Scientific Programmable

Program Library

sinclair

EXPLANATORY INFORMATION

The Sinclair Scientific Programmable program library is intended to cover a wide field of scientific and engineering disciplines. It is compiled in the form of separate cards to which additions will become available in due course extending both the range of subjects and the scope of subjects already covered. The card format allows the user to arrange the cards in the order most useful to him, and to write his own programs on similar cards to be kept together in the wallet under the appropriate headings.

The programs are not intended as a comprehensive list of formulae for a particular subject, but do attempt to cover a number of formulae that have reasonably general application. Formulae that give rise to rather trivial programs are included where the formula is felt to be of basic importance to the subject.

In many cases where a program is required to solve a particular problem, a standard program may be found in the library which can be adapted to suit. Library programs are made as general as possible, and it may often be useful to enter one or more of the "variables" as a constant in the program, to suit a particular application.

The programs are arranged as far as possible in a standard format as follows:-

(i) The formula to which the program relates.

(ii) Diagram or explanation of symbols where essential.

(iii) The program— written as a series of key strokes for direct entry into the machine. The number written after the program represents the number of program steps, and is the number that should be displayed in the exponent slot immediately prior to depressing C/CE—this acts as a check for correct program entry.

(iv) The keyboard entries necessary to execute the program.

Basic knowledge of the subject is assumed and explanation kept to a minimum.

ENTRY OF CONSTANTS INTO A PROGRAM

Since no decimal points or exponents can be entered into a program, non-integer constants must be formed by dividing by the appropriate power of 10. For example if it is required to multiply by 1.53, the program steps would be

|❛|1|5|3|❜| × |❛|1|0|0|❜| ÷ |

Where a very large or very small number is required it may be more convenient to use the antilog function to form the power of 10. For example 1.67×10^{-13} can be entered as follows

|❛|1|5|❜|enter| − |antilog|❛|1|6|7|❜| × |

When not used to store a program, the programming register can be used as an additional memory, the number being entered as if it were a program, and recalled as required by using the execute key. Several numbers may be stored at once seperated by "variable" provided that they are always required in sequence.

GENERAL CONSTANTS AND CONVERSIONS FOR USE IN PROGRAMS

In some circumstances the use of a full five digit constant or conversion factor in a program uses too much program space to enable the rest of the program to be fitted on. This is particularly so because decimal points and exponents cannot be entered into programs.

In many instances a shorter approximation can be used that will be acceptable in accuracy. Remember that a slide rule will not give much better than .05%, and four figure log tables never better than .01).

π — π can be generated by $355 \div 113$
this gives 3.1416 which is correct within the accuracy of the machine.
In some circumstances it may be helpful to use shorter approximations.

$4 \times (\arctan 1) \doteq 3.1408$ error $\sim .02\%$ (−ve)

$22 \div 7 \doteq 3.1428$ error $\sim .04\%$ (+ve)

e — e can be generated by $878 \div 323$
this gives 2.7183 which is correct within the accuracy of the machine.

ln10 — The logarithm to the base e of 10 can be generated by $175 \div 76$
this gives 2.3026 which is correct within the accuracy of the machine.

In some circumstances it may be helpful to use a shorter approximation.

2.3 will give an error of approximately 0.1% (- ve)
N.B. $\ln x = \log x \times \ln 10$

$\log\frac{10}{e}$ $= \log 3.6788 = 0.5657$

this can be generated by $99 \div 175$

log *e* $= 0.43430$

this can be generated by $119 \div 274$

$$N.B.\ e^x = \text{antilog}(x \times \log e) = \frac{10^x}{\text{antilog}\left(x \times \log \frac{10}{e}\right)}$$

When shorter approximations to the above constants are used in the calculation of exponential powers, the final error is dependent on the value of x.

$$\frac{\text{error in result}}{\text{result}} = 10^{Ex} - 1$$

$$\text{where } E = \frac{\text{error in constant}}{\text{constant}}$$

1 rad = 57.296 degrees
this can be generated by $1547 \div 27$

Arcsin x $= \arctan\left(\dfrac{x}{\sqrt{1-x^2}}\right)$

Program: B/E |enter|×|÷|‘|1|’|−|√x|÷|arctan|var| [11] C/CE

Execution: |x exec|

Arccos x $= \arctan\left(\dfrac{\sqrt{1-x^2}}{x}\right)$

Program: B/E |enter|×|÷|‘|1|’|−|√x|arctan|var| [10] C/CE

Tan x $= \dfrac{\sin x}{\cos x} = \sqrt{\dfrac{1}{\cos^2 x} - 1}$

Program: B/E |sto|enter|cos|x−m|sin|rcl|÷|var| [8] C/CE

Execution: |x exec|

or

Program: B/E |enter|cos|×|÷|‘|1|’|−|√x|var| [10] C/CE

Execution: |x exec|

Sinh x and Cosh x $\sinh x = \dfrac{e^x - e^{-x}}{2}$ $\cosh x = \dfrac{e^x + e^{-x}}{2}$

Program: B/E |enter|‘|1|1|9|’|×|‘|2|7|4|’|÷|antilog|sto|enter|÷|rcl|var|‘|2|’|÷|var| [24] C/CE

Execution: sinh x |x exec|− − exec|

cosh x |x exec|+ exec|

ln x $= \log x \times \ln 10$

Program: B/E |log|‘|1|7|5|’|×|‘|7|6|’|÷|var| [13] C/CE

Execution: |x exec|

e^x $\quad = \text{antilog}\,(x \times \log e)$

Program: B/E |enter|❛|1|1|9|❜|×|❛|2|7|4|❜|÷|antilog|var| [15] C/CE

Execution: |x exec|

y^x $\quad$ (x and y of similar magnitude) y + ve

Program: B/E |sto|÷|rcl|−|log|rcl|×|antilog|var| [9] C/CE

Execution: |(y enter)|x exec|

y^x $\quad$ (y + ve)

Program: B/E |log|var|×|antilog|var| [5] C/CE

Execution: |y exec|x exec|

π

Program: B/E |sto|enter|❛|3|5|5|❜|enter|❛|1|1|3|❜|÷|$x-m$|rcl|var| [17] C/CE

Execution: |exec|

Accumulating Memory (M +)

Program: B/E |enter|$x-m$|rcl|+|$x-m$|enter|var| [7] C/CE

Execution: |exec|

Live % key

Program: B/E |enter|sto|enter|var|×|❛|1|0|0|❜|÷|var|rcl|+|var| [15] C/CE

Execution: |A exec|B exec|(displays B% of A)|exec|(displays A + (B% of A))

|− exec|(displays A − (B% of A))

Degrees to Radians

Program: B/E| enter|❛|1|5|4|7|❜|÷|❛|2|7|❜|X| var| [14] C/CE

Execution: | Degrees exec|

EQUATION SOLVING

Solutions to the equation $f(x) = 0$ may be found using a programmable calculator by the use of iterative methods. If a procedure can be found which, when applied to an approximate value of x say x_0 yields a more accurate approximation x_1, then repeated use of this procedure will yield increasingly accurate approximations and this is called an iterative technique. Many methods exist and some are illustrated below. Unfortunately there is no simple universal method because those which yield increasingly accurate results (converging) with one formula may produce increasingly inaccurate results (diverging) with another. Also, an iterative technique can produce convergent or divergent results depending on the starting value chosen.

The method known as Newton-Raphson is very generally applicable but it involves differentiation of the function and the storage of both the function and its differential in the calculator which greatly limits the length of function that can be handled. Other methods given here are often slower to converge but simpler to use. The rate of convergence is, fortunately, less important than it might be because of the very high speed of this calculator.

Newton-Raphson

This method uses the fact that increasingly more accurate solutions to an equation $f(x) = 0$ are generated by the formula $x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$ where f' is the first differential of f

Thus by loading the calculator with a program to solve the above formula, successively more accurate approximations may be generated by entering an initial guess, and then repeatedly executing the program.

Example:-

To solve $f(x) \equiv x^3 + x + 1 = 0$

$f',(x) = 3x^2 + 1$

$$\therefore x_{n+1} = x_n - \frac{x_n^3 + x_n + 1}{3x_n^2 + 1} = \frac{2x_n^3 + 1}{3x_n^2 + 1}$$

Program: B/E |sto|enter| × |rcl| × |❛|2|❜| × |❛|1|❜| − |x–m|enter| × |❛|3|❜| × |❛|1|❜|var| [24] C/CE

Execution: 1|exec| + rcl ÷ ÷|

|exec| + rcl ÷ ÷|

⋮

Result — 0.68231 or −0.68236

A particularly simple alternative method is as follows:-

It only requires the writing of a program to evaluate $f(x)$ and perform a simple operation on it as follows:-

$$x_{n+1} = (f(x_n) \div k) + x_n$$

It requires the evaluation of $f(x)$ for two arbitrary values of x, x_0 and x_1 such that $f(x_0) = y_0$ and $f(x_1) = y_1$

Form $\left(\frac{y_1 - y_0}{x_0 - x_1}\right) = A$ K = integer part of A if $|A| \geq 1$

K = the reciprocal of the integer part of $1/A$ if $|A| < 1$

Example:-

To solve $f(x) \equiv x^3 + x + 1 = 0$

choose $x_0 = 0, x_1 = -1$ $\therefore$ $y_0 = 1, y_1 = -1$.

$\therefore$ $A = -2$ $\therefore$ $K = -2$

$x_{n+1} = (f(x_n) \div (-2)) + x_n$

Program B/E |sto|enter| × |⁽|1|⁾| + |rcl| × |⁽|1|⁾| + |⁽|2|⁾| ÷ | − |rcl| + |var| [21] C/CE

Execution: − 1|exec|

|exec|

⋮

NOTE If program diverges, increase $|K|$

If program converges too slowly, decrease $|K|$

FACTORIALS ($n!$)

Program: (i) B/E |$x-m$|enter|⁽|1|⁾|+|$x-m$|rcl|×|var| [10] C/CE

displays $n!$, stores n

Program: (ii) B/E |enter|⁽|1|⁾|+|$x-m$|rcl|×|$x-m$|var| [10] C/CE

displays n, stores $n!$

Execution: |1 sto exec|exec|exec| .....

POLYNOMIAL EVALUATION

$a_0 + a_1 x + a_2 x^2 + \ldots + a_n x^n$ can be written:-

$(\ldots (((x + a_n) x + a_{n-1}) x + a_{n-2}) x \ldots) x + a_0$

Program: B/E |rcl|+|var|+|var| [5] C/CE

Execution: |x sto enter 1|exec|a_n exec|

|exec|a_{n-1} exec|

⋮ ⋮

|exec| a_0 exec |

ROOTS OF A QUADRATIC EQUATION

$ax^2 + bx + c = O$ form $p = \frac{b}{a}$, $q = \frac{c}{a}$

Program: B/E |enter|⁽|2|⁾|÷|sto|enter|×|var|$\sqrt{x}$|$x-m$|−|var|rcl|+|var| [16] C/CE

Execution: |p exec|q−| If display $\geqslant 0$ go to (i) if < 0 go to (ii)

(i) |exec exec| displays one real root

|rcl−rcl−| displays other real root

(ii) |−exec| displays real part of both roots

|$x-m$| displays imaginary part of one root

|−| displays imaginary part of other root

|exec| completes program ready for re–use

$\dfrac{x + 1}{x - 1}$

Program: B/E |sto|enter|‘|1|’|−|$x-m$|enter|‘|1|’|+|rcl|÷|var| [15] C/CE

Execution: |x exec|

$\dfrac{x + 1}{x^2 + 1}$

Program: B/E |sto|enter|×|‘|1|’|+|$x-m$|enter|‘|1|’|+|rcl|÷|var| [16] C/CE

Execution: |x exec|

a) $\sqrt{1 + x^2}$

Program:
B/E |enter|×|‘|1|’|+|√x|var| [8] C/CE

b) $\sqrt{1 - x^2}$

Program:
B/E |enter|×|‘|1|’|−|−|√x|var| [9] C/CE

Execution: |x exec|

$\dfrac{1}{1 + x^2}$

Program: B/E |enter|×|‘|1|’|+|÷|var| [8] C/CE

Execution: |x exec|

$\dfrac{xy}{x + y}$

Program: B/E |enter|÷|sto|enter|var|enter|÷|rcl|+|÷|var| [11] C/CE

Execution: |x exec|y exec|

$\dfrac{x + y}{x - y}$

Program: B/E |enter|var|sto|−|$x-m$|enter|‘|2|’|×|rcl| : |‘|1|’|+|var| [17] C/CE

Execution: |x exec|y exec|

SERIES

$$\sum_{1}^{n} n = \tfrac{1}{2} N (N + 1)$$

Program: B/E |sto|enter|❛|1|❜|+|rcl|×|❛|2|❜|÷|var| [13] C/CE

Execution: |N exec|

$$\sum_{1}^{n} n^2 = \tfrac{1}{6} N (N + 1)(2N + 1)$$

Program: |enter|❛|2|❜|×|❛|1|❜|+|rcl|×|$x-m$|enter|❛|1|❜|+|rcl|×|❛|6|❜|÷|var| [24] C/CE

Execution: |N sto exec|

$$\sum_{1}^{n} n^3 = \tfrac{1}{4} N^2 (N + 1)^2$$

Program: B/E |sto|enter|❛|1|❜|+|rcl|×|❛|2|❜|÷|×|var| [14] C/CE

Execution: |N exec|

$$\sum_{1} \frac{1}{i}$$

Program: B/E |$x-m$|enter|÷|❛|1|❜|+|÷|$x-m$|rcl|+|var| [12] C/CE

Execution: |exec|exec|exec| . . .

