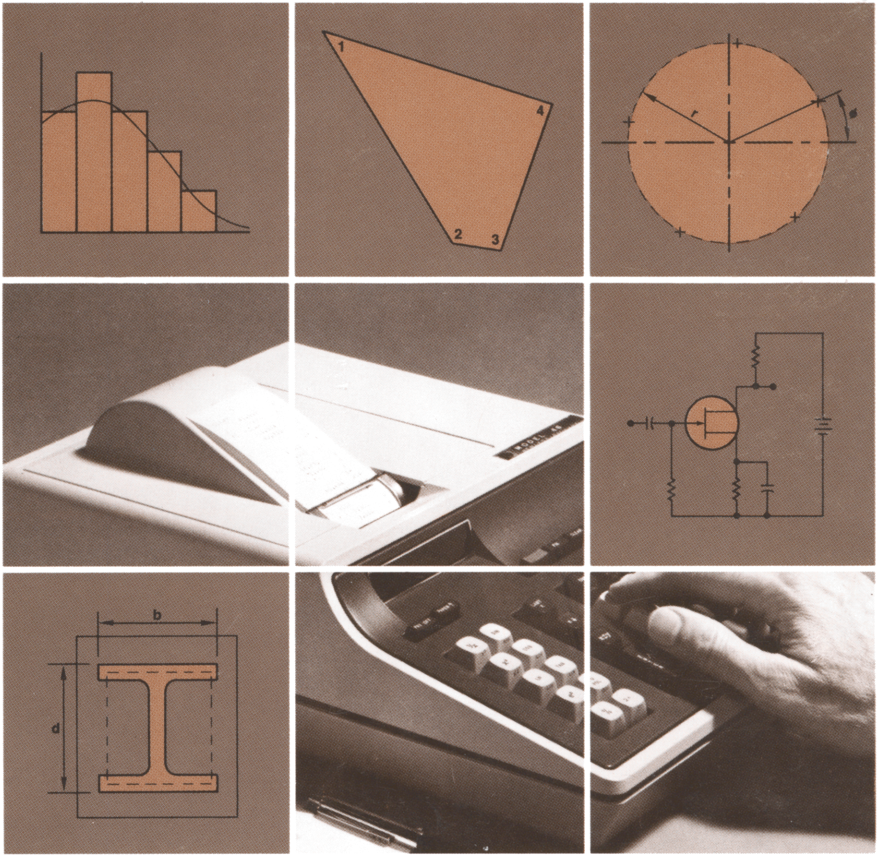
HEWLETT hp PACKARD

HP-46
sample applications

electronic • mechanical • structural • medical • surveying



Domestic U.S.A. price **$5.00**

HP-46 Applications

The HP-46 is a desk-top printing calculator which is power-packed for scientists and engineers. With its 9 data-storage registers and up to 10-digit accuracy (depending upon the calculation), it is a truly versatile machine.

This Applications Book is a representative collection of key-sequence routines for solving problems with your HP-46. The applications are arranged into five sections:

Before turning to the examples for your discipline, please read "Basic Operations" on the next few pages. This section provides an overview of the HP-46 and shows how to do some general math problems.

Contents

Basic Operations

Electrical and Electronic Engineering

Mechanical Engineering

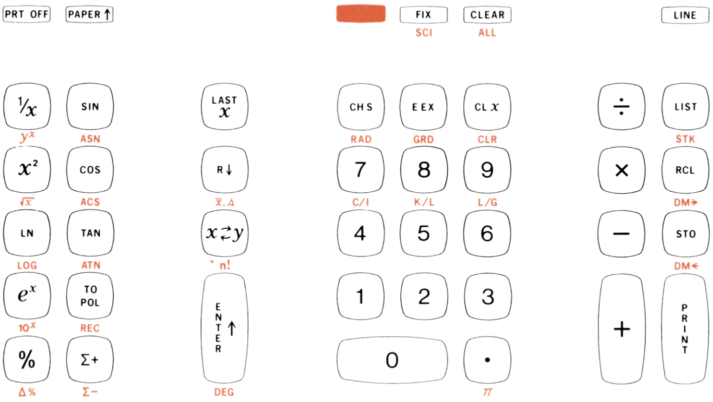
Clinical Lab. & Nuclear Medicine

Structural Engineering

Surveying

This section offers a brief overview of HP-46 operations. For complete details on the many operations not described here, see the Operating Guide.

HP-46 Keyboard



The ▬ is a "shift" key, which accesses the function shown below each key.

Basic Operations

Contents

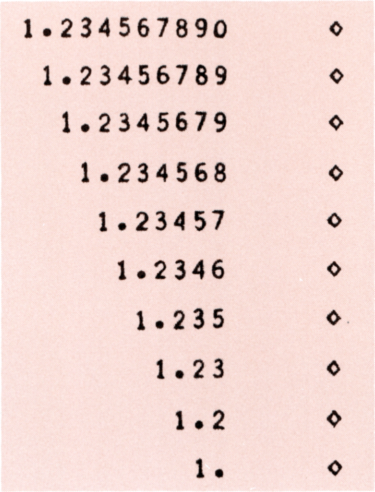
Printer and Display

The basic HP-46 has an impact printer with special alpha-numeric capability. The easy to read symbols make the hard copy a truly valuable permanent record.

A display is optional and can be used either with the printer or by itself with the printer shut off.

The format of printed and displayed numbers can be changed by pressing the FIX key followed by a number key between 0 and 9. FIX 5 , for example, rounds the number to show five decimal places after the decimal point. Scientific notation can be specified by pressing 🟥 FIX SCI . The 🟥 acts as a shift key; it gives two functions to one key.

The possible formats for the number 1.23456789 are shown below:

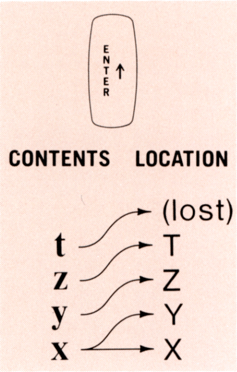


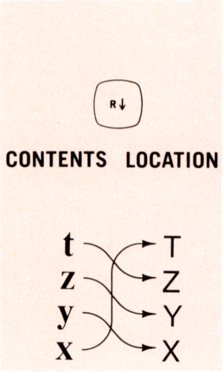
FIX 9	1.234567890 ◇
FIX 8	1.23456789 ◇
FIX 7	1.2345679 ◇
FIX 6	1.234568 ◇
FIX 5	1.23457 ◇
FIX 4	1.2346 ◇
FIX 3	1.235 ◇
FIX 2	1.23 ◇
FIX 1	1.2 ◇
FIX 0	1. ◇

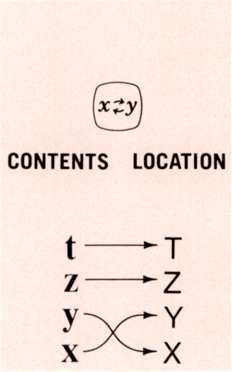
Certain errors, such as division by zero, cause a coded error printout. A list of error codes and their meanings can be found under the lid on top of the HP-46.

Moving Data

The HP-46 has four working registers (locations) that hold the number you have entered and the results of calculations. The contents of these registers can be moved to and fro to permit greater operating flexibility. Three keys are provided for manipulating (or moving) the contents as follows:







Clearing and Storing Data

Clear Functions:

CL x	erases the current contents of X.
CLEAR	erases the contents of X, Y, Z and T (the stack).
■ CLEAR ALL	erases the stack and the 9 storage locations.
■ CL x CLR	erases the statistics storage locations 5-8 and the stack.

Storing and Recalling Data:

In addition to the four working registers, the HP-46 has 10 more data registers. To store a value that is in X, press STO followed by the number key (1-9) specifying the location. That value is reproduced in the storage location leaving the original in X.

To retrieve a value, press RCL followed by the applicable number key. A duplicate of the recalled value is placed in X, pushing the stack up; the original value remains in the constant storage location.

Clearing and Storing Data (cont.)

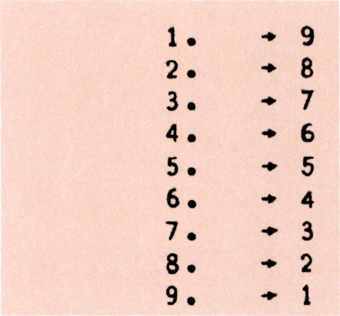
Example: Store the numbers one through nine in the storage locations 9 through 1:

Press: 1 STO 9 2 STO 8

3 STO 7 4 STO 6 5 STO 5

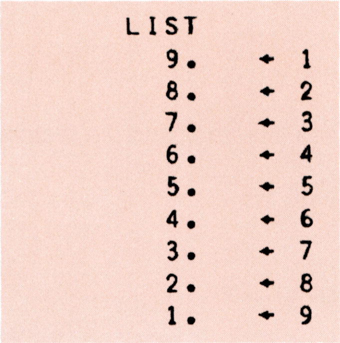
6 STO 4 7 STO 3 8 STO 2

9 STO 1



```
1.      → 9
2.      → 8
3.      → 7
4.      → 6
5.      → 5
6.      → 4
7.      → 3
8.      → 2
9.      → 1
```

List the contents of the storage locations by pressing LIST. Your printout should match the one below:



```
LIST
   9.      ← 1
   8.      ← 2
   7.      ← 3
   6.      ← 4
   5.      ← 5
   4.      ← 6
   3.      ← 7
   2.      ← 8
   1.      ← 9
```

Arithmetic Operations

In the HP-46, arithmetic answers appear immediately after pressing one of the arithmetic keys [+], [−], [×], [÷]. Each operation follows a number entry.

A number is changed from positive to negative, or vice versa, with the change sign key [CHS]

Example:

How much is 6 plus 2? Next, subtract 5 from the result, then multiply by 4, divide by 6, and change the sign of the final answer.

$$-\frac{((6+2)-5)4}{6}$$

Step	Key Strokes	Printer Tape	Description
1	6 [ENTER↑] 2 [+]	6.00 ↑ 2.00 +	add.
2	5 [−]	5.00 −	sub.
3	4 [×]	4.00 ×	multi.
4	6 [÷]	6.00 ÷	div.
5	[CHS]	⇄S	changes positive number to a negative number
	[PRINT]	− 2.00 ◇	

Complex Arithmetic

Complex arithmetic is used in many areas, but has particularly large usage in the field of electrical engineering. In this area, it is often necessary to multiply or divide complex quantities. The methods for doing this by hand are somewhat involved and quite tedious. The HP-46 with its polar, rectangular, logarithmic, and summation keys makes this problem very simple:

$$\frac{(A+jB)}{(C+jD)} = (X+jY)$$

Here's how the problem would be done by hand:

$$\frac{(A+jB)}{(C+jD)} = \frac{(A+jB)}{(C+jD)} \cdot \frac{(C-jD)}{(C-jD)}$$

$$= \frac{(AC+BD)+j(-AD+BC)}{C^2+D^2}$$

$$X = \frac{AC+BD}{C^2+D^2}$$

$$Y = \frac{-AD+BC}{C^2+D^2}$$

To solve the same problem using the HP-46:

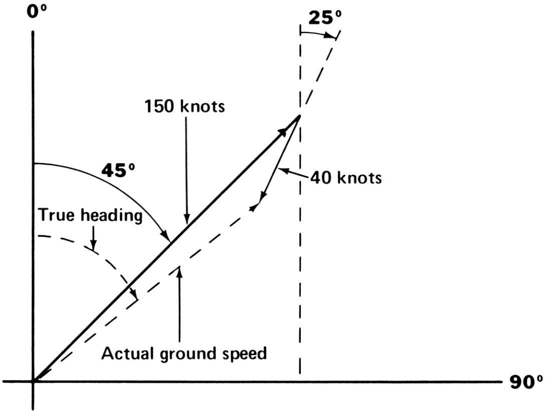
Step	Key Strokes	Printer Tape	Description
1	■ CL x FIX 3 CLR	CLEAR	
2	41 ENTER↑ 12 CHS	41.000 ↑	B
		− 12.000	A
	TO POL	TO POLAR	
		106.314 ◇	
		42.720 ◇	
3	LN Σ+	ln	
		Σ+	
4	3 ENTER↑ 4 TO POL LN	3.000 ↑	D
		4.000	C
		TO POLAR	
		36.870 ◇	
		5.000 ◇	
		ln	
	■ Σ+ Σ−	Σ−	
5	RCL Σ+ e^x	69.444 AC◇	
		2.145 AC◇	
		e^x	
6	■ TO POL REC	TO RECT	
		8.000 ◇	Y
		3.000 ◇	X

Navigation

An aircraft has a true air speed of 150 knots and an estimated heading of 45°. There is a head wind of 40 knots and 25°. What is the actual ground speed and true heading?

