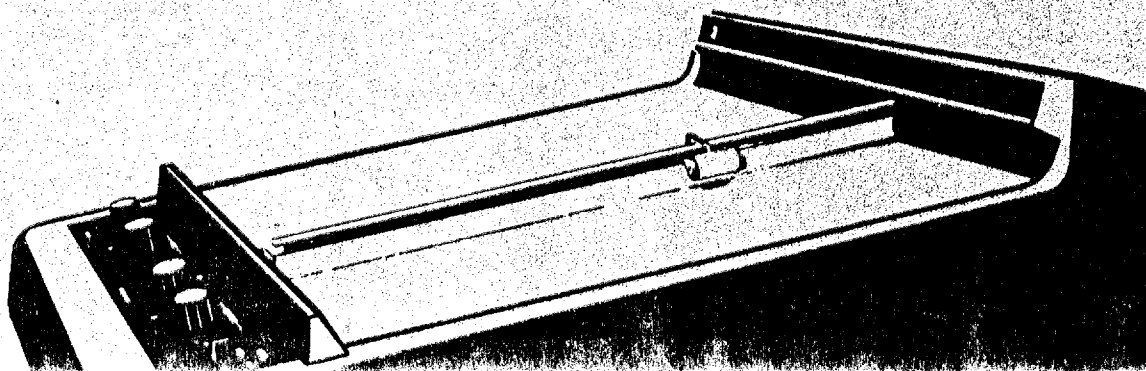




HEWLETT PACKARD X-Y PLOTTER

Model 9125A

PROGRAMS



MARCH 1, 1969

9125A PLOTTER PROGRAM LISTING

MISCELLANEOUS 09100-76000

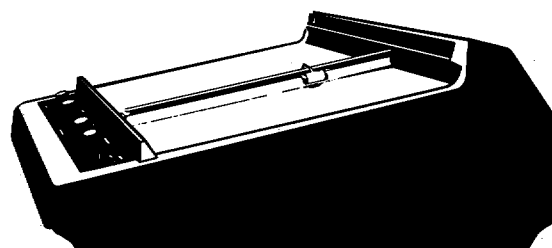
- 76006 - PLOTTER DIAGNOSTIC
This program checks the 9125A for proper execution of commands received from the 9100A.

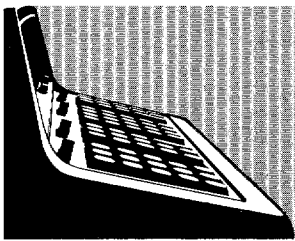
MATHEMATICS 09100-70000

- 70026 - MAXIMUM AND MINIMUM OF $y = f(x)$
This program will calculate the approximate maximum and minimum of an analytic function over a given range.
- 70027 - PLOT OF $y = f(x)$
This program will plot the curve specified by a given analytic function.
- 70028 - FIRST ORDER DIFFERENTIAL EQUATION PLOT
This program uses a Runge Kutta method to numerically solve a 1st order differential equation and plots the solution for incremented values of the independent variable.
- 70029 - MAXIMUM AND MINIMUM OF $r = f(\theta)$
This program will calculate the approximate maximum and minimum of a given function with variables in polar coordinates.
- 70030 - PLOT OF $r = f(\theta)$
This program will plot the curve of a function $r = f(\theta)$ in polar coordinates.

STATISTICS 09100-70800

- 70818 - LINEAR REGRESSION PLOT
This program will plot the set of data points entered by the user and the least squares linear curve determined by these points.
- 70819 - PARABOLIC REGRESSION AND PLOT
This program will plot the set of data points entered by the user and the least squares second degree curve determined by these points.
- 70820 - EXPONENTIAL REGRESSION AND PLOT
This program will plot the set of data points entered by the user and the least squares curve of the form $y = ae^{-bx}$ determined by these points.
- 70821 - POWER CURVE REGRESSION AND PLOT
This program will plot the set of data points entered by the user and plot the least squares curve of the form $y = ax^b$ determined by these points.





PART NO.
09100-76006

PLOTTER DIAGNOSTIC

The purpose of the Plotter Diagnostic is to test every programmable operation of the 9125A for proper execution.

To run the Diagnostic follow these directions:

Using Hewlett-Packard graph paper, calibrate the Plotter as explained in the Calibration Section of the Operating Manual.

SET: ☐ ON ☐ on the Calculator and Plotter

SET: ☐ RUN ☐

SET: ☐ DEGREES ☐

SET: Decimal Wheel at 3

PRESS: STOP

Set the Origin controls on the 9125A so that the pen is in the middle of the full-size (11" x 17") recording paper.

PRESS: END

Insert the magnetic card into the cardreader.

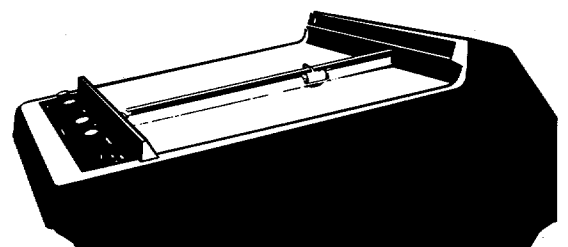
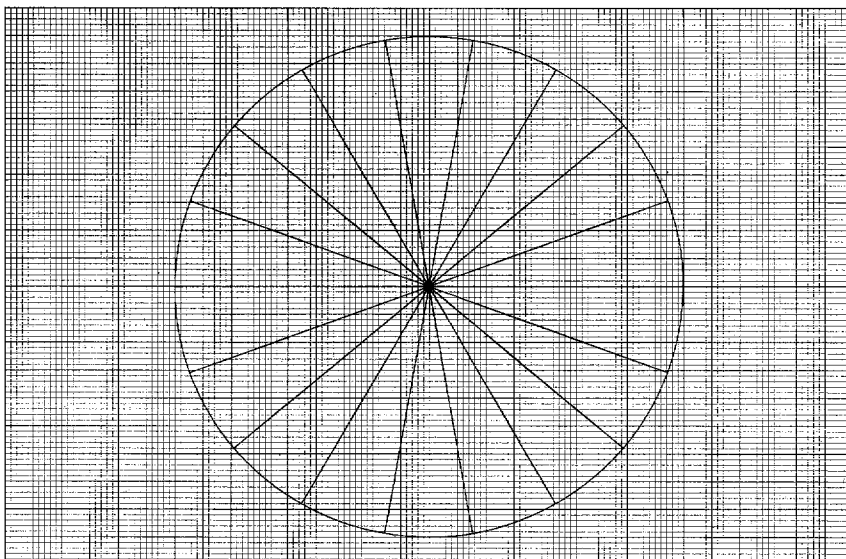
PRESS: ☐ ENTER ☐

PRESS: END

PRESS: CONTINUE

Proper execution of the program and proper operation of the Plotter is indicated by a circle enclosing 18 spokes.

The 9125A is operating correctly if the circle is well-formed and the spokes are retraced exactly showing only one line width per spoke. The exact diameter of the circle depends where the sensitivity controls are set, but it should be $9" \pm 0.25"$.



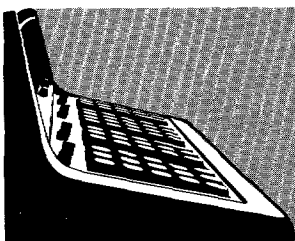
HEWLETT-PACKARD

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Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
0	CLEAR	20				3	ACC +	60				0					
1	2	02				1	RCL	61				1					
2	2	02				2	3	03				2					
3	5	05				3	6	06				3					
4	0	00				4	0	00				4					
5	$x \rightarrow ()$	23				5	IF $x < y$	52				5					
6	$\bar{a}$	13				6	3	03				6					
7	CLEAR x	37				7	$\bar{b}$	14				7					
8	$\uparrow$	27				8	GOTO () ()	44				8					
9	FMT	42				9	2	02				9					
$\bar{a}$	$\downarrow$	25				$\bar{a}$	7	07				$\bar{a}$					
$\bar{b}$	$\bar{E}$	12				$\bar{b}$	CLEAR	20				$\bar{b}$					
$\bar{c}$	$\uparrow$	27				$\bar{c}$	FMT	42				$\bar{c}$					
$\bar{d}$	$\bar{a}$	13				$\bar{d}$	$\uparrow$	27				$\bar{d}$					
1	TO RECT	66				4	END	46				0					
1	FMT	42				1						1					
2	$\downarrow$	25				2						2					
3	$\bar{E}$	12				3						3					
4	$\uparrow$	27				4						4					
5	2	02				5						5					
6	0	00				6						6					
7	+	33				7						7					
8	$y \rightarrow ()$	40				8						8					
9	$\bar{E}$	12				9						9					
$\bar{a}$	3	03				$\bar{a}$						$\bar{a}$					
$\bar{b}$	5	05				$\bar{b}$						$\bar{b}$					
$\bar{c}$	1	01				$\bar{c}$						$\bar{c}$					
$\bar{d}$	IF $x > y$	53				$\bar{d}$						$\bar{d}$					
2	0	00				0						Storage					
1	7	07				1						F					
2	CLEAR	20				2						$\bar{E}$					
3	FMT	42				3						$\bar{d}$					
4	$\downarrow$	25				4						$\bar{c}$					
5	FMT	42				5						$\bar{b}$					
6	$\uparrow$	27				6						$\bar{a}$					
7	$\bar{a}$	13				7						9					
8	TO RECT	66				8						8					
9	FMT	42				9						7					
$\bar{a}$	$\downarrow$	25				$\bar{a}$						6					
$\bar{b}$	TO POLAR	62				$\bar{b}$						5					
$\bar{c}$	2	02				$\bar{c}$						4					
$\bar{d}$	$\uparrow$	27				$\bar{d}$						3					
												2					
												1					
												0					

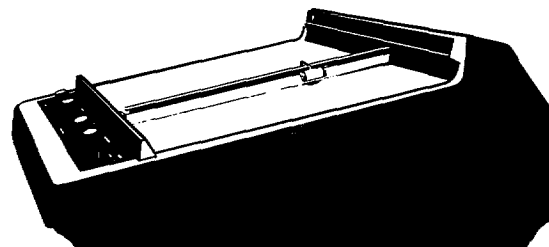


PART NO.
09100-70026

MAXIMUM AND MINIMUM OF $y = f(x)$

This program will compute the approximate maximum and minimum of the function $f(x)$ over a specified range of independent variable x .

The technique involved is a search over n increments of the range of x . n is specified by the user.



USER INSTRUCTIONS

ENTER PROGRAM: (Starting address is 0-0)

PRESS: GO TO () ()

PRESS: 3

PRESS: c

SET: PROGRAM

Note: Starting at (3)(c), enter program steps which take the independent variable from the X register (x is also in the e register) and program f(x). Place f(x) in the Y register and exit to location 2-7. The last four instructions of the f(x) subroutine should be:

GO TO

2

7

END

Memory locations 3-c through 9-d are available for programming and storage of f(x). The flag is unavailable.

SET: RUN

PRESS: END

PRESS: CONTINUE

ENTER DATA:

n → Z n = number of points scanned

X_{max} → Y

X_{min} → X

PRESS: CONTINUE

DISPLAY

0	—	Z
Y _{max}	—	Y
Y _{min}	—	X

— To enter new range of the independent variable x

— To enter new function

Note: To record $y = f(x)$ on the program card replace the END instruction in location 3-b with a STOP instruction.

EXAMPLE

$$y = \frac{\sin x}{x}$$

$$x_{\max} = 6\pi$$

$$x_{\min} = -6\pi$$

SET: RADIANS

The steps which generate f(x) are:

LOCATION	OPERATION
3 - a c	↑
3 - b d	sin x
3 - e 40	x ↔ y
3 - d 41	÷
4 - 0 2	GO TO () ()
4 - 1 3	2
4 - 2 4	7
4 - 3 5	END

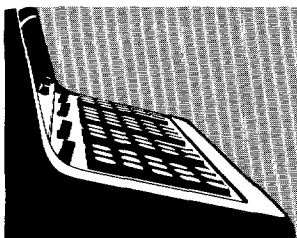
Let: n = 50

Solution:

$$Y_{\max} = 1.000$$

$$Y_{\min} = -.217$$

[illegible]

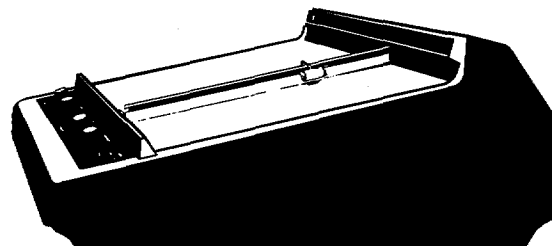


PART NO.
09100-70027

PLOT OF $y = f(x)$

This program will plot the function of $y = f(x)$ in rectangular coordinates. The number of plot points per inch, n , is specified by the user, as also are the plotting constants.

