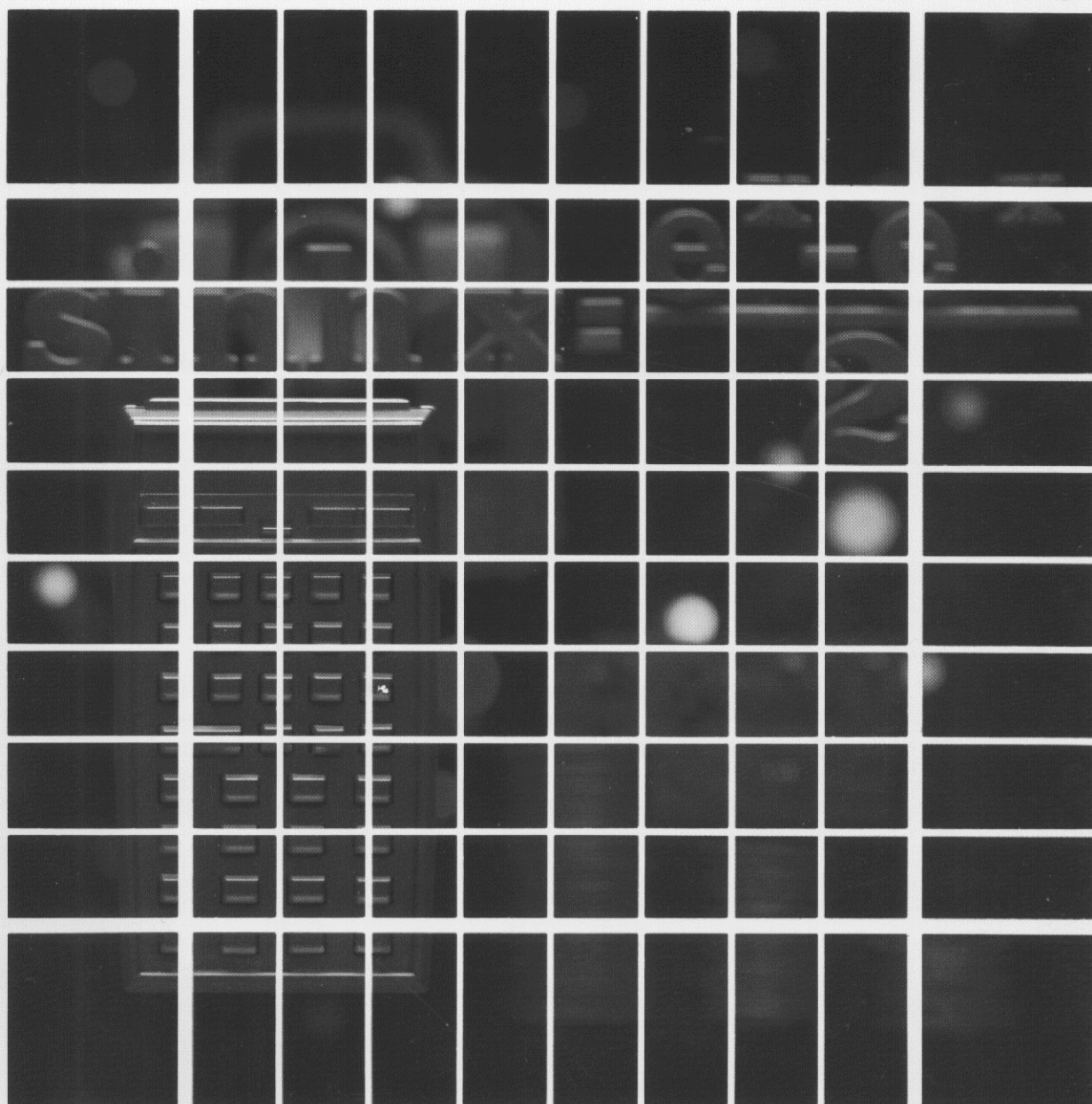


HEWLETT-PACKARD

HP-41C

USERS'
LIBRARY SOLUTIONS

Geometry



NOTICE

The program material contained herein is supplied without representation or warranty of any kind. Hewlett-Packard Company therefore assumes no responsibility and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.

INTRODUCTION

This HP-41C Solutions book was written to help you get the most from your calculator. The programs were chosen to provide useful calculations for many of the common problems encountered.

They will provide you with immediate capabilities in your everyday calculations and you will find them useful as guides to programming techniques for writing your own customized software. The comments on each program listing describe the approach used to reach the solution and help you follow the programmer's logic as you become and expert on your HP calculator.

KEYING A PROGRAM INTO THE HP-41C

There are several things that you should keep in mind while you are keying in programs from the program listings provided in this book. The output from the HP 82143A printer provides a convenient way of listing and an easily understood method of keying in programs without showing every keystroke. This type of output is what appears in this handbook. Once you understand the procedure for keying programs in from the printed listings, you will find this method simple and fast. Here is the procedure:

- At the end of each program listing is a listing of status information required to properly execute that program. Included is the SIZE allocation required. Before you begin keying in the program, press **[XEQ]** **[ALPHA]** **SIZE** **[ALPHA]** and specify the allocation (three digits; e.g., 10 should be specified as 010).

Also included in the status information is the display format and status of flags important to the program. To ensure proper execution, check to see that the display status of the HP-41C is set as specified and check to see that all applicable flags are set or clear as specified.

- Set the HP-41C to PRGM mode (press the **[PRGM]** key) and press **[GTO]** **[•]** **[•]** to prepare the calculator for the new program.
- Begin keying in the program. Following is a list of hints that will help you when you key in your programs from the program listings in this handbook.
 - When you see " (quote marks) around a character or group of characters in the program listing, those characters are ALPHA. To key them in, simply press **[ALPHA]**, key in the characters, then press **[ALPHA]** again. So "SAMPLE" would be keyed in as **[ALPHA]** "SAMPLE" **[ALPHA]**.
 - The diamond in front of each LBL instruction is only a visual aid to help you locate labels in the program listings. When you key in a program, ignore the diamond.
 - The printer indication of divide sign is /. When you see / in the program listing, press **[÷]**.
 - The printer indication of the multiply sign is ×. When you see × in the program listing, press **[×]**.
 - The ⌈ character in the program listing is an indication of the **[APPEND]** function. When you see ⌈, press **[APPEND]** in ALPHA mode (press **[•]** and the K key).
 - All operations requiring register addresses accept those addresses in these forms:

nn (a two-digit number)

IND nn (INDIRECT: **[•]**, followed by a two-digit number)

X, Y, Z, T, or L (a STACK address: **[•]** followed by X, Y, Z, T, or L)

IND X, Y, Z, T or L (INDIRECT stack: **[•]** **[•]** followed by X, Y, Z, T, or L)

Indirect addresses are specified by pressing **[•]** and then the indirect address. Stack addresses are specified by pressing **[•]** **[•]** followed by X, Y, Z, T, or L. Indirect stack addresses are specified by pressing **[•]** **[•]** and X, Y, Z, T, or L.

Printer Listing

```

01♦LBL "SAM
PLE"
02 "THIS IS
A"
03 ⌈SAMPLE
"
04 AVIEW
05 6
06 ENTER↑
07 -2
08 /
09 ABS
10 STO IND
L
11 "R3="
12 ARCL 03
13 AVIEW
14 RTN

```

Keystrokes

```

♦ [LBL] [ALPHA] SAMPLE [ALPHA]
[ALPHA] THIS IS A [ALPHA]
[ALPHA] ⌈ [APPEND] SAMPLE
[•] AVIEW [ALPHA]
6
[ENTER]
2 [CHS]
[+]
[XEQ] [ALPHA] ABS [ALPHA]
[STO] [•] L
[ALPHA] R3= [•] [ARCL] 03
[•] [AVIEW]
[ALPHA]
[•] [RTN]

```

Display

```

01 LBLT SAMPLE
02T THIS IS A
03T ⌈ SAMPLE
04 AVIEW
05 6
06 ENTER /
07 -2
08 /
09 ABS
10 STO IND L
11T R3=
12 ARCL 03
13 AVIEW
14 RTN

```



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	This program will accurately locate points of tangency between straight lines and arcs, between straight lines and a circle, and between two circles and a straight line.	
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	This program will calculate the point of intersection of two lines.	
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	This program calculates the coordinate of equidistant points on a straight line.	
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	This program complements "Grid of Points: Calculate All Points". It allows the calculation of specified points of grid.	

9. TANGENT CIRCLE TO TWO STRAIGHT LINES WITH A GIVEN RADIUS . . 46

This program calculates the X and Y coordinates of the center of a circle with a given radius tangent to two given straight lines.

10. DISTANCE BETWEEN LINES IN SPACE 52

Given two lines, each defined by any two points, this program calculates the shortest distance between the two lines. (This program was written to determine the clearance between electrical distribution circuits and guy wires or supporting structures).