Solution: The true heading and actual ground speed are equal to the difference of the vectors:

45°, 150 knots
25°, 40 knots



The true heading is 51.94°. The actual ground speed is 113.24 knots.

The calculator uses storage location number 9 to store intermediate results while performing coordinate conversions. Any data in this location stored previous to using these functions is erased.

Step	Key Strokes	Printer Tape	Description
1	▬ CL x CLR FIX 2	CLEAR	
2	45 ENTER ↑ 150 ▬ TO POL REC Σ+	45.00 ↑ 150.00 TO RECT 106.07 ◇ 106.07 ◇ Σ+	heading true air speed
3	25 ENTER ↑ 40 ▬ TO POL REC ▬ Σ+ Σ−	25.00 ↑ 40.00 TO RECT 16.90 ◇ 36.25 ◇ Σ−	headwind direction headwind speed
4	RCL Σ+ TO POL	89.16 AC◇ 69.81 AC◇ TO POLAR 51.94 ◇ 113.24 ◇	true heading actual ground speed

t Statistics

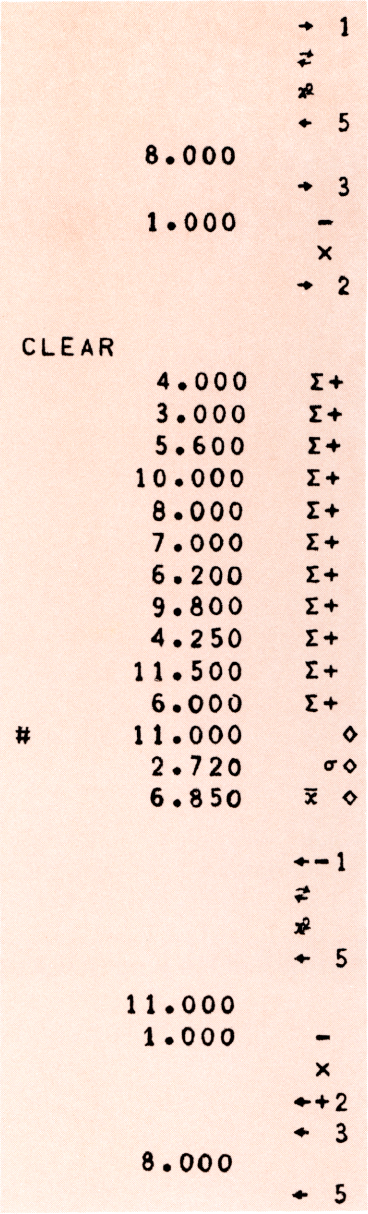
An example on general statistics can be found on page 63.

This example shows how the mean of one sample is compared to another sample to find out if they are statistically equivalent. This problem uses the stat functions on the HP-46 plus the storage registers and direct register arithmetic.

$$t = \frac{\bar{x}-\bar{y}}{\sqrt{\frac{(n_x-1)\sigma x^2+(n_y-1)\sigma y^2}{n_x+n_y-2}}\sqrt{\frac{1}{n_x}+\frac{1}{n_y}}}$$

Step	Key Strokes	Printer Tape	Description
1	▬ CL x CLR FIX 3	CLEAR	
2	Enter each number of the first set of data followed by Σ+. 6 Σ+ 5 Σ+ · · · 5.680 Σ+ ▬ R↓ $\bar{x}$,Δ	6.000 Σ+ 5.000 Σ+ 8.000 Σ+ 9.000 Σ+ 6.500 Σ+ 8.600 Σ+ 9.500 Σ+ 5.680 Σ+	
		# 8.000 ◇	number of entries
		1.697 σ◇	standard deviation
		7.285 $\bar{x}$ ◇	mean

3	STO 1 x⇄y x^2 RCL 5 STO 3	number of entries
4	1 – × STO 2	
5	Repeat steps 1 and 2 for second set of data.	
6	RCL – 1 x⇄y x^2 RCL 5	
7	1 – × RCL + 2 RCL 3 RCL 5	



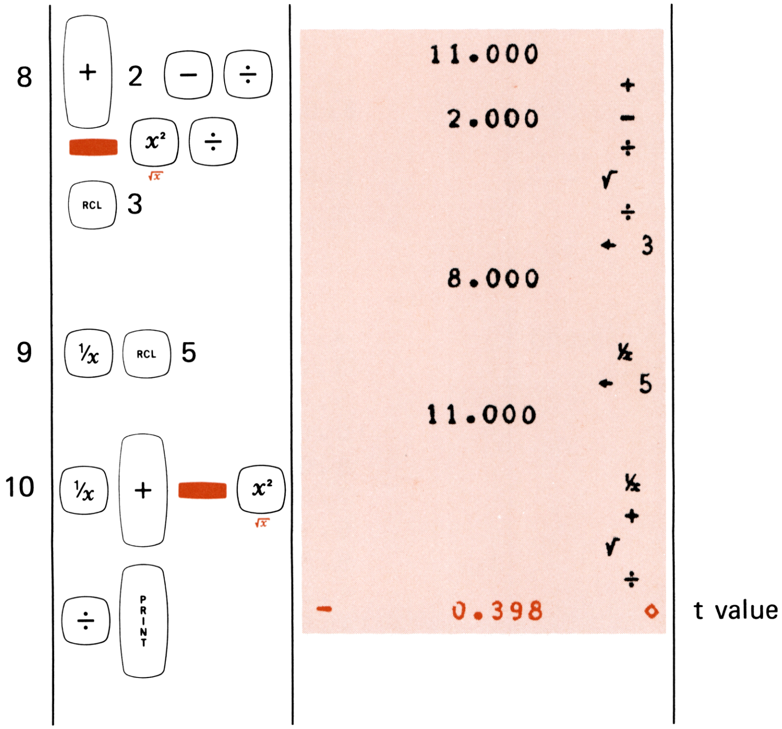
```
                         → 1
                         ⇄
                         x²
                         ← 5
            8.000
                         → 3
            1.000         -
                          ×
                         → 2

CLEAR
             4.000       Σ+
             3.000       Σ+
             5.600       Σ+
            10.000       Σ+
             8.000       Σ+
             7.000       Σ+
             6.200       Σ+
             9.800       Σ+
             4.250       Σ+
            11.500       Σ+
             6.000       Σ+
#           11.000         ◇
             2.720        σ◇
             6.850       x̄ ◇

                         ←-1
                         ⇄
                         x²
                         ← 5
            11.000
             1.000        -
                          ×
                         ←+2
                         ← 3
             8.000
                         ← 5
```

(continued)

t Statistics (cont.)



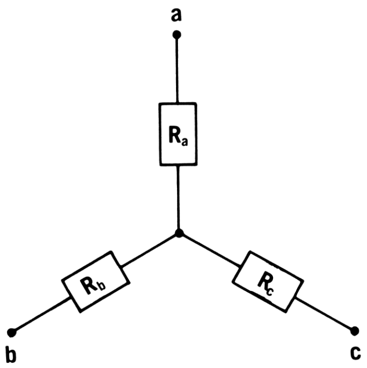
```
        11.000
                  +
         2.000    -
                  ÷
                 √
                  ÷
                 ←  3
         8.000
                  1/x
                 ←  5
        11.000
                  1/x
                  +
                 √
                  ÷
-        0.398    ◇
```

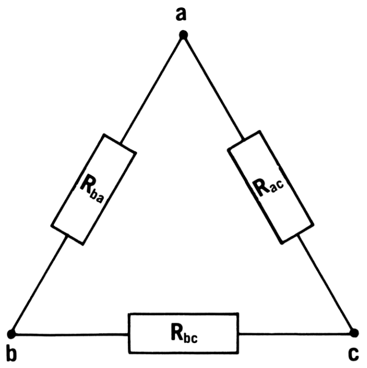
To use the t value .398 the user must refer to a statistical table which has degrees of freedom and level of significance. Degrees of freedom equal $n_1+n_2-2 = 17$. The user may determine his own level of significance, in this case 10%. The table value is 1.33. Since the t statistic .398 is less than 1.333 there is no statistical difference between x and y.

Electrical and Electronic Engineering

Contents

Wye to Delta Transformation





$$R_{ab} = \frac{R_aR_b + R_bR_c + R_cR_a}{R_c}$$

$$R_{bc} = \frac{R_aR_b + R_bR_c + R_cR_a}{R_a}$$

$$R_{ca} = \frac{R_aR_b + R_bR_c + R_cR_a}{R_b}$$

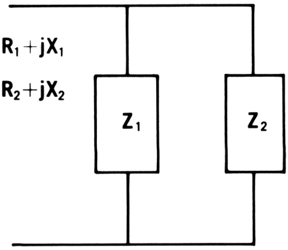
Step	Key Strokes	Printer Tape	Description
1	■ CL x CLR FIX 2	CLEAR	
2	83 STO 1 91 STO 2 ×	83.00 → 1 91.00 → 2 ×	R_a R_b
3	RCL LAST x 30 STO 3 × + RCL 3	← 0 91.00 30.00 → 3 × + ← 3 30.00	R_c
4	RCL × 1 + RCL ÷ 1 PRINT	←×1 + ←÷1 153.89 ◇	R_{bc}
5	RCL LAST x RCL ÷ 2 PRINT	← 0 12773.00 ←÷2 140.36 ◇	R_{ca}
6	RCL LAST x RCL ÷ 3 PRINT	← 0 12773.00 ←÷3 425.77 ◇	R_{ab}

Parallel Impedances

$$Z_{eq}=\frac{Z_1Z_2}{Z_1+Z_2}=\frac{1}{\frac{1}{Z_1}+\frac{1}{Z_2}}$$

Where $Z_1=R_1+jX_1$

$Z_2=R_2+jX_2$



By Hand:

$$Z_{eq}=R_{eq}+jX_{eq}=\frac{Z_1Z_2}{Z_1+Z_2}$$

$$R_{eq}=\frac{(R_1R_2-X_1X_2)(R_1+R_2)-(R_1X_2+R_2X_1)(X_1+X_2)}{(R_1+R_2)^2+(X_1+X_2)^2}$$

$$X_{eq}=\frac{(R_1R_2-X_1X_2)(X_1+X_2)+(R_1X_2-R_2X_1)(R_1+R_2)}{(R_1+R_2)^2+(X_1+X_2)^2}$$

Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 2	CLEAR	
2	.12 ENTER↑ 200 TO POL 1/x x⇄y CHS x⇄y	0.12 ↑ 200.00 TO POLAR 0.03 ◇ 200.00 ◇ 1/x ⇄ ⇄S ⇄	X_1 R_1
3	■ TO POL (REC) STO 1 x⇄y STO 2	TO RECT - 0.00 ◇ 0.00 ◇ → 1 ⇄ → 2	

4 .45 ENTER↑ 150 TO POL
1/x x⇄y CHS x⇄y

```
         0.45         ↑
       150.00
TO   POLAR
         0.17         ◊
       150.00         ◊
                   1/x
                  ⇄
                  ⇄S
                  ⇄
```

X_2
R_2

5 ▬ TO POL (REC) RCL
+ 1 x⇄y RCL
+ 2 x⇄y

```
TO   RECT
-        0.00         ◊
         0.01         ◊
                  ←+1
                  ⇄
                  ←+2
                  ⇄
```

6 TO POL 1/x x⇄y CHS
x⇄y

```
TO   POLAR
-        0.11         ◊
         0.01         ◊
                   1/x
                  ⇄
                  ⇄S
                  ⇄
```

7 ▬ TO POL (REC)

```
TO   RECT
         0.17         ◊
        85.71         ◊
```

X_{eq}
R_{eq}

Decibel Conversion

This program converts voltage or power ratios to decibels. In turn, decibels may be converted to voltage or power ratios.

$$\text{dB} = 10 \log \frac{P_2}{P_1} = 20 \log \frac{V_2}{V_1}$$

$$\frac{P_2}{P_1} = 10^{\frac{\text{dB}}{10}}$$

$$\frac{V_2}{V_1} = 10^{\frac{\text{dB}}{20}}$$

Examples:

