SURVEYING PROGRAMS

OLIVETTI P602

#E7719.1

GLOSSARY

Bearings and North Azimuth

Bearings and Azimuth are two ways of expressing the direction of a straight line in a horizontal plane.

A North Azimuth is the angle, measured in a clockwise direction, from North. It may have any value from 0° to 360°.

A Bearing is expressed in two parts, an Angle and Quadrant. The Angle is from South or North, and never greater than 90°. There are four Quadrants which are coded as follows:

NE = 1 SE = 2 SW = 3 NW = 4

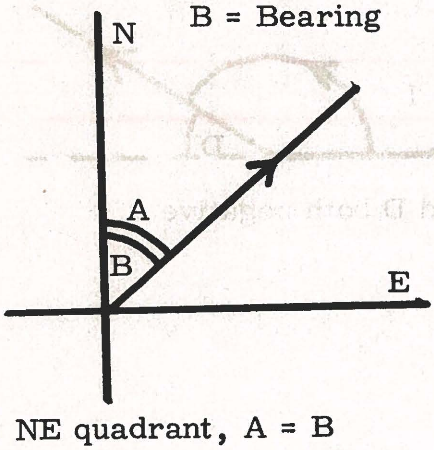
Any line with a direction between North and East, is in the first Quadrant. The Angle is measured clockwise from North.

Any line with a direction between South and East, is in the second Quadrant. The Angle is measured counter-clockwise from South.

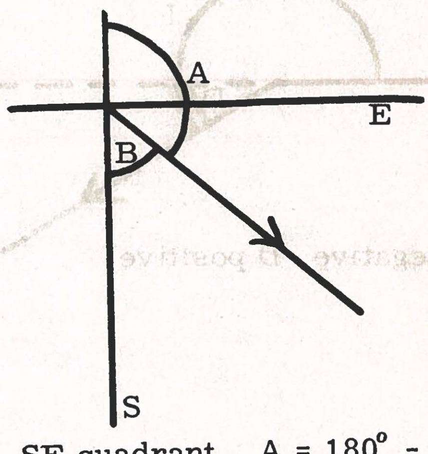
Any line with a direction between South and West, is in the third Quadrant. The Angle is measured clockwise from the South.

Any line with a direction between North and West, is in the fourth Quadrant. The Angle is measured counter-clockwise from the North.

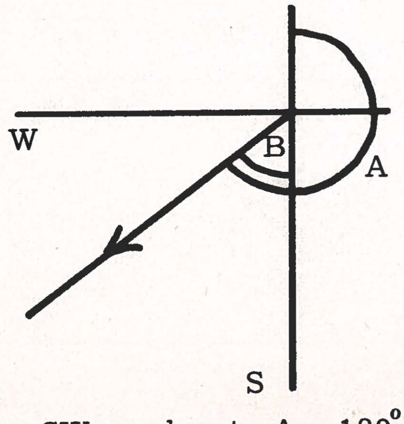
A = Azimuth
B = Bearing



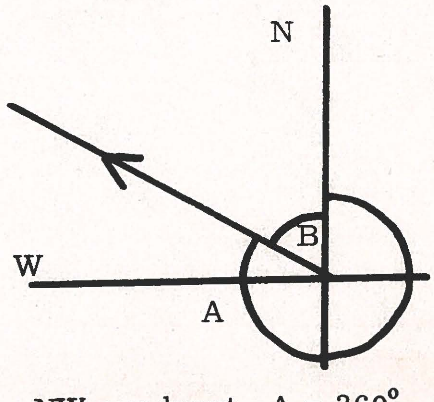
NE quadrant, A = B



SE quadrant, $A = 180^\circ - B$



SW quadrant, $A = 180^\circ + B$

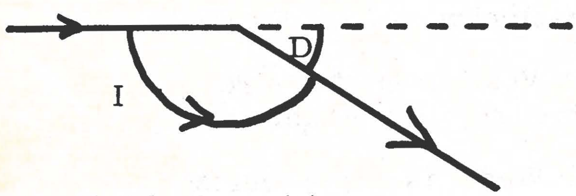


NW quadrant, $A = 360^\circ - B$

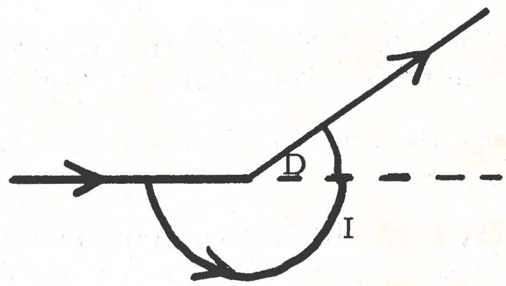
Included and Deflected Angles

Included Angles may have any value between -360° and +360°, and are turned from the Backsight. Included angles turned to the right are negative, turned to the left they are positive. Deflected Angles may have a value between -180° and +180°, and are turned from the continuation of the previous line. Deflected Angles turned right are positive, turned to the left they are negative.

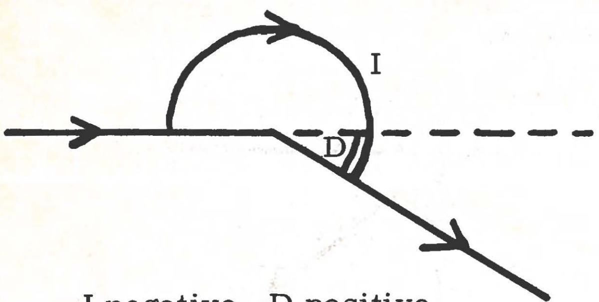
D = Deflected I = Included



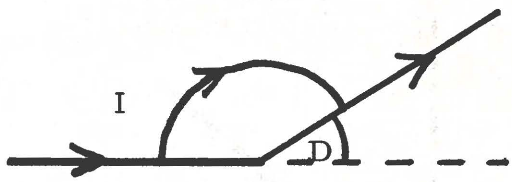
I and D both positive



I positive, D negative



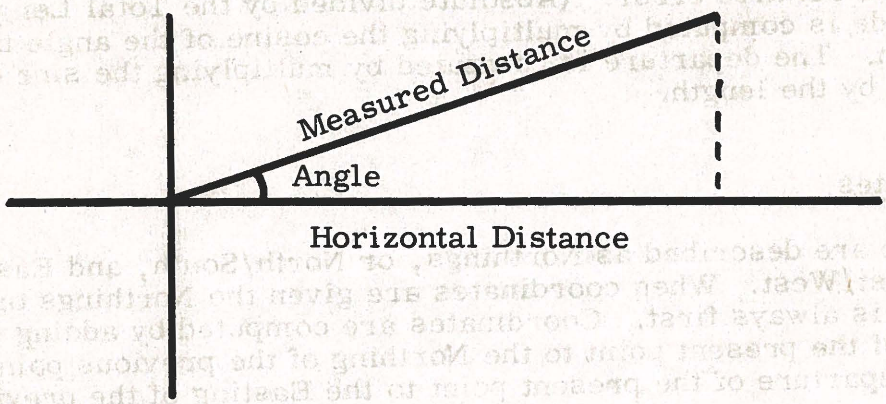
I negative, D positive



I and D both negative

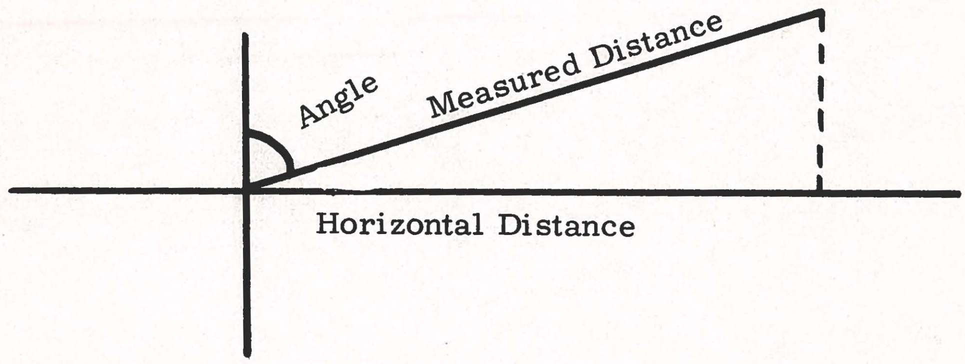
Vertical Angles

The Angle measured from the horizontal. The cosine of the angle times the measured distance (uphill or downhill) equals the adjusted horizontal distance.



Zenith Angle

The Angle measured from the vertical. The sine of the angle times the measured distance (uphill or downhill) equals the adjusted horizontal distance.



Temperature Correction

This corrects the recorded length of a steel tape. 68° F is the base temperature. For temperatures over this the steel tape will measure short due to expansion. For temperatures less than 68° F the tape measures long due to contraction.

Latitude and Departure

For computations and mapping. Each line has a North/South or Latitude, and East/West or Departure. North and East have a positive sign, South and West a negative sign. In a closed survey, the sum of the Latitudes and the sum of the Departures should be zero. The sums are used to compute the absolute error

$$\left(\sqrt{(\Sigma L)^2 + (\Sigma D)^2} \right)$$

and the relative error. (Absolute divided by the Total Length) The latitude is computed by multiplying the cosine of the angle by the length. The departure is computed by multiplying the sine of the angle by the length.

Coordinates

These are described as Northings, or North/South, and Eastings, or East/West. When coordinates are given the Northings or North/South is always first. Coordinates are computed by adding the latitude of the present point to the Northing of the previous point and the Departure of the present point to the Easting of the previous point.

SURVEYING PROGRAMS

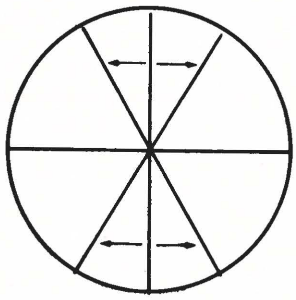
P602

TABLE OF CONTENTS

* ⇒ ON CARD

Title		
Conversion of Bearings to Azimuth and Vice Versa		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel as desired

The bearing of a line is its angle as measured from the NS line and so must be between 0° and 90° . Since a circle has 360° , the quadrant must also be given.



Each of the indicated angles is 30° but they lie in different quadrants, respectively NE, SE, SW, and NW. To enter the quadrant, the following coding is used:

NE = 1
SE = 2
SW = 3
NW = 4

Azimuth is the angle a direction makes from due north measured in a clock-wise direction

The bearings and azimuths of the above lines are:

Bearing	Azimuth
N 30° E	30°
S 30° E	150°
S 30° W	210°
N 30° W	330°

Sample run: Depress V if the bearing is given or W if the azimuth is given.

Bearing given			V
Bearing	degrees	29	S
	minutes	37	S
	seconds	23	S
	quadrant	2	S
Azimuth	degrees	150	A ◊
	minutes	22	A ◊
	seconds	37	B ◊
Bearing		48	S
		27	S
		41	S
		3	S
Azimuth		228	A ◊
		27	A ◊
		41	B ◊
Azimuth given			W
Azimuth		150	S
		22	S
		37	S
Bearing		29	A ◊
		37	A ◊
		23	B ◊
		2	b ◊
Azimuth		228	S
		27	S
		41	S
Bearing		48	A ◊
		27	A ◊
		41	B ◊
		3	b ◊

Accuracy: Same as the decimal wheel settings.