$$\sum_{i=1}^{\infty} iq^{i-1} = \frac{1}{(1-q)^2} \text{ for } |q| < 1$$

Program: B/E |enter|❛|1|❜|−|−|×|÷|var| [9] C/CE

Execution: |q exec|

$$\sum_{0}^{\infty} (-1)^i q^i = \frac{1}{1+q}$$

Program: B/E |enter|❛|1|❜|+|÷|var| [7] C/CE

Execution: |q exec|

$$\sum_{1}^{\infty} q^i = \frac{q}{1-q} \quad \text{for } |q| < 1$$

Program: B/E |sto|enter|❛|1|❜|−|−|$x-m$|rcl|÷|var| [11] C/CE

Execution: |q exec|

Sum of N terms in an arithmetic series

$$= N\left(a + \frac{(N-1)}{2} d\right) \quad \text{where } a = \text{first term, } d = \text{common difference}$$

Program: B/E |sto|enter|❛|1|❜|−|var|×|❛|2|❜|÷|var|+|rcl|×|var| [17] C/CE

Execution: |N exec|d exec| a exec|

Sum of N terms in a geometric series

$$= a\ \frac{(1-r^N)}{(1-r)} \quad \text{where } a = \text{first term, } r = \text{common ratio}$$

Program: B/E |sto|enter|❛|1|❜|−|$x-m$|log|var|×|antilog|❛|1|❜|−|rcl|÷|var|×|var| [20] C/CE

Execution: |r exec|N exec|a exec|

Arithmetic–Geometric Series

$$a + (a+\mathrm{d})r + (a+2\mathrm{d})r^2 + \ldots + (a+\mathrm{nd})r^n +$$

$$\text{Sum} = \frac{\dfrac{d.r}{1-r} + a}{1-r} \qquad (r < 1)$$

Program: B/E |sto|enter|❛|1|❜|−|−|x-m|enter|var|×|rcl|÷|var|+|rcl|÷|var| [18] C/CE

Execution: |r exec|d exec|a exec|

DECIMAL—BINARY CONVERSION

(i) Decimal to Binary integer

Program: B/E |enter|“|2|”| ÷ |var| [6] C/CE

Execution: |x exec|exec|exec| . . .

At each stage write 1 if non integer part of display increases, write 0 if non integer part stays constant or decreases, continue until integer passes zero. Produces Binary digits from most significant to least significant.

(ii) Binary to Decimal integer

Program: B/E |+|“|2|”| × |var| [6] C/CE

Execution: |*a* exec|*b* exec| . . . |*n* − 1 exec|*n* +|

Enter Binary digits in order from least significant to most significant.

(iii) Decimal to Binary fraction

Program: B/E |enter|“|2|”| × |var| [6] C/CE

Execution: |x exec|exec|exec| . . .

Write down 1 if integer part of display is odd

0 if integer part of display is even or zero.

Produces Binary digits in order form most significant to least significant.

(iv) Binary to Decimal fraction

Program: B/E |+|“|2|”| ÷ |var| [6] C/CE

Execution: |*a* exec|*b* exec| . . . |*n* exec|

Enter Binary digits in order from least significant to most significant.

COMPLEX NUMBERS

$z = a + ib$

$Magnitude = |z| = \sqrt{a^2 + b^2}$

Program: B/E |enter|×|sto|+|var|enter|×|rcl|+|$\sqrt{x}$|var| [11] C/CE

Execution: |a exec|b exec|

θ (= Arg z) = arctan b/a

Program: B/E |enter|sto|+|var|enter|rcl|÷|arctan|var| [9] C/CE

Execution: |a exec|b exec|

DETERMINANTS

$$\begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix} = a_1b_2 - a_2b_1$$

Program: B/E |enter|var|×|sto|+|var|enter|var|×|−|rcl|+|var| [13] C/CE

Execution: |a_1 exec|b_2 exec|a_2 exec|b_1 exec|

LOG BASE CHANGE

$$\log_b a = \frac{\log_c a}{\log_c b}$$

→ in particular $\log_b a = \dfrac{\log_{10} a}{\log_{10} b}$

Program: B/E |enter|log|sto|+|var|enter|log|rcl|÷|÷|var| [11] C/CE

Execution: |a exec|b exec|

TRIANGLES

$$AREA = \tfrac{1}{2} ab \sin \gamma \quad \text{(i)}$$
$$= \tfrac{1}{2} bc \sin \alpha \quad \text{(ii)}$$
$$= \tfrac{1}{2} ac \sin \beta \quad \text{(iii)}$$

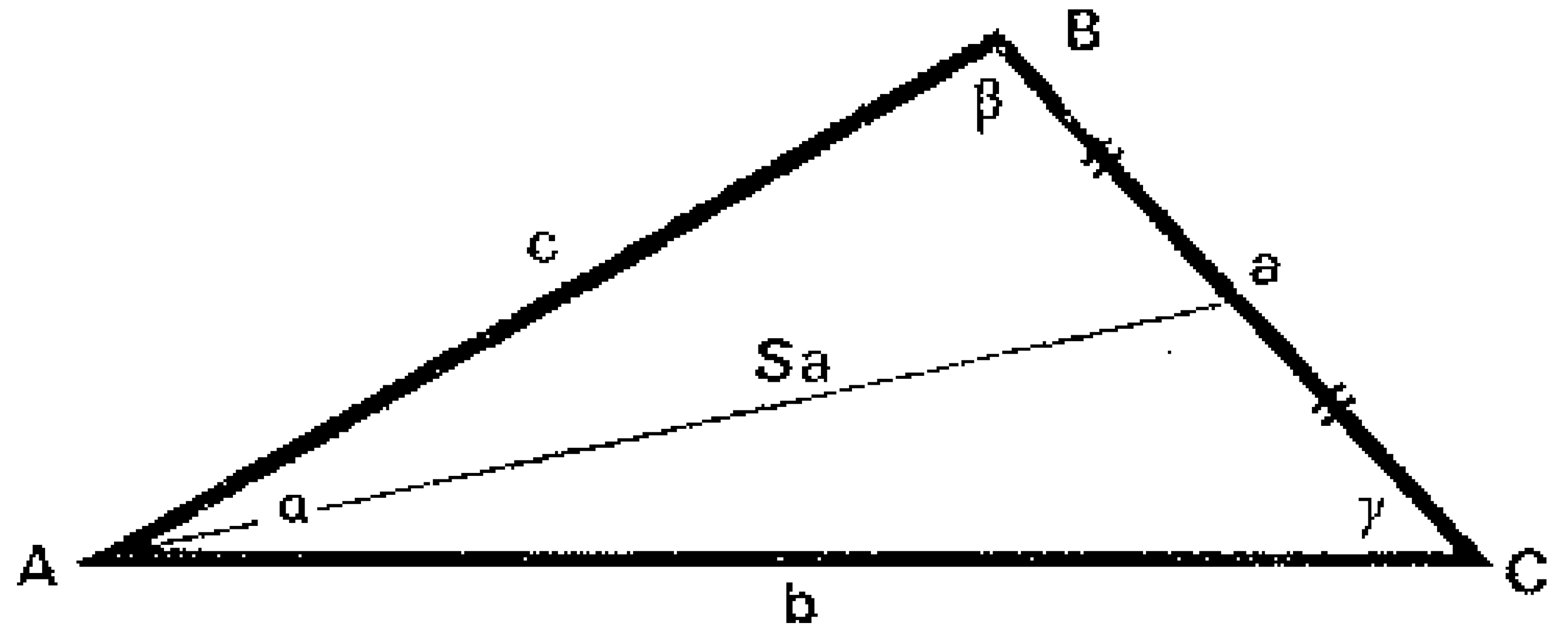
Program: B/E |enter|❛|2|❜|÷|var|×|sto|+|var|enter|sin|rcl|×|var| [15] C/CE

Execution:

(i) |a exec|b exec|γ exec|

(ii) |b exec |c exec|α exec|

(iii) |c exec|a exec|β exec|



$$\text{Area (alternative)} = \frac{ah_a}{2} \quad \text{(i)}$$
$$= \frac{bh_b}{2} \quad \text{(ii)}$$
$$= \frac{ch_c}{2} \quad \text{(iii)}$$

h = altitude

Program: B/E |enter|❛|2|❜|÷|var|×|var| [8] C/CE

Execution:

(i) |a exec|h_a exec|

(ii) |b exec|h_b exec|

(iii) |c exec|h_c exec|

LENGTH OF SIDE BISECTORS

$$Sa = \tfrac{1}{2}\sqrt{2(b^2 + c^2) - a^2} \qquad \text{(i)}$$

$$Sb = \tfrac{1}{2}\sqrt{2(c^2 + a^2) - b^2} \qquad \text{(ii)}$$

$$Sc = \tfrac{1}{2}\sqrt{2(a^2 + b^2) - c^2} \qquad \text{(iii)}$$

Program: B/E |enter| × |sto| + |var|enter| × |rcl| + |var| × |sto| + |
|var|enter| × | − |rcl| + |$\sqrt{x}$|var| ÷ |var| [23] C/CE

Execution:

(i)	|*b*	exec|*c*	exec|2	exec|*a*	exec|2	exec|
(ii)	|*c*	exec|*a*	exec|2	exec|*b*	exec|2	exec|
(iii)	|*a*	exec|*b*	exec|2	exec|*c*	exec|2	exec|

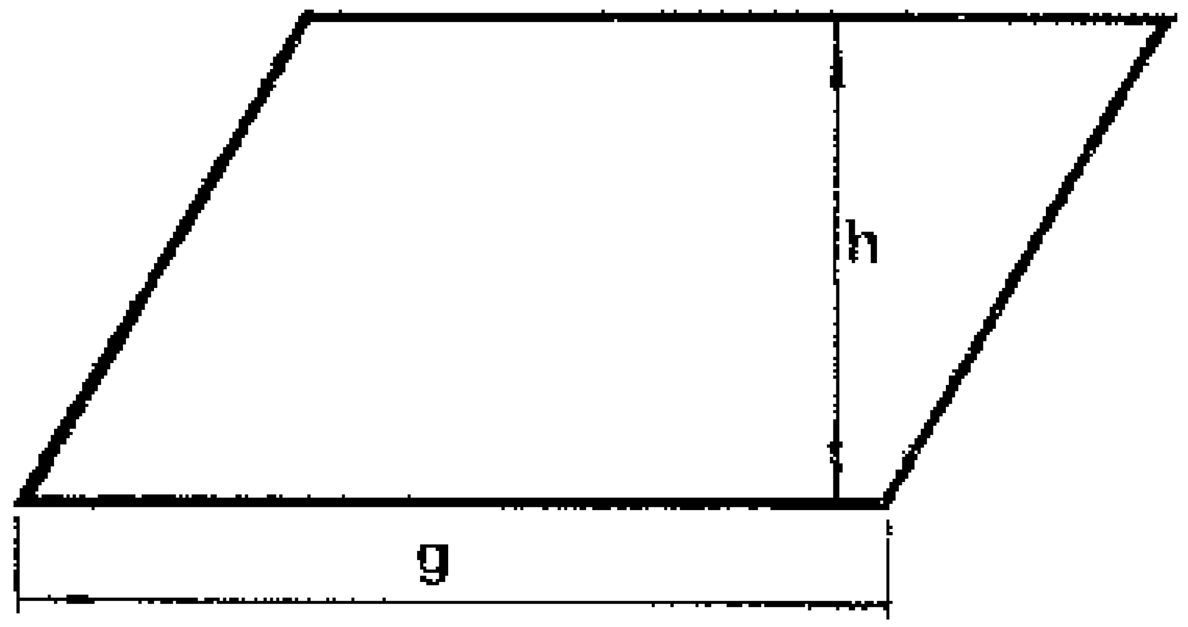
length of side $a = \dfrac{\sin\alpha}{\sin\beta} \times b \qquad \dfrac{a}{\sin\alpha} = \dfrac{b}{\sin\beta} = \dfrac{c}{\sin\gamma}$

Program: B/E |sin|sto|enter|var|enter|sin| ÷ |rcl| × |var| × |var| [12] C/CE

Execution: |α exec|β exec|*b* exec|

PARALLELOGRAMS

AREA = *gh*



Program: B/E |enter|var| × |var| [4] C/CE

Execution: |*g* exec|*h* exec|

RECTANGLES

LENGTH OF DIAGONAL $= \sqrt{a^2 + b^2}$

Program: B/E |enter| × |sto| + |var|enter| × |rcl| + |$\sqrt{x}$|var| [11] C/CE

Execution: |*a* exec|*b* exec|

GEOMETERY

CIRCLES

r = radius

CIRCUMFERENCE $= 2\pi r$

Program: B/E |enter|⁽|7|1|0|⁾|×|⁽|1|1|3|⁾|÷|var| [14] C/CE

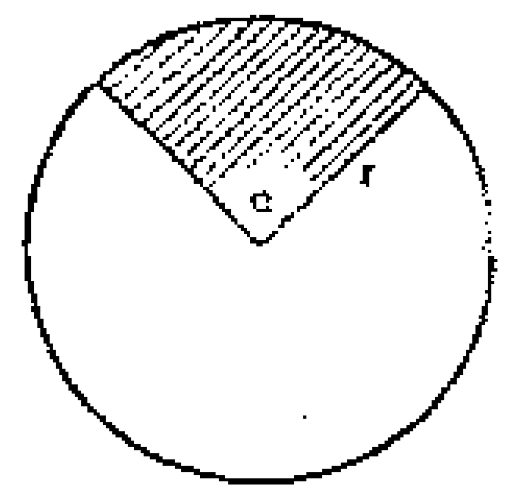
Execution: |r exec|

AREA $= \pi r^2$

Program: B/E |enter|×|⁽|3|5|5|⁾|×|⁽|1|1|3|⁾|÷|var| [15] C/CE

Execution: |r exec|

AREA OF SECTOR $= \frac{r^2}{2}\alpha$ (α radians)