The program was written to be used in conjunction with program 09100-70026, Maximum and Minimum of $y = f(x)$.



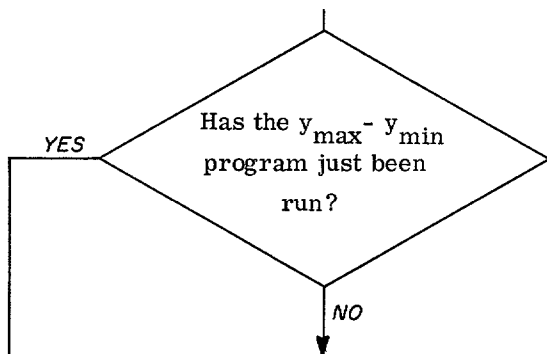
USER INSTRUCTIONS

PRESS: STOP

Use the Origin controls to place the pen in the lower left corner of the paper. (At the intersection of the border lines if chart paper is used.)

SET: Decimal wheel at 6 or less

ENTER PROGRAM: (Starting address is 0-0)



PRESS: GO TO () ()

PRESS: 3

PRESS: c

SET: PROGRAM

Note: Starting at (3)(c), enter program steps which take the independent variable from the X register (x is also in the e register) and program f(x). Place f(x) in the Y register and exit to location 2-7. The last four instructions of the f(x) subroutine should be:

GO TO

2

7

END

Memory locations 3-c through 9-d are available for programming and storage of f(x). The flag is available.

SET: RUN

PRESS: END

PRESS: CONTINUE

ENTER CONSTANTS*:

 $y_{\text{shift}} \rightarrow Y$ $x_{\text{shift}} \rightarrow X$

USER INSTRUCTIONS (con't)

PRESS: CONTINUE

ENTER CONSTANTS*:

 $n \rightarrow Z$ plot points/inch $y_{\text{scale}} \rightarrow Y$ $x_{\text{scale}} \rightarrow X$

PRESS: CONTINUE

Note: The function f(x) will now be plotted. To interrupt or stop the plot at its completion, PRESS: STOP.

To re-run program, return to beginning of USER INSTRUCTIONS and proceed as before. The magnetic card need not be re-entered.

* See general Plotter instructions.

EXAMPLE

Plot $y = \frac{\sin x}{x}$ for $-6\pi \leq x \leq 6\pi$

SET: RADIANS

Run the max-min of f(x) program. Letting $n = 50$ in this program, we find that

$$y_{\min} \approx -.22$$

$$y_{\max} \approx 1.$$

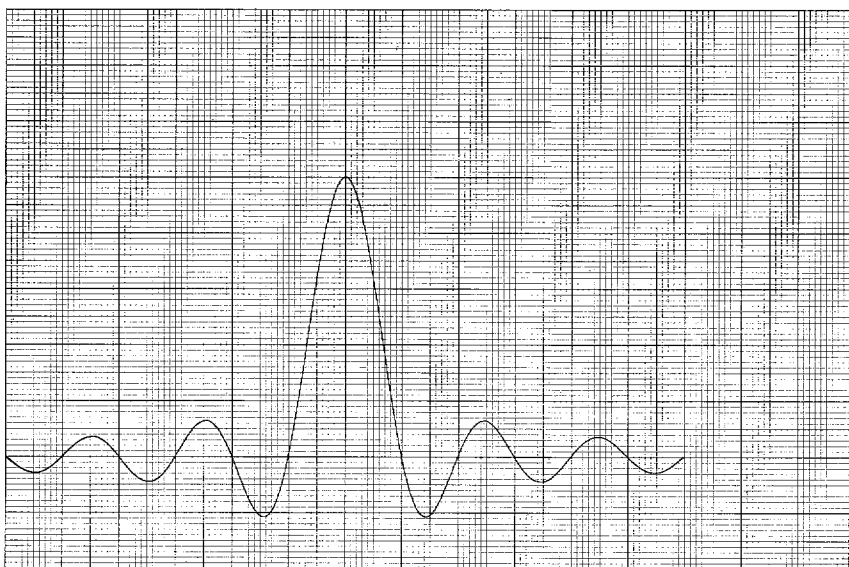
$$\text{Choose } y_{\text{scale}} = \frac{1 - (-.22)}{10} \approx .15 \frac{\text{units}}{\text{inch}}$$

$$y_{\text{shift}} = -.4$$

$$x_{\text{scale}} = \frac{6\pi - (-6\pi)}{15} \approx \pi \text{ units/inch}$$

$$x_{\text{shift}} = -6\pi \text{ units}$$

$$n = 15 \text{ plot points/inch}$$

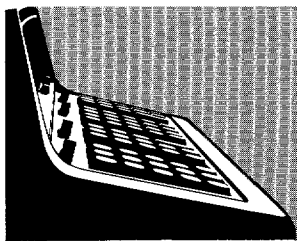


Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
0	0	CLEAR	20								
1	STOP	41	X _{shift}	Y _{shift}	0	ENTER TRANSLATION CONSTANTS					
2	X→()	23									
3	C	16	STORE TRANSLATION CONSTANTS								
4	y→()	40									
5	d	17									
6	CLEAR	20									
7	STOP	41	X _{scale}	Y _{scale}	n	ENTER SCALING CONSTANTS AND NUMBER OF POINTS PER INCH TO BE PLOTTED					
8	ROLL ↑	22									
9	÷	35	CALCULATE AND STORE $\Delta X = \frac{X_{scale}}{n}$								
a	y→()	40									
b	b	14									
c	x	36									
d	5	05									
1	0	00									
1	0	00									
2	÷	35	CALCULATE AND STORE $\frac{X_{scale}}{500}$ AND $\frac{500}{Y_{scale}}$								
3	y→()	40									
4	a	13									
5	ROLL ↑	22									
6	÷	35									
7	b	14									
8	y→()	40									
9	b	14									
a	↑	27									
b	C	16									
c	x↔y	30	INITIALIZE X TO X _{shift} - ΔX AND STORE								
d	-	34									
2	0	ACC +	60								
1	RCL	61									
2	+	33									
3	y→()	40	CALCULATE, STORE AND POSITION X = X + ΔX								
4	E	12									
5	↓	25									
6	GO TO ()	44									
7	3	03	BRANCH TO CALCULATE f(x)								
8	C	16									
9	d	17									
a	-	34	CALCULATE $Y_{plot} = \frac{500}{Y_{scale}} [Y - Y_{shift}]$								
b	b	14									
c	x	36									
d	E	12									

FROM 3-a

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
3	0	↑	27								
1	⌈	16	CALCULATE $X_{\text{plot}} = \frac{500}{X_{\text{scale}}} [X - X_{\text{shift}}]$								
2	—	34									
3	a	13									
4	÷	35									
5	↓	25									
6	FMT	42	PLOT THE CALCULATED LINE SEGMENT								
7	↓	25									
8	GO TO () ()	44	BRANCH TO CALCULATE NEXT PLOT COORDINATES								
9	2	02									
a	1	01									
b	END	46									
c											
d											
0											
1											
2											
3											
4											
5											
6											
7											
8											
9											
a											
b											
c											
d											
0											
1											
2											
3											
4											
5											
6											
7											
8											
9											
a											
b											
c											
d											

HEWLETT-PACKARD FROM 2-8



PART NO.
09100-70028

1st ORDER DIFFERENTIAL EQUATION PLOT

This program may be used to solve and plot the solution of a wide variety of first order (homogenous or non-homogenous, linear or non-linear) differential equations of the form

$$Y' = f(X, Y)$$

The solution is a numerical solution which calculates Y_i for X_i . The X values are closely spaced with increment h over the desired range. Specifically the solution used in this program is a Runge-Kutta Method (third-order) which uses the equations:

$$Y_{i+1} = Y_i + \frac{1}{6} (p + 2q + 2r + s)$$

where

$$p = hf(X_i, Y_i)$$

$$q = hf(X_i + \frac{h}{2}, Y_i + \frac{p}{2})$$

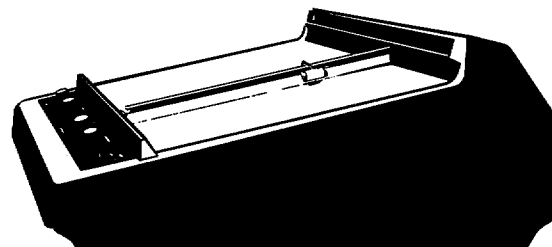
$$r = hf(X_i + \frac{h}{2}, Y_i + \frac{q}{2})$$

$$s = hf(X_i + h, Y_i + r)$$

$$h = X_{i+1} - X_i$$

The solution is plotted as successive Y_i 's are calculated.

Reference: Numerical Analysis
by Kaiser S. Kunz
McGraw-Hill Book Co., Inc. 1957



USER INSTRUCTIONS

PRESS: STOP

Using the Origin controls, locate the pen in the lower left corner of the paper.

SET: Decimal Wheel at 6 or less

ENTER PROGRAM: (Starting Address is (0)(0))

PRESS: GO TO (0)(4)

SET:

ENTER X_{shift} : Instruction locations 0-4 through 0-7 are available.*

PRESS: STEP PROGRAM

ENTER X_{scale} : Instruction locations 0-9 through 0-b are available.*

PRESS: STEP PROGRAM

ENTER Y_{shift} : Instruction locations 0-d through 1-2 are available.*

PRESS: STEP PROGRAM

PRESS: STEP PROGRAM

ENTER Y_{scale} : Instruction locations 1-5 through 1-7 are available.*

*PRESS: CONTINUE to fill in any instruction locations not used.

SET:

PRESS: GO TO (2)(8)

PRESS: CONTINUE

DISPLAY

0	—	Z
0	—	Y
1	—	X

ENTER INITIAL CONDITIONS: $Y_0 \rightarrow Z$ $X_0 \rightarrow Y$ $h \rightarrow X$

PRESS: CONTINUE

DISPLAY

0	—	Z
0	—	Y
2	—	X

PRESS: GO TO (2)(8)

SET:

USER INSTRUCTIONS (con't)

Starting at instruction location 2-8, enter the program steps which take X from the X register (also in the e register) and Y from the Y register (also in the d register) and generate $f(x, y)$. Leave $f(x, y)$ in the Y register and fill in the remaining instruction locations with continues. Note that 43 locations are available (2-8 through 5-8).

SET:

PRESS: GO TO (2)(5)

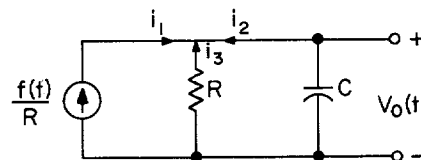
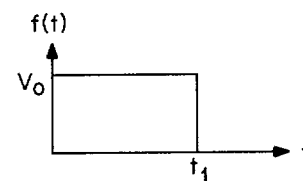
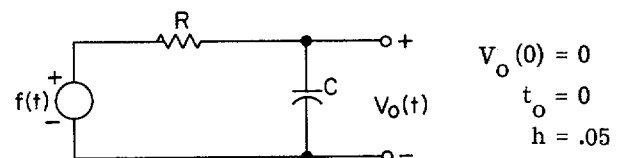
PRESS: CONTINUE

At each increment of the independent variable, the following display will be observed:

0	—	Z
Y_1	—	Y
X_1	—	X

and the line segment between successive solution points will be plotted.

EXAMPLE



$$i_1 + i_2 + i_3 = 0$$

$$\frac{f(t)}{R} - \frac{V_o(t)}{R} - C \frac{dV_o(t)}{dt} = 0 \quad \text{Initial Conditions } t_o = 0, V_o(0) = 0$$

$$\frac{dV_o(t)}{dt} = -\frac{V_o(t)}{CR} + \frac{f(t)}{CR} \quad \text{Increment } h = .05$$

Let $V_o = 1$ V, $C = 1$ F, $R = 1 \Omega$ and $t_1 = 4$ sec.