Method: Angles are reduced to seconds before conversion (C√), and afterwards are changed back to degrees, minutes and seconds. (D√)

Let Bearing = B
Quadrant = Q
Azimuth = A

If B and Q are given

$$A = 648000\left[\frac{Q}{2}\right] + B \qquad \text{if Q is odd}$$

$$A = 648000\left[\frac{Q}{2}\right] - B \qquad \text{if Q is even}$$

If A is given

$$Q = \left[\frac{2A + 648000}{648000}\right]$$

$$B = \left[\frac{Q}{2}\right] 648000 - A$$

Integer division is used throughout so the quotients in brackets contain no fractional part.

olivetti P 602

Code	Date	Page
502.01		4/4

Title

Conversion of Bearings to Azimuth and Vice Versa

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel
1	as desired	as desired

r ◇	d ↑	R ↓			
C √	/ ÷	A ◇			
B ↕	B S	B ◇			
S	F X	d √			
↓	B −				
A ↑	A ↓				
d ↑	D √				
/ ÷	b ◇				
R ↕	W				
A S	c √				
R V	S				
B ↓	↓				
A ↕	R S				
B ↕	F X				
r V	S				
R ↓	+				
B S	R S				
F X	F X				
B +	S				
D √	+				
V	c √				
/ W	d √				
r ◇	r ◇				
C √	R S				
A +	F +				
B ↑	−				
B S	/ ÷				
F +	B ↕				
/ ÷	R ↓				
b ↕	B ↕				
b ↓	/ ÷				
A ↑	A ◇				

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

648000 BF ◇
60 RF ◇

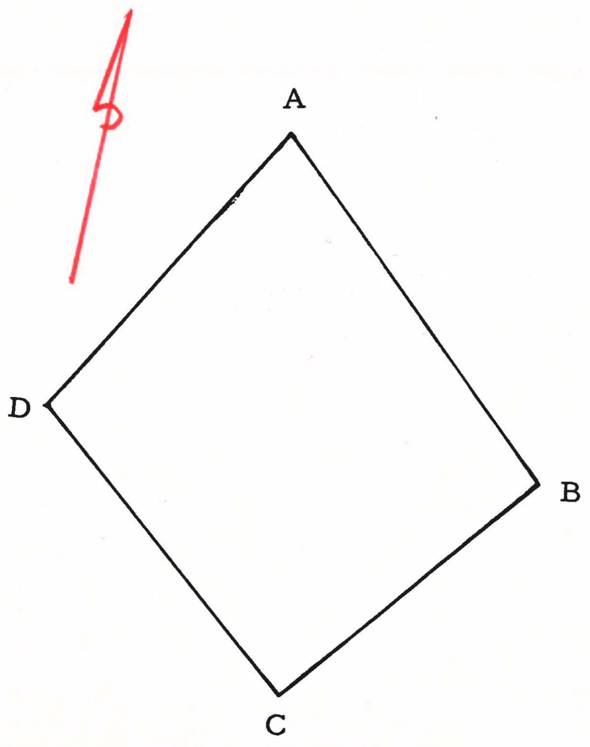
Title		
Computation of Bearings From Angle Observations		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel as desired

This program computes bearings of successive traverses, given the azimuth or bearing of the first one, and successive angles, either included or deflected. Angles are expressed in degrees, minutes and seconds, and may be entered either positive or negative.

Quadrants are coded as follows:

NW 4	NE 1
SW 3	SE 2

The final bearing should be the same as the initial bearing; this gives a check on the accuracy of the entries. The following is a typical traverse using included angles



Included Angles

			V
Bearing of DA	Degrees	29	S
	Minutes	40	S
	Seconds	0	S
	Quadrant	1	S
Included angle at A		58	S
		6	S
		10	S
Bearing of AB		28	A◊
		26	A◊
		10	B◊
		2	b◊
Included angle at B		138	S
		35	S
		50	S
Bearing of BC		12	A◊
		58	A◊
		0	B◊
		3	b◊
Included angle at C		58	S
		29	S
		40	S
Bearing of CD		45	A◊
		31	A◊
		40	B◊
		4	b◊
Included angle at D		104	S
		48	S
		20	S
Bearing of DA		29	A◊
		40	A◊
		0	B◊
		1	b◊

Deflected angles

		W
Bearing of DA	29	S
	40	S
	0	S
	1	S
Deflected angle at A	121	S
	53	S
	50	S
Bearing of AB	28	A◊
	26	A◊
	10	B◊
	2	b◊
Deflected angle at B	41	S
	24	S
	10	S
Bearing of BC	12	A◊
	58	A◊
	0	B◊
	3	b◊
Deflected angle at C	121	S
	30	S
	20	S
Bearing of CD	45	A◊
	31	A◊
	40	B◊
	4	b◊
Deflected angle at D	75	S
	11	S
	40	S
Bearing of DA	29	A◊
	40	A◊
	0	B◊
	1	b◊

Accuracy: Equal to the decimal wheel setting.

Method:

All angles are reduced to seconds (C √) and converted to degrees, minutes, seconds (D√) and quadrant before printing.

E converts from bearing to azimuth

If the running total after n angles is Bn, and the nth angle is An, then

$B_n = B_{n-1} - A_n + 648000$ if A_n is the included angle

$B_n = B_{n-1} + A_n$ if A_n is the deflected angle

Title

Computation of Bearings From Angle Observations

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel as desired

r ◊	◆	A ◊			
C √	c √	B ◊			
E √	d √	b ◊			
a V	r ◊	d √			
r ◊	B S	e √			
C √	f ◆	B ↕			
A ↕	/ +	S			
B S	R ↓	↓			
F ◆	A ◆	A ↑			
c ◆	c ↑	d ↑			
D √	B S	/ ÷			
A V	F ◆	R ↕			
/ W	/ +	A S			
r ◊	b ↕	R V			
C √	b ↓	B ↓			
E √	A ↑	A ↕			
a W	d ↑	B ↕			
r ◊	/ +	r V			
C √	B S	R ↓			
c ◆	F X	B S			
D √	c −	F X			
A W	A ↓	B ◆			
c √	R S	c ↕			
S	F ◆	e √			
↓	−				
R S	/ +				
F X	B ↕				
S	R ↓				
◆	B ↕				
R S	/ +				
F X	A ◊				
S	R ↓				

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

60 RF ◊
648000 BF ◊
1296000 Bf ◊

olivetti P 602	Code 502.03	Date	Page 1/4

Title		
Correction of Angular Errors		
Number of Sides	Lower Decimal Wheel 0	Upper Decimal Wheel 0

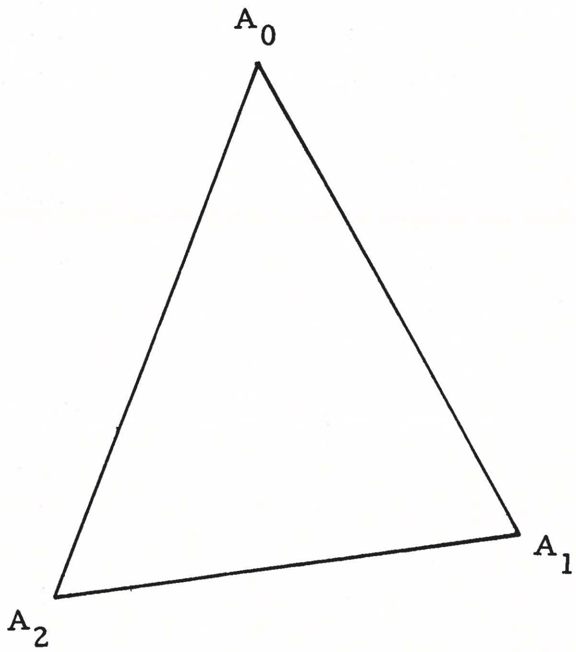
This program sums angles either included or deflected or at a point. It also counts the number of angles entered. It prints the actual total, the number of angles, the nominal total (either 360 or (n-2) 180), and the difference in seconds.

The computer prints the corrected angles.

Angles are expressed in degrees, minutes and seconds and up to 32 angles can be entered.

Decimals of a second cannot be entered.

When finished with entries, depress Z if angles were included or at a point; depress Y if angles were deflected.



To Start		V
A_o	50	S
	12	S
	45	S
A_1	60	S
	32	S
	0	S
A_2	69	S
	16	S
	10	S
For included angles		Z
Number of angles	3	b◊
Nominal total	180	A◊
Error	-55	A◊
Corrected angles		
A_o	50	A◊
	12	A◊
	27	A◊
A_1	60	A◊
	31	A◊
	42	A◊
A_2	69	A◊
	15	A◊
	51	A◊

To Start		V
A_o	129	S
	47	S
	15	S
A_1	119	S
	28	S
	0	S
A_2	110	S
	43	S
	50	S
For deflected angles		Y
Number of angles	3	b◊
Nominal total	360	A◊
Error	55	A◊
Corrected angles		
A_o	129	A◊
	47	A◊
	33	A◊
A_1	119	A◊
	28	A◊
	18	A◊
A_2	110	A◊
	44	A◊
	9	A◊

Accuracy: To the nearest second.

Method: The angles are reduced to seconds and stored in their corresponding registers. The angles are totalled in B, and counted in b.

The actual total is subtracted from the nominal total (360degrees or (n-2) 180 degrees), to give the error, C_n, for n angles.

The correction for the first angle is $E_1 = Cn/n$ with no fraction. This is applied to the angle which is converted to degrees, minutes and seconds before printing.

This leaves an error of $C_{n-1} = (C_n - E_1)$ for (n-1) angles, which is used to correct the next angle.

This method distributes the error without remainder, even if C_n is not exactly divisible by n.

olivetti P 602

Code 502.03	Date	Page 4/4

Title

Correction of Angular Errors

Number of Sides	Lower Decimal Wheel 0	Upper Decimal Wheel 0

r ◊	/ Y	b ∗	b ↓		
A ↑	/ +	a Z	-		
D S	/ Z	B ↓	b ↕		
r X	b ◊	b ÷	b ↓		
A S	A ↑	B ↕	A S		
b ↑	d ↑	B -	A Z		
b ∗	↓	B ↕	V		
B ∗	/ S	a S			
/ -	R Z	b +			
a V	b -	A ↑			
r ◊	A ↕	D S			
S	r Z	r X			
↓	A +	÷			
A S	+	R ↕			
b X	A S	A S			
S	b X	B ↕			
+	B ↕	R ↓			
A S	A S	÷			
b X	D V	r ◊			
S	B ↕	A ◊			
+	A ↕	R ↓			
B ↕	B ↕	A ◊			
B +	d V	A S			
B ↕	B ↕	B ↓			
/ S	A ◊	A ◊			
b ↑	X	A ↑			
b ↓	X	d ↓			
A ↑	r ◊	A S			
d ↓	B -	b ↓			
+	A ◊	+			
b ↕	B ↕	A S			
A V	A S	b ↕			

Register	Content	Register	Content
Ab'	60	b	number of angles
AB'	sum of angles	B	
Ac'	A_0	c	A_1
AC'	A_2	C	A_3
Ad'	A_4	d	A_5
AD'	A_6	D	A_7
Ae'	A_8	e	A_9
AE'	A_{10}	E	A_{11}
Af'	A_{12}	f	A_{13}
AF'	A_{14}	F	A_{15}
Bc'	A_{16}	Rc	A_{17}
BC'	A_{18}	RC	A_{19}
Bd'	A_{20}	Rd	A_{21}
BD'	A_{22}	RD	A_{23}
Be'	A_{24}	Re	A_{25}
BE'	A_{26}	RE	A_{27}
Bf'	A_{28}	Rf	A_{29}
BF'	A_{30}	RF	A_{31}