Program: B/E |enter|×|⁽|2|⁾|÷|var|×|var| [9] C/CE

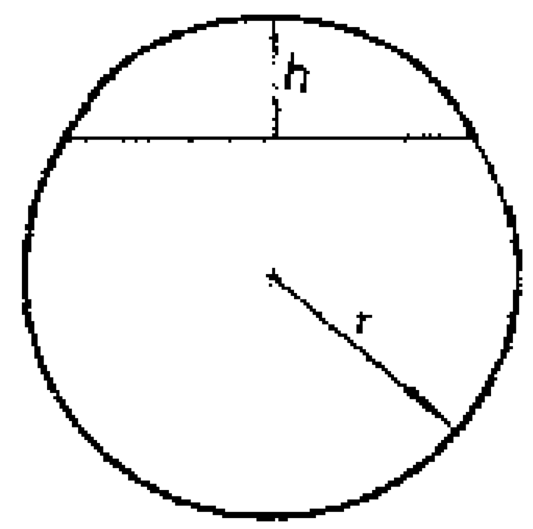
Execution: |r exec|α exec|

AREA OF SECTOR $= \frac{r^2}{2}\alpha$ (α degrees)

Program: B/E |enter|×|⁽|2|⁾|÷|var|×|⁽|5|7|3|⁾|÷|⁽|1|0|⁾|×|var| [20] C/CE

Execution: |r exec|α exec|

AREA OF SEGMENT $= 2\sqrt{2hr - h^2}$



Program: B/E |enter|sto|+|⁽|2|⁾|×|var|×|x–m|enter|×|–|rcl|+|
|$\sqrt{x}$|⁽|2|⁾|×|var| [21] C/CE

Execution: |h exec|r exec|

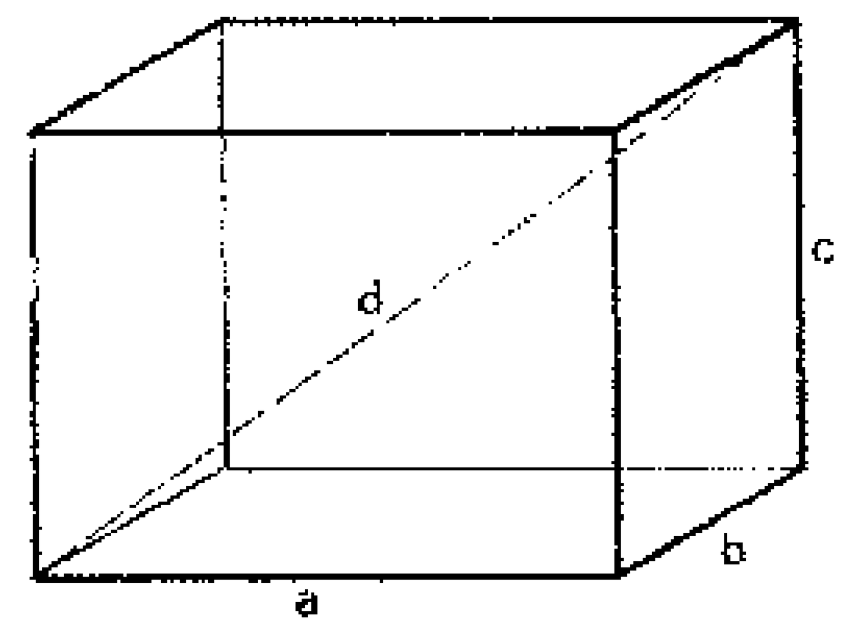
CIRCULAR RING

AREA $= \pi(R^2 - r^2)$

Program: B/E |enter| × |sto| + |var|enter| × | − |rcl| + |(|3|5|5|)| × |(|1|1|3|)| ÷ |var| [23] C/CE

Execution: |*R* exec|*r* exec|

RIGHT PARALLELAPIPED CUBOID



VOLUME $= a\,b\,c$

Program: B/E |enter|var| × |var| × |var| [6] C/CE

Execution: |*a* exec|*b* exec|*c* exec|

SURFACE AREA $= 2\,(ab + ac + bc)$

Program: B/E |enter|sto| + |var| × |x·m| + |var| + |var| × |rcl| + |(|2|)| × |var| [18] C/CE

Execution: |*b* exec|*c* exec|*c* exec|*a* exec|

DIAGONAL $= d = \sqrt{a^2 + b^2 + c^2}$

Program: B/E |enter| × |sto| + |var|enter| × |rcl| + |sto| + |var|enter| × |rcl| + |$\sqrt{x}$|var| [18] C/CE

Execution: |*a* exec|*b* exec|*c* exec|

RIGHT CIRCULAR CYLINDER

VOLUME $= \pi r^2 h$

Program: B/E |enter| × |var| × |‘|3|5|5|’| × |‘|1|1|3|’| ÷ |var| [17] C/CE

Execution: |r exec|h exec|

AREA OF CURVED SURFACE $= 2\pi rh$

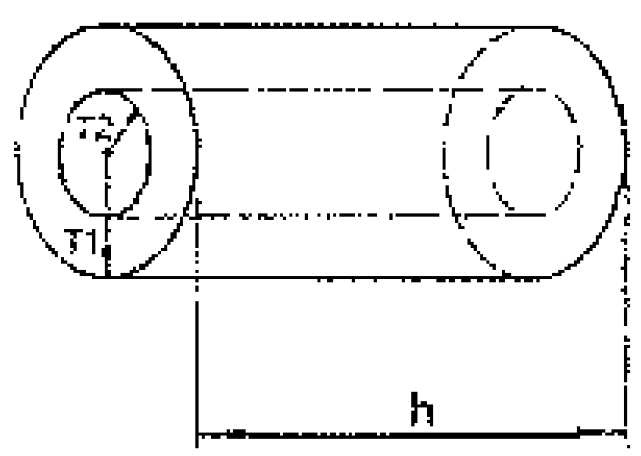
Program: B/E |enter|var| × |‘|7|1|0|’| × |‘|1|1|3|’| ÷ |var| [16] C/CE

Execution: |r exec|h exec|

AREA OF WHOLE SURFACE $= 2\pi r(r + h)$

Program: B/E |enter|sto| + |‘|7|1|0|’| × |‘|1|1|3|’| ÷ |x–m| + |var| + |rcl| × |var| [22] C/CE

Execution: |r exec|h exec|



HOLLOW CYLINDER TUBE

VOLUME $= \pi h(r_1^2 - r_2^2)$

Program: B/E |enter| × |sto| + |var|enter| × |rcl| – |var| × |‘|3|5|5|’| × |‘|1|1|3|’| ÷ |var| [24] C/CE

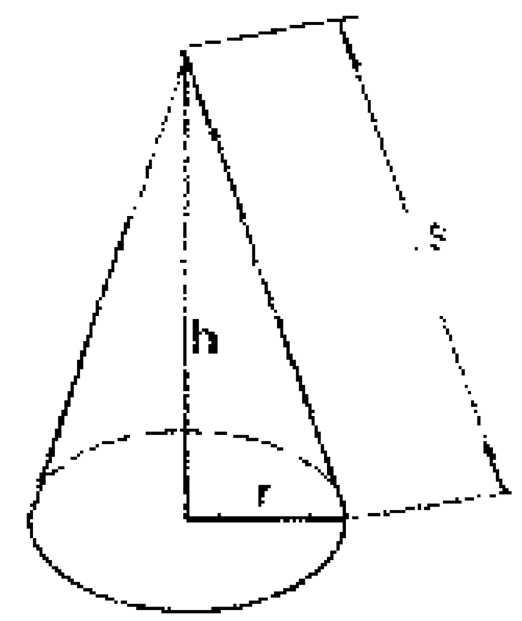
Execution: |r_2 exec|r_1 exec|h exec|

AREA OF CURVED SURFACE $= 2\pi h(r_1 + r_2)$

Program: B/E |enter|var| + |var| × |‘|7|1|0|’| × |‘|1|1|3|’| ÷ |var| [18] C/CE

Execution: |r_1 exec|r_2 exec|h exec|

RIGHT CIRCULAR CONE



VOLUME = $\frac{1}{3}\pi r^2 h$

Program: B/E |enter| × |var| × |‘|3|5|5|’| × |‘|3|3|9|’| ÷ |var| [17] C/CE

Execution: |r exec|h exec|

AREA CURVED SURFACE = $\pi r\sqrt{r^2 + h^2}$ (i)

= πrs (ii)

Program: (i) B/E |enter| × |sto|enter|var| × |rcl| + |rcl| × |$\sqrt{x}$|‘|3|5|5|’| × |‘|1|1|3|’| ÷ |var| |[24] C/CE

Execution: (i) |r exec|h enter exec |

Program: (ii) B/E |enter|var| × |‘|3|5|5|’| × |‘|1|1|3|’| ÷ |var| [16] C/CE

Execution: (ii) |r exec|s exec|

TOTAL SURFACE AREA = $\pi r\ (s + r)$

Program: B/E |sto|enter|var| + |rcl| × |‘|3|5|5|’| × |‘|1|1|3|’| ÷ |var| [19] C/CE

Execution: |r exec|s exec|

SPHERES

VOLUME = $\frac{4}{3}\pi r^3$

Program: B/E |enter|sto|rcl| × |rcl| × |‘|1|4|2|0|’| × |‘|3|3|9|’| ÷ |var| [20] C/CE

Execution: |r exec|

DISTANCE BETWEEN (x_1, y_1) & (x_2, y_2) = $\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

Program: B/E |enter|var| − | × |sto| + |var|enter|var| − | × |rcl| + |$\sqrt{x}$|var| [15] C/CE

Execution: |x_2 exec|x_1 exec|y_2 exec|y_1 exec|

STATISTICS

SUMMATIONS

$\sum x_i y_i$

Program: B/E |enter|var|×|rcl|+|sto|enter|var| [8] C/CE

Execution: |x_1 exec|y_1 exec|

|x_2 exec|y_2 exec|

etc.

$\sum (x_i - y_i)^2$

Program: B/E |enter|var|−|×|rcl|+|sto|enter|var| [9] C/CE

Execution: |x_1 exec|y_1 exec|

|x_2 exec|y_2 exec|

etc.

$\sum x_i^2$

Program: B/E |enter|×|rcl|+|sto|enter|var| [7] C/CE

Execution: |x_1 exec|x_2 exec| ...

Product of Sums

$\Pi(x_i + y_i)$

Program: B/E |enter|var|+|rcl|×|sto|enter|var| [8] C/CE

Execution: |1 sto|x_1 exec|y_1 exec|

|x_2 exec|y_2 exec|

etc.

$\sum x_i$

Program: B/E |enter|rcl|+|sto|enter|var| [6] C/CE

Execution: |x_1 exec|x_2 exec| ...

$$\sum \frac{1}{x_i}$$

Program: B/E |enter|÷|rcl|+|sto|enter|var| [7] C/CE

Execution: |x_1 exec|x_2 exec| ...

$$\frac{\sum_{1}^{N} x_i}{N} = \bar{x} \text{ (Sample mean)}$$

Program: B/E |+|$x-m$|enter|‘|1|’|+|$x-m$|enter|var| [10] C/CE

Execution: |x_1 exec|x_2 exec| ... |rcl ÷|

$$\frac{\sum_{1}^{N} dj}{N} = \bar{d} \text{ (Mean of differences)}$$

Program: B/E |+|var|−|$x-m$|enter|‘|1|’|+|$x-m$|enter|var| [12] C/CE

Execution: |x_{1a} exec|x_{1b} exec|

|x_{2a} exec|x_{2b} exec|

etc.

|rcl ÷|

$$\sum_{1}^{N} x_i^2$$

Program: B/E |enter|×|rcl|+|sto|enter|var| [7] C/CE

Execution: |x_1 exec|x_2 exec|

STANDARD DEVIATION (SAMPLE VARIANCE)

$$\sigma = \sqrt{\frac{\sum x_i^2 - n(\bar{x})^2}{n-1}}$$

Program: B/E |sto|$\sqrt{x}$|var|×|×|var|−|−|$x-m$|enter|‘|1|’|−|÷|rcl|×|$\sqrt{x}$|var| [19] C/CE

Execution: |n exec|$\bar{x}$ exec|$\Sigma \bar{x}_i^2$ exec|

z STATISTIC

$$z = \frac{\frac{x}{n} - \theta}{\sqrt{\frac{\theta(1-\theta)}{n}}}$$

Program: B/E |sto|enter|‘|1|’|−|−|rcl|×|var|÷|$\sqrt{x}$|$x-m$|enter|var|−|−|rcl|÷|var| [20] C/CE

Execution: |θ exec|n exec|x/n exec|

PROBABILITY THEORY

$p(1-p)$

Program: B/E |sto|enter|‘|1|’|−|−|rcl|×|var| [10] C/CE

Execution: |p exec|

QUALITY CONTROL

$$p \pm \sqrt{p\frac{(1-p)}{n}}$$

Program: |sto|enter|‘|1|’|−|−|rcl|×|var|÷|$\sqrt{x}$|$x-m$|rcl|var| [15] C/CE

Execution: |p exec|n exec +|

or |p exec|n exec −|

STANDARD ERROR OF DIFFERENCE

$$\sqrt{\frac{pq}{n_1} + \frac{pq}{n_2}}$$

Program: B/E |enter|÷|sto|enter|var|enter|÷|rcl|+|var|×|var|×|$\sqrt{x}$|var| [15] C/CE

Execution: |n_1 exec|n_2 exec|p exec|q exec|

CHI ^{2}

$$X^2 = \sum\left[\frac{(O - E)^2}{E}\right]$$

Program: B/E| enter| −| var| +| X| var| ÷| rcl| +| sto| enter| var| [12] C/CE

Execution: | O_i exec| E_i exec| E_i exec|
etc.