SINE PLATE SOLUTIONS, COORDINATE OF A POINT, POSITION AND SLOPE OF AN INCLINED HOLE

This program, with the aid of commonly available dowel pins and measuring tools, (and in the case of the sine plate, a sine plate and height blocks), will aid in accurately finding angles and heights for sine plates, position and slope of inclined holes and coordinates of points. All angular output is in decimal degrees.

Solution for Finding Coordinates of a Point:

Given: a , b , d and e , determine x and y

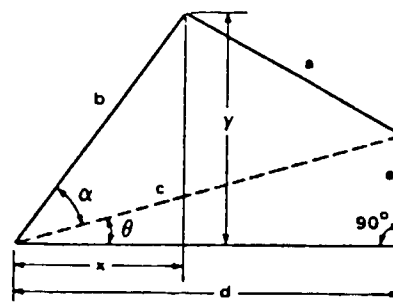
$$c = d^2 + e^2$$

$$\cos \alpha = \frac{b^2 + c^2 - a^2}{2bc}$$

$$\tan \theta = \frac{e}{d}$$

$$x = b \cos (\alpha + \theta)$$

$$y = b \sin (\alpha + \theta)$$

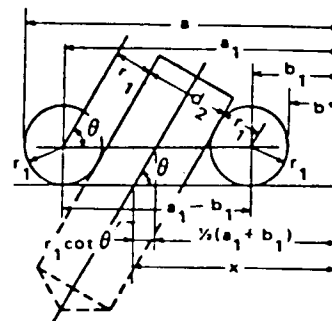


Solution for Finding the Location and Angle of an Inclined Hole:

Given: a , b , r_1 , and d_2 , determine θ and x

$$\sin \theta = \frac{2r_1 + d_2}{a_1 - b_1}$$

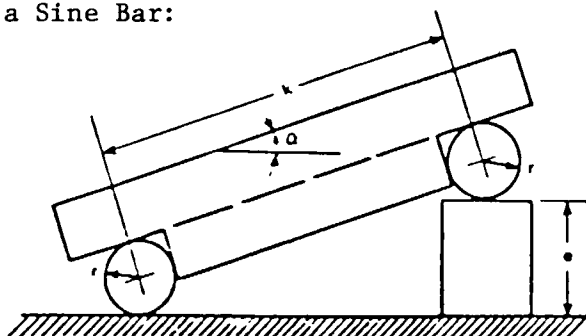
$$x = \frac{1}{2}(a_1 + b_1) + r_1 \cot \theta$$



Interchangeable Solutions for Work with a Sine Bar:

Given: e and k , determine α

$$\sin \alpha = \frac{e}{k}$$



Example:

Given: $a = 1.630''$
 $b = .260''$

$r_1 = .200''$
 $d_2 = .4375''$

Find θ , x of an inclined hole.

Keystrokes:

[USER]
 [XEQ] [ALPHA] SIZE [ALPHA] 003
 [XEQ] [ALPHA] SINP [ALPHA]
 [B]
 .2 [R/S]
 .4375 [R/S]
 1.63 [R/S]
 .26 [R/S]
 [R/S]

Display:

(set USER mode)

SINE PLATE
 R1 ?
 d2 ?
 a?
 b?
 THETA=59.7007
 X=1.0619

User Instructions

				SIZE: 003
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Key in the program and set USER mode.		[USER]	
2	Initialize the program.		[XEQ] SINP	SINE PLATE
3	To solve for the coordinates of a point:		[A]	a?
	Input a	a	[R/S]	b?
	b	b	[R/S]	d?
	d	d	[R/S]	e?
	and e.	e	[R/S]	X=(x)
			[R/S]	Y=(y)
4	To solve for the location and angle of an			
	inclined hole.		[B]	R1 ?
	Input r_1	r_1	[R/S]	d2 ?
	d_2	d_2	[R/S]	a?
	a	a	[R/S]	b?
	and b.	b	[R/S]	THETA=(θ)
			[R/S]	X=(x)
5	To solve for angles with a sine bar:		[C]	e?
	Input e	e	[R/S]	K?
	and K.	K	[R/S]	ALPHA=(α)
6	To solve for heights (of blocks) with a			
	sine bar:		[D]	K?
	Input K	K	[R/S]	ALPHA?
	and α .	α	[R/S]	e=(e)

Program Listings

01♦LBL "SIN P"	Initialize	50 PROMPT	
02 "SINE PL ATE"		51 +	
03 AVIEW		52 "a?"	
04 STOP		53 PROMPT	
05♦LBL A		54 RCL 00	
06 "a?"		55 -	
07 PROMPT	Input a, b, d, and e	56 STO 01	
08 X↑2		57 "b?"	
09 "b?"		58 PROMPT	
10 PROMPT	Calculate x,y	59 RCL 00	
11 STO 00		60 +	
12 X↑2		61 ST+ 01	
13 -		62 -	
14 "d?"		63 /	
15 PROMPT		64 ASIN	
16 "e?"		65 "THETA"	
17 PROMPT		66 XEQ 11	
18 X<>Y		67 TAN	
19 R-P		68 1/X	
20 STO 01		69 RCL 00	
21 X<>Y		70 *	
22 STO 02		71 RCL 01	
23 RDN		72 2	
24 X↑2		73 /	
25 -		74 +	
26 CHS		75 "X"	
27 RCL 00		76 XEQ 11	
28 /		77♦LBL C	Input e, k
29 RCL 01		78 "e?"	Calculate α
30 /		79 PROMPT	
31 2		80 "K?"	
32 /		81 PROMPT	
33 ACOS		82 /	
34 RCL 02		83 ASIN	
35 +		84 "ALPHA"	
36 RCL 00		85 XEQ 11	
37 P-R		86♦LBL D	Input α, k
38 "X"		87 "K?"	Calculate e
39 XEQ 11		88 PROMPT	
40 RDN		89 "ALPHA?"	
41 "Y"		90 PROMPT	
42 XEQ 11		91 SIN	
43♦LBL B		92 *	
44 "R1 ?"		93 "e"	
45 PROMPT	Input r ₁ , d ₂ , a, b	94♦LBL 11	Display routine
46 STO 00		95 "f="	
47 2		96 ARCL X	
48 *	Calculate θ, x	97 AVIEW	
49 "d2 ?"		98 STOP	
		99 RTN	
		100 .END.	

REGISTERS, STATUS, FLAGS, ASSIGNMENTS ⁵

DATA REGISTERS			STATUS			
00	b or r ₁	50	SIZE <u>003</u> TOT. REG. <u>29</u> USER MODE ENG _____ FIX _____ SCI _____ ON <u>X</u> OFF _____ DEG <u>X</u> RAD _____ GRAD _____			
	c or a ₁ , a ₁ + b ₁		FLAGS # INIT S/C SET INDICATES CLEAR INDICATES			
	θ					
05		55				
10		60				
15		65				
20		70				
25		75				
30		80				
35		85				
			ASSIGNMENTS FUNCTION KEY FUNCTION KEY			
40		90				
45		95				

V NOTCHES AND LONG RADII

This program, together with commonly available dowel pins and height gages, will accurately determine the position and angles of "V" grooves or notches. With the same tools, long radii are accurately measured. All angular output is in decimal degrees.

Given: a, b, c, d, r_1 and r_2 , determine x, y, α and β :

$$\tan \phi = \frac{b_1 - a_1}{d_1 - c_1}$$

$$\overline{O_1 O_2} = \frac{d_1 - c_1}{\cos \phi}$$

$$\sin \theta = \frac{r_2 - r_1}{\overline{O_1 O_2}}$$

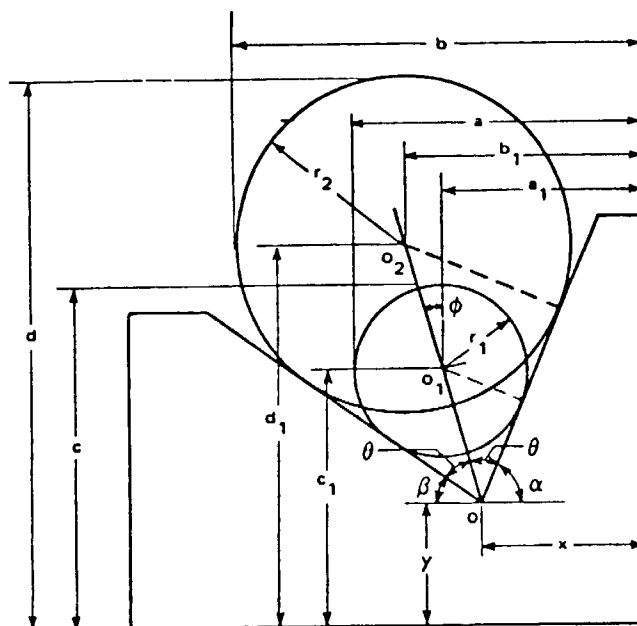
$$\overline{O O_1} = \frac{r_1}{\sin \theta}$$

$$x = a_1 - \overline{O O_1} \sin \phi$$

$$y = c_1 - \overline{O O_1} \cos \phi$$

$$\alpha = 90^\circ + \phi - \theta$$

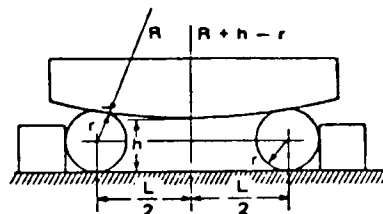
$$\beta = 90^\circ - \phi - \theta$$



Given: L, r and h , determine R :

$$(R + r)^2 = (R + h - r)^2 + \left(\frac{1}{2}\right) L^2$$

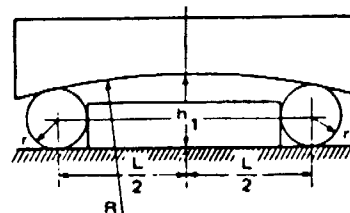
$$R = \frac{L^2}{8(2r - h)} - \frac{h}{2}$$



Given L, r and h , determine R :

$$(R - r)^2 = (R - h_1 + r)^2 + \left(\frac{1}{2} L\right)^2$$

$$R = \frac{L^2}{8(h_1 - 2r)} + \frac{h_1}{2}$$



Reference: HP-67/97 "Geometry" Users' Library Solutions Book.