$V_1 = 1$ volt
$V_2 = 2$ volt

Calculate $20 \log \frac{V_2}{V_1} = 6.02$ dB

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 2	CLEAR	
2	2 ENTER↑ 1 ÷	2.00 ↑ 1.00 ÷	enter V_2, enter V_1 V_2/V_1
3	■ LN LOG 20 × PRINT	lg 20.00 × 6.02 ◇	log ×20 result

$P_1 = 3$ mW
$P_2 = 7$ mW

Calculate $10 \log \frac{P_2}{P_1} = 3.68$ dB

1	7 ENTER↑ 3 ÷	7.00 ↑	enter P_2
		3.00 ÷	enter P_1, P_2/P_1
2	▬ LN LOG	lg	log
	10 × PRINT	10.00 ×	×10
		3.68 ◇	result

$\frac{P_2}{P_1} = 13.2$ dB

Calculate $\frac{P_2}{P_1} = 20.89$

1	13.2 ENTER↑ 10 ÷	13.20 ↑	enter P_2/P_1
		10.00 ÷	÷ 10
2	▬ e^x 10^x PRINT	10^x	exponent
		20.89 ◇	result

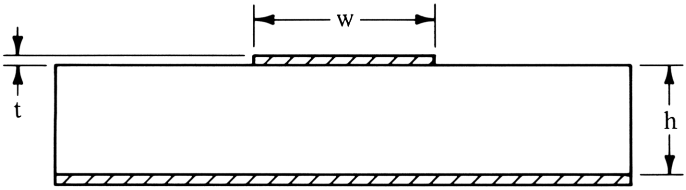
$\frac{V_2}{V_1} = 10$ dB

Calculate $\frac{V_2}{V_1} = 3.16$

1	10 ENTER↑ 20 ÷	10.00 ↑	enter V_2/V_1
		20.00 ÷	÷ 20
2	▬ e^x 10^x PRINT	10^x	exponent
		3.16 ◇	result

Microstrip Transmission Line

This program computes the characteristic impedance and propagation delay of microstrip line using the formulas from p. 39 of *MECL System Design Handbook,* Blood, William R.,Motorola, Inc., 1971.



The characteristic impedance of the line shown is:

$$Z_o = \frac{87}{\sqrt{\epsilon_r + 1.41}} \ln\left(\frac{5.98h}{0.8w + t}\right)$$

and the propagation delay is:

$$t_{pd} = 1.017\sqrt{0.475\epsilon_r + 0.67}\ \frac{ns}{ft.}$$

NOTE: The dimensions of w, h, and t may be anything as long as they are alike.

Example:

$w = 50$ mils
$t = 1.5$ mils
$h = 30$ mils
$\epsilon_r = 4.7$

Compute:

$Z_o = 51.52\Omega$

$t_{pd} = 1.73\frac{ns}{ft.}$

Step	Key Strokes	Printer Tape	Description
1	▬ CLEAR (ALL) FIX 2	CLEAR	
2	.8 ENTER↑ 50 ×	0.80 ↑ 50.00 ×	enter 0.8 Xw
	1.5 + 1/x	1.50 + 1/x	+ t inverse
3	5.98 ×	5.98 ×	X 5.98
	30 × LN	30.00 × ln	X h natural log
	87 × STO 1	87.00 × → 1	X 87 store in 1
4	4.7 ENTER↑ 1.41 +	4.70 ↑ 1.41 +	enter ϵ_r + 1.41
	▬ x^2 ($\sqrt{x}$) 1/x	√ 1/x	square root inverse
5	RCL 1 × PRINT	← 1 127.36 × 51.52 ◇	recall 1 contents of 1 multiply Z_0

Step	Key Strokes	Printer Tape	Description
1	CLEAR	CLEAR	
2	.475 ENTER↑ 4.7 ×	0.48 ↑ 4.70 ×	enter .475 X ϵ_r
	.67 + ▬ x^2 ($\sqrt{x}$)	0.67 + √	+ 0.67 square root
3	1.017 × PRINT	1.02 × 1.73 ◇	X 1.017 t

Impedance of Transmission Lines

This routine computes high frequency characteristic impedance for coaxial transmission lines.

The characteristic impedance of a coaxial line is:

$$Z_0 = \frac{K}{\sqrt{\epsilon_r}} \log \frac{D}{d}$$

where:

D = inner diameter of outer conductor
d = outer diameter of inner conductor
ϵ_r = relative permittivity of dielectric medium

$$K = \frac{\sqrt{\mu_0}}{2\pi\sqrt{\epsilon_0}\log e} \cong 138.06$$

Example:

D = .68 in. RG-218/U coaxial cable
d = .195 in.
ϵ_r = 2.3 (polyethylene)

Compute:

$Z\odot = 49.36\ \Omega$

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 2	CLEAR	
2	.68 ENTER↑ .195 ÷	0.68 ↑	enter D
		0.20 ÷	÷ d
	■ LN LOG 138 ×	lg	evaluate log
		138.00 ×	× K
	STO 1	→ 1	store in 1
3	2.3 ■ x^2 $\sqrt{x}$	2.30 √	enter ϵ_r,
			square root
		1/x	inverse
	RCL 1 × PRINT	← 1	recall 1
		74.86	contents of 1
		×	× $1/\sqrt{\epsilon_r}$
		49.36 ◇	$Z\odot$

Inductance of a Single-Layer Close-Wound Coil

The inductance of a single-layer coil is given approximately by Wheeler's formula:

$$L=\frac{N^2 R^2}{9R+10\,ND}$$

where:

L = inductance in μH
N = number of turns
R = inside radius of coil in inches
D = turn spacing in inches

NOTE: This formula is accurate to about 1% when $ND/R > 0.8$.

Example:

$R = 1$ inch
$D = 0.086$ inch
$N = 30$ turns

Compute:

$L = 25.86\ \mu$H (expect 26 μH)

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 2	CLEAR	
2	9 ENTER↑ 1 × STO 1	9.00 ↑ 1.00 × → 1	enter 9.0 X R store in 1
3	10 ENTER↑ 30 × .086 ×	10.00 ↑ 30.00 × 0.09 ×	enter 10.0 X N X D
4	RCL 1 + $1/x$	← 1 9.00 + $1/x$	recall 1 contents of 1 add inverse
5	30 x^2 × 1 x^2 × PRINT	30.00 x^2 × 1.00 x^2 × 25.86 ◇	N^2 product R^2 product result, L

Capacitance of Parallel Plates

The capacitance of parallel plates and thin strips is given approximately by:

$$C=0.0885419\frac{\epsilon_r LW}{d}[1+P]$$

where:

$P=0,\ 100\ W \geqslant L$

ϵ_r = relative permittivity of medium between plates

d = distance between plates in cm

L = length of plates in cm

W = width of plates in cm

C = capacitance in picofarads

The formula given is accurate only when L>>d and W>>d, however the error is only −4% for W/d = 2.

Example:

$\epsilon_r = 1$

d = .01 cm

L = 10 cm

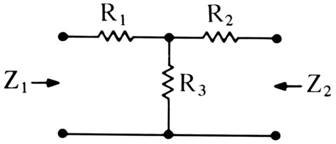
W = 1 cm

C = 88.5 pF

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 2	CLEAR	
2	.01 1/x	0.01 1/x	enter d, 1/x
	.0885419 ×	0.09 ×	enter constant, ×
	1 × 10 ×	1.00 ×	enter ϵ_r, ×
		10.00 ×	enter L, ×
	1 × PRINT	1.00 ×	enter W, ×
		88.50 ◇	result, C = 88.5 pF

T Attenuator

The T attenuator can be used to match between two impedances, Z_1 and Z_2.



The minimum loss in decibels is given by:

$$\text{Min Loss} = 10 \log\left(\sqrt{\frac{Z_1}{Z_2}} + \sqrt{\frac{Z_1}{Z_2} - 1}\right)^2$$

where: $Z_1 \geqslant Z_2$

If N is the desired loss of the attenuator expressed as a ratio (loss in dB = 10 log N), then:

$$R_3 = \frac{2\sqrt{N Z_1 Z_2}}{N-1}$$

$$R_1 = Z_1\left(\frac{N+1}{N-1}\right) - R_3$$

$$R_2 = Z_2\left(\frac{N+1}{N-1}\right) - R_3$$

NOTE: If the Desired Loss is less than the Minimum Loss, R_2 will be negative.

Example:

$Z_1 = 50$
$Z_2 = 50$
$\text{Loss} = 10 \text{ dB}$

Compute:

$\text{Min Loss} = 0$
$R_1 = 25.975$
$R_2 = 25.975$
$R_3 = 35.136$

T Attenuator (cont.)

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR (ALL) FIX 2	CLEAR	
2	50 ENTER↑ 50 ×	50.00 ↑ 50.00 ×	enter Z_1 × Z_2
	10 × ■ x^2 ($\sqrt{x}$)	10.00 × √	× N square root
	2 ×	2.00 ×	× 2
3	10 ENTER↑ 1 −	10.00 ↑ 1.00 −	enter N subtract 1
	$1/x$ × STO 3	$1/x$ × → 3	inverse product store in 3
4	10 ENTER↑ 1 − $1/x$	10.00 ↑ 1.00 − $1/x$	enter N subtract 1 inverse
	10 ENTER↑ 1 + ×	10.00 ↑ 1.00 + ×	enter N add 1 product
	50 × RCL 3 −	50.00 × ← 3 35.14 −	× Z_1 recall 3 value of R_3 minus R_3
	PRINT STO 1	25.97 ◇ → 1	value of R_1 store in 1

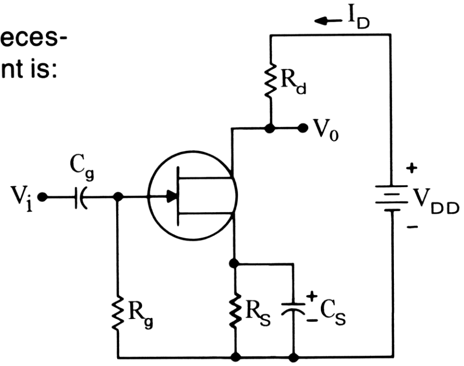
5	10 ENTER↑ 1 − 1/x	10.00 ↑	enter N
		1.00 −	subtract 1
		1/x	inverse
	10 ENTER↑ + ×	10.00 ↑	enter N
		1.00 +	plus 1
		×	product
	50 × RCL 3	50.00 ×	X Z_2
		← 3	recall 3
		35.14	value of R_3
	− PRINT	−	minus R_3
		25.97 ◇	value R_2
6	50 ENTER↑ 50 ÷	50.00 ↑	enter Z_1
		50.00 ÷	÷ Z_2
	1 − ■ x^2 $\sqrt{x}$	1.00 −	subtract 1
		√	square root
7	50 ENTER↑ 50 ÷	50.00 ↑	enter Z_1
		50.00 ÷	÷ Z_2
	■ x^2 $\sqrt{x}$ + x^2	√	square root
		+	sum
		x^2	square
	■ LN LOG	lg	log
	10 × PRINT	10.00 ×	X 10
		0.00 ◇	minimum loss

J-FET Bias and Transconductance

Given the FET parameters, V_p and I_{DDS} and the desired drain current and voltage gain for the circuit shown, this program computes V_{GS}, g_m, and values for R_d and R_s.