SIMPSON'S RULE

$$A = 1/3h\ (y_1 + 4y_2 + y_3)$$

Program: B/E| enter| ❛| 4| ❜| X| var| +| var| +| var| X| ❛| 3| ❜| ÷| var| [16] C/CE

Execution: | y_2 exec| y_3 exec| y_1 exec| h exec|

SOLVING FOR REGRESSION LINE $y = ax + b$

Solution of the simultaneous equations $\Sigma y = a\Sigma x + nb$, $\Sigma xy = a\Sigma x^2 + b\Sigma x$ is required.

The values of Σy etc. are derived from earlier programs and the equation is solved using the determinant program, as follows :

$$\Delta = \begin{vmatrix} \sum x & n \\ \sum x^2 & x \end{vmatrix}$$

$$a = \frac{\begin{vmatrix} \sum y & n \\ \sum xy & \sum x \end{vmatrix}}{\Delta}$$

$$b \quad \frac{\begin{vmatrix} \sum x & \sum y \\ \sum x^2 & \sum xy \end{vmatrix}}{\Delta}$$

ACCUMULATING MEMORY (M+)

Program: B/E |enter|$x-m$|rcl|+|$x-m$|enter|var| [7] C/CE

Depressing execute button adds contents of display to memory (M+ function)

ACCUMULATING OR DECREMENTING MEMORY ($M+$, or $M-$)

Program: B/E |enter|$x-m$|rcl|var|$x-m$|enter|var|[7] C/CE

|exec|+ exec|gives $M+$ function

|exec|− exec|gives $M-$ function

PERCENTAGES

LIVE % KEY OPERATION

Program: B/E |enter|sto|enter|var|×|'|1|0|0|'|÷|var|rcl|+|var| [15]

Execution: |A exec|B exec|(displays B% of A)|execute|(displays A + (B% of A))|
or |−exec|(displays A − (B% of A))|

MARK UP

A + (B% of A)

Program: B/E |sto|enter|var|×|'|1|0|0|'|÷|rcl|+|var| [13] C/CE

Execution: |A exec|B exec|

DISCOUNT

A − (B% of A)

Program: B/E |sto|enter|var|×|'|1|0|0|'|÷|rcl|−|−|var| [14] C/CE

Execution: |A exec|B exec|

COMPOUND INTEREST

FINAL SUM FROM INITIAL SUM INVESTED FOR n YEARS AT INTEREST RATE a

$F = I(1 + a)^n$

Program: B/E |sto|enter|var|enter|(|1|)|+|log|var|×|antilog|rcl|×|var| [15] C/CE

Execution: |I exec|a exec|n exec|

NUMBER OF YEARS REQUIRED TO ACHIEVE GIVEN RESULT

$n = \log_{(1+a)}\left(\frac{F}{I}\right)$

Program: B/E |enter|(|1|)|+|log|sto|enter|var|enter|var|÷|log|rcl|÷|var| [16] C/CE

Execution: |a exec|F exec|I exec|

INTEREST RATE NEEDED TO ACHIEVE GIVEN RESULT

$a = \sqrt[n]{\frac{F}{I}} - 1$

Program: B/E |enter|var|÷|log|var|÷|antilog|(|1|)|−|var| [12] C/CE

Execution: |F exec|I exec|n exec|

INITIAL SUM NECESSARY TO ACHIEVE GIVEN RESULT

$I = \frac{F}{(1+a)^n}$

Program: B/E |sto|enter|var|enter|(|1|)|+|log|var|×|antilog|÷|rcl|×|var| [16] C/CE

Execution: |F exec|a exec|n exec|

LOAN REPAYMENT

ANNUAL REPAYMENT $P = \frac{aY}{1 - \frac{1}{(1+a)^n}}$

Y = amount borrowed
a = yearly interest
n = term of loan in years

Program: B/E |sto|enter|(|1|)|+|log|var|×|antilog|÷|(|1|)|−|−|$x-m$|enter|var|×|rcl|÷|var| |[23] C/CE

Execution: |a exec|n exec|Y exec|

TERM OF LOAN $n = \log_{(1+a)}\left(\frac{P}{P-aY}\right)$

Program: B/E |sto|enter|var|×|var|÷|(|1|)|−|−|÷|log|$x-m$|enter|(|1|)|+|log|÷|rcl|×|var|

Execution: |a exec|Y exec|P exec| |[24] C/CE

LOAN REDEMPTION RECOGNISED REDEMPTION FIGURE $= PT - a\left(\frac{T(T+1)}{N(N+1)}\right)$

a = interest rate
T = number of remaining installments
N = Total number of payments
P = Payment value

Program: B/E |enter|(|1|)|+|rcl|×|sto|enter|var|enter|(|1|)|+|rcl|÷|var|×|var|−|var|×|var|

Execution: |N sto exec|T *exec*|a *exec*|P exec|T *exec*|−| |[24] C/CE

DISCOUNTED CASH FLOW

$$\text{Year}\,(n+1) = \frac{\text{Year}\,n}{(1+a)}$$

Program: B/E |enter|⁽|1|⁾|+|÷|var|×|var| [9] C/CE

Execution: |a exec|Year n exec|

$$YEAR\ n = \frac{\text{Initial}}{(1+a)^n}$$

Program: B/E |enter|⁽|1|⁾|+|log|var|×|antilog|÷|var|×|var| [13] C/CE

Execution: |a exec|n exec|I exec|

AMORTISATION FACTOR

$$AF = a + \frac{a}{(1+a)^n - 1}$$

Program: B/E |sto|enter|⁽|1|⁾|+|log|var|×|antilog|⁽|1|⁾|−|÷|rcl|×|rcl|+|var| [20] C/CE

Execution: |a exec|n exec|

DEGREES FAHRENHEIT TO DEGREES CENTIGRADE

Program: B/E| enter| “| 3| 2| ”| −| “| 5| ”| X| “| 9| ”| ÷| var| [15] C/CE

Execution: | °F exec|

DEGREES CENTIGRADE TO DEGREES FAHRENHEIT

Program: B/E| enter| “| 9| ”| X| “| 5| ”| ÷| “| 3| 2| ”| +| var| [15] C/CE

Execution: | °C exec|

ANGLE CONVERSION

DEGREES MINUTES AND SECONDS TO RADIANS

Program: B/E| rcl| X| var| +| rcl| X| var| +| rcl| ÷| “| 9| 2| 8| 2| 0| ”| ÷| “| 2| 7| ”| X| var| [24] C/CE

Execution: | 60 sto enter| Degrees exec| minutes exec| seconds exec|

TIME CONVERSION

HOURS, MINUTES AND SECONDS TO DECIMAL HOURS

Program: B/E| enter| “| 6| 0| ”| X| var| +| “| 6| 0| ”| X| var| +| “| 3| 6| 0| 0| ”| ÷| var| [23] C/CE

Execution: | Hours exec| minutes exec| seconds exec|

TALLY COUNTER

Program: B/E| “| 1| ”| +| var| [5] C/CE

Execution: | exec|

MAN AGAINST MACHINE (SUBTRACTION GAME)

The following program allows the user to have a contest with the calculator. The operator selects a starting total and then subtracts 1, 2 or 3 from that total. The calculator does the same and play continues alternately.

The object is to leave your opponent with '1' in the display. If '1' is left following your subtraction you win. If '1' is left after subtraction by the machine, you lose.

Program: B/E | enter | $x-m$ | rcl | − | var | $x-m$ | enter | (| 4 |) | − | rcl | + | sto | enter | var | [16] C/CE

Execution: | T sto enter |

| n exec | operator plays

| exec | calculator plays

| n exec |

| exec |

•
•
•

T = starting total
n = 1, 2 or 3

Start with $T = 25$

CURRENT, VOLTAGE, POWER AND RESISTANCE

$I = V/R = P/V = \sqrt{P/R}$

$V = IR = P/I = \sqrt{PR}$

$P = VI = I^2R = V^2/R$

$R = V/I = P/I^2 = V^2/P$

RESISTORS IN PARALLEL $R = \dfrac{1}{1/R_1 + 1/R_2}$

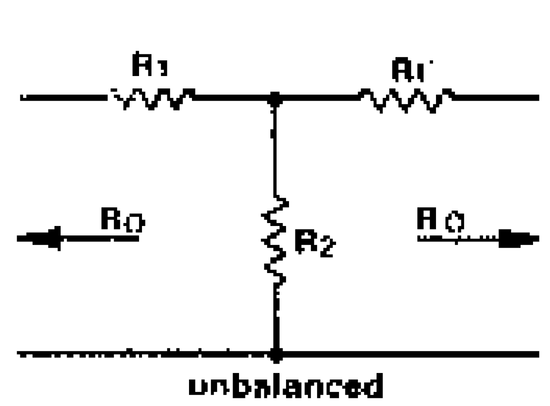
Program: B/E |enter|÷|sto|enter|var|enter|÷|rcl|+|÷|var| [11] C/CE

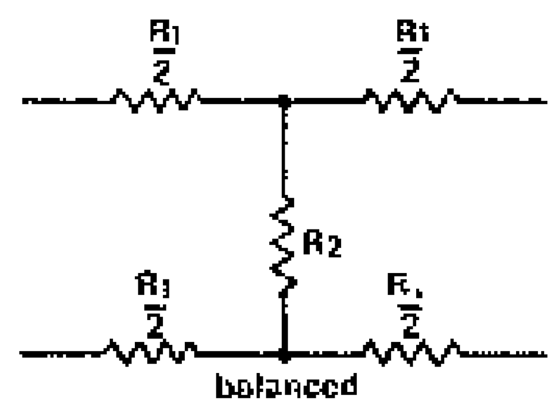
Execution: |R_1 exec|R_2 exec|

$$R = \frac{1}{1/R_1 + 1/R_2 + 1/R_3}$$

Program: B/E |enter|÷|sto|enter|var|enter|÷|rcl|+|sto|enter|var|enter|÷|rcl|+|
|÷|var| [18] C/CE

Execution: |R_1 exec|R_2 exec|R_3 exec|





RESISTIVE ATTENUATORS

$R_1 = R_o \dfrac{(n-1)}{(n+1)}$ *where n = voltage attenuation factor*

Program: B/E |sto|enter|‘|1|’|+|x-m|enter|‘|1|’|−|rcl|÷|var|×|var| [17] C/CE

Execution: |n exec|R_0 exec|

$$R_2 = \frac{2R_o n}{n^2 - 1}$$

Program: B/E |sto|enter|×|‘|1|’|−|÷|rcl|×|var|×|‘|2|’|×|var| [17] C/CE

Execution: |n exec|R_0 exec|

Single program for R_1 and R_2

Program: B/E |sto|enter|⁽|1|⁾|−|x–m|enter|⁽|1|⁾|+|÷|rcl|×|var|×|var|×|
|rcl|÷|rcl|÷|var| [24] C/CE

Execution: |n exec|R_0 exec|displays R_1 |2n exec|displays R_2

REACTANCE—FREQUENCY CHART

Program: B/E |enter|var|⁽|7|1|0|⁾|×|⁽|1|1|3|⁽|÷|÷|var| [16] C/CE

Execution:

$z = \frac{1}{2\pi fC}$ |f exec|C × exec|

$z = 2\pi fL$ |f exec|L × exec|÷|

$f = \frac{1}{2\pi Cz}$ |C exec|z × exec|

$f = \frac{z}{2\pi L}$ |L exec|z ÷ exec|

$C = \frac{1}{2\pi fz}$ |f exec|z × exec|

$L = \frac{z}{2\pi f}$ |f exec|z ÷ exec|

FREQUENCY TO WAVE LENGTH CONVERSION

$f = \frac{c}{\lambda}$ $\lambda = \frac{c}{f}$

Program: B/E |enter|÷|⁽|2|9|9|8|0|⁾|×|⁽|1|0|0|0|0|⁾|×|var| [19] C/CE

Execution: |f exec|

or |λ exec|

PEAK AMPLITUDE OF HARMONICS OF WAVEFORMS OF UNITY PEAK AMPLITUDE

SQUARE WAVE $a_n = \frac{4}{n\pi}$ (n odd)

Program: B/E |enter|÷|(|4|5|2|)|×|(|3|5|5|)|÷|var| [15] C/CE

Execution: |n exec|

TRIANGULAR WAVE $a_n = \frac{8}{n^2\pi^2}$ (n odd)