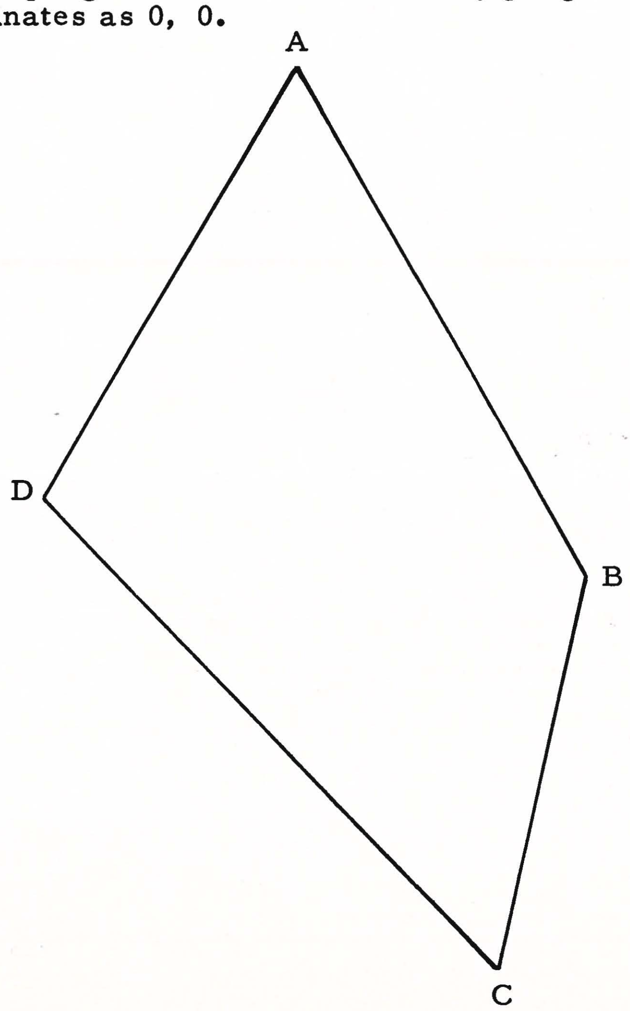
Title		
Summation of Latitudes and Departures		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program calculates latitude and departure from bearing and length. It also sums latitudes and departures for several successive courses of a traverse. It can be followed by program 50205 for calculation of error of closure, and correction of the traverse, or by program 50206 to force closure.

It can also be used to establish coordinates from bearings and lengths of a proved traverse with acceptable error of closure.

Error correction: If the angle has been entered incorrectly, enter the length as 0 and then continue with correct entries. If the error is in the length or is only noticed after the length has been entered, re-enter the same angle and re-enter the length as a negative number. This will bring the traverse back to the point of the last correct entry and the traverse may be continued from there.

Sample run: If this program is to be followed by program 50205 or 50206, enter the starting coordinates as 0, 0.



			V
		0	S
		0	S
Bearing of AB	Degrees	28	S
	Minutes	26	S
	Seconds	10	S
	Quadrant	2	S
	Length	256.67	S
	Latitude	-225.7047	A◊
	Departure	122.2207	A◊
	Sum of Latitudes	-225.7024	F◊
	Sum of Departures	122.2207	f◊
Bearing of BC	Degrees	12	S
	Minutes	58	S
	Seconds	0	S
	Quadrant	3	S
	Length	151.05	S
	Latitude	-147.1983	A◊
	Departure	-33.8932	A◊
	Sum of Latitudes	-372.9007	F◊
	Sum of Departures	88.3275	f◊
Bearing of CD	Degrees	45	S
	Minutes	31	S
	Seconds	40	S
	Quadrant	4	S
	Length	270.11	S
	Latitude	189.2291	A◊
	Departure	-192.7478	A◊
	Sum of Latitudes	-183.6715	F◊
	Sum of Departures	-104.4203	f◊
Bearing of DA	Degrees	29	S
	Minutes	40	S
	Seconds	0	S
	Quadrant	1	S
	Length	211.11	S
	Latitude	183.4376	A◊
	Departure	104.4895	A◊
	Sum of Latitudes	-0.2339	F◊
	Sum of Departures	0.0692	f◊
	Sum of Lengths (Manual Print-Out)	888.9400	C◊

Accuracy: The sines and cosines necessary to determine the latitudes and departures are calculated to 10 decimal places.

Method: The angles are reduced to degrees. If the angle is greater than 45 the cosine is computed. If it is less than 45 the sine is computed. Then the sine or cosine is computed from:

$$\sin\theta_n = \sqrt{1 - \cos^2\theta_n} \quad \text{or} \quad \cos\theta_n = \sqrt{1 - \sin^2\theta_n}$$

The signs are adjusted for quadrant.
If ln is the length of the nth course,

latitude = ln $\cos\theta_n$

departure = ln $\sin\theta_n$

The coordinates are the sums of the latitudes and departures added to the starting coordinates.

To use project coordinates and compute error to be used in program or, proceed as follows:

Final sum of latitudes
− Original Northing
error for N

Final sum of departures
− Original Easting
error for E

be sure to observe algebraic sign

The data is then placed in program or as follows:

1) Clear computer (reset)
2) Program with card (or)
3) ~~Key in [V]~~
4) Enter error for N on keyboard then key in to memory using [F] [↑]
5) Enter error for E on key board then key in to memory using [F] [/] [↑]
6) ENTER sum of lengths on key board then key in to memory using [C] [↑]
7) Key in [V]
8) Enter N (original coord)
9) Enter E " "
10) Enter Lat then dep and continue as programed

olivetti P 602

Code 502.04	Date	Page 4/4

Title

Summation of Latitudes and Departures

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

r ◊	/ *	X			
S	F W	r ◊			
F ↑	A ↓	A ◊			
S	A X	F ◆			
f ↑	B ↑	F ↕			
a V	A ↑	b ↓			
r ◊	d ↓	c X			
S	-	A ◊			
↓	A √	f ◆			
B S	/ S	f ↕			
E X	R W	C ↓			
S	B ↕	c ◆			
◆	r W	C ↕			
B S	b ↕	r ◊			
E X	A ↑	F ◊			
S	d -	f ◊			
◆	↓	A V			
/ ◆	S				
R S	-				
E -	-				
A S	b ↕				
R V	b X				
/ -	A ↓				
-	b +				
-	b ↕				
r V	A ↓				
◆	A ↑				
+	d ↑				
A ↑	-				
d ↑	B X				
+	S				
*	c ↑				

Register	Contents	
Ab'		b
AB'		B
Ac'	ln	c
AC'	sum of lengths	C
Ad'		d
AD'		D
Ae'		e
AE'		E
Af'	East coordinate	f
AF'	~~West~~ NORTH coordinate	F
Bc'		Rc
BC'		RC
Bd'		Rd
BD'		RD
Be'		Re
BE'		RE
Bf'		Rf
BF'		RF

162000 RE ◊
60 BE ◊

olivetti P 602

Code 502.041	Date	Page 15

Title		
Traverse by Deflected Angles		
Number of Sides 2	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program is used for traverses where the data is kept in delfected angles. It produces the latitude and departure of each course and the coordinates of the turning points. Further there is provision for curved sections in the traverse. For these sections, the traverse proceeds from the beginning of the curve to the radius point and from there to the end of the curve. The chord length and arc length of the curve are computed. At the end of the traverse, the following data is produced:

1) Area - square feet
2) Area - acres
3) Error of closure - north
4) Error of closure - east
5) Total length of the traverse
6) Total error of closure
7) Relative error of closure

Sample run: For curved sections traverse to the radius point. On leaving, depress w before entering angle away from center, if the curve bulges out of the area surveyed, depress y if it bulges into the area surveyed. Central angles must be less than 180°.

Note that the program has 2 SIDES.

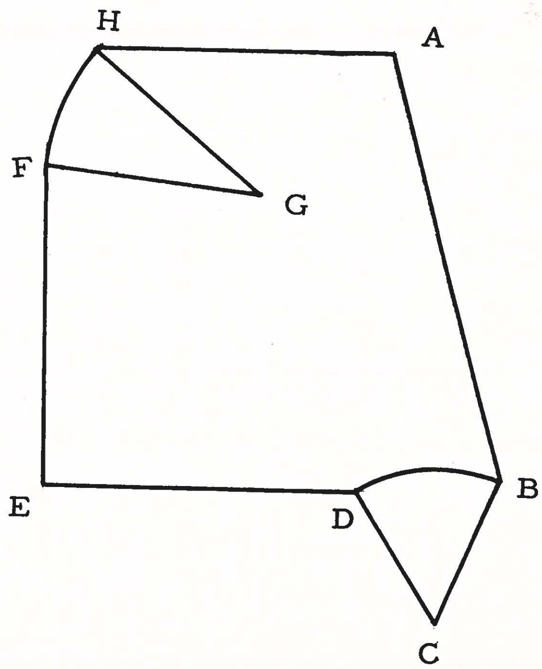
Enter the first side as usual. Then depress SECOND SIDE key and enter second side.

		V	Starting Coordinates
A	5362.25	S	North
	-235.75	S	East
			Initial Bearing
	17	S	Degrees
A	0	S	Minutes
	0	S	Seconds
	2	S	Quadrant
AB	275.00	S	Length
	-262.983	B◊	Latitude
	80.402	b◊	Departure
			Coordinates
B	5099.266	C◊	North
	-155.347	c◊	East
	48	S	Deflected Angle
B	0	S	
	0	S	
BC	118.75	S	Length
	-101.788	B◊	
	-61.160	b◊	
C	4997.477	C◊	
	-216.508	c◊	
	Y	[redacted]	Leaving Radius Point Curved Section Bent Inward
	119	S	
C	0	S	
	0	S	
CD	118.750	E◊	Length
	102.840	B◊	
	-59.375	b◊	
D	5100.318	C◊	
	-275.883	c◊	
BD	120.540	A◊	Chord Length
BD	126.427	A◊	Arc Length

Sample run (continued)

	-85	S
	0	S
D	0	S
DE	200	S
	-84.523	B◊
	-181.261	b◊
E	5015.794	C◊
	-457.145	c◊
	94	S
E	0	S
	0	S
EF	156.25	S
	145.871	B◊
	-55.994	b◊
F	5161.666	C◊
	-513.140	c◊
	90	S
F	0	S
	0	S
FG	200	S
	71.673	B◊
	186.716	b◊
G	5233.339	C◊
	-326.424	c◊
CURVE ~~Radius Point~~ BentOutward		~~#~~ W
	-137	S
G	0	S
	0	S
GH	200.000	E◊
	74.921	B◊
	-185.436	b◊
H	5308.261	C◊
FH	-511.860	c◊
FH	146.600	A◊
	150.098	A◊

	147	S
H	0	S
	0	S
	281.25	S
	53.665	B◊
	276.082	b◊
	5361.926	C◊
A	-235.778	c◊
Totals		Z
Area sq. ft.	83887.480	A◊
Acres	1.925	A◊
Error north	-0.323	A◊
Error east	-0.028	A◊
Total length	1550.000	d◊
Total error	0.324	A◊
Relative error	0.000	A◊
Manual print of relative error at D.W.S. of 7	0.0002096	A◊



Accuracy: The latitudes and departures are calculated to nine significant digits.