Example 1:

For Long Radius (concave arc)

L = 1.000''
 r = .15625''
 h = .270''

Keystrokes:

[USER]
 [XEQ] [ALPHA] SIZE [ALPHA] 006
 [XEQ] [ALPHA] VNOTCH [ALPHA]
 [B]
 1 [R/S]
 .15625 [R/S]
 .27 [R/S]

Display:

(set USER mode)

V NOTCHES, L.R.

L?

R?

H?

R=2.8062

Example 2:

For "V" Notch

a = 1.500'' d = 2.800''
 b = 2.125'' r₁ = .4375''
 c = 1.750'' r₂ = .875''

Keystrokes:

[A]
 .875 [R/S]
 .4375 [R/S]
 1.5 [R/S]
 2.125 [R/S]
 1.75 [R/S]
 2.8 [R/S]
 [R/S]
 [R/S]
 [R/S]

Display:

R2?

R1?

a?

b?

c?

d?

X=0.8750

Y=0.7000

ALPHA=63.9420

BETA=29.9010

Program Listings

01*LBL "VNO TCH"		50 STO 02	
02 CF 00	Initialize	51 "b?"	
03 "V NOTCH ES, L.R."		52 PROMPT	
04 AVIEW		53 RCL 00	
05 STOP		54 -	
06*LBL C	Concave arcs	55 -	
07 SF 00		56 "c?"	
08*LBL B		57 PROMPT	
09 "L?"		58 RCL 01	
10 PROMPT	Input L, r, h	59 -	
11 X↑2		60 STO 03	
12 "R?"		61 "d?"	
13 PROMPT	Calculate R	62 PROMPT	
14 2		63 RCL 00	
15 *		64 -	
16 FS? 00		65 -	Calculate x, y, α, β
17 CHS		66 STO 05	
18 "H?"		67 /	
19 PROMPT		68 ATAN	
20 FS?C 00		69 STO 04	
21 CHS		70 CLX	
22 STO 00		71 RCL 05	
23 -		72 CHS	
24 8		73 RCL 04	
25 *		74 COS	
26 /		75 /	
27 RCL 00		76 RCL 00	
28 2		77 RCL 01	
29 /		78 -	
30 -		79 /	
31 "R"		80 1/X	
32*LBL 11		81 ASIN	
33 "f="	Display routine	82 STO 05	
34 ARCL X		83 RCL 04	
35 AVIEW		84 RCL 01	
36 STOP		85 LASTX	
37 RTN		86 /	
38*LBL A		87 P-R	
39 "R2?"		88 ST- 03	
40 PROMPT		89 RDN	
41 STO 00	Input a, b, c, d, r ₁ , and r ₂	90 ST- 02	
42 "R1?"		91 RCL 04	
43 PROMPT		92 90	
44 STO 01		93 RCL 05	
45 -		94 -	
46 "a?"		95 +	
47 PROMPT		96 LASTX	
48 LASTX		97 RCL 04	
49 -		98 -	
		99 "X"	
		100 RCL 02	Display results

[illegible]



INTERNAL AND EXTERNAL TAPERS

This program, used with commonly available dowel pins, height bases, and balls, will accurately determine the position and angle of both external and internal tapers. All angular output is in decimal degrees.

Internal Taper:

Given b , c , d , r_1 and r_2 , determine C , D , ϕ and R_1

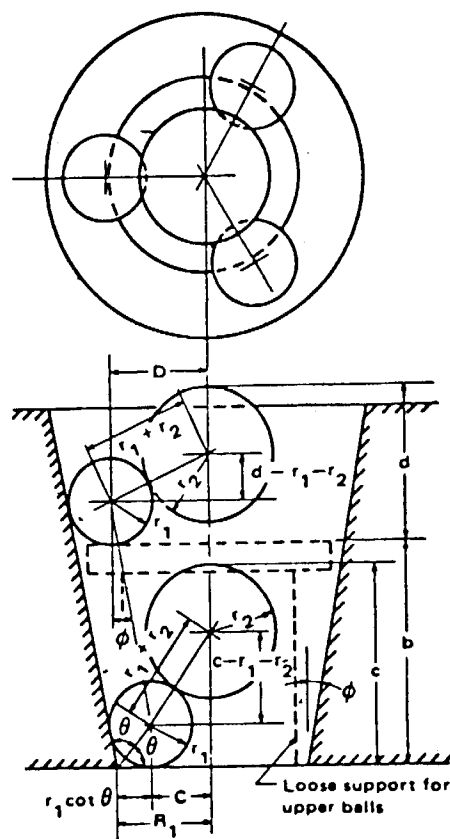
$$C^2 = 2c(r_1 + r_2) - c^2$$

$$D^2 = 2d(r_1 + r_2) - d^2$$

$$\tan \phi = \frac{D - C}{b}$$

$$2\theta = 90^\circ + \phi$$

$$R_1 = C + r_1 \cot \theta$$



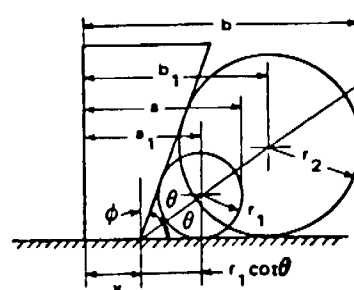
External Taper Case #1:

Given: a , b , r_1 and r_2 , determine x and ϕ

$$\tan \theta = \frac{r_2 - r_1}{b_1 - a_1}$$

$$\phi = 90^\circ - 2\theta$$

$$x = a_1 - r_1 \cot \theta$$



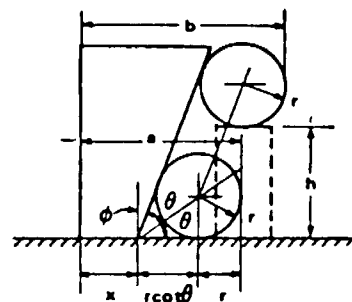
External Taper Case #2:

Given a , b , r and h , determine x and ϕ

$$\tan 2\theta = \frac{h}{b-a}$$

$$\phi = 90 - 2\theta$$

$$x = a - r - r \cot \theta$$

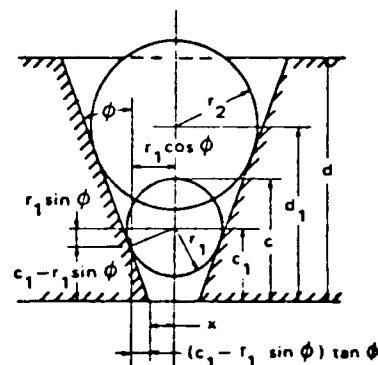


External Taper Case #3:

Given c , d , r_1 and r_2 , determine x and ϕ

$$\sin \phi = \frac{r_2 - r_1}{d_1 - c_1}$$

$$x = \frac{r_1}{\cos \phi} - c_1 \tan \phi$$



Reference: HP-67/97 "Geometry" Users' Library Solutions Book.

Example:

Internal Taper: Given $b = 1.150''$ $r_1 = .21875''$
 $c = 1.050''$ $r_2 = .34375''$
 $d = .800''$

Keystrokes:

[USER]
 [XEQ] [ALPHA] SIZE [ALPHA] 005
 [XEQ] [ALPHA] TAPERS [ALPHA]
 [A]
 .21875 [R/S]
 .34375 [R/S]
 1.05 [R/S]
 .8 [R/S]
 1.15 [R/S]
 [R/S]
 [R/S]
 [R/S]

Display:

(set USER mode)
 IN. ,EX. TAPERS
 R1?
 R2?
 c?
 d?
 b?
 C=0.2806
 D=0.5099
 PHI=11.2753 (deg)
 R1=0.4601

User Instructions

SIZE: 005

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Key in the program and set USER mode.		[USER]	
2	Initialize the program.		[XEQ] TAPERS	IN. ,EX. TAPERS
3	Determine the case from the drawings.			
4	For internal taper:		[A]	R1?
		r_1	[R/S]	R2?
		r_2	[R/S]	c?
		c	[R/S]	d?
		d	[R/S]	b?
		b	[R/S]	C=(c)
			[R/S]	D=(d)
			[R/S]	PHI=(ϕ)
			[R/S]	R1=(R1)
5	For an external taper, case 1:		[B]	R1?
		r_1	[R/S]	R2?
		r_2	[R/S]	a?
		a	[R/S]	b?
		b	[R/S]	X=(x)
			[R/S]	PHI=(ϕ)
6	For an external taper, case 2:		[C]	H?
		h	[R/S]	b?
		b	[R/S]	a?
		a	[R/S]	R?
		r	[R/S]	X=(x)
			[R/S]	PHI=(ϕ)
7	For an external taper, case 3:		[D]	R1?
		r_1	[R/S]	R2?
		r_2	[R/S]	c?