EXAMPLE (con't)

EXAMPLE (con't)

The equation becomes

$$\frac{dV_o(t)}{dt} = -V_o(t) + 1; \quad t \leq 4$$

$$\frac{dV_o(t)}{dt} = -V_o(t); \quad t > 4$$

The program steps that form $V_o = f(t, V_o)$ appear on Page. 1. See User Instructions.

Let:

$$\begin{aligned} X_{\text{shift}} &= 0 \text{ units} & Y_{\text{shift}} &= 0 \text{ units} \\ X_{\text{scale}} &= 1 \frac{\text{units}}{\text{inch}} & Y_{\text{scale}} &= .1 \frac{\text{units}}{\text{inch}} \end{aligned}$$

The steps which enter these values are given below.

PRESS: GO TO (0)(4)

SET:

PRESS: 0

PRESS: CONTINUE

PRESS: CONTINUE

PRESS: CONTINUE

PRESS: STEP PROGRAM

PRESS: 1

PRESS: CONTINUE

PRESS: CONTINUE

PRESS: STEP PROGRAM

PRESS: 0

PRESS: CONTINUE

PRESS: CONTINUE

PRESS: CONTINUE

PRESS: STEP PROGRAM

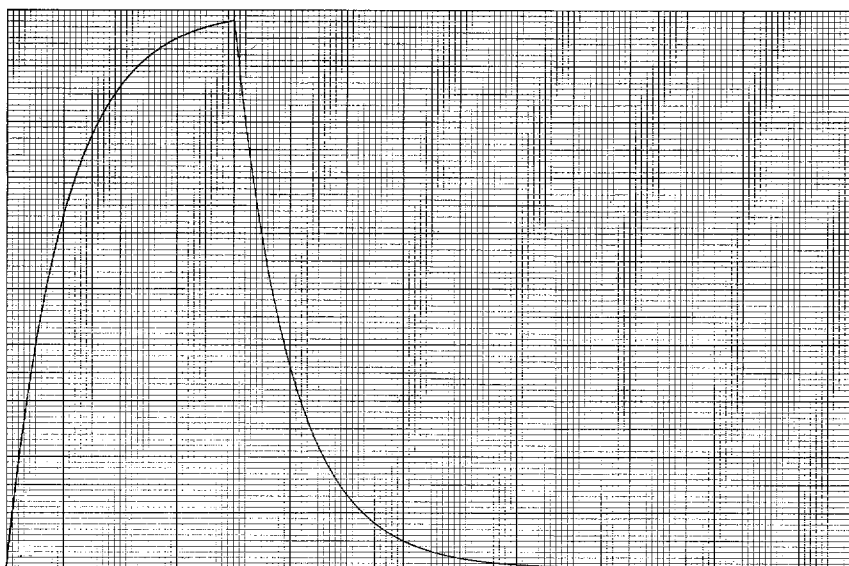
PRESS: STEP PROGRAM

PRESS: .

PRESS: 1

PRESS: CONTINUE

SET:



Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
2	0										
	1										
	2										
	3										
	4										
	5										
	6										
	7		t	V ₀							
	8	↑ 27		t	V ₀						
	9	4 04	4								
	a	IF x < y 52									
	b	3 03									
	c	7 07									
	d	ROLL ↑ 22	V ₀	4	t						
3	0	CHG SIGN 32	- V ₀								
	1	↑ 27		-V ₀	4						
	2	1 01	1								
	3	+ 33		1-V ₀							
	4	GO TO () () 44									
	5	5 05									
	6	9 11									
	7	ROLL ↑ 22	V ₀	4	t						
	8	CHG SIGN 32	- V ₀								
	9	↑ 27		-V ₀	4						
	a	GO TO () () 44									
	b	5 05									
	c	9 11									
	d										
	0										
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	a										
	b										
	c										
	d										

COMPARE t TO 4
AND BRANCH TO
APPROPRIATE
DIFFERENTIAL EQUATION

$$t \leq 4$$

$$\frac{dV_0(t)}{dt} = -V_0(t) + 1$$

EXIT

$$t > 4$$

$$\frac{dV_0(t)}{dt} = -V_0(t)$$

EXIT

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
0	0	PAUSE	57					Y_0	h	X_0	
	1	PAUSE	57								
	2	PAUSE	57								
	3	↑	27								
	4	CONTINUE	47	ENTER X_{shift} HERE							
	5	CONTINUE	47								
	6	CONTINUE	47								
	7	CONTINUE	47								
	8	—	34								
	9	CONTINUE	47	ENTER X_{scale} HERE							
	a	CONTINUE	47								
	b	CONTINUE	47								
	c	÷	35								
	d	CONTINUE	47								
1	0	CONTINUE	47	ENTER Y_{shift} HERE							
	1	CONTINUE	47								
	2	CONTINUE	47								
	3	ROLL ↑	22								
	4	—	34								
	5	CONTINUE	47	ENTER Y_{scale} HERE							
	6	CONTINUE	47								
	7	CONTINUE	47								
	8	CHG SIGN	32								
	9	÷	35								
	a	5	05	CALCULATE X_{plot} AND Y_{plot}							
	b	0	00								
	c	0	00								
	d	X	36								
2	0	ROLL ↑	22								
	1	X	36								
	2	↓	25								
	3	FMT	42	PLOT X_{plot} AND Y_{plot}							
	4	↓	25								
	5	d	17								
	6	↑	27	RECALL X_i AND Y_i							
	7	b	14								
	8	CLEAR	20	SET STEP INDICATOR							
	9	1	01								
	a	STOP	41	h	X_0	X_0	Y_0	ENTER INITIAL CONDITIONS AND INCREMENT			
	b	$x \rightarrow ()$	23								
	c	c	16								
	d	$y \rightarrow ()$	40								

FROM 7-b

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
3	0	b	14	STORE ENTRIES							
	1	↓	25								
	2	y→()	40								
	3	d	17								
	4	CLEAR	20	SET STEP INDICATOR							
	5	2	02								
	6	STOP	41								
	7	CONTINUE	47								
	8										
	9										
	a										
	b										
	c										
	d										
4	0	CONTINUE	47								
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	a										
	b										
	c										
	d										
5	0	CONTINUE	47								
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8	CONTINUE	47								
	9	C	16								
	a	X	36								
	b	1	01								
	c	IF FLAG	43								
	d	SET FLAG	54								

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

Step	Key	Code	Display			Storage							
			<i>x</i>	<i>y</i>	<i>z</i>	<i>f</i>	<i>e</i>	<i>d</i>	<i>c</i>	<i>b</i>	<i>a</i>		
6	0	ACC +	60										
	1	SET FLAG	54										
	2	ACC +	60										
	3	<i>f</i>	15										
	4	↑	27										
	5	5	05										
	6	IF <i>x</i> > <i>y</i>	53										
	7	7	07	BRANCH TO CALCULATE <i>q</i> OR <i>r</i>									
	8	<i>c</i>	16										
	9	IF <i>x</i> = <i>y</i>	50										
	<i>a</i>	8	10	BRANCH TO CALCULATE <i>s</i>									
	<i>b</i>	<i>d</i>	17										
	<i>c</i>	<i>e</i>	12										
	<i>d</i>	<i>x</i> ↔ <i>y</i>	30										
	7	0	÷	35									
		1	<i>d</i>	17									
		2	+	33									
		3	<i>y</i> → ()	40	CALCULATE $Y_i + \frac{1}{6} [P + 2q + 2r + s]$								
		4	<i>d</i>	17									
		5	CLEAR	20									
6		<i>d</i>	17										
7		↑	27										
8		<i>b</i>	14										
9		GOTO () ()	44										
	<i>a</i>	0	00	BRANCH TO PLOT									
	<i>b</i>	0	00										
	<i>c</i>	↓	25										
	<i>d</i>	2	02										
	8	0	÷	35									
		1	<i>d</i>	17									
		2	+	33									
		3	<i>c</i>	16	CALCULATE $X_i + \frac{h}{2}, Y_i + \frac{P}{2}, Y_i + \frac{q}{2}$								
		4	↑	27									
		5	2	02									
6		÷	35										
7		<i>b</i>	14										
8		+	33										
9		↓	25										
	<i>a</i>	GOTO () ()	44										
	<i>b</i>	2	02	BRANCH TO CALCULATE <i>q</i> OR <i>r</i>									
	<i>c</i>	8	10										
	<i>d</i>	IF FLAG	43	CLEAR FLAG									

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
9	0	↓	25								
	1	d	17								
	2	+	33								
	3	c	16								
	4	↑	27								
	5	b	14								
	6	+	33								
	7	y→()	40								
	8	b	14								
	9	↓	25								
	a	GO TO () ()	44								
	b	2	02								
	c	8	10								
	d	END	46								
	0										
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	a										
	b										
	c										
	d										
	0										
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	a										
	b										
	c										
	d										

CALCULATE $X_i + h, Y_i + r$ BRANCH TO CALCULATE $f(x, y)$

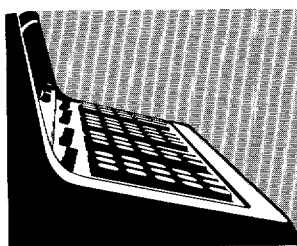
HEWLETT-PACKARD

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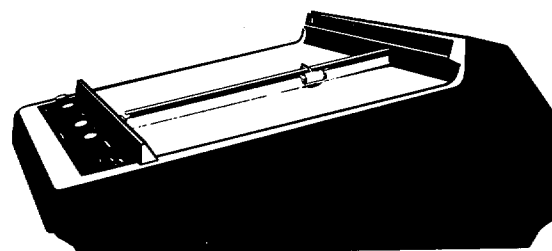


PART NO.
09100-70029

MAXIMUM AND MINIMUM OF $r = f(\theta)$

Given a function, $r = f(\theta)$, with polar coordinate values, this program will compute the approximate maximum and minimum of the function in rectangular coordinates over a specified range of the independent variable.

The technique involved is a search over n increments of the range of θ . n is specified by the user.



USER INSTRUCTIONS

EXAMPLE

ENTER PROGRAM: (Starting Address is 0-0)

PRESS: GO TO () ()

PRESS: 5

PRESS: 4

SET: PROGRAM

Note: Starting at 5-4, enter the program steps which will take the independent variable θ from X and e registers and generate $f(\theta)$, leave $f(\theta)$ in the Y register. The last steps should be

GO TO

2

7

END

Note steps 5-4 through 9-d are available.

SET: RUN

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

ENTER DATA:

n → Z n = number of points to be scanned

$\theta_{\max}$ → Y

$\theta_{\min}$ → X

PRESS: CONTINUE

DISPLAY

0	—	Z
$Y_{\max}$	—	Y
$Y_{\min}$	—	X

PRESS: CONTINUE

DISPLAY

0	—	Z
$X_{\max}$	—	Y
$X_{\min}$	—	X

To re-run program, return to beginning of USER INSTRUCTIONS; re-enter program and proceed as before. $f(\theta)$ need not be re-generated if it is to be used again.