Method: All angles are converted to seconds. The azimuth of each course is equal to the original azimuth plus the sum of the deflected angles B_i to that point.

The angle is then converted to radians, θ_i

$$\text{latitude } L_i = l_i \cos\theta_i$$
$$\text{departure } D_i = l_i \sin\theta_i$$

where l_i = length of that course.

The coordinates

$$X_i = Xo + \sum_{j=1}^{n} L_j$$

$$Y_i = Y_o + \sum_{j=1}^{n} D_j$$

are computed, where X_o, Y_o are the coordinates of the first point.

$$\text{Area} = \frac{1}{2}\left|\sum_{i=1}^{n} [2(X_i - X_o) + L_{i+1}]D_{i+1}\right|$$

For curved sections, the central angle is assumed to be less than 180°.

Then the central angle $C_i = 180° - |B_i|$

and arc length $= \frac{\pi}{180} C_i$

$$\text{chord length} = 2 \sin\left(\frac{C_i}{2}\ \frac{\pi}{180}\right)$$

$$\text{Area} = \frac{R^2}{2}\ \frac{C_i\pi}{180}$$

This area is added if the curve bulges out, subtracted if it bulges in.

The errors north and east are calculated as the sum of the latitudes and departures respectively and the total error is the square root of the sum of the squares.

The relative error is the total error divided by the total length of the traverse.

olivetti P 602

Code	Date	Page
502.041		5/5

Title

Traverse by Deflected Angles

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel
2	as desired	FL

a *	r ◊	B ↓	A ◊	A ◊	d X
S	C √	C +	b ↓	A ↑	S
C ↑	f Z	C ↕	X	D S	+
R S	A ↓	R S	A ◊	R X	B S
C ↑	e ↕	C -	X	R -	d X
S	R ↓	-	a S	R ↕	S
c ↑	f +	C +	B W	r +	+
R S	f ↕	b X	A ↕	‡	c √
c ↑	f ↓	D +	b W	A ◊	
r ◊	R S	D ↕	F +	r ◊	
/ +	D ÷	b ↓	F ↕	C ↓	
C √	b ↕	c +	/ +	R S	
B ↕	b ↓	c ↕	A V	C -	
S	/ *	r ◊	/ W	A ◊	
↓	R W	C ◊	/ -	A X	
A ↑	b ↕	c ◊	a +	c ↕	
d ↑	/ *	/ S	A V	R S	
b ↑	R V	A V	/ Y	c -	
/ ‡	/ S	R S	/ -	A ◊	
R ↕	R Z	d ↓	a -	A X	
A S	E ◊	e -	A V	c +	
R Y	b Z	R S	r Z	A √	
B ↕	E X	D ‡	S	d ◊	
A ↕	b ↕	b ↕	E ↑	r ◊	
B ↕	X	b ↓	B Z	A ◊	
r Y	B ↕	A ↑	/ Z	d ÷	
R S	↓	d ↑	D ↓	A ◊	
d ↓	d +	÷	A ↓	V	
R X	d ↕	/ *	F +	c √	
B +	r ◊	R V	A ↑	S	
F Z	B ◊	A +	d ↑	↓	
a V	b ◊	E X	‡	B S	

Register	Content	
Ab	Departure	b
AB	Latitude	B
Ac	Coordinate E	c
AC	Coordinate N	C
Ad	Total Length	d
AD	Area	D
Ae	Angle	e
AE	Length	E
Af	Azimuth	f
AF	Area of segments	F
Bc	STARTING COORDINATE E	Rc
BC	STARTING COORDINATE N	RC
Bd	60 / 648000	Rd
BD	206264.806247096	RD
Be		Re
BE	INSTRUCTIONS	RE
Bf	INSTRUCTIONS	Rf
BF	INSTRUCTIONS	RF

60 Bd ◊

648000 Rd ◊

206264.806247096 RD ◊

Title		
Correction of Latitudes and Departures (Compass Rule)		
Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel

This program is used following program 50204 to correct the courses of a traverse using the compass rule. In this method, the angles and lengths are assumed to be measured with equal precision and therefore contribute equally to the error of closure.

Each course is corrected proportionate to its length.

It automatically prints the sum of the latitudes, sum of departures and sum of traverse lengths. The absolute and relative lengths are computed.

If the errors are within permitted limits, the coordinates of the starting point are entered followed by the latitudes and departures of each course.

The program then supplies the corrected latitudes, departure, bearing and length of each course.

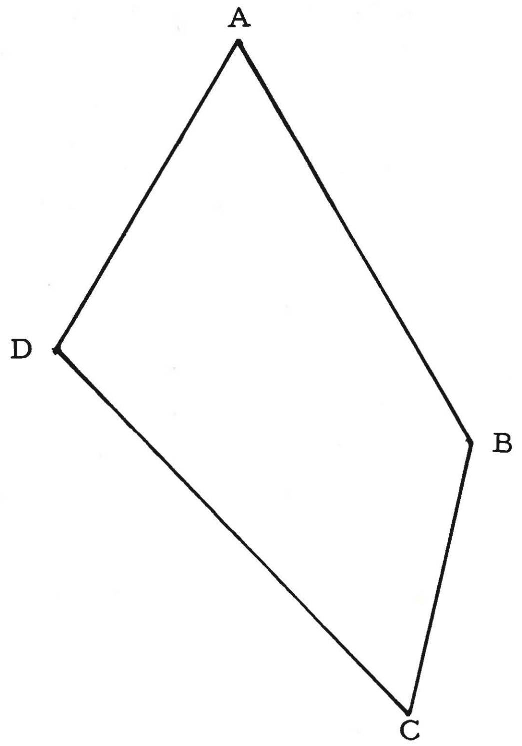
Verification is provided by comparing the uncorrected length of each traverse with the original survey, and by comparing the coordinates of the end point with those of the starting point.

Sample run: DO NOT press General Reset after running program 50204.

olivetti P 602

Code 502.05	Date	Page 2/4

			V
	Sum of Latitudes	-0.2339	F◊
	Sum of Departures	0.0692	f◊
	Sum of Lengths	888.9400	C◊
	Absolute Error	0.2439	A◊
	Relative Error	0.0002	A◊
	N/S Coordinate of A	4500	S
	E/W Coordinate of A	2800	S
AB	Latitude	-225.7024	S
	Departure	122.2207	S
	Length	256.6699	e◊
	Adjusted Latitude	-225.6348	D◊
	Adjusted Departure	122.2007	d◊
	Adjusted Length	256.6010	A◊
	N/S	4274.3651	C◊
	E/W	2922.2007	c◊
		28.0000	◊
	Adjusted Bearing of AB	26.0000	◊
		21.6998	A◊
BC		-147.1983	S
		-33.8932	S
		151.0499	e◊
		-147.1585	D◊
		-33.9049	d◊
		151.0138	A◊
		4127.2066	C◊
		2888.2957	c◊
		12.0000	◊
		58.0000	◊
		27.8244	A◊
CD		189.2291	S
		-192.7478	S
		270.1099	e◊
		189.3001	D◊
		-192.7688	d◊
		270.1747	A◊
		4316.5067	C◊
		2695.5268	c◊
		45.0000	◊
		31.0000	◊
		12.5444	A◊
DA		183.4376	S
		104.4895	S
		211.1099	e◊
		183.4931	D◊
		104.4730	d◊
		211.1500	A◊
		4499.9999	C◊
		2799.9999	c◊
		29.0000	◊
		39.0000	◊
		19.1200	A◊



From Program 50204 these results are printed:

Sum (or error) of latitudes = F
Sum (or error) of departures = f
Sum of lengths = C

The machine computes and prints:

Absolute error = $\sqrt{F^2 + f^2}$ = A
Relative error = A/C

It also computes without printing:

Relative latitude error x = F/C
Relative departure error y = f/C

On re-entry of latitude (X) and departure (Y), the machine computes and prints:

Uncorrected length e = $\sqrt{X^2 + Y^2}$
Corrected latitude D = X - ex
Corrected departure d = Y - ey
Corrected length = $\sqrt{D^2 + d^2}$
Coordinates, which are progressive totals of D and d

The machine also computes $\theta = \text{Tan}^{-1} (\frac{d}{D})$ and converts this angle from radians to give the corrected bearing.

See 04 for error entry to program

Title

Correction of Latitudes and Departures (Compass rule)

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel

r ◊	e ↕	A X	◊		
F ◊	D ↓	d ↑	B S		
F ↓	A X	e +	E X		
A X	e +	A √	r ↕		
c ↕	A √	A ◊	◊		
f ◊	e ↕	D ↓	B S		
f ↓	e ◊	d -	E X		
A X	e ↓	A S	A ◊		
c +	f X	B W	B V		
A √	D ↕	D -			
C ◊	D -	D ↕			
A ◊	C ↕	b W			
C ÷	C +	↓			
A ◊	D ↑	D ÷			
F ↓	D ◊	C ◊			
÷	C ↕	c ◊			
f ↕	e ↓	/ *			
÷	F X	R Z			
F ↕	d ↕	R S			
r ◊	d -	e X			
S	c ↕	D ↕			
C ↑	c +	A S			
S	d ↑	B Y			
c ↑	d ◊	A ↑			
b V	c ↕	D S			
r ◊	D ↓	r *			
S	A ↓	↓			
D ↑	A X	D +			
S	D ↑	D ↕			
d ↑	e ↕	b Y			
↓	d ↓	D ↓			
X	A ↓	r ↕			

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

57.2957795130823 Re ◊
60 BE ◊

Title		
Intersection of Two Lines		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program computes the coordinates of an inaccessible point if its bearings from two known stations are given.

Bearings are expressed in degrees, minutes and seconds. Quadrants are coded as follows:

NE	=	1
SE	=	2
SW	=	3
NW	=	4

Sample run:

		V
Bearing of first line	12	S
	58	S
	0	S
	3	S
Coordinates of station	77.455	S
	62.208	S
Bearing of second line	45	S
	31	S
	40	S
	4	S
Coordinates of station	81.731	S
	39.617	S
Coordinates of intersection	62.8531	A◊
	58.8458	A◊
distance from first station	14.9839	•◊
distance from second station	26.9466	E◊

Method: The sin and cos of the first angle θ , are computed and the signs are adjusted for quadrant. The coordinates of the station X_N, X_E are stored. This is repeated for the second angle ϕ and station Y_N, Y_E.

Let
$$Z_N = Y_N - X_N$$
$$Z_E = Y_E - X_E$$

then the distance to the first station from the intersection is

$$\frac{Z_N \sin\theta - Z_E \cos\theta}{\sin\phi \cos\theta - \sin\theta \cos\phi} = s$$

and the distance to the second station is

$$\frac{Z_N \sin\phi - Z_E \cos\phi}{\sin\phi \cos\theta - \sin\theta \cos\phi} = t$$

and the coordinates of intersection are

$$X_N + Z_N s$$
$$X_E + Z_E s$$

Accuracy: The answers are accurate to 9 significant digits.