Program Listings

01♦LBL "TAPERS"		50 RCL 04	
02 CF 01	Initialize	51 "D"	
03 "IN.,EX.TAPERS"		52 XEQ 11	
04 AVIEW		53 RCL 03	
05 STOP		54 "PHI"	
06♦LBL A		55 XEQ 11	
07 "R1?"		56 RCL 02	
08 PROMPT		57 RCL 00	
09 STO 00		58 +	
10 "R2?"		59 "R1"	
11 PROMPT		60 XEQ 11	
12 +		61♦LBL B	
13 2	Internal taper	62 "R1?"	
14 *		63 PROMPT	
15 STO 01	Input r_1 , r_2 , c , d and b	64 STO 00	
16 "c?"		65 "R2?"	
17 PROMPT		66 PROMPT	
18 *	Calculate C , D , ϕ , $R1$	67 STO 01	
19 LASTX		68 -	
20 $X\uparrow 2$		69 "a?"	
21 -		70 FS? 01	
22 SQRT		71 "c?"	
23 STO 02		72 PROMPT	
24 RCL 01		73 RCL 00	
25 "d?"		74 -	
26 PROMPT		75 STO 02	
27 *		76 "b?"	
28 LASTX		77 FS? 01	
29 $X\uparrow 2$		78 "d?"	
30 -		79 PROMPT	
31 SQRT		80 RCL 01	
32 STO 04		81 -	
33 RCL 02		82 -	
34 -		83 /	
35 "b?"		84 FS?C 01	
36 PROMPT		85 RTN	
37 /		86 ATAN	
38 ATAN		87 STO 03	
39 STO 03		88 LASTX	
40 90		89 $1/X$	
41 +		90 RCL 00	
42 2		91 *	
43 /		92 RCL 02	
44 TAN		93 -	
45 $1/X$		94 CHS	
46 ST* 00		95 90	
47 RCL 02		96 RCL 03	
48 "C"		97 2	
49 XEQ 11		98 *	
		99 -	
		100 X<>Y	
			External taper case 1
			Input r_1 , r_2 , a and b
			Calculate x , ϕ

Program Listings

101 GTO 05		152 AVIEW
102 LBL C		153 STOP
103 "H?"		154 RTN
104 PROMPT	External taper, case 2	155 .END.
105 "b?"		
106 PROMPT		
107 "a?"	Input h, b, a and r	
108 PROMPT		
109 STO 00		
110 -	Calculate x, ϕ	60
111 /		
112 ATAN		
113 STO 01		
114 CHS		
115 90		
116 +		
117 RCL 00		
118 RCL 01		
119 2		
120 /		
121 TAN		70
122 1/X		
123 1		
124 +		
125 "R?"		
126 PROMPT		
127 *		
128 -		
129 LBL 05		
130 "X"	Display x, ϕ	80
131 XEQ 11		
132 RDN		
133 "PHI"		
134 XEQ 11		
135 LBL D		
136 SF 01	External taper, case 3	
137 XEQ B		
138 ASIN		
139 STO 03		
140 RCL 00	Input r ₁ , r ₂ , c and d	90
141 LASTX		
142 RCL 02	Calculate x, ϕ	
143 *		
144 -		
145 RCL 03		
146 COS		
147 /		
148 GTO 05		
149 LBL 11		
150 "I="	Display routine	
151 ARCL X		00

[illegible]

POINTS OF TANGENCY WITH CIRCLES AND ARCS

This program will accurately locate points of tangency between straight lines and arcs, between straight lines and a circle, and between two circles and a straight line. All angular outputs are in decimal degrees.

Solutions for Finding Point of Tangency With an Arc:

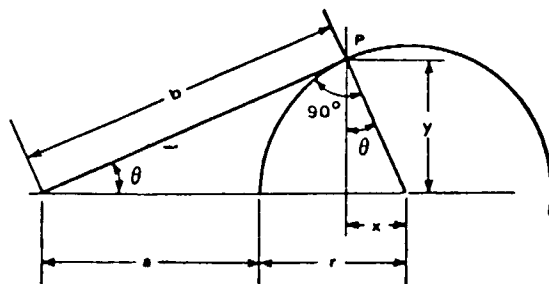
Given: a and r , determine x and y

$$b^2 = (a + r)^2 - r^2$$

$$\sin \theta = \frac{r}{a + r} = \frac{y}{b} = \frac{x}{r}$$

$$x = \frac{r^2}{a + r}$$

$$y = \frac{br}{a + r}$$



Solution for Finding Points of Tangency with A Circle:

Given: b , c and r , determine x_1 and y_1

$$a = \sqrt{b^2 + c^2} - r$$

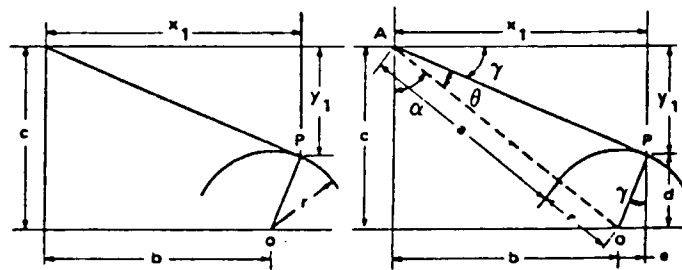
$$\sin \theta = \frac{r}{a + r}$$

$$\tan \alpha = \frac{b}{c}$$

$$\gamma = 90^\circ - \theta - \alpha$$

$$e = r \sin \gamma, \text{ then } x_1 = b + e$$

$$d = r \cos \gamma, \text{ then } y_1 = c - d$$



Solution for Finding Points of Tangency with Two Circles:

Given: a , b , r_1 and r_2 , determine x_1 , y_1 , x_2 and y_2

$$c = a^2 + b^2$$

$$\tan \theta = \frac{b}{a}$$

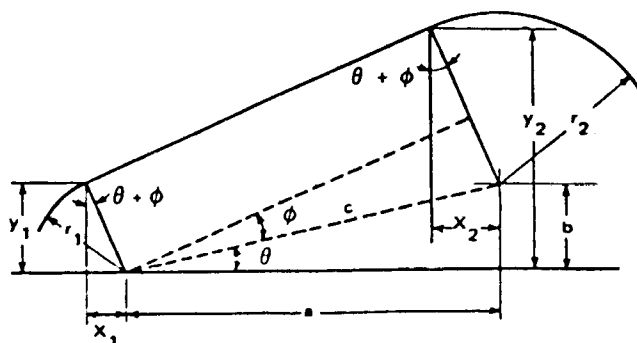
$$\sin \phi = \frac{r_2 - r_1}{c}$$

$$x_1 = r_1 \sin(\theta + \phi)$$

$$y_1 = r_1 \cos(\theta + \phi)$$

$$x_2 = r_2 \sin(\theta + \phi)$$

$$y_2 = b + r_2 \cos(\theta + \phi)$$



Reference: HP-67/97 "Geometry" Users' Library Solutions Book.

Example:

Find the point of tangency with an arc given: $a = 1.125''$ and $r = .750''$.

Keystrokes:

```
[USER]
[XEQ] [ALPHA] SIZE [ALPHA] 007
[XEQ] [ALPHA] POINTS [ALPHA]
[A]
1.125 [R/S]
.75 [R/S]
[R/S]
[R/S]
[R/S]
```

Display:

(set USER mode)

POINTS OF T.

a?

R?

