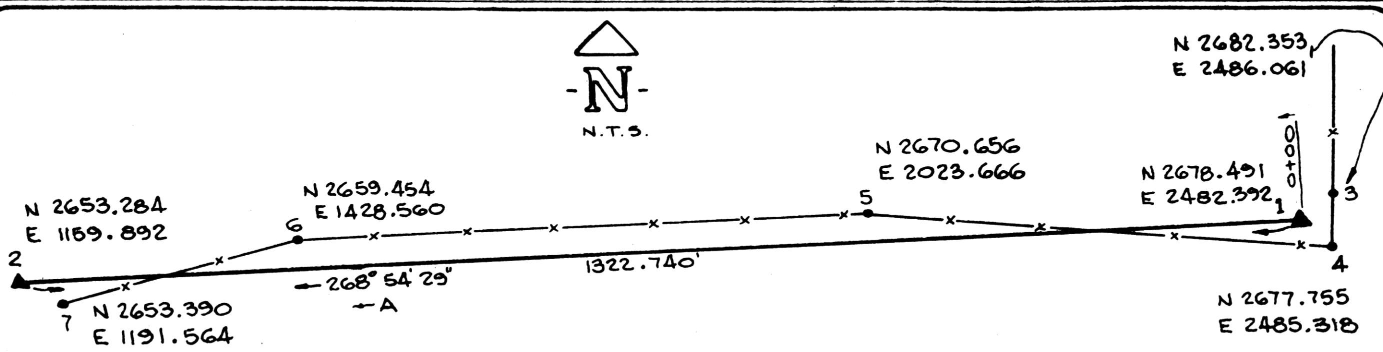
WHERE: A = azimuth of the line

$$B = \tan^{-1} \frac{E2-E1}{N2-N1} - A$$

$$d = \sqrt{(E2-E1)^2 + (N2-N1)^2}$$

Operating Limits and Warnings None

Program Description II



Sample Problem(s) (1) Compute the stationing and offsets of points 2 through 7 with respect to line (1-2) with point 1 being station 0+00.

STEPS: A, 2678.491R/S, 2482.392R/S, 268.5429R/S, B, 2653.284R/S, 1159.892, R/S, R/S, 2682.353R/S, 2486.061R/S, R/S, 2677.755R/S, 2485.318R/S, R/S, 2670.656R/S, 2023.666R/S, R/S, 2659.454R/S, 1428.56 R/S, R/S, 2653.39R/S, 1191.564 R/S, R/S.

(2) Compute the coordinates of the points. Start by pressing C key, then inter the desired stationing R/S, then the offset R/S, see the northing and press R/S to see the easting.

Solution(s)

	NO. 1		NO. 2	
POINT	STATIONING	OFFSET	N	E
2	13+22.740	0.000	2653.284	1159.892
3	-0+03.742	3.791R	2682.353	2486.061
4	-0+02.911	-0.792L	2677.755	2485.318
5	4+58.792	0.908R	2670.656	2023.666
6	10+54.003	1.049R	2659.454	1428.560
7	12+91.072	-0.497L	2653.390	1191.564

Reference(s) None

User Instructions

STA.-OFFSET CALC.

N-E-A | Calc. STA-OFF | Calc. COORD.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	Start (See flag)		A		9.
3	Input N1	N1	R/S		
4	Input E1	E1	R/S		
5	Input north azimuth of line	A	R/S		
6	Calc. stationing and offset (see flag)		B		2.
7	Input N2	N2	R/S		
8	Input E2 (note 1)	E2	R/S		Sta.
9	(note 2)		R/S		Off.
10	Return to step 7 or go to step 2 or 11				
11	or calc. coordinates (see flag)		C		3.
12	Input stationing (note 1)		R/S		
13	Input offset (note 2)		R/S		N2
14			R/S		E2
15	Return to step 12 or go to step 2 or 6				
	NOTES:				
1	If sta. is negative, it is back stationing				
2	If positive, it is right of line, if negative, it is left				
	of line				
3	Input format for A is DDD.MMSS				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
DSP	21	
•	83	
0	00	
9	09	flag
RTN	24	Input N1
STO 1	3301	
DSP	21	
•	83	
3	03	
R/S	84	Input E1
STO 2	3302	
R/S	84	Input azimuth
STO 5	3305	
f-1	32	
→D.MS	03	
STO 3	3303	
9	09	
0	00	
+	61	
STO 7	3307	
RCL 5	3405	
DSP	21	
•	83	
4	04	
R/S	84	
LBL	23	
B	12	
DSP	21	
•	83	
0	00	
2	02	
LBL	23	
0	00	
R/S	84	Input N2(see offset)
RCL 1	3401	
-	51	
STO 4	3304	
gLSTx	3500	
+	61	
DSP	21	
•	83	
3	03	
R/S	84	Input E2
RCL 2	3402	
-	51	
RCL 4	3404	
f	31	
R→P	01	

KEY ENTRY	CODE SHOWN	COMMENTS
gx⇄y	3507	
RCL 3	3403	
-	51	
gx⇄y	3507	
f-1	32	
R→P	01	
gx⇄y	3507	
STO 6	3306	
gx⇄y	3507	
R/S	84	
RCL 6	3406	
GTO	22	
0	00	
LBL	23	
C	13	
DSP	21	
•	83	
0	00	
3	03	
LBL	23	
1	01	
R/S	84	Input STA (see E2)
DSP	21	
•	83	
3	03	
STO 6	3306	
R/S	84	Input OFFSET
RCL 7	3407	
gx⇄y	3507	
f-1	32	
R→P	01	
RCL 1	3401	
+	61	
gx⇄y	3507	
RCL 2	3402	
+	61	
RCL 3	3403	
RCL 6	3406	
f-1	32	
R→P	01	
g↓	3508	
+	61	
STO 4	3304	
g↑	3508	
+	61	
R/S	84	See N2
RCL 4	3404	
GTO	22	
1	01	

REGISTERS	
R_1	N1
R_2	E1
R_3	azimuth DDD.DDDD
R_4	N2-N1
R_5	azimuth DDD.MMSS
R_6	offset
R_7	azimuth +90
R_8	
R_9	
LABELS	
A	N1-E1-A
B	calc. S-O
C	calc. coord.
D	
E	
0	used
1	used
2	
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title BEARING TRAVERSE/CURVES

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Card One contains traverse routine similar to program 00116A, except lettered keys are used to define bearing quadrant. Also closing errors and area(sq. ft. and acres) are computed. Card One is used to enter first radial of curve(from PC to radius point). Bearing of second radial of curve(from RP to PT) is entered with Card Two. Central(delta) angle of curve, arc length, and coordinates of PT are computed with Card Two. The program may be used in conjunction with "CLOSURE FOR FIELD ANGLE AND BEARING TRAVERSE NO. 00117A" and "SIDE SHOTS NO. 00119B".

Formulas same as program No. 00116A except:

$$\text{arc length} = \frac{\pi \Delta R}{180}$$

$$\text{area sector of circle} = \frac{\text{radius x length}}{2}$$

delta = difference in bearing of radials

En = error in northing Ee = error in easting

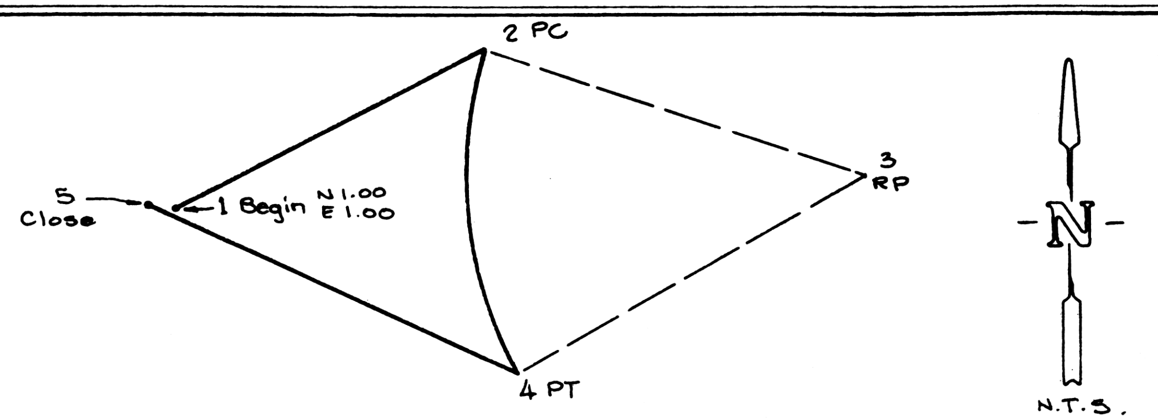
N1 = North coordinate of point 1 E1 = East coordinate of point 1

Operating Limits and Warnings (1) Flashing 0(zero) after displaying easting, indicates R/S was pushed. CLX and enter bearing with B, C, D, or E key or press the A key.

(2) Only curves with delta angle less than 180 degrees is legal. For delta angles greater than 180 degrees, break curve into two parts.

(3) The arc length of curves is summed in register two.

Program Description II



Sample Problem(s) Check the following partial land description for closure and area: Beginning at SE corner of said lot: thence N 58° 16' 32" E along southerly line thereof 251.78 feet to a curve having a radius of 248.92 feet, the radius point of which, bears S 72° 15' 19" E: thence southerly along said curve 374.85 feet to a point which bears S 21° 27' 45" W from said radius point; thence N 64° 04' 00"W 400.50 feet to the place of beginning, containing 0.616 of an acre.

STEPS: Enter Card 1, RTN, R/S, R/S, R/S, 58.1632B, 251.78R/S, R/S, 72.1519C, 248.92 R/S, R/S, Enter Card 2, 21.2745D, R/S, CHS, R/S, R/S, Enter Card 1, 64.04E, 400.5R/S, R/S, A, R/S, R/S, R/S.

For total length of traverse RCL 2.

Solution(s)

POINT	N	E	
1	1.000	1.000	
2	133.395	215.161	
3	57.530	452.238	
4	-174.130	361.160	Δ =86°16'56"
5	1.019	0.989	L =374.851

Errors N=0.019 E=-0.011

area = 26,853.522 square feet or 0.616 acres.

Total length of traverse = 1027.131

Reference(s) None. The program will either work or it won't work, like being pregnant, either you are or you aren't.

User Instructions

BRG TRA/CURVES Card 1				
ERROR AREA	NE	SE	SW	NW

BRG TRA/CURVES Card 2				
	NE	SE	SW	NW

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter Card 1			
2	Initilize		RTN R/S	1.00
3	Input beginning north coordinate	N1	R/S	N1
4	Input beginning east coordinate	E1	R/S	E1
5	Input bearing NE	dd.mmss	B	north azimuth
5	Input bearing SE	dd.mmss	C	north azimuth
5	Input bearing SW	dd.mmss	D	north azimuth
5	Input bearing NW	dd.mmss	E	north azimuth
6	Input distance		R/S	N2
7	(Optional)		R/S	E2
8	See note			
9	Go to step 5 for next course. If last course was first			
	radial of curve(from PC to RP, continue with step 10.			
10	Enter Card 2			
11	Enter bearing of second radial of curve(from RP to PT)	NE dd.mmss	B	delta angle
11	Enter bearing of second radial of curve(from RP to PT)	SE dd.mmss	C	delta angle
11	Enter bearing of second radial of curve(from RP to PT)	SW dd.mmss	D	delta angle
11	Enter bearing of second radial of curve(from RP to PT)	NW dd.mmss	E	delta angle
12	Compute arc length		R/S	arc length
13	If curve is arcing right from PC to PT		R/S	N of PT
13	If curve is arcing left from PC to PT		CHS R/S	N of PT
14	(Optional)		R/S	E of PT
15	See note			
16	Error of failing to close in northing		A	En
17	Error of failing to close in easting		R/S	Ee
18	For area of polygon (square feet)		R/S	sq. ft.
19	For area of polygon (acres)		R/S	acres
20	See note			
	NOTE: If side shots are needed after 6 or 7 or after steps 12 or 13, go to program 00119B. When finished re-enter card 1 and continue at step 5. If last course is last course in traverse, go to step 16 with card 1 entered or enter program 00117A for closure data.			

Program Form

CARD 1

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
f	31	
REG	43	
1	01	Flag
DSP	21	
•	83	
3	03	
R/S	84	Input N (one)
STO 6	3306	
STO 8	3308	
R/S	84	Input E1
STO 5	3305	
STO 7	3307	
LBL	23	
1	01	
R/S	84	See easting
0	00	
÷	81	
LBL	23	
A	11	
RCL 8	3408	
RCL 6	3406	
-	51	
RTN	24	See error northing
RCL 7	3407	
RCL 5	3405	
-	51	
R/S	84	See error easting
RCL 4	3404	
2	02	
÷	81	
g	35	
ABS	06	
R/S	84	See area sq. feet
4	04	
3	03	
5	05	
6	06	
0	00	
÷	81	
R/S	84	See area acres
LBL	23	
B	12	
0	00	
LBL	23	
2	02	
9	09	
0	00	
x	71	
gx⇄y	3507	
f-1	32	

KEY ENTRY	CODE SHOWN	COMMENTS
→D.MS	03	
-	51	
g	35	
ABS	06	
STO 1	3301	
RTN	24	Input dist. or radius
STO 3	3303	
STO	33	
+	61	
2	02	
RCL 1	3401	
gx⇄y	3507	
f-1	32	
R→p	01	
RCL 8	3408	
+	61	
STO 8	3308	
gLSTx	3500	
+	61	
gx⇄y	3507	
x	71	
STO	33	
+	61	
4	04	
gLSTx	3500	
RCL 7	3407	
+	61	
STO 7	3307	
RCL 8	3408	
R/S	84	See northing
RCL 7	3407	
GTO	22	
1	01	
LBL	23	
C	13	
2	02	
GTO	22	
2	02	
LBL	23	
D	14	
2	02	
CHS	42	
GTO	22	
2	02	
LBL	23	
E	15	
4	04	
GTO	22	
2	02	

REGISTERS	
R_1	azimuth
R_2	sum of distances
R_3	distance or radius
R_4	double area sq. feet
R_5	E1.....
R_6	N1....
R_7	En
R_8	Nn
R_9	

LABELS	
A	finish
B	NE
C	SE
D	SW
E	NW
0	used
1	used
2	used
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Form

CARD 2

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RTN	24	Kill A key
LBL	23	
B	12	
0	00	
LBL	23	
2	02	
9	09	
0	00	
x	71	
gx⇄y	3507	
f-1	32	
→D.MS	03	
-	51	
g	35	
ABS	06	
RCL 3	3403	
1	01	
8	08	
0	00	
RCL 1	3401	
g ↓	3509	
STO 1	3301	
gx > y	3524	
gx⇄y	3507	
gnop	3501	
-	51	
gx=y	3523	
CLX	44	
gnop	3501	
-	51	
g	35	
ABS	06	
DSP	21	
.	83	
4	04	
f	31	
→D.MS	03	
RTN	24	See delta angle
DSP	21	
.	83	
3	03	
g ↓	3508	
gLSTx	3500	
g	35	
π	02	
x	71	
x	71	
1	01	
8	08	
0	00	

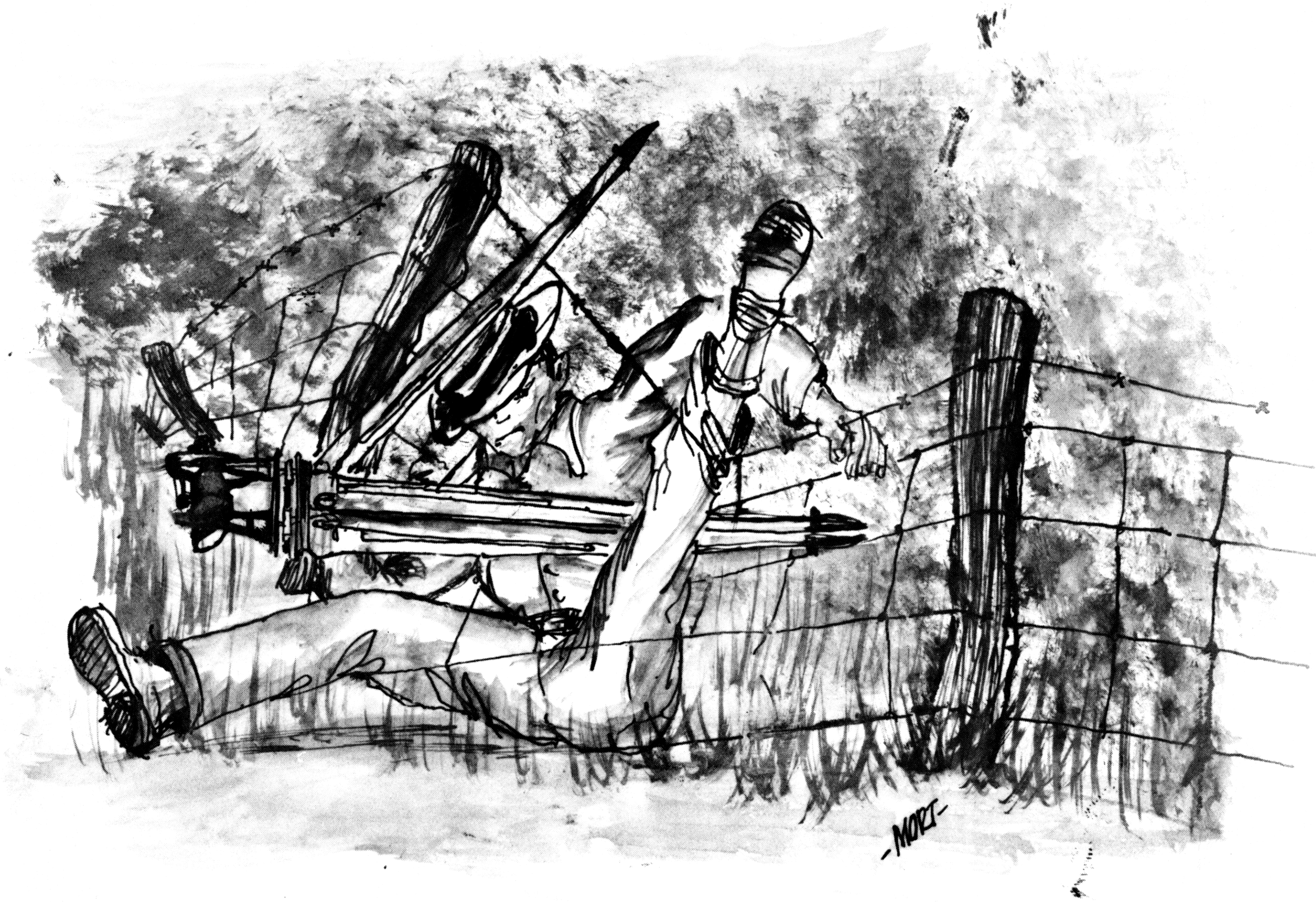
KEY ENTRY	CODE SHOWN	COMMENTS
÷	81	
STO	33	
+	61	
2	02	
R/S	84	See arc length
x	71	
STO	33	
+	61	
4	04	
RCL 1	3401	
g ↓	3509	
STO	33	
-	51	
2	02	
f-1	32	
R → P	01	
RCL 8	3408	
+	61	
STO 8	3308	
gLSTx	3500	
+	61	
gx⇄y	3507	
x	71	
STO	33	
+	61	
4	04	
gLSTx	3500	
RCL 7	3407	
+	61	
STO 7	3307	
RCL 8	3408	
R/S	84	See northing PT
RCL 7	3407	
R/S	84	See easting PT
LBL	23	
C	13	
2	02	
GTO	22	
2	02	
LBL	23	
D	14	
2	02	
CHS	42	
GTO	22	
2	02	
LBL	23	
E	15	
4	04	
GTO	22	
2	02	

REGISTERS	
R_1	
R_2	
R_3	
R_4	
R_5	
R_6	
R_7	
R_8	
R_9	

LABELS	
A	
B	NE
C	SE
D	SW
E	NW
0	
1	
2	used
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.


-MORI-

Program Description I

Program Title HORIZONTAL STREET CURVES

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes tangent, radius, degree of curve, arc length and chord length for centerline, inside R/W line and outside R/W line, given R/W width, delta and tangent or delta and radius, for concentric street curves.

$R = T \text{ co tan } \Delta/2$
$D = 18000/\pi R$
$L = \Delta(100)/D$
$C = 2R \sin \Delta/2$

WHERE:

T = tangent
R = radius
D = degree of curve
L = arc length
C = chord length

Operating Limits and Warnings

Program Description II

Sample Problem(s)

R/W width = 50'
centerline Δ = 36° 15' 22"
centerline T = 150.00'

Solution(s) Δ	T	R	D	L	C
CL 36° 15' 22"	150.000	458.166	12.5054701	289.922	285.109
IN "	141.815	433.166	13.2272187	274.102	269.552
OUT "	158.185	483.166	11.8584111	305.742	300.666

Reference(s) Bouchard, Harry and Moffitt, Francis H., SURVEYING, fifth edition, pages 269-274, International Textbook Company, Scranton, Pennsylvania, 1965.

User Instructions

CURVES(cl-in-out) T-R-D-L-C

R/W	Δ	T	R	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	Input R/W width	R/W	A		
3	Input delta angle	Δ	B		
4	Input tangent length	T	C		T cl
5	or radius	R	D		T cl
6			R/S		R cl
7			R/S		D cl
8			R/S		L cl
9			R/S		C cl
10			R/S		T in
11			R/S		R in
12			R/S		D in
13			R/S		L in
14			R/S		C in
15			R/S		T out
16			R/S		R out
17			R/S		D out
18			R/S		L out
19			R/S		C out
20	Return to step 3 for next curve or to step 2 for R/W width change.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
STO 1	3301	
RTN	24	
LBL	23	
B	12	
f-1	32	
→D.MS	03	
STO 2	3302	
gLSTx	3500	
DSP	21	
•	83	
4	04	
RTN	24	
LBL	23	
C	13	
E	15	
x	71	
GTO	22	
0	00	
LBL	23	
D	14	
E	15	
g ↓	3508	
LBL	23	
0	00	
DSP	21	
•	83	
3	03	
f	31	
SF 2	71	
0	00	
LBL	23	
1	01	
+	61	
STO 3	3303	
RCL 6	3406	
÷	81	
R/S	84	Tangent
RCL 3	3403	
R/S	84	Radius
1	01	
8	08	
0	00	
g	35	
π	02	
RCL 3	3403	
x	71	
÷	81	
STO 5	3305	

KEY ENTRY	CODE SHOWN	COMMENTS
EEX	43	
2	02	
x	71	
DSP	21	
•	83	
7	07	
R/S	84	Degree
DSP	21	
•	83	
3	03	
RCL 2	3402	
RCL 5	3405	
÷	81	
R/S	84	Length
RCL 3	3403	
2	02	
x	71	
RCL 4	3404	
x	71	
R/S	84	Chord
RCL 3	3403	
RCL 1	3401	
f-1	32	
TF 2	81	
GTO	22	
1	01	
2	02	
÷	81	
CHS	42	
f-1	32	
SF 2	71	
GTO	22	
1	01	
LBL	23	
E	15	
RCL 2	3402	
2	02	
÷	81	
1	01	
f-1	32	
R→P	01	
gx⇄y	3507	
STO 4	3304	
÷	81	
STO 6	3306	
RTN	24	

REGISTERS	
R_1	R/W width
R_2	Δ
R_3	R
R_4	Sin Δ/2
R_5	D/foot
R_6	co tan Δ/2
R_7	
R_8	
R_9	

LABELS	
A	R/W
B	Δ
C	T
D	R
E	used
0	✓
1	✓
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	✓

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title LEAST SQUARES TRAVERSE ADJUSTMENT

Contributor's Name Richard H. Cassera

Address 524 Ferro Lane

City Paso Robles **State** California **Zip Code** 93446

Program Description, Equations, Variables, etc. If a traverse does not close on a fixed point because the angles were measured with greater precision than were the distances then it can be adjusted as follows:

Let $B_1, B_2, B_3, \ldots, B_i$ be the bearings of a traverse
Let $D_1, D_2, D_3, \ldots, D_i$ be the corrections to the distances along the bearings
Let dN be the error in latitude (total correction)
Let dE be the error in departure (total correction)
The latitudes will close if:

$$D_1 \text{Cos} B_1 + D_2 \text{Cos} B_2 + D_3 \text{Cos} B_3 + \ldots + D_i \text{Cos} B_i - dN = 0$$

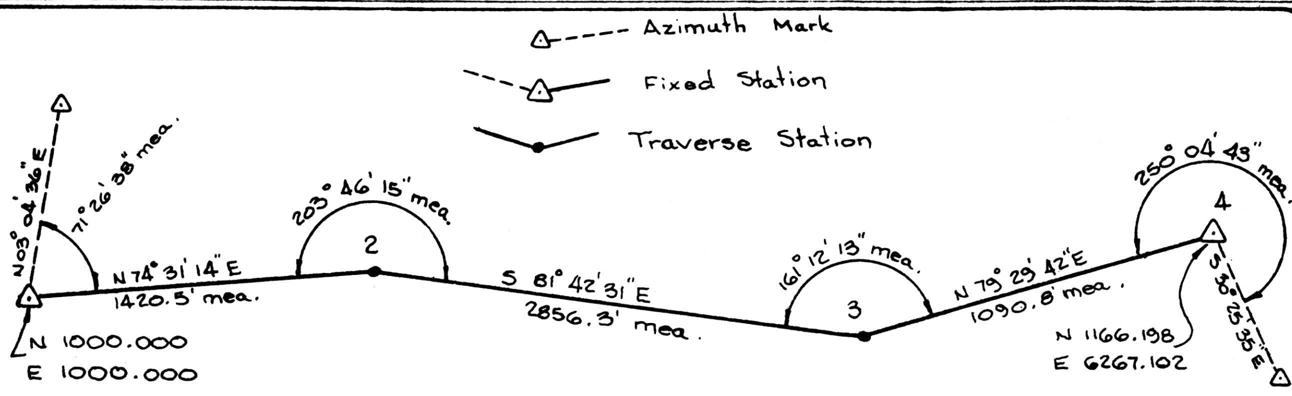
The departure will close if:

$$D_1 \text{Sin} B_1 + D_2 \text{Sin} B_2 + D_3 \text{Sin} B_3 + \ldots + D_i \text{Sin} B_i - dE = 0$$

These two equations in "n" unknowns can be solved by the method of correlatives derived from the principle of least squares which is fully explained by David Clark in PLANE and GEODETIC SURVEYING VOL. II HIGHER SURVEYING on page 270.

Operating Limits and Warnings As in all adjustment methods this adjustment should be applied to field work after all systematic errors have been removed.

Program Description II



Sample Problem(s) Given: Traverse from pt. 1 to pt. 4 with angles turned to 1" with T-2 and distances chained to .1'

	COURSE	DISTANCE	NORTHING	EASTING
1				
	N74 31 14E	1420.5	1000.000	1000.000
2			1379.121	2368.973
	S81 42 31E	2856.3		
3			967.221	5195.418
	N79 29 42E	1090.8		
4			1166.097	6267.935
True coordinates of point 4			1166.198	6267.102
	Corrections:		.101	-.833
	Precision:		1:6300	

Solution(s)

	COURSE	DISTANCE	NORTHING	EASTING
1	N74 31 14E	1420.55	1000.000	1000.000
2	S81 42 31E	2855.53	1379.134	2369.021
3	N79 29 42E	1090.68	967.345	5194.707
4			1166.198	6267.102

Reference(s) Clark, David. PLANE and GEODETIC SUEVEYING, Volume II. HIGHER SURVEYING. London: Constable & Company, Ltd., 1951.

User Instructions

LEAST SQ. TRAVERSE ADJ. #1

dN,dE	Bearing	Compute		

LEAST SQ. TRAVERSE ADJ. #2

NE	Bearing	Compute	Distance	Easting

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program #1				
2			f	REG	
3	Enter correction to latitudes	dN	A		
4	Enter correction to departures	dE	A		
5	Enter bearing of courses to be adj.	Bi	↑		
6	Enter quadrant number		B		
	Go to step 5 until all bearings have been entered				
7	Compute		C		
8	Enter program #2 for adjusted coordinates				
9	Enter beginning northing		A		
10	Enter beginning easting		A		
11	Enter bearing		↑		
12	Enter quadrant number		B		
13	If distance is to be adjusted	distance	D		adjusted distance
13	If distance is not to be adjusted	distance	STO	4	
14	Compute coordinates		C		Northing
15	Display Easting		E		Easting
16	Go to step 11 until all courses have been entered.				
	NOTE: quadrant 1 is NE bearing				
	quadrant 2 is SE bearing				
	quadrant 3 is SW bearing				
	quadrant 4 is NW bearing				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
STO 1	3301	S N in R1
RTN	24	
LBL	23	
A	11	
STO 2	3302	S E in R2
RTN	24	
LBL	23	
B	12	(Bearing to azimuth)
STO 8	3308	quadrant in R8
gR↓	3508	
f-1	32	
→D.MS	03	
g	35	
DSZ	83	
GTO	22	
00	00	
GTO	22	
02	02	
LBL	23	
00	00	
01	01	
08	08	
00	00	
-	51	
CHS	42	
g	35	
DSZ	83	
GTO	22	
01	01	
GTO	22	
02	02	
LBL	23	
01	01	
03	03	
06	06	
00	00	
-	51	
CHS	42	
g	35	
DSZ	83	
GTO	22	
00	00	
GTO	22	
02	02	azimuth in x
LBL	23	
02	02	
f	31	
COS	05	

KEY ENTRY	CODE SHOWN	COMMENTS
gLSTx	3500	
f	31	
SIN	04	
↑	41	
↑	41	
X	71	Sin^2 Bi
gR↓	3508	
X	71	Sin^2 Bi Cos^2Bi
STO	33	
+	61	
04	04	Σ Sin^2Bi Cos^2Bi
gR↓	3508	
↑	41	
X	71	Cos^2Bi
STO	33	
+	61	
03	03	Σ Cos^2Bi
gR↓	3508	
STO	33	
+	61	
05	05	Σ Sin^2Bi
RTN	24	
LBL	23	
C	13	(program to solve:)
RCL 1	3401	$C_1 Cos^2$ Bi+C_2 Σ Cos^2 Bi
RCL 4	3404	Sin Bi=0
X	71	C_1ΣCos^2Bi Sin^2Bi+C_2
RCL 2	3402	ΣSinBi=0
RCL 3	3403	
X	71	
-	51	
RCL 4	3404	
↑	41	
X	71	
RCL 3	3403	
RCL 5	3405	
X	71	
-	51	
÷	81	
STO 7	3307	C_2 in R7
RCL 4	3404	
X	71	
RCL 1	3401	
-	51	
CHS	42	
RCL 3	3403	
÷	81	
STO 6	3306	C_1 in R6
RTN	24	
gnop	3501	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

REGISTERS

- R_1 dN
- R_2 dE
- R_3 $\sum_{i=1}^{n}$ Cos^2Bi
- R_4 $\sum_{i=1}^{n}$ Cos^2Bi+ Sin^2Bi
- R_5 $\sum_{i=1}^{n}$ Sin^2Bi
- R_6 C_1
- R_7 C_2
- R_8 quad
- R_9

LABELS

- A dN, dE
- B bearing
- C compute
- D
- E
- 0 quad
- 1 quad
- 2 quad
- 3
- 4
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1
- 2

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY. PROGRAM 2

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
STO 1	3301	Northing in R1
RTN	24	
LBL	23	
A	11	
STO 2	3302	Easting in R2
RTN	24	
LBL	23	
B	12	(bearing to azimuth)
STO 8	3308	quadrant in R8
gR↓	3508	
f-1	32	
→D.MS	03	
g	35	
DSZ	83	
GTO	22	
00	00	
GTO	22	
02	02	
LBL	23	
00	00	
01	01	
08	08	
00	00	
-	51	
CHS	42	
g	35	
DSZ	83	
GTO	22	
01	01	
GTO	22	
02	02	
LBL	23	
01	01	
03	03	
06	06	
00	00	
-	51	
CHS	42	
g	35	
DSZ	83	
GTO	22	
00	00	
GTO	22	
02	02	
LBL	23	
02	02	
STO 5	3305	azimuth in R5
f	31	

KEY ENTRY	CODE SHOWN	COMMENTS
COS	05	Cos Bi
gLSTx	3500	
f	31	
SIN	04	Sin Bi
RCL 7	3407	
X	71	C2 Sin Bi
gx⇌y	3507	
RCL 6	3406	
X	71	C1 Cos Bi
+	61	Di=C1cosBi+C2SinBi
STO4	3304	Di in 4
RCL 5	3405	azimuth in x
RTN	24	
LBL	23	
D	14	
RCL 4	3404	
+	61	distance + Di
RTN	24	
LBL	23	
C	13	prog. to comp. coords.
f-1	32	
R←P	01	
STO	33	
+	61	
01	01	
gx⇌y	3507	
STO	33	
+	61	
02	02	
RCL 2	3402	
RCL 1	3401	Northing in X
RTN	24	
LBL	23	
E	15	
gx⇌y	3507	Easting in X
RTN	24	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	
gnop	3501	

REGISTERS	
R_1	northing
R_2	easting
R_3	
R_4	distance
R_5	azimuth
R_6	
R_7	
R_8	quad
R_9	
LABELS	
A	N & E
B	bearing
C	compute
D	distance
E	easting
0	quad
1	quad
2	quad
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM


MORT

Program Description I

Program Title CURVE FROM C & L

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

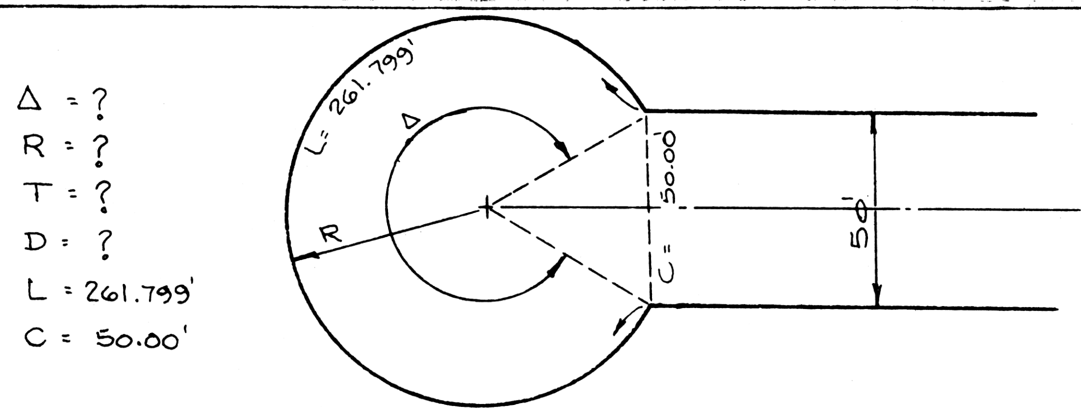
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Given the arc and chord lengths of a curve the program computes the Delta Angle utilizing the Bassham Iteration; computes radius, tangent, and degree of curve; and also displays the arc length and chord length entered.

See reference for the Iteration of 1/2 delta, otherwise standard curve formulas are used.

Operating Limits and Warnings See notes on page 3 herein. The accuracy of delta is unknown by CCC, but is believed to be $\pm$ 0.5 seconds.

Program Description II



Sample Problem(s) Compute the unknown curve information in the above sketch.

STEPS: 50A, 261.799B, C, R/S, R/S, R/S, R/S, R/S

Solution(s)

Δ = 300°00'00"
R= 50.000'
T= -28.868' (back tangent)
D= 114.59170° (approx.)
L= 261.79900' (as entered)
C= 50.00000' (as entered)

Reference(s) Bassham, Elbert F., on "THE TH FUNCTION" by William C. Thompson, Surveying and Mapping Quarterly Journal, American Congress on Surveying and Mapping, March 1975, page 70.