Title

Intersection of Two Lines

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

r ◊	e ↕	A S	B ↕		
C √	B ↓	R V	A ↑		
b ↓	e X	/ -	d ↑		
c ↕	D ◆	-	-		
B ↓	r ◊	-	b X		
C ↕	A ◊	r V	b ↕		
S	b ↓	◆	r ◊		
D ↑	e X	*	c √		
S	d ◆	/ *	d √		
d ↑	A ◊	F W	c ↓		
r ◊	r ◊	A ↓	B X		
C √	e ◊	A X	f ↕		
S	E ◊	B ↑	C ↓		
↓	V	A ↑	b X		
D -	c √	d ↓	f -		
E ↕	S	-	d √		
S	↓	A √	e √		
↓	B S	/ S	b ↓		
d -	f X	R W	c ↕		
e ↕	S	B ↕	e ↕		
D √	◆	r W	b ↕		
F ↕	B S	b ↕	B ↓		
E √	f X	A ↑	C ↕		
D √	S	d -	E ↕		
A ↕	◆	↓	B ↕		
↕	R S	S	e √		
E √	f +	-			
E ↑	A ↑	-			
D √	R -	A ↓			
F +	d S	B ↕			
E ↕	-	R X			
+	/ ◆	B +			

Ab'		b
AB'		B
Ac'		c
AC'		C
Ad'		d
AD'		D
Ae'		e
AE'		E
Af'		f
AF'		F
Bc'		Rc
BC'		RC
Bd'		Rd
BD'		RD
Be'		Re
BE'		RE
60 Bf'	324000	Rf
BF'		RF

60 Bf ◊
324000 Rf ◊

olivetti P 602

Code 502.09	Date	Page 1/3

Title		
Intersection of Line and Curve		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

Given a circular curve and a line intersecting the curve, this program will compute the coordinates of the points of intersection.

Quadrants are coded as follows:

NE	=	1
SE	=	2
SW	=	3
NW	=	4

Sample run:

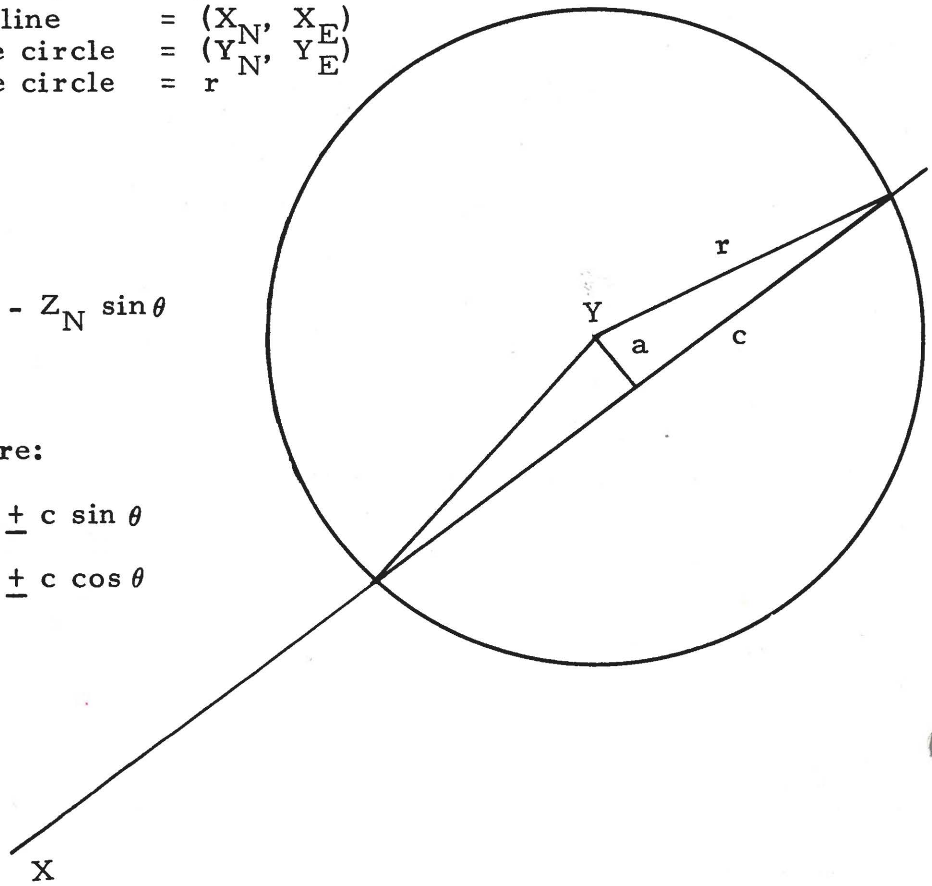
		V
Bearing of line	45	S
	31	S
	40	S
	4	S
Point of line	31.73	S
	-10.39	S
Center of circle	27.45	S
	12.21	S
radius	15	S
First intersection	23.8345	A◊
	-2.3477	A◊
Second intersection	12.8280	A◊
	8.8633	A◊

Method:

Let the bearing of the line $= \theta$
the point on the line $= (X_N, X_E)$
the center of the circle $= (Y_N, Y_E)$
the radius of the circle $= r$

$$Z_N = X_N - Y_N$$
$$Z_E = X_E - Y_E$$

$$a = Z_E \cos\theta - Z_N \sin\theta$$
$$c = \sqrt{r^2 - a^2}$$



Then the solutions are:

$$Y_N - a\cos\theta \pm c\sin\theta$$
$$Y_E + a\sin\theta \pm c\cos\theta$$

Accuracy: The accuracy depends on the central angle of the curve cut off by the two points of intersection. Accuracy may be lost when the central angle is very small.

Accuracy is lost when the line approaches being tangent to curve

OLIVETTI P600	PROGRAM SHEET HALF MEMORY	USER Garrold Co.		DATE 1/30/78	PAGE
APPLICATION Int. line curve		B	AB	b	Ab
PROG. BY N.G.Staples	MACHINE	C 3	AC 2	c 1	Ac 0
PRIOR CARD OR BLOCK		D 7	AD 6	d 5	Ad 4
NEXT CARD OR BLOCK		E 11	AE 10	e 9	Ae 8
OTHER MEMORY CONTENTS	CARD/ BLOCK · ZONE/ SECT.	F 15	AF 14	f 13	Af 12
		RC 19	BC 18	Rc 17	Bc 16
THIS CARD OR BLOCK	SECTION OR ZONE	RD 23	BD 22	Rd 21	Bd 20
NOTES		RE 27	BE 26	Re 25	Be 24
		RF 31	BF 30	Rf 29	Bf 28

NOTES:

deleted steps - 30, 31,32,33,77,78 from Olivetti program.

JUMPS FROM	TO						
	A V		A W		A Y		A Z
	B V		B W		B Y		B Z
	C V		C W		C Y		C Z
	D V		D W		D Y		D Z
	E V		E W		E Y		E Z
	F V		F W		F Y		F Z
	R V		R W		R Y		R Z
	C √		D √		E √		F √

SWITCHES			
/ −	/ +	/ S
a −	a +	a S
r −	r +	r S

Step	Instr.	Step	Instr.	Step	Instr.	Step	Instr.	Step	Instr.	Step	Instr.
	S		↓		A X		A ◊				
2	↓	34	S	66	c ↑	98	c ↓	130		162	
3	B S	35	−	67	C ↕	99	b −	131		163	
4	f X	36	−	68	S	100	A ◊	132		164	
5	S	37	B ↕	69	↓	101	r ◊	133		165	
6	+	38	B X	70	X	102	V	134		166	
7	B S	39	A ↓	71	C −	103	/ Y	135		167	
8	f X	40	B ÷	72	A ↕	104	+	136		168	
	S		B ↕		A √		✱				
10	+	42	A ↓	74	C ↕	106	/ +	138		170	
11	R S	43	A ↑	75	b ↓	107	Z	139		171	
12	f ÷	44	d ↑	76	c X	108	V	140		172	
13	A ↑	45	−	77	d +	109	/ Y	141		173	
14	B −	46	b X	78	c ↕	110	+	142		174	
15	f S	47	b ↕	79	B X	111	✱	143		175	
16	+	48	r ◊	80	A ↕	112	/ +	144		176	
	A S		S		D +		Z				
18	Y	50	c ↑	82	B ↕	114	S	146		178	
19	/ −	51	S	83	C X	115	S	147		179	
20	/ Z	52	↓	84	b ↕	116	S	148		180	
21	/ ✱	53	r ◊	85	C X	117		149		181	
22	F W	54	S	86	C ↕	118		150		182	
23	A ↓	55	D ↑	87	r ◊	119		151		183	
24	A X	56	S	88	B ↓	120		152		184	
	B ↑		d ↑		C +						
26	A ↑	58	−	90	A ◊	122		154		186	
27	d ↓	59	b X	91	c ↓	123		155		187	
28	−	60	c ↕	92	b +	124		156		188	
29	A √	61	D −	93	A ◊	125		157		189	
30	b ↕	62	B X	94	r ◊	126		158		190	
31	A ↑	63	c −	95	B ↓	127		159		191	
32	d −	64	A ↕	96	C −	128		160		192	

ON CARD but not necessary

olivetti P 602

Code 502.09	Date	Page 3/3

Title

Intersection of Line and Curve

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

S	omit / W	D -	c ↓		
↓	b ↕	B X	b +		
B S	A ↑	c -	A ◊		
f X	d -	A ↕	r ◊		
S	↓	A X	B ↓		
+	S	c ↕	C -		
B S	-	C ↕	A ◊		
f X	-	S	c ↓		
S	B ↕	↓	b -		
+	B X	X	A ◊		
R S	A ↓	C -	r ◊		
f ÷	B ÷	A ↕	V		
A ↑	B ↕	omit { A S	/ Y		
B -	A ↓	omit { D W	+		
f S	A ↑	A √	✱		
+	d ↑	C ↕	/ +		
A S	-	b ↓	Z		
Y	b X	c X			
/ -	b ↕	d +			
/ Z	r ◊	c ↕			
/ ✱	S	B X			
F W	c ↑	A ↕			
A ↓	S	D +			
A X	↓	B ↕			
B ↑	r ◊	C X			
A ↑	S	b ↕			
d ↓	D ↑	C X			
-	S	C ↕			
A √	d ↑	r ◊			
omit { / S	-	B ↓			
omit { W	b X	C +			
omit { B ↕	c ↕	A ◊			

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

60 B f ◊

324000 R f ◊

Title		
Intersection of Two Circles		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program is used to find the coordinates of a point where its distance from two known points are given.

A red light will light if there is no solution.