X=0.3000

Y=0.6874

b=1.7185

THETA=23.5782 (deg)

User Instructions

				SIZE: 007
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Key in the program and set USER mode.		[USER]	
2	Initialize the program.		[XEQ] POINTS	POINTS OF T.
3	Determine the case from the drawings.			
4	For the point of tangency with an arc:		[A]	a?
		a	[R/S]	R?
		r	[R/S]	X=(x)
			[R/S]	Y=(y)
	(optional)		[R/S]	b=(b)
			[R/S]	THETA=(θ)
5	For the point of tangency with a circle:		[B]	b?
		b	[R/S]	c?
		c	[R/S]	R?
		r	[R/S]	X1=(x ₁)
			[R/S]	Y1=(y ₁)
	(optional)		[R/S]	a=(a)
			[R/S]	THETA=(θ)
			[R/S]	ALPHA=(α)
6	For the points of tangency with two			
	circles:		[C]	a?
		a	[R/S]	b?
		b	[R/S]	R2?
		r ₂	[R/S]	R1?
		r ₁	[R/S]	X1=(x ₁)
			[R/S]	Y1=(y ₁)
			[R/S]	X2=(x ₂)
			[R/S]	Y2=(y ₂)
	(optional)		[R/S]	c=(c)

DISPLAY

[illegible]

Program Listings

01*LBL "POINTS OF T."	Initialize	50 STO 02	Calculate x_1 , y_1 , a , θ , α
02 "POINTS OF T."		51 LASTX	
03 AVIEW		52 LASTX	
04 STOP		53 RCL 02	
05*LBL A		54 +	
06 "a?"		55 /	
07 PROMPT	Tangency with an arc	56 ASIN	
08 "R?"		57 STO 03	
09 PROMPT		58 90	
10 STO 01		59 -	
11 +	Input a, r	60 CHS	
12 STO 00		61 RCL 00	
13 X↑2		62 RCL 01	
14 RCL 01		63 /	
15 X↑2	Calculate x, y, b, θ	64 ATAN	
16 -		65 STO 05	
17 SQRT		66 -	
18 STO 02		67 RCL 04	
19 RCL 01		68 P-R	
20 RCL 00		69 RCL 01	
21 /		70 -	
22 *		71 CHS	
23 LASTX		72 X<>Y	
24 RCL 01		73 RCL 00	
25 *		74 +	
26 "X"		75 "X1"	
27 XEQ 11		76 XEQ 11	
28 RDN		77 RDN	
29 "Y"		78 "Y1"	
30 XEQ 11		79 XEQ 11	
31 RCL 02		80 RCL 02	
32 "b"		81 "a"	
33 XEQ 11		82 XEQ 11	
34 /		83 RCL 03	
35 ASIN		84 "THETA"	
36 "THETA"		85 XEQ 11	
37 XEQ 11		86 RCL 05	
38*LBL B		87 "ALPHA"	
39 "b?"		88 XEQ 11	
40 PROMPT	Tangency with a circle	89*LBL C	
41 STO 00		90 "a?"	
42 "c?"		91 PROMPT	Tangency with two circles
43 PROMPT		92 STO 00	
44 STO 01		93 "b?"	
45 R-P	Input b, c, r	94 PROMPT	
46 "R?"		95 STO 01	
47 PROMPT		96 R-P	
48 STO 04		97 STO 02	
49 -		98 "R2?"	
		99 PROMPT	
		100 STO 04	

Program Listings

101 "R1?"		51	
102 PROMPT			
103 STO 05			
104 -	Input a, b, r ₁ ,		
105 /	r ₂		
106 1/X			
107 ASIN			
108 STO 03	Calculate x ₁ ,		
109 RCL 01	y ₁ , x ₂ , y ₂ , c,		
110 RCL 00	θ, φ	60	
111 /			
112 ATAN			
113 STO 00			
114 +			
115 STO 06			
116 RCL 05			
117 P-R			
118 X<>Y			
119 "X1"			
120 XEQ 11		70	
121 X<>Y			
122 "Y1"			
123 XEQ 11			
124 RCL 06			
125 RCL 04			
126 P-R			
127 RCL 01			
128 +			
129 X<>Y			
130 "X2"			
131 XEQ 11		80	
132 X<>Y			
133 "Y2"			
134 XEQ 11			
135 RCL 02			
136 "c"			
137 XEQ 11			
138 RCL 00			
139 "THETA"			
140 XEQ 11			
141 RCL 03		90	
142 "PHI"			
143♦LBL 11			
144 "I="			
145 ARCL X	Display routine		
146 AVIEW			
147 STOP			
148 RTN			
149 .END.			
50		00	

LINE-LINE INTERSECTION

This program will calculate the point of intersection of two lines. For each line the user specifies two points, or one point and the angle from horizontal, or one point and the slope. Slope will be converted to angle by the relation $\theta = \tan^{-1}(\text{slope})$. Given two points (x_1, y_1) and (x_2, y_2) on the line, the angle is:

$$\theta = \tan^{-1} \frac{y_2 - y_1}{x_2 - x_1}$$

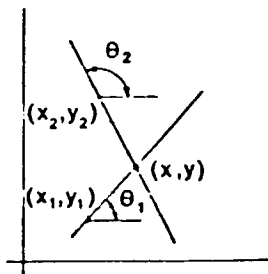
(x, y) = Coordinates of point of intersection

(x_1, y_1) = Coordinates of point on line one

(x_2, y_2) = Coordinates of point on line two

θ_1 = Angle from horizontal to line one

θ_2 = Angle from horizontal to line two



Equations:

$$x = \frac{x_1 \tan \theta_1 - x_2 \tan \theta_2 + y_2 - y_1}{\tan \theta_1 - \tan \theta_2}$$

$$y = y_1 + (x - x_1) \tan \theta_1$$

Reference: HP-67/97 "Geometry" Users' Library Solutions Book.

Example:

Find the point of intersection of two lines, one passing through (10,20) (40,30), and the other through (-10,30) (50,10).

Keystrokes:

```
[USER]
[XEQ] [ALPHA] SIZE [ALPHA] 007
[XEQ] [ALPHA] LINE [ALPHA]
[A]
10 [R/S]
20 [R/S]
40 [R/S]
30 [R/S]
[A]
10 [CHS] [R/S]
30 [R/S]
50 [R/S]
10 [R/S]
[R/S]
```

Display:

```
(set USER mode)

LINE INTRSEC
X1 ?
Y1 ?
X2 ?
Y2 ?
NEXT LINE ?
X1 ?
Y1 ?
X2 ?
Y2 ?
X=15.0000
Y=21.6667
```

User Instructions

				SIZE: 007
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Key in the program and set USER mode.		[USER]	
2	Initialize the program.		[XEQ] LINE	LINE INTRSEC
	LINE-LINE INTERSECTION:			
3a	Input two points on line:		[A]	X1 ?
		x ₁	[R/S]	Y1 ?
		y ₁	[R/S]	X2 ?
		x ₂	[R/S]	Y2 ?
		y ₂	[R/S]	NEXT LINE ?
3b	Or, input one point and the slope, m:		[B]	X ?
		x	[R/S]	Y ?
		y	[R/S]	M ?
		m	[R/S]	NEXT LINE ?
3c	Or, input one point and the angle θ :		[C]	X ?
		x	[R/S]	Y ?
		y	[R/S]	THETA ?
		θ	[R/S]	NEXT LINE ?
3d	Or, for the case where the second line is vertical, input the x coordinate:	x	[D]	Y=(y)
4	Repeat step 3 for the second line.			
5	After the parameters for the second line are input, the intersection coordinates are automatically displayed.		[R/S]	X=(x) Y=(y)
6	For a new case, go to step 2.			

Program Listings

01*LBL "LINE E"		45 TAN	
02 CF 00	Initialize	46*LBL a	
03 1.006		47 ISG 00	
04 STO 00		48 STO IND	
05 "LINE IN TRSEC"		00	
06 AVIEW		49 "NEXT LI NE ?"	
07 STOP		50 ISG 00	
08*LBL 01		51 GTO 01	
09 AVIEW		52*LBL E	
10 STOP		53 RCL 01	Calculate x, y
11*LBL A	Input x_1, y_1 and x_2, y_2	54 RCL 03	
12 "X1 ?"		55 *	
13 PROMPT		56 RCL 04	
14 STO IND	Calculate θ	57 RCL 06	
00		58 *	
15 ISG 00		59 -	
16 "Y1 ?"		60 RCL 05	
17 PROMPT		61 +	
18 STO IND		62 RCL 02	
00		63 -	
19 X<>Y		64 RCL 03	
20 "X2 ?"		65 RCL 06	
21 PROMPT		66 -	
22 -		67 /	
23 X<>Y		68 "X"	
24 "Y2 ?"		69 XEQ 11	
25 PROMPT		70*LBL D	
26 -		71 RCL 01	
27 /		72 -	
28 1/X		73 RCL 03	
29 GTO a		74 *	
30*LBL C		75 RCL 02	
31 SF 00		76 +	
32*LBL B		77 "Y"	
33 "X ?"		78*LBL 11	
34 PROMPT	Input x, y and slope or θ	79 "F="	Display routine
35 STO IND		80 ARCL X	
00		81 AVIEW	
36 ISG 00		82 STOP	
37 "Y ?"		83 RTN	
38 PROMPT		84 .END.	
39 STO IND			
00			
40 "M ?"			
41 FS? 00			
42 "THETA ?"			
"			
43 PROMPT			
44 FS?C 00			
		00	

[illegible]

POINTS ON A STRAIGHT LINE

This program calculates the coordinates of equidistant points on a straight line.