The gate-source voltage necessary for a desired drain current is:

$$V_{GS} = V_p\left[1 - \left(\frac{I_D}{I_{DSS}}\right)^{1/2}\right]$$



where:

I_D = drain current ($I_D > 0$ for n-channel FET)
I_{DSS} = saturation drain current with gate shorted to source
V_{GS} = gate to source voltage ($V_{GS} < 0$ for n-channel FET)
V_p = pinch-off voltage

Knowing V_{GS}, we can compute the transconductance and the source and drain resistors.

$$g_m = -\frac{2I_{DSS}}{V_p}\left(1 - \frac{V_{GS}}{V_p}\right)$$

$$R_s = -\frac{V_{GS}}{I_D}$$

$$R_d = \frac{|A_V|}{|g_m|}$$

where:

g_m = transconductance in siemens
$|A_V|$ = magnitude of voltage gain

Example:

$V_p = -2V$
$I_{DSS} = 1.5$ mA
$I_D = .7$ mA
$A_V = 10$

Compute:

$V_{GS} = -0.63V$
$g_m = 1.025$ mS
$R_s = 905\ \Omega$
$R_d = 9759\ \Omega$

Step	Key Strokes	Printer Tape	Description
1	CLEAR ■ FIX (SCI) 2	CLEAR	
2	7 EEX CHS 1 ENTER↑ 1.5 ÷ ■ x^2 ($\sqrt{x}$) CHS 1 + 2 CHS × PRINT	7.00 -01 ↑ 1.50 +00 ÷ √ ⇄S 1.00 +00 + -2.00 +00 × -6.34 -01 ◇	enter I_D ÷ I_{DSS} square root change sign plus 1 × V_p result, V_{GS}
3	CLEAR 6.3 EEX CHS 1 ENTER↑ CHS 2 ÷ CHS 1 + 2 × 1.5 EEX CHS 3 × CHS 2 CHS ÷ PRINT	CLEAR 6.30 -01 ↑ ⇄S 2.00 +00 ÷ ⇄S 1.00 +00 + 2.00 +00 × 1.50 -03 × ⇄S -2.00 +00 ÷ 1.03 -03 ◇	enter V_{GS} change sign ÷ V_p change sign + 1 × constant × I_{DSS} change sign ÷ V_p result, g_m

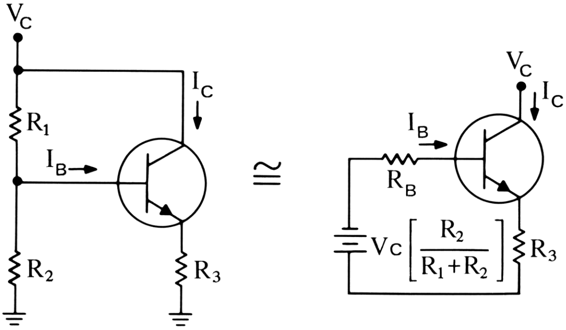
(continued)

J-FET Bias (cont.)

Step	Key Strokes	Printer Tape	Description
4	CLEAR	CLEAR	
	6.3 EEX CHS 1 ENTER↑	-6.30 -01 ↑	enter V_{GS}
	7 EEX CHS 4 ÷	-7.00 -04 ÷	÷ I_D
	PRINT	9.00 +02 ◇	result, R_S
5	CLEAR 1 EEX 1 ENTER↑	CLEAR 1.00 +01 ↑	enter $\lvert A_V \rvert$
	1.03 EEX CHS 3	1.03 -03 ÷	÷ $\lvert g_m \rvert$
	÷ PRINT	9.71 +03 ◇	result, R_d

Transistor Bias

This routine computes the dc collector current of the bipolar transistor circuit shown below.



It is assumed that $I_B <<$ current through R_1 and R_2. Given R_1, R_2, R_3, β_{DC}, and V_C, we have:

$$I_C=\beta\left[\frac{KV_C-V_{BE}}{R_B+(\beta+1)R_3}\right]=\beta\left[\frac{KV_C-.6}{R_B+(\beta+1)R_3}\right]$$

where:

$K=\frac{R_2}{R_1+R_2}$

$\beta=h_{FE}=$ dc current gain

$R_B=\frac{R_1R_2}{R_1+R_2}=$ parallel combination of R_1 and R_2

$V_{BE}=0.6$ volts = Base-emitter voltage drop for silicon transistor

Transistor Bias (cont.)

Example:

$R_1 = 1000\ \Omega$
$R_2 = 5000\ \Omega$
$R_3 = 1000\ \Omega$
$V_C = 10$ volts
$\beta = 100$

Compute:

$I_C = 7.6$ mA

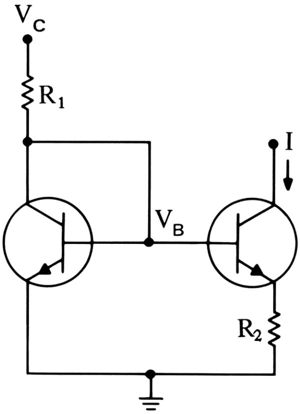
Step	Key Strokes	Printer Tape	Description
1	CLEAR ■ FIX 2 SCI	CLEAR	
2	1 EEX 3 ENTER↑	1.00 +03 ↑	enter R_1
	5 EEX 3 × STO 1	5.00 +03 × → 1	R_2 store in register 1
3	1 EEX 3 ENTER↑	1.00 +03 ↑	enter R_1
	5 EEX 3 + 1/x y^x	5.00 +03 + 1/x	+ R_2 inverse
	RCL 1 ×	← 1 5.00 +06 ×	recall register 1 contents register 1 multiply
	PRINT STO 1	8.33 +02 ◇ → 1	value of R_B store in register 1

4	1 EEX 2 ENTER↑	1.00 +02 ↑	enter β
		1.00 +00 +	$\beta + 1$
		1.00 +03 ×	$\times R_3$
	1 + 1 EEX 3 ×	← 1	recall register 1
		8.33 +02	contents of register 1
	RCL 1 + 1/x	+	add: $R_B +$
		1/x	$(1 + \beta) R_3$ inverse
	1 EEX 2 ×	1.00 +02 ×	$\times$ B
		→ 2	store in register 2
	STO 2 RCL 1	← 1	recall register 1
		8.33 +02	contents register 1
5	1 EEX 3 ÷	1.00 +03 ÷	$R_B \div R_1$
	1 EEX 1 ×	1.00 +01 ×	$K \times V_C$
		6.00 -01 -	$- V_{BE}$
	6 EEX CHS 1 −	← 2	recall register 2
		9.82 -04	contents of register 2
	RCL 2 × PRINT	×	$\times (K V_C - .6)$
		7.59 -03 ◇	result, I_C

Integrated Circuit Current Source

For this common IC bias circuit shown below, the resistance R_2 can be found from:

$$R_2 = \frac{kT}{qI} \ln\left[\frac{V_C - V_B}{R_1 I}\right]$$



where:

$k = 1.38 \times 10^{-23} \frac{J}{K}$, Boltzman's constant
T = absolute temperature of junction in Kelvins
$q = 1.6 \times 10^{-19}$ C, the electronic charge
$V_B = 0.6$ volts, the work function for Si

This routine evaluates the above equation given:

T, the junction temperature in °C
I, the desired current in amperes
R_1, the desired value for R_1 in ohms
V_C, the supply voltage in volts

Example:	Compute:
1. $T = 50°C$ $I = 10\ \mu A$ $R_1 = 10\ k\Omega$ $V_C = 10V$	$R_2 = 12.7\ k\Omega$

Step	Key Strokes	Printer Tape	Description
1	CLEAR ■ FIX 2 SCI	CLEAR	
2	1 EEX 1 ENTER↑	1.00 +01 ↑	enter V_C
	6 EEX CHS 1 −	6.00 −01 −	subtract V_B
	1 EEX 4 ÷	1.00 +04 ÷	÷ R_1
	1 EEX CHS 5 ÷	1.00 −05 ÷	÷ I
	LN	ln	take natural log
	1.38 EEX CHS 23 ×	1.38 −23 ×	× k
	1.60 EEX CHS 19 ÷ 1 EEX CHS 5	1.60 −19 ÷	÷ q
	÷ STO 1	1.00 −05 ÷ → 1	÷ I store in 1
3	5 EEX 1 ENTER↑	5.00 +01 ↑	enter T, in °C
	2.73 EEX 2 +	2.73 +02 +	calculate T in °
	RCL 1 × PRINT	← 1 3.92 +01 × 1.27 +04 ◇	recall 1 × T in °K R_2 in ohms

Resistor Noise

The thermal noise of a resistor used in low-level amplifiers can be calculated from the expression:

$$i_n = \sqrt{\frac{4KTB}{R}}$$

where:

K = Boltzman's constant = 1.38×10^{-23} joules/°K
T = temperature in °K
B = bandwidth of system
R = resistor value

Example:

$R = 10K$
$B = 1K\ Hz$
$T = 100°C$

Compute:

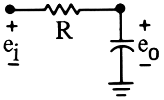
$i_n = 44.5$ picoamps

Step	Key Strokes	Printer Tape	Description
1	CLEAR ■ FIX (SCI) 2	CLEAR	
2	2.73 EEX 2 ENTER↑	2.73 +02 ↑	enter 273° K add T
3	1 EEX 2 + 4 ×	1.00 +02 + 4.00 +00 ×	× 4 × K
4	1.38 EEX CHS 23 × 1 EEX 3 × 1 EEX 4 1/x ×	1.38 −23 × 1.00 +03 × 1.00 +04 1/x ×	× B enter R, inverse R product
5	■ x^2 ($\sqrt{x}$) PRINT	√ 4.45 −11 ◇	square root result

Integrator Response

The response of single pole integrator to a unit step function U(t) can be evaluated for any time t.

Consider the RC network:



and its response expression for $e_i(t)=U(t)$.

$$\frac{e_o}{e_i}=\left[1-\epsilon^{-\frac{t}{RC}}\right]$$

Example:

$R=1K$
$C=1\ \mu F$

Compute:

$e_o/e_i=.632$ at $t=1$ millisec.

Step	Key Strokes	Printer Tape	Description
1	CLEAR ■ FIX 2 SCI	CLEAR	
2	1 EEX CHS 3 ENTER↑	1.00 −03 ↑	enter t
	1 EEX 3 1/x ×	1.00 +03 1/x ×	enter R, 1/R X t
3	1 EEX CHS 6 1/x	1.00 −06 1/x ×	enter C, 1/R X t R
	× CHS e^x CHS	⇄S e^x ⇄S	change sign e^x change sign
	1 + PRINT	1.00 +00 + 6.32 −01 ◇	add 1 e_o/e_i

MOS-LSI Device Current

The drain-source current of a MOS-LSI device can be calculated for given terminal conditions. Using Sah's equation:

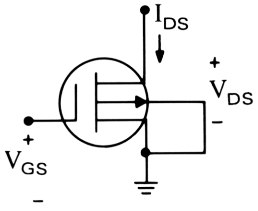
$$I_{DS}=K\left(\frac{W}{L}\right)[2(V_{GS}-V_t)V_{DS}-V_{DS}{}^2]$$

$$|V_{GS}-V_t|>|V_{DS}|$$

where:

K = process gain constant,
(assume $K=-1.6\times10^{-6}$ amps/v²)
W = device width
L = effective device length
V_{GS} = gate-source voltage
V_T = device threshold, assume $V_T=-1V$
V_{DS} = drain-source voltage

one can calculate the current I_{DS} for the given circuit.



Example:

$K=-1.6\times10^{-6}$ amps/volt²
$W=1.0$ mils
$L=0.26$ mils
$V_{GS}=-4$ volts
$V_{DS}=-1.5$ volts
$V_T=-1.0$ volt

Calculate:

$I_{DS}=41.5\ \mu$ amps

Step	Key Strokes	Printer Tape	Description
1	CLEAR ■ FIX SCI 2	CLEAR	
2	4 CHS ENTER↑ 1 +	-4.00 +00 ↑	enter V_{GS}
		1.00 +00 +	subtract V_T
	2 × 1.5 CHS ×	2.00 +00 ×	× 2
		-1.50 +00 ×	× V_{DS}
	1.5 x^2 − 1 ×	1.50 +00 x^2	$V_{DS}{}^2$
		−	$-V_{DS}{}^2$
		1.00 +00 ×	× W
3	2.6 EEX CHS 1 ÷	2.60 -01 ÷	× 1/L
4	1.6 CHS EEX CHS 6 × PRINT	-1.60 -06 ×	× K
		-4.15 -05 ◇	result

Notes

Mechanical Engineering

Contents

Grid Pattern

Point-to-point x & y coordinates.

$$x = x_0 + x_{inc.}$$
$$y = y_0 + y_{inc.}$$

Sample: $x_0 = .92$ $x_{inc.} = .55$

$y_0 = .88$ $y_{inc.} = .47$

no. of pts. in x = 4

no. of pts. in y = 3

Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 4	CLEAR	Clear storage, stack
2	.92 ENTER↑ PRINT	0.9200 ↑ 0.9200 ◇	x_0
3	.55 STO 1	0.5500 → 1	$x_{inc.}$
4	+ PRINT	+ 1.4700 ◇	x coordinate
5	RCL 1	← 1 0.5500	