$$r = f(\theta) = \sin\theta \cos\theta$$

Choose

$$n = 50 \text{ and } 0 \leq \theta \leq 2\pi$$

SET: RADIANS

Solution:

$$-.38 \leq y \leq +.38$$

$$-.38 \leq x \leq +.38$$

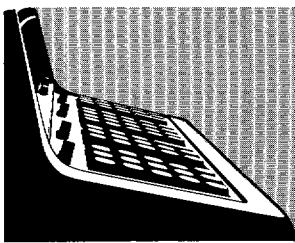
HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
0	CLEAR	20	ENTER			3	$y \rightarrow ()$	40				5					
1	STOP	41	$\theta_{\min}$	$\theta_{\max}$	0	1	$\bar{C}$	16				1					
2	$y \rightarrow ()$	40				2	$\bar{a}$	13				2	EXAMPLE				
3	$\bar{b}$	14				3	IF $x < y$	52				3					
4	$-$	34				4	$y \rightarrow ()$	40				4	$\uparrow$	27	θ	θ	
5	ROLL $\downarrow$	31				5	$\bar{a}$	13				5	$\sin x$	70	$\sin \theta$	θ	
6	$x \rightleftharpoons y$	30				6	$\downarrow$	25				6	$x \rightleftharpoons y$	30	θ	$\sin \theta$	
7	$\div$	35				7	$\bar{d}$	17				7	$\cos x$	73	$\cos \theta$	$\sin \theta$	
8	ROLL $\downarrow$	31				8	IF $x > y$	53				8	$\times$	36	$\sin \theta \cdot \cos \theta$		
9	$-$	34				9	$y \rightarrow ()$	40				9	GO TO () ()	44			
$\bar{a}$	ACC $+$	60				$\bar{a}$	$\bar{d}$	17				$\bar{a}$	2	02			
$\bar{b}$	ENTER EXP	26				$\bar{b}$	$\downarrow$	25				$\bar{b}$	7	07			
$\bar{C}$	9	11				$\bar{C}$	$y \rightleftharpoons ()$	24				$\bar{C}$	END	46			
$\bar{d}$	9	11				$\bar{d}$	0	00				$\bar{d}$					
1	$x \rightarrow ()$	23				4	$y \rightarrow ()$	40				0					
1	$\bar{d}$	17				1	0	00				1					
2	$x \rightarrow ()$	23				2	IF $x > y$	53				2					
3	$\bar{C}$	16				3	$x \rightarrow ()$	23				3					
4	CHG SIGN	32				4	0	00				4					
5	$x \rightarrow ()$	23				5	IF FLAG	43				5					
6	$\bar{a}$	13				6	1	01				6					
7	$x \rightarrow ()$	23				7	9	11				7					
8	0	00				8	CLEAR	20				8					
9	RCL	61				9	$y \rightleftharpoons ()$	24				9					
$\bar{a}$	$+$	33				$\bar{a}$	0	00				$\bar{a}$					
$\bar{b}$	$\bar{b}$	14				$\bar{b}$	$\bar{d}$	17	DISPLAY			$\bar{b}$					
$\bar{C}$	SET FLAG	54				$\bar{C}$	STOP	41	$Y_{\min}$	$Y_{\max}$	0	$\bar{C}$					
$\bar{d}$	IF $x < y$	52				$\bar{d}$	CLEAR	20				$\bar{d}$					
2	$x \rightleftharpoons y$	30				5	$\bar{a}$	13				Storage					
1	IF FLAG	43				1	$\uparrow$	27				F	$\Delta \theta$				
2	$y \rightarrow ()$	40				2	$\bar{C}$	16	DISPLAY			E	θ				
3	$\bar{e}$	12				3	END	46	$X_{\min}$	$X_{\max}$	0	$\bar{d}$	$Y_{\min}$				
4	$\downarrow$	25				4						$\bar{C}$	$X_{\min}$				
5	GO TO () ()	44				5						$\bar{b}$	$\theta_{\max}$				
6	5	05				6						$\bar{a}$	$X_{\max}$				
7	4	04				7						9					
8	$\bar{e}$	12				8						8					
9	$x \rightleftharpoons y$	30				9						7					
$\bar{a}$	TO RECT	66				$\bar{a}$						6					
$\bar{b}$	$\uparrow$	27				$\bar{b}$						5					
$\bar{C}$	$\bar{C}$	16				$\bar{C}$						4					
$\bar{d}$	IF $x > y$	53				$\bar{d}$						3					
												2					
												1					
												0	$Y_{\max}$				

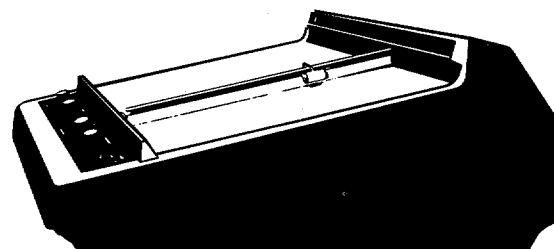


PART NO.
09100-70030

PLOT OF $r = f(\theta)$ IN POLAR COORDINATES

This program will plot the function $r = f(\theta)$ in polar coordinates. The number of plot points, n , is specified by the user as also are the plotting constants.

The program was written to be used in conjunction with program 09100-70029, Maximum and Minimum of $r = f(\theta)$.



USER INSTRUCTIONS

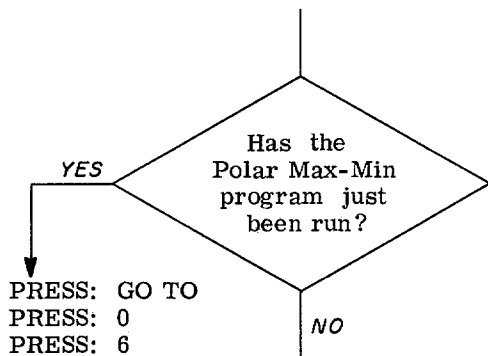
USER INSTRUCTIONS (con't)

PRESS: STOP

Using the Origin controls, locate the pen in the lower left corner of the paper.

SET: Decimal wheel at 6 or less

ENTER PROGRAM: (Starting Address is 0-0)



PRESS: GO TO () ()

PRESS: 5

PRESS: 4

SET: PROGRAM

Note: Beginning at location 5-4, enter the program steps which will take the independent variable θ from the X register (θ is also in the e register) and generate $f(\theta)$. Leave $f(\theta)$ in the Y register. The last steps should be

GO TO

2

7

END

Note that steps 5-4 through 9-d are available.

SET: RUN

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

ENTER TRANSLATION CONSTANTS:

$Y_{\text{shift}} \rightarrow Y$

$X_{\text{shift}} \rightarrow X$

PRESS: CONTINUE

ENTER SCALING CONSTANTS:

$Y_{\text{scale}} \rightarrow Y$

$X_{\text{scale}} \rightarrow X$

PRESS: CONTINUE

ENTER DATA:

$n \rightarrow Z$ n = number of points to be plotted

$\theta_{\text{max}} \rightarrow Y$

$\theta_{\text{min}} \rightarrow X$

PRESS: CONTINUE

The function will now be plotted. To interrupt the plot: **PRESS: STOP**

To re-run program, return to beginning of USER INSTRUCTIONS, re-enter program and proceed as before. $f(\theta)$ need not be generated again unless it is to be changed.

EXAMPLE

Plot $r = \sin\theta \cos\theta$ where $0 \leq \theta \leq 2\pi$

Run the max-min of $r = f(\theta)$ program. Results of this program are:

$$-.4 \leq x \leq .4$$

$$-.4 \leq y \leq .4$$

SET: RADIANS

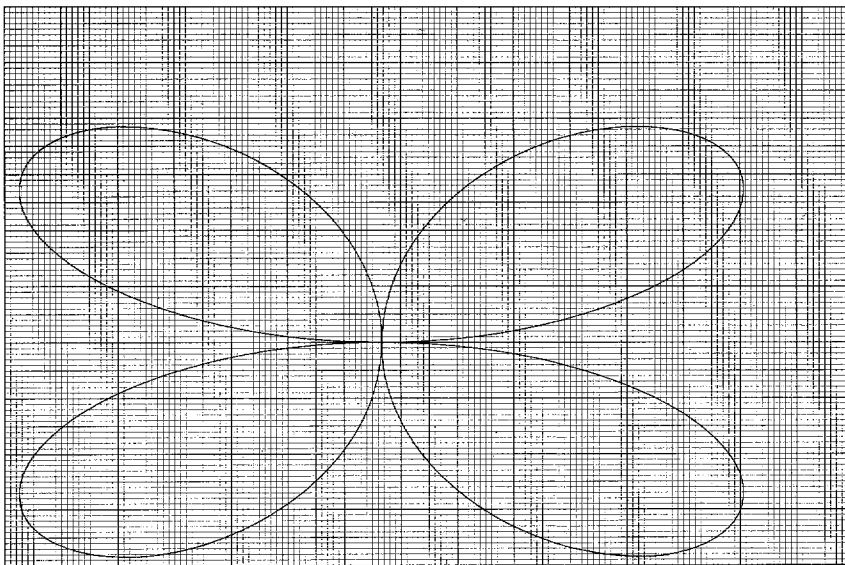
Choose

$$X_{\text{shift}} = Y_{\text{shift}} = -0.4$$

$$X_{\text{scale}} = .06 \frac{\text{units}}{\text{inch}}$$

$$Y_{\text{scale}} = 0.1 \frac{\text{units}}{\text{inch}}$$

$n = 250$ plot points



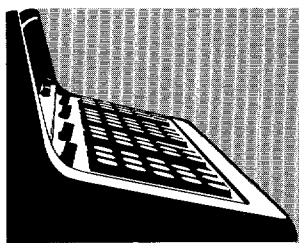
HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
0	CLEAR	20	ENTER			3	X	36				0					
1	STOP	41	X _{shift}	Y _{shift}	0	1	d	17				1					
2	x→()	23				2	ROLL ↑	22				2					
3	C	16				3	x↔y	30				3					
4	y→()	40				4	—	34				4					
5	d	17				5	b	14				5					
6	CLEAR	20	ENTER			6	÷	35				6					
7	STOP	41	X _{scale}	Y _{scale}	0	7	↓	25				7					
8	↑	27				8	x↔y	30				8					
9	5	05				9	FMT	42				9					
a	0	00				a	↓	25				a					
b	0	00				b	RCL	61				b					
c	x↔y	30				c	+	33				c					
d	ROLL ↓	31				d	y→()	40				d					
10	÷	35				4	E	12				0					
1	y→()	40				1	↓	25				1					
2	b	14				2	y↔()	24				2					
3	ROLL ↑	22				3	0	00				3					
4	÷	35				4	y→()	40				4					
5	y→()	40				5	0	00				5					
6	a	13				6	IF x < y	52				6					
7	CLEAR	20	ENTER			7	2	02				7					
8	STOP	41	θ _{min}	θ _{max}	n	8	3	03				8					
9	y→()	40				9	IF x = y	50				9					
a	0	00				a	2	02				a					
b	—	34				b	3	03				b					
c	ROLL ↓	31				c	CLEAR	20				c					
d	x↔y	30				d	FMT	42				d					
20	÷	35				5	↑	27							Storage		
1	↓	25				1	END	46				F	Δθ				
2	ACC +	60				2						E	θ				
3	E	12				3						d	Y _{shift}				
4	GOTO () ()	44				4						c	X _{shift}				
5	5	05				5						b	500 / Y _{scale}				
6	4	04				6						a	X _{scale} / 500				
7	E	12				7						9					
8	x↔y	30				8						8					
9	TO RECT	66				9						7					
a	↑	27				a						6					
b	C	16				b						5					
c	—	34				c						4					
d	a	13				d						3					
												2					
												1					
												0	θ _{max}				



PART NO.
09100-70818

LINEAR REGRESSION AND PLOT

This program calculates the equation of the straight line of best fit of a set of data points. It also plots each data point and the straight line determined by the calculated equation. The best fit is determined by minimizing the sum of the squares of the deviations of the data points from the line.

The program calculates m and C for the equation:

$$Y = mX + C$$

The program also calculates a correlation coefficient r , an indication of goodness of fit. Note: $-1 \leq r \leq 1$ where the sign corresponds to the slope m . If $r = 0$, there is no correlation, and if $r = \pm 1$, there is perfect correlation or a perfect fit.

The defining equations are:

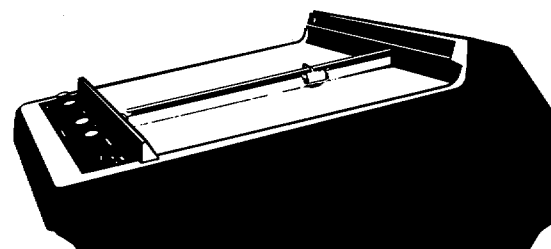
$$m = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sum_{i=1}^n (X_i - \bar{X})^2}$$

$$C = \bar{Y} - m\bar{X}$$

where $\bar{Y} = \frac{\sum_{i=1}^n Y_i}{n}$ and $\bar{X} = \frac{\sum_{i=1}^n X_i}{n}$

$$r = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2 \sum_{i=1}^n (Y_i - \bar{Y})^2}} = \frac{n \sum_{i=1}^n X_i Y_i - (\sum_{i=1}^n X_i)(\sum_{i=1}^n Y_i)}{\sqrt{\left[n \sum_{i=1}^n X_i^2 - (\sum_{i=1}^n X_i)^2 \right] \left[n \sum_{i=1}^n Y_i^2 - (\sum_{i=1}^n Y_i)^2 \right]}}$$

Reference: Mathematical Statistics
by John E. Freund
Prentice-Hall, 1962



USER INSTRUCTIONS

PRESS: STOP

Note: Use the origin controls to locate the pen in the lower left corner of the paper (on intersection of border lines if graph paper is being used).