User Instructions

CURVE FROM C & L

C	L	Compute		

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2a	Input chord length	C	A		xx.xxx
2b	Input arc length	L	B		xx.xxx
3	Compute △ (note 1)		C		DDD.MMSS
4	Compute R		R/S		xx.xxx'
5	Compute T (note 2)		R/S		xx.xxx'
6	Compute D (note 3)		R/S		DD.DDDDD
7	(Optional) Check L entered		R/S		xx.xxxxx'
8	(Optional) Check C entered		R/S		xx.xxxxx'
9	Go to step 3 to re-compute				
9	Or hold C or L, execute step 2a or 2b and go to step				
	3 to compute.				
9	Or new case, go to step 2a.				
9	(Note 4) To see seconds and fractions: of △		RCL	6	
			f-1	INT	
			6	0	
			X		
			f-1	INT	
			6	0	
			X		SS.S
	NOTE 1: If the given chord is larger than or equal to the given				
	arc length, a flashing "0" will be displayed.				
	NOTE 2: If tangent is negative, it is the back tangent (△ more				
	than 180 degrees)				
	NOTE 3: D denotes "degree of curve"				
	NOTE 4: An idiosyncrasy of the HP 65 is on decimal				
	angle to DD.MMSS conversions, the 65 truncates but				
	does not always round.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	C
A	11	
STO 1	3301	
DSP	21	
.	83	
3	03	
RTN	24	
LBL	23	
B	12	L
STO 2	3302	
R/S	84	
LBL	23	
C	13	Compute
RCL1	3401	
RCL2	3402	
gx ≤ y	3522	
0	00	
÷	81	
÷	81	
STO 3	3303	
1	01	
8	08	
1	01	
STO 4	3304	
1	01	
-	51	
g	35	
π	02	
÷	81	
STO 5	3305	
LBL	23	
D	14	
RCL 4	3404	
RCL 4	3404	
1	01	
f-1	32	
R → P	01	
STO 7	3307	
÷	81	
RCL 4	3404	
RCL 5	3405	
÷	81	
-	51	
RCL 5	3405	
x	71	
RCL 3	3403	
RCL 7	3407	
÷	81	
1	01	
-	51	

KEY ENTRY	CODE SHOWN	COMMENTS
÷	81	
STO 4	3304	
gx ⇄ y	3507	
gx ≤ y	3522	
GTO	22	
E	15	
GTO	22	
D	14	
LBL	23	
E	15	
+	61	
STO 6	3306	
f	31	
→D.MS	03	
DSP	21	
.	83	
4	04	
R/S	84	
DSP	21	
.	83	
3	03	
RCL 2	3402	
RCL 5	3405	
x	71	
RCL 6	3406	
÷	81	
STO 8	3308	
R/S	84	R
RCL 8	3408	
RCL 6	3406	
2	02	
÷	81	
f	31	
TAN	06	
x	71	
R/S	84	T
RCL 5	3405	
RCL 8	3408	
÷	81	
EEX	43	
2	02	
x	71	
DSP	21	
.	83	
5	05	
R/S	84	Degree of curve
RCL 2	3402	
R/S	84	L check
RCL 1	3401	
R/S	84	C check

REGISTERS	
R_1	C
R_2	L
R_3	C/L
R_4	Δ/2
R_5	180/π
R_6	Δ
R_7	cos Δ/2
R_8	R
R_9	used trig. & tests

LABELS	
A	C
B	L
C	compute
D	used
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM

Program Description I

Program Title SPECIAL ANGLE COMPUTATION, CASE 1

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Three-point resection. Computes X and Y angles given distances A & B and angles A, B, and G according to the formulas on USC&GS form 655A. Handy for locating topo instrument stations in corn fields, etc.

$$\tan \text{alpha} = \frac{b \sin A}{a \sin B}$$

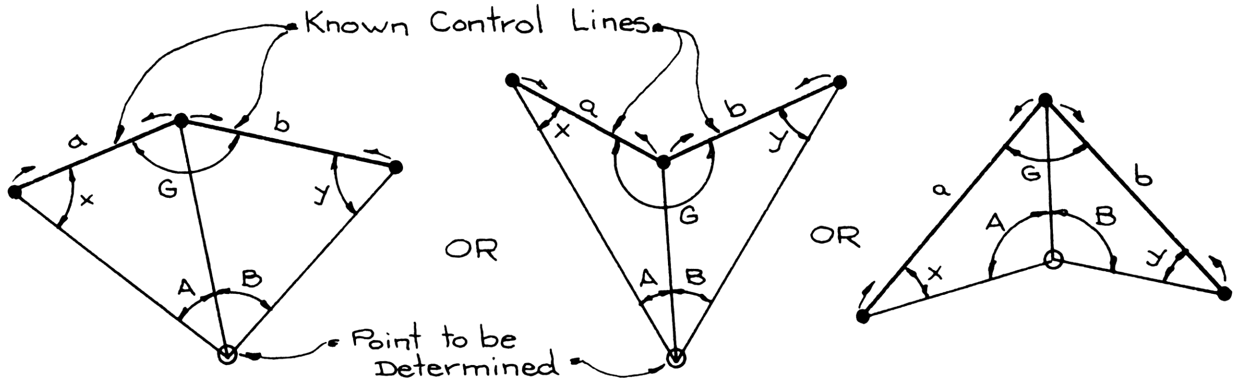
$$\tan 1/2(y-x) = \tan(\text{alpha}-45) \quad \tan 1/2(y+x)$$

$$1/2(y+x) = 180-1/2(A+B+G)$$

Alpha is an auxillary angle computed and used in the program.

Operating Limits and Warnings If all points are located on the circumference of the same circle, the problem is indeterminate.

Program Description II



Sample Problem(s) Calc. x and y IF

a = 12859.41

b = 4409.70

A = 84°12'57.9"

B = 21°38'06.8"

G = 86°29'42.3"

STEPS: A, 12859.41R/S, 4409.7R/S, 84.12579R/S, 21.38068R/S, 86.29423R/S, R/S, R/S, R/S.

Solution(s)

dd.mmss	ss.ssss
x = 64°06'15"	14.7144
y = 103-32-58	58.2857

Reference(s) Gossett, F.R., MANUAL OF GEODETIC TRIANGULATION, Special Publication No. 247, Superintendent of Documents, U.S. Gov. Printing Off., Washington D.C., 1959 Pages 174-176

User Instructions

SP. ANGLE CALC. CASE 1

Start				

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter Program			
2	Start (see flag)		A	1.0000
3	Input distance a	a	R/S	
4	Input distance b	b	R/S	
5	Input angle A	A	R/S	
6	Input angle B	B	R/S	
7	Input angle G (see x)	G	R/S	x
8	See seconds and fraction of x (note)		R/S	x ss.ssss
9	See y		R/S	y
10	See seconds and fraction of y (note)		R/S	y ss.ssss

NOTE: The x and y angles should be considered no more accurate than the least accurate angle known, (A, B, or G angles).

If x = 90 and y = 0 all the points lie on the circumference of a circle, in which case the problem is indeterminate.

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
DSP	21	
.	83	
4	04	
1	01	flag
RTN	24	Input a
STO 1	3301	
STO 3	3303	
R/S	84	Input b
STO 4	3304	
C	13	
g	35	
1/x	04	
R/S	84	Input A
STO 5	3305	
R/S	84	Input B
STO 6	3306	
R/S	84	Input G
STO 7	3307	
f-1	32	
→D.MS	03	
RCL 5	3405	A
E	15	
gLSTx	3500	
gx⇄y	3507	
C	13	
CLX	44	
RCL 6	3406	B
E	15	
D	14	
CLX	44	
gLSTx	3500	
+	61	
+	61	
2	02	
÷	81	
CHS	42	
1	01	
8	08	
0	00	
+	61	
↑	41	
f	31	
TAN	06	
RCL 1	3401	
f-1	32	
TAN	06	
4	04	
5	05	
-	51	
f	31	

KEY ENTRY	CODE SHOWN	COMMENTS
TAN	06	
x	71	
f-1	32	
TAN	06	
+	61	
STO 2	3302	
g↓	3508	
gLSTx	3500	
-	51	
STO 1	3301	
LBL	23	
0	00	
f	31	
→D.MS	03	
R/S	84	See x then y
gLSTx	3500	
B	12	
B	12	
R/S	84	
RCL 2	3402	
GTO	22	
0	00	
LBL	23	
B	12	
f-1	32	
INT	83	
6	06	
0	00	
x	71	
RTN	24	
LBL	23	
C	13	
g	35	
1/x	04	
LBL	23	
D	14	
STO	33	
x	71	
1	01	
RTN	24	
LBL	23	
E	15	
f-1	32	
→D.MS	03	
f	31	
SIN	04	
RTN	24	

REGISTERS	
R_1	x in D.DDD
R_2	y in D.DDD
R_3	a
R_4	b
R_5	A in D.MS
R_6	B in D.MS
R_7	G in D.MS
R_8	
R_9	

LABELS	
A	start
B	used
C	used
D	used
E	used
0	used
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title SPECIAL DISTANCE COMPUTATION, CASE 1

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis State Indiana Zip Code 46229

Program Description, Equations, Variables, etc. Computes all the unknown distances of the Case 1 problem shown on USCGS form 655A. Intended to follow the "SPECIAL ANGLE COMPUTATION, CASE 1" program, which leaves the needed data in the proper format in the proper registers, although the distances could be computed without using said program first. Provided the X and Y angles are known.

USES SINE LAW:

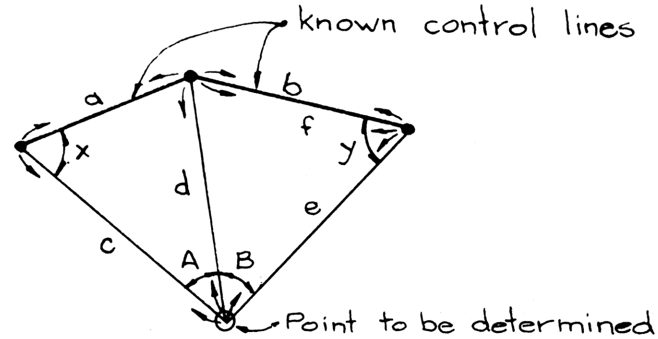
$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin (A + B)}$$

Operating Limits and Warnings

Enter degrees, minutes, and seconds as DDD.MMSSS

If you stop in middle of computations, push RTN before restarting with the A key.

Program Description II



Sample Problem(s) Execute the sample problem from "SPECIAL ANGLE COMPUTATION, CASE 1" program first or store the following in the proper registers:

a = 12859.41	in R3	x = 64.1040873°	in R1
b = 4409.70	in R4	y = 103.5495238°	in R2
A = 84°12'57.9"	in R5		
B = 21°38'06.8"	in R6		

Then the steps are: A, R/S, R/S, R/S, R/S

Solution(s)

c = 6787.961

d = 11627.378 or 11627.377

e= 9775.099

f = 4409.700 = b

f-b = -0.000 displayed

Reference(s) Gossett, F.R., MANUAL OF GEODETIC TRIANGULATION, Special Publication No. 247, Superintendent of Documents, U.S. Gov. Printing Off., Washington D.C., 1959, Pages 174-176

User Instructions

SP. DISTANCE CALC. CASE 1

Start

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	If not from "Special Angle Computation" program,				
	then load proper registers with x, y, A, & B angles				
	and distance a and b in proper format.		A		c
2	If from "Special Angle Computation" program		A		c
3			R/S		d
4			R/S		e
5	Equal b?		R/S		f
6	What is f-b equal to?		R/S		f-b
	Should be 0.000 plus or minus.				
7	Did you forget to write down a distance(s)?				
	Go to the second step 2. (Push A)				
	NOTE: Flashing 0 indicates all distances have been				
	computed and R/S was pushed.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
DSP	21	
•	83	
3	03	
RCL 3	3403	
STO 8	3308	a
RCL 5	3405	A
E	15	
↓	41	
D	14	
B	12	
RCL 1	3401	x
C	13	
R/S	84	
RCL 2	3402	y
↓	41	
D	14	
B	12	
RCL 6	3406	B
E	15	
C	13	
R/S	84	
RCL 4	3404	b
-	51	
R/S	84	
0	00	
÷	81	
LBL	23	
B	12	
STO	33	
÷	81	
8	08	
g↓	3508	
RTN	24	
LBL	23	
C	13	
↓	41	
g↓	3508	
+	61	
f	31	
SIN	04	
RCL 8	3408	
×	71	
R/S	84	
g↓	3509	
f	31	
SIN	04	
RCL 8	3408	
×	71	

KEY ENTRY	CODE SHOWN	COMMENTS
STO8	3308	
RTN	24	
LBL	23	
D	14	
f	31	
SIN	04	
RTN	24	
LBL	23	
E	15	
f-1	32	
→D.MS	03	
RTN	24	

REGISTERS	
R_1	x in D.DD
R_2	y in D.DD
R_3	a
R_4	b
R_5	A in D.MS
R_6	B in D.MS
R_7	
R_8	used
R_9	

LABELS	
A	start
B	used
C	used
D	used
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title SPECIAL ANGLE COMPUTATION CASE 2

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes x and y angles given angles A, B, C, D, E, and F according to the formulas on USCGS form 655A. Handy for locating topo instrument stations in corn fields, etc.

$$\tan \text{alpha} = \frac{\sin A \sin C \sin E}{\sin B \sin D \sin F}$$

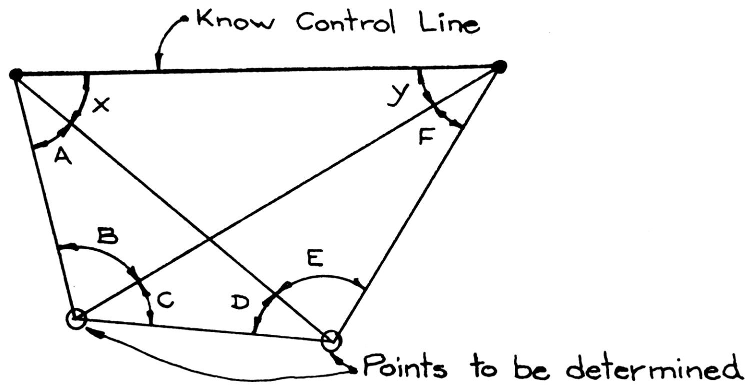
$$\tan 1/2(y-x) = \tan(\text{alpha}-45) \tan 1/2(y+x)$$

$$1/2(y+x) = 1/2(C+D)$$

Alpha is an auxillary angle computed and used in the program.

Operating Limits and Warnings None.

Program Description II



Sample Problem(s) Calc. x and y if:

A = 22°26'03.6   D = 72°33'56.4"
B = 43°50'44"   E = 52°26'03.6"
C = 41°09'16"   F = 13°50'44"

STEPS: A, 22.26036R/S,43.5044R/S, 41.0916R/S, 72.33564R/S, 52.26036R/S, 13.5044R/S, R/S, R/S, R/S.

Solution(s)

	dd.mmss	ss.ssss
x	= 66-48-36	36.2927
y	= 46-54-36	36.1073

Reference(s) Gossett, F.R., MANUAL OF GEODETIC TRIANGULATION, Special Publication No. 247, Superintendent of Documents, U.S. Gov. Printing Off., Washington D.C., 1959   Pages 174–176

User Instructions

SPECIAL ANGLE COMP., CASE 2

Start				

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Start (See flag)		A	2.0000
3	Input Angle A	A	R/S	
4	Input Angle B	B	R/S	
5	Input Angle C	C	R/S	
6	Input Angle D	D	R/S	
7	Input Angle E	E	R/S	
8	Input Angle F (See x)	F	R/S	x
9	See seconds and fraction of x (note)		R/S	x ss.ssss
10	See y		R/S	y
11	See seconds and fraction of y		R/S	y ss.ssss
	NOTE: The x and y angles should be considered no more accurate than the least accurate angle known (A, B, C, D, E, or F angles).			

Program Form

SWITCH TO W/PRGM. PRESS f PRGM TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
DSP	21	
•	83	
4	04	
2	02	flag
RTN	24	Input A
STO 3	3303	
R/S	84	Input B
STO 4	3304	
R/S	84	Input C
STO 5	3305	
R/S	84	Input D
STO 6	3306	
R/S	84	Input E
STO 7	3307	
R/S	84	Input F
STO 8	3308	
E	15	
STO 1	3301	
RCL 4	3404	B
E	15	
D	14	
RCL 6	3406	D
E	15	
D	14	
gLSTx	3500	
RCL 5	3405	C
E	15	
gLSTx	3500	
gx⇄y	3507	
C	13	
g ↑	3508	
+	61	
2	02	
÷	81	
STO 2	3302	1/2 y+x
RCL 3	3403	A
E	15	
C	13	
RCL 7	3407	E
E	15	
C	13	
RCL 1	3401	
f-1	32	
TAN	06	
4	04	
5	05	
-	51	
f	31	
TAN	06	
RCL 2	3402	

KEY ENTRY	CODE SHOWN	COMMENTS
f	31	
TAN	06	
x	71	
f-1	32	
TAN	06	
RCL 2	3402	
gx⇄y	3507	
STO	33	
+	61	
2	02	
-	51	
STO 1	3301	
LBL	23	
0	00	
f	31	
→D.MS	03	
R/S	84	See x & y
gLSTx	3500	
B	12	
B	12	
R/S	84	
RCL 2	3402	
GTO	22	
0	00	
LBL	23	
B	12	
f-1	32	
INT	83	
6	06	
0	00	
x	71	
RTN	24	
LBL	23	
C	13	
g	35	
1/x	04	
LBL	23	
D	14	
STO	33	
x	71	
1	01	
RTN	24	
LBL	23	
E	15	
f-1	32	
→D.MS	03	
f	31	
SIN	04	
RTN	24	

REGISTERS

- R_1 accumulator x in D.DD
- R_2 y in D.DD
- R_3 A in D.MS
- R_4 B in D.MS
- R_5 C in D.MS
- R_6 D in D.MS
- R_7 E in D.MS
- R_8 F in D.MS
- R_9

LABELS

- A start
- B used
- C used
- D used
- E used
- 0 used
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1
- 2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title SPECIAL DISTANCE COMPUTATION, CASE 2

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis State Indiana Zip Code 46229

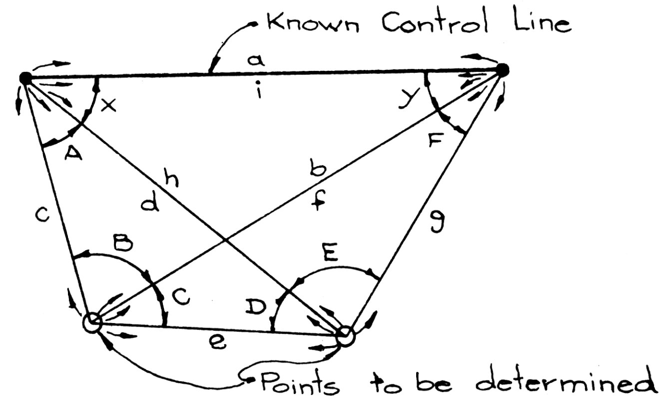
Program Description, Equations, Variables, etc. Computes all the unknown distances of the Case 2 problem shown on USCGS form 655A. Intended to follow the "Special Angle Computation, Case 2" program, which leaves the needed data in the proper format in the proper registers, although the distances could be computed without using said program first, provided the X and Y angles are known.

USES SINE LAW:

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin (A+B)}$$

Operating Limits and Warnings Enter degrees, minutes, and seconds as DDD.MMSSS. If you stop in middle of computations push RTN before restarting with the A key.

Program Description II



Sample Problem(s) Execute the sample problem from "Special Angle Computation, Case 2" program first, or store the following in the proper registers:

A	= $22°26'03.6''$	in R3	E	= $52°26'03.6''$	in R7
B	= $43°50'44''$	in R4	F	= $13°50'44''$	in R8
C	= $41°09'16''$	in R5	x	= $66.8100813°$	in R1
D	= $72°33'56.4''$	in R6	y	= $46.9100298°$	in R2

Then the steps are if "a" = 500: 500A, R/S, R/S, R/S, R/S, R/S, R/S, R/S.

Solution(s)

b = 721.733
c = 527.114
d = 550.393
e = 210.846
f = 721.733 =b
g = 579.826
h = 550.393 = d
i = 500.000 = a

Reference(s) Gossett, F.R., MANUAL OF GEODETIC TRIANGULATION, Special Publication No. 247, Superintendent of Documents, U.S. Gov. Printing Off., Washington D.C., 1959 Pages 174-176

User Instructions

SP. DISTANCE CALC. CASE 2

Start

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	If not from "Special Angle Computation" program,				
	then load proper registers with x,y,A,B,C,D,E and				
	F angles in proper format				
2	If from "Special Angle Computation" program, do				
	nothing.				
3	Enter "a" distance	a	A		b
4			R/S		c
5			R/S		d
6			R/S		e
7	equal b?		R/S		f
8			R/S		g
9	equal d?		R/S		h
10	equal a?		R/S		i
11	Did you forget to write down a distance(s)?				
	Go to step 3.				
	NOTE: Flashing 0 indicates all distances have been				
	computed and R/S was pushed.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
DSP	21	
•	83	
3	03	
RCL 4	3404	B
E	15	
D	14	
B	12	
RCL 2	3402	y
C	13	
R/S	84	
RCL 6	3406	D
E	15	
D	14	
B	12	
RCL 3	3403	A
E	15	
C	13	
R/S	84	
RCL 8	3408	F
E	15	
D	14	
B	12	
RCL 5	3405	C
E	15	
C	13	
R/S	84	
RCL 1	3401	x
D	14	
B	12	
RCL 7	3407	E
E	15	
C	13	
R/S	84	
0	00	
÷	81	
LBL	23	
B	12	
gLSTx	3500	
g ↑	3508	
÷	81	
g ↓	3509	
RTN	24	
LBL	23	
C	13	
↑	41	
g ↑	3508	
+	61	
f	31	

KEY ENTRY	CODE SHOWN	COMMENTS
SIN	04	
gx⇄y	3507	
x	71	
R/S	84	
gLSTx	3500	
g ↓	3509	
f	31	
SIN	04	
x	71	
RTN	24	
LBL	23	
D	14	
f	31	
SIN	04	
RTN	24	
LBL	23	
E	15	
f-1	32	
→D.MS	03	
RTN	24	

REGISTERS	
R_1	x in D.DD
R_2	y in D.DD
R_3	A in D.MS
R_4	B in D.MS
R_5	C in D.MS
R_6	D in D.MS
R_7	E in D.MS
R_8	F in D.MS
R_9	

LABELS	
A	start
B	used
C	used
D	used
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title SPECIAL ANGLE COMPUTATION, CASE 3

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis State Indiana Zip Code 46229

Program Description, Equations, Variables, etc. Computes X and Y angles given distances A and B and angles A, B, C, and G according to the formulas on USCGS form 655A. Handy for locating topo instrument stations in corn fields, etc.

$$\tan \text{alpha} = \frac{b \sin A \sin C}{a \sin B \sin D}$$

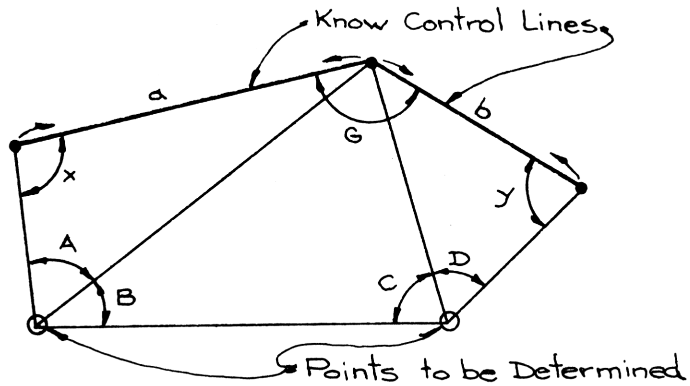
$$\tan 1/2(y-x) = \tan(\text{alpha}-45) \tan 1/2(y+x)$$

$$1/2(y+x) = 270 - 1/2(A+B+C+D+G)$$

Alpha is an auxillary angle computed and used in the program.

Operating Limits and Warnings None

Program Description II



Sample Problem(s) Calc. x and y if:

a = 300.000

b = 350.000

A = 58°30'29.9"

B = 77°20'20"

C = 72°10'10"

D = 69°40'40.1"

G = 150°05'05"

STEPS: A, 300R/S, 350R/S, 58.30299R/S, 77.202R/S, 72.101R/S, 69.40401R/S, 150.0505R/S, R/S, R/S, R/S.

Solution(s)

	dd.mmss	ss.ssss
x	= 57-34-50	49.8207
y	= 54-38-25	25.1788

Reference(s) Gossett, F.R., MANUAL OF GEODETIC TRIANGULATION, Special Publication No. 247, Superintendent of Documents, U.S. Gov. Printing Off., Washington D.C., 1959 Pages 174-176

User Instructions

SP. ANGLE COMP., CASE 3

Start				

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Start (See flag)		A	3.0000
3	Input distance a	a	R/S	
4	Input distance b	b	R/S	1/b
5	(Opt.) See b just entered		g 1/x	
6	Input angle A	A	R/S	
7	Input angle B	B	R/S	
8	Input angle C	C	R/S	
9	Input angle D	D	R/S	
10	Input angle G	G	R/S	x
11	See seconds and fraction of x (Note)		R/S	x ss.ssss
12	See y		R/S	y
13	See seconds and fraction of y (Note)		R/S	y ss.ssss
	NOTE: The x and y angles should be considered no			
	more accurate than the least accurate angle known			
	(A, B, C, D, or G angles.)			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
DSP	21	
.	83	
4	04	
f	31	
REG	43	
3	03	flag
RTN	24	Input a
STO 1	3301	
STO 7	3307	
R/S	84	Input b
C	13	
R/S	84	Input A
STO 3	3303	
R/S	84	Input B
STO 4	3304	
R/S	84	Input C
STO 5	3305	
R/S	84	Input D
STO 6	3306	
R/S	84	Input G
E	15	
RCL 3	3403	A
E	15	
C	13	
RCL 4	3404	B
E	15	
D	14	
RCL 5	3405	C
E	15	
C	13	
RCL 6	3406	D
E	15	
D	14	
2	02	
7	07	
0	00	
RCL 2	3402	
2	02	
÷	81	
–	51	
↓	41	
f	31	
TAN	06	
RCL 1	3401	
f-1	32	
TAN	06	
4	04	
5	05	
–	51	
f	31	

KEY ENTRY	CODE SHOWN	COMMENTS
TAN	06	
x	71	
f-1	32	
TAN	06	
+	61	
STO 2	3302	
g ↓	3508	
gLSTx	3500	
–	51	
STO 1	3301	
LBL	23	
0	00	
f	31	
→D.MS	03	
R/S	84	See x and y
gLSTx	3500	
B	12	
B	12	
R/S	84	See fraction of second
RCL 2	3402	
GTO	22	
0	00	
LBL	23	
B	12	
f-1	32	
INT	83	
6	06	
0	00	
x	71	
RTN	24	
LBL	23	
C	13	
g	35	
1/x	04	
LBL	23	
D	14	
STO	33	
x	71	
1	01	
RTN	24	
LBL	23	
E	15	
f-1	32	
→D.MS	03	
STO	33	
+	61	
2	02	
f	31	
SIN	04	
RTN	24	

REGISTERS	
R_1	accumulator x dec.
R_2	angle accumulator y dec.
R_3	A in D.MS
R_4	B in D.MS
R_5	C in D.MS
R_6	D in D.MS
R_7	a
R_8	
R_9	
LABELS	
A	start
B	used
C	used
D	used
E	used
0	used
1	
2	
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title SPECIAL DISTANCE COMPUTATION, CASE 3

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st STreet

City Indianapolis State Indiana Zip Code 46229

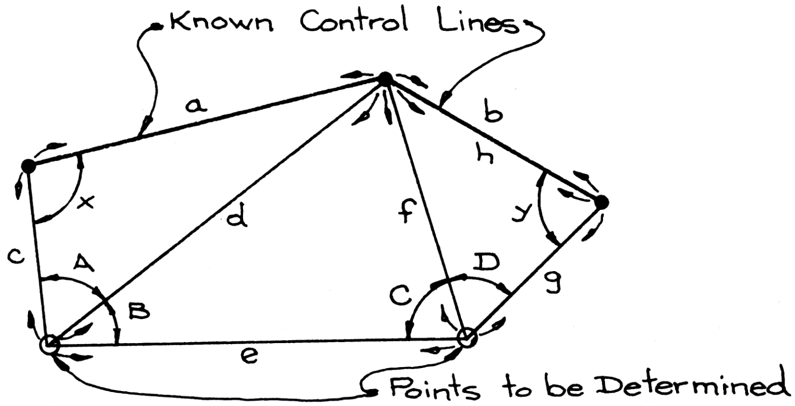
Program Description, Equations, Variables, etc. Computes all the unknown distances of the Case 3 problem shown on USCGS form 655A. Intended to follow the "Special angle Computation, Case 3" program, which leaves the needed data in the proper format in the proper registers, although the distances could be computed without using said program first, provided the X and Y angles are known.

USES SINE LAW:

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin(A+B)}$$

Operating Limits and Warnings Enter degrees, minutes, and seconds as DDD.MMSSS. If you stop in middle of computations, push RTN before restarting with the A key.

Program Description II



Sample Problem(s) Execute the sample problem from "Special Angle Computation, Case 3" program first, or store the following in the proper registers:

a = 300.00	in R7	C = 72°10'10"	in R5
A = 58°30'29.9"	in R3	D = 69°40'40.1"	in R6
B = 77°20'20"	in R4	x = 57.5805058°	in R1
		y = 54.6403274°	in R2

Then the steps are: A, R/S, R/S, R/S, R/S, R/S.

Solution(s)

c = 315.972
d = 296.985
e = 158.298
f = 304.384
g = 308.260
h = 350.000 = b

Reference(s) Gossett, F.R., MANUAL OF GEODETIC TRIANGULATION, Special Publication No. 247, Superintendent of Documents, U.S. Gov. Printing Off., Washington D.C., 1959 Pages 174–176

User Instructions

SP. DISTANCE CALC. CASE 3

Start				

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	If not from "Special Angle Computation" program,			
	then load proper registers with x, y, A, B, C, & D			
	angles and distance a in proper format.			
2	If from "Special Angle Computation" program			
	do nothing.			
3			A	c
4			R/S	d
5			R/S	e
6			R/S	f
7			R/S	g
8	Equal b?		R/S	h
9	Did you forget to write down a distance(s)? Go to			
	step 3.			
	NOTE: Flashing 0 indicates all distances have been			
	computed and R/S was pushed.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS	KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23		RTN	24	
A	11		LBL	23	
DSP	21		B	12	
.	83		STO	33	
3	03		÷	81	
RCL 7	3407	a	8	08	
STO 8	3308		g ↓	3508	
RCL 3	3403	A	RTN	24	
E	15		LBL	23	
↑	41		D	14	
D	14		f	31	
B	12		SIN	04	
RCL 1	3401	x	RTN	24	
C	13		LBL	23	
R/S	84		E	15	
RCL 5	3405	C	f-1	32	
E	15		→D.MS	03	
↑	41		RTN	24	
D	14				
B	12				
RCL 4	3404	B			
E	15				
C	13				
R/S	84				
RCL 2	3402	y			
↑	41				
D	14				
B	12				
RCL 6	3406	D			
E	15				
C	13				
R/S	84				
0	00				
÷	81				
LBL	23				
C	13				
↑	41				
g ↓	3508				
+	61				
f	31				
SIN	04				
RCL 8	3408				
x	71				
R/S	84				
g ↑	3509				
f	31				
SIN	04				
RCL 8	3408				
x	71				
STO 8	3308				

REGISTERS	
R_1	x in Dec.
R_2	y in Dec.
R_3	A in D.MS
R_4	B in D.MS
R_5	C in D.MS
R_6	D in D.MS
R_7	a
R_8	used
R_9	

LABELS	
A	start
B	used
C	used
D	used
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title TANGENT ELEVATIONS

Contributor's Name Charles C. Campbell, LS
Address 9841 E. 21st Street
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Given an interval, beginning stationing and elevation, and percent of grade, the program computes elevation of the station, which station is computed based on the interval, or a special station entered by the user. The program is designed to be used in conjuntion with "Vert. Curve Elevations", so that an entire street may be computed without re-entry of known data.

$$\text{New Elev} = \text{Last Elev.} + \left[\frac{g1}{100} \times (\text{New Sta} - \text{Last Sta})\right]$$

$$\text{Next Station} = \left(n \text{ of } \left[\frac{\text{last station}}{\text{interval}}\right] + 1\right) \text{ Interval}$$

Elev. = Elevation

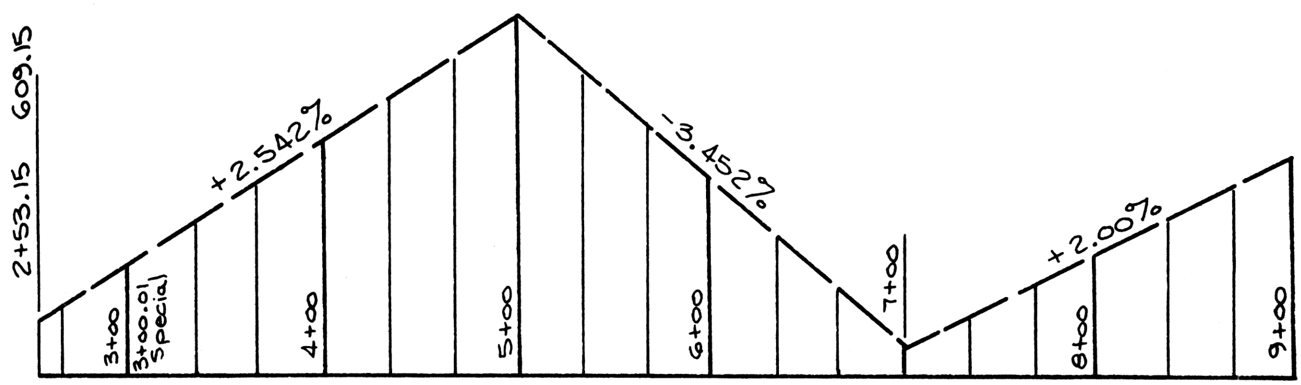
g1 = first grade in %

n = integer

Operating Limits and Warnings

If interval is fractional: round and truncate to 7 significant digits or less.
If below sea level, elevations are negative, including the entry thereof.

Program Description II



Sample Problem(s) Compute the elevations every 33.33 feet plus the special station for the problem in the above sketch.