6	Repeat steps 4 & 5 for each remaining x coordinate (in this case 2 more repeats)	+ 2.0200 ◇ ← 1 0.5500 + 2.5700 ◇	
7	0.88 ENTER↑ PRINT	0.8800 ↑ 0.8800 ◇	y_0
8	.47 STO 2	0.4700 ← 2	$y_{inc.}$
9	+ PRINT	+ 1.3500 ◇	y coordinate
10	RCL 2	← 2 0.4700 + 1.8200 ◇	
11	Repeat steps 9 & 10 for each remaining y coordinate (in this case 1 more repeat)		
12	Match appropriate x & y values to get x, y coordinate		

Bolt Hole Circle

$$x = x_c + (\text{radius} \times \cos \alpha_{acc})$$
$$y = y_c + (\text{radius} \times \sin \alpha_{acc})$$

Sample:

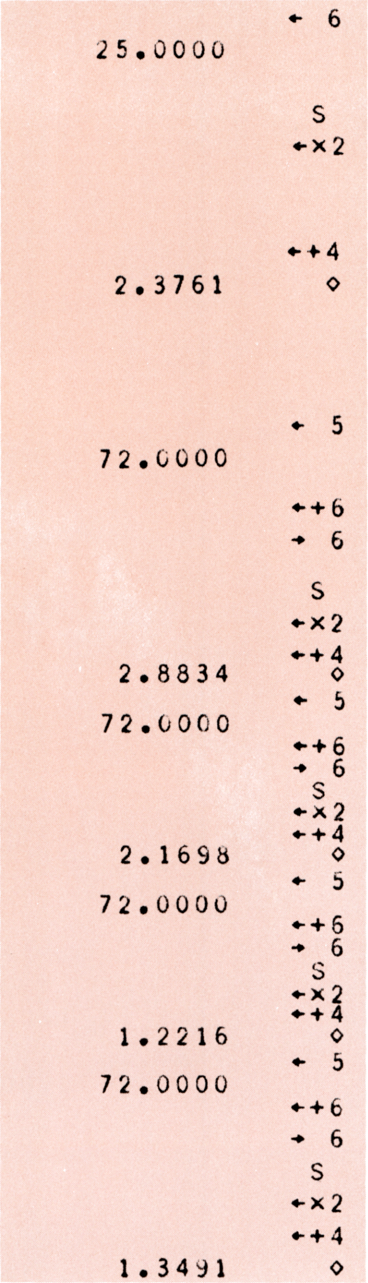
x_c = 1.5	radius = .89
y_c = 2	angle between
No. of holes = 5	x axis & first
	hole = 25°

Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 4	CLEAR	Clear storage, stack
2	■ ENTER↑ (DEG)	D	Sets degrees
3	25 STO 1 STO 6 360 ENTER↑ 5 ÷ STO 5	25.0000 → 1 → 6 360.0000 ↑ 5.0000 ÷ → 5	Angle (α)
4	.89 STO 2	0.8900 → 2	Radius
5	1.5 STO 3	1.5000 → 3	x_c
6	2 STO 4	2.0000 → 4	y_c
7	RCL 1	← 1 25.0000	
8	COS RCL × 2	C ←× 2	radius × cos α_{acc}

Step	Key Strokes	Printer Tape	Description
9	RCL + 3 PRINT	←+3 2.3066 ◇	x coordinate
10	RCL 5	← 5 72.0000	$\alpha_{acc.} + \alpha_{inc.}$
	RCL + 1	←+1	
	STO 1	→ 1	
11	Repeat steps 8-10 for each remaining x coordinate	C ←×2 ←+3 1.3915 ◇ ← 5 72.0000 ←+1 → 1 C ←×2 ←+3 0.6264 ◇ ← 5 72.0000 ←+1 → 1 C ←×2 ←+3 1.0685 ◇ ← 5 72.0000 ←+1 → 1 C ←×2 ←+3 2.1070 ◇	

(continued)

Bolt Hole Circle (cont.)



Step	Key Strokes	Printer Tape	Description
12	RCL 6	← 6 25.0000	
13	SIN RCL × 2	S ←×2	radius x sin α_{acc}
14	RCL + 4 PRINT	←+4 2.3761 ◇	y coordinate
15	RCL 5	← 5 72.0000	α_{acc} + $\alpha_{inc.}$
	RCL + 6 STO 6	←+6 → 6	Puts $\alpha_{inc.}$ + α_{acc} into α_{acc}
16	Repeat steps 13-15 for each remaining y coordinate	S ←×2 ←+4 2.8834 ◇ ← 5 72.0000 ←+6 → 6 S ←×2 ←+4 2.1698 ◇ ← 5	
17	Match appropriate x & y values to get x, y coordinate	72.0000 ←+6 → 6 S ←×2 ←+4 1.2216 ◇ ← 5 72.0000 ←+6 → 6 S ←×2 ←+4 1.3491 ◇	

Polar to Rectangular

Rectangular coordinates of a point defined in polar coordinates.

Sample:

Angle = 30° Radius = 1.3750″	} Polar Coordinates

Step	Key Strokes	Printer Tape	Description
1	■ CL x FIX 4 CLR	CLEAR	Clear storage, stack
2	■ ENTER ↑ DEG	D	Sets degrees
3	30 ENTER ↑ 1.3750	30.0000 ↑	Angle & radius
	■ TO POL REC	1.3750 TO RECT 0.6875 ◇ 1.1908 ◇	Rectangular coordinates

Points on Line at Angle

Point-to-point x & y coordinates.

$$x = x_0 + x_{acc} \cos \alpha$$
$$y = y_0 + x_{acc} \sin \alpha$$

Sample:

x_0 = . 4

y_0 = .26

no. of holes = 4

$$x_{acc} = \sum_{n=0}^{\text{no. of holes} - 1} x_n + x_{inc.}$$

$\alpha = 35°$

$x_{inc.} = .47$

Step	Key Strokes	Printer Tape	Description
1	▬ CL x (CLR) FIX 4 ▬ ENTER↑ (DEG)	CLEAR D	Clear storage, stack. Sets degrees
2	35 ENTER↑	35.0000 ↑	Angle (α)
3	COS STO 2	C → 2	Cosine α
4	R↓ SIN STO 3	↓ S → 3	Sine α
5	.26 STO 6	0.2600 → 6	y_0
6	.47 STO 1	0.4700 → 1	$x_{inc.}$

	STO 4	→ 4	
7	.4 STO 5 ENTER↑ PRINT	0.4000 → 5 ↑ 0.4000 ◇	x_0
8	RCL 4	← 4 0.4700	x_{acc}
9	RCL × 2	←×2	$x_{acc} \cos \alpha$
10	RCL + 5 PRINT	←+5 0.7850 ◇	x coordinate
11	RCL 1	← 1 0.4700	$x_{inc.}$
	RCL + 4	←+4	$x_{acc} + x_{inc.}$
	STO 4	→ 4	
12	Repeat steps 9-11 for each remaining x coordinate	←×2 ←+5 1.1700 ◇ ← 1 0.4700 ←+4 → 4 ←×2 ←+5 1.5550 ◇	

(continued)

Points on Line at Angle (cont.)

Step	Key Strokes	Printer Tape	Description
13	RCL 6 ENTER↑ PRINT	← 6 0.2600 ↑ 0.2600 ◇	y_0
14	RCL 1 STO 4	← 1 0.4700 → 4	$x_{inc.}$
15	RCL × 3	←× 3	x_{acc} sin α
16	RCL + 6 PRINT	←+ 6 0.5296 ◇	y coordinate
17	RCL 1	← 1 0.4700	$x_{inc.}$
	RCL + 4	←+ 4	$x_{acc} + x_{inc.}$
	STO 4	→ 4	

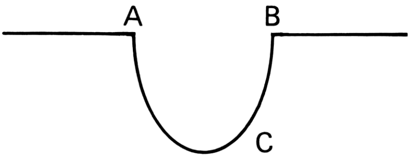
18	Repeat steps 15-17 for each remaining y coordinate	←×3 ←+6 0.7992 ◇ ← 1 0.4700 ←+4
19	Match appropriate x & y values to get x, y coordinates	→ 4 ←×3 ←+6 1.0687 ◇

Quadratic Equation

Find the x coordinate of points A and B if the curve labeled C is a parabola with an equation of:

$y = x^2 - 4x$
$o = x^2 - 4x + 3$

where $y = -3$



Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 4	CLEAR	Clear storage
2	1 ENTER↑ 2 × STO 3	1.0000 ↑ 2.0000 × → 3	2a
3	2 × 3 × 4 CHS STO 1	2.0000 × 3.0000 × - 4.0000 → 1	4ac
4	x^2 $x⇄y$ − ■ x^2 ($\sqrt{x}$) STO 2	x^2 ⇄ − √ → 2	$\sqrt{b^2 - 4ac}$

5	RCL 1 CHS RCL − 2 RCL ÷ 3 PRINT	← 1 − 4.0000 ⇄S ←−2 ←÷3 1.0000 ◇	x coordinate of point A
6	RCL 1 CHS RCL + 2 RCL ÷ 3 PRINT	← 1 − 4.0000 ⇄S ←+2 ←+3 3.0000 ◇	x coordinate of point B

Law of Cosines

$a^2 = b^2 + c^2 - 2bc \cos A$

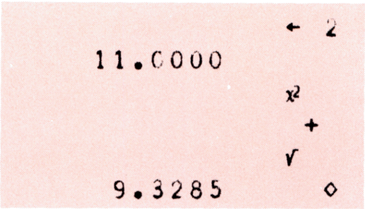
Sample:
b = 11
c = 9
A = 54° 30′

Find the other side, a, of the triangle.

Step	Key Strokes	Printer Tape	Description
1	🟧 CL x (CLR) FIX 4	CLEAR	Clear storage
2	54.30 🟧 RCL (DM→)	54.3000 DMS→	DMS to degrees
3	cos	C	cos A
4	9 STO 1 × 11 STO 2 × 2 ×	9.0000 → 1 × 11.0000 → 2 × 2.0000 ×	2bc cos A
5	RCL 1 x^2 $x \rightleftarrows y$ −	← 1 9.0000 x^2 ⇄ −	c^2 - 2bc cos A

6 RCL 2 x^2 +

■ x^2 ($\sqrt{x}$) PRINT



```
                    ←  2
  11.0000
                  x²
                     +
                  √
   9.3285            ◇
```

a.

Notes

Clinical Laboratory & Nuclear Medicine

Contents

General Statistics

For Computing:

Mean, Standard Deviation, Coefficient of Variation (%), Variance, Standard Error, 95% Confidence Limits.

Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 3	CLEAR	Clears all memory and sets 3 decimal places
2	Enter each number of the data set followed by Σ+ after each	100.362 Σ+ 101.452 Σ+ 96.073 Σ+ 98.001 Σ+ 106.235 Σ+ 104.239 Σ+ 102.333 Σ+ 100.600 Σ+ 99.600 Σ+ 99.700 Σ+ 98.260 Σ+ 103.256 Σ+	
3	■ R↓ (x̄,Δ)	# 12.000 ◇ 2.855 Δ◇ 100.843 x̄ ◇	No. of entries (n) Standard Deviation Mean
4	÷ ENTER↑ 100 × PRINT	÷ ↑ 100.000 × 2.831 ◇	Coefficient of Variation (%)
5	Repeat "Step 3"	# 12.000 ◇ 2.855 Δ◇ 100.843 x̄ ◇	

Step	Key Strokes	Printer Tape	Description
6	x⇄y x² PRINT	⇄ x² 8.151 ◇	Variance (S.D.)^2
7	Repeat "Step 3"	# 12.000 ◇ 2.855 Δ◇ 100.843 $\bar{x}$ ◇	
8	x⇄y RCL 5 ■ x² (√x) ÷ PRINT	⇄ ← 5 12.000 √ ÷ 0.824 ◇	Standard error
9	Repeat "Step 3"	# 12.000 ◇ 2.855 Δ◇ 100.843 $\bar{x}$ ◇	
10	x⇄y ENTER↑ 2 × PRINT	⇄ ↑ 2.000 × 5.710 ◇	± 95% confidence limits about mean

Strictly speaking, $\pm 1.96s$ (not $\pm 2s$) is the correct width for 95% normal limits of gaussian-distributed data. The number 1.96 is often rounded to 2 before calculation and this could influence the first digit after the decimal point in the calculated limits.