ENTER PROGRAM A: (Starting Address is (0)(0))

SET: Decimal wheel at 6 or less

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

ENTER TRANSLATION CONSTANTS*:

 $Y_{\text{shift}} \rightarrow Y$ $X_{\text{shift}} \rightarrow X$

PRESS: CONTINUE

ENTER SCALING CONSTANTS*:

 $Y_{\text{scale}} \rightarrow Y$ $X_{\text{scale}} \rightarrow X$

*See General Plotter Instructions

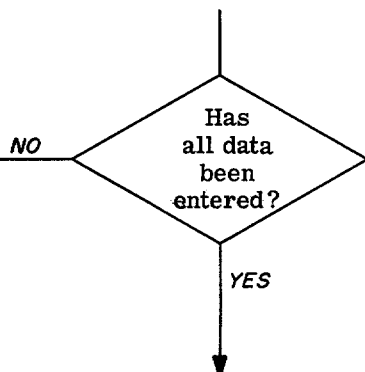
PRESS: CONTINUE

DISPLAY

i	_____	Z
0	_____	Y
0	_____	X

ENTER DATA: $Y_i \rightarrow Y$ $X_i \rightarrow X$

PRESS: CONTINUE

Note: (X_i, Y_i) is now plotted

USER INSTRUCTIONS (con't)

ENTER PROGRAM B: (Starting Address is (0)(0))

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

DISPLAY

r	_____	Z
C	_____	Y
m	_____	X

PRESS: CONTINUE

ENTER SCALING CONSTANTS: $Y_{\text{scale}} \rightarrow Y$ $X_{\text{scale}} \rightarrow X$

PRESS: CONTINUE

Note: The straight line of best fit is now plotted.

As the pen approaches any of the boundaries,
PRESS: STOP

EXAMPLE

<u>X</u>	<u>Y</u>
26	92
30	85
44	78
50	81
62	54
68	51
74	40

Let: $X_{\text{shift}} = 25$

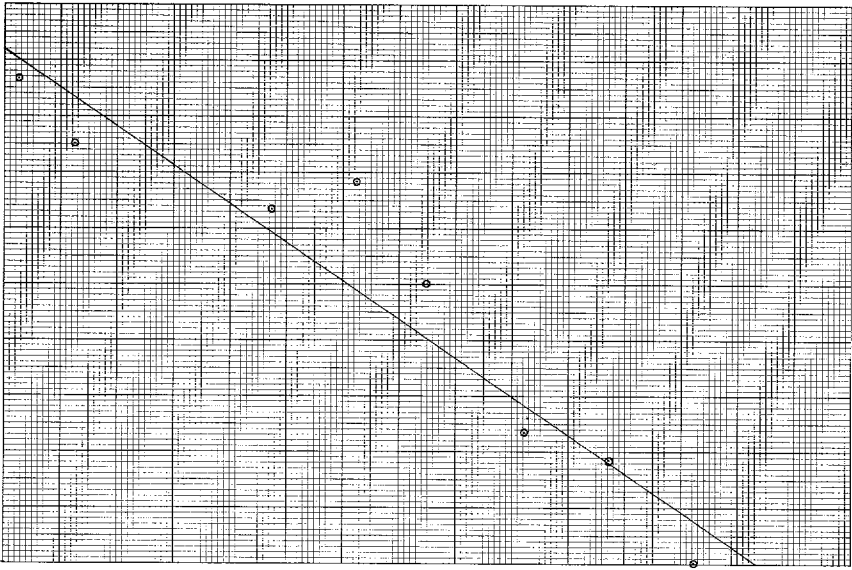
$$X_{\text{scale}} = \frac{74-25}{15} \approx 4$$

 $Y_{\text{shift}} = 40$

$$Y_{\text{scale}} = \frac{92-40}{10} \approx 6$$

Solution: $r = -.96$ $C = 121.04$ $m = -1.03$

$$Y = -1.03 X + 121.04$$



Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
3	0	b	14								
	1	+	33								
	2	y $\rightarrow$ ()	24								
	3	b	14								
	4	↓	25								
	5	ROLL ↓	31								
	6	x	36								
	7	x $\rightarrow$ y	30								
	8	y $\rightarrow$ ()	24	CALCULATE $\sum Y_i^2$							
	9	c	16								
	a	+	33								
	b	y $\rightarrow$ ()	24								
	c	c	16								
4	d	ROLL ↑	22								
	0	y $\rightarrow$ ()	24								
	1	9	11								
	2	y $\rightarrow$ ()	40								
	3	9	11								
	4	ROLL ↓	31								
	5	-	34								
	6	x $\rightarrow$ y	30								
	7	y $\rightarrow$ ()	24								
	8	8	10								
	9	y $\rightarrow$ ()	40								
	a	8	10								
5	b	ROLL ↓	31								
	c	-	34								
	d	5	05								
	0	0	00								
	1	0	00	CALCULATE $X_{plot} = \frac{500}{X_{scale}} [X_i - X_{shift}]$							
	2	x	36	$Y_{plot} = \frac{500}{Y_{scale}} [Y_i - Y_{shift}]$							
	3	ROLL ↑	22								
	4	x	36								
	5	x $\rightarrow$ y	30								
	6	y $\rightarrow$ ()	24								
	7	0	00								
	8	y $\rightarrow$ ()	40								
	9	0	00								
	a	ROLL ↓	31								
	b	÷	35								
	c	x $\rightarrow$ y	30								
	d	y $\rightarrow$ ()	24								

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
6	0	7	07								
	1	y→()	40								
	2	7	07								
	3	ROLL ↓	31								
	4	÷	35								
	5	↓	25								
	6	x↔y	30								
	7	FMT	42								
	8	↑	27								
	9	FMT	42								
	a	↓	25								
	b	GO TO () ()	44								
	c	1	01								
	d	6	06								
7	0	END	46								
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	a										
	b										
	c										
	d										
	0										
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	a										
	b										
	c										
	d										

PLOT LAST DATA POINT

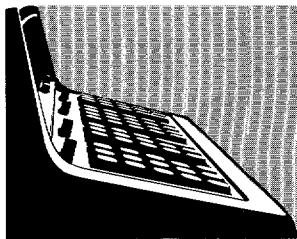
BRANCH TO RECEIVE NEXT POINT

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
0	0	↓	25								
	1	1	01								
	2	—	34	RESET COUNTER							
	3	y→()	40								
	4	a	13								
	5	e	12								
	6	x↔y	30	CALCULATE $\bar{y}$							
	7	÷	35								
	8	y↔()	24								
	9	f	15								
	a	÷	35	CALCULATE $\bar{x}$							
	b	y→()	40								
1	c	e	12								
	d	x	36								
	0	e	12								
	1	x	36								
	2	d	17	CALCULATE $\sum (x_i - \bar{x})^2$							
	3	x↔y	30								
	4	—	34								
	5	y→()	40								
	6	d	17								
	7	c	16								
	8	↑	27								
	9	f	15								
2	a	↑	27								
	b	x	36								
	c	a	13	CALCULATE $\sum (y_i - \bar{y})^2$							
	d	x	36								
	0	↓	25								
	1	—	34								
	2	y→()	40								
	3	c	16								
	4	b	14								
	5	↑	27								
	6	f	15								
	7	↑	27								
	8	e	12	CALCULATE $\sum (x_i - \bar{x})(y_i - \bar{y})$							
	9	x	36								
	a	a	13								
	b	x	36								
	c	↓	25								
	d	—	34								

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
3	0	d	17								
	1	↑	27								
	2	↓	25								
	3	$\sqrt{x}$	76	CALCULATE r							
	4	÷	35								
	5	C	16								
	6	$\sqrt{x}$	76								
	7	÷	35								
	8	d	17								
	9	ROLL ↑	22								
	a	$x \leftrightarrow y$	30	CALCULATE m							
	b	÷	35								
	c	$y \rightarrow ()$	40								
	d	a	13								
4	0	e	12								
	1	x	36								
	2	f	15	CALCULATE c							
	3	$x \leftrightarrow y$	30								
	4	—	34								
	5	a	13								
	6	STOP	41	m	c	r	DISPLAY				
	7	$y \rightarrow ()$	40	STORE c							
	8	b	14								
	9	CLEAR	20								
	a	$x \rightarrow ()$	23	CLEAR DISPLAY AND C REGISTER							
	b	C	16								
	c	FMT	42	RESET PEN TO ORIGIN							
	d	↑	27								
5	0	STOP	41	X _{scale}	Y _{scale}	0	ENTER SCALING CONSTANTS				
	1	ACC +	60	STORE SCALING CONSTANTS							
	2	↓	25								
	3	f	15								
	4	x	36								
	5	5	05								
	6	0	00								
	7	0	00	CALCULATE Y FROM X _{plot}							
	8	÷	35								
	9	ROLL ↓	31								
	a	$y \rightarrow ()$	24								
	b	8	10								
	c	$y \rightarrow ()$	40								
	d	8	10								

FROM 7-b

HEWLETT-PACKARD ^(hp) HEWLETT-PACKARD ^(hp) HEWLETT-PACKARD ^(hp) HEWLETT-PACKARD ^(hp)



PART NO.
09100-70819

PARABOLIC REGRESSION AND PLOT

The least square parabola approximating the set of points $(X_1, Y_1) \dots (X_i, Y_i)$ has the equation:

$$Y = a_0 + a_1 X + a_2 X^2$$

where the constants a_0 , a_1 , and a_2 are determined by solving simultaneously the following normal equations:

$$\sum Y = a_0 n + a_1 \sum X + a_2 \sum X^2$$

$$\sum XY = a_0 \sum X + a_1 \sum X^2 + a_2 \sum X^3$$

$$\sum X^2 Y = a_0 \sum X^2 + a_1 \sum X^3 + a_2 \sum X^4$$

In the program, the constant a_2 is found by matrix algebra; the determinate (D) involved in the solution is:

$$D = \begin{vmatrix} n & \sum X & \sum X^2 \\ \sum X & \sum X^2 & \sum X^3 \\ \sum X^2 & \sum X^3 & \sum X^4 \end{vmatrix}$$

The equation for a_2 is therefore:

$$a_2 = \frac{\{n(\sum X^2 \sum X^2 Y - \sum X^3 \sum XY) - \sum X (\sum X \sum X^2 Y - \sum X^2 \sum XY) + \sum Y [\sum X \sum X^3 - (\sum X^2)^2]\}}{D}$$

After finding a_2 , the solution is reduced to two equations in two unknowns which are:

$$N = a_0 n + a_1 \sum X$$

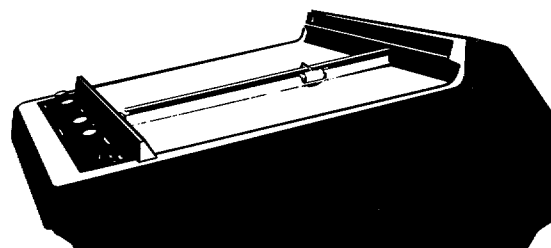
$$M = a_0 \sum X + a_1 \sum X^2$$

$$\text{where } M = \sum XY - a_2 \sum X^3 \quad N = \sum Y - a_2 \sum X^2$$

These equations are then solved for a_0 and a_1 .

The program will plot each data point as it is entered and then the least squares curve after the coefficients are calculated.

Reference: Introduction into the Theory of Statistics
Alexander Mood and Franklin Graybill
McGraw-Hill, 1961



USER INSTRUCTIONS

Using the origin controls, locate the pen in the lower left corner of the paper.

SET: Decimal wheel at 6 or less

ENTER PROGRAM A: (Starting Address is
(0)(0))

PRESS: END

SET:

PROGRAM	
---------	--

ENTER X_{shift} : Storage locations 0-0, 0-1,
and 0-2 are available.*

PRESS: STEP PROGRAM

ENTER X_{scale} : Storage locations 0-4, 0-5,
and 0-6 are available.*

PRESS: STEP PROGRAM

PRESS: STEP PROGRAM

PRESS: STEP PROGRAM

PRESS: STEP PROGRAM

ENTER Y_{shift} : Storage locations 0-b, 0-c, and
0-d are available.*

PRESS: STEP PROGRAM

PRESS: STEP PROGRAM

ENTER Y_{scale} : Storage locations 1-2, 1-3,
and 1-4 are available.*

*If a three digit number is not used,
PRESS: CONTINUE at each of the
other locations.