Sample run:

		V
X_N	17.53	S
X_E	-143.95	S
R	269.11	S
Y_N	-24.82	S
Y_E	81.74	S
R	150.00	S
First Solution	123.6124	A◊
	103.3690	A◊
Second Solution	-170.9961	A◊
	48.0867	A◊

Method:

Let X_N, X_E the coordinates of the first point

R the distance from this point

Y_N, Y_E the coordinates of the second point

S the distance from this point

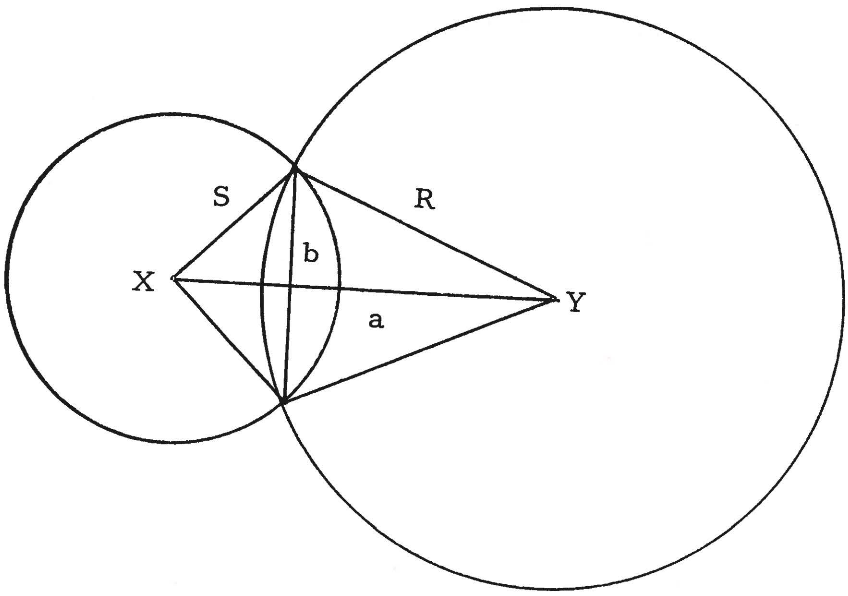
$$Z_N = Y_N - X_N$$

$$Z_E = Y_E - X_E$$

$$a = \sqrt{Z_N^2 + Z_E^2}$$

$$r = \frac{R}{a}$$

$$s = \frac{S}{a}$$



Then the solutions are:

$$X_N + a\, Z_N \pm b\, Z_E$$

$$X_E + a\, Z_E \mp b\, Z_N$$

Accuracy: The accuracy depends on the size of the central angle subtended by the intersection points. For very small central angles, accuracy may be lost.

olivetti P 602

Code	Date	Page
502.10		3/3

Title

Intersection of Two Circles

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel
1	as desired	FL

S	D ×	A ◊			
b ↑	A ↑	c ↓			
S	d ↓	e −			
B ↑	−	A ◊			
S	A ↑	r ◊			
e ↑	f ↑	D ↓			
r ◊	÷	C −			
S	A ×	A ◊			
↓	D ↑	e ↓			
b −	e ↕	c +			
A ×	A ×	A ◊			
c ↑	e −	V			
D ↕	A S	/ V			
S	A V				
↓	D W				
B −	a V				
A ×	A √				
C ↑	e ↕				
D +	c ↓				
A √	e ×				
D ↕	e ↕				
S	C ×				
↓	C ↕				
D ÷	D ×				
e ↕	B +				
÷	c ↕				
e ↕	D ×				
e −	b +				
D ↕	D ↕				
D ↓	D ↓				
+	r ◊				
+	C +				

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

olivetti P 602

Code 502.12	Date	Page 1/3

Title		
Triangle with Three Sides Given		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program is used to find the angles of a triangle where the three sides are known.

If there is no solution, the red light will light.

Sample run:

		V
a	500	S
b	300	S
c	400	S
Area in sq. ft.	60000.0000	A ◊
acres	1.3774	A ◊
	89.0000	◊
A	59.0000	◊
	59.9999	A ◊
	36.0000	◊
B	52.0000	◊
	11.6315	A ◊
	53.0000	◊
C	7.0000	◊
	48.3684	A ◊

Method: the sides are rearranged so that a is the smallest side.

The semiperimeter $s = \frac{a + b + c}{2}$ is computed

then the area $\Delta = \sqrt{(s-a)(s-b)(s-c)}$

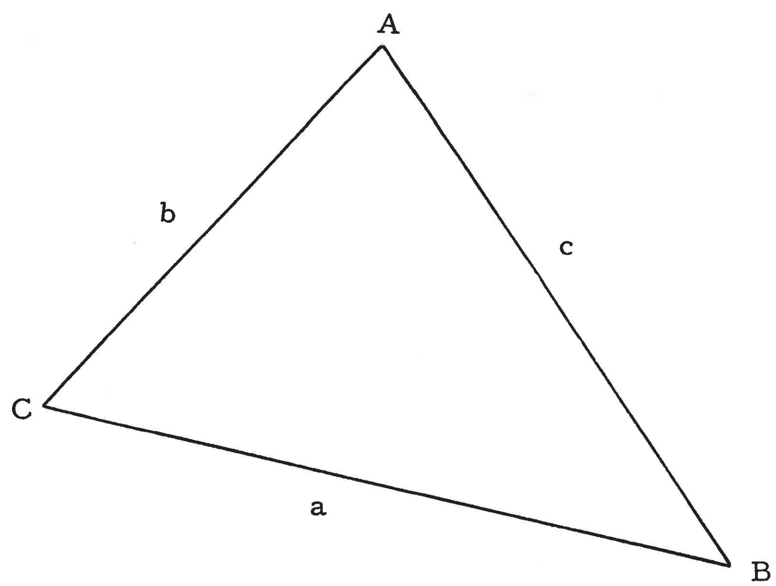
$$B = \arctan [\Delta / s(s-b)]$$

$$C = \arctan [\Delta / s(s-c)]$$

$$A = \frac{\pi}{2} - B - C$$

These are rearranged to print out in the order A, B, C corresponding to the order of entry of their opposing sides.

Accuracy: if one of the angles is close to 180°, accuracy may be lost.



olivetti P 602

Code	Date	Page
502. 12		3/3

Title

Triangle with Three Sides Given

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel
1	as desired	FL

A ↑	d X	f ↓	◆		
d ↓	A ↕	c ↕	f ↕		
f ↑	A S	/ S	a V		
S	D W	f ↕	/ S		
c ↑	A √	c ↓	f ↓		
↓	r ◊	D √	c √		
S	A ◊	C ↓			
C ↑	e ↕	D √			
C √	e ↓	d ↓			
S	R S	D √			
d ↑	E ‡	V			
C √	A ◊	d √			
c ↕	r ◊	R S			
/ S	e ↓	f X			
f ↕	D ‡	r ↕			
c ↓	e ↕	◊			
C ◆	e ↓	R S			
d ◆	C ÷	F X			
A ↑	/ *	r ↕			
d ↑	R Z	◊			
‡	C ↕	R S			
D ↕	e ↓	F X			
D ↓	d ‡	A ◊			
d -	/ *	r ◊			
d ↕	R Z	d √			
D ↓	d ↕	c √			
C -	R S	-			
C ↕	e ↓	A S			
D ↓	d -	A V			
c -	C -	f ↓			
D X	c ↕	A ↑			
C X	/ S	d ↑			

Register	Value	Register
Ab'		b
AB'		B
Ac'		c
AC'		C
Ad'		d
AD'		D
Ae'		e
AE'		E
Af'		f
AF'		F
Bc'		Rc
BC'		RC
Bd'		Rd
BD'		RD
Be'	$\pi/2$	Re
BE'	43560	RE
Bf'	$360/\pi$	Rf
BF'	60	RF

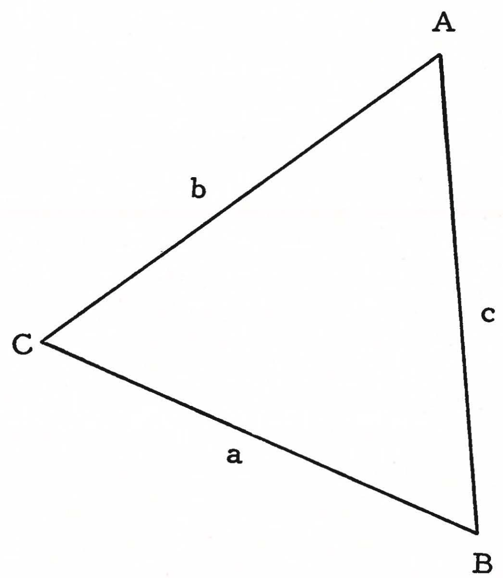
```
               60  RF ◊
114.591559026164  Rf ◊
            43560  RE ◊
1.57079632679489  Re ◊
```

Title
Triangle with Two Sides and One Angle Given

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel

This program is used to solve a triangle when two sides and an angle are known whether included or opposite.

Sample run: If a, C, b are known, depress V; if C, b, c are known, depress W. In the second case, there are two possible solutions.



		V
a	400	S
C	46	S
	34	S
	3	S
b	350	S
Area in sq. ft.	50832.9371	A ◊
acres	1.1669	A ◊
A	75.0000	◊
	31.0000	◊
	20.8628	A ◊
	57.0000	◊
	54.0000	◊
B	36.1371	A ◊
c	300.0002	• ◊

		W
C	28	S
	46	S
	10	S
b	4.4321	S
c	2.5098	S
Area in sq. ft.	5.5540	A ◊
acres	0.0001	A ◊
	93.0000	◊
A	1.0000	◊
	42.4789	A ◊
	58.0000	◊
C	12.0000	◊
	7.5210	A ◊
b	5.2074	c ◊
Area in sq. ft.	2.7330	A ◊
acres	0.0000	A ◊
	29.0000	◊
A	25.0000	◊
	57.5210	A ◊
	121.0000	◊
C	47.0000	◊
	52.4789	A ◊
b	2.5625	c ◊

Method:

If a, b, C are given:

The sin and cos of C are computed

$$\text{area} = \frac{ab \sin C}{2}$$

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

$$B = 2 \tan^{-1} \frac{b \sin C}{a + c - b \cos C}$$

$$A = 180^\circ - B - C$$

If C, b, c given

$$a = b \cos C \pm \sqrt{c^2 - b^2 \sin^2 C}$$

There are two possible solutions depending on the sign of the radical.

$$B = 2 \tan^{-1} \frac{b \sin C}{a + C - b \cos C} \qquad A = 180^\circ - B - C$$

Accuracy: If C is the included angle then accuracy is lost for C very small.