Radioactive Decay

$$Y = Ae^{-\lambda} = Ae^{\left(\frac{-\ln 2}{\gamma}\right) t}$$

t = Time elapsed since original activity (A) measured

A = Original Activity (at time = zero)

Y = New Activity (decayed from A) after time t

λ = Decay Constant = $\frac{.693}{\gamma}$

γ = half-life (in same unit as t)

Sample:

γ = 3.5 days
t = 1.25 days
A = 10 units

Step	Key Strokes	Printer Tape	Description
1	🟧 CL x (CLR) FIX 3	CLEAR	
2	2 LN ENTER↑	2.000 ln ↑	
3	3.5 ÷ ENTER↑	3.500 ÷ ↑	γ (half-life)
4	1.25 × CHS e^x ENTER↑	1.250 × ⇄S e^x	t
5	10 × PRINT	↑ 10.000 × 7.807 ◇	A Y (new Activity after Time, t)

Body Surface Area

$$\text{Log}A = (0.425 \log W) + (0.725 \log H) - 2.144$$

A = Body Surface Area in m^2

W = Weight in kg.

H = Height in cm.

Sample: (child)	weight = 4 kg. height = 35 cm.

Step	Key Strokes	Printer Tape	Description
1	🟧 CL x CLR FIX 3	CLEAR	
2	4 🟧 LN LOG ENTER ↑	4.000 lg ↑	Weight
3	.425 × STO 1	0.425 × → 1	
4	35 🟧 LN LOG ENTER ↑	35.000 lg ↑	Height
5	.725 × ENTER ↑ RCL 1 + ENTER ↑	0.725 × ↑ ← 1 0.256 + ↑	
6	2.144 − 🟧 e^x 10^x PRINT	2.144 − 10^x 0.170 ◇	Body Surface Area (m^2)

Creatinine Clearance

$$\text{C.C.} = \left(\frac{1}{T}\right)\left(\frac{1.73}{BSA}\right)\left(\frac{CV}{S}\right)$$

ml/min (corrected for Body Surface Area)

T = Collection Time (min.)
BSA = Patient's Body Surface Area (m^2)
C = Creatinine Concentration in Urine (mg%)
V = Urine Volume (ml.)
S = Serum Creatinine (mg%)
1.73 = Body Surface area for "Standard Man"

Sample:

T = 1500 min.
BSA = 1.8 m^2
C = 65 mg%
V = 1250 ml
S = 1.2 mg%

Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 3	CLEAR	
2	1.73 ENTER↑	1.730 ↑	
3	1500 ÷ ENTER↑	1500.000 ÷ ↑	T
4	65 × ENTER↑	65.000 × ↑	C
5	1.8 ÷ ENTER↑	1.800 ÷ ↑	BSA
6	1250 × ENTER↑	1250.000 × ↑	V
7	1.2 ÷ PRINT	1.200 ÷ 43.383 ◇	S Creatinine Clearance (ml/min)

Schilling Test

Radioactive isotope determination of B_{12} absorption :

$$\% \text{ Absorption} = \frac{V_u d_u (C_u - N)}{C_s d_s} \times 100\%$$

V_u = Urine Volume
d_u = Dilution of Urine
C_u = Urine Counts/ml.
N = Background Count
C_s = Standard Counts/ml.
d_s = Standard Dilution

Sample:

$V_u = 2$
$d_u = 10$
$C_u = 300$
$N = 0$
$C_s = 13{,}000$
$d_s = 10$

Step	Key Strokes	Printer Tape	Description
1	■ CL x CLR FIX 3	CLEAR	
2	300 ENTER ↑	300.000 ↑	C_u
3	0 − ENTER ↑	0.000 − ↑	N
4	10 × ENTER ↑	10.000 × ↑	d_u (Dilution of Urine)
5	2 × ENTER ↑	2.000 × ↑	V_u
6	100 × ENTER ↑ STO 1	100.000 × ↑	100%
7	13,000 ENTER ↑	→ 1 13000.000 ↑ 10.000 × ↑	C_s d_s (Standard Dilution)
8	10 × ENTER ↑ RCL 1 $x⇄y$ ÷ PRINT	← 1 600000.000 ⇄ ÷ 4.615 ◇	% Absorption

Beers Law

$$O.D. = A = abc = \mathrm{Log}(\frac{100}{\%T}) = 2 - \log\%T$$

A = Absorbance (Optical Density)
a = Absorptivity
b = light path of Solution (cm)
c = concentration of substance of interest
%T = % Transmittance

Sample:

If %T = 30, find O.D.
or
If O.D. = .8, find %T.

$$O.D. = 2 - \log\%T$$

$$\%T = 10^{(2-O.D.)}$$

Step	Key Strokes	Printer Tape	Description
1	🟥 CL x CLR FIX 3	CLEAR	
2	30 🟥 LN LOG CHS ENTER ↑	30.000 lg ⇄S ↑	%T
3	2 + PRINT	2.000 + 0.523 ◇	O.D.
4	Repeat Step 1		
5	2 ENTER ↑		
6	.8 − 🟥 e^x 10^x PRINT	CLEAR 2.000 ↑ 0.800 − 10^x 15.849 ◇	O.D. %T

O.D. to Concentration

$$\frac{\text{O.D. Standard}}{\text{Concentration Standard}} = \frac{\text{O.D. Unknown}}{\text{Concentration Unknown}}$$

$$\text{Concentration Unknown} = \text{O.D. Unknown}\left(\frac{\text{Concentration Standard}}{\text{O.D. Standard}}\right)$$

Sample:

$$\text{Concentration Standard} = 50$$
$$\text{O.D. Standard} = .7$$
$$\text{O.D.'s of Unknowns} = \begin{cases} .8 \\ .6 \\ .2 \end{cases}$$

Step	Key Strokes	Printer Tape	Description
1	■ CL x CLR FIX 3	CLEAR	
2	50 ENTER↑	50.000 ↑	Concentration of Standard
3	.7 ÷ STO 1	0.700 ÷ → 1	Optical Density of Standard
4	.8 ENTER↑ RCL	0.800 ↑ ← 1 71.429	Unknown #1 O.D.
	1 × PRINT	× 57.143 ◇	Unknown #1 Concentration
5	Repeat Step 4 for .6, ...	0.600 ↑ ← 1 71.429	Unknown #2 O.D.
		× 42.857 ◇	Unknown #2 Concentration
	.2, etc.	0.200 ↑ ← 1 71.429	Unknown #3 O.D.
		× 14.286 ◇	Unknown #3 Concentration etc.

Temperature Conversion

$$°C = \frac{5}{9}\ (°F - 32) \qquad °F = (\frac{9}{5}°C) + 32$$

Sample:

If °F = 98.6°, find °C.
and
If °C = 25°, find °F.

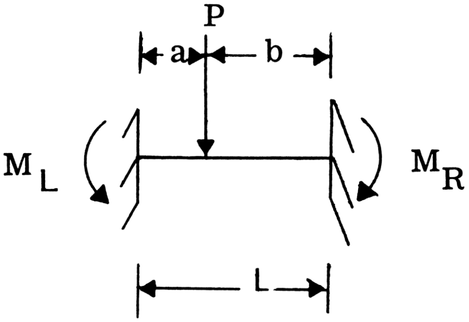
Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 3	CLEAR	
2	98.6 ENTER↑	98.600 ↑	°F
3	32 − ENTER↑	32.000 − ↑	
4	5 × ENTER↑	5.000 × ↑	
5	9 ÷ PRINT	9.000 ÷ 37.000 ◇	°C
6	Repeat Step 1	CLEAR	
7	25 ENTER↑	25.000 ↑	°C
8	9 × ENTER↑	9.000 × ↑	
9	5 ÷ ENTER↑	5.000 ÷ ↑	
10	32 + PRINT	32.000 + 77.000 ◇	°F

Notes

Structural Engineering

Contents

Fixed-End Moment (concentrated load)



$$M_L = P\frac{ab^2}{L^2}$$

$$M_R = P\frac{a^2b}{L^2}$$

Example:

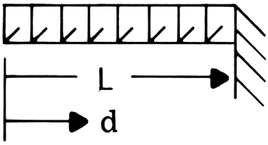
P = 3 Kips
a = 6 feet = 72 inches
b = 14 feet = 168 inches
L = 20 feet = 240 inches

Results:

M_L = 105.84 Kip inches = 8.82 Kip feet
M_R = 45.36 Kip inches = 3.78 Kip feet

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 2	CLEAR	
2	3 STO 1	3.00 → 1	Enter P
3	72 STO 2 ×	72.00 → 2 ×	Enter a
4	168 STO 3 x^2 ×	168.00 → 3 x^2 ×	Enter b
5	240 x^2 ÷ PRINT	240.00 x^2 ÷ 105.84 ◇	Enter L M_L
6	RCL 3 ÷	← 3 168.00 ÷	
7	RCL 2 × PRINT	← 2 72.00 × 45.36 ◇	M_R

Cantilever (uniform load)



$$M_d = -\frac{Wd^2}{2}$$

$$Y_d = -\frac{W}{24\,EL}\left(d^4 - 4L^3d + 3L^4\right)$$

Example:

$W = .3$ Kips/in.
$d = 2$ ft. $= 24$ in.
$L = 20$ ft. $= 240$ in.
$E = 29,000$ KSI
$I = 584$ in.^{4}

Results:

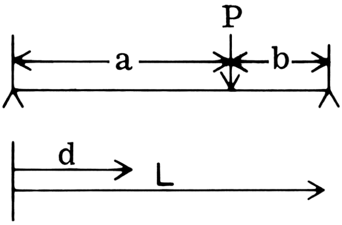
$M_d = 86.40$ Kip - in.

$Y_d = 6.37$ in.

Step	Key Strokes	Printer Tape	Description
1	🟥 CLEAR ALL FIX 2	CLEAR	
2	0.3 STO 1	0.30 → 1	Enter W
3	24 STO 2 x^2 ×	24.00 → 2 x^2 ×	Enter d
4	2 ÷ CHS PRINT	2.00 ÷ ⇄S - 86.40 ◇	
5	240 STO 3 4 🟥 $1/x$ y^x 3 ×	240.00 → 3 4.00 y^x 3.00 ×	Enter L
6	RCL 2 RCL 3	← 2 24.00 ← 3 240.00	
7	3 🟥 $1/x$ y^x × 4 ×	3.00 y^x × 4.00 ×	
8	− RCL 2 4 🟥 $1/x$ y^x	− ← 2 24.00 4.00 y^x	
9	+ RCL 1 × CHS	+ ← 1 0.30 × ⇄S	
10	24 ÷	24.00 ÷	
11	29000 ÷	29000.00 ÷	Enter E
12	584 ÷ PRINT	584.00 ÷ - 6.37 ◇	Enter I Y d

Simple Beam

With intermediate concentrated load, moment & deflection at any distance from left end (where a must be greater than d).



$$M_d = P \times b \times d/L$$

$$Y_d = -\frac{Pbd}{6EIL}\left[2L(L-d) - b^2 - (L-d)^2\right]$$

Example:

P = 3 Kips
a = 14 ft. = 168 in.
b = 72 ins.
L = 20 ft. = 240 in.
d = 10 ft. = 120 in.
E = 29,000 Kips/in.^{2}
I = 584 in.

Results:

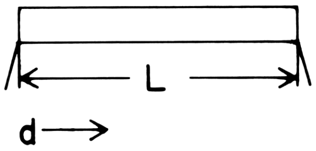
M_d = 108 Kip - in.

Y_d = 0.04 in.

Step	Key Strokes	Printer Tape	Description
1	▬ CLEAR ALL FIX 2	CLEAR	
2	3 STO 1	3.00 → 1	Enter P
3	72 STO 2 ×	72.00 → 2 ×	Enter b
4a	120 STO 3 ×	120.00 → 3 ×	Enter d
4b	240 STO 4 ÷ PRINT	240.00 → 4 ÷ 108.00 ◊	Enter L M_d
5	6 CHS ÷	-6.00 ÷	
6	29000 ÷	29000.00 ÷	Enter E
7	584 ÷ STO 5	584.00 ÷ → 5	Enter I
8	RCL 4 RCL 3 − ENTER↑ x² CHS RCL 2 x² − x⇄y RCL 4 × 2 × + RCL 5 × PRINT	← 4 240.00 ← 3 120.00 − ↑ x² ⇄S ← 2 72.00 x² − ⇄ ← 4 240.00 × 2.00 × + ← 5 -0.00 × -0.04 ◊	Y_d

Simple Beam with Uniform Load

Moment & Deflection at Any Distance from Left End.



$$W = \text{Force}(F)/\text{Unit Length}(L)$$

$$M_d = 1/2\ W\ L\ (d - \frac{d^2}{L})$$

$$Y_d = \frac{-\ W\ d}{24\ EI}\ (L^3 - 2Ld^2 + d^3)$$

where

d = distance to the point to be calculated

M_d = moment at point D in Kips

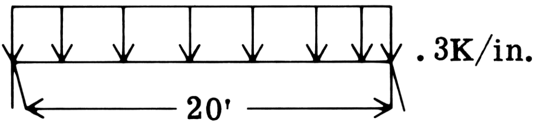
Y = deflection at point d, in.