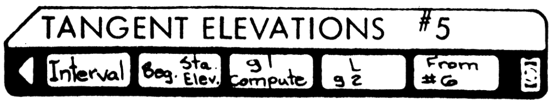
STEPS: 33.33333A, 253.15R/S, 609.15R/S, 2.542R/S, R/S, R/S, R/S, R/S, 300.01R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, OOPS! To far, 500R/S, 3.452 CHS C R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, 2C, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S,

Solution(s)

STA	ELEV.	STA.	ELEV.		
2+66.67	609.49	5+33.33	614.27	8+66.67	611.85
3+00.	610.34	5+66.67	613.12	9+00	612.52
3+00.01	610.34	6+00.	611.97		
3+33.33	611.19	6+33.33	610.82		
3+66.67	612.04	6+66.67	609.67		
4+00.00	612.88	7+00	608.52		
4+33.33	613.73	7+33.33	609.19		
4+66.67	614.58	7+66.67	609.85		
5+00	615.42	8+00	610.52		
		8+33.33	611.19		

Reference(s) Bouchard, Harry and Moffitt, Francis H., SURVEYING, fifth edition, pages 284–285, International Textbook Company, Scranton, Pennsylvania. 1965.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	(Optional) See flag		RTN	R/S	5
3	Input interval	I	A		
4	If from "Vert. Curve " program push E then go to step				
	8(skip step 3 or change interval)				
4	Or input beginning station and elevation		B		
5	Input beginning station	STA	R/S		
6	Input beginning elevation	ELEV	R/S		
7	Input grade and compute(see next station)	g1	C		STA
8	Accept		R/S		ELEV
8	Or override with special station	STA	R/S		ELEV
9	If at BVC, go to Vert. Curve program				
9	Or see next station		R/S		STA
9	Or go to step 3 or 4				
	Repeat steps 8 and 9 as desired.				
	NOTES: If D is pressed, a 6 will be displayed, which				
	means enter "Vert. Curve Elevation" program, then				
	press D to enter VC length and g2.				
	BVC = Beginning of vertical curve				
	g1 is "grade one", g2 is grade two"				
	B and C keys do not have to be pushed if coming from				
	preceeding funtion key (A or B).				
	use R/S to enter data				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
5	05	flag
DSP	21	
•	83	
0	00	
R/S	84	See flag
LBL	23	
E	15	
g ↓	3509	
STO 2	3302	
RCL 5	3405	
STO 3	3303	
RCL 4	3404	
STO 1	3301	
DSP	21	
•	83	
2	02	
GTO	22	
0	00	
LBL	23	
D	14	
6	06	flag(go to VC prog.)
RTN	24	
LBL	23	
A	11	Inp. interval
STO 8	3308	
LBL	23	
B	12	
DSP	21	
•	83	
2	02	
RTN	24	Inp. Bgn. Sta.
STO 1	3301	
R/S	84	Inp. Bgn. Elev.
STO 2	3302	
R/S	84	
LBL	23	Inp. g1 grade
C	13	
DSP	21	
•	83	
2	02	
EEX	43	
2	02	
÷	81	
STO 3	3303	
LBL	23	
0	00	
RCL 1	3401	
RCL 8	3408	
÷	81	
f	31	

KEY ENTRY	CODE SHOWN	COMMENTS
INT	83	
1	01	
+	61	
RCL 8	3408	
x	71	
R/S	84	See station
RCL 1	3401	
gx⇌y	3507	
STO 1	3301	
gx⇌y	3507	
-	51	
RCL 3	3403	
x	71	
RCL 2	3402	
+	61	
STO 2	3302	
R/S	84	See elevation
GTO	22	
0	00	

REGISTERS

- R_1 last station
- R_2 last elevation
- R_3 g1
- R_4
- R_5
- R_6
- R_7
- R_8 interval
- R_9

LABELS

- A used
- B used
- C used
- D used
- E used
- 0 used
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1
- 2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title VERT. CURVE ELEVATION

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis State Indiana Zip Code 46229

Program Description, Equations, Variables, etc. Given an interval, the stationing and elevation of the beginning of the curve, the two grades in %, and the length of curve, the program computes sta. and elev. of high or low point, if grades have different signs, and the elevation of the stations, which stations are computed based on the interval or a special station entered by the user. The program is designed to be used in conjuntion with "Tangent Elevations".

Equations of the Parabola:

$$r = \frac{g2 - g1}{L}$$

Next Station = (n of $\left[\frac{\text{last sta.}}{\text{interval}}\right]$ +1) interval

$$\text{Elev} = \text{Elev BVC} + (\text{Sta.}-\text{Sta.BVC})\,g1 + \left[\frac{r}{2} \times (\text{Sta.}-\text{Sta. BVC})^2\right]$$

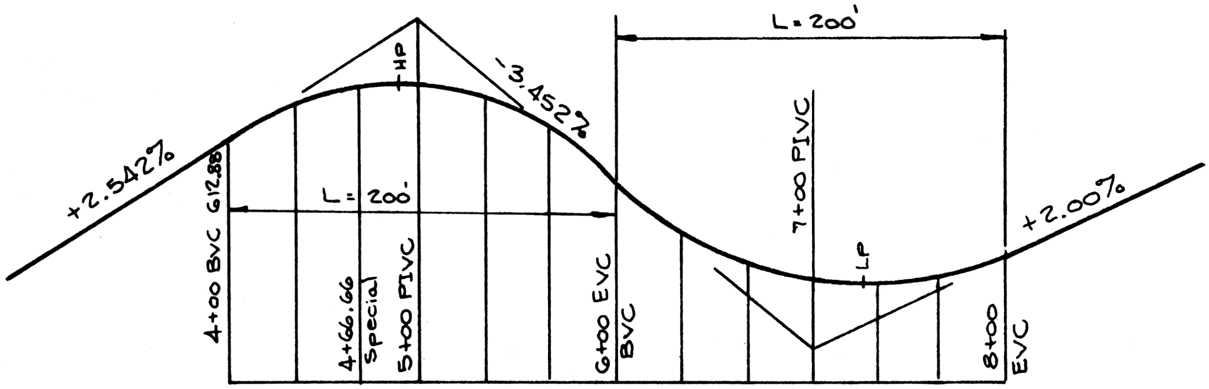
$$\text{Sta. Low Point} = \frac{-g1}{r} + \text{Sta. BVC}$$

r = rate of change of grade
g1 = initial grade (decimal)
g2 = final grade (decimal)
L = length of curve

BVC = Beginning of Vert. Curve
EVC = End of Vert. Curve
n = Integer

Operating Limits and Warnings If interval is fractional: round and truncate to 7 significant digits or less. If interval is fractional: EVC, STA. and ELEV. may have to be computed twice before the 5 is displayed. If below sea level, elevations are negative, including the entry thereof. It is possible to compute elevations of the parabola which is outside that part used for the VC.

Program Description II



Sample Problem(s) Compute the elevations for every 33.33 feet plus the special station for the above two curves:

STEPS: 33.33333A, 400R/S, 612.88R/S, 2.542R/S, 200R/S, 3.452 CHS R/S, R/S, R/S, R/S, R/S, 466.66R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S.

If you have "Tangent Elev," program: with 5 displayed, enter program, push E, re-enter VC elevation program, go to "then".
If no "Tangent Elev." program press B, 600R/S, 611.97R/S, 3.452CHS, R/S, then D, 200R/S, 2R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S.

Solution(s)

High Pt.	4+84.82	613.96	Low Pt.	7+26.63	609.78
	4+33.33	613.56		6+33.33	610.97
	4+66.66	613.91		6+66.67	610.27
	4+66.67	613.91		7+00	609.88
	5+00	613.92		7+33.33	609.79
	5+33.33	613.61		7+66.67	610.00
	5+66.67	612.95	Pt.	8+00	610.52
Pt.	6+00	611.97			

Reference(s) Bouchard, Harry and Moffitt, Francis H., SURVEYING, fifth edition, pages 280–289, International Textbook Company, Scranton, Pennsylvania, 1965.

User Instructions

VERT. CURVE ELEVATION #6

Interval | BC Sta. Elev. | g1 | Length g2 |

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	(Optional) see flag		RTN R/S	6.00
3	If from "Tan Elev" program; go to step 9			
4	Input interval	I	A	
5	Input BVC, STA and ELEV		B	
6	Input BVC STA	STA	R/S	
7	Input BVC ELEV	ELEV	R/S	
8	Input g1(first grade) in %	g1	C	
9	Input VC length and g2(second grade)		D	
10	Input VC length	L	R/S	
11	Input g2 in % (see STA high or low point if there	g2	R/S	STA
	is one)			
12	See ELEV of high or low point if there is one		R/S	ELEV
13	Next station (accept STA)		R/S	ELEV
13	Or override with special station	STA	R/S	ELEV
14	See next sta		R/S	STA
	Repeat steps 13 and 14 until a 5 is displayed, which			
	means you are at the end of cutve, then enter			
	"Tan Elev" program and continue on tangent.			
	Or go to step 4 to change interval.			
	Or go to step 5 for next curve.			
	NOTES: BVC=Beginning of Vertical Curve			
	B, C, and D keys do not have to be pushed if coming			
	from preceding function key(A, B, or C key), use			
	R/S to enter data.			
	If Step 3: You may do step 4, then go to step 9.			
	If error is detected at steps 13 or 14: You may re-			
	start computations at step 9 or excute step 4 and/or			
	excute steps 5, 6, 7 first, then go to step 9.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
6	06	flag
R/S	84	See flag
LBL	23	
A	11	
STO 8	3308	
LBL	23	
B	12	
RTN	24	Inp. BC STA
STO 1	3301	
R/S	84	Inp. BC ELEV
STO 2	3302	
R/S	84	
LBL	23	Inp. g1 in %
C	13	
EEX	43	
2	02	
÷	81	
STO 3	3303	
LBL	23	
D	14	
R/S	84	Inp. VC length
STO 4	3304	
R/S	84	Inp. g2 in %
EEX	43	
2	02	
÷	81	
STO 5	3305	
RCL 3	3403	
-	51	
RCL 4	3404	
÷	81	=R
STO 6	3306	
gLSTx	3500	
RCL 3	3403	
CHS	42	
RCL 6	3406	
÷	81	
0	00	
gx> y	3524	
GTO	22	
1	01	
+	61	
gx > y	3524	
GTO	22	
1	01	
RCL 1	3401	
+	61	
R/S	84	See low or high sta.
E	15	
R/S	84	See elev high or low

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
1	01	
RCL 1	3401	
STO	33	
+	61	
4	04	= EVC STA
LBL	23	
2	02	
RCL 8	3408	
÷	81	
f	31	
INT	83	
1	01	
+	61	
RCL 8	3408	
x	71	
RCL 4	3404	
gx > y	3524	
g ↓	3508	
gnop	3501	
R/S	84	See next sta.
STO 7	3307	
E	15	
R/S	84	See elevation
RCL 4	3404	
RCL 7	3407	
gx=y	3523	
5	05	
R/S	84	
GTO	22	
2	02	
LBL	23	Compute elevation
E	15	
RCL 1	3401	
-	51	
↑	41	
f-1	32	
√x	09	
RCL 6	3406	
2	02	
÷	81	
x	71	
gx⇄y	3507	
RCL 3	3403	
x	71	
RCL 2	3402	
+	61	
+	61	
RTN	24	

REGISTERS	
R_1	BVC STA
R_2	BVC ELEV
R_3	g1
R_4	L Sta EVC
R_5	g2
R_6	R
R_7	present Sta.
R_8	interval
R_9	used tests

LABELS	
A	used
B	used
C	used
D	used
E	used
0	
1	used
2	used
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title YARDAGE

Contributor's Name Charles C. Campbell, LS
Address 9841 East 21st Street
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Program utilizes the cross section(x-section) method to determine the volumes of Cut and Fill, where the End Areas(EA's) of adjacent x-sections are averaged and multiplyed by distance(Reach) between them and divided by 27 to obtain cubic yards. The program also displays the Mass Ordinate(MO) (Vol. cut-Vol. filled). The EA's are developed in segments defined by points consisting of stationing, proposed elevation, and existing elevation and computed according to the following CASES:

CASE 1: Section F End Area $= \dfrac{(F1+F2)\ D}{2}$

CASE 2: Section C End Area $= \dfrac{(-C1+-C2)\ D}{2}$

See Sketches
Next Page

CASE 3: Section F End Area $= \dfrac{F^2 \quad D}{(C + F)\ \ 2}$

Section -C End Area $= \dfrac{C^2\ \ D}{-(C+F)\ 2}$

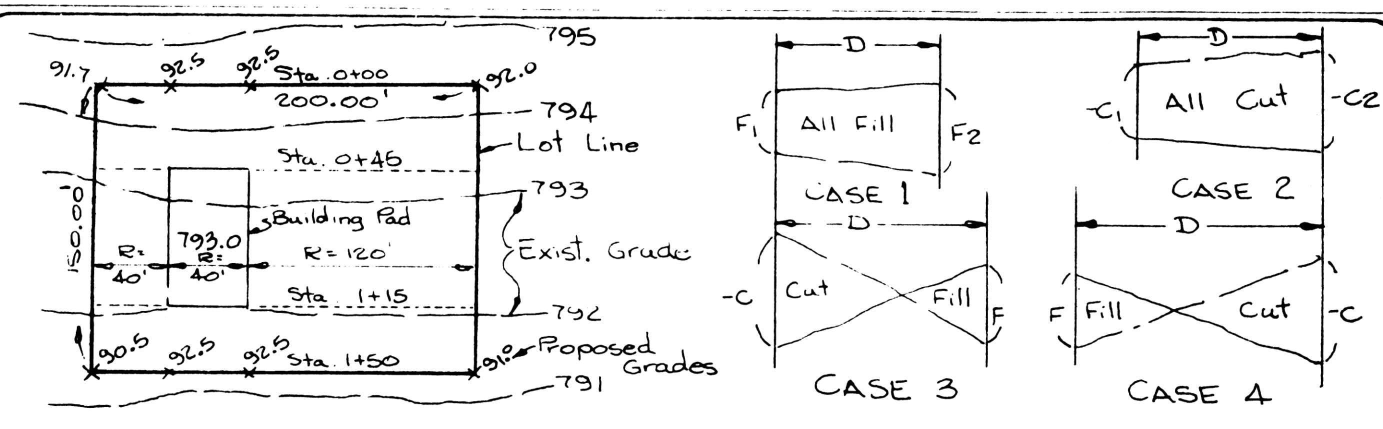
CASE 4: -C and F are exchanged to form a CASE 3 problem.

Operating Limits and Warnings None known.

The data for the program is normally taken from a Development Plan for a particular project.

It is not necessary to index the scale at "0" at the edge of the cross section.

Program Description II



Sample Problem(s)

STA.	P. ELEV.	E.ELEV.
0	91.7	94.4
150	90.5	91.4
	R=None	
0	92.5	94.5
45	93.0	93.5
115	93.0	92.0
150	92.5	91.2
	R=40	
	DUPE x-sec.	
	R=40	
0	92.0	94.3
150	91.0	91.3
	R=120	

STEPS: Enter Card 1, RTN, R/S, A, R/S, 91.7R/S, 94.4R/S, Enter Card 2, 150R/S, 90.5R/S, 91.4R/S, Enter Card 1, A, R/S, 92.5R/S, 94.5R/S, Enter Card 2, 45R/S, 93R/S, 93.5R/S, 115R/S, 93R/S, 92R/S, 150R/S, 92.5R/S, 91.2R/S, Enter Card 1, 40B, C, D, R/S, E, 40B, C, D, R/S, A, R/S, 92R/S, 94.3R/S, Enter Card 2, 150R/S, 91R/S, 91.3R/S, Enter Card 1, 120B, C, D, R/S.

Solution(s)

		CUT cy	FILL cy	MO cy
	X1-2	-245.99	47.10	+198.89
	X1-3	-337.96	141.30	+196.67
TOTAL	X1-4	-909.26	282 .59	+626.67

Reference(s) Bouchard, Harry and Moffitt, Francis H, SURVEYING, fifth edition, Chapter 16, page 520, International Textbook Company, Scranton, Pennsylvania, 1965.

User Instructions

YARDAGE Initilize RTN/R/S Card 1
X-Sec. | Reach | V. Cut | V. Fill | Dup. X-Sec.

YARDAGE Card 2

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Card 1				
2	Initilize (Vol. accumulators)		RTN	R/S	
3	Input X-section		A		
3	If re-starting X-section after mistake.		GTO	5	
4	Input first station	STA	R/S		STA
5	Input first proposed elevation	PE	R/S		PE
6	Input first existing elevation	EE	R/S		2
7	Enter Card 2				
8	Input next station	STA	R/S		
9	Input next proposed elevation	PE	R/S		PE
10	Input next existing elevation	EE	R/S		1
11	Repeat steps 8,9, & 10 for each point in X section				
12	Re-enter Card 1				
13	Input reach between last two X-section	reach	B		
14	See Volume Cut(cu. yards) to date		C		cut
15	(Optional) See mass-ordinate		R/S		MO
16	See Volume Fill(cu. yards) to date		D		FILL
17	(Optional) See mass-ordinate		R/S		MO
18	Duplicate end areas of last X-section(optional)		E		
19	Go to step 3 for next X-section				
	NOTES: At step 13: two x-sections should be computed before a reach				
	is entered and volumes computed, excepting at the beginning of				
	a job where the first x-section has EA's of zero, provided the				
	"last" EA was initilized by merely pushing the A key. (zeros				
	out registers 1 and 2) and the second pushing moves the zeros				
	to the last EA position.				
	Steps 14 through 18 are optional except after the last				
	x-section in job.				
	GTO 5 prevents movement of "last x-section" EA's.				

Program Form

YARDAGE CARD 1

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
0	00	Initilize Vol.
STO 7	3307	
STO 8	3308	
R/S	84	
0	00	
÷	81	Error stop
LBL	23	
A	11	Start new x-section
RCL 1	3401	transfer end areas
STO 3	3303	
RCL 2	3402	
STO 4	3304	
LBL	23	
5	05	re-start x-section
0	00	
STO 1	3301	zero accumulators
STO 2	3302	zero accumulators
R/S	84	input first station
STO 5	3305	
R/S	84	Input first PE
R/S	84	Input first EE
-	51	
STO 6	3306	
2	02	flag
R/S	84	go to Card 2
0	00	
÷	81	error stop
LBL	23	
B	12	input reach
STO	33	
9	09	
RCL 1	3401	
RCL 3	3403	
+	61	
x	71	
5	05	
4	04	
÷	81	
STO	33	
+	61	
7	07	
RCL	34	
9	09	
RCL 2	3402	
RCL 4	3404	
+	61	
x	71	
5	05	
4	04	
÷	81	

KEY ENTRY	CODE SHOWN	COMMENTS
STO	33	
+	61	
8	08	
RTN	24	
LBL	23	
C	13	
RCL 8	3408	
GTO	22	
6	06	
LBL	23	
D	14	
RCL 7	3407	
LBL	23	
6	06	
RTN	24	See Cut or Fill
RCL 8	3408	
CHS	42	
RCL 7	3407	
-	51	
R/S	84	See MO
0	00	
÷	81	error stop
LBL	23	
E	15	duplicate last x-section
RCL 1	3401	
STO 3	3303	
RCL 2	3402	
STO 4	3304	
RTN	24	
0	00	
÷	81	

REGISTERS	
R_1	EA Fill accumulator (current)
R_2	EA Cut accumulator (current)
R_3	EA Fill (last)
R_4	EA Cut (last)
R_5	STA
R_6	PE-EE
R_7	Vol. Fill accumulator (cu. yds.)
R_8	Vol. Cut accumulator (cu. yards)
R_9	used tests & reach
LABELS	
A	x-sec.
B	reach
C	Cut
D	Fill
E	dupe.
0	x-sec.
1	
2	
3	
4	
5	used
6	used
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM

Program Form

YARDAGE CARD 2

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RCL 5	3405	
gx > y	3524	
GTO	22	Sta. enter too small
0	00	
g ↓	3508	Sta. is ≥ last Sta.
R/S	84	Input PE2----n
R/S	84	Input EE2----n
-	51	
gx⇌y	3507	
RCL 5	3405	
-	51	
STO	33	
+	61	
5	05	
gx⇌y	3507	
RCL 6	3406	
gx⇌y	3507	
STO 6	3306	
0	00	
gx > y	3524	
GTO	22	
1	01	R side Cut
+	61	R side Fill
gx⇌y	3507	
0	00	
gx > y	3524	
GTO	22	
2	02	L cut R fill(case 3)
+	61	L fill R fill (case 1)
+	61	
D	14	
GTO	22	
4	04	End Case 1
LBL	23	
1	01	
+	61	
gx⇌y	3507	
0	00	
gx > y	3524	
GTO	22	
3	03	L cut R cut(case 2)
+	61	L fill R cut(case 4)
gx⇌y	3507	Cont. to Case 3
0	00	
LBL	23	Case 3
2	02	
+	61	
↑	41	
f-1	32	
√x	09	

KEY ENTRY	CODE SHOWN	COMMENTS
g ↓	3508	
gx⇌y	3507	
-	51	
gLSTx	3500	
f-1	32	
√x	09	
g ↓	3508	
÷	81	
↑	41	
CHS	42	
g ↓	3508	
C	13	
g ↓	3508	
D	14	
GTO	22	
4	04	End Case 3
LBL	23	
3	03	Case 2
+	61	
+	61	
C	13	
GTO	22	
4	04	End Case 2
LBL	23	Fill Routine
D	14	
x	71	
2	02	
÷	81	
STO	33	
+	61	
1	01	
RTN	24	
LBL	23	Cut Routine
C	13	
x	71	
2	02	
÷	81	
STO	33	
+	61	
2	02	
RTN	24	
LBL	23	
4	04	
1	01	
LBL	23	
0	00	
R/S	84	
gnop	3501	
gnop	3501	
gnop	3501	

REGISTERS

- R_1 EA Fill accumulator (current)
- R_2 EA Cut accumulator (current)
- R_3 EA Fill (last)
- R_4 EA Cut (last)
- R_5 STA
- R_6 prop. elev.-exist. elev.
- R_7 Vol. Fill accumulator (cu. yards)
- R_8 Vol. Cut accumulator (cu. yds.)
- R_9 used tests

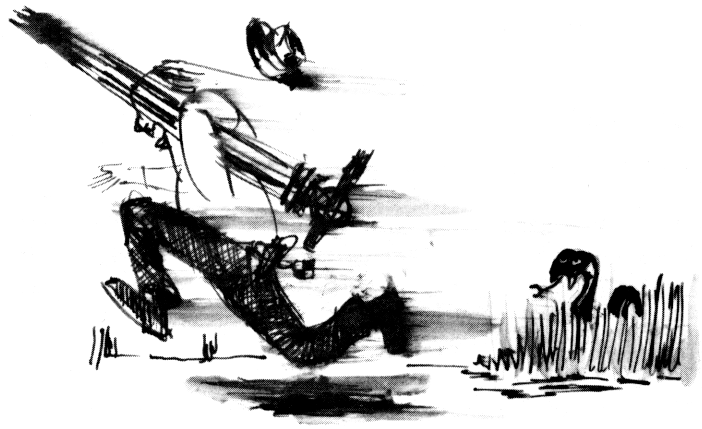
LABELS

- A
- B
- C used
- D used
- E
- 0 used
- 1 used
- 2 used
- 3 used
- 4 used
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1
- 2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM



Program Description I

Program Title Q FOR DITCH(MANNINGS)

Contributor's Name Charles C. Campbell, LS

Address 9841 E. 21st Street

City Indianapolis State Indiana Zip Code 46229

Program Description, Equations, Variables, etc. Computes the Q (discharge in cubic feet per second) for a trapezoidal ditch utilizing Manning's formula, given width of bottom, side slope (horizontal distance for the rise of 1 foot), depth of ditch, slope(in feet per foot), and the roughness factor n. Also displays V (mean Velocity) in feet per second.

$$Q = A \cdot \frac{1.486}{n} \cdot R^{2/3} \cdot S^{1/2}$$

Where $A = D(DX+W)$ = cross sectional area

x = side slope x to 1

R = Hydraulic Radius in feet= A/WP

WP = Wetted Perimeter = $W+(2D\sqrt{X^2+1})$

V= Velocity = Q/A

D = Depth of ditch

S = Slope or grade in feet per foot

n = coefficient of roughness

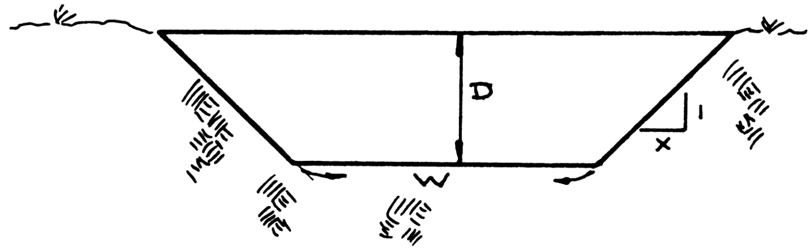
Operating Limits and Warnings See reference and other works for roughness factors which are not listed on program description II.

If box culvert: use 0 for X in side slope of X to 1.

Program Description II

Mannings coefficient of Roughness (n) for channels:

Lining	n
ordinary earth, graded	.02
sod, depth more than 6"	.04
sod, depth less than 6"	.06
type A riprap, rough	.04
concrete paved gutter	.016



Sample Problem(s) (1) What is the discharge (Q) of a ditch where slope is 4 feet per mile, bottom width of 16 feet, depth of 8 feet, side slopes of 2:1, and a roughness factor of 0.025? Also, what is the velocity?

STEPS: 16A, 2B, 8C, 4 Enter 5280 ÷ D, .025E, R/S, R/S.

(2) What is the end area of the above ditch?

STEPS: After executing problem 1 above, press ÷ .

Solution(s)

Q = 1215.53 cfs.

V = 4.75 feet per second

End Area = 256 square feet

Reference(s) <u>HANDBOOK OF STEEL DRAINAGE & HIGHWAY CONSTRUCTION PRODUCTS</u>, Second Edition, Chapter 4, page 146, published by American Iron and Steel Institute, 150 East 42nd Street, New York, New York, 10017, 1971.

User Instructions

Q FOR DITCH(MANNINGS)

W	X to 1	D	S	n

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input ditch bottom width	W	A		W
3	Input side slope, X to 1	X	B		X
4	Input depth of flow	D	C		D
5	Input slope (feet per foot) (Note 1)	S	D		S
6	Input roughness factor n (Note 2)		E		n
7	Compute Q in cfs		R/S		Q
8	(Optional) See velocity		R/S		V
9	(Optional) See End Area		÷		A
9	Or (optional) See End Area		RCL	6	A
10	Return to steps 2, 3, 4, 5 or 6 to change any				
	design factor then go to step 7 to recompute.				
10	Or recompute by pressing ⟶		RTN	R/S	Q
	and then go to step 8				
	NOTE 1: To see $S^{1/2}$ after executing step 5,				
	press gx⇄y or RCL 4.				
	NOTE 2: To see $\frac{1.486}{n}$ after executing				
	step 6, press gx⇄y or RCL 5.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	Compute
1	01	
RCL 3	3403	
RCL 3	3403	
RCL 2	3402	
x	71	
RCL 1	3401	
+	61	
x	71	
STO 6	3306	
RCL 1	3401	
RCL 2	3402	
f-1	32	
$\sqrt{x}$	09	
1	01	
+	61	
f	31	
$\sqrt{x}$	09	
RCL 3	3403	
x	71	
2	02	
x	71	
+	61	
÷	81	
STO 7	3307	
2	02	
↑	41	
3	03	
÷	81	
g	35	
y^x	05	
STO 8	3308	
RCL 4	3404	
RCL 5	3405	
x	71	
x	71	
STO	33	
9	09	
x	71	
R/S	84	See Q
RCL	34	
9	09	
GTO	22	
0	00	
LBL	23	
A	11	
STO 1	3301	W
GTO	22	
0	00	
LBL	23	

KEY ENTRY	CODE SHOWN	COMMENTS
B	12	
STO 2	3302	X
GTO	22	
0	00	
LBL	23	
C	13	
STO 3	3303	D
GTO	22	
0	00	
LBL	23	
D	14	S
f	31	
$\sqrt{x}$	09	
STO 4	3304	
gLSTx	3500	
GTO	22	
0	00	
LBL	23	
E	15	n
1	01	
•	83	
4	04	
8	08	
6	06	
gx⇄y	3507	
÷	81	
STO 5	3305	
gLSTx	3500	
LBL	23	
0	00	
DSP	21	
•	83	
2	02	
R/S	84	
GTO	22	
1	01	

REGISTERS
R_1 W (bottom)
R_2 X (side slope) x to 1
R_3 D (depth of flow)
R_4 $S^{1/2}$
R_5 $\frac{1.486}{n}$
R_6 A (end area)
R_7 R
R_8 $R^{2/3}$
R_9 V velocity

LABELS	
A	W
B	x
C	D
D	S
E	n
0	used
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title D FOR DITCH(MANNINGS)

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Uses "The Franklin Interation" to compute the D(depth) of a trapezoidal ditch utilizing Manning's formula, given width of bottom, side slope(horizontal distance for the rise of 1 foot), Q(discharge in cubic feet per second), slope(in feet per foot) and the roughness factor n.

$$Q = A \cdot \frac{1.486}{n} \cdot R^{2/3} \cdot S^{1/2}$$

Where
- A = $D(Dx+W)$ = cross sectional area
- X = side slope x to 1
- R = hydraulic radius = A/wp
- WP = wetted perimeter = $W+(2D\sqrt{X^2+1})$
- V = velocity = Q/A
- D = depth of ditch
- S = slope or grade in feet per foot
- n = coefficient of roughness

D_1 is assumed by the program to be 5.00 feet, then:

$$\text{(A)} \quad D2 \ldots n = D1 \ldots n + \frac{(Q1 \ldots n) - (Q2 \ldots n)}{V\left[W + (2 \times D1 \ldots n)\right]}$$

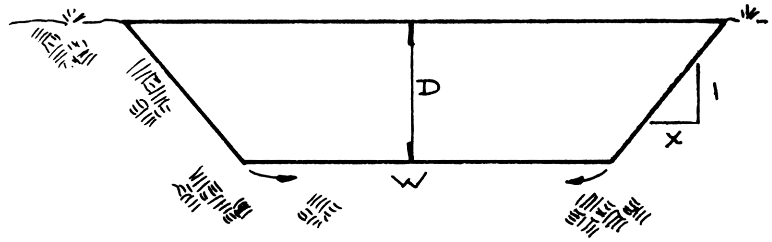
The program interates until $Dn = Dn-1$. The right term in the right member of the above equation(A) is truncated to two decimal places and may be positive or negative. A value of 0.005 is added to said term to force Dn to equal $Dn-1$. This sometimes makes D high, up to 0.01 foot, which should be of no consequence.

Operating Limits and Warnings See reference and other works for roughness factors which are not listed on Program Description II. If box culvert: use 0 for X in side slope of X to 1.

Program Description II

Mannings coefficient of Roughness
(n) for channels:

Lining	n
ordinary earth, graded	.02
sod, depth more than 6"	.04
sod, depth less than 6"	.06
type A riprap, rough	.04
concrete paved gutter	.016



Sample Problem(s) What is the depth required for a ditch where slope is 4 feet per mile, bottom width of 16 feet, Q of 1215 cfs, side slopes of 2:1, and a roughness factor of 0.025?

STEPS: 16A, 2B, 1215C, 4 Enter 5280 ÷ D, 0.025E, RTN, R/S.

Solution(s) D = 8.00'

Reference(s) Handbook of Steel Drainage & Highway Construction Products, second edition, Chapter 4, page 146, published by American Iron and Steel Institute, 150 East 42nd Street, New York, New York, 10017, 1971.

User Instructions

D for DITCH (MANNINGS)				
W	xto 1	Q	S	n

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input ditch bottom width	W	A		W
2	Input side slope to the depth of 1	X	B		X
2	Input discharge in cfs.	Q	C		Q
2	Input slope(feet per foot) (Note 1)	S	D		S
2	Input roughness factor (Note 1)	n	E		
3	Compute D		RTN	R/S	D
4	Change one or more of the design parameters at				
	step 2 and recompute at step 3.				
	Note 1: to see data entered		g	LSTX	s or n
	Note 2: after step 4, to see:				
	Q		RCL	8	Q
	W		RCL	1	W
	x		RCL	2	x
	D		RCL	3	D
	$S^{1/2}$		RCL	4	$S^{1/2}$
	1.486/n		RCL	5	1.486/n
	A		RCL	6	A
	R (hydraulic radius)		RCL	7	R
	V (velocity in feet per second)		RCL	8	
			RCL	6	
			÷		V

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
5	05	Compute
LBL	23	
1	01	
STO 3	3303	
RCL 3	3403	
RCL 2	3402	
x	71	
RCL 1	3401	
+	61	
x	71	
STO 6	3306	
RCL 1	3401	
RCL 2	3402	
f-1	32	
$\sqrt{x}$	09	
1	01	
+	61	
f	31	
$\sqrt{x}$	09	
RCL 3	3403	
x	71	
2	02	
x	71	
+	61	
÷	81	
STO 7	3307	
2	02	
↑	41	
3	03	
÷	81	
g	35	
y^x	05	
RCL 4	3404	
RCL 5	3405	
x	71	
x	71	
x	71	
gLSTx	3500	
RCL 3	3403	
2	02	
x	71	
RCL 2	3402	
x	71	
RCL 1	3401	
+	61	
x	71	
RCL 8	3408	
g ↓	3509	
-	51	
gx⇄y	3507	

KEY ENTRY	CODE SHOWN	COMMENTS
÷	81	
EEX	43	
2	02	
x	71	
.	83	
5	05	
+	61	
f	31	
INT	83	
EEX	43	
2	02	
÷	81	
RCL 3	3403	
+	61	
RCL 3	3403	
gx⇄y	3507	
gx=y	3523	
R/S	84	See D
gnop	3501	
GTO	22	Refine D
1	01	
LBL	23	
A	11	Input W
STO 1	3301	
RTN	24	
LBL	23	
B	12	Input x to 1
STO 2	3302	
RTN	24	
LBL	23	
C	13	Input Q
STO 8	3308	
RTN	24	
LBL	23	
D	14	Input S
f	31	
$\sqrt{x}$	09	
STO 4	3304	
RTN	24	
LBL	23	
E	15	Input n
1	01	
.	83	
4	04	
8	08	
6	06	
gx⇄y	3507	
÷	81	
STO 5	3305	
RTN	24	

REGISTERS	
R_1	W
R_2	x to 1
R_3	D
R_4	$S^{1/2}$
R_5	1.486/n
R_6	A
R_7	R
R_8	Q
R_9	

LABELS	
A	W
B	x to 1
C	Q
D	S
E	n
0	
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title BOX CULVERT(CDH METHOD)

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. For storm drainage design, the program computes rectangular box culvert dimensions or Q10 or d of round pipe, utilizing the California Division of Highways method which requires the following criteria for balanced design: (1) a 10-year flood without static head at entrance and (2) a 100-year flood utilizing the available head at entrance.

$$Q10 = 3.086\ H^{1.5} \quad W = 2.581\left(\frac{d}{12}\right)^{2.5}$$

$$H = \left(\frac{Q10}{3.086W}\right)^{2/3}$$

$$W = \frac{Q10}{3.086H^{1.5}}$$

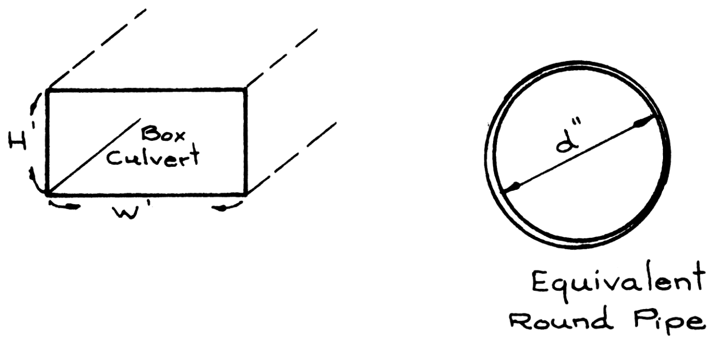
$$d = 12\left(\frac{Q10}{2.581}\right)^{.4}$$

Operating Limits and Warnings

1. If d is unknown, R4 must contain a zero before Q10 can be computed from H & W. You may input 0 for d. (If HP65 was just used with another program).

2. Program leaves Flag 2 on.

Program Description II



Sample Problem(s) 1a. If d equals 36", what is Q10?

STEPS: Enter Card 1, A, enter card 2, 36D, EC.

1b. What is Q10 for a 3.0' x 6.0' box culvert and what is the equivalent in round pipe?

STEPS: 0 D,3A, 6B, EC, ED.

1c. What widths of box culvert is needed and what is the cfs, if H=2.5' and carries the contents of a 42" round pipe?

STEPS: 2.5A, 42D, EC, EB.