Program: B/E |enter|×|÷|(|1|8|4|)|×|(|2|2|7|)|÷|var| [16] C/CE

Execution: |n exec|

SAWTOOTH WAVE $a_n = \frac{2}{n\pi}$

Program: B/E |enter|÷|(|2|2|6|)|×|(|3|5|5|)|÷|var| [15] C/CE

Execution: |n exec|

RCL CIRCUITS

DISCHARGE OF CAPACITOR $v = Ve^{-t/CR}$ (i)

Program: B/E |enter|var|÷|var|÷|−|(|1|1|9|)|×|(|2|7|4|)|÷|antilog|var|×|var| [22] C/CE

Execution: |t exec|C exec|R exec|V exec| (i)

CHARGING OF CAPACITOR $v = V(1 - e^{-t/CR})$ (ii)

Execution: |t exec|C exec|R exec|1 − − V exec| (ii)

TIME TAKEN TO DISCHARGE CAPACITOR $t = CR \ln \frac{v}{V_o}$

Program: |enter|var|÷|log|◆|1|7|5|◆|×|◆|7|6|◆|÷|var|×|var|×|−|var| [21] C/CE

Execution: |v exec|V_0 exec|C exec|R exec|

TIME TAKEN TO CHARGE CAPACITOR $t = CR \ln\left(1 - \frac{v}{V_o}\right)$

Program: B/E |enter|var|÷|◆|1|◆|−|−|log|◆|1|7|5|◆|×|◆|7|6|◆|÷|var|×|−|var| [24] C/CE

Execution: B/E |v exec|V_0 exec|$C \times R$ exec|

CURRENT DECAY IN AN R−L CIRCUIT $i = Ie^{-Rt/L}$ (i)

Program: B/E |enter|var|×|var|÷|−|◆|1|1|9|◆|×|◆|2|7|4|◆|÷|antilog|var|×|var| [22] C/CE

Execution: |R exec|t exec|L exec|I exec| (i)

CURRENT BUILD UP $i = I(1 - e^{-Rt/L})$ (ii)

Execution: |R exec|t exec|L exec|1 − −I exec| (ii)

GENERAL FORMULA FOR INDUCTANCE OF COIL $L = 4\pi\mu An^2 \times 10^{-3}\,\mu H$

Program: B/E |enter|×|var|×|var|×|◆|1|4|2|◆|×|◆|1|1|3|0|0|◆|÷|var| [21] C/CE

Execution: |n exec|μ exec|A exec|

DECIBEL CONVERSION

$$N = 10\log_{10}\frac{P_2}{P_1} = 20\log_{10}\frac{E_2}{E_1} = 20\log_{10}\frac{I_2}{I_1}$$

Program: B/E |enter|var|÷|log|(|1|0|)|×|var| [10]

Execution: |P_2 exec|P_1 exec|

$$P_2 = P_1 \text{ antilog}\frac{N}{10}$$

Program: B/E |enter|(|1|0|)| : |antilog|var|×|var| [10] C/CE

Execution: |N exec|P_1 exec|

TRANSISTOR TRANSCONDUCTANCE $\delta i = (10^{\delta v/60} - 1)I_o$ δv *in mV*

Program: B/E |enter|(|6|0|)|÷|antilog|(|1|)|−|var|×|var| [14] C/CE

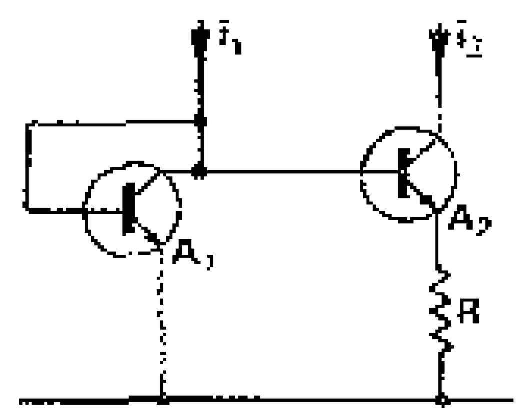
Execution: |δV exec|I_0 exec|

TRANSISTOR VBE IN mV $VBE_2 = VBE_1 + 60\log\frac{i_2}{i_1}$

Program: B/E |enter|var| : |log|(|6|0|)|×|var|+|var| [12] C/CE

Execution: |i_2 exec|i_1 exec|VBE_1 exec|

$$K = \frac{A_2}{A_1}$$



INTEGRATED CIRCUIT CURRENT SOURCE $R = \frac{.06}{i_2}\log K\frac{i_2}{i_1}$

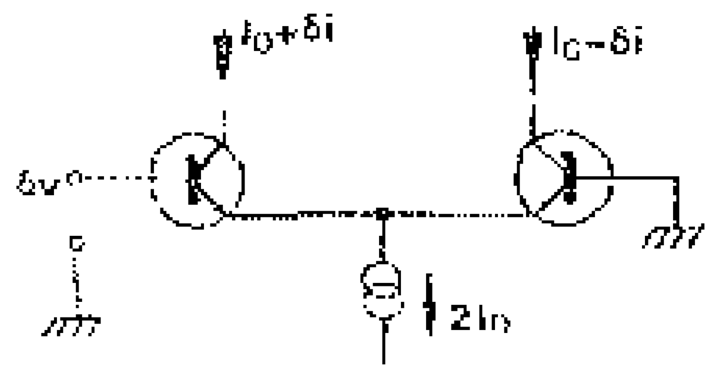
Program: B/E |sto|enter|var|enter|var|×|rcl|÷|log|(|6|)|×|(|1|0|0|)|÷|rcl|÷|var| [22] C/CE

Execution: |i_2 exec|i_1 exec|K exec|

TRANSFER FUNCTION OF LONG TAILED PAIR $\frac{\delta i}{Io} = \frac{(10^{\delta v/60} - 1)}{(10^{\delta v/60} + 1)}$ δv in mV

Program: B/E |enter|⁶|6|0|⁹|÷|antilog|sto|enter|⁶|1|⁹|+|x–m|enter|⁶|1|⁹|–
|rcl|÷|var| [22] C/CE

Execution: |δv exec|



MOS TRANSISTORS

NON SATURATED CONDITION $I_{DS} = K(2(V_{GS} - V_T) - V_{DS})V_{DS}$

Program: B/E |sto|enter|var|enter|var|–|⁶|2|⁹|×|rcl|–|rcl|×|var|×|var| [17] C/CE

Execution: |V_{DS} exec|V_{GS} exec|V_T exec|K exec|

SATURATED CONDITIONS $I_{DS} = K(V_{GS} - V_T)^2$

Program: B/E |enter|var|–|×|var|×|var| [7] C/CE

Execution: |V_{GS} exec|V_T exec|K exec|

GROUND EFFECT $V_T = V_{To} + \frac{1}{2}\sqrt{V_{BS}}$

Program: B/E |enter|$\sqrt{x}$|⁶|2|⁹|÷|var|+|var| [9] C/CE

Execution: |V_{BS} exec|V_{To} exec|

POWER AMPLIFIERS

POWER OUTPUT FROM PK—PK VOLTAGE SWING $P = \frac{(Vpk-pk)^2}{8R}$

Program: B/E |enter| × |⁽|8|⁾| ÷ |var| ÷ |var| [9] C/CE

Execution: |$Vpk-pk$ exec|R exec|

EFFICIENCY OF CLASS B STAGE $\eta = \frac{\pi}{4} \frac{V_Q - V\text{min}}{V_Q}$ V_Q = *quiescent output voltage*

Program: B/E |enter|var| ÷ |⁽|1|⁾| − | − |⁽|3|5|5|⁾| × |⁽|4|5|2|⁾| ÷ |var| [21] C/CE

Execution: |Vmin exec|V_Q exec|

DISSIPATION OF CLASS A STAGE $P = \frac{V_{CC}^2}{4R}\left(1 - \frac{x^2}{2}\right)$ $x = \frac{\text{Vout } pk-pk}{V_{CC}}$

Program: B/E |enter| × |⁽|2|⁾| ÷ |⁽|1|⁾| − | − |⁽|4|⁾| ÷ |var| : |$\sqrt{x}$|var| × | × |var| [22] C/CE

Execution: |x exec|R exec|V_{CC} exec|

DISSIPATION OF CLASS B STAGE $P = \frac{V_{CC}^2}{4R}\left(\frac{2x}{\pi} - \frac{x^2}{2}\right)$

Program: B/E |sto|enter| × |⁽|8|⁾| ÷ |x–m|enter|⁽|7|1|0|⁾| ÷ |⁽|1|1|3|⁾| × |rcl| − |var| [24] C/CE

Execution: | x exec| V_{CC}^2 x| R ÷ |

DISSIPATION OF CLASS C STAGE $P = \frac{V_Q I_M}{\pi}(\sin\theta - \theta\cos\theta)$

V_Q = quiescent voltage
I_M = mean current
θ = power transfer angle

Program: B/E |sto|cos|rcl| × |x–m|sin|rcl| − |⁽|3|5|5|⁾| : |⁽|1|1|3|⁾| × |var| × |var| [23] C/CE

Execution: |θ exec|$V_Q \times I_M$ exec|

3db POINT $f_2 = \frac{1}{2\pi CR}$

Program: B/E |enter|var|×|“|7|1|0|”|×|“|1|1|3|”|÷|÷|var| [17] C/CE
Execution: |*C* exec|*R* exec|

3 *db POINT OF IDENTICAL CASCADED SECTIONS* $\frac{f_n 3db}{f_1 3db} = \frac{1}{\sqrt{2^{1/n} - 1}}$

Program: B/E |sto|enter|“|2|”|log|rcl|÷|antilog|“|1|”|−|$\sqrt{x}$|÷|var| [16] C/CE
Execution: |*n* exec|

SHUNT PEAKING —VALUE OF L FOR MINIMUM RISE TIME $L = 0.414\, R^2C$

Program: B/E |enter|×|var|×|“|4|1|4|”|×|“|1|0|0|0|”|÷|var| [18] C/CE
Execution: |*R* exec|*C* exec|

VALUE OF L FOR MINIMUM OVERSHOOT $L = 0.25\, R^2C$

Program: B/E |enter|×|var|×|“|2|5|”|×|“|1|0|0|”|÷|var| [16] C/CE
Execution: |*R* exec|*C* exec|

RISE TIME $t_r = 2.2\, CR$

Program: B/E |enter|var|×|“|2|2|”|×|“|1|0|”|÷|var| [14] C/CE
Execution: |*C* exec|*R* exec|

NEGATIVE FEEDBACK

SERIES VOLTAGE FEEDBACK $A_F = \dfrac{A_{0L}}{1 + \beta A_{0L}}$

Program: B/E |sto|enter|var|×|‘|1|’|+|÷|rcl|×|var| [12] C/CE

Execution: |A_{0L} exec|β exec|

THERMAL NOISE

$E_n = \sqrt{4k\ TBR} \quad = \quad \sqrt{1176\, kBR}$ *at Room Temperature*

Program: B/E |enter|var|×|var|×|‘|1|1|7|6|’|×|$\sqrt{x}$|var| [14] C/CE

Execution: |k exec|B exec|R exec|

$I_n \quad = \sqrt{1176\, kB/R}$ *at Room temperature*

Program: B/E |enter|var|×|var|÷|‘|1|1|7|6|’|×|$\sqrt{x}$|var| [14] C/CE

Execution: |k exec|B exec|R exec|

OPTIMUM SOURCE IMPEDANCE FOR MINIMUM TRANSISTOR NOISE

$$Ropt. = \sqrt{(r_b + r_e)2\beta r_e + (r_b + r_e)^2}$$

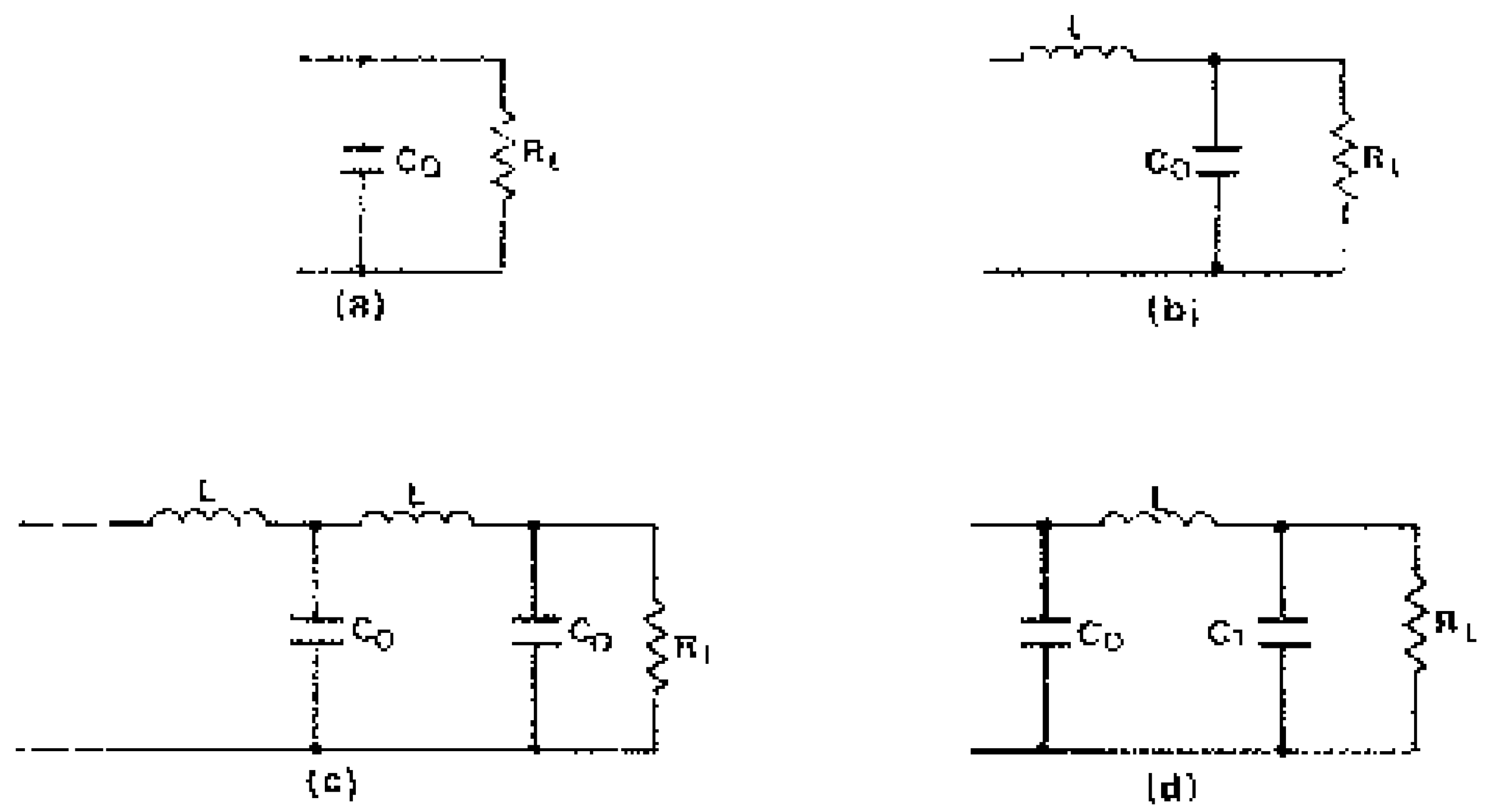
Program: B/E |sto|enter|var|+|x–m|enter|‘|2|’|×|var|×|rcl|×|
|x–m|enter|×|rcl|+|$\sqrt{x}$|var| [21] C/CE