Equations:

Point P_i is calculated by

$$x_i = x_1 + (i - 1)H \cos \theta$$

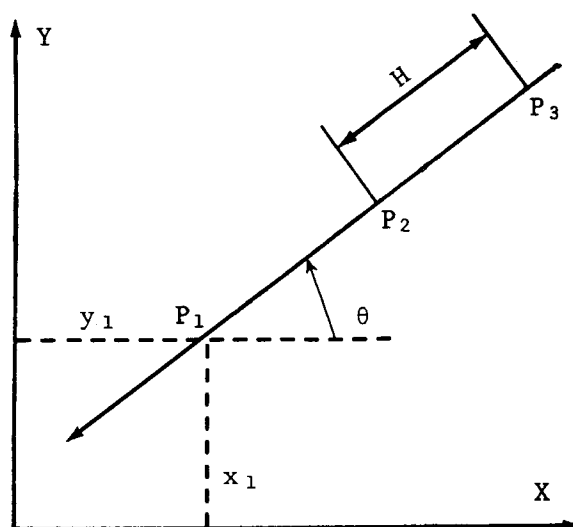
$$y_i = y_1 + (i - 1)H \sin \theta, \quad i = \pm 0, 1, 2, \dots$$

where

$P_1 = (x_1, y_1)$ (the starting point);

θ is the angle of the straight line with the x axis;

H is the distance between consecutive points in the direction of the straight line.



Reference: HP-67/97 "Geometry" Users' Library Solutions Book.

Example:

For the straight line designated by $X_1 = 10$, $Y_1 = 10$, $\theta = -30^\circ$, calculate P_i for $H = 20$ and $i = 1, 2$, and 3 .

Keystrokes:

```
[USER]
[XEQ] [ALPHA] SIZE [ALPHA] 005
[XEQ] [ALPHA] PLINE [ALPHA]

10 [R/S]
10 [R/S]
30 [CHS] [R/S]
20 [R/S]
1 [R/S]
[R/S]
[R/S] [R/S]
[R/S]
[R/S] [R/S]
[R/S]
```

Display:

```
(set USER mode)

PTS. ON ST. L.
X1 ?
Y1 ?
THETA ?
H ?
I ?
X=10.0000
Y=10.0000
X=27.3205
Y=0.0000
X=44.6410
Y=-10.0000
```

[illegible]

Program Listings

01♦LBL "PLI NE"		51	
02 "PTS. ON ST. L."	Initialize		
03 AVIEW			
04 PSE	Input x_1 , y_1 , θ , and H		
05 "X1 ?"			
06 PROMPT			
07 STO 02			
08 "Y1 ?"			
09 PROMPT	Input I	60	
10 STO 03			
11 "THETA ?"			
12 PROMPT	Calculate x , y		
13 "H ?"			
14 PROMPT			
15 P-R			
16 STO 00			
17 RDN			
18 STO 01		70	
19♦LBL 01			
20 "I ?"			
21 PROMPT			
22 1			
23 -			
24 STO 04			
25 RCL 00			
26 *			
27 RCL 02			
28 +		80	
29 "X"			
30 XEQ 11			
31 RCL 04			
32 RCL 01			
33 *			
34 RCL 03			
35 +			
36 "Y"			
37 XEQ 11			
38 RCL 04		90	
39 2			
40 +			
41 GTO 01			
42♦LBL 11			
43 "F="			
44 ARCL X	Display routine		
45 AVIEW			
46 STOP			
47 RTN			
48 .END.		00	

DATA REGISTERS				STATUS			
00	h cos	50		SIZE 005	TOT. REG. 19	USER MODE	
	h sin			ENG	FIX	SCI	ON X OFF
	x ₁			DEG X	RAD	GRAD	
	y ₁			FLAGS			
	i+1			#	INIT S/C	SET INDICATES	CLEAR INDICATES
05		55					
10		60					
15		65					
20		70					
25		75					
30		80					
35		85					
				ASSIGNMENTS			
				FUNCTION	KEY	FUNCTION	KEY
40		90					
45		95					

GRID OF POINTS: CALCULATE ALL POINTS

This program calculates the X and Y coordinates of all the points on a grid defined as follows:

a. First direction of a grid:

the angle, θ_1 , with the positive X axis

the algebraic distance between each point, H_1 , in this direction

the total number, N_1 , of points (including the first one)

b. Second direction of the grid:

the angle, θ_2 , with the positive X axis

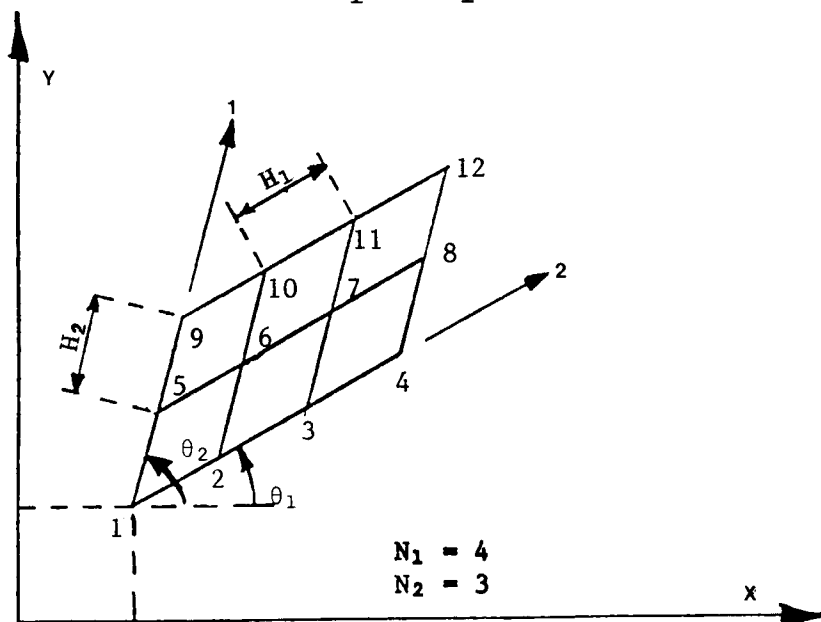
the algebraic distance between two points, H_2 , in that direction

the total number, N_2 , of points (including the first one)

c. Starting point (noted 1) with coordinates X and Y.

The calculation is incremental from point 1 to point (N_1, N_2) . For each point we find:

The index i , the X_i and Y_i coordinates



Reference: HP-67/97 "Geometry" Users' Library Solutions Book.

Example:

Find the grid points for:

$$\theta_1 = 0^\circ, \quad H_1 = 10, \quad N_1 = 3, \quad X_1 = 10$$

$$\theta_2 = 90^\circ, \quad H_2 = 20, \quad N_2 = 2, \quad Y_2 = 10$$

Keystrokes:

[USER]
 [XEQ] [ALPHA] SIZE [ALPHA] 010
 [XEQ] [ALPHA] GRIDALL [ALPHA]

 3 [R/S]
 2 [R/S]
 10 [R/S]
 10 [R/S]
 10 [R/S]
 20 [R/S]
 0 [R/S]
 90 [R/S]
 [R/S]
 [R/S]
 [R/S]
 :
 [R/S]
 [R/S]
 [R/S]

Display:

(set USER mode)

GRID ALL PTS
 N1 ?
 N2 ?
 X1 ?
 Y1 ?
 H1 ?
 H2 ?
 THETA 1 ?
 THETA 2 ?
 X1=10.0000
 Y1=10.0000
 X2=20.0000
 Y2=10.0000
 :
 X6=30.0000
 Y6=30.0000
 END

[illegible]

Program Listings

01♦LBL "GRI DALL"		48 STO 05	
02 1	Initialize	49 GTO d	
03 STO 09		50♦LBL 01	
04 CF 29		51 1	
05 "GRID AL L PTS"		52 ST+ 09	
06 AVIEW		53 ISG 06	Loop control routine
07 PSE		54 GTO d	
08 "N1 ?"		55 RCL 08	
09 PROMPT		56 STO 06	
10 1		57 ISG 07	
11 -		58 GTO d	
12 1 E3	Input N1, N2, X1, X2, H1, H2 01, 02	59 "END"	
13 /		60 AVIEW	
14 STO 06		61 STOP	
15 STO 08		62♦LBL d	
16 "N2 ?"		63 RCL 06	
17 PROMPT		64 INT	
18 1		65 RCL 02	
19 -		66 *	Calculate X, Y
20 1 E3		67 RCL 04	
21 /		68 RCL 07	
22 STO 07		69 INT	
23 "X1 ?"		70 *	
24 PROMPT		71 +	
25 STO 00		72 RCL 00	
26 "Y1 ?"		73 +	
27 PROMPT		74 "X"	
28 STO 01		75 XEQ 12	
29 "H1 ?"		76 RCL 03	
30 PROMPT		77 RCL 06	
31 +		78 INT	
32 "H2 ?"		79 *	
33 PROMPT		80 RCL 05	
34 STO 04		81 RCL 07	
35 "THETA 1 ?"	Calculate ΔX's and ΔY's	82 INT	
36 PROMPT		83 *	
37 LASTX		84 +	
38 P-R		85 RCL 01	
39 STO 02		86 +	
40 RDN		87 "Y"	
41 STO 03		88 XEQ 12	
42 "THETA 2 ?"		89 GTO 01	
43 PROMPT		90♦LBL 12	
44 RCL 04		91 FIX 0	
45 P-R		92 ARCL 09	Display routine
46 STO 04		93 "I="	
47 RDN		94 FIX 4	
		95 ARCL X	
		96 AVIEW	
		97 STOP	
		98 RTN	