Solution(s)

1a. = 40.23 cfs.

1b. = 96.21cfs & 51.02"

1c. = 59.15cfs & 4.85'

Reference(s) HANDBOOK of STEEL DRAINAGE & HIGHWAY CONSTRUCTION PRODUCTS, Second Edition, pages 158-160, published by American Iron and Steel Institute, 150 East 42nd Street, New York, New York 10017, 1971.

User Instructions

BOX CULVERT (CDH METHOD) 2				
H	W	Q 10	d	Comp

1				
start		3.086	2.581	1.5

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Card 1				
2	Generate and store constants		A		0.00
3	(Optional) Check 3.086 constant		C		3.086
3	(Optional) Check 2.581 constant		D		2.581
3	(Optional) Check 1.5 constant		E		1.5
3	(Optional) re-set display 2 places		B		X.XX
4	Enter Card 2				
5	Input knowns:				
	Height	H	A		H
	or Width	W	B		B
	or Q10	Q10	C		Q10
	or diameter of round pipe eq.	d	D		
6	Compute: (NOTE 1)				
	height		E	A	H
	Width		E	B	W
	Q10		E	C	Q10
	d		E	D	d
	NOTE 1: Don't distrube the "1" displayed after the				
	E key is pressed.				
	Q10 must be computed first if unknown.				
	NOTE 2: d is in inches				
	Q = cubic feet per second, 10 year rain(see program description)				
	H & W are in feet and decimal thereof.				
	d must be 0 if Q10 is computed from H & W				
	NOTE 3: Any step 6 may be executed in order to see				
	the variables entered, after the unknown(s) are computed.				

Program Form

BOX CULVERT CARD 1

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
3	03	
.	83	
0	00	
8	08	
6	06	
STO 5	3305	
2	02	
.	83	
5	05	
8	08	
1	01	
STO 6	3306	
1	01	
.	83	
5	05	
STO 7	3307	
f	31	
SF 2	71	On
DSP	21	
.	83	
2	02	
0	00	
RTN	24	0.0
LBL	23	
B	12	
DSP	21	
.	83	
2	02	
RTN	24	
LBL	23	
C	13	3.086 Constant
RCL 5	3405	
DSP	21	
.	83	
3	03	
RTN	24	
LBL	23	
D	14	2.581 Constant
RCL 6	3406	
DSP	21	
.	83	
3	03	
RTN	24	
LBL	23	
E	15	1.5 Constant
RCL 7	3407	
DSP	21	
.	83	

KEY ENTRY	CODE SHOWN	COMMENTS
1	01	
RTN	24	

REGISTERS	
R_1	
R_2	
R_3	
R_4	
R_5	3.086 constant
R_6	2.581 constant
R_7	1.5 constant
R_8	
R_9	

LABELS	
A	set
B	DSP.2
C	3.086
D	2.581
E	1.5
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	used

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Form

BOX CULVERT CARD 2

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
g	35	LBL A
DSZ	83	
STO 1	3301	
RTN	24	
STO 8	3308	
RCL 3	3403	
RCL 2	3402	
RCL 5	3405	
x	71	
÷	81	
RCL 7	3407	
g	35	
1/x	04	
E	15	
STO 1	3301	
RTN	24	See H
LBL	23	
B	12	
g	35	
DSZ	83	
STO 2	3302	
RTN	24	
STO 8	3308	
RCL 3	3403	
RCL 5	3405	
RCL 1	3401	
RCL 7	3407	
E	15	
÷	81	
STO 2	3302	
RTN	24	See W
LBL	23	
C	13	
g	35	
DSZ	83	
STO 3	3303	
RTN	24	
STO 8	3308	
0	00	
RCL 4	3404	
gx=y	3523	
GTO	22	
0	00	
RCL 6	3406	
gx⇄y	3507	
1	01	
2	02	
÷	81	
2	02	
.	83	

KEY ENTRY	CODE SHOWN	COMMENTS
5	05	
E	15	
STO 3	3303	
RTN	24	See Q from d
LBL	23	
0	00	
RCL 2	3402	
RCL 1	3401	
RCL 7	3407	
E	15	
RCL 5	3405	
x	71	
STO 3	3303	
RTN	24	See Q from H&W
LBL	23	
D	14	
g	35	
DSZ	83	
STO 4	3304	
RTN	24	
STO 8	3308	
1	01	
2	02	
RCL 3	3403	
RCL 6	3406	
÷	81	
.	83	
4	04	
E	15	
STO 4	3304	
RTN	24	See d
LBL	23	
E	15	
g	35	
DSZ	83	
GTO	22	
1	01	
f-1	32	
TF 2	81	
0	00	
÷	81	No constant stop
g	35	
y^x	05	
x	71	
RTN	24	
LBL	23	
1	01	
1	01	
STO 8	3308	
RTN	24	

REGISTERS	
R_1	H
R_2	W
R_3	Q
R_4	d
R_5 constant	3.086
R_6 constant	2.581
R_7 constant	1.5
R_8	DSZ
R_9	test

LABELS	
A	H
B	W
C	Q
D	d
E	compute
0	used
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	used

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

NOTES

Program Description I

Program Title AZ. FROM SUN (H.A. METHOD)

Contributor's Name Charles C. Campbell, LS
Address 9841 East 21st Street
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Utilizing the Hour Angle method, this program computes North azimuth to mark and sun. Accurate time is a must. Vertical angle to sun is not required. Inputs with card #1 are: Latitude, longitude, declination of sun at 0H, difference per hour, equation of time at 0H, change per hour. The computations are made with card two after entering mean horizontal angle and mean Coordinated Universal Time(UCT).

$$\text{N. Azimuth to Sun} = \frac{\sin t}{\cos \phi \ \tan \delta - \sin \phi \ \cos t}$$

where:

t = UCT + EOT(ephemeris) + UCT [Difference/Hour(ephemeris)] -West λ

δ = δ (ephemeris) + UCT [Change/Hour(ephemeris)]

EOT = Equation of Time

UCT = Coordinated Universal Time

ϕ = latitude (North)

λ = longitude (West)

Δ = clockwise angle, mark to sun's center

N. Azimuth to Mark = Az. to Sun $- \Delta$

Operating Limits and Warnings The author has had little experience with this program. Watch for 180^0 error in azimuth.

Program Description II

UCT is also known as Greenwich Civil Time or Greenwich Mean Time.
The author has found that utilizing time signals received from stations WWV, United States or CHU, Canada, by short wave radio, the "Realistic Time Kube" available from "Radio Shack" (Registered Trademarks) and a stopwatch to measure the elaspe time from the moment of pointing to the voice announcement at the even minute on said radio, is the best way to obtain UCT.

Sample Problem(s) An observation of the sun was made, where the following field and ephemeris data was obtained.

DATE: May 13, 1975

Latitude ϕ : 39°47'46"

Longitude λ: 85°59'33"

Mean angle : 33°10'59.7" to center of sun

Mean UCT : $23^h28^m09.1^s$

EPHEMERIS DATA:

δ = N 18°10.4'

DIFF./h = $+0.62^m$

EOT = $03^m41.2^s$

CHANGE/h = $+0.03^s$

What is the N. Azimuth to the mark and sun?
STEPS: Enter Card 1, 39.4746A, 85.5933A, 18.1024B, .62C, .03412D, .03E,
Enter Card 2, 33.10597A, 23.28091B, C, R/S,

Solution(s) North Azimuth to:

Mark: 249°21'00"

Sun : 282°31'59"

Reference(s) Curtis, Kenneth S., MERIDIAN DETERMINATION BY SOLAR AND POLARIS OBSERVATION, Manual #4, ISPLS Inc., 111N. Capitol Ave., Indpls. In. 46204, 1975

User Instructions

AZIMUTH FROM SUN CARD 1
φ/λ | δ | DIFF^m | EOT | CHANGE^S

AZIMUTH FROM SUN CARD 2
Δ | UCT | Compute | |

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program Card #1				
2	Input instrument station data:				
3	φ scaled from map	DD.MMSS	A		
4	λ scaled from map	DD.MMSS	A		
5	δ (declination from ephemeris) (Note 1)	DD.MMSS	B		
6	DIFF. in declination for 1 hour(Note 2)	M.MM	C		
7	EOT(equation of time from ephemeris(Note 3)	H.MMSS	D		
8	Change for 1 hour (Note 2)	S.SS	E		
9	Enter program Card #2				
10	Input observation data:				
11	Δ , clockwise angle mark to sun (Note 4)	DDD.MMSS	A		
12	UCT, coordinated universal time (Note 4)	HH.MMSS	B		
13	Compute North azimuth to Mark		C		DD.MMSS
14	(Optional) See N. azimuth to sun		R/S		DD.MMSS
15	See N. azimuth to mark again		R/S		
16	New observation data, same station, go to step 11				
16	New station; go to step 1				
	NOTE 1: Enter δ as negative value if South or				
	positive value if North.				
	NOTE 2: If decreasing towards next day, enter as				
	negative value. If increasing, enter as positive				
	value. Watch signs.				
	NOTE 3: Enter negative values with CHS.				
	NOTE 4: Mean angle and time to center of sun.				

Program Form

CARD 1

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	ø
f-1	32	
→D.MS	03	
STO 3	3303	
gLSTx	3500	
DSP	21	
.	83	
4	04	
RTN	24	
LBL	23	
A	11	λ
f-1	32	
→D.MS	03	
STO 2	3302	
gLSTx	3500	
RTN	24	
LBL	23	
B	12	δ
f-1	32	
→D.MS	03	
STO 5	3305	
gLSTx	3500	
RTN	24	
LBL	23	
C	13	DIFF. m
↑	41	
↑	41	
6	06	
0	00	
÷	81	
STO 6	3306	
g ↓	3508	
RTN	24	
LBL	23	
D	14	EOT
f-1	32	
→D.MS	03	
STO 7	3307	
gLSTx	3500	
RTN	24	
LBL	23	
E	15	Change s
↑	41	
↑	41	
3	03	
6	06	
0	00	
0	00	
÷	81	

KEY ENTRY	CODE SHOWN	COMMENTS
STO 8	3308	
g ↓	3508	
RTN	24	

REGISTERS

- R_1 UCT
- R_2 λ
- R_3 ø
- R_4 Δ
- R_5 δ
- R_6 DIFF
- R_7 EOT
- R_8 Change
- R_9

LABELS

- A ø λ
- B δ
- C DIFF.
- D EOT
- E Change
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1
- 2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Form

CARD 2

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	△
f-1	32	
→D.MS	03	
STO 4	3304	
GTO	22	
D	14	
LBL	23	
B	12	UCT
f-1	32	
→D.MS	03	
STO 1	3301	
LBL	23	
D	14	
gLSTx	3500	
RTN	24	
LBL	23	
C	13	Compute
RCL3	3403	
1	01	
f-1	32	
R → P	01	
RCL 1	3401	
RCL 6	3406	
x	71	
RCL 5	3405	
+	61	
f	31	
TAN	06	
x	71	
RCL 1	3401	
RCL 8	3408	
x	71	
RCL 7	3407	
+	61	
RCL 1	3401	
+	61	
1	01	
5	05	
x	71	
RCL 2	3402	
-	51	
1	01	
8	08	
0	00	
f-1	32	
SF 2	71	
gx > y	3524	
f	31	
SF 2	71	

KEY ENTRY	CODE SHOWN	COMMENTS
-	51	
g	35	
ABS	06	
1	01	
f-1	32	
R → P	01	
g ↑	3509	
x	71	
CHS	42	
g ↑	3509	
1	01	
8	08	
0	00	
g ↓	3508	
+	61	
÷	81	
f-1	32	
TAN	06	
0	00	
gx > y	3524	
+	61	
gnop	3501	
+	61	
f-1	32	
TF 2	81	
-	51	
+	61	
LBL	23	
E	15	
↑	41	
↑	41	
RCL 4	3404	
-	51	
0	00	
gx > y	3524	
3	03	
6	06	
0	00	
+	61	
+	61	
f	31	
→D.MS	03	
R/S	84	Azimuth to mark
g ↓	3508	
f	31	
→D.MS	03	
R/S	84	Azimuth to sun
g ↓	3508	
GTO	22	
E	15	

REGISTERS	
R_1	UCT
R_2	λ
R_3	∅
R_4	△
R_5	δ at 0h
R_6	DIFF.°
R_7	EOT at 0h
R_8	Change °
R_9	used trig. & tests

LABELS	
A	△
B	UCT
C	compute
D	used
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	used

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title AZIMUTH FROM POLARIS

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. This program computes the North Azimuth from an observation station to a second mark from a polaris observation when given latitude and longitude(could be scaled from a USGS map), UCT(coordinated universal time) and clockwise angle, mark to polaris, measured in field, and GHA for Oh and polar distance from an ephemeride. Also will display the azimuth of polaris.

$$\text{Azimuth to polaris} = \frac{\sin\ t\ \sin\ pd}{\cos\ h}$$

Where t = G.H.A. (Greenwich Hour Angle) - West Longitude

pd = polar distance

h = altitude = ϕ +pd (cos t)

ϕ = latitude of station

λ = longitude of station

Operating Limits and Warnings UCT is also known as Greenwich Civil Time or Greenwich Mean Time. The author has found that utilizing time signals received from stations WWV, United States or CHU Canada, by short wave radio, the "Realistic Time Kube" available from "Radio Shack"(Registered Trademarks) and a stopwatch to measure the elaspe time from the moment of pointing to the voice announcement at the even minute on said radio, is the best way to obtain UCT.

Program Description II

Sample Problem(s) An observation of polaris was made in which the following field data was obtained:

N ϕ = 39°47'46"

Date: May 11, 1975 W λ = 85°59'33"

MARK	POLARIS	WWV TIME	STOPWATCH ELASPE TIME
36°02'10"^{D}	146°16'35"^{D}	3:11	16.8"
216°02'07"^{R}	326°16'55"^{R}	3:13	17.4"

Mean Angle = 110°14'36.5" pd from ephemeris = 0°50'58.8"

Mean UCT = 3h 11m 42.9s GHA Oh from ephemeris = 196°26'36"

What is the North Azimuth to mark and to polaris?

STEPS: 39.4746A, 85.5933A, 3.11429B, 110.14365C, 196.2636D, .50588E, R/S

Solution(s)

Azimuth to mark = 249°21'21"

Azimuth to polaris = 359°35'58"

Reference(s) Curtis, Kenneth S., MERIDIAN DETERMINATION BY SOLAR AND POLARIS OBSERVATION, ISPLS Inc., 111 N. Capitol Ave., Indpls. In. 46204, 1975

User Instructions

AZIMUTH FROM POLARIS

φ λ	UCT	Δ	GHA	pd

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	Input (latitude of station)	DD.MMSS	A		
3	Input (west longitude of station)	DD.MMSS	A		
4	Input Mean UCT of observation	HH.MMSSS	B		
5	Input Mean clockwise angle (mark to polaris)	DDD.MMSS	C		
6	Input GHA Oh for date (from ephemeris)	DDD.MMSS	D		
7	Input polar distance for date (from ephemeris)				
	and compute azimuth to mark	D.mmss	E		DD.MMSS
8	(Optional) See azimuth to polaris		R/S		DD.MMSS
	See Azimuth to mark again		R/S		DD.MMSS
	For next case, same date and station,				
	execute steps 4 and 5 then compute with		RTN	R/S	DD.MMSS
	Or go to step 2 for next station				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RCL 6	3406	
RCL 5	3405	
RCL 1	3401	
1	01	
5	05	
•	83	
0	00	
4	04	
1	01	
0	00	
6	06	
5	05	
x	71	
+	61	
RCL 2	3402	
−	51	
CHS	42	
1	01	
f-1	32	
R→P	01	
g ↓	3509	
x	71	
RCL 3	3403	
+	61	
f	31	
COS	05	
÷	81	
x	71	= azimuth
STO 7	3307	
LBL	23	
7	07	
RCL 4	3404	
−	51	
0	00	if negative: add 360
gx>y	3524	
3	03	
6	06	
0	00	
+	61	
+	61	
f	31	
→D.MS	03	
R/S	84	Azimuth to mark
RCL 7	3407	
0	00	
gx>y	3524	
3	03	
6	06	
0	00	
+	61	

KEY ENTRY	CODE SHOWN	COMMENTS
+	61	
f	31	
→D.MS	03	
R/S	84	Azimuth to polaris
RCL 7	3407	
GTO	22	
7	07	
LBL	23	
A	11	Input ∅
f-1	32	
→D.MS	03	
STO 3	3303	
gLSTx	3500	
DSP	21	
•	83	
4	04	
RTN	24	
LBL	23	
A	11	Input λ
f-1	32	
→D.MS	03	
STO 2	3302	
gLSTx	3500	
RTN	24	
LBL	23	Input UCT
B	12	
f-1	32	
→D.MS	03	
STO 1	3301	
gLSTx	3500	
RTN	24	
LBL	23	
C	13	Input angle
f-1	32	
→D.MS	03	
STO 4	3304	
gLSTx	3500	
RTN	24	
LBL	23	
D	14	Input GHA Oh
f-1	32	
→D.MS	03	
STO 5	3305	
gLSTx	3500	
RTN	24	
LBL	23	
E	15	Input pd
f-1	32	
→D.MS	03	
STO 6	3306	continues at step 1

REGISTERS	
R_1	UCT
R_2	λ
R_3	∅
R_4	mean angle
R_5	GHA for Oh
R_6	polar distance
R_7	azimuth of polaris (dec. deg.)
R_8	
R_9	

LABELS	
A	∅ λ
B	UCT
C	angle
D	gha Oh
E	pd/comp
0	
1	
2	
3	
4	
5	
6	
7	used
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title POLAR DIST. INTERPRETER

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. This is a support program used to generate the polar distance of polaris, for a particular date, which is required for the reduction of observation data to determine azimuth of polaris and which is required for use with the "AZIMUTH FROM POLARIS" program, utilizing the Ephemeris Tables which list the polar distance about every ten days.

$$pd = \frac{pda-pdb\ (nb)}{nb+na} + pdb$$

where: pda = polar distance after date of observation(from tables)

pdb = polar distance before date of observation (from tables)

nb = number of days before date of observation

na = number of days after date of observation

pd = polar distance required for the date of observation

Operating Limits and Warnings None

Program Description II

Sample Problem(s) On May 8, 1975, an observation was made on polaris. What was the polar distance of polaris on that date?

Polar distance from ephemeris: May 1, 1975: pd = 50.93'

May 11. 1975: pd = 50.98'

STEPS: 7A, 50.93B, 3C, 50.98D, E, R/S, R/S.

Solution(s) pd=50.965 minutes or 0°50'58" (57.9")

Reference(s) Curtis, Kenneth S., MERIDIAN DETERMINATION by SOLAR and POLARIS OBSERVATION, Manual #4 ISPLS Inc., 111 N. Capitol Ave., Indpls. In. 46204, 1975

NOTE: The within formulas are the work of CCC.

User Instructions

POLAR DIST. INTERPRETER

days before	pd before	days after	pd after	Compute

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Input number of days before	nb	A	
2	Input polar distance before	pdb	B	
2	Input number of days after	na	C	
2	Input polar distance after	pda	D	
3	Compute polar distance in minutes		E	MM.MMM
4	(Optional) See polar dist. in D.MMSS		R/S	D.MMSS
5	(Optional) See seconds and tenths		R/S	SS.S
6	See step 4 again (jumps to step 4)		R/S	D.MMSS
	for new case go to step 2			
	NOTE: Days before and after refer to before and			
	after date of observation. Polar Distance is			
	entered from the table in the format of MM.MM			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	Input nb
STO 6	3306	
DSP	21	
•	83	
0	00	
RTN	24	
LBL	23	
B	12	Input pdb
STO 7	3307	
DSP	21	
•	83	
2	02	
RTN	24	
LBL	23	
C	13	Input na
STO 8	3308	
DSP	21	
•	83	
0	00	
RTN	24	
LBL	23	
D	14	Input pda
STO	33	
9	09	
DSP	21	
•	83	
2	02	
RTN	24	
LBL	23	
E	15	Compute
RCL	34	
9	09	
RCL 7	3407	
−	51	
RCL 6	3406	
×	71	
RCL 8	3408	
gLSTx	3500	
+	61	
÷	81	
RCL 7	3407	
+	61	
DSP	21	
•	83	
3	03	
↑	41	
↑	41	
↑	41	
RTN	24	See pd in minutes

KEY ENTRY	CODE SHOWN	COMMENTS
g ↓	3509	
6	06	
0	00	
÷	81	
LBL	23	
8	08	
↑	41	
↑	41	
↑	41	
f	31	
→D.MS	03	
DSP	21	
•	83	
4	04	
R/S	84	See pd D.MMSS
g ↓	3509	
f-1	32	
INT	83	
6	06	
0	00	
×	71	
f-1	32	
INT	83	
6	06	
0	00	
×	71	
DSP	21	
•	83	
1	01	
R/S	84	See seconds & tenths
g ↓	3509	
GTO	22	
8	08	

REGISTERS	
R_1	
R_2	
R_3	
R_4	
R_5	
R_6	n days before
R_7	pd before in minutes
R_8	n days after
R_9	pd after in minutes
LABELS	
A	nb
B	pdb
C	na
D	pda
E	compute
0	
1	
2	
3	
4	
5	
6	
7	
8	used
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title MEAN TIME/ANGLE

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. This is a support program for any other program which requires average time and/or angle as input data for meridian determination from solar or star observation, which time is obtained from short wave radio time signals and elaspe time obtained from a stopwatch and angle obtained from direct and reverse transit (Theodolite) observations of a mark and the sun or star.

For Angle: $\frac{\Sigma\ so}{nso} - \frac{\Sigma\ mo}{nmo}$ plus 180° if negative

so = star angle direct reading or reverse reading - 180°
mo = mark angle direct reading or reverse reading - 180°
n = number observations

For Time: $\frac{\Sigma\ wwv}{nwwv} - \frac{\Sigma\ sw}{nsw}$

n = number of
WWV = Radio time signals
SW = Stopwatch elaspe time

Operating Limits and Warnings

All angle/time inputes are in format of DDD.MMSSS and HH.MMSSS Time signals obtained are from short wave radio. Best radio for this purpose that the author has found is the "Realistic Time Kube" available from "Radio Shack", Registered Trademarks.

Steps could be:

For angle: D, cLx, E, 0B, 180.0003CB, 33.0543A, 33.1439A, 33.2119A, 212.5928CA, 213.0816CA, 213.1642CA, D, R/S, (R/S to reset display)

For time: E, 23.26A, 23.27A, 23.28A, 23.29A, 23.30A, 23.31A .00147B, .00166B, .00315B, .00187B, .00201B, .00239B, D, R/S

Sample Problem(s) A sun shot was made where the following field data was obtained:

MARK	SUN	WWV TIME	SW
00°00'00"D	33°05'43"D	23:26	14.7"
	33°14'39"D	23:27	16.6"
	33°21'19"D	23:28	31.5"
	212°59'28"R	23:29	18.7"
	213°08'16"R	23:30	20.1"
180°00'03"R	213°16'42"R	23:31	23.9"

What is the mean angle (mark to sun) and the mean UCT(coordinated universal time)?

Solution(s)

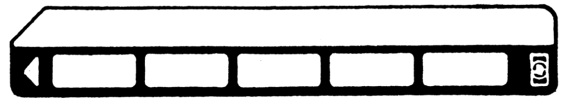
Mean Angle = 33°10'59.7"

Mean UCT = 23h28m09.1s

Reference(s) Curtis, Kenneth., MERIDIAN DETERMINATION BY SOLAR AND POLARIS OBSERVATION, Manual #4, ISPLS Inc., 111 N. Capitol Ave., Indpls. In. 46204, 1975

NOTE: The within formulas are the work of CCC.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	(Optional) Set display to 4 places (DSP.4)				
2	or		D	CLx	
3	Clear (Reg. 5,6,7 & 8)		E		00.0000
4	For Mean Angle:				
5	Enter Star angles: direct telescope	DD.MMSS	A		DD.MMSS
6	Repeat step 5 for any number				
7	Enter Star angles: reverse telescope	DD.MMSS	C	A	DD.MMSS
	(To reconvert to direct angle push R/S				
	after pushing C)				
8	Repeat step 7 for any number				
9	Compute mean angle		D		DDD.MMSS
10	See seconds and tenths		R/S		SS.S
11	See angle DDD.MMSS again and to reset				
	display to 4 places.		R/S		DDD.MMSS
12	Return to step 3 for next mean angle				
12	Or for mean time:				
13	Clear		E		00.0000
14	Enter Radio time(Hours & Minutes)	HH.MM	A		HH.MM00
15	Repeat step 14 for any number				
16	Enter elasped stopwatch time	0.MMSSS	B		0.MMSSS
	(from time of pointing to radio time)				
	Repeat step 16 for any number				
17	Compute mean UCT		D		HH.MMSS
18	See seconds and tenths		R/S		SS.S
19	See time, HH.MMSS again and to reset display to				
	4 places.		R/S		HH.MMSS
20	return to step 13 for next mean time				
	or to step 3 for next mean angle				
	NOTE: Direct and reverse telescope pointings, star				
	or mark pointings, or radio and stopwatch times may				
	be entered in any sequence. Reg. 1 through 4 remain unchanged.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	WWV or star
↑	41	
f-1	32	
→D.MS	03	
f	31	
TF 1	61	
1	01	
8	08	
0	00	
-	51	
STO	33	
+	61	
5	05	
1	01	
STO	33	
+	61	
6	06	
LBL	23	
9	09	
g ↓	3508	
g ↓	3508	
f-1	32	
SF 1	51	Turn off
RTN	24	
LBL	23	
B	12	Stopwatch or mark
↑	41	
f-1	32	
→D.MS	03	
f	31	
TF 1	61	
1	01	
8	08	
0	00	
-	51	
STO	33	
+	61	
7	07	
1	01	
STO	33	
+	61	
8	08	
GTO	22	
9	09	
LBL	23	
C	13	Reverse angle
f	31	
SF 1	51	turn on
RTN	24	

KEY ENTRY	CODE SHOWN	COMMENTS
f-1	32	if accident: push
SF 1	51	R/S to cancel
R/S	84	
LBL	23	
D	14	compute
DSP	21	
•	83	
4	04	
RCL 5	3405	
RCL 6	3406	
÷	81	
RCL 7	3407	
RCL 8	3408	
÷	81	
-	51	
0	00	
gx> y	3524	if negative:
1	01	add 180
8	08	
0	00	
+	61	
+	61	
f	31	
→D.MS	03	
R/S	84	See mean angle
gLSTx	3500	
f-1	32	
INT	83	
6	06	
0	00	
×	71	
f-1	32	
INT	83	
6	06	
0	00	
×	71	
DSP	21	
•	83	
1	01	
R/S	84	See seconds & tenths
GTO	22	
D	14	re-compute
LBL	23	
E	15	clear
0	00	
STO 5	3305	
STO 6	3306	
STO 7	3307	
STO 8	3308	
RTN	24	

REGISTERS
R_1
R_2
R_3
R_4
R_5 Σ of WWV or star
R_6 n of WWV or star
R_7 Σ of SW or mark
R_8 n of SW or mark
R_9 used tests

LABELS	
A	FS/WWV
B	BS/SW
C	re-versed
D	compute
E	clear
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	used

FLAGS	
1	used
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title STOPWATCH

Contributor's Name Grant J. Munsey

Address 1331 S. Wolfe Rd. Apt. 80

City Sunnyvale **State** Ca. **Zip Code** 94087

Program Description, Equations, Variables, etc. This program allows the HP 65 to be used as a stopwatch. Elasped time may either be set to zero or allowed to accumulate at the start of the program(A or B Function). The program has a built in calibration routine which allows one to compensate for variations between different calculators. The constant derived from calibration may be incorporated into the program itself to provide a custom tailored card which will give more accurate results. Tests have shown that(after calibration) accuracy of approximatly one second is attainable over the calculators normal temperature operating range.

Operating Limits and Warnings The timer functions(A or B) will only run for about one and one half hours continuously if the calculator is using its battries(fully charged) for power.

Program Description II

Sample Problem(s) Find the accuracy of an auto speedometer given that mile markers are available along the roadside.

Solution(s) Upon passing a mile mark on the road start the timing function(A key) and hold the auto's speed constant. Stop the timing function (R/S key) at the next mile mark. Calculate the elasped time (C key). Now use the calculator to divide 3600 by the elasped time. The result will be the average speed (miles/hour) of the auto between the mile marks.

Reference(s) N.A.

User Instructions

STOPWATCH

Start	Cont.	Time	Calib.	Init.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Initialize		E	constant
3	Start timer(from zero)		A	
	or			
3	Start timer (accumulating		B	
	from last run)			
4	Stop timer		R/S	
5	Calculate total elasped time		C	elapsed time(sec.)
	convert time to HH.MMSS			
	HH=HRS., MM=MIN., SS=SEC.		R/S	HH.MMSS
6	To run timer again go to 3 above			
	** STOPWATCH CALIBRATION **			
1	Run program as above and use a real stopwatch to			
	obtain the actual elapsed time in seconds.			
2	Enter the time from step 1	elapsed time(sec)		
3	Compute constant		D	constant
4	To custom configure a program card for a particular			
	HP 65 replace the constant 10.000 under label "E"			
	with the value obtained in step 3.			
	NOTE: Be sure to retain the CHS instruction after the			
	constant since the program requires that the value in			
	register 1 be negative.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	set time ≅ 0
A	11	and count
1	01	
CHS	42	
STO 8	3308	set up dez count
LBL	23	loop
0	00	
g	35	
DEZ	83	INC. count(add-1)
GTO	22	
0	00	
RTN	24	end of "A"
LBL	23	leave time alone
B	12	and count
GTO	22	
0	00	
RTN	24	end of "B"
LBL	23	compute total
C	13	elapsed time
RCL 8	3408	get count
RCL 1	3401	get const.
÷	81	calculate
DSP	21	# of seconds
.	83	show time to
1	01	nearest tenth
R/S	84	stop
3	03	convert time
6	06	to hours,
0	00	minutes, seconds
0	00	
÷	81	
f	31	
→D.MS	03	HH.MMSS
DSP	21	
.	83	
4	04	
RTN	24	end "C"
LBL	23	calibrate
D	14	function
RCL 8	3408	actual count
x⇄y	3507	put # sec in x
÷	81	compute const.
STO 1	3301	(-) and store
DSP	21	show const. to
.	83	3 places so it can
3	03	be put under "E"
RTN	24	end "D"
LBL	23	initialize
E	15	
1	01	### replace

KEY ENTRY	CODE SHOWN	COMMENTS
0	00	this value
.	83	with the result
0	00	from "D"
0	00	
0	00	
CHS	42	
STO 1	3301	store const.
RTN	24	end "E"

REGISTERS	
R_1	const.
R_2	
R_3	
R_4	
R_5	
R_6	
R_7	
R_8	DEZ count
R_9	

LABELS	
A	start
B	cont.
C	compute
D	calib.
E	in it.
0	used
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title PHOTOGRAMMETRY I

Contributor's Name John A. Gilbert

Address 12214 East Kepner Place

City Aurora State Colorado Zip Code 80012

Program Description, Equations, Variables, etc. This program will convert measurements on a tilted aerial photograph into ground coordinates and find the datum scale at the point represented by the measured coordinates. The photo measurements are made in a right-handed system with the principal point as the origin and the ground coordinates are calculated with the nadir point as the origin of another right hand system. θ, the first rotation, is clockwise about the optical axis, while t, the tilt angle, is counter-clockwise about the once-rotated photo x-axis.

Formulas used are:

$$s = \frac{-y' \sin t + f \sec t}{H-h}$$

$$x = \frac{(H-h) \quad x'}{f \sec t - y' \sin t} \qquad x' = x \cos \theta + y \sin \theta$$

$$y = \frac{(H-h) \quad y' \cos t}{f \sec t - y' \sin t} \qquad y' = x \sin \theta + y \cos \theta + f \tan t$$

Operating Limits and Warnings For counter-clockwise values of θ and clockwise values of t, the stored parameters are negative.

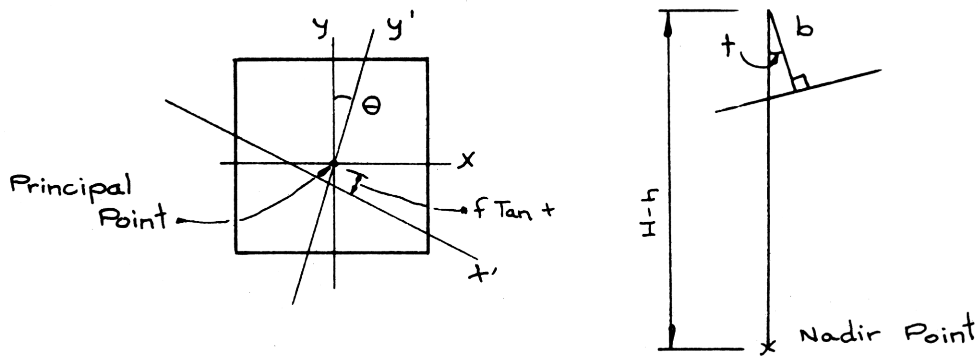
Focal length is in inches. Flying height above terrain (H-h) is in feet.

Photo coordinate measurements (x & y) are in inches.

Ground x & y are in feet.

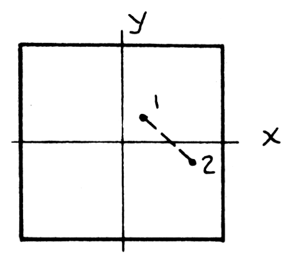
f = focal length

Program Description II



Sample Problem(s) For a photo taken 5000 ft. above the ground with a 6 inch focal length camera and orientation angles θ=5°, t=2°. Find the length of a line between two points whose photo coordinates are:

X_1 = 1.00 in	X_2 = 3.26 in
Y_1 = 1.15 in	Y_2 = -0.51 in



Solution(s) 5.0 STO 1 2.0 STO 2 5000.0 STO 3 6.0 STO 4

1.00 STO 7 1.15 STO 8 A B C D	X_1 = 752.49 Ft.
E	Y_1 = 1210.61 Ft.
3.26 STO 7 0.51 CHS STO 8 A B C D	X_2 = 2741.47 Ft.
E	Y_2 = -11.99 Ft.

2741.47 ↑ 752.49 - 11.99 CHS ↑ 1210.61 - f R→P = 2334.69

Thus the distance between the two points is 2334.69 Ft. on the ground.