E = modulus of elasticity

I = moment of inertia of beam

Example:

Find Moment & Deflection at a point 6' from left end. (i.e. d = 72 in.) For a beam with I = 584 in.^{4} E = 29,000 KSI



Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 2	CLEAR	
2	72 STO 1 x^2	72.00 → 1 x^2	Enter d
3	240 STO 2 ÷	240.00 → 2 ÷	Enter L
4	RCL 1 $x \rightleftarrows y$ −	← 1 72.00 ⇄ −	
5	RCL 2 × 2 ÷	← 2 240.00 × 2.00 ÷	
6	.3 STO 3 × PRINT	0.30 → 3 × 1814.40 ◇	Enter W M d
7	RCL 1 3 ■ $1/x$ y^x	← 1 72.00 3.00 y^x	
8	2 RCL 2 ×	2.00 ↑ ← 2 240.00 ×	
9	RCL 1 x^2 ×	← 1 72.00 x^2 ×	
10	− RCL 2	− ← 2 240.00	
11	3 ■ $1/x$ y^x + RCL 1 ×	3.00 y^x + ← 1 72.00 ×	
12	RCL 3 ×	← 3 0.30 ×	
13	24 ÷	24.00 ÷	
14	29000 ÷	29000.00 ÷	Enter E
15	584 ÷ CHS PRINT	584.00 ÷ ⇄S − 0.62 ◇	Enter I Y d

Steel Column Design

For a steel column acting under compressive loads only the axial stress permitted (Fa) is defined according to AISC 7th Edition equation 1.5–1 as:

$$F_a = \frac{\left[1 - \frac{(K\ l/r)^2}{2\ C_c{}^2}\right] F_y}{\frac{5}{3} + \frac{3(K\ l/r)}{8\ C_c} - \frac{(K\ l/r)^3}{8\ C_c{}^3}}$$

$$\text{where } C_c = \sqrt{\frac{2\ \pi^2 E}{F_y}}$$

when: $K\ l/r$ is the largest effective slenderness ratio.

C_c is the column slenderness ratio dividing elastic and inelastic buckling.

F_y is the specified minimum yield stress of the type of steel being used.

E is the modulus of elasticity of steel = 29,000,000 PSI.

Example:

Determine the permissible axial stress for a column (F_a).

when: $K\ l/r = 115$

$F_y = 36{,}000$ PSI

Result:

Fa = 10987.96 PSI or 10.99 KSI

Step	Key Strokes	Printer Tape	Description
1	▬ CL x FIX 2 CLR	CLEAR	
2	▬ • x^2 π	3.14 x^2	
	2 ×	2.00 ×	

3 29 EEX 6 ×

4 36 EEX 3 STO 3

÷ ■ x^2 $\sqrt{x}$ PRINT

5 STO 1

6 115 STO 2

7 x^2 RCL 1 x^2

2 × ÷ 1 $x \rightleftarrows y$

− RCL 3 ×

PRINT

8 RCL 2 3 ■ $1/x$ y^x

RCL 1 3 ■ $1/x$ y^x

8 × ÷ CHS

9 5 ENTER↑ 3 ÷ +

10 RCL 2

3 × 8 ÷

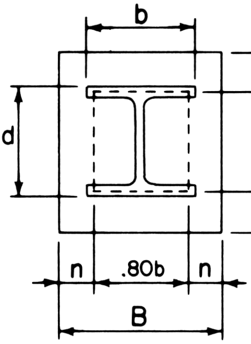
RCL 1 ÷ +

PRINT ÷ PRINT

29000000.00	×	Enter E
36000.00	→ 3	EnterF y
	÷	
	√	
126.10	◇	C c
	→ 1	
115.00	→ 2	Enter K L/r
	x^2	
	← 1	
126.10		
	x^2	
2.00	×	
	÷	
1.00	≠	
	−	
36000.00	×	
21029.27	◇	numerator
	← 2	
115.00		
3.00	y^x	
	← 1	
126.10		
3.00	y^x	
8.00	×	
	÷	
	≠S	
5.00	↑	
3.00	÷	
	+	
	← 2	
115.00		
3.00	×	
8.00	÷	
	← 1	
126.10		
	÷	
	+	
1.91	◇	denominator
	÷	
10987.96	◇	F a

Column Base-Plate Design

Steel Base Plates are generally used under columns for distributing the column loads over a sufficient area of concrete support.



$A = P/F_p$

$B = A/N$

$m = (N - .95d)/2$

$n = (B - .80b)/2$

$f_p = P/(B \times N)$

$t =$ the larger of $\sqrt{\dfrac{3 + f_p m^2}{F_b}}$ or $\sqrt{\dfrac{3 f_p n^2}{F_b}}$

$P =$ total column load, KIPS

$A =$ area of plate in square inches

$F_p =$ allowable bearing pressure of support, KSI

$F_b =$ allowable bending stress in base plate, KSI

$f_p =$ actual bearing pressure, KSI

Example:

Determine the base plate dimensions for a column carrying 480 KIPS where d = 14.12", b = 14.545", where $F_b = 27$ KSI, on a concrete support with $F_p = .750$ KIPS/inches^2. Assume N = 26" when the entire area of the concrete support is covered.

Step	Key Strokes	Printer Tape	Description
1	■ CL x FIX 2 CLR	CLEAR	
2	480 STO 1 ENTER↑	480.00 → 1	Enter P
		↑	
3	.75 ÷ PRINT	0.75 ÷	Enter F_p
		640.00 ◇	AREA
4	26 STO 2	26.00 → 2	Enter N
	÷ PRINT	÷	
		24.62 ◇	B(use 25″)
5	RCL 2 ENTER↑	← 2	
		26.00	
		↑	
	.95 ENTER↑	0.95 ↑	
6	14.12 × −	14.12 ×	Enter d
		−	
	2 ÷ PRINT	2.00 ÷	
		6.29 ◇	m
7	25 STO 3 ENTER↑	25.00 → 3	Enter B
		↑	
	.80 ENTER↑	0.80 ↑	
8	14.545 × −	14.55 ×	Enter b
		−	
	2 ÷ PRINT	2.00 ÷	
		6.68 ◇	n

(continued)

Column Base-Plate Design (cont.)

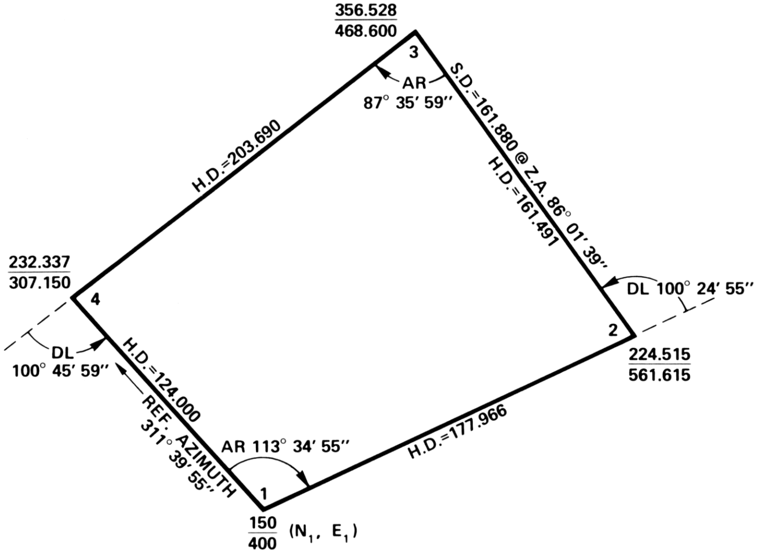
Step	Key Strokes	Printer Tape	Description
9	x^2 3 ×	x^2	
		3.00 ×	
	RCL 1 ×	← 1	
		480.00	
	RCL 3 ÷	×	
		← 3	
	RCL 2 ÷	25.00	
		÷	
10	27 ÷	← 2	
		26.00	
		÷	
	■ x^2 ($\sqrt{x}$) PRINT	27.00 ÷	Enter F_b
		√	
		1.91 ◇	t

Surveying

Contents

Field Angle Traverse

Example:



Step	Key Strokes	Printer Tape	Description
1	🟧 CLEAR ALL FIX 4	CLEAR	
2	150 ENTER↑ 400 STO 3 Σ+	150.0000 ↑ 400.0000 → 3 Σ+	Enter N_1 Enter E_1
3	311.3955 🟧 RCL DM→	311.3955 DMS→	Reference azimuth
4	180 − STO 1 STO 2	180.0000 − → 1 → 2	
5	113.3455 🟧 RCL DM→	113.3455 DMS→	Field angle

6	180 [+]	(See table on page 96)
	[RCL] 2 [+] [STO] 2	Distance
7	177.9660 [ENTER↑]	See Note 1
8	(slope angle) ■ [RCL] DM→	
9	[SIN] [×] [ENTER↑] [PRINT]	See Note 2
10	[R↓] ■ [TO POL] REC	
11	[x⇄y] [Σ+] [RCL] 3	Departure Latitude
12	[RCL] 7 [STO] 3 [+]	
13	[×] [STO] [+] 4	
14	[RCL] [Σ+]	Current N.E.

```
           180.0000        +
                         ← 2
           131.6653
                           +
                         → 2
           177.9660        ↑
```

```
                           ↓
TO         RECT
           161.6150        ◇
            74.5150        ◇
                         ⇄
                         Σ+
                         ← 3
           400.0000
                         ← 7
           561.6150
                         → 3
                           +
                           ×
                         →+4
           224.5150      AC◇
           561.6150      AC◇
```

Return to step 5 for successive courses. Continue on to step 15 for closure and area.

Note 1: Skip steps 8 and 9 if distance is horizontal.

Note 2: Program set for zenith angles: change "sin" to "cos" in step 9 for vertical angles.

Field Angle (cont.)

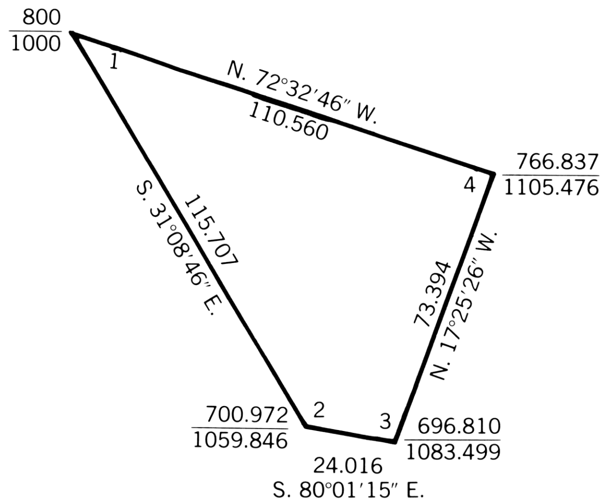
Step	Key Strokes	Printer Tape	Description
15	150 ENTER↑	150.0000 ↑	Enter N₁
16	400 ■ Σ+ (Σ-) LAST x x⇄y R↓	400.0000 Σ- ← 0 400.0000 ⇄ ↓	Enter E₁
17	+ RCL Σ+	+ - 0.0952 AC◇ - 0.2171 AC◇	Closing Latitude Closing Departure
18	R↓ × RCL − 4	↓ × ←−4	
19	2 ÷ PRINT	2.0000 ÷ - 26558.8223 ◇	Area (ignore sign if neg.)
20	RCL 1 RCL 2 − PRINT	← 1 131.6653 ← 2 491.6653 − 360.0000 + 0.0000 ◇	Angular Closure

Angular closure may contain multiples of 360°. Add or subtract 360 until logical results are obtained.