DATA REGISTERS				STATUS			
00	X1	50		SIZE	010	TOT. REG.	37
	Y1			ENG		FIX	
	ΔX_1			DEG	X	RAD	
	ΔY_1					SCI	
	ΔX_2					ON	X OFF
05	ΔY_2	55		FLAGS			
	1.00N ₁ -1			#	INIT S/C	SET INDICATES	CLEAR INDICATES
	1.00N ₂ -1			29	C	For proper display format	
	.00N ₁ -1 Counter						
10		60					
15		65					
20		70					
25		75					
30		80					
35		85					
				ASSIGNMENTS			
				FUNCTION KEY		FUNCTION KEY	
40		90					
45		95					

GRID OF POINTS: CALCULATE DISCRETE POINTS

This program calculates the cartesian coordinates of specified points of a grid defined as follows:

a. First direction:

the angle θ_1 (related to positive X axis)

the distance between each point, H_1 , in this direction

b. Second direction:

the angle θ_2

the distance H_2

c. Starting point (origin of the grid), X_{11} and Y_{11} .

Formulas:

$$X_{ij} = X_1 + (j-1) \Delta X_1 + (i-1) \Delta X_2$$

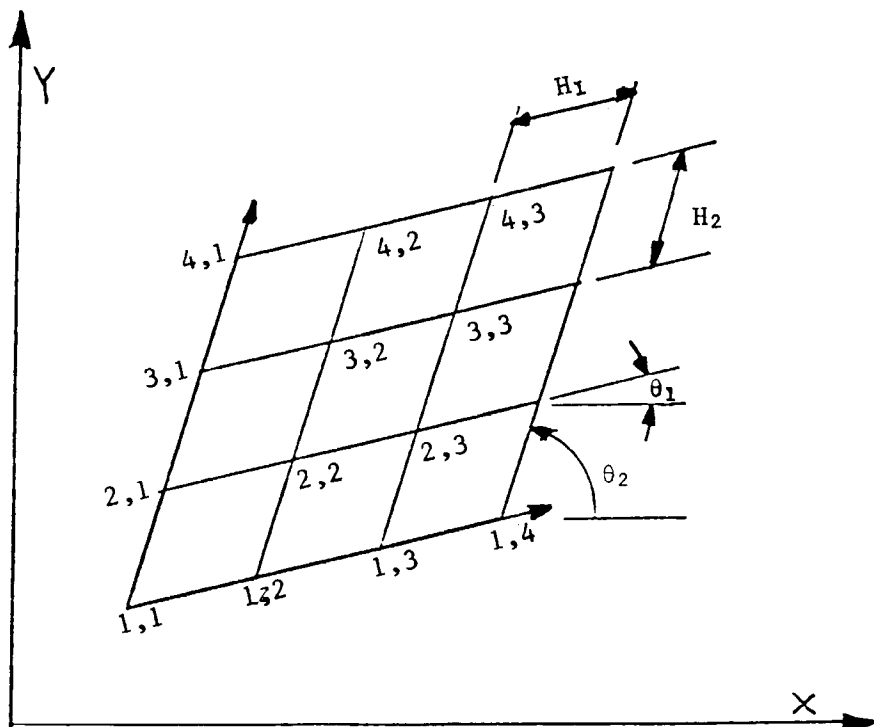
$$Y_{ij} = Y_1 + (j-1) \Delta Y_1 + (i-1) \Delta Y_2$$

where $\Delta X_1 = H_1 \cos \theta_1$

$$\Delta Y_1 = H_1 \sin \theta_1$$

$$\Delta X_2 = H_2 \cos \theta_2$$

$$\Delta Y_2 = H_2 \sin \theta_2$$



Example:

For a grid with its origin at (1,1), $H_1 = 2$, $H_2 = 3$, $\theta_1 = 30$, and $\theta_2 = 90^\circ$, find the cartesian coordinates for the following grid coordinates: (1,1), (2.5,4).

Keystrokes:

```
[USER]
[XEQ] [ALPHA] SIZE [ALPHA] 008
[XEQ] [ALPHA] GRIDISC [ALPHA]

1 [R/S]
1 [R/S]
2 [R/S]
3 [R/S]
30 [R/S]
90 [R/S]
1 [R/S]
1 [R/S]
[R/S]
[A]
2.5 [R/S]
4 [R/S]
[R/S]
```

Display:

```
(set USER mode)

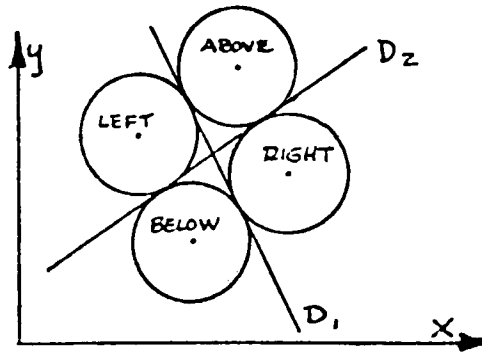
GRID DIS. PTS.
X1 ?
Y1 ?
H1 ?
H2 ?
THETA 1 ?
THETA 2 ?
I?
J?
X=1.0000
Y=1.0000
I?
J?
X=6.1962
Y=8.5000
```


DATA REGISTERS				STATUS					
00	X ₁	50		SIZE 008		TOT. REG. 27		USER MODE	
	Y ₁			ENG		FIX		SCI	
	ΔX ₁			DEG X		RAD		GRAD	
	ΔY ₁								
	ΔX ₂								
05	ΔY ₂	55							
	I-1								
	J-1								
10		60							
15		65							
20		70							
25		75							
30		80							
35		85							
40		90							
45		95							

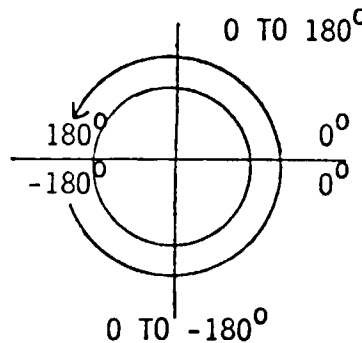
FLAGS			
#	INIT S/C	SET INDICATES	CLEAR INDICATES

TANGENT CIRCLE TO TWO STRAIGHT LINES WITH A GIVEN RADIUS

This program calculates the X and Y coordinates of the centers of the four circles with a given radius, R, which are tangent to two given lines.



The straight lines are each defined by one point and an angle which follows the convention below:



The straight lines are first shifted by R. The calculation is then one of the intersection of two straight lines.

Formulas used:

$$X = \frac{(Y_2 - Y_1) \cos \theta_1 \cos \theta_2 + X_1 \sin \theta_1 \cos \theta_2 - X_2 \sin \theta_2 \cos \theta_1}{\sin(\theta_1 - \theta_2)}$$

$$Y = Y_1 + (X - X_1) \tan \theta_1, \quad |\theta| \geq 90^\circ$$

$$Y = Y_2 + (X - X_2) \tan \theta_2, \quad |\theta| < 90^\circ$$

Reference: HP-67/97 "Geometry" Users' Library Solutions Book.

Example:

Find the tangent circle for:

$$D_1 = [10, 20, 30^\circ] \quad D_2 = [-20, 30, -60^\circ] \quad R = 10$$

Executing the program four times will yield:

	X	Y
Above (A)	-4.5096	23.1699
Below (B)	-11.8301	-4.1506
Left (L)	-21.8301	13.1699
Right (R)	5.4904	5.8494

Keystrokes:

[XEQ] [ALPHA] SIZE [ALPHA] 009
[XEQ] [ALPHA] TANGENT [ALPHA]

10 [R/S]
A [R/S]
10 [R/S]
20 [R/S]
30 [R/S]
20 [CHS] [R/S]
30 [R/S]
60 [CHS] [R/S]
[R/S]

Display:

TANGENT CIRC.
R?
WHERE (L,R,A,B) ?
X?
Y?
THETA?
X?
Y?
THETA ?
X=-4.5096
Y=23.1699

User Instructions

SIZE: 009

[illegible]