Reference(s) PHOTOGRAMMETRY by F. H. Moffitt, International Textbook Company, second edition, 1967

User Instructions

PHOTOGRAMMETRY I

X'	Y'	S	X	Y

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Enter parameters				
	Rotation Angle	θ	STO	1	
	Tilt Angle	t	STO	2	
	Height Above				
	Terrain	(H-h) ft.	STO	3	
	Camera Focal				
	Length	f ft.	STO	4	
3	Store Photo				
	Coordinates	X	STO	7	
	of any point	Y	STO	8	
4	Compute X'		A		X' in
5	Compute Y'		B		Y' in
6	Compute Scale at the point		C		S
7	Find Ground				
	X coordinate		D		X Ft.
8	Find Ground				
	Y coordinate		E		Y Ft.
9	To obtain data for any other point, repeat 3				
	through 8				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
RCL 7	3407	
RCL 1	3401	
f	31	
COS	05	
x	71	
RCL 8	3408	
RCL 1	3401	
f	31	
SIn	04	
x	71	
-	51	
STO 5	3305	
RTN	24	
LBL	23	
B	12	
RCL 7	3407	
RCL 1	3401	
f	31	
SIN	04	
x	71	
RCL 8	3408	
RCL 1	3401	
f	31	
COS	05	
x	71	
+	61	
RCL 4	3404	
RCL 2	3402	
f	31	
TAN	06	
x	71	
+	61	
STO 6	3306	
RTN	24	
LBL	23	
C	13	
RCL 4	3404	
RCL 2	3402	
f	31	
COS	05	
÷	81	
RCL 6	3406	
RCL 2	3402	
f	31	
SIN	04	
x	71	
-	51	
RCL 3	3403	

KEY ENTRY	CODE SHOWN	COMMENTS
÷	81	
g	35	
1/x	04	
1	01	
2	02	
x	71	
STO 7	3307	
RTN	24	
LBL	23	
D	14	
RCL 7	3407	
RCL 5	3405	
x	71	
1	01	
2	02	
÷	81	
RTN	24	
LBL	23	
E	15	
RCL 7	3407	
RCL 6	3406	
x	71	
RCL 2	3402	
f	31	
COS	05	
x	71	
1	01	
2	02	
÷	81	
RTN	24	
gnop	3501	

REGISTERS	
R_1	θ
R_2	t
R_3	(H-h)
R_4	f
R_5	X'
R_6	Y'
R_7	X S
R_8	Y
R_9	

LABELS	
A	X'
B	Y'
C	S
D	X
E	Y
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title PHOTOGRAMMETRY II

Contributor's Name John A. Gilbert

Address 12214 E. Kepner Place

City Aurora **State** Colorado **Zip Code** 80012

Program Description, Equations, Variables, etc. This program will compute the values of differential orientation element corrections for independent relative orientation of two photographs in an analytical plotter(Kelsh, A-7, etc.). The output values of omega, phi, and kappa are the result of a least squares adjustment of observed y- parallax at six points in the stereo model formed by the two photos.

The equations used are:

$$\delta\omega_L = \frac{h\,(-2P1-2P2+P3+P4+P5+P6)}{4d^2}$$

$$\delta\phi_L = \frac{h\,(P4-P6)}{2\,bd}$$

$$\delta\phi_R = \frac{h\,(P3-P5)}{2\,bd}$$

$$\delta K_L = \frac{(P2+P4+P6-(3h+\frac{2d^2}{h})\,\delta\omega_L)}{3b}$$

The ΔK correction

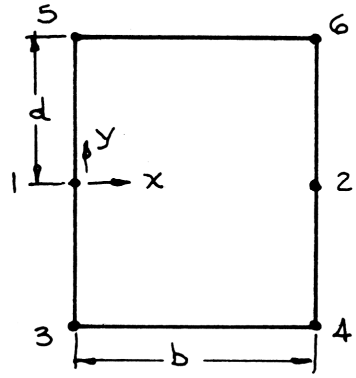
$$\delta K_R = \frac{(P1+P3+P5-(3h+\frac{2d^2}{h})\,\delta\omega_L)}{3b}$$

Operating Limits and Warnings User must press R/S after computing $\delta\omega_L$ using subroutine A, then use B & C to find δK_L and δK_R.

All linear measurements must be in the same units (inches or MM).

Output angles are in radians.

Program Description II



h is the projector principal distance.*
Points 1 and 2 should be at or near the conjugate principal points

*-Projector Focal Pt. to Table

Sample Problem(s) For a stereo model with dimensions d = 125mm, b = 250mm, h = 300mm, an operator estimates parallax values as:

P_1 = 1.0mm	P_2 = -1.0mm	P_3 = 1.25mm
P_4 =-1.50mm	P_5 = 2.0mm	P_6 = 1.50mm

Find initial approximations to the needed differential rotations.

Solution(s) 1.0, STO 1, 1.0, CHS, STO 2, 1.25, STO 3, 1.5, CHS, STO 4, 2.0, STO 5, 1.5 STO 6, 250.0, STO 7, 125.0 STO 8, 300, STO 9, DSP,

. 9, A $\delta\omega_L$	= 0.002517361	RAD
R/S, B $\delta\kappa_L$	= - 0.001333333	RAD
C $\delta\kappa_R$	= 0.005666667	RAD
D $\delta\phi_L$	= - 0.002500000	RAD
E $\delta\phi_R$	= - 0.000625000	RAD

Now the operator should make the corrections, then observe parallax and repeat if needed.

Reference(s)

User Instructions

PHOTOGRAMMETRY II

$\delta\omega_L$	$\delta\kappa_L$	$\delta\kappa_R$	$\delta\phi_L$	$\delta\phi_R$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	Store constants:	constants	STO	1	Parallax
	Parallax at	(mm or in.)	STO	2	
	Points 1 - 6		STO	3	
	Model Dimensions		ETC.		
	b		STO	7	b
	h		STO	8	h
	d		STO	9	d
3	Compute $\delta\omega_L$		A		$\delta\omega_L$
4	Compute the correction to the $\delta\kappa$ element		R/S		$\Delta\kappa$
5	Compute $\delta\kappa_L$		B		$\delta\kappa_L$
6	Compute $\delta\kappa_R$		C		$\delta\kappa_R$
7	Compute $\delta\phi_L$		D		$\delta\phi_L$
8	Compute $\delta\phi_R$		E		$\delta\phi_R$
	(NOTE: $\delta\kappa_L = \delta\kappa - \Delta\kappa$)				
	From B, C				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	Compute $\delta\omega_L$
RCL 1	3401	
RCL 2	3402	
-	51	
2	02	
x	71	
RCL 3	3403	
+	61	
RCL 4	3404	
RCL 5	3405	
RCL 6	3406	
+	61	
+	61	
+	61	
RCL 8	3408	
x	71	
RCL	34	
9	09	
f-1	32	
$\sqrt{x}$	09	
÷	81	
4	04	
÷	81	
R/S	84	
↑	41	
RCL	34	
9	09	
f-1	32	
$\sqrt{x}$	09	
2	02	
x	71	Compute
RCL 8	3408	δK_L & δK_R
÷	81	Corrections
RCL 8	3408	
3	03	
x	71	
+	61	
x	71	
3	03	
÷	81	
RCL 7	3407	
÷	81	
R/S	84	
RTN	24	
LBL	23	
B	12	Compute δK_L
RCL 2	3402	
RCL 4	3404	
RCL 6	3406	

KEY ENTRY	CODE SHOWN	COMMENTS
+	61	
+	61	
3	03	
÷	81	
RCL 7	3407	
÷	81	
RTN	24	
LBL	23	
C	13	Compute δK_R
RCL 1	3401	
RCL 3	3403	
RCL 5	3405	
+	61	
+	61	
3	03	
÷	81	
RCL 7	3407	
÷	81	
RTN	24	
LBL	23	
D	14	Compute $\delta\Phi_L$
RCL 4	3404	
RCL 6	3406	
-	51	
RCL 8	3408	
x	71	
RCL	34	
9	09	
÷	81	
RCL 7	3407	
÷	81	
2	02	
÷	81	
RTN	24	
LBL	23	
E	15	Compute $\delta\Phi_R$
RCL 3	3403	
RCL 5	3405	
-	51	
RCL 8	3408	
x	71	
RCL	34	
9	09	
÷	81	
RCL 7	3407	
÷	81	
2	02	
÷	81	
RTN	24	
gnop	3501	

REGISTERS	
R_1	P_1
R_2	P_2
R_3	P_3
R_4	P_4
R_5	P_5
R_6	P_6
R_7	b
R_8	h
R_9	d

LABELS	
A	$\delta\omega_L$
B	δK_L
C	δK_R
D	$\delta\Phi_L$
E	$\delta\Phi_R$
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title PHOTOGRAMMETRY III

Contributor's Name John A. Gilbert

Address 12214 East Kepner Place

City Aurora **State** Colorado **Zip Code** 80012

Program Description, Equations, Variables, etc. This program computes the values of differential orientation element corrections for dependent relative orientation to another in a universal plotter (Kelsh, A - 7, etc.). The output values of b y, b z , Omega, Phi, and Kappa result from a least squares adjustment of observed y - parallax at six points in the stereo model formed by the two photos.

The equations used are:

δY_1

$$\delta Y = 1/3\,(P1+P3+P5) - h\left(1+\frac{2d^2}{3h^2}\right)\delta\omega$$

ΔY

$$\delta z = \frac{h\,(P5-P3)}{2d}$$

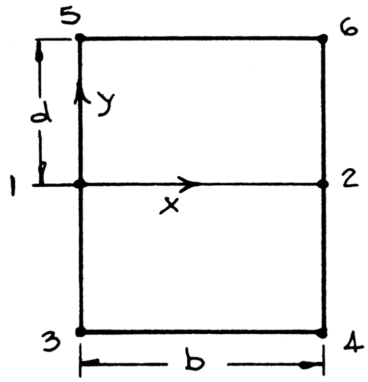
$$\delta\omega = \frac{h\,(-2P1-2P2+P3+P4+P5+P6)}{4d^2}$$

$$\delta\phi = \frac{h(P4-P6+P5-P3)}{2bd}$$

$$\delta K = \frac{P2+P4+P6-P1-P3-P5}{3b}$$

Operating Limits and Warnings All linear input quantities must be in the same units. Output linear values will be the same as input. Angular output is in radians.

Program Description II



h is the distance from projector focal point to the model plane.

Points 1 and 2 should be at or near the conjugate principal points.

Sample Problem(s) For a stereo model with dimensions d = 125mm, b = 250mm, h = 300mm, an operator estimates parallax values as:

$P_1 = 1.0$mm	$P_2 = -1.0$mm	$P_3 = 1.25$mm
$P_4 = -1.50$mm	$P_5 = 2.0$mm	$P_6 = 1.50$mm

Find initial approximations to the needed differential translations and rotations.

Solution(s) 1.0, STO 1, 1.0, CHS, STO 2, 1.25, STO 3, 1.5, CHS, STO 4, 2.0, STO 5, 1.5, STO 6, 250.0 STO 9, 125, STO 8, 300, STO 7, DSP, . 9,

Key		Result	Value	Unit
A	→	δy_1	= 1.416666667	mm
B	→	δz	= 0.900000000	mm
C	→	$\delta \phi$	= -0.010800000	RAD
D	→	$\delta \kappa$	= 0.002333333	RAD
E	→	$\delta \omega$	= 0.015600000	RAD
R/S	→	Δy	= 5.221666668	mm
		$\delta y = \delta y_1 - \Delta y$	= -3.805000001	mm

Correct and repeat as needed.

Reference(s)

User Instructions

PHOTOGRAMMETRY III

δy_1	δz	$\delta \Phi$	δK	$\delta \omega$

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Program				
2	Store constants:	constants	STO	1	constants
	Parallax at	(mm or in.)	STO	2	
	points 1 - 6		ETC.		
	Model Dimensions				
	h		STO	7	
	d		STO	8	
	b		STO	9	
3	Compute δy_1		A		δy_1
4	Compute δz		B		δz
5	Compute $\delta \Phi$		C		$\delta \Phi$
6	Compute δK		D		δK
7	Compute $\delta \omega$		E		$\delta \omega$
8	Calculate the correction to δy_1		R/S		Δy
	(NOTE: $\delta y = \delta y_1 - \Delta y$)				
	true correction				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	calculate δy
RCL 1	3401	
RCL 3	3403	
RCL 5	3405	
+	61	
+	61	
3	03	
÷	81	
RTN	24	
LBL	23	
B	12	calculate δz
RCL 5	3405	
RCL 3	3403	
-	51	
RCL 7	3407	
x	71	
RCL 8	3408	
2	02	
x	71	
÷	81	
RTN	24	
LBL	23	
C	13	calculate δΦ
RCL 4	3404	
RCL 6	3406	
-	51	
RCL 5	3405	
+	61	
RCL 3	3403	
-	51	
RCL 7	3407	
x	71	
RCL 8	3408	
RCL	34	
9	09	
2	02	
x	71	
x	71	
÷	81	
RTN	24	
LBL	23	
D	14	Calculate δK
RCL 2	3402	
RCL 4	3404	
RCL 6	3406	
+	61	
+	61	
RCL 1	3401	
RCL 3	3403	

KEY ENTRY	CODE SHOWN	COMMENTS
RCL 5	3405	
-	51	
-	51	
RCL	34	
9	09	
÷	81	
3	03	
÷	81	
RTN	24	
LBL	23	
E	15	Calculate δω
RCL 1	3401	
RCL 2	3402	
+	61	
2	02	
x	71	
CHS	42	
RCL 3	3403	
+	61	
RCL 4	3404	
RCL 5	3405	
RCL 6	3406	
+	61	
+	61	
+	61	
RCL 7	3407	
x	71	
RCL 8	3408	
f-1	32	
√x	09	
÷	81	
4	04	
÷	81	
R/S	84	
↑	41	
RCL 8	3408	
RCL 7	3407	
÷	81	
f-1	32	
√x	09	Compute Δy
2	02	
x	71	
3	03	
÷	81	
1	01	
+	61	
RCL 7	3407	
x	71	
x	71	
R/S	84	

REGISTERS	
R_1	P_1
R_2	P_2
R_3	P_3
R_4	P_4
R_5	P_5
R_6	P_6
R_7	h
R_8	d
R_9	b

LABELS	
A	δy
B	δz
C	δΦ
D	δK
E	δω
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title CURVED STREET FIT

Contributor's Name Charles C. Campbell, LS
Address 9841 East 21st Street
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes the centerline tangent length and coordinates of the PI of a curved street so that the R/W PC and PT will fall on the R/W line of the curved street, on each side, given the coordinates of the PC centerline, the azimuth of one tangent, the R/W width of the connecting curved street, the radius and the coordinates of the radius point of the opposite curve. Both tangent lines are radial to the curves.

$$T = \frac{B^2 - A^2}{2B \cos \Delta + 2A}$$

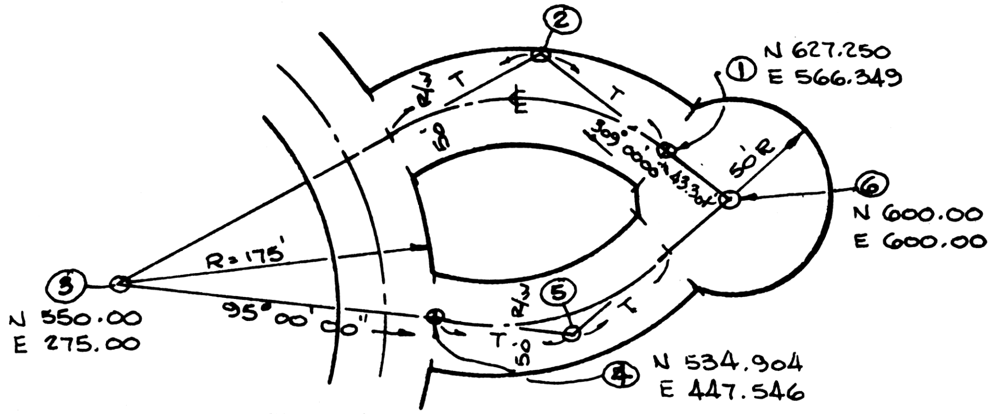
Where: $A = \sqrt{R^2 - (1/2\ R/W)^2}$

$B = \sqrt{(N3-N1)^2 + (E3-E1)^2}$

$\Delta = \text{Azimuth} - \tan^{-1}\left(\frac{E3 - E1}{N3 - N1}\right)$

Operating Limits and Warnings See notes on page 3

Program Description II



Sample Problem(s) NO. 1: Solve for the curve tangent and coordinates of the PI for curve with PI numbered 2 in the above sketch.

STEPS: A, 627.25R/S, 566.349R/S, 309R/S, 50R/S, 175R/S, 550R/S, 275R/S, R/S, R/S

NO.2: Solve for curve with PI numbered 5.

STEPS: A, 534.904R/S, 447.546R/S, 95R/S, 50R/S, R/S, 600R/S, R/S, R/S, R/S

Solution(s)

Solution No. 1:	T = 86.681	No. 2: T = 67.558
	N2 = 681.800	N5 = 529.016
	E2 = 498.985	E5 = 514.847

Reference(s) None: The within formula for T is the work of CCC.

User Instructions

CURVED STREET FIT

N1 E1	AZ	R/W	R	N3 E3

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input coordinates of Point 1		A		
3	Enter N1	N1	R/S		N1
4	Enter E1	E1	R/S		E1
5	Input N. azimuth (point 1 to 2)	DD.MMSS	B		A2
6	Input R/W width	R/W	C		R/W
7	Input radius (from point 3)	R	D		R
8	Input coordinates of Point 3 and compute		E		
9	Enter N3	N3	R/S		N3
10	Enter E3	E3	R/S		T
11			R/S		N2
12			R/S		E2
	The coordinates of Point 2(the PI) are now in the				
	starting position for use with the "Azimuth Traverse/				
	Inverse" program				
13	Recompute using the last data entered.				
	(allows changing a known data item without		RTN	R/S	T
	reentering the rest.)		R/S		N2
			R/S		E2
	NOTES:				
	T=Tangent length of curve				
	R=Radius				
	Steps 3 through 10 may be executed in order by				
	entering data with R/S and the function keys need				
	not be pushed. The function keys are used to change				
	or correct given data. Flashing "zero" indicates that				
	the problem is ambiguous, eg: R/W > 2R				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RCL	34	
9	09	
STO 2	3302	
RCL 4	3404	
-	51	
RCL 8	3408	
RCL 3	3403	
-	51	
f	31	
R→P	01	
STO 1	3301	
f-1	32	
√x	09	
RCL 6	3406	
2	02	
÷	81	
f-1	32	
√x	09	
CHS	42	
RCL 7	3407	
f-1	32	
√x	09	
+	61	
-	51	
gLSTx	3500	
f	31	
√x	09	
2	02	
x	71	
RCL 5	3405	
g↓	3509	
-	51	
f	31	
COS	05	
RCL 1	3401	
X	71	
2	02	
x	71	
+	61	
÷	81	
g	35	
ABS	06	
STO 1	3301	
RCL 2	3402	
STO	33	
9	09	
RCL 1	3401	
R/S	84	See T
RCL 5	3405	
RCL 1	3401	

KEY ENTRY	CODE SHOWN	COMMENTS
f-1	32	
R→P	01	
RCL 3	3403	
+	61	
STO 1	3301	
RCL 2	3402	
STO	33	
9	09	
RCL 4	3404	
g↓	3509	
+	61	
STO 2	3302	
RCL 1	3401	
R/S	84	See N2
RCL 2	3402	
R/S	84	See E2
0	00	
÷	81	error stop
LBL	23	
A	11	
DSP	21	
.	83	
3	03	
CLX	44	
R/S	84	Input N1
STO 3	3303	
R/S	84	Input E1
STO 4	3304	
R/S	84	Input azimuth
LBL	23	
B	12	
f-1	32	
→D.MS	03	
STO 5	3305	
gLSTx	3500	
R/S	84	Input R/W
LBL	23	
C	13	
STO 6	3306	
R/S	84	Input R
LBL	23	
D	14	
STO 7	3307	
LBL	23	
E	15	
R/S	84	Input N3
STO 8	3308	
R/S	84	Input E3
STO	33	
9	09	

REGISTERS	
R_1	B, T, and N2
R_2	E3 temp. & E2
R_3	N1
R_4	E1
R_5	azimuth
R_6	R/W
R_7	radius
R_8	N3
R_9	E3

LABELS	
A	N1 E1
B	Az
C	R/W
D	R
E	N3 E3
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title EQUAL DELTA REVERSE CURVES

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes the radius of the second curve, the delta of both curves(equal), and the coordinates of the point of reverse curve, given the azimuth (RP to PC), radius and coordinates of the radius point of the first curve and the coordinates of the PT of the second curve.

$$R2 = \frac{a^2 - R1^2}{2a\cos A + 2R1}$$

$$\sin \Delta = \frac{a \sin A}{R1 + R2}$$

WHERE:

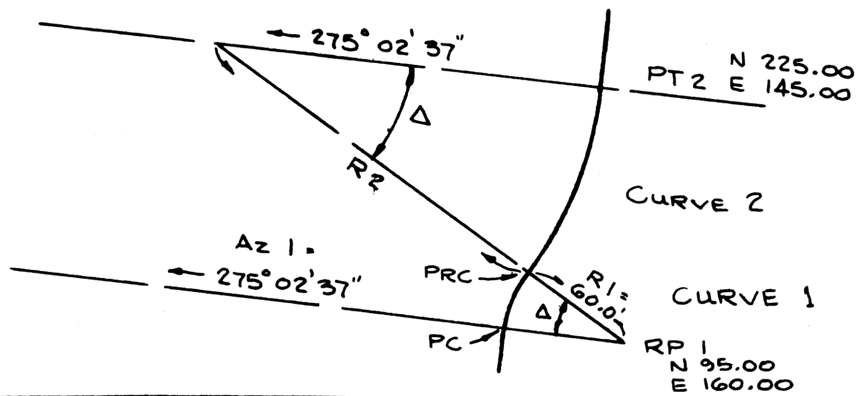
$$a = \sqrt{(Nrp1 - Npt2)^2 + (Erp1 - Ept2)^2}$$

$$A = \tan^{-1} \frac{Erp1 - Ept\ 2}{Nrp1 - Npt\ 2} - Az1$$

See page 3 for connotations

Operating Limits and Warnings See notes on page 3

Program Description II



Sample Problem(s) Compute for R2, delta, and coordinates of the PRC for the problem in the above sketch:
STEPS: A, 95R/S, 160R/S, 275.0237R/S, 60R/S, 225R/S, 145R/S, R/S, R/S, R/S, R/S.

Solution(s)

R2 = 201.090

Delta = 29°24'07"

NPRC = 128.937
EPRC = 110.520

Reference(s) None: The formula for R2 is from the files of Ursell Cox.

User Instructions

EQUAL Δ REVERSED CURVES

RP1	AZ1	R1	PT 2	compu

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input coordinates of Rad. Pt. 1		A		
3	Enter Northing	Nrp1	R/S		
4	Enter Easting	Erp1	R/S		
5	Input azimuth curve 1 (RP to PC)	DD.MMSS	B		
6	Input radius curve 1	R1	C		
7	Input coordinates of point 3 (PT)		D		
8	Enter Northing	Npt2	R/S		
9	Enter Easting	Ept2	R/S		
10	Compute (push R/S or)		E		R2
11			R/S		Δ
12			R/S		Nprc
13			R/S		Eprc
	The coordinates of the PRC are now in the starting				
	position for use with the "Azimuth Traverse/Inverse"				
	program.				
	NOTES: Steps 3 through 10 may be executed				
	in order by entering data with R/S and the function				
	keys need not be pushed.				
	The function keys are used to change or correct				
	given data.				
	A negative value or a flashing "0" for R2 means the				
	problem is indeterminate or ambiguous.				
	R2 = radius of second curve				
	pt = point of tangent				
	pc = point of curvature				
	rp = radius point				
	prc = point of reverse curve				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
DSP	21	
.	83	
3	03	
CLX	44	
R/S	84	Inpute Nrp1
STO 3	3303	
R/S	84	Inpute Erp1
STO 4	3304	
R/S	84	Inpute Az1
LBL	23	
B	12	
f-1	32	
→D.MS	03	
STO 5	3305	
gLSTx	3500	
R/S	84	Inpute R1
LBL	23	
C	13	
STO 6	3306	
LBL	23	
D	14	
R/S	84	Inpute Npt2
STO 7	3307	
R/S	84	Inpute Ept2
STO 8	3308	
R/S	84	
LBL	23	
E	15	compute
RCL 4	3404	
RCL 8	3408	
-	51	
RCL 3	3403	
RCL 7	3407	
-	51	
f	31	
R→P	01	
STO 2	3302	
f-1	32	
√x	09	
RCL 6	3406	
f-1	32	
√x	09	
-	51	
RCL 2	3402	
2	02	
x	71	
RCL 5	3405	
g ↑	3509	
-	51	
1	01	

KEY ENTRY	CODE SHOWN	COMMENTS
f-1	32	
R→P	01	
gx⇌y	3507	
STO	33	
x	71	
2	02	
g ↓	3508	
x	71	
RCL 6	3406	
2	02	
x	71	
+	61	
÷	81	
STO 1	3301	
R/S	84	See R2
RCL 2	3402	
RCL 1	3401	
RCL 6	3406	
+	61	
÷	81	
f-1	32	
SIN	04	
STO 2	3302	
f	31	
→D.MS	03	
DSP	21	
.	83	
4	04	
R/S	84	See Δ
RCL 2	3402	
RCL 5	3405	
+	61	
RCL 6	3406	
f-1	32	
R→P	01	
RCL 3	3403	
+	61	
STO 1	3301	
gx⇌y	3507	
RCL 4	3404	
+	61	
STO 2	3302	
RCL 1	3401	
DSP	21	
.	83	
3	03	
R/S	84	See Nprc
RCL 2	3402	
R/S	84	See Eprc

REGISTERS
R_1 R2 Nprc
R_2 a, aSinA, Δ, Eprc
R_3 Nrp1
R_4 Erp1
R_5 Az1
R_6 R1
R_7 Npt2
R_8 Ept 2
R_9 used (trig.)

LABELS
A NErp1
B Az1
C R1
D NEpt 2
E compute
0
1
2
3
4
5
6
7
8
9

FLAGS
1
2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title CURVE THRU POINT

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes radius and tangent of curve joining give tangents and passing through given point. Useful for computing curb radius to pass through storm structure or placing street curve so that an existing tree will lie in middl of grass strip between curb and sidewalk, etc.

Given central angle (Δ) of curve, angle measured at P.I. from either tangent to point, and distance from P.I. to point.

$$r = \frac{d \sin(\Delta + A)}{1 - \cos(1/2\,\Delta + B)} \qquad t = r \tan 1/2\,\Delta$$

where

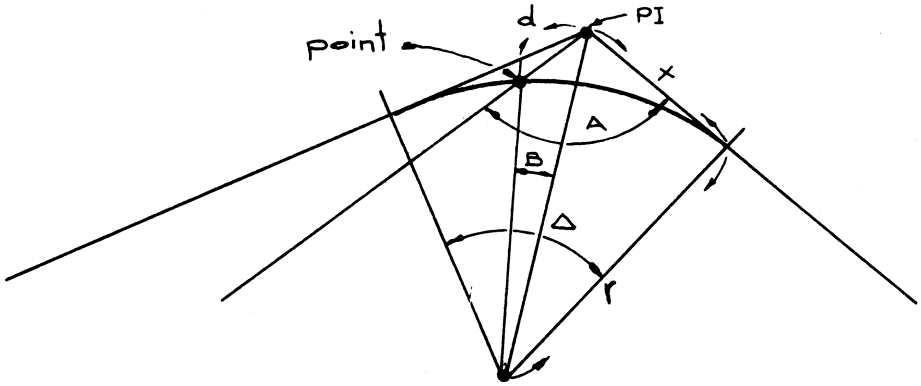
$$B = C - \left[90 - (1/2\,\Delta + A) \right]$$

$$\sin C = \frac{\cos(1/2\,\Delta + A)}{\cos 1/2\,\Delta}$$

t = tangent
r = radius
d = distance, pi to point

Operating Limits and Warnings Flashing zero obtained during calculation indicates problem is ambiguous, eg: delta angle greater than 180 degrees.

Program Description II



Sample Problem(s)

No. 1	Δ =43°14'32"	A=5°20'15"	d = 43.15
		or 131°25'13"	
No. 2	Δ =145°43'56"	A=14°19'18"	d = 151.98
		or 19°56'46"	

Solution(s)

No. 1	r=211.980	t=84.019
No. 2	r=63.213	t=205.046

Reference(s) Unknown

User Instructions

CURVE THRU POINT

△	A	d		comp

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input △ angle	△	A		
3	Input A angle	A	B		
4	Input d distance	d	C		
5	Compute radius		E		r
6	(Optional) Compute tangent		R/S		t
7	Go to step 2 for next problem				
	NOTE: Angles are entered DD.MMSS				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	Input Δ angle
A	11	
f-1	32	
→D.MS	03	
STO 1	3301	
gLSTx	3500	
DSP	21	
.	83	
4	04	
RTN	24	
LBL	23	Input A angle
B	12	
f-1	32	
→D.MS	03	
STO 2	3302	
gLSTx	3500	
DSP	21	
.	83	
4	04	
RTN	24	
LBL	23	Input d
C	13	
STO 3	3303	
DSP	21	
.	83	
3	03	
RTN	24	
LBL	23	
D	14	
LBL	23	
E	15	
RCL 1	3401	
2	02	
÷	81	
STO 4	3304	
RCL 2	3402	
+	61	
STO 5	3305	
f	31	
COS	05	
RCL 4	3404	
f	31	
COS	05	
÷	81	
f-1	32	
SIN	04	
9	09	
0	00	
RCL 5	3405	
-	51	

KEY ENTRY	CODE SHOWN	COMMENTS
-	51	
RCL 1	3401	
RCL 2	3402	
+	61	
f	31	
SIN	04	
RCL 3	3403	
x	71	
gx⇌y	3507	
1	01	
gx⇌y	3507	
RCL 4	3404	
+	61	
f	31	
COS	05	
-	51	
÷	81	=Radius
DSP	21	
.	83	
3	03	
STO 6	3306	
RTN	24	=Radius
RCL 6	3406	
RCL 4	3404	
f	31	
TAN	06	
x	71	
R/S	84	=Tangent

REGISTERS	
R_1	Δ
R_2	A
R_3	d
R_4	1/2 Δ
R_5	1/2 Δ+A
R_6	r
R_7	
R_8	
R_9	
LABELS	
A	Δ
B	A
C	d
D	
E	comp.
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title CURVE/FROM 3 POINTS

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Program computes the radius of the curve(circle) and the coordinates of the radius point(center), given the coordinates of three points on the curve(circle). The computed coordinates are stored for use as the starting coordinates with the "Azimuth Traverse/Inverse program, so that the radials may then be inversed to determine the azimuths thereof.

Standard traverse and inverse routines are utilized and:

$$\text{Radius} = R = \frac{\text{distance of line 1 to 2}}{1/2 \sin (\text{Az line 3 to 2} - \text{Az line 3 to 1}}$$

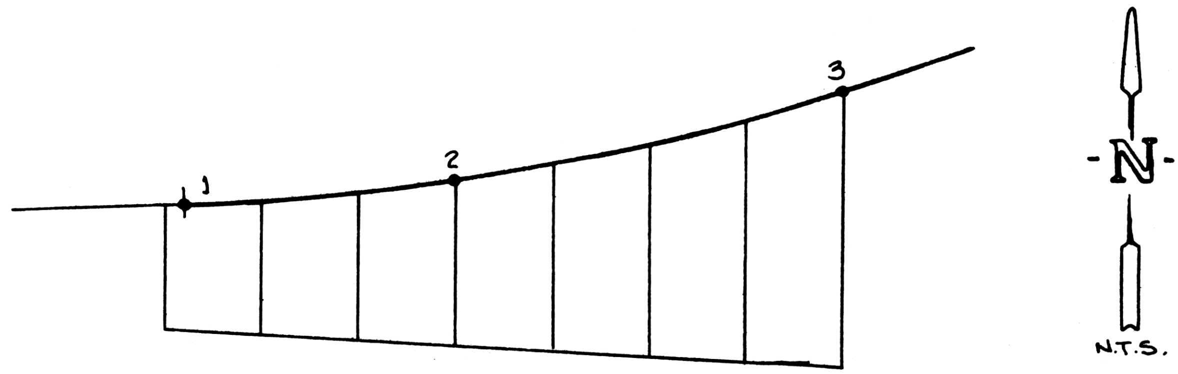
Az = azimuth

This program is dedicated to my good friend and fellow Land Surveyor, Tom H. Murphy, who spends his Sundays calculating his next weeks work.

Operating Limits and Warnings Flashing "0" obtained during computation, means the three points lie on a straight line or the curve has an infinate radius, like way outside of this universe.

Points 1 and 3 may be exchanged, but leave point 2 in the middle. Radius and coordinates are not limited to 3 decimal places.

Program Description II



Sample Problem(s) Tom Murphy phones and wants to know the curve radius and the coordinates of the radius point of the curve depicted in the above sketch so he can stake the lots.

He says the coordinates of points 1, 2 & 3 are:

N1	458.800
E1	188.090
N2	522.557
E2	746.951
N3	756.893
E3	1343.611

STEPS: A, 458.8R/S, 188.09R/S, 522.557R/S, 746.951R/S, 756.893R/S, 1343.611R/S,R/S, R/S.

Solution(s)

R =2315.356

Nrp =2774.079

Erp =207.021

It won't be long until Tom gets his own HP 65!

He has one now!

Reference(s) Any surveying textbook.

User Instructions

CURVE /FROM 3 POINTS

PT 1	PT 2	PT 3	comp	

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Input point 1		A	1.000
3	Input N1	N1	R/S	N1
4	Input E1 (Note 1)	E1	R/S	2.000
5	Input point 2 (Optional)		B	2.000
6	Input N2	N2	R/S	N2
7	Input E2 (Note 1)	E2	R/S	3.000
8	Input point 3 (Optional)		C	3.000
9	Input N3	N3	R/S	N3
10	Input E3	E3	R/S	R
11	Optional		R/S	Nrp
12	Optional		R/S	Erp
13	Execute steps 2, 3 & 4 for new point 1			
13	Or execute steps 5, 6 & 7 for new point 2			
13	Or go to step 8 for new point 3			
14	Compute		D	R
15	Optional		R/S	Nrp
16	Optional		R/S	Erp
17	Enter program "Azimuth Traverse/Inverse" program			
	to inverse ıne azimuths from the radius point to the			
	points. The coordinates of the rp are in the starting			
	position if steps 11 or 15 above was executed.			
	NOTE 1: g↓ after R/S to see easting entered,			
	(optional).			
	NOTE 2: rp = radius point			
	NOTE 3: Flashing "0" means problem is indeterminate.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
DSP	21	
.	83	
3	03	
1	01	
R/S	84	Input N1
STO 3	3303	
R/S	84	Input E1
STO 4	3304	
LBL	23	
B	12	
2	02	
R/S	84	Input N2
STO 5	3305	
R/S	84	Input E2
STO 6	3306	
LBL	23	
C	13	
3	03	
R/S	84	Input N3
STO 7	3307	
R/S	84	Input E3
STO 8	3308	
LBL	23	
D	14	Compute
RCL 4	3404	
RCL 8	3408	
RCL 3	3403	
RCL 7	3407	
E	15	
gx⇄y	3507	
STO 1	3301	
RCL 6	3406	
RCL 8	3408	
RCL 5	3405	
RCL 7	3407	
E	15	
gx⇄y	3507	
STO 2	3302	
RCL 6	3406	
RCL 4	3404	
RCL 5	3405	
RCL 3	3403	
E	15	
2	02	
÷	81	
RCL 2	3402	
RCL 1	3401	
-	51	

KEY ENTRY	CODE SHOWN	COMMENTS
STO 1	3301	
f	31	
SIN	04	
÷	81	
STO 2	3302	
g	35	
ABS	06	
R/S	84	See radius
CLX	44	
RCL 1	3401	
+	61	
9	09	
0	00	
+	61	
RCL 2	3402	
f-1	32	
R→P	01	
RCL 5	3405	
+	61	
STO 1	3301	
gx⇄y	3507	
RCL 6	3406	
+	61	
STO 2	3302	
RCL 1	3401	
R/S	84	See Nrp
RCL 2	3402	
R/S	84	See Erp
GTO	22	
D	14	to compute again
LBL	23	
E	15	
-	51	
g ↓	3508	
-	51	
g ↑	3509	
f	31	
R→P	01	
RTN	24	

REGISTERS	
R_1	Az 3 to 1/alpha/Nrp
R_2	Az 3 to 2/R/Erp
R_3	N1
R_4	E1
R_5	N2
R_6	E2
R_7	N3
R_8	E3
R_9	used trig.

LABELS	
A	PT 1
B	PT 2
C	PT 3
D	compute
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM

Program Description I

Program Title GROUND/GRID CONV.