Execution: |r_e exec|r_b exec|β exec|

SHOT NOISE IN A TEMPERATURE LIMITED DIODE $In = \sqrt{2eIB}$

Program: B/E |enter|var|×|var|×|‘|2|’|×|$\sqrt{x}$|var| [11] C/CE

Execution: |e exec|I exec|B exec|



a) $\alpha_1 = \dfrac{1}{\sqrt{2}\,\pi f C_0 R_L}$

Program: B/E |enter|var|×|var|×|sto|enter|❛|4|5|4|❜|×|❛|2|3|❜|÷|√x|rcl|×|÷|var| [23] C/CE

Execution: |*f* exec|C_0 exec|R_L exec|

b) $\alpha_2 = \dfrac{1}{w^2 LC_0 - 1}$

Program: B/E |enter|×|var|×|var|×|❛|1|❜|−|÷|var| [12]

Execution: |*w* exec|*L* exec|C_0 exec|

c) $\alpha_2 = \dfrac{1}{(w^2\, LC_o - 1)^n}$

Program: B/E |enter|×|var|×|var|×|❛|1|❜|−|÷|log|var|×|antilog|var| [16] C/CE

Execution: |*w* exec|*L* exec|C_0 exec|*n* exec|

d) $\alpha_3 = \alpha_1 . \alpha_2$

CRITICAL FILTER INDUCTANCE $LC = \dfrac{R_L(\sqrt{2}k - 1)}{w}$

k = rectifier voltage conversion factor (normally 1.11)

Program: B/E |enter|×|❛|2|❜|×|√x|❛|1|❜|−|var|×|var|÷|var| [16] C/CE

Execution: |*k* exec|R_L exec|*w* exec|

TRANSMISSION LINES

LINE EQUATIONS

$$\frac{d^2V}{dx^2} = ZYV$$

$$\frac{d^2I}{dx^2} = ZYI$$

Z = line impedance per unit length
Y = parallel admittance per unit length
V = line volts
I = line current

CHARACTERISTIC IMPEDANCE $Z_0 = \sqrt{\frac{Z}{Y}}$

Program: B/E |enter|var|÷|$\sqrt{x}$|var| [5] C/CE

Execution: |Z exec| Y exec|

CHARACTERISTIC ADMITTANCE $Y_0 = \frac{1}{Z_0} = \frac{1}{\sqrt{Z/Y}}$

Program: B/E |enter|var|÷|$\sqrt{x}$|÷|var| [6]

Execution: |Z exec| Y exec|

COMPLEX PROPAGATION CONSTANT $\gamma = \sqrt{ZY}$

Program: B/E |enter|var|×|$\sqrt{x}$|var| [5] C/CE

Execution: |Z exec| Y exec|

LOSSLESS LINE $Z_0 = \sqrt{L/C}$

Program: B/E |enter|var|÷|√x|var| [5] C/CE

Execution: |L exec|C exec|

PHASE VELOCITY

$$= \frac{w}{\beta}$$

$$= \frac{1}{\sqrt{LC}}$$

Program: B/E |enter|var|×|√x|÷|var| [6] C/CE

Execution: |L exec|C exec|

REFLECTION COEFFICIENT

$$PL = \frac{Z_L - Z_O}{Z_L + Z_O}$$

Program: B/E |enter|var|sto|+|x–m|enter|‘|2|’|×|rcl|÷|‘|1|’|– –|V| [18] C/CE

Execution: |Z_L exec|Z_O exec|

AERIALS

POWER OUTPUT OF ISOTROPIC RADIATOR $P = \frac{E_{rms}^2}{120\pi}$

Program: B/E |enter| × |◀|4|2|6|0|0|▶| : |◀|1|1|3|▶| × |var| [17] C/CE

Execution: |E_{rms} exec|

RADIATION RESISTANCE OF HERTZIAN DIPOLE R $= 80\pi^2\left(\frac{le}{\lambda}\right)^2$

Program: B/E |enter|var| ÷ | × |◀|1|8|1|6|0|▶| × |◀|2|3|▶| : |var| [18] C/CE

Execution: |*le* exec|λ exec|

RADIATION RESISTANCE OF SHORT UNIPOLE ABOVE EARTH $R = 160\pi^2\left(\frac{he}{\lambda}\right)^2$

Program: B/E |enter|var| ÷ | × |◀|3|6|3|2|0|▶| × |◀|2|3|▶| : |var| [18] C/CE

Execution: |*he* exec|λ exec|

VARIATION OF FIELD FROM HALF WAVE DIPOLE WITH ANGLE

$$\frac{E_\theta}{E_o} = \frac{\cos(\pi/2 \cos\theta)}{\sin\theta}$$

Program: B/E |sto|sin|$x-m$|cos|◀|3|5|5|▶| × |◀|2|2|6|▶| ÷ |cos|rcl| ÷ |var| [20] C/CE

Execution: |θ exec|

VARIATION OF FIELD FROM RHOMBIC AERIAL WITH ANGLE

$$\frac{E_\theta}{E_o} = \frac{\sin\theta}{1-\cos\theta} \sin\left[\frac{\pi l}{\lambda}(1-\cos\theta)\right]$$

Program: B/E |sto|cos|◀|1|▶| − | − |$x-m$|sin|rcl| ÷ |$x-m$|enter|var| × |var| × |var| ÷ |sin|
|rcl| × |var| [23] C/CE

Execution: |θ exec|π exec|*l* exec|λ exec|

OUTPUT VOLTAGE OF LOOP AERIAL $\frac{Vrms}{E} = \frac{2\pi A N \cos\theta}{\lambda}$

Program: B/E |cos|var| × |var| × |var| ÷ |⁽|7|1|0|⁾| × |⁽|1|1|3|⁾| ÷ |var| [20] C/CE

Execution: |θ exec|A exec|N exec|λ exec|

COMMUNICATION THEORY

AMPLITUDE OF FREQUENCY TERMS CONTAINED IN PULSE WAVEFORM OF DUTY CYCLE $\frac{\tau}{T}$ *AND AMPLITUDE E*

$$a_n = 2E\tau/T \quad \frac{\sin n\pi\,\tau/T}{n\pi\,\tau/T}$$

Program: B/E |enter|⁽|3|5|5|⁾| × |⁽|1|1|3|⁾| : |sto|enter|var| × |sin|rcl| ÷ |var| × |var| [23] C/CE

Execution: |n exec|τ/T exec|$2 \times E$ exec|

CHANNEL CAPACITY OF PULSE CODE MODULATION SYSTEM

$C = B \log_2 (1 + S/N)$

Program: B/E |enter|⁽|1|⁾| + |log|⁽|3|3|2|2|⁾| × |⁽|1|0|0|0|⁾| ÷ |var| × |var| [23] C/CE

Execution: |S/N exec|B exec|

EXPONENTIAL WEIGHTING OF QUANTIZATION STEPS $y = k \log_e (1 + x)$

Program: B/E |enter|⁽|1|⁾| + |log|⁽|1|7|5|⁾| × |⁽|7|6|⁾| ÷ |var| × |var| [20] C/CE

Execution: |x exec|k exec|

RANGE DETERMINATION FOR PULSE RADAR SYSTEM

$$R = \left[\frac{Pe\,\sigma\,Ar}{16\pi^2\,Pr}\right]^{\frac{1}{4}}$$

Pe = effective radiated power
Pr = power received back
σ = surface area of object
Ar = surface area of aerial

Program: B/E |enter|var| × |var| × |var| ÷ |⁽|3|6|3|2|⁾| ÷ |⁽|2|3|⁾| × |√x|√x|var| [22] C/CE

Execution: |Pe exec|σ exec|Ar exec|Pr exec|

FREQUENCY TO ANGULAR VELOCITY

$w = 2\pi f$

Program: B/E |enter|“|7|1|0|”| × |“|1|1|3|”| ÷ |var| [14] C/CE

Execution: |*f* exec|

ANGULAR VELOCITY TO FREQUENCY

$$f = \frac{w}{2\pi}$$

Program: B/E |enter|“|7|1|0|”| ÷ |“|1|1|3|”| × |var| [14] C/CE

Execution: |*w* exec|

CHARACTERISTIC IMPEDANCES

SINGLE LINE ABOVE EARTH PLANE $Z_o = 138 \log \frac{2h}{r}$

Program: B/E |enter|“|2|”| × |var| ÷ |log|“|1|3|8|”| × |var| [15] C/CE

Execution: |*h* exec|*r* exec|

BALANCED 2 WIRE LINE SEPERATION s $Z_o = 276 \log \frac{s}{r}$

Program: B/E |enter|var| ÷ |log|“|2|7|6|”| × |var| [11] C/CE

Execution: |*s* exec|*r* exec|

SKIN EFFECT

RATIO OF AC TO DC RESISTANCE OF SOLID CYLINDRICAL WIRE

$$x = \sqrt{\frac{8\pi\mu f}{R \times 10^9}} = 1.585 \times 10^{-4} \sqrt{\frac{\mu f}{R}} \qquad R = DC \text{ resistance of } 1\,cm \text{ of wire}$$

Program: B/E |enter|var| × |var| ÷ |$\sqrt{x}$|sto|enter|“|7|”|enter| − |antilog|“|1|5|8|5|”| × |rcl|
|× |var| [24] C/CE

Execution: |*u* exec|*f* exec|*R* exec|

MAGNITUDE AND PHASE ANGLE OF IMPEDANCE

$$z = R + iX$$

$$|z| = \sqrt{R^2 + X^2} \text{ (i)} \qquad \phi = \arctan\left(\frac{X}{R}\right) \text{ (ii)}$$

Program: B/E |enter| × |sto|enter|var|enter| × |rcl| + |√x|var| [11] C/CE

Execution: |*R* exec|*X* exec| (i)

Program: B/E |enter|var| ÷ |arctan|var| [5] C/CE

Execution: |*X* exec|*R* exec| (ii)

SERIES RESONANT CIRCUIT

$$RESONANT\ \ FREQUENCY = \frac{1}{2\pi\sqrt{LC}}$$

Program: B/E |enter|var| × |√x|❛|7|1|0|❜| × |❛|1|1|3|❜| ÷ | ÷ |var| [18] C/CE

$$IMPEDANCE\ |z| = \sqrt{R^2 + (wL - 1/wc)^2} \qquad phase\ angle\ \phi = \arctan\frac{wL - 1/wc}{R}$$

$$To\ form\ \left(wL - \frac{1}{wC}\right)$$

Program: B/E |❛|7|1|0|❜| × |❛|1|1|3|❜| ÷ |sto|enter|var| × | ÷ |*x-m*|enter|var| × |rcl| − |var| [24] C/CE

Execution: |*f* enter exec|*C* exec|*L* exec|

$$Q = \frac{2\pi f L}{R}$$

Program: B/E |enter|var| × |var| ÷ |❛|7|1|0|❜| × |❛|1|1|3|❜| ÷ |var| [18] C/CE

Execution: |*f* exec|*L* exec|*R* exec|

ELECTROSTATICS

FIELD STRENGTH DUE TO POINT CHARGE $E = \frac{q}{4\pi\varepsilon r^2}$

Program: B/E |enter| × |÷|var| × |var|÷|‘|1|4|2|0|’|÷|‘|1|1|3|’| × |var| [21] C/CE