SET:

	RUN
--	-----

PRESS: GO TO (2)(9)

PRESS: CONTINUE

→DISPLAY

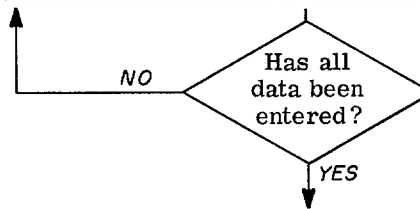
i	—	Z
0	—	Y
0	—	X

ENTER DATA: $Y_i \rightarrow Y$
 $X_i \rightarrow X$

PRESS: CONTINUE

[Note: (X_i, Y_i)
will now be
plotted.]

USER INSTRUCTIONS (con't)



PRESS: SET FLAG

PRESS: CONTINUE

ENTER PROGRAM B: (Starting Address is
(2)(2))

PRESS: GO TO (2)(2)

PRESS: CONTINUE

ENTER PROGRAM C: (Starting Address is
(2)(2))

PRESS: GO TO (2)(7)

PRESS: CONTINUE

DISPLAY

a_0	—	Z
a_1	—	Y
a_2	—	X

PRESS: CONTINUE

The least squares parabola will now be plotted.
As the pen approaches any border
PRESS: STOP.

EXAMPLE

EXAMPLE (con't)

<u>X</u>	<u>Y</u>
3	34
0	1
5	75
2	12
4	50
1	5
7	130
6	84
-1	0

Note: 11 x 17 inch paper is used for this example.

Let:

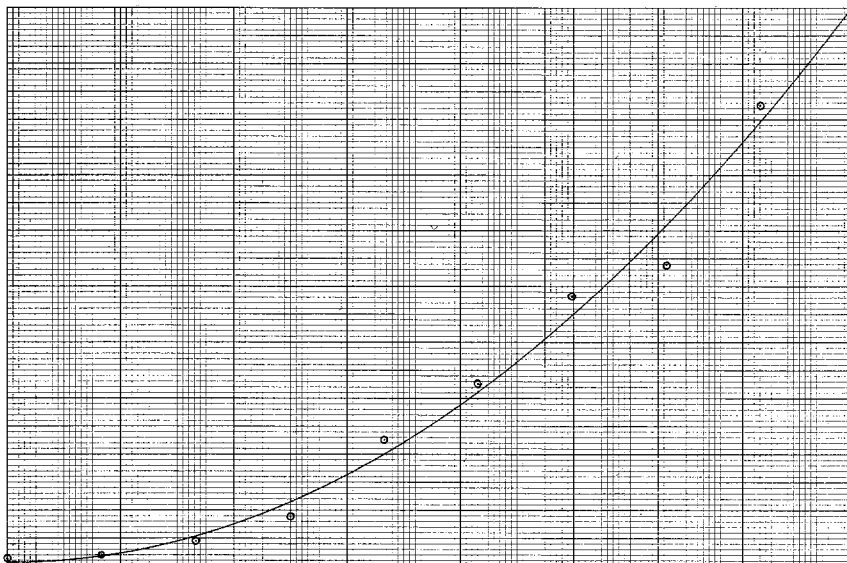
$$X_{\text{shift}} = -1 \quad X_{\text{scale}} = \frac{7 - (-1)}{15} \approx .6 \frac{\text{units}}{\text{inch}}$$

$$Y_{\text{shift}} = -2 \quad Y_{\text{scale}} = \frac{130 - (-2)}{10} \approx 16 \frac{\text{units}}{\text{inch}}$$

Solution: $Y = .7939 + 3.6989X + 2.0141X^2$

The steps which enter the scale and shift constants are given below:

PRESS: END
 SET: PROGRAM
 PRESS: 1
 PRESS: CHANGE SIGN
 PRESS: CONTINUE
 PRESS: STEP PROGRAM
 PRESS: .
 PRESS: 6
 PRESS: CONTINUE
 PRESS: STEP PROGRAM
 PRESS: STEP PROGRAM
 PRESS: STEP PROGRAM
 PRESS: STEP PROGRAM
 PRESS: 2
 PRESS: CHANGE SIGN
 PRESS: CONTINUE
 PRESS: STEP PROGRAM
 PRESS: STEP PROGRAM
 PRESS: 1
 PRESS: 6
 PRESS: CONTINUE
 SET: RUN



			Display				Storage														
Step	Key	Code	x	y	z	f	e	d	c	b	a										
0	0	CONTINUE	47	ENTER X_{shift} HERE																	
	1	CONTINUE	47																		
	2	CONTINUE	47																		
	3	—	34																		
	4	CONTINUE	47	ENTER X_{scale} HERE																	
	5	CONTINUE	47																		
	6	CONTINUE	47																		
	7	IF FLAG	43																		
	8	7	07	ENTER Y_{shift} HERE																	
	9	6	06																		
a	÷	35																			
b	CONTINUE	47																			
c	CONTINUE	47	ENTER Y_{scale} HERE																		
d	CONTINUE	47																			
1	0	ROLL ↑										22	ENTER Y_{scale} HERE								
	1	—										34									
	2	CONTINUE	47																		
	3	CONTINUE	47																		
	4	CONTINUE	47	CALCULATE $X_{\text{plot}} = \frac{500}{X_{\text{scale}}} [X - X_{\text{shift}}]$ $Y_{\text{plot}} = \frac{500}{Y_{\text{scale}}} [Y - Y_{\text{shift}}]$																	
	5	÷	35																		
	6	5	05																		
	7	0	00																		
	8	0	00	POSITION AND PLOT LAST DATA POINT																	
	9	CHG SIGN	32																		
a	X	36																			
b	ROLL ↑	22																			
c	$x \leftrightarrow y$	30	BRANCH TO AVOID CLEARING THE e AND f REGISTERS AFTER THE FIRST PASS																		
d	CHG SIGN	32																			
2	0	X										36	INCREMENT COUNTER AND POSITION DISPLAY								
	1	ROLL ↓										31									
	2	FMT	42																		
	3	↑	27																		
	4	FMT	42	INCREMENT COUNTER AND POSITION DISPLAY																	
	5	↓	25																		
	6	GOTO ()	44																		
	7	2	02																		
	8	a	13																		
	9	CLEAR	20																		
a	1	01	INCREMENT COUNTER AND POSITION DISPLAY																		
b	$y \leftrightarrow ()$	24																			
c	8	10																			
d	+	33																			

HEWLETT-PACKARD
FROM 9-80R 6-b

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
3	0	y→()	40								
	1	8	10								
	2	CLEAR X	37								
	3	↑	27								
	4	STOP	41	X_i	Y_i	0	ENTER DATA POINT				
	5	IF FLAG	43								
	6	6	06	BRANCH IF ALL DATA POINTS HAVE BEEN ENTERED							
	7	C	16								
	8	ACC +	60	CALCULATE $\sum X$ AND $\sum Y$							
	9	↑	27								
4	a	X	36								
	b	ROLL ↓	31								
	c	y→()	24								
	d	b	14	CALCULATE $\sum X^2$							
	0	+	33								
	1	y→()	24								
	2	b	14								
	3	x→y	30								
	4	X	36								
	5	x→y	30								
5	6	y→()	24	CALCULATE $\sum X^2 Y$							
	7	d	17								
	8	+	33								
	9	y→()	24								
	a	d	17								
	b	↓	25								
	c	X	36								
	d	ROLL ↓	31								
	0	y→()	24	CALCULATE $\sum XY$							
	1	C	16								
6	2	+	33								
	3	y→()	24								
	4	C	16								
	5	↓	25								
	6	↑	27								
	7	X	36								
	8	X	36								
	9	x→y	30	CALCULATE $\sum X^3$							
	a	y→()	24								
	b	a	13								
7	c	+	33								
	d	y→()	24								

HEWLETT-PACKARD
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HEWLETT-PACKARD

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
6	0	a	13								
	1	x $\rightarrow$ y	30								
	2	x	36								
	3	x $\rightarrow$ y	30								
	4	y $\rightarrow$ ()	24								
	5	9	11								
	6	+	33								
	7	y $\rightarrow$ ()	24								
	8	9	11								
	9	GO TO () ()	44								
	a	0	00								
	b	0	00								
	c	$\downarrow$	25								
	d	1	01								
7	0	-	34								
	1	y $\rightarrow$ ()	40								
	2	8	10								
	3	a	13								
	4	$\uparrow$	27								
	5	f	15								
	6	x	36								
	7	2	02								
	8	x	36								
	9	b	14								
	a	x	36								
	b	$\uparrow$	27								
	c	x	36								
	d	STOP	41								
8	0	0	00								
	1										
	2										
	3										
	4										
	5										
	6										
	7										
	8										
	9										
	a										
	b										
	c										
	d										

CALCULATE $\sum x^4$

BRANCH TO CALCULATE X_{plot} AND Y_{plot}

CALCULATE $n = \text{NUMBER OF DATA POINTS ENTERED}$

BEGIN TO CALCULATE D

CLEAR STORAGE REGISTERS

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
5	0	C	16								
	1	X	36								
	2	↓	25								
	3	—	34								
	4	f	15								
	5	X	36								
	6	y→()	40								
	7	4	04								
	8	↑	27								
	9	a	13								
	a	X	36								
	b	b	14								
	c	↑	27								
	d	X	36								
6	0	↓	25								
	1	—	34								
	2	e	12								
	3	X	36								
	4	↓	25								
	5	y↔()	24								
	6	4	04								
	7	—	34								
	8	y↔()	24								
	9	3	03								
	a	b	14								
	b	X	36								
	c	a	13								
	d	↑	27								
7	0	C	16								
	1	X	36								
	2	↓	25								
	3	—	34								
	4	↓	25								
	5	y↔()	24								
	6	8	10								
	7	↑	27								
	8	↓	25								
	9	y↔()	24								
	a	3	03								
	b	ROLL ↑	22								
	c	X	36								
	d	END	46								

CALCULATE $\sum Y [\sum X \sum X^3 - (\sum X^2)^2]$

CALCULATE $n(\sum X^2 \sum X^2 Y - \sum X^3 \sum XY)$

(99) HEWLETT·PACKARD **(76)** HEWLETT·PACKARD **(42)** HEWLETT·PACKARD **(76)** HEWLETT·PACKARD **(99)** HEWLETT·PACKARD

Step	Key	Code	Display			Storage						
			x	y	z	f	e	d	c	b	a	
2	0											
	1											
	2	FMT	42	PLOT A SECTION OF THE CURVE ($\frac{1}{6}$ INCH)								
	3	↓	25									
	4	GO TO() ()	44	BRANCH TO CALCULATE NEXT CURVE COORDINATE								
	5	8	10									
	6	1	01	CALCULATE a_2								
	7	ROLL ↑	22									
	8	$y \rightarrow z$	24									
	9	d	17									
	a	ROLL ↑	22									
	b	$x \rightarrow y$	30									
	c	—	34									
	d	↓	25	CALCULATE N								
3	0	$x \rightarrow y$	30									
	1	÷	35									
	2	↑	27									
	3	↓	25									
	4	$y \rightarrow z$	24									
	5	E	12									
	6	b	14									
	7	ROLL ↑	22									
	8	X	36									
	9	ROLL ↓	31									
a	—	34	CALCULATE M									
b	$y \rightarrow z$	24										
c	C	16										
d	a	13										
4	0	ROLL ↑										22
	1	X	36									
	2	↓	25									
	3	—	34									
	4	d	17									
	5	X	36									
	6	C	16									
	7	↑	27									
	8	f	15									
	9	X	36									
a	ROLL ↓	31	CALCULATE $a_1 = \frac{N\sum X - nM}{(\sum X)^2 - n\sum X^2}$									
b	—	34										
c	$y \rightarrow z$	24										
d	b	14										

Step	Key	Code	Display			Storage					
			x	y	z	f	e	d	c	b	a
5	0	d	17								
	1	x	36								
	2	↓	25								
	3	ROLL ↓	31								
	4	x	36								
	5	ROLL ↓	31								
	6	—	34								
	7	b	14								
	8	x↔y	30								
	9	÷	35								
	a	y→()	40								
	b	a	13								
	c	↓	25								
	d	x	36								
6	0	c	16								
	1	x↔y	30								
	2	—	34								
	3	d	17								
	4	÷	35								
	5	y→()	40								
	6	d	17								
	7	a	13								
	8	↑	27								
	9	e	12								
	a	x→()	23								
	b	c	16								
	c	STOP	41	a ₂	a ₁	a ₀	DISPLAY				
	d	CLEAR	20								
7	0	FMT	42								
	1	↑	27								
	2	SET FLAG	54								
	3	GOTO () ()	44								
	4	0	00								
	5	0	00								
	6	↑	27								
	7	6	06								
	8	÷	35								
	9	↓	25								
	a	+	33								
	b	x↔y	30								
	c	CHG SIGN	32								
	d	x↔y	30								

CALCULATE $a_0 = \frac{N - a_1 \sum X}{m}$

POSITION DISPLAY

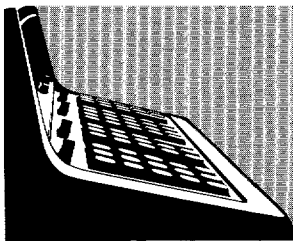
RESET PEN

SET FLAG AND BRANCH TO
OBTAIN X_{scale} AND X_{shift}

CALCULATE $\Delta X = \frac{X_{scale}}{6}$ AND $X = X_{shift} - \Delta X$

HEWLETT·PACKARD [hp] HEWLETT·PACKARD [hp] HEWLETT·PACKARD [hp] HEWLETT·PACKARD [hp] FROM 2-6

[illegible]



PART NO.
09100-70820

EXPONENTIAL REGRESSION AND PLOT

This program computes the least squares fit and a correlation coefficient of n pairs of data points for an exponential function of the form:

$$y = ae^{bx}$$

The program also plots each point and the least squares curve after the unknowns have been calculated.