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Converts ground distance to state plane grid distance or grid distance to ground distance in zones utilizing transverse mercator projection. While the program is for Indiana E and W zones, the constants for each mercator zone in the continental United States is listed and may be substituted in the program. Inputs are elevation and X co-crdinate. EF, SF, and CF are also displayed.

$$\text{Elevation factor} = EF = \frac{20906000}{20906000 + \text{elevation}}$$

$$\text{Scale factor} = SF = (X')^2 \;\; k - \frac{1}{r} \quad +1$$

$$\text{Combination factor} = CF = EF \times SF$$

Where k and r are constants which vary with each zone and are listed on next page.

Operating Limits and Warnings User should assure the constants are correct and program will do the job it is intended to do in a particular zone.

	r	k
AL	E 25EEX3	114 512
AL	W 15EEX3	114 524
AK	2 unknown	113 770
AK	3 unknown	113 770
AK	4 unknown	113 770
AK	5 unknown	113 770
AK	6 unknown	113 770
AK	7 unknown	113 770
AK	8 unknown	113 770
AK	9 unknown	113 770
AZ	E 1EEX4	114 495
AZ	C 1EEX4	114 495
AZ	W 15EEX3	114 487
DE	2EEX5	114 345
FL	E 17EEX3	114 640
FL	W 17EEX3	114 640
GA	E 1EEX4	114 530
GA	W 1EEX4	114 530
HI	1 unknown	114 795
HI	2 unknown	114 773
HI	3 unknown	114 753
HI	4 unknown	114 744
HI	5 unknown	114 746
ID	E 19EEX3	114 229
ID	C 19EEX3	114 229
ID	W 15EEX3	114 187
IL	E 4EEX4	114 330
IL	W 17EEX3	114 324
IN	E 3EEX4	114 334
IN	W 3EEX4	114 334
ME	E 1EEX4	114 189
ME	W 3EEX4	114 197
MI	E 175EEX2	114 218
MI	C 11EEX3	114 208
MI	W 11EEX3	114 208
MS	E 25EEX3	114 522
MS	W 17EEX3	114 516
MO	E 15EEX3	114 377
MO	C 15EEX3	114 377
MO	W 17EEX3	114 373
NH	3EEX4	114 216
NJ	4EEX4	114 321
NM	E 11EEX3	114 492
NM	C 10EEX3	114 495
NM	W 12EEX3	114 472
NY	E 3EEX4	114 256
NY	C 16EEX3	114 263

	r	k
NY	W 16EEX3	114 263
RI	16EEX4	114 289
VT	28EEX3	114 223
WY	E 17EEX3	114 253
WY	EC 17EEX3	114 253
WY	WC 17EEX3	114 253
WY	W 17EEX3	114 253
NV	E EEX4	
NV	C EEX4	unknown
NV	W EEX4	try 114400

Note: k constant from Berry, Ralph Moore, Simple Algorithms for the calculation of Scale-Factors for Plane Coordinate Systems, papers from the 1972(32nd)annual meeting ACSM, March 1972. r constant from Mitchell, Hugh C. and Simmons, Lansing G., The State Coordinate Systems(A Manual for Surveyors) SP 235, Sup. of Documents, reprint 1957

Reference(s) Curtis, Kenneth S., The Indiana State Plane Coordinate System, Manual #2, ISPLS Inc., 111 N. Capitol Ave. Indpls. In. 46204, 1974.

McEntyre, Dr. John G., The Perpetuation of Corners in Indiana, Manual # 1, ISPLS Inc., 111 N. Capitol Ave. Indpls. In. 46204, 1972.

Program Description II

Sample Problem(s)

NO. 1: In Indiana where average elevation is 750 feet and average x coordinate is 615,000 and ground distance is 1826.52 feet, what is EF, SF, CF and grid distance?

NO. 2: Same area, convert grid distance of 352.249 meters to ground distance.

NO. 3: Same area: state plane coordinates were used to compute an area of 41.249 acres: what is the acreage on the ground?

NOTE: divide by CF^2. Steps 41.249DD, assuming EF and SF was computed.

Solution(s)

NO. 1 EF=.9999641 SF=.9999818 CF=.9999459
grid distance = 1826.421 feet

NO. 2 352.268 meters

NO. 3 41.253 acres

Reference(s)

User Instructions

GROUND/GRID CONV.IN E&W

elev.	X	comp grid	comp ground	CF

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input average elev.	elev.	A		
3	(Optional) See EF		R/S		EF
4	Input x (East co-ord.)	X	B		
5	(Optional) See SF		R/S		SF
6	Input ground length	distance	C		grid distance
6	Or input grid length	distance	D		ground distance
7	Return to step 6, 2 or 4		E		CF
8	(Optional) See CF				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	Input elev.
STO 3	3303	
2	02	
0	00	
9	09	
0	00	
6	06	
EEX	43	
3	03	
+	61	
gLSTx	3500	
gx⇄y	3507	
÷	81	
STO 1	3301	
RCL 3	3403	
DSP	21	
•	83	
2	02	
RTN	24	
RCL 1	3401	
DSP	21	
•	83	
7	07	
R/S	84	See EF
LBL	23	
B	12	Input x coord.
STO 3	3303	
5	05	
EEX	43	NJ Zone use
5	05	2 EEx6
-	51	
f-1	32	
√x	09	
1	01	
1	01	
4	04	
3	03	constant k
3	03	
4	04	
EEX	43	
CHS	42	
2	02	
0	00	
x	71	
1	01	
+	61	
gLSTx	3500	
3	03	
EEX	43	constant r

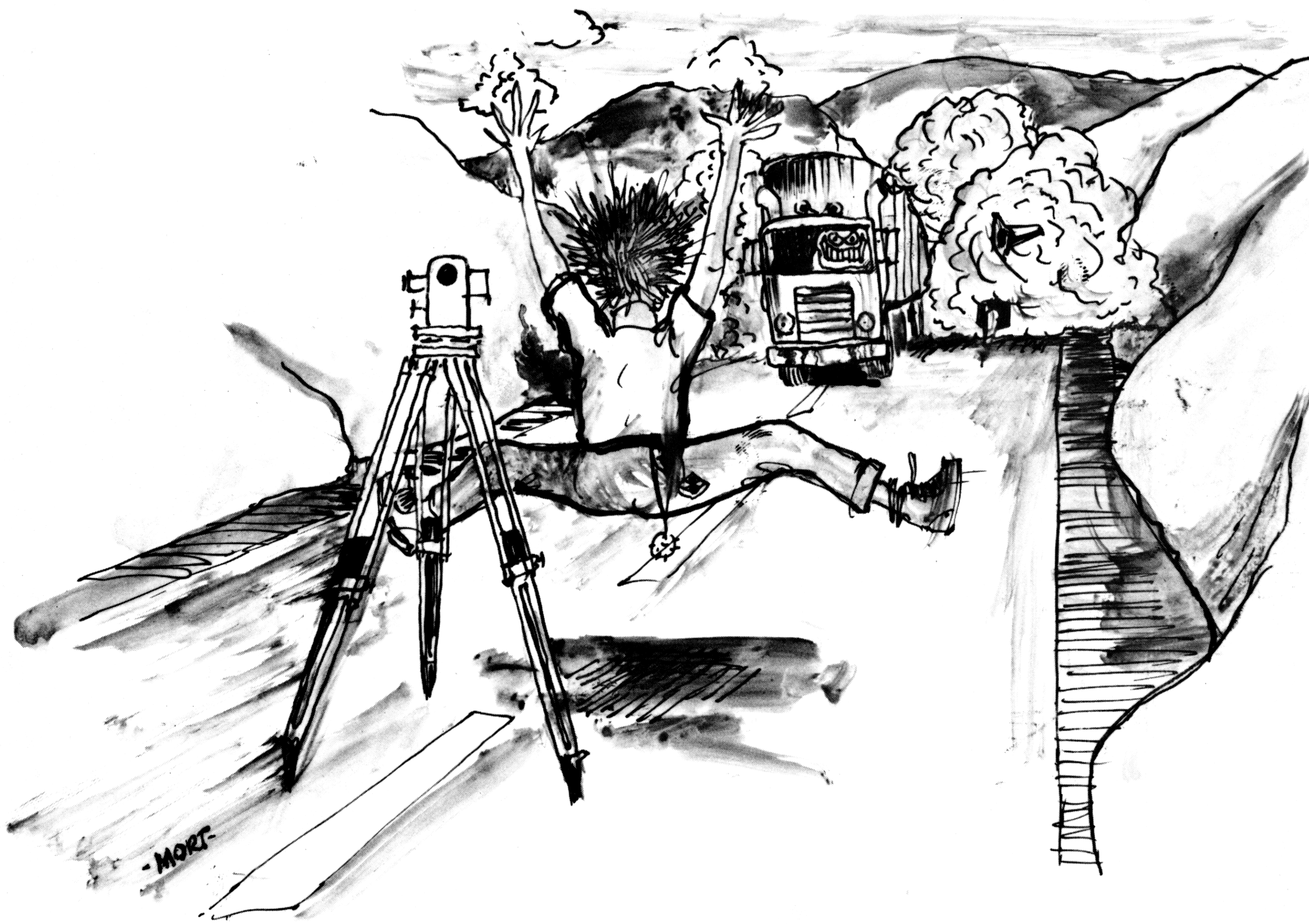
KEY ENTRY	CODE SHOWN	COMMENTS
4	04	
g	35	
1/x	04	
-	51	
x	71	
STO 2	3302	
RCL 3	3403	
DSP	21	
•	83	
2	02	
RTN	24	
RCL 2	3402	
DSP	21	
•	83	
7	07	
R/S	84	See SF
LBL	23	
C	13	
E	15	
x	71	
DSP	21	
•	83	
3	03	
RTN	24	See grid distance
LBL	23	
D	14	
E	15	
÷	81	
DSP	21	
•	83	
3	03	
RTN	24	See ground distance
LBL	23	
E	15	
RCL 1	3401	
RCL 2	3402	
x	71	
DSP	21	
•	83	
7	07	
RTN	24	See CF

REGISTERS	
R_1	EF
R_2	SF
R_3	used
R_4	
R_5	
R_6	
R_7	
R_8	
R_9	

LABELS	
A	elev.
B	x
C	to grid
D	" ground
E	CF
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.


-MORT-

Program Description I

Program Title GEO/GRID AZ CONV.

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis State Indiana Zip Code 46229

Program Description, Equations, Variables, etc. Converts state plane grid azimuth to geodetic azimuth or geodetic az. to grid az. in zones utilizing transverse mercator projection, given latitude and longitude of point and azimuth. Any two zones may be incorporated in the program. While the program is for Indiana E and W zones, the constants for each mercator zone in the continental United States is listed and may be substituted in the program.

$$\Delta a = \Delta \lambda \sin \phi$$

Grid azimuth = Geodetic Azimuth − Δa

where;

ϕ = latitude

Geodetic Azimuth = Grid Azimuth + Δa

λ = longitude

$\Delta\lambda = \lambda$ central meridian − λ station

Operating Limits and Warnings Second term g has been omitted since in Indiana it is always less than 1/2 second. User should assure the program will do the job the program is intended to do.

Substitiude any two longitude of central meridian in program:

AL E 85.5	ID E 112.1	MI C 85.45	NH 71.4	WY 1 105.1
AL W 87.3	ID C 114	MI N 88.45	NJ 74.4	WY 2 107.2
AZ E 110.1	ID W 115.45	MS E 88.5	NM E 104.2	WY 3 108.45
AZ C 111.55	IL E 88.2	MS W 90.2	NM C 106.15	WY 4 110.05
AZ W 113.45	IL W 90.1	MO E 90.3	NM W 107.5	
DE 75.25	IN E 85.4	MO C 92.3	NY E 74.2	
FL E 81	IN W 87.05	MO W 94.3	NY C 76.35	
FL W 82	ME E 68.3	NV E 115.35	NY W 78.35	
GA E 82.1	ME W 70.1	NV C 116.4	RI 71.3	
GA W 84.1	MI E 83.4	NV W 118.35	VT 72.3	

Sample Problem(s)

NO. 1: A sun shot was made in Indiana W zone where ϕ=40°12'22", λ =86°57'08" and the true azimuth of a line was determined to be 220°38'39". What is grid azimuth of this line?

NO. 2: Indiana E zone, ϕ=40°41'03.949", λ =86°23'30.437", grid Az= 181°46'14.3". What is geodetic azimuth?

Solution(s)

1. 220°33'34.31"

2. 181°17'52.58"

Reference(s) Curtis, Kenneth S., THE INDIANA STATE PLANE COORDINATE SYSTEM, Manual #2, ISPLS Inc. 111 N. Capitol Ave. Indpls. In. 46204, 1974

McEntyre, Dr. John G., THE PERPETUATION OF CORNERS IN INDIANA, Manual #1, ISPLS Inc. 111 N. Capitol Ave. Indpls. In. 46204, 1972

Mitchell and Simmons, THE STATE COORDINATE SYSTEMS, Special Pub. No. 235

User Instructions

GEO./GRID AZ. CONV.IN.E&W

W Zone	E Zone	ϕ λ	Comp. Grid	Comp. Geo.

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Choose zone (IN W)		A	
2	Or (IN E)		B	
3	Inter latitude	ϕ	C	
4	Inter longitude	λ	C	
5	Inter geodetic Az compute grid azimuth		D	Grid Az.
5	or compute geodetic azimuth		E	Geo. Az.
6	(Optional) See seconds and hundreths of		R/S	
	computed azimuth.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
f	31	
SF 2	71	
RTN	24	
LBL	23	
B	12	
f-1	32	
SF 2	71	
RTN	24	
LBL	23	
C	13	
DSP	21	
•	83	
4	04	
STO 3	3303	
f-1	32	
→D.MS	03	
f	31	
SIN	04	
STO 1	3301	
RCL 3	3403	
RTN	24	
LBL	23	
C	13	
f-1	32	
→D.MS	03	
STO 2	3302	
gLSTx	3500	
RTN	24	
LBL	23	
D	14	compute grid
f	31	
SF 1	51	
GTO	22	
2	02	
LBL	23	
E	15	compute geo
f-1	32	
SF 1	51	
LBL	23	
2	02	
f-1	32	
→D.MS	03	
RCL 1	3401	
f	31	
TF 2	81	
GTO	22	
0	00	
8	08	

KEY ENTRY	CODE SHOWN	COMMENTS
5	05	sub. desired
•	83	ZONE UNDER B KEY
4	04	
LBL	23	
1	01	
f-1	32	
→D.MS	03	
RCL 2	3402	
−	51	
x	71	
f	31	
TF 1	61	
−	51	
0	00	
+	61	
f	31	
→D.MS	03	
DSP	21	
•	83	
4	04	
RTN	24	
gLSTx	3500	
f-1	32	
INT	83	
6	06	
0	00	
x	71	
f-1	32	
INT	83	
6	06	
0	00	
x	71	
DSP	21	
•	83	
2	02	
R/S	84	seconds & hundreths
0	00	
÷	81	
LBL	23	
0	00	
8	08	
7	07	Sub. desired
•	83	zoned under A key
0	00	
5	05	
GTO	22	
1	01	

REGISTERS	
R_1	Sin ϕ
R_2	λ
R_3	ϕ
R_4	
R_5	
R_6	
R_7	
R_8	
R_9	
LABELS	
A	W. Zone
B	E. Zone
C	ϕ λ comp.
D	grid
E	comp.geo
0	used
1	used
2	used
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	used
2	used

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM

Program Description I

Program Title BUILDING RADIAL STAKE-OUT

Contributor's Name Charles C. Campbell, LS
Address 9841 East 21st Street
City Indianapolis State Indiana Zip Code 46229

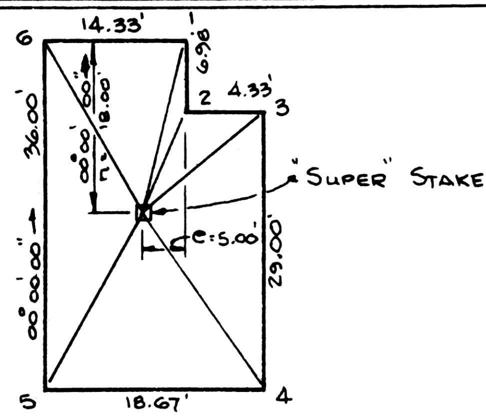
Program Description, Equations, Variables, etc. Computes azimuth and distance from a "SUPER-STAKE" placed near the centroid of a building, given stake location dimensions, and "walking" around the building inputing building dimensions with right and left 90 degree deflections controlled by the A and E keys. The footing offsets of building may then be staked with only one transit setup. The same "SUPER-STAKE" is also used to pin the footing, utilizing a second set of computations. The staking can be accomplished with a roll-up tape hooked onto a tack on the "SUPER STAKE". The building stakes may be checked for proper location by measuring directly between them.

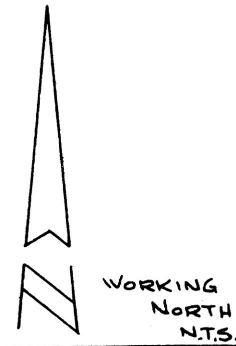
Point 1 is always a "NE" corner of the building. Dimensions n and e represents the rectangular coordinates of point 1. The first distance from point 1 is always a right deflection(E key).

Standard traverse and inverse routines are used in the program. The "SUPER-STAKE" is assigned a coordinate value of 0 north and 0 east.

Operating Limits and Warnings A flashing 0 after displaying a distance indicates R/S was pushed when the program was ready for a lettered function key. Push CLX and continue.

Program Description II





Sample Problem(s)

Computes the azimuths and distances for the building in the above sketch.

STEPS: C, 18, R/S, 5R/S, R/S, 6.98E, R/S, 4.33A, R/S, 29E, R/S, 18.67A, OBVIOUS ERROR, D, 18.67E, R/S, 36E, R/S, 14.33BE, R/S.

Solution(s)

POINT	AZIMUTH	DISTANCE
1	15°31'27"	18.682
2	24°24'17"	12.101
3	40°15'10"	14.439
4	152°34'29"	20.257
5	207°27'01"	20.261
6	332°36'06"	20.297

ERRORS: +0.020 n direction & -0.010 e direction

Reference(s) None

User Instructions

BLDG. RADIAL STAKEOUT 1st.dist.

L	last dist.	start	back up 1 line	R

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Start (initialize) (See flag)		C		90.000
3	Input n	n	R/S		n
4	Input e (See polar azimuth to first point)	e	R/S		Pa 1
5	See polar distance to first point		R/S		Pd
6	Inpute length of line (if line is defl. L)	l	A		Pa
6	Inpute length of line (if line is defl. R)	l	E		Pa
7	See polar distance		R/S		Pd
8	Repeat steps 6 and 7 for each line of building except				
	last line.				
9	If error is made at step 6(back up 1 line)		D		Pa-1
10	(Optional)		R/S		Pd-1
11	Return to step 6				
12	If last line(length of last line) L	l	B	A	En
12	or R	l	B	E	En
13	See error e direction		R/S		Ee
	En=error in n direction(closing)				
	Ee=error in e direction(closing)				
	Pa=polar azimuth				
	Pd=polar distance				
	l=length of line of building				
	R=deflect 90° right from last line traversed				
	L=deflect 90° left from last line traversed				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
RCL 8	3408	
CHS	42	
GTO	22	
1	01	
LBL	23	
B	12	Set flag 1 on
f	31	
SF 1	51	
RTN	24	
LBL	23	
C	13	
9	09	
0	00	
STO 3	3303	
STO 8	3308	
DSP	21	
.	83	
3	03	
f-1	32	
SF 1	51	Set flag 1 off
R/S	84	Input n
STO 4	3304	
STO 6	3306	
R/S	84	Input e
STO 5	3305	
STO 7	3307	
RCL 6	3406	
LBL	23	
2	02	
f	31	
R→P	01	
gx⇄y	3507	
0	00	
gx > y	3524	
3	03	
6	06	
0	00	
+	61	
+	61	
f	31	
→D.MS	03	
DSP	21	
.	83	
4	04	
RTN	24	See azimuth polar
gx⇄y	3507	
DSP	21	
.	83	

KEY ENTRY	CODE SHOWN	COMMENTS
3	03	
R/S	84	See polar dist.
0	00	
÷	81	
LBL	23	
D	14	
RCL 3	3403	
RCL 2	3402	
-	51	
STO 3	3303	
gLSTx	3500	
+	61	
RCL 1	3401	
CHS	42	
GTO	22	
3	03	
LBL	23	
E	15	
RCL 8	3408	
LBL	23	
1	01	
STO 2	3302	
RCL 3	3403	
+	61	
STO 3	3303	
gx⇄y	3507	
STO 1	3301	distance
LBL	23	
3	03	
f-1	32	
R→P	01	
gx⇄y	3507	
RCL 5	3405	
+	61	
STO 5	3305	
gx⇄y	3507	
RCL 4	3404	
+	61	
STO 4	3304	
f-1	32	
TF 1	61	
GTO	22	
2	02	
RCL 6	3406	
-	51	
RTN	24	En
gx⇄y	3507	
RCL 7	3407	
-	51	
R/S	84	Ee

REGISTERS	
R_1	d
R_2	last direction
R_3	azimuth
R_4	N1...n
R_5	E1...n
R_6	N1
R_7	E1
R_8	90°
R_9	

LABELS	
A	L
B	last line
C	start
D	back up
E	R
0	
1	used
2	used
3	used
4	
5	
6	
7	
8	
9	

FLAGS	
1	used
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title EDM/STAKE-OUT

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc.

GIVEN:

Ae = Azimuth to EDM
He = Horizontal distance to EDM
Ze = Zenith angle to EDM
Ar = Azimuth to reflector (point)
Hp = Horizontal distance to point
Zr = Zenith angle to reflector
Ser = Slope distance, EDM to reflector

At = Angle, reflector-theodolite-EDM on plane through reflector and optical centers of theodolite and EDM.

DIFF. = Horizontal distance to reflector minus horizontal distance to point

Htr = Horizontal distance, theodolite to reflector.

$$At = 2\,\mathrm{ArcSin}\,\frac{\sqrt{(\mathrm{Cos}Zr-\mathrm{Cos}Ze)^2+(\mathrm{SinZeCos}\,[Ae-Ar]-\mathrm{Sin}Zr)^2+(\mathrm{SinZeSin}\,[Ae-Ar]\,)^2}}{2}$$

$$Htr = \left[\frac{\mathrm{CosAt}\,(He)}{\mathrm{SinZe}}+\sqrt{Ser^2-\left(\frac{\mathrm{SinAt}\,(He)}{\mathrm{SinZe}}\right)^2}\,\right]\mathrm{SinZr}$$

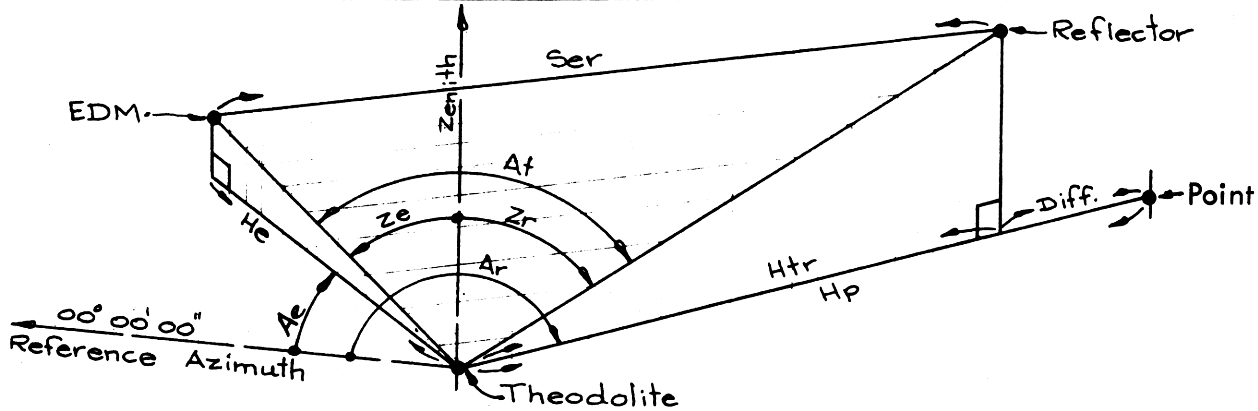
$$DIFF. = Htr - Hp$$

Operating Limits and Warnings Ze can not be 0 degrees (flashing 0).

Check values entered under "A" key by measuring distance to the control point sighted. EDM-Theo.-Control Point angle should be approximately 45° or 135° in order to check all three values and to assure the correct control points are occupied.

For accurate work, the reflector should not be off line, particularly when theo.-refl.-EDM angle is not small.

Program Description II



Sample Problem(s)

(1): Compute distance from reflector to point to be set. Start by pushing "A" key, see "1.00".

$A_e = 103°\ 45'29"$	$H_e = 28.39'$	$Z_e = 89°07'56"$
$A_r = 269°33'47"$	$H_p = 454.85'$	
$Z_r = 90°23'08"$	$S_{er} = 479.24'$	

(2): Compute next distance using above data, except $S_{er} = 482.43'$
Start by pushing "D" key, see "4.00".

(3): Compute distance from reflector to next point to be set. Start by pushing "B" key, see "2.00".

$A_r = 178°47'00"$	$H_p = 163.01'$
$Z_r = 92°39'26"$	$S_{er} = 165.50'$

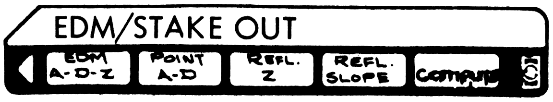
(4): Compute distance same point, changing Z_r to $92°52'40"$ and S_{er} to 158.31'. Push "C" key, see "3.00" to start.

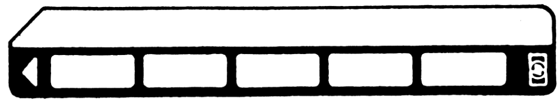
Solution(s)

	DIFF.	MEANS	Htr
(1)	-3.20'	move away from theo. 3.20'	451.65'
(2)	-0.01'	move away from theo. 0.01'	454.84'
(3)	7.32'	move toward theo. 7.32'	170.33'
(4)	0.00'	at point to be set	163.01'

Reference(s) None

User Instructions





STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	Input EDM location data:		A	1.00
	azimuth to EDM	A_e	R/S	
	horizontal distance to EDM	H_e	R/S	
	zenith angle to EDM	Z_a	R/S	
3	Input point to be set data:		B	2.00
	azimuth to point(reflector)	A_r	R/S	
	horizontal distance to point	H_p	R/S	
4	Input zenith angle to reflector:		C	3.00
	zenith angle to reflector	Z_r	R/S	
5	Input slope distance to reflector:		D	4.00
	slope distance to reflector	S_{er}	R/S	DIFF.
			R/S	H_{tr}
	Return to step 3 for next point OR;			
	return to step 4 for new zenith angle OR;			
	return to step 5 for new slope distance.			
6	Compute using previous slope distance		E	DIFF.
			R/S	H_{tr}
	NOTES: (1) Data entered under steps 2, 3, 4 & 5 re-			
	mains unchanged after computation.			
	(2) Not necessary to push function key going			
	from step 2 to 3, 3 to 4, or 4 to 5.			
	(3) Enter angles as DDD.MMSS			
	(4) Push DSP . 3 for 3 decimal display.			
	(5) Not necessary to push R/S and see Htr			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
1	01	(flag)
R/S	84	Input Ae
STO 1	3301	
R/S	84	Input He
STO 2	3302	
R/S	84	Input Ze
f-1	32	
→D.MS	03	
STO 3	3303	
LBL	23	
B	12	
2	02	(flag)
R/S	84	Input Ar
STO 4	3304	
R/S	84	Input Hp
STO 5	3305	
LBL	23	
C	13	
3	03	(flag)
R/S	84	Input Zr
f-1	32	
→D.MS	03	
STO 6	3306	
LBL	23	
D	14	
4	04	(flag)
R/S	84	Input Ser
STO 7	3307	
LBL	23	
E	15	
RCL 1	3401	
RCL 4	3404	
f-1	32	
D.MS+	02	
f-1	32	
→D.MS	03	
STO 8	3308	
RCL 6	3406	
1	01	
f-1	32	
R → P	01	Compute Sin & Cos Zr
RCL 3	3403	
1	01	
f-1	32	
R → P	01	Compute Sin & Cos Ze
gx⇄y	3507	
g↓	3508	
-	51	

KEY ENTRY	CODE SHOWN	COMMENTS
RCL 8	3408	
g↑	3509	
STO 8	3308	
f-1	32	
R → P	01	
g↑	3509	
-	51	
f	31	
R → P	01	
g↑	3509	
f	31	
R → P	01	= 2 Sin 1/2 At
2	02	
÷	81	= Sin 1/2 At
f-1	32	
SIN	04	
2	02	
X	71	= At
RCL 2	3402	
RCL 8	3408	
÷	81	=slope dist. ⊼ to EDM
f-1	32	
R → P	01	
gx⇄y	3507	
RCL 7	3407	
f-1	32	
√x	09	
gx⇄y	3507	
f-1	32	
√x	09	
-	51	
f	31	
√x	09	
+	61	= slope dist. ⊼ to refl.
RCL 6	3406	
f	31	
SIN	04	
X	71	= Htr
STO 8	3308	
RCL 5	3405	
-	51	
R/S	84	See DIFF.
RCL 8	3408	
RTN	24	See Htr

REGISTERS

- R_1 Ae = Az. to EDM
- R_2 He = Horiz. dist. to EDM
- R_3 Ze = Zen. angle to EDM
- R_4 Ar = Az. to reflector
- R_5 Hp = Horiz. dist. to point
- R_6 Zr = Zen. angle to refl.
- R_7 Ser = slope dist. EDM to refl.
- R_8 used
- R_9

LABELS

- A EDM
- B point
- C Zr
- D Ser
- E compute
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1
- 2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title EDM/STAKE-OUT TWO

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc.

Ae = azimuth to EDM
He = horizontal distance to EDM
Δh = height of EDM axis with respect to theo.
Ar = azimuth to reflector(point)
Hp = horizontal distance to point
Zr = zenith angle to reflector
Ser = slope distance, EDM to reflector

DIFF. =Horizontal distance to reflector minus horizontal dist. to point
Htr. = Horizontal distance, theodolite to reflector.

$$Htr = \frac{\sqrt{B^2 + 4AC} \quad +B}{2A}$$

where:

$A = 1+(\tan\ 90-Zr)^2$

$B = \left[He\ \cos(Ae-Ar) + \Delta h(\tan\ 90-Zr)\right]^2$

$C = Ser^2 - (He^2 + \Delta h^2)$

Elev. = HI + tan 90–ZrHtr

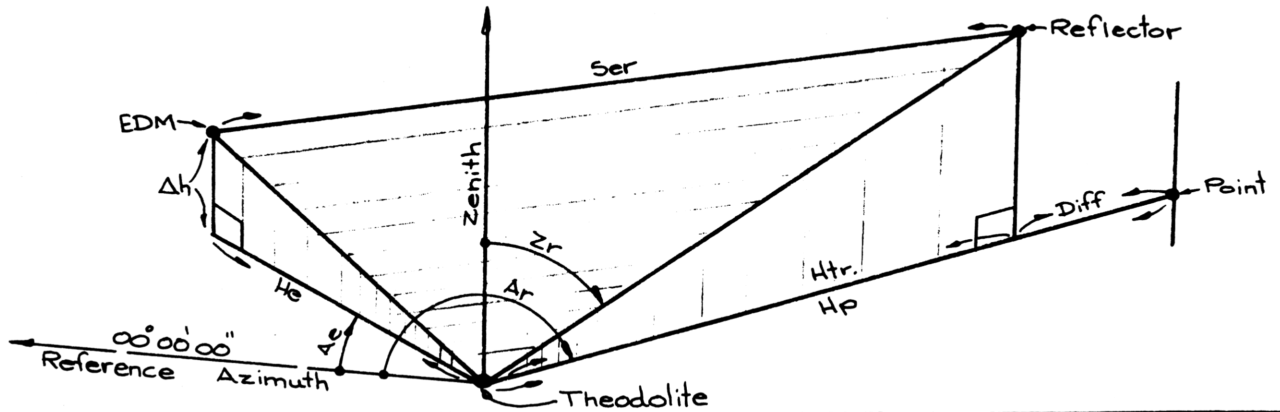
DIFF. = Htr – Hp

NOTE: For accuracy, elevation determined by trigonometric leveling on lines over 1000 feet in length should be corrected for curvature and refraction. c+r = horiz. distance in feet $^2 \times 2.059\times10^{-8}$.

Operating Limits and Warnings (1) Check values entered under "A" key by measuring distance to the control point sighted. EDM-Theo. -Control Point angle should be approximately 45° or 135° in order to check all three values and to assure the correct control points are occupied.

(2) For accurate work, the reflector should not be off line, particularly when theo. - refl.-EDM angle is not small.

Program Description II



Sample Problem(s)

(1): Compute distance from reflector to point to be set and reflector elevation. Start by pushing RTN R/S key, see "5.00". HI=1000.00

Ae=103°45'29"	He=28.39'	Δh=0.43
Ar=269°33'47"	Hp=454.85'	
Zr= 90°23'08"	Ser=479.24'	

(2): Compute next distance using above data, except Ser=482.43' Start by pushing "D" key, see "4.00".

(3): Compute distance from reflector to next point to be set. Start by pushing "B" key, see "2.00".

Ar=178°47'00"	Hp=163.01'
Zr= 92°39'26"	Ser=165.50'

(4): Compute distance, same point, changing Zr to 92°52'40" and Ser to 158.31'. Push "C" key, see "3.00" to start.

Solution(s)

	DIFF.	MEANS		HTR.	ELEV.
(1)	-3.20'	move away from theo.	3.20'	451.65'	996.96
(2)	-0.01'	move away from theo.	0.01'	454.84'	996.94
(3)	7.32'	move toward theo.	7.32'	170.33'	992.09
(4)	0.00'	at point to be set		163.01'	991.81

Reference(s)

INSIGHTS, Vol. 2, No. 4 by Hewlett-Packard Company, 1974
EDM STAKEOUT written by CCC.