Execution: |r exec|q exec|ε exec|

SELF POTENTIAL OF CHARGED SPHERE RADIUS $V = \frac{q}{4\pi\varepsilon a}$

Program: B/E |enter|var|÷|var|÷|‘|1|4|2|0|’|÷|‘|1|1|3|’| × |var| [19] C/CE

Execution: |q exec|a exec|ε exec|

POTENTIAL OF CHARGED CYLINDER RADIUS $V = \frac{-q}{2\pi\varepsilon} ln \left(\frac{a}{z}\right)$

z = distance to ground point

Program: B/E |enter|var|÷|log|−|var| × |var|÷|‘|9|9|’| × |‘|2|7|0|’|÷|var| [21] C/CE

Execution: |a exec|z exec|q exec|ε exec|

CAPACITANCE C.G.S. UNITS

PARALLEL PLATE CAPACITOR $C = .08842\, k\frac{A}{d}\, pF$ $\qquad k$ = dialectric constant

Program: B/E |enter|var| × |var|÷|sto|enter|‘|5|’|enter|−|antilog|‘|8|8|4|2|’| × |rcl| × |var|
[23] C/CE

Execution: |k exec|A exec|d exec|

LONG PARALLEL STRIPS $\qquad C = \frac{0.121}{\log_{10} 4d/w}\, pF/cm$ $\qquad$ seperation d much greater than width w

Program: B/E |enter|var|÷|‘|4|’| × |log|÷|‘|1|2|1|’| × |‘|1|0|0|0|’|÷|var| [23] C/CE

Execution: |d exec|w exec|

CONCENTRIC SPHERES $C = 0.556 \dfrac{d_1 d_2 k}{d_2 - d_1}$ *Pfs*

d_1 = outer diam. of inside sphere
d_2 = inner diam. of outside sphere

Program: B/E |sto|enter|var|÷|❛|1|❜|−|÷|rcl|×|var|×|var| [14] C/CE

Execution: |d_2 exec|d_1 exec|k × 0.556 exec|

INDUCTANCE C.G.S. UNITS

LOW FREQUENCY INDUCTANCE OF CONCENTRIC CABLE

$L = 0.383 \log_{10} r_2/r_1 + 0.041\ pH/\text{metre}$

Program: B/E |enter|var|÷|log|❛|3|8|3|❜|×|❛|4|1|❜|+|❛|1|0|0|0|❜|÷|var| [23] C/CE

Execution: |r_2 exec|r_1 exec|

INDUCTANCE OF A VERY LONG THIN COIL $L = 0.01256\, n^2 \dfrac{A}{l}\ pH$

Program: B/E |enter|×|sto|enter|❛|5|❜|enter|−|antilog|❛|1|2|5|6|❜|×|var|×|var|÷|rcl|×|var|
[24]C/CE

Execution: |n exec|A exec|l exec|

H.F. INDUCTANCE OF STRAIGHT ROUND WIRE OF NON MAGNETIC MATERIAL

$$L = .002\left(2.3 \log \frac{4l}{d} - 1\right) pH/\text{metre}$$

Program: B/E |❛|4|❜|×|var|÷|log|❛|4|6|❜|×|❛|2|0|❜|−|❛|1|0|0|❜|÷|var| [24] C/CE

Execution: |l enter exec|d exec|

INDUCTANCE OF SINGLE LAYER SOLENOID $L \sim \dfrac{0.395\, r^2 n^2}{9r + 10l}$

Program: B/E |enter|❛|9|❜|×|sto|enter|var|enter|❛|1|0|❜|×|rcl|+|x–m|enter|var|×|×|
|rcl|÷|var| [24] C/CE

Execution: |r exec|l exec|n × .0698 exec|

MAGNETOSTATICS (Rationalized units)

TURNING MOMENT ON COIL OF AREA A CARRYING CURRENT I

$T = BIA\sin\theta$

Program: B/E |sin|var| × |var| × |var| × |var| [8] C/CE

Execution: |θ exec|B exec|I exec|A exec|

MAGNETIC POTENTIAL AT DISTANCE R ANGLE θ FROM CURRENT LOOP

$$M = \frac{IA\cos\theta}{4\pi r^2}$$

Program: B/E |cos|var| × |var| × |sto|enter|var|enter| × |÷|rcl| × |◀|7|▶| × |◀|8|8|▶| ÷ |var| [23] C/CE

Execution: |θ exec|A exec|I exec|r exec|

INCREMENTAL ELEMENT OF FIELD DUE TO INCREMENTAL LENGTH OF CURRENT CARRYING CONDUCTOR

$$\delta H = \frac{I\delta l\sin\theta}{4\pi r^2}$$

Program: B/E |sin|var| × |var| × |sto|enter|var| × |enter| × |÷|rcl| × |◀|7|▶| × |◀|8|8|▶| ÷ |var| [23] C/CE

Execution: |θ exec|I exec|δl exec|r exec|

FIELD AT CENTRE SQUARE COIL SIDE L

$$H = \frac{2\sqrt{2}I}{\pi L}$$

Program: B/E |enter|var| ÷ | × |◀|1|8|4|▶| × |◀|2|2|7|▶| ÷ |$\sqrt{x}$|var| [18] C/CE

Execution: |I exec|L exec|

FIELD AT POINT ON AXIS OF CIRCULAR COIL SUBTENTING ANGLE α TO RIM

$$H = \frac{I}{2R}\sin^3\alpha$$

Program: B/E |sin|sto|rcl| × |rcl| × |var| × |var| ÷ |‘|2|’| ÷ |var| [15] C/CE

Execution: |α exec|*I* exec|*R* exec|

FIELD AN AXIS OF SINGLE LAYER SOLENOID SUBTENDING ANGLES α AND β TO EITHER END

$$H = \frac{IT}{2}(\cos\beta - \cos\alpha)$$

Program: B/E|cos|sto|enter|var|cos|rcl| − |var| × |var| × |‘|2|’| ÷ |var| [16] C/CE

Execution |α exec|β exec|*I* exec|*T* exec|

ELECTRIC FLUX REFRACTION

$$\theta_1 = \arctan\left[\tan\theta_2 \times \frac{\varepsilon_1}{\varepsilon_2}\right]$$

Program: B/E |sto|cos|*x*–*m*|sin|rcl| ÷ |var| × |var| ÷ |arctan|var| [12] C/CE

Execution: |θ_2 exec|ε_1 exec|ε_2 exec|

ELECTRON DYNAMICS

CORRECTED VELOCITY OF AN ELECTRON CORRESPONDING TO A POTENTIAL E

$$\frac{m}{me} = 1 + 1.94 \times 10^{-6}E$$

Program: B/E |sto|enter|❛|8|❜|enter|−|antilog|❛|1|9|4|❜|×|rcl|×|❛|1|❜|+|var| [21] C/CE

Execution: |E exec|

CORRECT VELOCITY OF AN ELECTRON CORRESPONDING TO A POTENTIAL E

$$\frac{v_e}{c} = \sqrt{1-(1 + 1.94 \times 10^{-6}E)^{-2}}$$

Program: B/E |enter|−|antilog|❛|1|9|4|❜|×|var|×|❛|1|❜|+|÷|×|❛|1|❜|−|−|√x|var| [24] C/CE

Execution: |8 exec|E exec|

VELOCITY OF AN ION CORRESPONDING TO A POTENTIAL E

$$v = 5{\cdot}97 \times 10^7 \sqrt{\frac{En}{m/me}}$$

$$m/m_e = \frac{\text{mass}}{\text{electron mass}}$$

$$n = \frac{charge}{\text{electron charge}}$$

Program: B/E |enter|var|×|var|÷|√x|sto|enter|❛|5|❜|enter|antilog|❛|5|9|7|❜|×|rcl|×|var| [22] C/CE

Execution: |E exec|n exec|m/m_e exec|

RADIUS OF CIRCULAR PATH $r = \frac{3.37\sqrt{E}}{B}$

Program: B/E |enter|$\sqrt{x}$|var| ÷ |❛|3|3|7|❜| × |❛|1|0|0|❜| ÷ |var| [17] C/CE

Execution: |*E* exec|*B* exec|

PERIOD $T = \frac{0.355 \times 10^{-6}}{B}$

Program: B/E |sto|enter|❛|9|❜|enter| − |antilog|❛|3|5|5|❜| × |rcl| ÷ |var| [17] C/CE

Execution: |*B* exec|

RADIUS OF HELICAL PATH $r = \frac{3.37\sqrt{E}\sin\theta}{B}$

Program: B/E |$\sqrt{x}$|var| ÷ |sto|enter|var|enter|sin|rcl| × |❛|3|3|7|❜| × |❛|1|0|0|❜| ÷ |var| [23] C/CE

Execution: |*E* exec|*B* exec|*θ* exec|

PITCH OF HELICAL PATH $p = \frac{21.2\sqrt{E}\cos\theta}{B}$

Program: B/E |$\sqrt{x}$|var| ÷ |sto|enter|var|enter|cos|rcl| × |❛|2|1|2|❜| × |❛|1|0|❜| ÷ |var| [22] C/CE

Execution: |*E* exec|*B* exec|*θ* exec|

DC MACHINES

Notation				
	ϕ	effective flux/pole	p	number of poles
	z	number of conductors	a	parallel paths through armature
	n	speed, rev/s	i_a	armature current

E.M.F., $E. = \phi\, z . n \dfrac{p}{a}$

Program: B/E |enter|var| × |var| × |var| × |var| ÷ |var| [10] C/CE

Execution: |ϕ exec|z exec|n exec|p exec|a exec|

GROSS TORQUE $= \dfrac{Ei_a}{2\pi n}$

Program: B/E |enter|var| × |var| ÷ |‘|1|1|3|’| × |‘|7|1|0|’| ÷ |var| [18] C/CE

Execution: |E exec|i_a exec|n exec|

ARMATURE REACTION $= \dfrac{zi_a}{2pa}$ *ampere turns/pole*

Program: B/E |enter|var| × |‘|2|’| ÷ |var| ÷ |var| ÷ |var| [12] C/CE

Execution: |z exec|i_a exec|p exec|a exec|

INDUCTION MOTORS

SYNCHRONOUS SPEED $= \dfrac{f_s}{p}$

f_s = supply frequency
p = number of pairs of poles

SLIP $= \dfrac{n_1 - n_2}{n_1} = S$

n_2 = rotor speed
n_1 = synch. speed

Program: B/E |enter|sto| + |var| − |rcl| ÷ |var| [8] C/CE

Execution: |n_1 exec|n_2 exec|

ROTOR FREQUENCY $= (n_1 - n_2)p$

Program: B/E |enter|var|−|var|×|var| [6] C/CE

Execution: |n_1 exec|n_2 exec|p exec|

ROTOR CURRENT/PHASE $= \dfrac{SE_2}{\sqrt{R_2^2 + S^2X_2^2}}$

Program: B/E |enter|×|sto|÷|var|enter|var|×|×|rcl|+|$\sqrt{x}$|var|÷|var|÷|÷|var| [18] C/CE

Execution: |R_2 exec|X_2 exec|S exec|S exec|E_2 exec|

R_2 = rotor resistance/phase
X_2 = rotor equivalent reactance per phase at standstill.
E_2 = induced emf. per phase at standstill.

TRANSFORMERS

$$E_2 = E_1 \frac{n_2}{n_1} \quad \text{(i)}$$

$$I_2 = I_1 \frac{n_1}{n_2} \quad \text{(ii)}$$

$_1$ = primary
$_2$ = secondary
E = emf.
I = current
n = turns

Program: B/E |enter|var|×|var|÷|var| [6] C/CE

Execution: |E_1 exec|n_2 exec|n_1 exec| (i)
|I_1 exec|n_1 exec|n_2 exec| (ii)

POWER FACTOR

Power $= VI\cos\phi$ single phase (i)
$= \sqrt{3}\ VI\cos\phi$ per phase, 3 phase (ii)

Program: (i) B/E |enter|cos|var|×|var|×|var| [7] C/CE
(ii) B/E |enter|cos|var|×|var|×|sto|+|❛|3|❜|enter|$\sqrt{x}$|rcl|×|var| [16] C/CE

Execution: (i) |ϕ exec|V exec|I exec|
(ii) |ϕ exec|V exec|I exec|

PARALLELOGRAM LAW FOR FORCES

$R = \sqrt{P^2 + Q^2 + 2PQ\cos\alpha}$

Program: B/E | cos | (| 2 |) | x | var | sto | x | var | x | x - m | enter | x | rcl | + | sto | enter | var | enter | X | rcl | + | $\sqrt{x}$ | var | [24] C/CE

Execution: | α exec | P exec | Q exec | Q exec |

FOR $\alpha = 90°$

$R = \sqrt{P^2 + Q^2}$

Program: B/E | enter | × | sto | + | var | enter | × | rcl | + | $\sqrt{x}$ | var | [11] C/CE

Execution: | P exec | Q exec |

STATICS IN 3 DIMENSIONS

$R = \sqrt{R_x^2 + R_y^2 + R_z^2}$

Program: B/E | enter | × | sto | + | var | enter | × | rcl | + | sto | + | var | enter | × | rcl | + | $\sqrt{x}$ | var | [18] C/CE

Execution: | Rx exec | Ry exec | Rz exec |

DYNAMICS

$$RADIUS\ OF\ CURVATURE = \frac{\left(1 + \left(\frac{\partial y}{\partial x}\right)^2\right)^{3/2}}{\frac{\partial^2 y}{\partial x^2}}$$

Program: B/E | enter | × | (| 1 |) | + | log | (| 3 |) | × | (| 2 |) | ÷ | antilog | var | ÷ | var | [19] C/CE