The equation is linearized into

$$\ln y = \ln a + bx$$

or

$$Y = A + bx$$

Using a linear regression method,

$$b = \frac{n \sum x Y - \sum x \sum Y}{n \sum x^2 - (\sum x)^2}$$

$$A = \frac{\sum Y - b \sum x}{n}$$

$$a = e^A$$

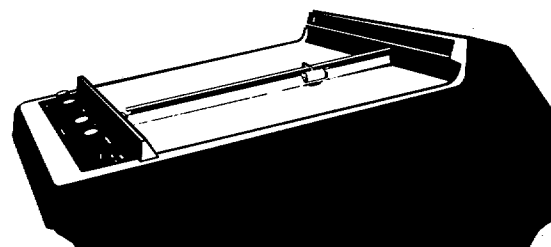
the correlation coefficient is given by

$$r = \frac{n \sum x Y - \sum x \sum Y}{\sqrt{[n \sum x^2 - (\sum x)^2] [n \sum Y^2 - (\sum Y)^2]}}$$

Note: $Y_i > 0$ $i = 1, \dots, n$

Reference: Statistical Theory and Methodology in Science and Engineering
by K. A. Brownlee

John Wiley and Sons, 1965



USER INSTRUCTIONS

Using the origin controls, locate the pen in the lower left corner.

ENTER PROGRAM A: (Starting Address is (0)(0))

SET: Decimal wheel at 6 or less

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

ENTER TRANSLATION CONSTANTS:

$Y_{\text{shift}} \rightarrow Y$

$X_{\text{shift}} \rightarrow X$

PRESS: CONTINUE

ENTER SCALING CONSTANTS:

$Y_{\text{scale}} \rightarrow Y$

$X_{\text{scale}} \rightarrow X$

PRESS: CONTINUE

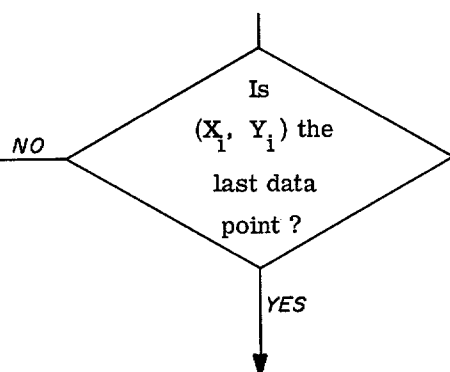
DISPLAY

0 ——— Z
0 ——— Y
i ——— X

Each data point will be plotted as entered.

ENTER DATA: $Y_i \rightarrow Y$

$X_i \rightarrow X$



PRESS: SET FLAG

PRESS: CONTINUE

USER INSTRUCTIONS (con't)

ENTER PROGRAM B: (Starting Address is (0)(0))

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

DISPLAY

a ——— Z
b ——— Y
r ——— X

PRESS: CONTINUE

The least squares curve $y = ae^{bx}$ will now be plotted. To interrupt the plot or stop it when finished, PRESS: STOP.

To re-run program return to beginning of USER INSTRUCTIONS, ENTER PROGRAM B and proceed as before.

EXAMPLE

<u>X</u>	<u>Y</u>
.5	7.12
1.2	11.67
2.9	38.85
3.3	48.03
4.8	138.70
5.6	262.00
7.4	935.64

$$\text{Let: } X_{\text{shift}} = .5 \quad X_{\text{scale}} = \geq \frac{7.4 - .5}{15} \approx .5 \frac{\text{units}}{\text{inch}}$$

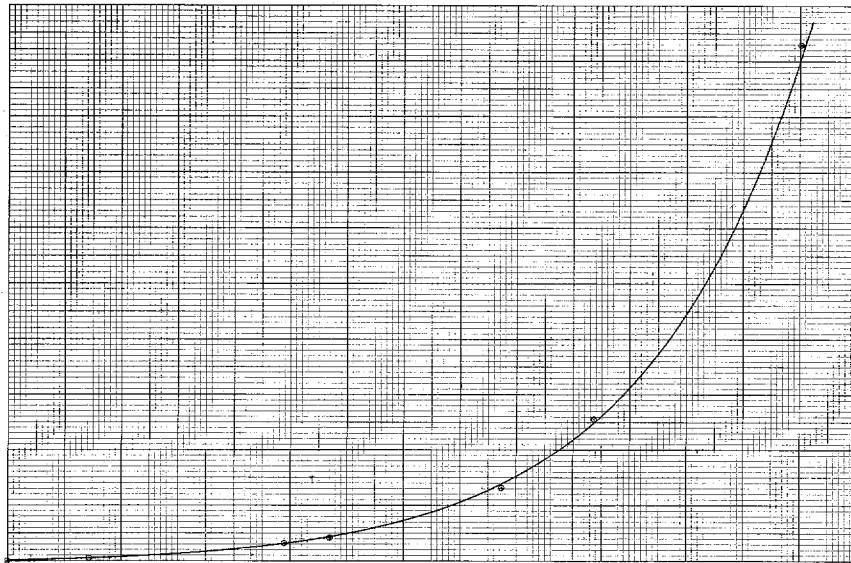
$$Y_{\text{shift}} = 5 \quad Y_{\text{scale}} = \geq \frac{935.64 - 5}{10} \approx 100 \frac{\text{units}}{\text{inch}}$$

Solution: $a = 4.925$

$b = .705$

$r = .9998$

$$Y = 4.925e^{.705X}$$



HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
0	CLEAR	20	ENTER			3	+	33				6	8	10			
1	STOP	41	Xshift	Yshift	0	1	y _z ()	24				1	X	36			
2	x→()	23				2	8	10				2	E	12			
3	θ	13				3	ROLL ↑	22				3	↑	27			
4	y→()	40				4	e ^x	74				4	X	36			
5	b	14				5	ROLL ↓	31				5	↓	25			
6	CLEAR	20	ENTER			6	θ	13				6	—	34			
7	STOP	41	Xscale	Yscale	0	7	—	34				7	↑	27			
8	x→()	23				8	C	16				8	y _z ()	24			
9	C	16				9	÷	35				9	7	07			
10	y→()	40				10	b	14				10	xzy	30			
11	d	17				11	ROLL ↑	22				11	y _z ()	24			
12	CLEAR	20				12	xzy	30				12	8	10			
13	1	01				13	—	34				13	STOP	41			
14	x→()	23				14	d	17				14	0	00			
15	0	00	ENTER			15	÷	35				15					
16	STOP	41	X _i	Y _i	0	16	5	05				16					
17	xzy	30				17	0	00				17					
18	ln x	65				18	0	00				18					
19	ACC +	60				19	X	36				19					
20	↑	27				20	ROLL ↑	22				20					
21	X	36				21	X	36				21					
22	xzy	30				22	CLEAR X	37				22					
23	y _z ()	24				23	ROLL ↓	31				23					
24	7	07				24	FMT	42				24					
25	+	33				25	↓	25				25					
26	y _z ()	24				26	FMT	42				26					
27	7	07				27	↑	27				27	0	00			
28	↓	25				28	y _z ()	24				28					
29	X	36				29	0	00				29					
30	xzy	30				30	IF FLAG	43				30	ΔX				
31	y _z ()	24				31	5	05				31	X				
32	9	11				32	b	14				32	Yscale				
33	+	33				33	1	01				33	Xscale				
34	y _z ()	24				34	+	33				34	Yshift				
35	9	11				35	↓	25				35	Xshift				
36	↓	25				36	GOTO()	44				36					
37	ROLL ↓	31				37	1	01				37					
38	X	36				38	0	00				38					
39	xzy	30				39	↓	25				39					
40	y _z ()	24				40	↑	27				40					
41	8	10				41	y _z ()	24				41					

Storage

Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
8	0	00				0						0					
1						1						1					
2						2						2					
3						3						3					
4						4						4					
5						5						5					
6						6						6					
7						7						7					
8						8						8					
9						9						9					
a						a						a					
b						b						b					
c						c						c					
d						d						d					
90	0	00				0						0					
1						1						1					
2						2						2					
3						3						3					
4						4						4					
5						5						5					
6						6						6					
7						7						7					
8						8						8					
9						9						9					
a						a						a					
b						b						b					
c						c						c					
d						d						d					
0						0						0					
1						1						1					
2						2						2					
3						3						3					
4						4						4					
5						5						5					
6						6						6					
7						7						7					
8						8						8					
9						9						9					
a						a						a					
b						b						b					
c	0	00				c						c					
d	END	46				d						d					
0						0						0					
1						1						1					
2						2						2					
3						3						3					
4						4						4					
5						5						5					
6						6						6					
7						7						7					
8						8						8					
9						9						9					
a						a						a					
b						b						b					
c						c						c					
d						d						d					

Storage

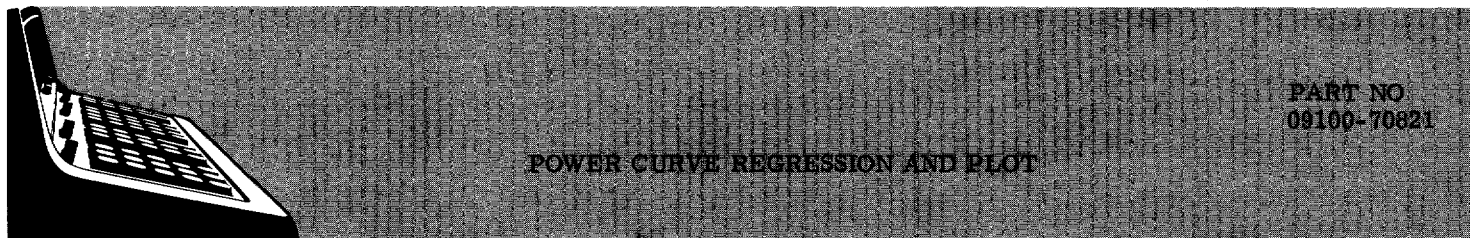
QUESTIONS

Fidelity Investments

WILLIAMS-FAKED

 HEWLETT-PACKARD

Step	Step	Key	Code	Display			Step	Step	Key	Code	Display			Step	Step	Key	Code	Display		
				x	y	z					x	y	z					x	y	z
0	0	y→()	40				3	0	↑	27				6	0	y→()	40			
1	1	8	10				1	1	↓	25				1	1	1	01			
2	2	X	36				2	2	CHG SIGN	32				2	2	X	36			
3	3	↓	25				3	3	X	36				3	3	b	14			
4	4	y↔()	24				4	4	f	15				4	4	—	34			
5	5	f	15				5	5	+	33				5	5	d	17			
6	6	x↔y	30				6	6	x↔y	30				6	6	÷	35			
7	7	↑	27				7	7	y↔()	24				7	7	e	12			
8	8	X	36				8	8	8	10				8	8	↑	27			
9	9	ROLL ↓	31				9	9	x↔y	30				9	9	a	13			
a	a	—	34				a	a	÷	35				a	a	—	34			
b	b	↓	25				b	b	↓	25				b	b	⌈	16			
c	c	y↔()	24				c	c	e ^x	74				c	c	÷	35			
d	d	f	15				d	d	y↔()	24				d	d	5	05			
1	0	y→()	40				4	0	0	00				7	0	0	00			
1	1	0	00				1	1	x→()	23				1	1	0	00			
2	2	X	36				2	2	1	01				2	2	X	36			
3	3	↓	25				3	3	ROLL ↓	31				3	3	ROLL ↑	22			
4	4	√x	76				4	4	STOP	41				4	4	X	36			
5	5	y↔()	24				5	5	CLEAR	20				5	5	↓	25			
6	6	8	10				6	6	⌈	16				6	6	x↔y	30			
7	7	y→()	40				7	7	↑	27				7	7	FMT	42			
8	8	8	10				8	8	6	06				8	8	↓	25			
9	9	x↔y	30				9	9	÷	35				9	9	GO TO () ()	44			
a	a	y↔()	24				a	a	a	13				a	a	5	05			
b	b	9	11				b	b	x↔y	30				b	b	0	00			
c	c	X	36				c	c	—	34				c	c	END	46			
d	d	↑	27				d	d	ACC +	60				d	d					



PART NO
09100-70821

POWER CURVE REGRESSION AND PLOT

This program computes the least squares fit and correlation coefficient of N pairs of data points for a power curve of the form:

$$Y = aX^b$$

The program will also plot each data point and the curve after the unknowns have been calculated.