User Instructions

EDM/STAKE -OUT 2

EDM A-D-h	POINT A-D	Refl Z	Refl Slope	Compute

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	(Optional) Input HI Elev.		RTN R/S	5.00
	See Note 5	HI	R/S	
3	Input EDM location data:		A	1.00
	Azimuth to EDM	Ae	R/S	
	Horizontal distance to EDM	He	R/S	
	Delta h (If EDM higher than theo.)	Δ h	R/S	
	Delta h (If EDM lower than theo.)	Δ h	CHS R/S	
4	Input point to be set data:		B	2.00
	Azimuth to point (reflector)	Ar	R/S	
	Horizontal distance to point	Hp	R/S	
5	Input zenith angle to reflector:		C	3.00
	Zenith angle to reflector	Zr	R/S	
6	Input slope distance to reflector:		D	4.00
	Slope distance to reflector	Ser	R/S	DIFF.
7	Optional		R/S	Htr.
8	Return to step 4 for next point OR:		R/S	Elev.
	Return to step 5 for new zenith angle OR:			
	Return to step 6 for new slope distance			
9	Compute using previous slope distance		E	DIFF.
			R/S	Htr.
	NOTES: (1) Data entered under steps 2, 3, 4, 5, 6		R/S	Elev.
	remains unchanged after computation.			
	(2) Not necessary to push function key going			
	from step 2 to 3, 3 to 4, 4 to 5, or 5 to 6			
	(3) Enter angles as DDD.MMSS			
	(4) Push DSP .3 for 3 decimal display.			
	(5) HI elevation could be: elevation of			
	theodolite station + height of theodolite-height of			
	reflector to compute ground elevation at			
	reflector station.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
5	05	flag
R/S	84	
STO 8	3308	HI Elevation
LBL	23	
A	11	
1	01	flag
R/S	84	Ae
STO 1	3301	
R/S	84	He
STO 2	3302	
R/S	84	h
STO 3	3303	
LBL	23	
B	12	
2	02	flag
R/S	84	Ar
STO 4	3304	
R/S	84	Hp
STO 5	3305	
LBL	23	
C	13	
3	03	flag
R/S	84	Zr
9	09	
0	00	
g $x \rightleftarrows y$	3507	
f-1	32	
→D.MS	03	
−	51	
f	31	
Tan	06	
STO 6	3306	
LBL	23	
D	14	
4	04	
R/S	84	
f-1	32	
$\sqrt{x}$	09	
STO 7	3307	
LBL	23	
E	15	
RCL 2	3402	
RCL 1	3401	
RCL 4	3404	
f-1	32	
D.MS+	02	
f-1	32	
→D.MS	03	
f	31	
COS	05	

KEY ENTRY	CODE SHOWN	COMMENTS
x	71	
RCL 3	3403	
RCL 6	3406	
x	71	
+	61	
2	02	
x	71	
RCL 6	3406	
f-1	32	
$\sqrt{x}$	09	
1	01	
+	61	
STO	33	
9	09	
4	04	
x	71	
RCL 3	3403	
f-1	32	
$\sqrt{x}$	09	
RCL 2	3402	
f-1	32	
$\sqrt{x}$	09	
+	61	
RCL 7	3407	
g $x \rightleftarrows y$	3507	
−	51	
x	71	
g ↓	3509	
f-1	32	
$\sqrt{x}$	09	
+	61	
f	31	
$\sqrt{x}$	09	
+	61	
RCL	34	
9	09	
2	02	
x	71	
÷	81	
RCL 5	3405	
−	51	
R/S	84	See Diff.
RCL 5	3405	
+	61	
R/S	84	See Horiz. Dist.
RCL 6	3406	
x	71	
RCL 8	3408	
+	61	
R/S	84	See elev.

REGISTERS	
R_1	Ae
R_2	He
R_3	Δh
R_4	Ar
R_5	Hp
R_6	tan. 90−Zr
R_7	Ser
R_8	elev.
R_9	used

LABELS	
A	used
B	used
C	used
D	used
E	used
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title ELEVATION & HORIZ. DISTANCE FROM ZENITH ANGLE & SLOPE DISTANCE

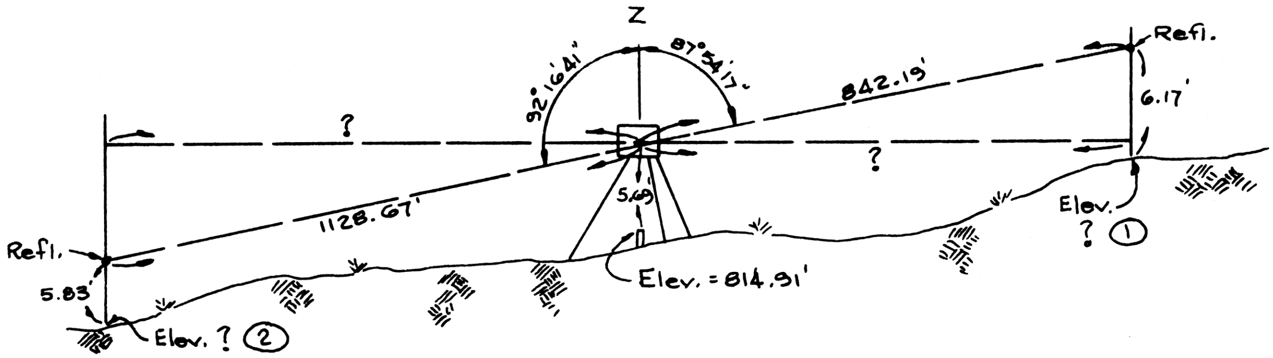
Contributor's Name Charles C. Campbell, LS
Address 9841 East 21st Street
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Primarily a program for the trigonometric leveling with an EDM instrument. Computes the elevation of and horizontal distance to a point, given the zenith angle and slope distance after the elevation of the ground(stake) at the instrument, the height of the horizontal axis of EDM above the stake, and the height of the reflector above the ground are given. The elevation is corrected for curvature and refraction utilizing the standard "textbook" factor.

Hd = Horizontal Distance = S sin Z
Elevation = G + Mu - Rh + S cos Z + (c+r)
Where:
S = Slope distance
Z = Zenith angle
G = Ground
Mu = "Measure up"
Rh = Reflector height
(c+r) = curvature + refraction = $2.059 \times 10^{-8} \times Hd^2$

Operating Limits and Warnings Elevation determined by trigonometric leveling on lines over 1000 feet in length should be considered approximate due to uncertainty caused by refraction. Reciprocal zenith angles at both ends of the line would improve accuracy.

Program Description II



Sample Problem(s) Compute the horizontal distance to and the elevation for the two points in the above sketch:

STEPS: 814.91A, 5.69B, 6.17C, 87.5417R/S, 842.19R/S, R/S
5.83C, 92.1641R/S, 1128.67R/S, R/S.

Solution(s)

1. HD = 841.627 Elevation = 845.236

2. HD = 1127.778 Elevation = 769.933

Reference(s) Bouchard, Harry and Moffitt, Francis H., SURVEYING, fifth edition, pages 32, 33 and 34, International Textbook Company, Scranton, Pennsylvania, 1965

User Instructions

ELEV. & HD FROM ZA & SD

Ground @ Instr.	Meas. up	Refl. Height		Compute

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input elevation of ground(stake) @ Inst.	G	A		G
3	Input height of inst. above stake (Mu)	Mu	B		Mu
4	Input height of reflector above ground	Rh	C		Rh
5	To enter Z & S (Notes 1 and 2)		E		
6	Input Z	DD.MMSS	R/S		DD.MMSS
7	Input S	S	R/S		Hd
8			R/S		Elev.
9	Return to step 6 for next case, same A, B, C data.				
9	Or change AB and/or C data and continue at step 6.				
	NOTE 1: Z denotes zenith angle and S denotes slope distance				
	NOTE 2: Steps 2, 3, and 4 end with the execution of step 5 and the HP 65 is ready for step 6.				
	NOTE 3: Hd denotes horizontal distance and elev. denotes elevation.				
	NOTE 4: Mu denotes "measure up".				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	ground @ inst.
STO 1	3301	
GTO	22	
D	14	
LBL	23	
B	12	"measure up"
STO 2	3302	
GTO	22	
D	14	
LBL	23	
C	13	refl. height
STO 3	3303	
LBL	23	
D	14	
RCL 1	3401	
RCL 2	3402	
RCL 3	3403	
-	51	
+	61	
STO 5	3305	
g ↑	3509	
DSP	21	
.	83	
3	03	
LBL	23	
E	15	compute (see elev.)
R/S	84	input zenith
f-1	32	
→D.MS	03	
STO 7	3307	
gLSTx	3500	
DSP	21	
.	83	
4	04	
R/S	84	input SD
STO 6	3306	
RCL 7	3407	
gx⇄y	3507	
f-1	32	
R → P	01	
STO 8	3308	
g ↓	3508	
STO	33	
9	09	
DSP	21	
.	83	
3	03	
R/S	84	See HD
RCL	34	

KEY ENTRY	CODE SHOWN	COMMENTS
9	09	
f-1	32	
√x	09	
2	02	
.	83	
0	00	
5	05	
9	09	
EEX	43	
CHS	42	
8	08	
x	71	
RCL 8	3408	
RCL 5	3405	
+	61	
+	61	
GTO	22	
E	15	

REGISTERS	
R_1	Ground @ Inst.
R_2	MU
R_3	RH
R_4	
R_5	G+Mu-Rh
R_6	SD
R_7	zenith
R_8	height diff.
R_9	HD
LABELS	
A	G @inst.
B	meas. up
C	Refl. H
D	used
E	compute
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title ELEVATION FROM ZENITH ANGLE & HORIZONTAL DISTANCE

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Primarily a program for trigonometric leveling with an EDM instrument. Computes the elevation of a point given the zenith angle and horizontal distance after the elevation of the ground(stake) at the instrument, the height of the horizontal axis of EDM above the stake and the height of the reflector above the ground are given. The elevation is corrected for curvature and refraction utilizing the standard "textbook" factor.

$$\text{Elevation} = G + Mu - Rh + \left[\tan(90-Z)\right] \times D + (c+r)$$

Where:

G = Elevation of ground at instrument

Mu = "Measure up"

Rh = reflector height

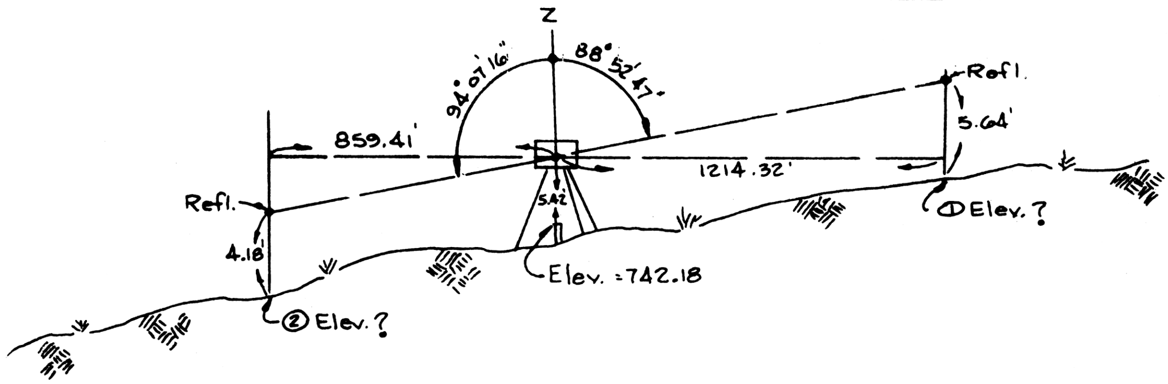
Z = zenith angle

D = horizontal distance

$(c+r)$ = curvature + refraction = $2.059 \times 10^{-8} \times D^2$

Operating Limits and Warnings Elevation determined by trigonometric leveling on lines over 1000 feet in length should be considered approximate due to uncertainty caused by refraction. Reciprocal zenith angles at both ends of the line would improve accuracy.

Program Description II



Sample Problem(s) Compute the elevations for the two points in the above sketch:

STEPS: 742.18A, 5.42B, 5.64C, 88.5247R/S, 1214.32R/S,

4.18C, 94.0716R/S, 859.41R/S.

Solution(s)

Elevation 1 = 765.736

2 = 681.514

Reference(s) Bouchard, Harry and Moffitt, Francis H., SURVEYING, fifth edition, pages 32, 33 and 34, International Textbook Company, Scranton, Pennsylvania, 1965.

User Instructions

ELEV. FROM ZA & HD

Ground @ Inst.	Meas. up	Refl. Height		Compute

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input elevation of ground(stake) @ inst.	G	A		G
3	Input height of inst. above stake(Mu)	Mu	B		Mu
4	Input height of reflector above ground	Rh	C		Rh
5	To enter Z & D (Notes 1 and 2)		E		
6	Input Z	DD.MMSS	R/S		DD.MMSS
7	Input D	D	R/S		Elev.
8	Return to step 6 for next case, same A, B, C data				
8	Or change AB and/or C data and continue at step 6.				
	NOTE 1: Z denotes zenith angle and D denotes horizontal distance.				
	NOTE 2: Steps 2, 3, and 4 end with the execution of step 5 and the HP 65 is ready for step 6.				
	NOTE 3: Mu denotes "measure up"				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	ground @ inst.
STO 1	3301	
GTO	22	
D	14	
LBL	23	
B	12	"measure up"
STO 2	3302	
GTO	22	
D	14	
LBL	23	
C	13	refl. height
STO 3	3303	
LBL	23	
D	14	
RCL 1	3401	
RCL 2	3402	
RCL 3	3403	
-	51	
+	61	
STO 5	3305	
g ↓	3509	
LBL	23	
E	15	compute
DSP	21	
.	83	
3	03	
R/S	84	inpute ZA(See elev.)
f-1	32	
→D.MS	03	
STO 7	3307	
gLSTx	3500	
DSP	21	
.	83	
4	04	
R/S	84	inpute HD
STO 4	3304	
9	09	
0	00	
RCL 7	3407	
-	51	
f	31	
TAN	06	
x	71	
RCL 5	3405	
+	61	
RCL 4	3404	
f-1	32	
√x	09	
2	02	

KEY ENTRY	CODE SHOWN	COMMENTS
.	83	
0	00	
5	05	
9	09	
EEX	43	
CHS	42	
8	08	
x	71	
+	61	
GTO	22	
E	15	

REGISTERS	
R_1	ground @ inst.
R_2	"measure up"
R_3	refl. height
R_4	HD
R_5	G+M-R
R_6	
R_7	ZA
R_8	
R_9	

LABELS	
A	G @inst.
B	meas. up
C	refl. H
D	used
E	compute
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title EDM/RADIAL CURVE STAKE-OUT OS

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes angles and distance for curves for both sides of a street for curb offset staking, with instrument set up on outside PC or PT offset stake, using total station type EDM setup or a long tape for short length curves, given minumum known data and staking interval, program computes the station of the PT (PC) first for data entry and plan dimension verification. The computed station may be overridden by the users own special station. The staking may be checked by measuring between the stakes at each station.

Standard traverse and inverse routines are used and:

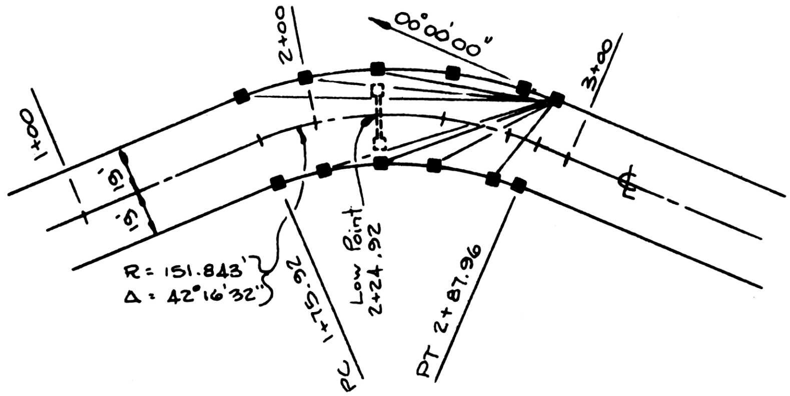
$$\text{Next station} = \left(n \text{ of } \left[\frac{\text{last sta}}{\text{interval}}\right] + 1\right) \text{interval}$$

$$\text{Deflection angles} = (\text{sta} - \text{PC Sta}) \times \frac{90}{\pi R} \quad \text{or angle} = (\text{Sta} - \text{PC STA}) \times \frac{180}{\pi R}$$

Chord = 2RxSin deflection angle
R == Radius
n == integer

Operating Limits and Warnings Program will not compute beyond the PT(PC) station. If interval is fractional: round and truncate to 7 significant digits or less. If from PT of curve: input PT station with opposite sign in place of PC station. All stations are then entered and displayed with opposite signs. All angles are "right angles". 0 degrees is toward the PI of the curve occupied. Program on card 2 could be put on top of card 1. Don't distrube stack during program execution.

Program Description II



Proposed 30 foot pave. back to back of curbs. Offsets 4' back of curb.

Sample Problem(s) Compute angles and distances to each proposed stake in the above sketch, for each 25 foot station, including the low point, and excluding station 2+25, from the PT of the curve. (All stationing entered and displayed negative.)

STEPS: (Enter Card 1) 25A, B, D, 287.96CHS R/S, 19R/S, 151.843R/S, 42.1632R/S, (See PC stationing) (Enter Card 2) A, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, R/S, 224.92CHS, R/S, R/S, R/S, R/S, etc.

Solution(s)

	STA	ANGLE OUT	DISTANCE OUT	ANGLE IN	DISTANCE IN
PT	2+87.96	0° toward PI of curve			
	2+75	357°33'18"	14.58	286-23-51	40.12
	2+50	352-50-17	42.60	307-57-28	53.43
LP	2+24.92	348-06-23	70.42	317-23 29	72.80
	2+00	343-24-17	97.59	320-37-44	94.07
PC	1+75.92	338-51-44	123.22	320-55 42	115.11

Reference(s) None used. Any surveying textbook.

User Instructions

EDM CURVE STAKE-OUT OS #1
Interval | Curve L | Curve R | PC-OS R-Δ |

EDM CURVE STAKE-OUT OS #2
Compute | | | |

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter Card 1 program				
2	Input interval	INT	A		
3	Choose curve left		B		
3	Or curve right		C		
4	Data for curve (Note 1)		D		
5	Input PC station	STA	R/S		
5	Or if PT STA	STA	CHS	R/S	
6	Input offset from center line	OFF	R/S		
7	Input curve center line radius	R	R/S		
8	Input curve delta	DD.MMSS	R/S		PT STA
9	Enter Card 2 program				
10	Compute		A		1ST STA
11	Accept STA shown		R/S		ANG OUT
11	Or input special Sta	STA	R/S		ANG OUT
12			R/S		DIST OUT
13			R/S		ANG IN
14			R/S		DIST IN
15			R/S		NEXT STA
16	Return to step 11 until PT is reached.				
	NOTE 1: Not necessary to push D key if coming from				
	steps 2 or 3.				
	NOTE 2: If from PT to PC, all stations are of				
	opposite sign.				
	NOTE 3: To restart calc., go to step 10 or go to step				
	4 for next curve with same interval, to step 2 to				
	change interval, or to step 3 to change direction				
	with Card 1 entered. If curve data entered at steps				
	5,6,7 and 8 is OK, then go to step 10 to compute,				
	with Card 2 entered.				
	NOTE 4: Don't distrube stack between any of these				
	steps. If stack is distrubed it is most convient to				
	restart computations at step 10. Keep your finger				
	on the R/S key!				

Program Form

CARD 1

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RTN	24	Kill E key
LBL	23	Input interval
A	11	
STO 8	3308	
GTO	22	
D	14	
LBL	23	
B	12	
f	31	
SF 1	51	
GTO	22	
D	14	
LBL	23	
C	13	
f-1	32	
SF 1	51	
LBL	23	
D	14	
DSP	21	
.	83	
2	02	
RTN	24	Input PC STA
STO 1	3301	
R/S	84	Input offset
2	02	
gx⇄y	3507	
x	71	
f	31	
TF 1	61	
CHS	42	
gnop	3501	
STO 2	3302	
gLSTx	3500	
R/S	84	Input CL radius
STO 3	3303	
R/S	84	Input delta angle
f-1	32	
→D.MS	03	
1	01	
8	08	
0	00	
g	35	
π	02	
÷	81	
RCL 3	3403	
÷	81	
STO 4	3304	
÷	81	= Arc length
RCL 1	3401	
+	61	

KEY ENTRY	CODE SHOWN	COMMENTS
STO 5	3305	
RCL 3	3403	
RCL 3	3403	
+	61	
RCL 2	3402	
g	35	
ABS	06	
-	51	
↑	41	
↑	41	
gLSTx	3500	
gLSTx	3500	
+	61	
+	61	
STO 6	3306	
÷	81	
STO 7	3307	
RCL 5	3405	
R/S	84	See PT STA
0	00	
÷	81	flash 0 if R/S is pushed

REGISTERS

- R_1 PC STA
- R_2 2x OFF. =easting inside
- R_3 CL R
- R_4 Deg. of curve per foot
- R_5 PT STA
- R_6 2R out
- R_7 chord constant out to in
- R_8 interval
- R_9 used trig. & tests

LABELS

- A interval
- B used
- C used
- D used
- E killed
- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1 used
- 2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Form

CARD 2

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
RCL 1	3401	
LBL	23	
0	00	
RCL 8	3408	
÷	81	
f	31	
INT	83	
gLSTx	3500	
gx⇄y	3507	
gx≤y	3522	
1	01	
+	61	
RCL 8	3408	
x	71	
RCL 5	3405	
gx>y	3524	
g↓	3508	
gnop	3501	
LBL	23	
1	01	
R/S	84	Inp. or accept STA
RCL 5	3405	
gx⇄y	3507	
gx>y	3524	
GTO	22	
1	01	
↑	41	
↑	41	
RCL 1	3401	
-	51	
RCL 4	3404	
x	71	
2	02	
÷	81	
f	31	
SIN	04	
gLSTx	3500	
f	31	
TF 1	61	
CHS	42	
gnop	3501	
gx⇄y	3507	
RCL 6	3406	
x	71	
B	12	
R/S	84	See angle out
C	13	
R/S	84	See distance out

KEY ENTRY	CODE SHOWN	COMMENTS
gx⇄y	3507	
CLX	44	
gLSTx	3500	
gx⇄y	3507	
RCL 7	3407	
x	71	
f-1	32	
R→P	01	
gx⇄y	3507	
RCL 2	3402	
+	61	
gx⇄y	3507	
f	31	
R→P	01	
B	12	
R/S	84	See angle in
C	13	
R/S	84	See distance in
g↑	3509	
GTO	22	
0	00	
LBL	23	
B	12	
gx⇄y	3507	
0	00	
gx⇄y	3507	
gx>y	3524	
GTO	22	
2	02	
gx⇄y	3507	
CLX	44	
3	03	
6	06	
0	00	
LBL	23	
2	02	
+	61	
f	31	
→D.MS	03	
DSP	21	
.	83	
4	04	
RTN	24	
LBL	23	
C	13	
gx⇄y	3507	
DSP	21	
.	83	
2	02	
RTN	24	

REGISTERS	
R_1	PC STA
R_2	2 x OFF = easting inside
R_3	CL R
R_4	Deg. of curve per foot
R_5	PT STA
R_6	2R OUT
R_7	chord constant out to in
R_8	interval
R_9	used trig. & tests

LABELS	
A	compute
B	used
C	used
D	
E	
0	used
1	used
2	used
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	used
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.


-MORI-

Program Description I

Program Title CURVE STAKEOUT

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes deflection angles and chords for curves for both sides of a street for curb offset staking, given a staking interval, PC stationing, offset from CL, CL radius, and the delta angle of the curve. Program computes the station of the PT first for data entry and plan dimension verification. The program computes the stationing based on the given interval, which station may be accepted or overridden with a special station.

2Ri = (Rcl-offset)2

2Ro = (Rcl+offset)2

out chord = 2RoSin(last angle)

in chord = $\frac{2Ri}{2Ro}$ x out chord

where n = integer

Next station=(n of $\left[\frac{\text{LAST STA}}{\text{Interval}}\right]$ + 1) interval

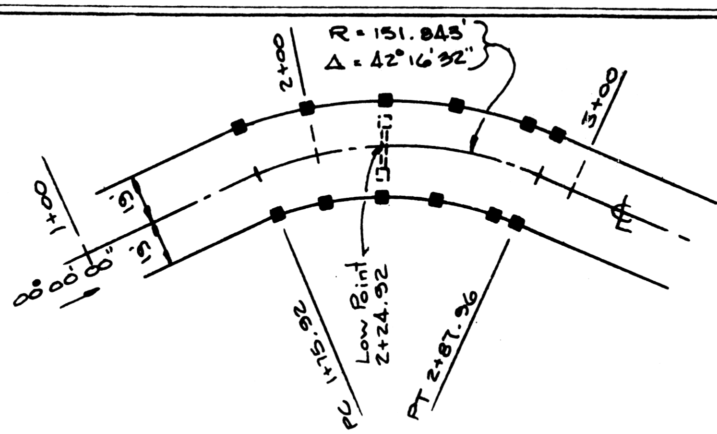
defl. angle = (STA-PC STA) x $\frac{90}{\pi R}$

Deflection angles are right if curve is arcing right(radius point is to the right) or left if curve is arcing left.

Negative stations may be entered and/or displayed, if less than zero.

Operating Limits and Warnings Program will not compute beyond the PT of the curve, except when a special station is entered which is larger that the PT station, then funny things happen, although still mathematically correct. If interval is fractional: round and truncate to 7 significant digits or less. Offset may be 0 to compute CL chords(twice).

Program Description II



Proposed 30' pavement back to back of curbs. Offsets 4' back of curb.

Sample Problem(s) Compute deflection angles and chords to stake the points in the above sketch for each 25 foot stationing, including low point and skip station 2+25.

STEPS: 25A, 175.92R/S, 19R/S, 151.843R/S, 42.1632R/S, (see PT stationing), C, R/S, R/S, R/S, R/S, 224.92R/S, R/S, R/S, R/S,250R/S, R/S, R/S, etc.

Forget to write down an answer? Recompute; start by pushing C, or change interval with A key and recompute with C.

Solution(s)

	STA	DEFLECTION	CHORD out	CHORD in
PC	1+75.92	0° toward PI of curve		
	2+00.	4-32-35	27.06	21.04
LP	2+24.92	9-14-41	28.01	21.78
	2+50	13-58-35	28.19	21.92
	2+75	18-41-35	28.10	21.85
PT	2+87.96	21-08-16	14.57	11.33

Reference(s) None used. Any surveying textbook.

User Instructions

CURVE STAKEOUT #7

Interval	PC-OFF R-Δ	Compute		

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	(Optional) See flag, push D or E or		RTN	R/S	7.00
3	Input interval	INT	A		
4	Data for curve		B		
5	Input PC station	STA	R/S		
6	Input offset from center line	OFF	R/S		
7	Input curve CL radius	R	R/S		
8	Input curve delta	DD.MMSS	R/S		PT. STA.
9	Compute		C		1st. STA
10	Accept STA shown		R/S		DEF ANG
10	Or input special STA	STA	R/S		DEF ANG
11			R/S		CHORD OUT
12			R/S		CHORD IN
13			R/S		NEXT STA
14	Return to step 10 until PT is reached.				
	NOTE 1: Step 4 is optional if coming from step 3				
	NOTE 2: To restart calc: go to step 9, or to step 4				
	for next curve with same interval or step 3 to change				
	interval. If curve data entered at steps 5, 6, 7 & 8				
	OK, then go to step 9 to compute.				
	NOTE 3: Negative stations may be used.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
7	07	
R/S	84	See flag
LBL	23	Inp. interval
A	11	
STO 8	3308	
LBL	23	
B	12	
RTN	24	Inp. PC STA
STO 1	3301	
R/S	84	Inp. Offset
STO 2	3302	
R/S	84	Inp. CL R
STO 3	3303	
R/S	84	Inp. delta
f-1	32	
→D.MS	03	
9	09	
0	00	
g	35	
π	02	
÷	81	
RCL 3	3403	
÷	81	
STO 4	3304	
÷	81	
2	02	
÷	81	
RCL 3	3403	
RCL 2	3402	
-	51	
2	02	
x	71	
RCL 3	3403	
RCL 2	3402	
+	61	
2	02	
x	71	
STO6	3306	
÷	81	
STO 7	3307	
g ↓	3508	
RCL 1	3401	
+	61	
STO 5	3305	
R/S	84	See PT stationing
LBL	23	
C	13	
0	00	
STO 3	3303	
RCL 1	3401	

KEY ENTRY	CODE SHOWN	COMMENTS
STO 2	3302	
LBL	23	
0	00	
RCL 2	3402	
RCL 8	3408	
÷	81	
f	31	
INT	83	
1	01	
+	61	
RCL 8	3408	
x	71	Next even station
RCL 5	3405	
gx> y	3524	
g ↓	3508	
gnop	3501	
R/S	84	Inp sta. or use sta. shown
RCL 3	3403	
RCL 4	3404	
RCL 2	3402	
g ↑	3509	
STO 2	3302	
gx⇄y	3507	
-	51	
x	71	
+	61	
STO 3	3303	
gLSTx	3500	
gx⇄y	3507	
f	31	
→D.MS	03	
DSP	21	
.	83	
4	04	
R/S	84	See DEF angle
DSP	21	
.	83	
2	02	
gx⇄y	3507	
f	31	
SIN	04	
RCL 6	3406	
x	71	
R/S	84	See chord out
RCL 7	3407	
x	71	
R/S	84	See chord in
GTO	22	
0	00	

REGISTERS	
R_1	PC STA
R_2	1 offset, 2 last Sta.
R_3	0, last Δ/2
R_4	degree of curve per ft.
R_5	PT STA
R_6	2R OUT
R_7	chord constant
R_8	inter val
R_9	used trig. & tests
LABELS	
A	interval
B	used
C	compute
D	
E	
0	used
1	
2	
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM

Program Description I

Program Title CURVE-STAKE FROM PI

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes the radial angles and distances from the PI of a curve, given a staking interval, PC stationing, radius, and delta angle. The program computes the station of the PT first for data entry and plan dimension verification. The program computes the stationing based on the given interval, which station may be accepted or overridden with a special station.

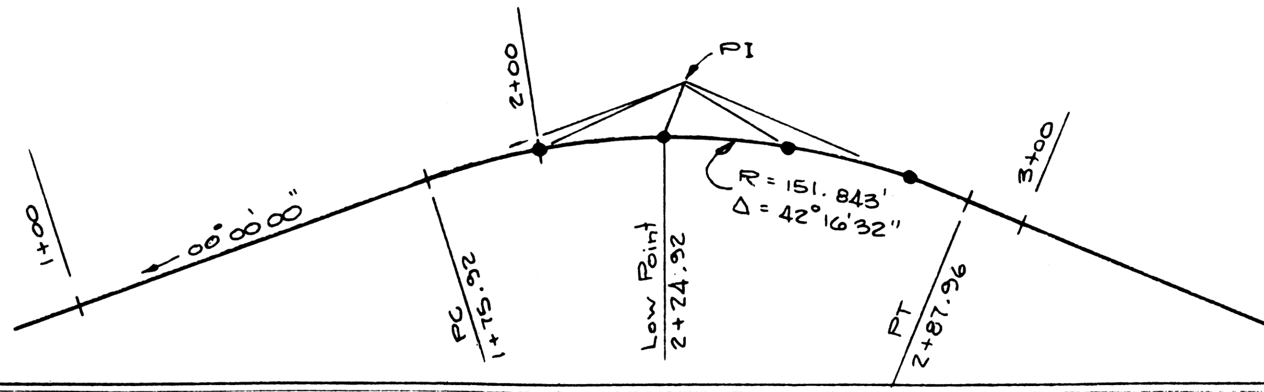
$$\text{Next station} = \left(n \text{ of} \left[\frac{\text{Last Sta}}{\text{Interval}} \right] + 1 \right) \text{Interval} , \quad \text{where } n = \text{integer}$$

$$\text{(Station to PC) angle} = (\text{Sta.} - \text{PC Sta.}) \times \frac{180}{\pi R}$$

Otherwise standard traverse and inverse routines are used.

Operating Limits and Warnings Program will not compute beyond the subject curve. If interval is fractional: round and truncate to 7 significant digits or less. Zero degrees is toward the PC if stationing is normal and toward the PT if stationing has opposite sign. Angles are to left or right, depending on direction of curve.

Program Description II



Sample Problem(s) Compute the angles and distances to the points on the curve in the above sketch for each 25 foot interval, including the low point and excluding station 2+25.

STEPS: 25A, 175.92R/S, 151.843R/S, 42.1632R/S, (See PT stationing),
R/S, R/S, R/S, R/S, 224.92R/S, R/S, R/S, 250R/S, R/S, etc.

You may now recompute by pushing C key or change interval with A key then recompute with C key.

Solution(s)

	STATION	ANGLE	DISTANCE
PC	1+75.92	0° to PC of curve	
	2+00	3-08-26	34.78
LP	2+24.92	36-36-11	13.14
	2+50	125-08-29	21.66
	2+75	137-01-58	45.77
PT	2+87.96	137-43-28	58.71 = tangent length of curve

Reference(s) None used.

User Instructions

CURVE STAKE FROM PI

Interval	PC Sta R-Δ	Compute		

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input interval	INT	A		
3	Data for curve		B		
4	Input PC station	STA	R/S		
5	Input curve radius	R	R/S		
6	Input curve delta	DD.MMSS	R/S		PT STA
7	Compute		C		1st STA
8	Accept STA shown		R/S		ANGLE
8	Or input special STA	STA	R/S		ANGLE
9			R/S		DISTANCE
10			R/S		NEXT STA
11	Repeat steps 8, 9 and 10 until PT is reached.				
	NOTE 1: Steps 3 and 7 are optional if coming from preceeding step.				
	NOTE 2: To restart calc., go to step 7, or go to step 3 for next curve with same interval, or to step 2 to change interval.				
	NOTE 3: OK to skip steps 3, 4, 5 and 6, when changing interval and curve data has been entered correctly.				
	NOTE 4: Negative stations may be used.				
	NOTE 5: Normal calculation is with 0° to PC. For 0° to PT, use opposite signs on all stationing.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RTN	24	Kill D & E keys
LBL	23	
A	11	Input interval
STO 8	3308	
LBL	23	
B	12	
RTN	24	Input PC STA
STO 1	3301	
R/S	84	Input CL radius
STO 3	3303	
R/S	84	Input delta angle
f-1	32	
→D.MS	03	
1	01	
8	08	
0	00	
g	35	
π	02	
RCL 3	3403	
x	71	
÷	81	
STO 4	3304	
÷	81	
RCL 1	3401	
+	61	
STO 5	3305	
g ↑	3509	
2	02	
÷	81	
f	31	
TAN	06	
RCL 3	3403	
x	71	
STO 7	3307	
RCL 5	3405	
R/S	84	See PT STA
LBL	23	
C	13	
RCL 1	3401	
STO 2	3302	
LBL	23	
0	00	Begin loop
RCL 2	3402	
RCL 8	3408	
÷	81	
↑	41	
f	31	
INT	83	
gx ≤ y	3522	
1	01	

KEY ENTRY	CODE SHOWN	COMMENTS
+	61	
RCL 8	3408	
x	71	
RCL 5	3405	
gx > y	3524	
g ↓	3508	
gnop	3501	
LBL	23	
1	01	
R/S	84	See new STA
STO 2	3302	
RCL 5	3405	
gx ⇄ y	3507	
gx > y	3524	
GTO	22	
1	01	
RCL 1	3401	
gx > y	3524	
g ↓	3508	
GTO	22	
1	01	
g ↓	3508	
−	51	= arc length
RCL 4	3404	
x	71	
RCL 3	3403	
CHS	42	
f-1	32	
R → P	01	
RCL 3	3403	
+	61	
gx ⇄ y	3507	
RCL 7	3407	
+	61	
f	31	
R → P	01	
gx ⇄ y	3507	
f	31	
→D.MS	03	
DSP	21	
.	83	
4	04	
R/S	84	See angle
gx ⇄ y	3507	
DSP	21	
.	83	
2	02	
R/S	84	See distance
GTO	22	
0	00	

REGISTERS	
R_1	PC Sta
R_2	Last Sta
R_3	CL radius
R_4	degree of curve per foot
R_5	PT STA
R_6	
R_7	tangent
R_8	interval
R_9	used trig. & tests

LABELS	
A	interval
B	data
C	compute
D	killed
E	killed
0	used
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title TANGENT OFFSET

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes the distance along the tangent from the end of the curve and the right angle offset to points on a curve, given a staking interval, PC/PT stationing, radius, and delta angle. The program computes the station of the PT/PC first for data entry and plan dimension verification. The program computes the stationing based on the given interval, which station may be accepted or overridden with a special station.