If C is opposite a given side, then accuracy is lost for C small or for one of the unknown angles close to 90°.

olivetti P 602

Code 502.13	Date	Page 4/4

Title

Triangle with Two Sides and One Angle Given

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel

r ◊	C +	S	÷
S	c ↕	↓	A ◊
c ↑	F √	R S	B S
E √	c ◊	E ÷	f ÷
f ↕	F ↓	B +	A ◊
c ↓	C −	R S	r ◊
F −	c ↕	E ÷	c ↓
−	F √	b +	e +
c X	c ◊	R S	F −
b ↕	W	e X	f ↓
d ↓	d √	B S	R ÷
A X	B S	E ÷	/ *
b +	E X	E ↕	R Z
A √	R S	r ◊	A +
e ↕	e ÷	S	D ↕
F √	r ↕	d ↑	R S
e ◊	◊	E ↓	e ↓
V	R S	/ *	E −
/ W	E X	R W	D −
r ◊	r ↕	d X	D √
E √	◊	F ↕	D ↓
A X	R S	E ↓	D √
f ↑	E X	/ *	r ◊
b ↕	A ◊	R V	f √
S	r ◊	d X	
e ↑	d √	r ◊	
↓	e √	e √	
X	r ◊	f √	
b −	S	f ↓	
A √	b ↑	c X	
C ↕	S	A ↑	
F ↓	B ↑	d ↑	

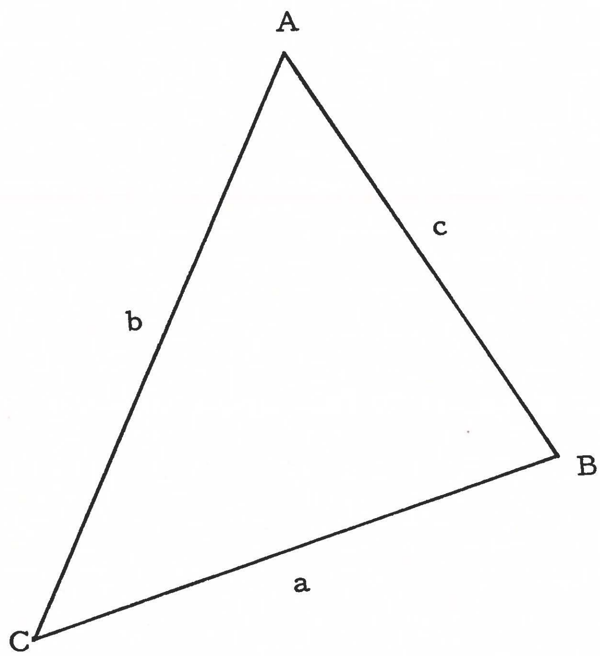
Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

3.14159265358979 Re ◊
180 BE ◊
60 RE ◊
43560 Bf ◊

Title		
Triangle With One Side and Two Angles Given		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program computes the missing parts of a triangle when given two angles and any side.

Sample run: If included side is given depress V; if given side is not included, depress W.



Included Side		V
	28	S
A	46	S
	10	S
c	4.4321	S
B	29	S
	25	S
	57.519	S
	121.00000	A◊
C	47.00000	A◊
	52.48100	b◊
a	2.50980	A◊
b	2.56254	A◊
area in sq. ft.	2.73308	A◊
acres	0.00006	A◊
Side Not Included		W
c	35	S
B	69	S
	47	S
	35	S
C	56	S
	35	S
	46	S
A	53.00000	A◊
	36.00000	A◊
	39.00000	b◊
a	33.75042	A◊
b	39.34520	A◊
area in sq. ft.	554.27970	A◊
acres	0.01272	A◊

Method: Given A, c, B or c, B, C, the missing angle is computed as 180° minus the sum of the two given angles.

Then:

$$a = \frac{c \sin A}{\sin C}$$

$$b = \frac{c \sin B}{\sin C}$$

$$\text{Area} = \frac{ab \sin C}{2}$$

Accuracy: Accuracy is lost if any of the angles of the triangle is very small.

olivetti P 602

Code	Date	Page
502.15		4/4

Title

Triangle With One Side and Two Angles Given

Number of Sides	Lower Decimal Wheel	Upper Decimal Wheel
1	as desired	FL

r ◊	+	R S
C √	B S	E ÷
E ↕	e X	/ ✱
E √	S	R V
R S	+	D ↕
e ↓	r ◊	R S
D -	c √	E ÷
E -	d √	/ ✱
C ↕	B S	R V
C ↓	e +	E ↕
F √	-	R S
V	/ ÷	E ÷
/ W	R ↕	/ ✱
r ◊	b ↕	R V
E √	R ↕	c X
r ◊	/ ÷	D ÷
C √	A ◊	A ◊
C ↕	R ↓	E ↕
R S	A ◊	c X
e ↓	b ◊	D ÷
C -	r ◊	A ◊
D -	d √	X
E ↕	e √	E X
E ↓	S	A ↑
F √	c ↑	d ↑
W	r ◊	÷
c √	C √	r ◊
S	D ↕	A ◊
↓	e √	B S
B S	f √	f ÷
e X	D √	A ◊
S	C ↓	f √

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

```
          60.......... Be◊
      648000.......... Re◊
206264.806247095 RE◊
       43560.......... Bf◊
```

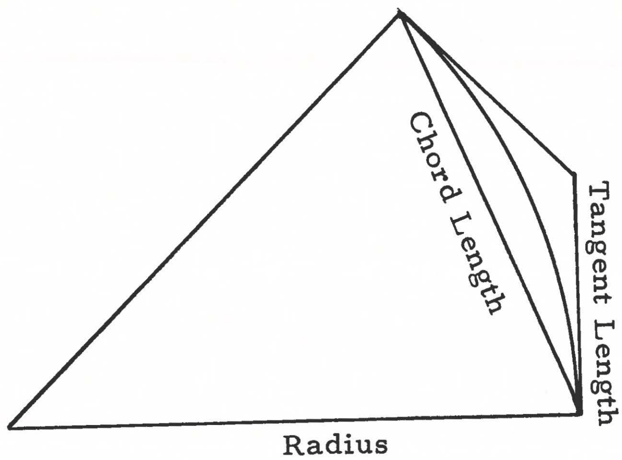
Title		
Circular Curve, Given Radius and Angle or Arc Length		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program computes the following parameters of a circular curve given the radius and the angle or arc length:

1) Arc length or angle
2) Tangent Length
3) Chord Length
4) Area of sector
5) Area of segment
6) Area of triangle bounded by chord and 2 radii.

The angle subtended at the center must be less than 180°.

Sample run: If arc length is given, depress V; if the central angle is given, depress W.



Method: Given the radius and either the arc or the angle, the other is found by the relation

arc = radius X angle in radians

then $\cos\frac{\theta}{2}$ is computed

and $\sin\frac{\theta}{2} = \sqrt{1 - \cos^2\frac{\theta}{2}}$

Tangent = $R \sin\frac{\theta}{2} / \cos\frac{\theta}{2}$

Chord = $2R \sin\frac{\theta}{2}$

Sector = $\frac{1}{2} R\theta^2$

Segment = sector - triangle

Triangle = $R^2 \sin\frac{\theta}{2} \cos\frac{\theta}{2}$

Accuracy: Accuracy may be lost for central angles close to 180°.

		V
arc length	3284.69	S
radius	3625.47	S
	51.00	◊
central angle	54.00	◊
	36.72	A ◊
tan length	1764.74	A ◊
chord length	3173.49	A ◊
sector area	5954272.52	A ◊
segment area	781800.82	A ◊
triangle area	5172471.70	C ◊

		W
	63	S
central angle	31	S
	47	S
radius	5012.36	S
arc length	5557.71	A ◊
tan length	3103.54	A ◊
chord length	5277.35	A ◊
sector area	13928644.03	A ◊
segment area	2683683.07	A ◊
triangle area	11244960.95	C ◊

olivetti P 602

Code 502.21	Date	Page 4/4

Title

Circular Curve, Given Radius and Angle or Arc Length

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

r ◊	↓	◆	b ↓		
S	R S	A ↑	B X		
f ↑	E ÷	d ↑	F X		
S	B ◆	+	C ↕		
F ↑	R S	/ *	C −		
f ↓	E +	R W	A ◊		
+	b ◆	A X	C ◊		
c ↕	r ◊	B ↑	c √		
c ↓	R S	A ↑			
r ◊	e X	d ↓			
B S	B S	−			
E X	E ÷	A √			
R S	c ↕	/ S			
e +	c ↓	R W			
r ↕	S	B ↕			
◊	F ↑	r W			
R S	X	F X			
E X	A ◊	b ↕			
r ↕	f ↕	r ◊			
◊	C √	b ↓			
R S	W	B ÷			
E X	c √	A ◊			
A ◊	c ↓	b ↓			
C √	R S	A ◆			
V	e −	A ◊			
/ W	/ ◆	f ↓			
r ◊	A S	F X			
S	R V	A ↑			
b ↑	/ −	d ↑			
S	−	+			
B ↑	−	A ◊			
S	r V	C ↕			

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

1.57079632679489 R e ◊
90 B E ◊
60 R E ◊

Title		
Circular Curve Given Radius and Chord		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program computes the following parameters for a circular curve, when the radius and chord length are given:

1) Tangent length
2) Arc length
3) Area of sector
4) Area of segment
5) Area of triangle bounded by chord and two radii
6) Angle subtended at center

The computation is always made for the subtended angly less than 180°.

The red light goes on if there is no solution.

Sample run:

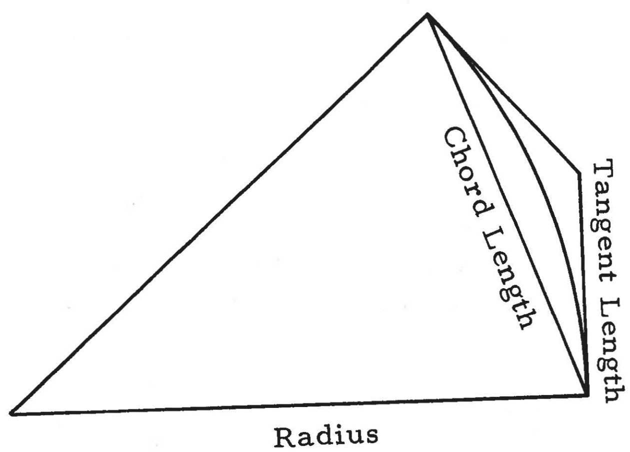
		V
chord length	8956.14	S
radius	5216.48	S
Tangent length	8730.83	A◊
Arc length	10769.25	A◊
Sector area	28088790.43	A◊
Segment area	16107502.91	A◊
Triangle area	11981287.52	D◊
Central angle	118.00	◊
	17.00	◊
	6.88	A◊

Method:

If the radius R and the chord C are given, the following computations are made:

Tangent	=	$\frac{CR}{\sqrt{4R^2 - C^2}}$
A	=	$\arctan\left(\frac{C}{\sqrt{4R^2 - C^2}}\right)$
Arc	=	$2RA$
Sector	=	R^2A
Segment	=	R^2A - Triangle
Triangle	=	$\frac{1}{4}C\sqrt{4R^2 - C^2}$
Angle	=	$\frac{360\ A}{\pi}$

Accuracy: Accuracy may be lost when the central angle is close to 180°.