Program Listings

01♦LBL "TANGENT"		48♦LBL B	
02 CF 01	Initialize	49 RCL 08	
03 CF 02		50 GTO 01	
04 CF 03		51♦LBL C	
05 CF 04		52 RCL 08	
06 "TANGENT CIRC."		53 CHS	
07 AVIEW		54♦LBL 01	
08 PSE		55 X<>Y	
09 "R?"		56 FS?C 01	
10 PROMPT	Input R	57 GTO 02	Calculate X_1 , Y_1
11 STO 08		58 STO 03	
12 "WHERE<L R, A, B>?"		59 X<>Y	
13 AON	Input position	60 P-R	
14 PROMPT		61 X<>Y	
15 AOFF		62 RDN	
16 ASTO Y		63 +	
17 "A"		64 STO 02	
18 ASTO X		65 RDN	
19 X=Y?		66 X<>Y	
20 SF 02		67 -	
21 "B"		68 STO 01	
22 ASTO X		69 SF 01	
23 X=Y?		70 GTO 07	
24 SF 03		71♦LBL 02	
25 "L"		72 STO 06	
26 ASTO X		73 X<>Y	Calculate X, Y
27 X=Y?		74 P-R	
28 SF 04		75 X<>Y	
29♦LBL 07		76 RDN	
30 "X?"		77 +	
31 PROMPT	Input X, Y, 0	78 STO 05	
32 "Y?"		79 RDN	
33 PROMPT		80 X<>Y	
34 "THETA ?"		81 -	
35 PROMPT	Set up calculations	82 STO 04	
36 FS? 02		83 RCL 05	
37 GTO B		84 RCL 02	
38 FS? 03		85 -	
39 GTO C		86 RCL 03	Calculate X
40 FS? 04		87 COS	
41 GTO D		88 STO 07	
42 X<0?		89 *	
43 GTO B		90 RCL 06	
44 GTO C		91 COS	
45♦LBL D		92 STO 08	
46 X<0?		93 *	
47 GTO C		94 RCL 01	
		95 RCL 08	
		96 *	
		97 RCL 03	
		98 SIN	

Program Listings

99 *		51	
100 +			
101 RCL 04			
102 RCL 07			
103 *			
104 RCL 06			
105 SIN			
106 *			
107 -			
108 RCL 03		60	
109 RCL 06			
110 -			
111 SIN			
112 /			
113 STO 07			
114 "X"			
115 XEQ 11			
116 RCL 03			
117 ABS			
118 90			
119 X>Y?	Calculate Y	70	
120 GTO 03			
121 RCL 07			
122 RCL 01			
123 -			
124 RCL 03			
125 TAN			
126 *			
127 RCL 02			
128 GTO 04			
129♦LBL 03		80	
130 RCL 07			
131 RCL 04			
132 -			
133 RCL 06			
134 TAN			
135 *			
136 RCL 05			
137♦LBL 04			
138 +			
139 "Y"		90	
140♦LBL 11			
141 "f="			
142 ARCL X	Display routine		
143 RVIEW			
144 STOP			
145 RTN			
146 .END.			
50		00	

DATA REGISTERS				STATUS			
00		50		SIZE	009	TOT. REG.	44
	X ₁			ENG		FIX	
	Y ₁			DEG	X	SCI	
	θ ₁			RAD		GRAD	
	X ₂						
05	Y ₂	55		FLAGS			
	θ ₂			#	INIT S/C	SET INDICATES	CLEAR INDICATES
	cos θ ₁ , X			01		1st pass, input X ₁	2nd pass, input X ₂ ,...
	R, cos θ ₂			02		circle above	
				03		circle below	
10		60		04		circle left	
15		65					
20		70					
25		75					
30		80					
35		85					
				ASSIGNMENTS			
				FUNCTION	KEY	FUNCTION	KEY
40		90					
45		95					

DISTANCE BETWEEN LINES IN SPACE

Given two lines, each defined by two points, this program calculates the shortest distance between the two lines. (This program was originally written to determine the clearance between electrical distribution circuits and guy wires or supporting structures).

The program takes lines defined by the two-point form,

$$\frac{x - x_1}{x_1' - x_1} = \frac{y - y_1}{y_1' - y_1} = \frac{z - z_1}{z_1' - z_1}$$

changes them to the point-direction form,

$$\frac{x - x_1}{a} = \frac{y - y_1}{b} = \frac{z - z_1}{c}$$

and the shortest distance (D) is calculated by:

$$D = \pm \frac{\begin{vmatrix} x_2 - x_1 & y_2 - y_1 & z_2 - z_1 \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix}}{\sqrt{\begin{vmatrix} b_1 & c_1 \\ b_2 & c_2 \end{vmatrix}^2 + \begin{vmatrix} c_1 & a_1 \\ c_2 & a_2 \end{vmatrix}^2 + \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}^2}}$$

Reference: Handbook of Tables for Mathematics, Third Edition, Samuel M. Selby, Published by The Chemical Rubber Co., 1967, page 509.

Example:

Given two lines in three-dimensional space:

Line #1 defined by points $(X_1, Y_1, Z_1) = (30, 14, 10)$ and $(X'_1, Y'_1, Z'_1) = (0, 46, 10)$;

Line #2 defined by points $(X_2, Y_2, Z_2) = (124, 50, -30)$ and $(X'_2, Y'_2, Z'_2) = (0, 36, 16)$.

Calculate the shortest distance between the two lines.

Keystrokes:

Display:

[XEQ] [ALPHA] SIZE [ALPHA] 014

[XEQ] [ALPHA] DIST [ALPHA]

DIST. B. LINES

X1 ?

30 [R/S]

Y1 ?

14 [R/S]

Z1 ?

10 [R/S]

X1-PRIME ?

0 [R/S]

Y1-PRIME ?

46 [R/S]

Z1-PRIME ?

10 [R/S]

X2 ?

124 [R/S]

Y2 ?

50 [R/S]

Z2 ?

30 [CHS] [R/S]

X2-PRIME ?

0 [R/S]

Y2-PRIME ?

36 [R/S]

Z2-PRIME ?

16 [R/S]

D=2.5940

Program Listings

01♦LBL "DIS T"		50 RCL 13	
02 "DIST. B LINES"	Initialize	51 RCL 05	
03 AVIEW		52 RCL 07	
04 2.2		53 RCL 11	
05 STO 00		54 XEQ 14	
06 1.002		55 RCL 05	
07 STO 01		56 X↑2	Calculate D
08 CF 29		57 RCL 03	
09 FIX 0		58 X↑2	
10♦LBL 02		59 +	
11 "X"		60 RCL 04	
12 XEQ 12	Input data	61 X↑2	
13 "Y"		62 +	
14 XEQ 12		63 SQRT	
15 "Z"		64 1/X	
16 XEQ 12		65 RCL 08	
17 "X"		66 RCL 04	
18 XEQ 13		67 *	
19 "Y"		68 RCL 09	
20 XEQ 13		69 RCL 05	
21 "Z"		70 *	
22 XEQ 13		71 +	
23 ISG 01		72 RCL 10	
24 GTO 02		73 RCL 03	
25 RCL 08		74 *	
26 ST- 11		75 +	
27 RCL 09		76 *	
28 ST- 12	Calculate a_i , b_i , c_i , ΔX , ΔY , ΔZ	77 FIX 4	
29 RCL 10		78 "D="	
30 ST- 13		79 ARCL X	
31 RCL 02		80 AVIEW	
32 ST- 05		81 STOP	
33 ST- 08		82♦LBL 13	
34 RCL 03		83 ARCL 01	
35 ST- 06		84 "F-PRIME ?"	Input prompting routine
36 ST- 09		85 GTO 15	
37 RCL 04		86♦LBL 12	
38 ST- 07		87 ARCL 01	
39 ST- 10		88 "F ?"	
40 RCL 11		89♦LBL 15	
41 RCL 06		90 PROMPT	
42 RCL 05	Calculate (A-B), (B-C) (C-A)	91 STO IND	
43 RCL 12		00	
44 XEQ 14		92 ISG 00	
45 RCL 12		93 RTN	
46 RCL 07		94♦LBL 14	
47 RCL 06		95 *	
48 RCL 13		96 STO IND	Calculate 2x2 matrix
49 XEQ 14		01	
		97 RDN	

Program Listings

98 *		51	
99 ST- IND			
01			
100 ISG 01			
101 RTN			
102 .END.			
10		60	
20		70	
30		80	
40		90	
50		00	

REGISTERS, STATUS, FLAGS, ASSIGNMENTS

DATA REGISTERS			STATUS			
00	pointer	50	SIZE	014	TOT. REG.	41
	counter		ENG		FIX	SCI
	x ₁		DEG	X	RAD	GRAD
	y ₁ , (A-B)		USER MODE			
	z ₁ , (B-C)		ON OFF X			
05	x ₁ , a ₁ , (C-A)	55	FLAGS			
	y ₁ , b ₁		#	INIT S/C	SET INDICATES	CLEAR INDICATES
	z ₁ , c ₁		29	C	For proper display	
	x ₂ , x ₂ -x ₁				format	
	y ₂ , y ₂ -y ₁					
10	z ₂ , z ₂ -z ₁	60				
	x ₂ , a ₂					
	y ₂ , b ₂					
	z ₂ , c ₂					
15		65				
20		70				
25		75				
30		80				
35		85				
			ASSIGNMENTS			
			FUNCTION	KEY	FUNCTION	KEY
40		90				
45		95				

NOTES

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DISTANCE BETWEEN LINES IN SPACE



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