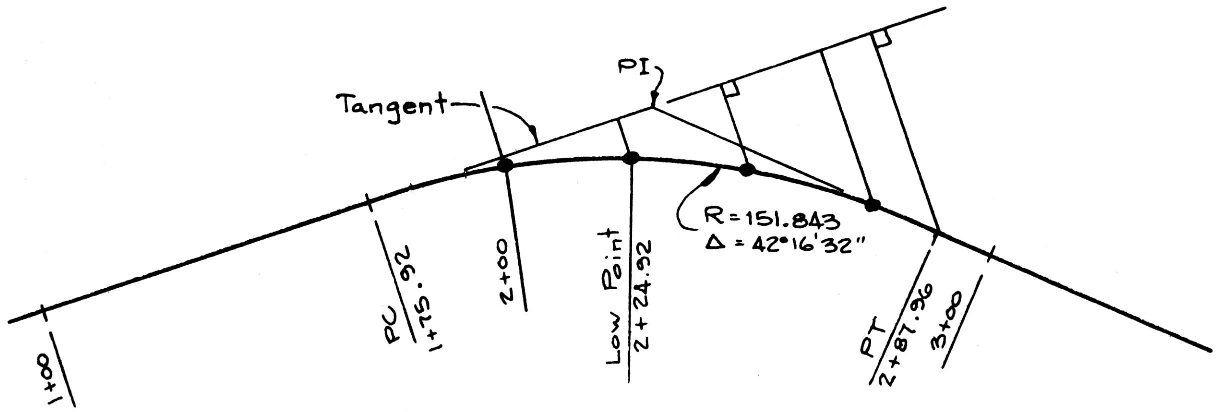
$$\text{Next station} = \left(n \text{ of} \left[\frac{\text{Last Sta}}{\text{Interval}} \right] + 1 \right) \text{Interval}, \quad \text{where } n = \text{integer}$$

$$\text{(Station to PC) angle} = (\text{Sta.} - \text{PC Sta.}) \times \frac{180}{\pi R}$$

Otherwise standard traverse and inverse routines are used.

Operating Limits and Warnings Program will not compute beyond the subject curve. If interval is fractional: round and truncate to 7 significant digits or less. The distances are measured along the tangent and its extension, from the PC if stationing has normal sign and from the PT if stationing has opposite sign.

Program Description II



Sample Problem(s) Compute the distances and offsets to the points on the curve in the above sketch for each 25 foot interval including the low point and skipping station 2+25.

STEPS: 25A, 175.92R/S, 151.843R/S, 42.1632R/S, (See PT stationing),
R/S, R/S, R/S, R/S, 224.92R/S, R/S, R/S, 250R/S, R/S, etc.

Solution(s)

	STATION	TANGENT DISTANCE	OFFSET
PC	1+75.92	0+00	0.00
	2+00	0+23.98	1.91
LP	2+24.92	0+48.15	7.84
	2+50	0+71.18	17.72
	2+75	0+92.20	31.19
PT	2+87.96	1+02.14	39.49

Reference(s) None used.

User Instructions

TANGENT OFFSET

Interval	PC sta. R-Δ	Compute		

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input interval	INT	A		
3	Data for curve		B		
4	Input PC station	STA	R/S		
5	Input curve radius	R	R/S		
6	Input curve delta	DD.MMSS	R/S		PT STA
7	Compute		C		1st STA
8	Accept STA shown		R/S		distance from PC
8	Or input special STA	STA	R/S		distance from PC
9			R/S		tangent offset
10			R/S		Next Sta.
11	Repeat steps 8, 9 and 10 until PT is reached.				
	NOTE 1: Steps 3 and 7 are optional if coming from preceeding step.				
	NOTE 2: To restart calc., go to step 7, or to step 3 for next curve with same interval or to step 2 to change interval.				
	NOTE 3: OK to skip steps 3, 4, 5 and 6 when changing interval and curve data has been entered correctly.				
	NOTE 4: Negative stations may be used.				
	NOTE 5: Normal calculation is from PC. If from PT, use opposite signs on all stationing.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RTN	24	Kill D & E keys
LBL	23	
A	11	Input interval
STO 8	3308	
LBL	23	
B	12	
DSP	21	
.	83	
2	02	
RTN	24	Input PC STA
STO 1	3301	
R/S	84	Input CL R
STO 3	3303	
R/S	84	Input delta angle
f-1	32	
→D.MS	03	
1	01	
8	08	
0	00	
g	35	
π	02	
÷	81	
RCL 3	3403	
÷	81	
STO 4	3304	
÷	81	
RCL 1	3401	
+	61	
STO 5	3305	
R/S	84	See PT STA
LBL	23	
C	13	Compute
RCL 1	3401	
STO 2	3302	
LBL	23	
0	00	Begin loop
RCL 2	3402	
RCL 8	3408	
÷	81	
↑	41	
f	31	
INT	83	
gx≤y	3522	
1	01	
+	61	
RCL 8	3408	
x	71	
RCL 5	3405	
gx>y	3524	
g↓	3508	

KEY ENTRY	CODE SHOWN	COMMENTS
gnop	3501	
LBL	23	
1	01	
R/S	84	See new sta
RCL 5	3405	
gx⇄y	3507	
gx>y	3524	
GTO	22	
1	01	
RCL 1	3401	
gx>y	3524	
g↓	3508	
GTO	22	
1	01	
g↓	3508	
gx⇄y	3507	
STO 2	3302	
-	51	
CHS	42	
RCL 4	3404	
x	71	
RCL 3	3403	
f-1	32	
R→P	01	
STO 6	3306	
gx⇄y	3507	
R/S	84	See dist. from PC
RCL 3	3403	
RCL 6	3406	
-	51	
R/S	84	See offset
GTO	22	
0	00	

REGISTERS	
R_1	PC STA
R_2	Last STA
R_3	CL radius
R_4	degree of curve per foot
R_5	PT STA
R_6	offset
R_7	
R_8	interval
R_9	used trig. & tests

LABELS	
A	interval
B	data
C	compute
D	killed
E	killed
0	used
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title CHORD OFFSETS

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes the distance along the chord from the end of the curve and right angle offset to points on a curve, given a staking interval, PC/PT stationing, radius, and delta angle. The program computes the station of the PT/PC first for data entry and plan dimension verification. The program computes the stationing based on the given interval, which station may be accepted or overridden with a special station.

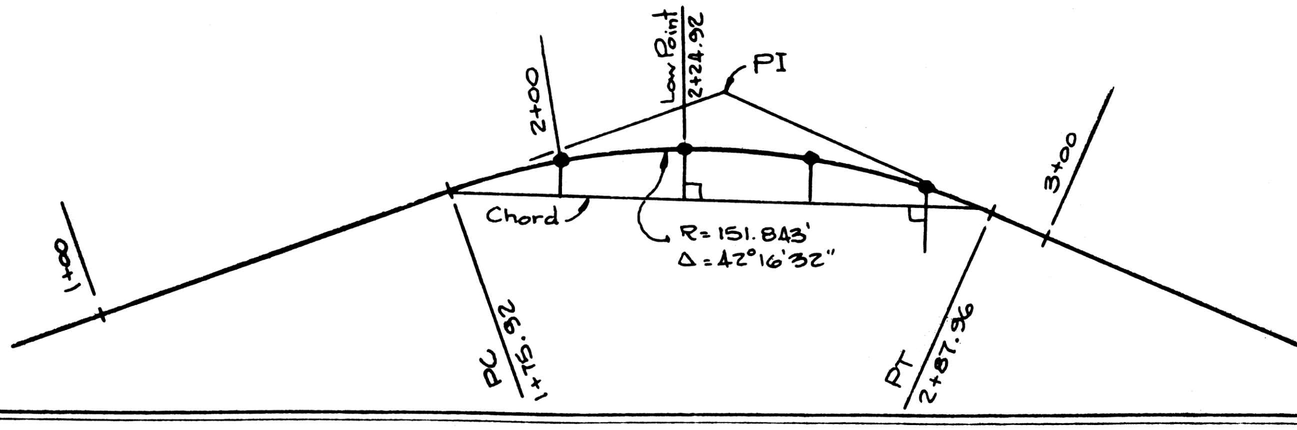
$$\text{Next station} = \left(n \text{ of} \left[\frac{\text{Last Sta}}{\text{Interval}} \right] + 1 \right) \text{Interval}, \quad \text{where } n = \text{integer}$$

$$(\text{Station to PC}) \text{ angle} = (\text{Sta.} - \text{PC Sta.}) \times \frac{180}{\pi R}$$

Otherwise standard traverse and inverse routines are used.

Operating Limits and Warnings Program will not compute beyond the subject curve. If interval is fractional: round and truncate to 7 significant digits or less. The distances are measured along the long chord, from the PC if stationing is normal and from the PT if stationing has opposite sign.

Program Description II



Sample Problem(s) Compute the distances and offsets to the points on the curve in the above sketch for each 25 foot interval including the low point and excluding station 2+25.

STEPS: 25A, 175.92R/S, 151.843R/S, 42.1632R/S, (See PT stationing),
R/S, R/S, R/S, R/S, 224.92R/S, R/S, R/S,250R/S, R/S, etc.

Solution(s)

	STATION	CHORD DISTANCE	OFFSET
PC	1+75.92	0+00	0.00
	2+00	0+23.05	6.87
LP	2+24.92	0+47.74	10.05
	2+50	0+72.78	9.14
	2+75	0+97.24	4.15
PT	2+87.96	1+09.51	0.00

Reference(s) None used.

User Instructions

CHORD OFFSETS

Interval	PC Sta. R-Δ	Compute		

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input interval	INT	A		
3	Data for curve		B		
4	Input PC station	STA	R/S		
5	Input curve radius	R	R/S		
6	Input curve delta	DD.MMSS	R/S		PT STA
7	Compute		C		1st STA
8	Accept STA shown		R/S		distance PC (from)
8	Or input special STA	STA	R/S		distance from PC
9			R/S		chord offset
10			R/S		Next Sta
11	Repeat steps 8, 9 and 10 until PT is reached.				

NOTE 1: Steps 3 and 7 are optional if coming from preceeding step.

NOTE 2: To restart calc., go to step 7, or to step 3 for next curve with same interval, or to step 2 to change interval.

NOTE 3: OK to skip steps 3, 4, 5 and 6, when changing interval and curve data has been entered correctly.

NOTE 4: Negative stations may be used.

NOTE 5: Normal calculation is from PC. If from PT, use opposite signs on all stationing.

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
RTN	24	Kill D & E keys
LBL	23	
A	11	Input interval
STO 8	3308	
LBL	23	
B	12	Input PC Sta
DSP	21	
.	83	
2	02	
RTN	24	
STO 1	3301	
R/S	84	Input CL R
STO 3	3303	
R/S	84	Input delta angle
f-1	32	
←D.MS	03	
2	02	
÷	81	
STO 7	3307	
9	09	
0	00	
g	35	
π	02	
÷	81	
RCL 3	3403	
÷	81	
STO 4	3304	
÷	81	
RCL 1	3401	
+	61	
STO 5	3305	
R/S	84	See PT Sta
LBL	23	
C	13	
RCL 1	3401	
STO 2	3302	
LBL	23	
0	00	Begin loop
RCL 2	3402	
RCL 8	3408	
÷	81	
↑	41	
f	31	
INT	83	
gx≤y	3522	
1	01	
+	61	
RCL 8	3408	
x	71	
RCL 5	3405	

KEY ENTRY	CODE SHOWN	COMMENTS
gx>y	3524	
g ↓	3508	
g nop	3501	
LBL	23	
1	01	
R/S	84	See new sta.
RCL 5	3405	
gx⇄y	3507	
gx>y	3524	
GTO	22	
1	01	
RCL 1	3401	
gx>y	3524	
g ↓	3508	
GTO	22	
1	01	
g ↓	3508	
gx⇄y	3507	
STO 2	3302	
-	51	
CHS	42	
RCL 4	3404	
x	71	
RCL 7	3407	
gx⇄y	3507	
-	51	
gLSTx	3500	
f	31	
SIN	04	
RCL 3	3403	
2	02	
x	71	
x	71	
f-1	32	
R→P	01	
gx⇄y	3507	
STO 6	3306	
g ↓	3508	
R/S	84	See dist. from PC
RCL 6	3406	
R/S	84	See offset
GTO	22	
0	00	

REGISTERS

- R_1 PC STA
- R_2 Last Sta
- R_3 CL radius
- R_4 degree of curve per 1/2 ft.
- R_5 PT STA
- R_6 offset
- R_7 1/2 delta
- R_8 interval
- R_9 used trig. & tests

LABELS

- A interval
- B data
- C compute
- D killed
- E killed
- 0 used
- 1 used
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

FLAGS

- 1
- 2

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title STADIA REDUCTION

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes difference in rod readings, horizontal distance, and elevation given instrument height, bottom, top, and middle hair rod readings and vertical angle. Also computes horizontal distance and elevation given instrument height, stadia distance, middle hair rod reading and vertical angle.

SD = TH-BH (100)

HD = $(\cos VA)^2 \times SD$

EL = HI- MH + SinVA x CosVA x SD

See page 3 for connotations.

Operating Limits and Warnings Program under B key uses TH-BH to determine horizontal distance and MH to determine elevation.

Horizontal distance is displayed to two decimal places. For all practical purposes it should be rounded to nearest foot (.1 meter?).

Negative HI and elevation is below sea level.

Program Description II

Sample Problem(s) Compute the following:

POINT	HI / BH	SD / TH	MEAS UP / MH	VA	ELEV,
⊼@ A	1000.00HI		4.91MU		995.09
1	4.02	6.00	5.00	-2°09'	
2	1.24	4.31	2.77	0	
B	6.78	9.32	8.04	3°19'	(1006.63)

Instrument at B sight_____

	1011.67HI		5.04MU	
3		219	4.03	-3°16'
4		124	6.78	0
5		178	12.17	4°14'

STEPS: 995.09 Enter, 4.91+, A, B4.02R/S 6R/S, 5R/S, 2.09 CHS, R/S, R/S,1.24 R/S, 4.31R/S, 2.77 R/S, R/S, R/S,6.78 R/S, 9.32R/S,8.04 R/S, 3.19R/S, R/S, 5.04+A, C, 219R/S, 4.03R/S, 3.16CHS R/S, R/S, 124R/S, 6.78R/S, R/S, R/S, 178R/S, 12.17R/S, 4.14R/S, R/S,

Solution(s)

	DIFF.	HD	ELEVATION
1	0.02	197.72	987.58
2	0.01	307.00	997.23
B	0.02	253.15	1006.63
3		218.29	995.18
4		124.00	1004.89
5		177.03	1012.60

Reference(s) Any surveying textbook.

User Instructions

STADIA REDUCTION

HI | B-T-M | SD-M

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Optional (See flag)		RTN	R/S	15
3	Input beginning HI	HI	A		
4	Choose BH-TH-MH type		B		
5	Input BH	BH	R/S		
6	Input TH	TH	R/S		
7	Input MH	MH	R/S		DIFF
8	If VA= 0 degrees (If stack is undistrubed)		R/S		HD
8	If VA is downward	VA	CHS	R/S	HD
8	If VA is upward	VA	R/S		HD
9			R/S		EL
10	Go to step 5(input BH) for next "shot" of this type				
4	Or choose SD-MH type		C		
5	Input SD	SD	R/S		
6	Input MH	MH	R/S		
7	If VA=0° (If stack is undisturbed)		R/S		HD
7	If VA is downward	VA	CHS	R/S	HD
7	If VA is upward	VA	R/S		HD
8			R/S		EL
9	Go to step 5(input SD) for next "shot" of this type				
	BH = Bottom Hair Reading				
	TH = Top Hair Reading				
	MH = Middle Hair Reading				
	VA = Vertical Angle (0° is 90° from zenith)				
	SD = Stadia Distance				
	HD = Horizontal Distance				
	EL = Elevation				
	DIFF. = (TH-MH)-(MH-BH) absolute value				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
DSP	21	
•	83	
0	00	
1	01	
5	05	flag
R/S	84	
LBL	23	Inpute HI
A	11	
DSP	21	
•	83	
2	02	
STO 1	3301	
RTN	24	
LBL	23	
B	12	
R/S	84	Inpute BH(See EL)
STO 2	3302	
R/S	84	Inpute TH
STO 3	3303	
R/S	84	Inpute MH
STO 4	3304	
RCL 2	3402	
-	51	
RCL 3	3403	
RCL 4	3404	
-	51	
-	51	
g	35	
ABS	06	
↑	41	
g↓	3508	
R/S	84	See diff.(inp. VA)
E	15	
RCL 3	3403	
RCL 2	3402	
-	51	
EEX	43	
2	02	
x	71	
STO 6	3306	
x	71	
R/S	84	See HD
D	14	
GTO	22	
B	12	
LBL	23	
C	13	
R/S	84	Inpute SD
STO 6	3306	
R/S	84	Inpute MH

KEY ENTRY	CODE SHOWN	COMMENTS
↑	41	
g↓	3508	
STO 4	3304	
R/S	84	Inpute VA
E	15	
RCL 6	3406	
x	71	
R/S	84	See HD
D	14	
GTO	22	
C	13	
LBL	23	
D	14	
g↓	3508	
RCL 5	3405	
x	71	
RCL 6	3406	
x	71	
RCL 4	3404	
+	61	
RCL 1	3401	
gx⇄y	3507	
-	51	
RTN	24	
LBL	23	
E	15	
g↑	3509	
gx=y	3523	
0	00	
↑	41	
g↓	3508	
0	00	
gx=y	3523	
GTO	22	
1	01	
g↓	3508	
f-1	32	
→D.MS	03	
CHS	42	
1	01	
f-1	32	
R→P	01	
STO 5	3305	
f-1	32	
$\sqrt{x}$	09	
RTN	24	
LBL	23	
1	01	
1	01	
RTN	24	

REGISTERS

R_1	HI
R_2	BH
R_3	TH
R_4	MH
R_5	Cos VA
R_6	SD
R_7	
R_8	used
R_9	used trig. & tests

LABELS

A	HI
B	B-T-M
C	SD-M
D	used
E	used
0	used
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS

1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title GEODIMETER ATMOSPHERIC CORRECTIONS

Contributor's Name Charles C. Campbell, LS
Address 9841 East 21st Street
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Given: ^{o}F and In. Hg.

The program computes the correction in ppm. to be applied to the measured slope distance from Model 76 or Model 700 Geodimeter.

For Model 76:

$$\text{Correction in ppm} = 281 - \frac{2741.295 \times \text{Pressure(in. Hg.)}}{\text{Temp. } (^{o}\text{K})}$$

For Model 700:

$$\text{Correction in ppm} = 308.6 - \frac{2741.295 \times \text{Pressure (in. Hg.)}}{\text{Temp. } (^{o}\text{K})}$$

where $^{o}K = 5/9\ (^{o}F-32) + 273.15$

K = Kelvin

F = Fahrenheit

Operating Limits and Warnings None

Program Description II

Sample Problem(s)

1. Find correction for Model 76 if pressure = 29.25 and temperature = 84°

2. Find correction for Model 700 if pressure = 29.15 and temperature = 72°

Solution(s)

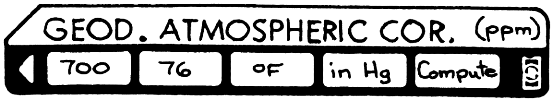
1. 15.5

2. 38.1

Reference(s)

Geodimeter operating manuals and training lecture notes.

User Instructions



STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Choose Model 700		A		700
	Or Model 76		B		76
3	Input temperature	°F	C		
4	Input pressure	In. Hg.	D		
5	Compute correction factor (ppm)		E		ppm
	Go to step 3 or 4 for next problem				
	NOTE: Temperature or pressure may be changed without reentering the other.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
A	11	
3	03	
0	00	
8	08	
.	83	
6	06	
STO 3	3303	
1	01	
STO 8	3308	
C	13	
7	07	
0	00	
0	00	
RTN	24	
LBL	23	
B	12	
2	02	
8	08	
1	01	
STO 3	3303	
1	01	
STO 8	3308	
C	13	
7	07	
6	06	
RTN	24	
LBL	23	
C	13	
g	35	
DSZ	83	
GTO	22	
9	09	
DSP	21	
.	83	
0	00	
2	02	
7	07	
4	04	
1	01	
.	83	
2	02	
9	09	
5	05	
STO 4	3304	
2	02	
7	07	
3	03	
.	83	
1	01	

KEY ENTRY	CODE SHOWN	COMMENTS
5	05	
STO 5	3305	
RTN	24	
LBL	23	
9	09	
DSP	21	
.	83	
1	01	
STO 1	3301	
RTN	24	
LBL	23	
D	14	
DSP	21	
.	83	
2	02	
STO 2	3302	
RTN	24	
LBL	23	
E	15	
RCL 3	3403	
RCL 4	3404	
RCL 2	3402	
×	71	
RCL 1	3401	
3	03	
2	02	
−	51	
5	05	
×	71	
9	09	
÷	81	
RCL 5	3405	
+	61	
÷	81	
−	51	
DSP	21	
.	83	
1	01	
RTN	24	

REGISTERS	
R_1	°F
R_2	in.Hg.
R_3	used
R_4	used
R_5	used
R_6	
R_7	
R_8	used
R_9	

LABELS	
A	700
B	76
C	°F
D	in. Hg.
E	compute
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	used

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title GEODIMETER MD. 700 REDUCTIONS

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Given atmos. correction in ppm, F2, F3, and zenith angle, computes horizontal distance and vertical distance from plane through horizontal axis of 700, to reflector. Also computes reflector elevation, corrected for curvature and refraction, given HI.

Slope distance = $S = (1 + A \times 10^{-6})\ (na + F2)$
Horizontal Distance = $HD = S \sin Z$
Vertical Distance = $V = S \cos Z$
Reflector Elevation = $HI + V + (c{+}r)$

Where: A = Atmospheric correction in ppm
n = Integer $F3 - F2(1000)/a$ Note: when $F3 \leq F2$ add 16.404 to F3
a = 500 meters in feet = 1640.41667
F2 = Frequency 2
F3 = Frequency 3
HI = Instrument Height
Z = Zenith Angle
$c{+}r = 2.059 \times 10^{-8}\ HD^2$ = standard correction for curvature and refraction

Operating Limits and Warnings Elevation determined by trigonometric leveling on lines over 1000 feet in length should be considered approximate, due to uncertainty caused by refraction. Reciprocal zenith angles at both ends of the line would improve accuracy.

Program Description II

Sample Problem(s)

No. 1 Given:

HI=1000.00
A = 21
F2 = 477.858
F3 = 481.594
Z = 91°45'23"

No. 2 Given:

HI = 1000.00
A = 17
F2 = 1390.364
F3 = 1386.879
Z = 89°06'12"

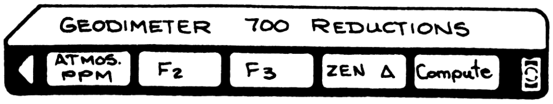
Solution(s)

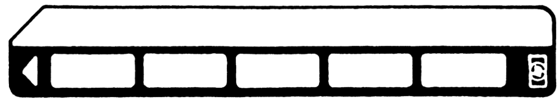
	No. 1	No. 2
Horizontal Distance	= 3757.004	12871.923
Vertical Distance	= -115.206	201.459
Reflector Elevation	= 885.084	1204.871

Reference(s)

Geodimeter Model 700 Operating Manual.
Bouchard, Harry and Moffitt, Francis H., SURVEYING, fifth edition, pages 32, 33, 34, International Textbook Company, Scranton, Pennsylvania, 1965.

User Instructions





STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	(Optional)		RTN R/S	700
3	(Optional) Input HI	HI	R/S	
4	Input atmospheric correction (ppm)	A	A	
5	Input F2	F2	B	
6	Input F3	F3	C	
7	Input Zenith Angle	Z	D	
8	Compute Horizontal Distance		E	HD
9	Compute Vertical Distance (Optional)		R/S	V
10	Compute Reflector Elevation (Optional)		R/S	ELEV. *
	Return to step 4 or 2 for next reduction.			
	* corrected for curvature and refraction.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
7	07	
0	00	
0	00	
R/S	84	
STO 7	3307	
R/S	84	
LBL	23	
A	11	
STO 8	3308	
EEX	43	
6	06	
÷	81	
1	01	
+	61	
STO 1	3301	
RCL 8	3408	
RTN	24	
LBL	23	
B	12	
STO 2	3302	
DSP	21	
.	83	
3	03	
RTN	24	
LBL	23	
C	13	
STO 3	3303	
3	03	
9	09	
3	03	
7	07	
↑	41	
2	02	
4	04	
0	00	
÷	81	
STO 6	3306	
EEX	43	
2	02	
x	71	
STO 4	3304	
g ↓	3508	
RTN	24	
LBL	23	
D	14	
f-1	32	
→D.MS	03	
STO 5	3305	
gLSTx	3500	
RTN	24	

KEY ENTRY	CODE SHOWN	COMMENTS
LBL	23	
E	15	
RCL 5	3405	
0	00	
RCL 3	3403	
RCL 2	3402	
−	51	
gx≤y	3522	
+	61	
RCL 6	3406	
+	61	
EEX	43	
3	03	
x	71	
RCL 4	3404	a
÷	81	
f	31	
INT	83	n
RCL 4	3404	
x	71	na
RCL 2	3402	
+	61	
RCL 1	3401	
x	71	S
f-1	32	
R→P	01	
gx⇄y	3507	
g	35	
ABS	06	
RTN	24	HD
gx⇄y	3507	
R/S	84	V
gx⇄y	3507	
f-1	32	
√x	09	
2	02	
.	83	
0	00	
5	05	
9	09	
EEX	43	
CHS	42	
8	08	
x	71	
+	61	
RCL 7	3407	
+	61	
R/S	84	Elev.

REGISTERS	
R_1	Atmos. correction factor
R_2	F2
R_3	F3
R_4	500 meters in feet
R_5	Z Zen. ∆
R_6	5 meters in feet
R_7	HI
R_8	used
R_9	
LABELS	
A	A(ppm)
B	F2
C	F3
D	Z
E	compute
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title GEODIMETER (REG.) 76 REDUCTIONS

Contributor's Name Charles C. Campbell, LS

Address 9841 East 21st Street

City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. Computes horiz. distance & vert. distance from plane through horiz. axis of theodolite to reflector given atmospheric corrected slope dist. or uncorrected slope dist. and zenith angle. Temperature and pressure are given with uncorrected slope dist., eliminating the determination of the ppm correction factor and setting the factor in the Geodimeter. Optionally computes elevation of the reflector, corrected for curvature and refraction, given HI elevation. A zero (0) entered for pressure, tells the HP 65 that the slope distance is corrected for atmospheric conditions.

Corrected Slope Dist. $S = (1+A10^{-6})\,M$
Horizontal Distance $D = S \sin Z$
Vertical Distance $V = S \sin Z$
Reflector Elevation $= HI+V+(c+r)$

Where: $A = 281 - \dfrac{2741.295(\text{pressure inches Hg.})}{°K}$ = atmospheric correct. in ppm

$°K = 5/9(F-32) + 273.15$ = degree Kelvin
F = °Fahrenheit
M = uncorrected Measured distance(slope)
Z = Zenith Angle
HI = Instrument Height
$c+r = 2.059 \times 10^{-8}\ D^2$ = standard correction for curv. and refraction

Operating Limits and Warnings

Elevation determined by trigonometric leveling on lines over 1000 feet in length should be considered approximate, due to uncertainty caused by refraction. Reciprocal zenith angles at both ends of the line would improve accuracy.

Program Description II

Sample Problem(s)

No. 1 Given:

HI = 1000.00'
°F = 78
Hg = 30.55
Z = 92° 11' 14"
M = 7289.14'

No. 2 Given:

HI = 1000.00'
Z = 88° 44' 17"
S = 9478.92'

Note: Inter pressure as zero (0).

Solution(s)

	No. 1	No. 2
Horizontal distance	7283.83'	9476.62'
Vertical distance	-278.19'	208.76'
Reflector elevation	722.90'	1210.61'

Reference(s) Geodimeter Model 76 Operating Manual.

Bouchard, Harry and Moffitt, Francis H., SURVEYING, fifth edition, pages 32, 33, 34, International Textbook Company, Scranton, Pennsylvania, 1965.

User Instructions

GEODIMETER 76 REDUCTIONS

°F	in Hg.	ZEN Δ	MEAS	COMPUTE

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1	Enter program			
2	(Optional)		RTN R/S	76
3	(Optional) Input HI	HI	R/S	
4	Input °F (skip if meas. is atmos. corr.)	°F	A	
5	Input in. Hg. (0 if meas. is atmos. corr.)	in. Hg.	B	
6	Input zenith angle (DDD.MMSS)	Z	C	
7	Input measured slope distance	S or M	D	
8	Compute horizontal distance		E	D
9	Compute vertical distance (optional)		R/S	V
10	Compute reflector elevation (optional)		R/S	Elev. *
	Return to step 4, 5, 6, 7, or 2.			
	(Data entered at steps 3, 4, 5, 6, and 7 remains			
	unchanged after computation)			
	* corrected for curvature and refraction.			

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
7	07	
6	06	
R/S	84	flag
STO 5	3305	HI
R/S	84	
LBL	23	
A	11	
STO 8	3308	
3	03	
2	02	
-	51	
5	05	
x	71	
9	09	
÷	81	
2	02	
7	07	
3	03	
.	83	
1	01	
5	05	
+	61	
STO 1	3301	°K
RCL 8	3408	
RTN	24	°K
LBL	23	
B	12	
STO 8	3308	
2	02	
7	07	
4	04	
1	01	
.	83	
2	02	
9	09	
5	05	
x	71	
STO 2	3302	
RCL 8	3408	
RTN	24	in. Hg.
LBL	23	
C	13	
f-1	32	
→D.MS	03	
STO 3	3303	
gLSTx	3500	
RTN	24	
LBL	23	
D	14	
STO 4	3304	

KEY ENTRY	CODE SHOWN	COMMENTS
RTN	24	
LBL	23	
E	15	compute
2	02	
8	08	
1	01	
RCL 2	3402	
1	01	
gx > y	3524	
GTO	22	
0	00	skip atmos. corr.
CL x	44	
RCL 1	3401	°K
÷	81	
-	51	A (ppm)
EEX	43	
6	06	
÷	81	
1	01	
+	61	$1+A10^{-6}$
LBL	23	
0	00	
RCL 4	3404	
x	71	
RCL 3	3403	
gx⇄y	3507	
f-1	32	
R → P	01	
gx⇄y	3507	
g	35	
ABS	06	
RTN	24	D
gx⇄y	3507	
R/S	84	V
gx⇄y	3507	
f-1	32	
√x	09	
2	02	
.	83	
0	00	
5	05	
9	09	
EEX	43	
CHS	42	
8	08	
x	71	
+	61	
RCL 5	3405	
+	61	
R/S	84	elevation

REGISTERS	
R_1	°K
R_2	2741.295 X in. Hg.
R_3	Z
R_4	M or S
R_5	HI
R_6	
R_7	
R_8	used
R_9	

LABELS	
A	°F
B	in Hg.
C	Z
D	M or S
E	compute
0	used
1	
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.

Program Description I

Program Title TIME TRIALS

Contributor's Name Charles C. Campbell, LS
Address 9841 East 21st Street
City Indianapolis **State** Indiana **Zip Code** 46229

Program Description, Equations, Variables, etc. This program computes single lap speed from time in minutes and seconds, and (optional) computes average speed, total elaspe time, and/or number of laps run, from the accumulation of the single lap times entered. The track length is entered as a constant. Additionally the program computes either time, speed, or number of laps, given the other two.

$$S = \frac{LM}{T}$$

Where: S = Speed in MPH (Miles Per Hour)
T = Time in minutes
M = Track length in miles x 60
L = Laps

Note: Time is entered and displayed as MM.SSSS where MM is minutes and SSSS is seconds and decimal parts thereof.

Operating Limits and Warnings

Program Description II

Sample Problem(s) (1). A.J. qualified and won the pole position at the "INDY 500" (2.5 mile track) with lap times of 46.91, 46.72, 46.15, and 47.23 seconds. What was his speed for each lap, average speed after each lap, and his total elaspe time? STEPS:

2.5 A, EE, .4691 B, .4672 B, EC, .4615 B, EC, .4723 B, EB, EC.

(2). Ole Rube was exactly 3/4 through the last lap (3.75 laps completed) and his elaspe time was 2^m 55.31^s, when his engine "blew". He said he would have beated A. J. out of the pole if his xxxxx car would have held together. Would he? assuming he maintained his average speed for the last 1/4 lap. STEPS:

EE, 2.5531 B, 3.75 D, EC.

The within problems are hypothetical, any resemblence to real times, persons or places is purely coincidental.

Solution(s)

(1)

$time^s$	lap speed	average speed
46.91	191.857	191.857
46.72	192.637	192.246
46.15	195.016	193.161
47.23	190.557	192.503

Total time 3^m 07.01^s

(2) Yes, at 192.516 mph. Tough luck, Rube.

Reference(s)

User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Enter program				
2	Input track length in miles (Note 1)	length	A		
	FOR QUALIFICATIONS				
3	Clear		E	E	
4	Input time (MM.SSSS)	T	B		S
5	(Optional) display total elaspe time		E	B	T
6	(Optional) display average speed		E	C	S
7	(Optional) display no. of laps		E	D	L
8	return to step 4 for next lap				
9	or return to step 3 for next qualification.				
	COMPUTE TIME, SPEED, OR NO. LAPS				
10	Clear		E	E	
11	Input two of the following:				
	Time (MM.SSSS) (Note 2)	T	B		disregard
	Speed (MPH)	S	C		S
	No. Laps	L	D		L
12	Compute the unknown:				
	Time (MM.SSSS)		E	B	T
	or Speed (MPH)		E	C	S
	or Laps		E	D	L
	Return to step 10 or step 3				
	Note 1: Track length may be changed at any time.				
	Note 2: Time must be entered first, if known.				

Program Form

SWITCH TO W/PRGM. PRESS [f] [PRGM] TO CLEAR MEMORY.

KEY ENTRY	CODE SHOWN	COMMENTS
6	06	
0	00	
gx⇄y	3507	
x	71	
STO 1	3301	M
gLSTx	3500	
RTN	24	track length
LBL	23	
B	12	
g	35	
DSZ	83	
GTO	22	
1	01	
RCL 1	3401	
RCL 2	3402	
RCL 4	3404	
÷	81	
x	71	
STO 3	3303	
f	31	
INT	83	
gLSTx	3500	
f-1	32	
INT	83	
.	83	
6	06	
x	71	
+	61	
DSP	21	
.	83	
4	04	
RTN	24	T in MM.SSSS
LBL	23	
1	01	
f	31	
INT	83	
gLSTx	3500	
f-1	32	
INT	83	
.	83	
6	06	
÷	81	
+	61	
STO 5	3305	T single lap
STO	33	
+	61	
3	03	
1	01	
STO	33	
+	61	

KEY ENTRY	CODE SHOWN	COMMENTS
2	02	
STO 8	3308	
C	13	
RCL 1	3401	
RCL 5	3405	
÷	81	
RTN	24	S single lap
LBL	23	
C	13	
g	35	
DSZ	83	
STO 4	3304	
RTN	24	
RCL 1	3401	
RCL 2	3402	
RCL 3	3403	
÷	81	
x	71	
STO 4	3304	S for single lap
DSP	21	
.	83	
3	03	
RTN	24	
LBL	23	
D	14	
g	35	
DSZ	83	
STO 2	3302	
RTN	24	
RCL 4	3404	
RCL 3	3403	
RCL 1	3401	
÷	81	
x	71	
STO 2	3302	
DSP	21	
.	83	
3	03	
RTN	24	L
LBL	23	
E	15	
1	01	
g	35	
DSZ	83	
STO 8	3308	
RTN	24	compute
CLx	44	clear
STO 2	3302	
STO 3	3303	
RTN	24	

REGISTERS	
R_1	M
R_2	L
R_3	T
R_4	S
R_5	used
R_6	
R_7	
R_8	DSZ
R_9	

LABELS	
A	Tk. Len.
B	Time
C	MPH
D	Laps
E	Com/Cl
0	
1	used
2	
3	
4	
5	
6	
7	
8	
9	

FLAGS	
1	
2	

TO RECORD PROGRAM INSERT MAGNETIC CARD WITH SWITCH SET AT W/PRGM.