olivetti P 602

Code 502.22	Date	Page 3/3

Title

Circular Curve Given Radius and Chord

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

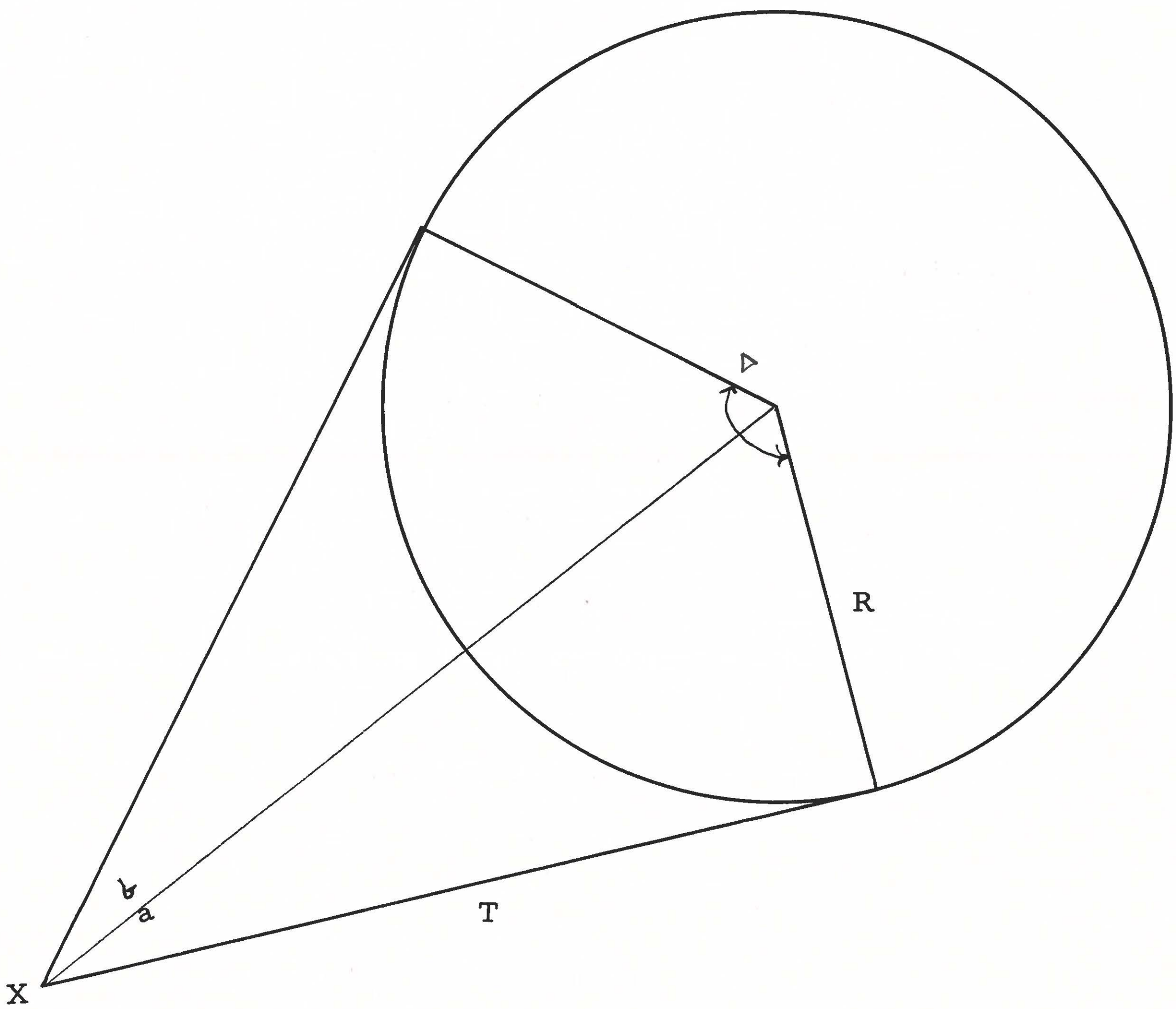
r ◊	↓
S	F X
C ↑	r ◊
S	A ◊
F ↑	D ↕
↓	C X
A +	A ↑
C −	a +
D ↕	÷
D ↓	D ↕
+	D −
+	A ◊
A ↕	D ◊
D X	r ◊
A S	c ↓
D W	R S
A √	e X
D ↕	r ↕
C ↓	◊
D ÷	B S
/ *	E X
R Z	r ↕
c ↕	◊
C ↓	B S
F X	E X
D ÷	A ◊
r ◊	V
A ◊	
c ↓	
F X	
A +	
A ◊	

Ab′	b
AB′	B
Ac′	c
AC′	C
Ad′	d
AD′	D
Ae′	e
AE′	E
Af′	f
AF′	F
Bc′	Rc
BC′	RC
Bd′	Rd
BD′	RD
Be′	Re
BE′	RE
Bf′	Rf
BF′	RF

```
              60  BE◊
114.591559029439  Re◊
```

Title		
Circular Curve With Two Tangents Given		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

If two tangents to a circular curve are given by their bearings and the point where they intersect, this program will compute the points of intersection with the circular curve, the angle subtended, the arc length between intersection points and the distance along the tangents to the points of intersection.



Sample run:

			V
First Bearing		79	S
		20	S
		53	S
		2	S
Second Bearing		16	S
		31	S
		15	S
		3	S
Intersection	N	-103.87	S
	E	386.98	S
Radius		546.23	S
Central angle		84.0000	A ◊
		7.0000	A ◊
		52.0000	B ◊
Arc length		802.0649	A ◊
Tangent length		492.9605	• ◊
Intersection	N	-194.9900	A ◊
	E	871.4459	A ◊
Intersection	N	-576.4793	A ◊
	E	246.7997	A ◊

Accuracy: Accuracy may be lost if the two tangents are almost parallel.

Method: The two bearings A, and B are converted to azimuth in seconds.

Then

$$a = \frac{B-A}{2}$$

$$b = \frac{B-A}{2}$$

The central angle = 180° - 2|a|. sin a, cos a, sin b, and cos b, are computed. Let R be the radius of the circle.

tangent length T = R cot a
and the intersections are

$$X_N + T\ (\cos b \cos a + \sin b \sin a)$$

$$X_E + T\ (\sin b \cos a - \cos b \sin a)$$

$$X_N + T\ (\cos b \cos a - \sin b \sin a)$$

$$X_E + T\ (\sin b \sin a + \cos b \sin a)$$

olivetti P 602

Code 502.23	Date	Page 4/4

Title

Circular Curve With Two Tangents Given

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

r ◊	R ↕	B ↕	c ↓	e X	
C √	B ↕	B ↓	C +	B +	
c ↕	R ↕	e X	e X	r ◊	
C √	/ ÷	b ÷	D +	c √	
c −	A ◊	e ↕	A ◊		
A ↑	R ↓	e ◊	V		
d ↑	A ◊	r ◊	c √		
÷	B ◊	b ↓	S		
c ↕	r ◊	c X	↓		
c +	C ↓	b ↕	B S		
R S	e X	C X	e X		
E ÷	R S	C ↕	S		
b ↕	E ÷	B X	+		
S	A ◊	B ↕	B S		
d ↑	r ◊	c X	e X		
S	b ↓	c ↕	S		
D ↑	/ *	B ↓	+		
S	R W	b +	B ↕		
e ↑	b ↕	e X	S		
r ◊	/ *	d +	↓		
c ↓	R V	A ◊	A ↑		
A ↓	c ↕	c ↓	d ↑		
A ↕	R S	C −	/ ÷		
A +	E ÷	e X	R ↕		
R S	b ↕	D +	A S		
e +	C ↕	A ◊	R V		
C ↕	b ↓	r ◊	B ↓		
C ↓	/ *	B ↓	A ↕		
A ↑	R V	b −	B ↕		
D S	b ↕	e X	r V		
r X	/ *	d +	R ↓		
/ ÷	R W	A ◊	R S		

Ab'	b
AB'	B
Ac'	c
AC'	C
Ad'	d
AD'	D
Ae'	e
AE'	E
Af'	f
AF'	F
Bc'	Rc
BC'	RC
Bd'	Rd
BD'	RD
Be'	Re
BE'	RE
Bf'	Rf
BF'	RF

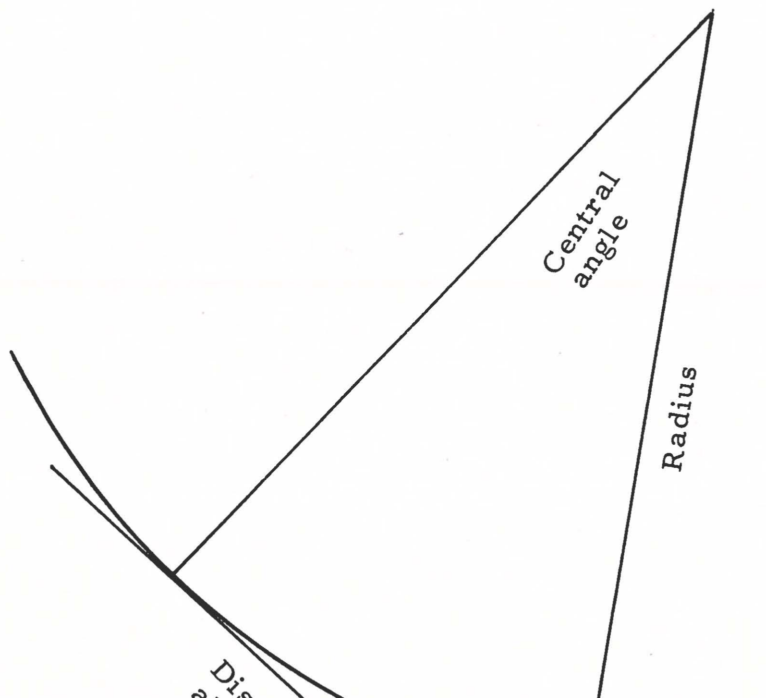
60 Be ◊
648000 Re ◊
206264.806247096 RE ◊

olivetti P 602

Code 502.24	Date	Page 1/4

Title		
Circular Curve, Offsets from Tangent		
Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

This program computes the offsets of a circular curve of given radius from a set of stations on the tangent, and also the total central angle for the curve to the last station. It is used when it is desired to lay off a small circular curve by tape alone.



Sample run:

		V
Radius of curve	5000	S
Total distance on tangent	623	S
Distance between stations	100	S
Distance along tangent	100.0000	D ◊
Offset from tangent	1.0001	A ◊
Second station	200.0000	D ◊
	4.0016	A ◊
Third station	300.0000	D ◊
	9.0081	A ◊
Fourth station	400.0000	D ◊
	16.0256	A ◊
Fifth station	500.0000	D ◊
	25.0628	A ◊
Sixth station	600.0000	D ◊
	36.1305	A ◊
Seventh station	623.0000	D ◊
	38.9647	A ◊
Total central angle	7.0000	A ◊
	9.0000	A ◊
	27.5647	B ◊

Accuracy: The offsets are computed to 14 significant figures, and the angle to 10 significant figures.

Method: For R = Radius and D = Distance along tangent,

$$\text{offset} = R - \sqrt{R^2 - D^2}$$

and

$$\text{central angle} = \arctan\left[\frac{R}{\sqrt{R^2 - D^2}}\right]$$

This angle is converted from radians to degrees, minutes and seconds.

olivetti P 602

Code 502.24	Date	Page 4/4

Title

Circular Curve, Offsets from Tangent

Number of Sides 1	Lower Decimal Wheel as desired	Upper Decimal Wheel FL

r ◊	R S				
S	e X				
↓	A ↑				
X	D S				
c ↑	r X				
C ↕	/ ÷				
S	R ↕				
↓	B ↕				
S	R ↕				
-	/ ÷				
d ↑	A ◊				
D ↑	R ↓				
r ◊	A ◊				
r V	B ◊				
e ↕	V				
C √	c √				
D ↓	D ↓				
d +	A X				
D ↕	C -				
e ↓	A √				
-	c -				
A S	A ↕				
R V	D ◊				
D +	A ◊				
D ↕	r ◊				
C √	c √				
-					
D ↓					
R +					
A ↕					
/ *					
R Z					

Register	Contents	Register
Ab'		b
AB'		B
Ac'	R	c
AC'	R^2	C
Ad'	Distance between stations	d
AD'	Present station	D
Ae'	Counter	e
AE'		E
Af'		f
AF'		F
Bc'		Rc
BC'		RC
Bd'		Rd
BD'		RD
Be'		Re
BE'		RE
Bf'		Rf
BF'		RF

2 0 6 2 6 4 . 8 0 6 2 4 7 0 9 6 R ◊