If turned angle is:	Press (step 6):
AL-	CHS 180 +
AR-	180 +
DL-	CHS
DR-	No action needed

Bearing Traverse

Example:



Step	Key Strokes	Printer Tape	Description
1	■ CL x FIX 4 CLR	CLEAR	
2	800 STO 1	800.0000 → 1	starting northing
3	1000 STO 2 STO 3 Σ+	1000.0000 → 2 → 3 Σ+	starting easting
4	31.0846 ■ RCL DM→	31.0846 DMS→	bearing (DMS)

Bearing Traverse (cont.)

Step	Key Strokes	Printer Tape	Description
5	CHS 180 +	⇄S 180.0000 + 	add 180 since SE (See table below.)
6	115.7070 ▬ TO POL REC	115.7070 TO RECT 59.8462 ◇ - 99.0280 ◇	departure latitude
7	x⇄y Σ+ RCL 3	⇄ Σ+ ← 3 1000.0000	
8	RCL 7 STO 3	← 7 1059.8462 → 3	
9	+ × STO + 4	+ × →+4 700.9720 AC◇	new northing
10	RCL Σ+	1059.8462 AC◇	new easting

Return to step 5 for successive courses; continue on to step 11 for closure and area.

If bearing is:	Press (step 6):
NE	No action needed
SE	CHS 180 +
SW	180 +
NW	CHS

11 RCL 1 RCL 2
■ Σ+ (Σ−)

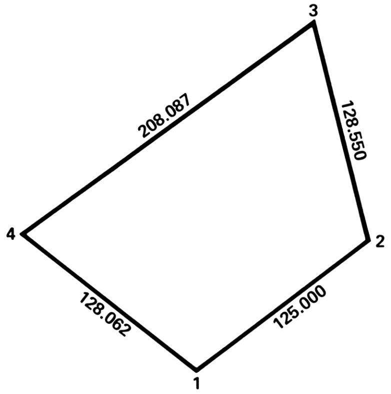
12 R↓ x⇄y R↓ +

13 RCL Σ+
R↓ ×
RCL − 4
2 ÷ PRINT

```
                   ←  1
     800.0000
                   ←  2
    1000.0000
                 Σ−
                      ↓
                 ⇄
                      ↓
                     +
-      0.0022    AC◇      closing latitude
       0.0062    AC◇      closing departure
                      ↓
                     ×
                 ←−4
       2.0000        ÷
-   5103.6196         ◇   area(ignore sign
                          if neg.)
```

Inverse From Coordinates with Area

Example:



N_1 = 150.000
E_1 = 400.000
N_2 = 225.000
E_2 = 500.000
N_3 = 350.000
E_3 = 470.000
N_4 = 230.000
E_4 = 300.000

Az_{1-2} = 53° 7’ 48”

Az_{2-3} = 346° 30’ 15”

Az_{3-4} = 234° 46’ 56”

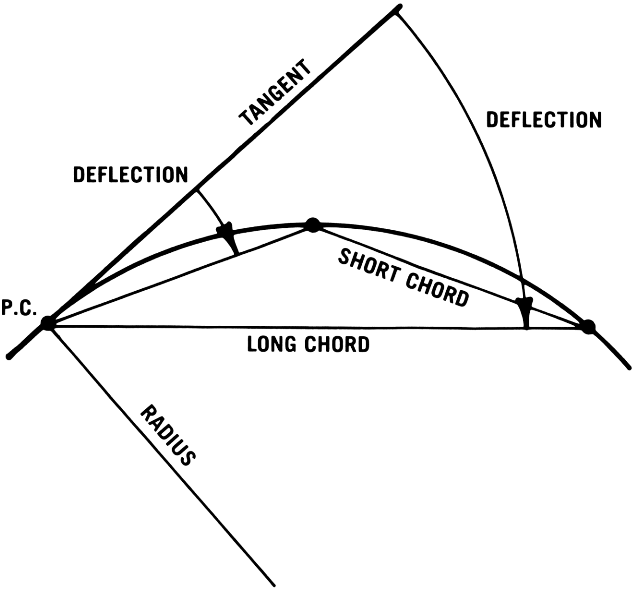
Az_{4-1} = 128° 39’ 35”

AREA = 20,175.000 Sq. Ft.

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 3	CLEAR	
2	150 ENTER↑ 400 STO 1	150.000 ↑ 400.000 → 1	Enter N_1 Enter E_1
3	x⇄y Σ+	⇄ Σ+	
4	225 ENTER↑	225.000 ↑ 500.000 ←−8	Enter N_2 Enter E_2
5	500 RCL − 8 x⇄y RCL − 7 STO 2 Σ+ LAST x TO POL	⇄ ←−7 → 2 Σ+ ← 0 75.000 TO POLAR	
6	x⇄y ■ STO DM← PRINT	53.130 ◇ 125.000 ◇ ⇄ DMS← 53.0748 ◇	Azimuth (DEC) Distance Azimuth (DMS)
7	RCL 1 RCL 8 STO 1 + RCL 2 × STO + 3	← 1 400.000 ← 8 500.000 → 1 + ← 2 75.000 × →+3	Calculate and accumulate area. Repeat for each side.
8	RCL 3 2 ÷ PRINT	40350.000 ← 3 2.000 ÷ 20175.000 ◇	Area (sq. ft.)

Horizontal Curve Layout

Example:



Radius = 900.000 Ft.

STATION	ARC	DEFLECTION	LONG CHORD
12+57.00	(Point of Curvature (P.C.))		
12+75.00	18.00	00°34′22″	18.000
13+00.00	43.00	01°22′07″	42.996
13+25.00	68.00	02°09′52″	67.984
13+50.00	93.00	02°57′37″	92.959
13+75.00	118.00	03°45′21″	117.915
13+89.00	132.00	04°12′06″	131.882

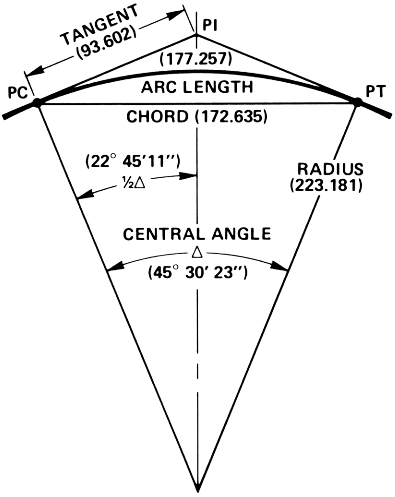
Computation of the long chord (steps 9 & 10) can be omitted if regular intervals (25, 50, 75, etc.) are used. Calculate odd intervals, then calculate the short chord (which remains constant). Deflections are then turned from one point, and chords measured from station to station.

Step	Key Strokes	Printer Tape	Description
1	■ CL x (CLR) FIX 3	CLEAR	
2	900 ENTER↑	900.000 ↑	radius
3	2 × ENTER↑ ENTER↑	2.000 × ↑ ↑	
4	180 ENTER↑	180.000 ↑	
5	■ • (π) ÷ ÷ 1/x Σ+	3.142 ÷ ÷ 1/x Σ+	
6	RCL Σ+	1800.000 AC◇ 0.032 AC◇	
7	43 ×	43.000 ×	arc length from P.C.
8	■ STO (DM←) PRINT	DMS← 1.2207 ◇	deflection angle (DMS)
9	CL x LAST x	← 0 1.369	
10	SIN × PRINT	S × 42.996 ◇	chord
11	CL x		

Return to 6 for additional computations.

Curve Solution

Example:



Tangent Distance = R (tan ½Δ)

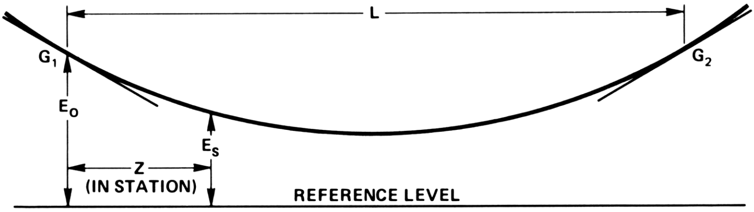
Chord Distance = 2 R (sin ½Δ)

Arc Length = $\left(\frac{½\Delta}{90}\right)\pi R$

Step	Key Strokes	Printer Tape	Description
1	🟥 CLEAR ALL FIX 4	CLEAR	
2	45.3023 🟥 RCL DM→	45.3023 DMS→	Δ (DMS)
3	2 ÷ ENTER↑	2.0000 ÷ ↑	
	🟥 STO DM← PRINT	DMS← 22.4511 ◇	½ Δ (DMS)
4	x⇄y TAN	⇄ T	
5	223.181 STO 1	223.1810 → 1	Radius
	× PRINT	× 93.6022 ◇	Tangent distance
6	R↓ 🟥 RCL DM→ ENTER↑	↓ DMS→	
	SIN RCL 1 ×	↑ S ← 1 223.1810	
	2 × PRINT	× 2.0000 × 172.6350 ◇	Long chord
7	R↓ RCL 1 ×	↓ ← 1 223.1810	
	🟥 • π ×	× 3.1416	
	90 ÷ PRINT	× 90.0000 ÷ 177.2574 ◇	arc length

Elevations Along a Vertical Curve

Example:



Elevation at any station = $\frac{1}{2} Az^2 + G_1 Z + E_0$

Where E_0 = Elevation at beginning of curve
Z = Distance in stations measured from beginning of curve
G_1 = Grade in % of beginning of curve
A = $100 (G_2 - G_1)/L$
L = Length of curve

G_2 (Ending Grade) = 1.600%
G_1 (Beginning Grade) = -1.065%
L (Length of Curve) = 340 Ft.
E_0 (Elevation at G_1) = 614 Ft.

Stationing Interval assumed = 100 Ft.;
Z for 120 Ft. interval would be entered as 1.2

STATION	ELEVATION (E_S)
17 + 00.00	614.000
18 + 00.00	613.327
19 + 00.00	613.438
20 + 00.00	614.332
20 + 40.00	614.910

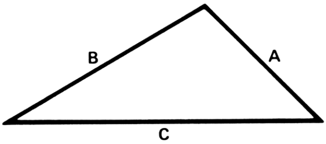
Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 4	CLEAR	
2	1.6 ENTER↑	1.6000 ↑	Enter G_1
	1.065 CHS STO 1	- 1.0650 → 1 -	Enter G_2
3	− 50 ×	50.0000 ×	
4	340 ÷ STO 2	340.0000 ÷ → 2	Enter L
5	614 ENTER↑ ENTER↑	614.0000 ↑ ↑	Elevation at g_1
6	1 ENTER↑	1.0000 ↑	Distance in stations (Z)
7	x^2 RCL × 2	x^2 ←×2	
	$x \rightleftarrows y$ RCL × 1	⇄ ←×1	
	+ + PRINT	+ + 613.3269 ◇	E_s

Return to step 6 for next station, or continue through steps 8 and 9 to determine number of stations (Z) from beginning of curve to lowest (or highest) point on the curve. Then return to step 6 using the calculated "Z" to determine elevation.

8	CL x	0.0000 ←−1 ←÷2	
9	RCL − 1	↑ 2.0000 ÷	
	RCL ÷ 2	1.3587 ◇ ↑	Station (Z) where grade is 0.
	ENTER↑ 2 ÷ PRINT	x^2 ←×2 ⇄ ←×1	
	(repeat steps 6 and 7)	+ + 613.2765 ◇	Elevation

Area of a Triangle

Example:



$$\text{Area} = \sqrt{P\,(P-A)\,(P-B)\,(P-C)}$$

where P = Perimeter/2

A = 2489.621
B = 2543.150
C = 3322.312
AREA = 3139465.857

Step	Key Strokes	Printer Tape	Description
1	■ CLEAR ALL FIX 3	CLEAR	
2	2489.621 STO 1	2489.621 → 1	Side A
	2543.15 STO 2	2543.150 → 2	Side B
	3322.312 STO 3	3322.312 → 3	Side C
3	+ + 2 ÷	+ + 2.000 ÷	
	ENTER↑ ENTER↑ ENTER↑	↑ ↑ ↑	
	RCL − 1 R↓	←− 1 ↓	
	RCL − 2 R↓	←− 2 ↓	
	RCL − 3 R↓	←− 3 ↓	
	× × ×	× × ×	
	■ x^2 $\sqrt{x}$ PRINT	√ 3139465.857 ◊	Area

Notes

Hewlett-Packard Calculator Products Division
P.O. Box 301 Loveland, Colorado 80537, Tel. (303) 667-5000
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