The equation is linearized into $\ln Y = b \ln X + \ln a$

where

$$b = \frac{N \sum (\ln X \ln Y) - \sum \ln X \sum \ln Y}{N \sum (\ln X)^2 - (\sum \ln X)^2}$$

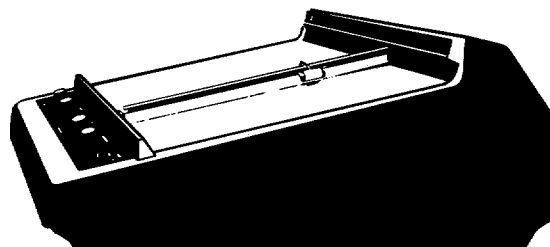
and

$$r = \frac{N \sum (\ln X \ln Y) - (\sum \ln X) (\sum \ln Y)}{\sqrt{[N \sum (\ln X)^2 - (\sum \ln X)^2] [N \sum (\ln Y)^2 - (\sum \ln Y)^2]}}$$

$$\ln a = \frac{\sum \ln Y}{N} - \frac{\sum \ln X}{N} b$$

Note: $X_i > 0$, $Y_i > 0$, $i = 1, \dots, N$ and $X_{\text{shift}} > 0$

Reference: Statistical Theory and Methodology in Science and Engineering
by K. A. Brownlee
John Wiley and Sons, 1965



USER INSTRUCTIONS

PRESS: STOP

Using the origin controls, locate the pen in the lower left corner of the paper.

ENTER PROGRAM A: (Starting Address is (0)(0))

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

ENTER TRANSLATION CONSTANTS*:

 $Y_{\text{shift}} \rightarrow Y$ $X_{\text{shift}} \rightarrow X$ Note: $X_{\text{shift}} > 0$

PRESS: CONTINUE

ENTER SCALING CONSTANTS*:

 $Y_{\text{scale}} \rightarrow Y$ $X_{\text{scale}} \rightarrow X$

PRESS: CONTINUE

DISPLAY

0	—	Z
0	—	Y
i	—	X

Each data point will be plotted
as entered.

ENTER DATA: $Y_i \rightarrow Y$ $X_i \rightarrow X$

NO

Last
entry?

YES

PRESS: SET FLAG

PRESS: CONTINUE

ENTER PROGRAM B: (Starting Address is (0)(0))

PRESS: GO TO (0)(0) [or END]

PRESS: CONTINUE

USER INSTRUCTIONS (con't)

DISPLAY

r	—	Z
b	—	Y
a	—	X

PRESS: CONTINUE

The Plotter will now plot the least squares
curve. To interrupt the plot or stop it when
finished, PRESS: STOP.

To re-run program, return to beginning of
USER INSTRUCTIONS, ENTER PROGRAM A
and proceed as before.

*See general Plotter instructions.

EXAMPLE

X	Y
1.2	15.25
1.7	6.68
2.3	4.54
2.9	1.74
4.4	.87
4.8	.51
5.7	.33
7.2	.23
8.4	.17

Let:

$$X_{\text{shift}} = 1.1 \quad X_{\text{scale}} = \frac{8.4 - 1.1}{15} \approx .5 \frac{\text{units}}{\text{inch}}$$

$$Y_{\text{shift}} = 0 \quad Y_{\text{scale}} = \frac{15.25 - .17}{10} \approx 2 \frac{\text{units}}{\text{inch}}$$

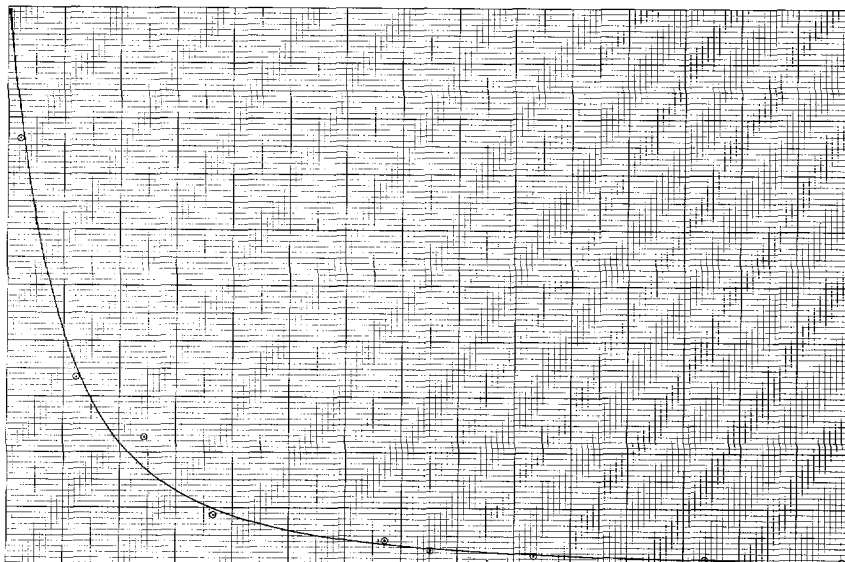
Solution:

$$r = -.9952$$

$$b = -2.384$$

$$a = 24.949$$

$$Y = 24.949 X^{-2.384}$$



HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
00	CLEAR	20	ENTER			30	7	07				60	0	00			
1	STOP	41	X _{shift}	Y _{shift}	0	1	+	33				1	E	12			
2	X→()	23				2	yz()	24				2	↑	27			
3	a	13				3	7	07				3	X	36			
4	y→()	40				4	↓	25				4	ROLL ↑	22			
5	b	14				5	e ^x	74				5	yz()	24			
6	CLEAR	20	ENTER			6	xzy	30				6	7	07			
7	STOP	41	X _{scale}	Y _{scale}	0	7	e ^x	74				7	X	36			
8	X→()	23				8	↑	27				8	ROLL ↓	31			
9	c	16				9	b	14				9	—	34			
a	y→()	40				a	—	34				a	yz()	24			
b	d	17				b	d	17				b	f	15			
c	CLEAR	20				c	÷	35				c	↓	25			
d	1	01				d	a	13				d	STOP	41			
10	X→()	23				40	ROLL ↑	22				70	0	00			
1	0	00	ENTER			1	xzy	30				1					
2	STOP	41	X _i	Y _i	0	2	—	34				2					
3	ln x	65				3	c	16				3					
4	xzy	30				4	÷	35				4					
5	ln x	65				5	5	05				5					
6	ACC +	60				6	0	00				6					
7	↑	27				7	0	00				7					
8	X	36				8	X	36				8					
9	xzy	30				9	ROLL ↑	22				9					
a	yz()	24				a	X	36				a					
b	8	10				b	CLEAR x	37				b					
c	+	33				c	ROLL ↓	31				c					
d	yz()	24				d	xzy	30				d					
20	8	10				50	FMT	42				Storage					
1	↓	25				1	↓	25				f	ΔX				
2	X	36				2	FMT	42				e	X				
3	xzy	30				3	↑	27				d	Y _{scale}				
4	yz()	24				4	yz()	24				c	X _{scale}				
5	9	11				5	0	00				b	Y _{shift}				
6	+	33				6	IF FLAG	43				a	X _{shift}				
7	yz()	24				7	6	06				9					
8	9	11				8	1	01				8					
9	↓	25				9	1	01				7					
a	ROLL ↓	31				a	+	33				6					
b	X	36				b	↓	25				5					
c	xzy	30				c	GO TO () ()	44				4					
d	yz()	24				d	1	01				3					
												2					
												1					
												0					

Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
8	0	00				0						0					
1						1						1					
2						2						2					
3						3						3					
4						4						4					
5						5						5					
6						6						6					
7						7						7					
8						8						8					
9						9						9					
a						a						a					
b						b						b					
c						c						c					
d						d						d					
9	0	00				0						0					
1						1						1					
2						2						2					
3						3						3					
4						4						4					
5						5						5					
6						6						6					
7						7						7					
8						8						8					
9						9						9					
a						a						a					
b						b						b					
c	0	00				c						c					
d	END	46				d						d					
0						0						Storage					
1						1						F					
2						2						E					
3						3						D					
4						4						C					
5						5						B					
6						6						A					
7						7						9					
8						8						8					
9						9						7					
a						a						6					
b						b						5					
c						c						4					
d						d						3					
												2					
												1					
												0					

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

HEWLETT-PACKARD

Step	Key	Code	Display			Step	Key	Code	Display			Step	Key	Code	Display		
			x	y	z				x	y	z				x	y	z
0	↑	27				3	—	34				6	0	00			
1	X	36				1	$x \rightarrow y$	30				1	$y \rightarrow ()$	40			
2	$x \rightarrow y$	30				2	$y \rightarrow ()$	24				2	0	00			
3	$y \rightarrow ()$	24				3	8	10				3	X	36			
4	8	10				4	$x \rightarrow y$	30				4	b	14			
5	ROLL ↓	31				5	÷	35				5	—	34			
6	$x \rightarrow y$	30				6	$x \rightarrow y$	30				6	d	17			
7	X	36				7	e^x	74				7	÷	35			
8	ROLL ↓	31				8	$y \rightarrow ()$	24				8	E	12			
9	—	34				9	9	11				9	↑	27			
a	f	15				a	ROLL ↓	31				a	a	13			
b	X	36				b	÷	35				b	—	34			
c	↓	25				c	E	12				c	C	16			
d	$\sqrt{x}$	76				d	ROLL ↑	22				d	÷	35			
1	↑	27				4	$x \rightarrow ()$	23				7	0	05			
1	$y \rightarrow ()$	24				1	0	00				1	0	00			
2	9	11				2	$y \rightarrow ()$	40				2	0	00			
3	↓	25				3	1	01			DISPLAY	3	X	36			
4	X	36				4	STOP	41	a	b	r	4	ROLL ↑	22			
5	ROLL ↑	22				5	CLEAR	20				5	X	36			
6	$x \rightarrow y$	30				6	C	16				6	↓	25			
7	$y \rightarrow ()$	24				7	↑	27				7	$x \rightarrow y$	30			
8	8	10				8	8	10				8	FMT	42			
9	$y \rightarrow ()$	40				9	÷	35				9	↓	25			
a	0	00				a	a	13				a	GO TO () ()	44			
b	E	12				b	$x \rightarrow y$	30				b	5	05			
c	X	36				c	—	34				c	0	00			
d	↓	25				d	ACC +	60				d	END	46			
2	—	34				5	RCL	61				Storage					
1	↑	27				1	ACC —	63				F					
2	↓	25				2	+	33				E					
3	f	15				3	ACC +	60				d					
4	CHG SIGN	32				4	↓	25				C					
5	÷	35				5	ln z	65				b					
6	↓	25				6	$y \rightarrow ()$	24				a					
7	↑	27				7	1	01				9					
8	$y \rightarrow ()$	24				8	$y \rightarrow ()$	40				8					
9	E	12				9	1	01				7					
a	X	36				a	X	36				6					
b	$x \rightarrow y$	30				b	↓	25				5					
c	$y \rightarrow ()$	24				c	e^x	74				4					
d	0	00				d	$y \rightarrow ()$	24				3					
												2					
												1					
												0					

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