Execution: | $\frac{dy}{dx}$ exec | $\frac{d^2y}{dx^2}$ exec |

RELATAVISTIC EFFECTS

MASS CHANGE $m = \dfrac{m_0}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$

m = mass
m_0 = rest mass
v = velocity
c = velocity of light

Program: B/E |enter|var|÷|×|−|(|1|)|+|$\sqrt{x}$|sto|+|var|enter|rcl|÷|var| [17] C/CE

Execution: |v exec|c exec|m_0 exec|

EQUIVALENT OF MASS—ENERGY

$E = mc^2$

Program: B/E |enter|×|var|×|var| [5] C/CE

Execution: |c exec|m exec|

FREQUENCY, ANGULAR VELOCITY, WAVELENGTH

$f = \dfrac{w}{2\pi}$

f = frequency Hz
w = angular velocity rad/s

Program: B/E |enter|(|1|1|3|)|×|(|7|1|0|)|÷|var| [14] C/CE

Execution: |w exec|

$f = \dfrac{c}{\lambda}$

c = velocity light
λ = wavelength

Program: B/E |enter|var|÷|var| [4] C/CE

Execution: |c exec|λ exec|

FORCES IN COORDINATE SYSTEMS

RECTANGULAR CARTESIAN COORDINATES

$F_x = m\ddot{x}$ (i)

$F_y = m\ddot{y}$ (ii)

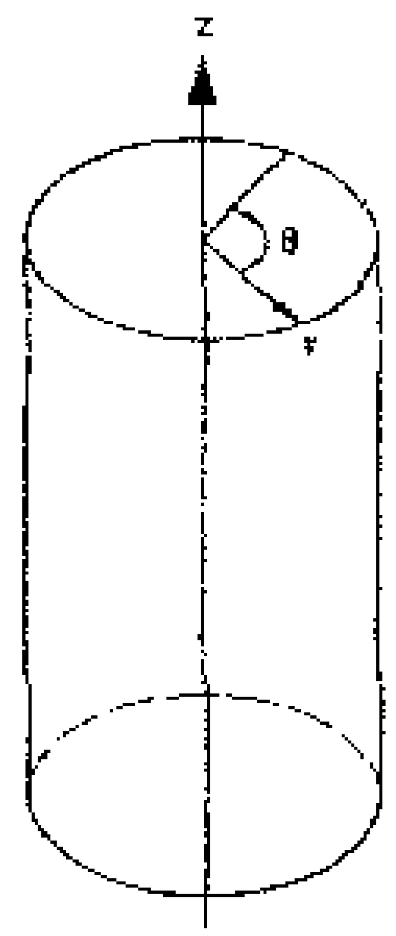
$F_z = m\ddot{z}$ (iii)

Program: B/E |enter|var|×|var| [4] C/CE

Execution: (i) |m exec|$\ddot{x}$ exec|

(ii) |m exec|$\ddot{y}$ exec|

(iii) |m exec|$\ddot{z}$ exec|



CYLINDRICAL COORDINATES

(i) $F_r = m(\ddot{r} - r\dot{\theta}^2)$

(ii) $F_\theta = m(r\ddot{\theta} + 2\dot{r}\dot{\theta})$

(iii) $F_z = m\ddot{z}$

(i) Program: B/E |enter|×|var|×|−|var|+|var|×|var| [10] C/CE

Execution: |$\dot{\theta}$ exec|r exec|$\ddot{r}$ exec|m exec|

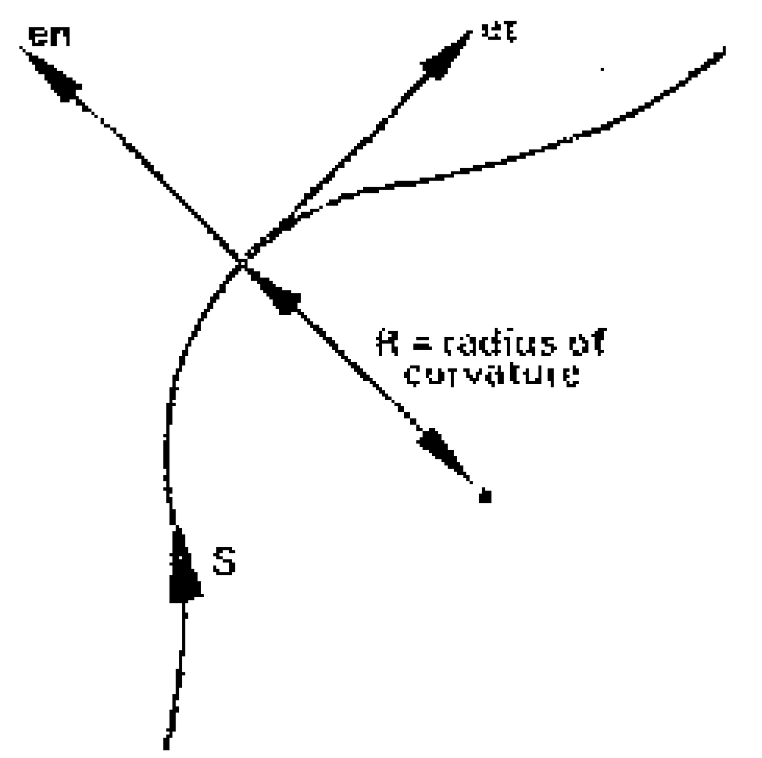
(ii) Program: B/E |enter|var|×|sto|+|var|enter|var|×|^6|2|^9|×|rcl|+|var|×|var| [18] C/CE

Execution: |r exec|$\ddot{\theta}$ exec|$\dot{r}$ exec|$\dot{\theta}$ exec|m exec|

(iii) Program: B/E |enter|var|×|var| [4] C/CE

Execution: |m exec|$\ddot{z}$ exec|

TANGENTIAL AND NORMAL COMPONENTS



$$F_n = \frac{-m\dot{s}^2}{R}$$

Program: B/E |enter| × |var| × |var| ÷ | − |var| [8] C/CE

Execution: |$\dot{s}$ exec|m exec|R exec|

$$F_t = m\ddot{s}$$

Program: B/E |enter|var| × |var| [4] C/CE

Execution: |m exec|$\ddot{s}$ exec|

SCALAR PRODUCT

$$(a.\,b) = (a_1 i + a_2 j + a_3 k).\,(b_1 i + b_2 j + b_3 k)$$
$$= a_1 b_1 + a_2 b_2 + a_3 b_3$$

Program: B/E |enter|var| × |sto| + |var|enter|var| × |rcl| + |sto| + |var|enter|var| × |rcl| + |var| [20] C/CE

Execution: |a_1 exec|b_1 exec|a_2 exec|b_2 exec|a_3 exec|b_3 exec|

ENERGY IN A GRAVITATIONAL FIELD

KINETIC ENERGY $= \frac{1}{2} m v^2$

Program: B/E |enter| × |var| × |‘|2|’| ÷ |var| [9] C/CE

Execution: |v exec|m exec|

POTENTIAL ENERGY $= mgh$

Program: B/E |enter|var| × |‘|9|8|1|’| × |‘|1|0|0|’| ÷ |var| [16] C/CE

Execution: |m exec|h exec|

MOTION DUE TO VARIOUS FORCE FIELDS

SIMPLE HARMONIC MOTION—SIMPLE PENDULUM SPRING/MASS

Period $T = 2\pi\sqrt{\frac{l}{g}}$ (i)

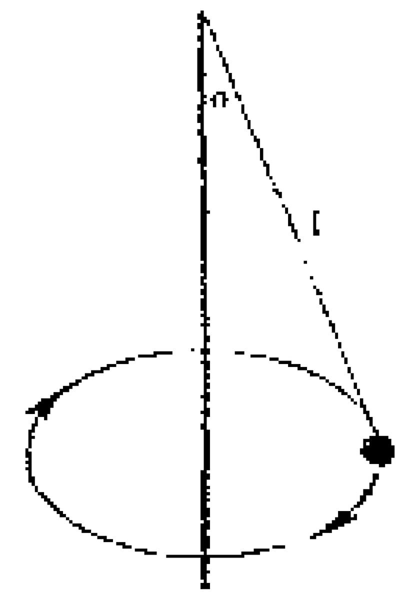
$T = 2\pi\sqrt{\frac{m}{k}}$ (ii)

Program: B/E |enter|var|÷|√x|⁽|7|1|0|⁾|×|⁽|1|1|3|⁾|÷|var| [17] C/CE

Execution: (i) |l exec|9.81 exec|

(ii) |m exec|k exec|

CONICAL PENDULUM

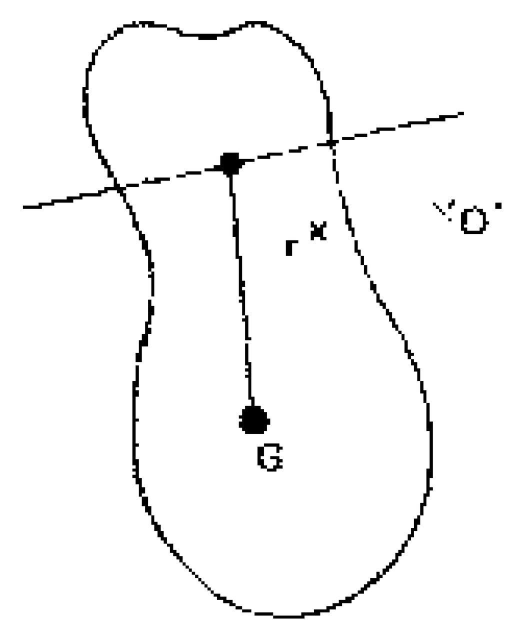


$T = 2\pi\sqrt{\frac{l\cos\alpha}{g}}$

Program: B/E |enter|cos|var|×|var|÷|√x|⁽|7|1|0|⁾|×|⁽|1|1|3|⁾|÷|var| [20] C/CE

Execution: |α exec|l exec|9.81 exec|

COMPOUND PENDULUM



$T = \frac{2\pi k_0}{\sqrt{gr^*}}$

k_0 = Radius of gyration about 0

r^* = dist. from 0 to centre of gravity

g = acceleration due to gravity

Program: B/E |enter|var|×|√x|var|÷|÷|⁽|7|1|0|⁾|×|⁽|1|1|3|⁾|÷|var| [20] C/CE

Execution: |r exec|9.81 exec|k_0 exec|

EQUIVALENT LENGTH OF SIMPLE PENDULUM OF SAME PERIOD AS ABOVE

$l = \frac{k_0^2}{r^*}$

Program: B/E |enter|×|var|÷|var| [5] C/CE

Execution: |k_0 exec|r^* exec|

MOMENTS OF INERTIA THEOREMS

PARALLEL AXES THEOREM

$I_A = I_{CG} + mR^2$

CG = centre gravity

R = dist. from A to CG

Program: B/E |enter| × |var| × |var| + |var| [7] C/CE

Execution: |R exec|m exec|I_{CG} exec|

PERPENDICULAR AXES THEOREM

$I_{0x} = I_{0y} + I_{0z}$

Program: B/E |enter|var| + |var| [4] C/CE

Execution: |I_{0y} exec|I_{0z} exec|

MOMENT OF INERTIA $= mk^2$

m = mass

k = radius of gyration

Program: B/E |enter| × |var| × |var| [5] C/CE

Execution: |k exec|m exec|

WORK EQUATION

$w = \frac{1}{2} Ig\, w^2 + \frac{1}{2} M v^2$

Ig = moment of inertia about CG

w = angular velocity

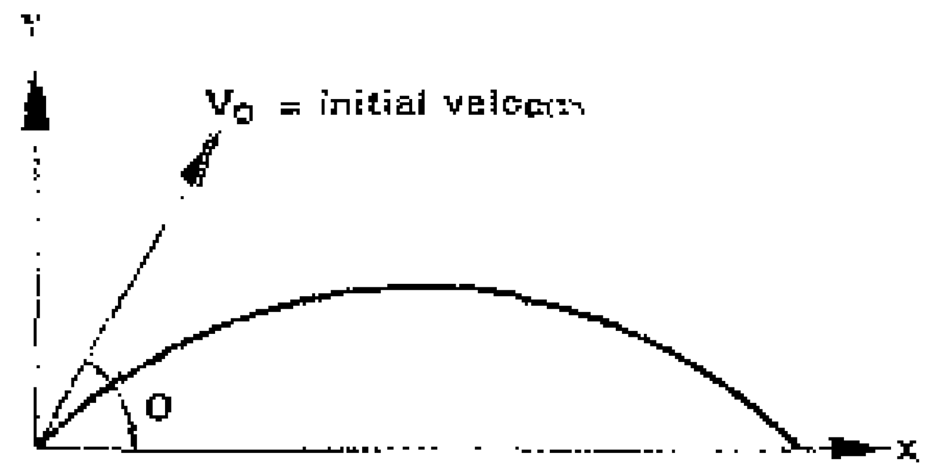
M = mass

v = velocity

Program: B/E |enter| × |var| × |(|2|)| ÷ |sto| + |var|enter| × |var| × |(|2|)| ÷ |rcl| + |var| [22] C/CE

Execution: |w exec|Ig exec|$v$exec|M exec|

PROJECTILE MOTION



$x = v_0 \cos\theta\, t$

Program: B/E |enter|cos|var|×|var|×|var| [7] C/CE

Execution: |θ exec|v_0 exec|t exec|

$v_x = \frac{dx}{dt} = v_o \cos\theta = \text{constant}$ v_x = *velocity in x–direction*

Program: B/E |enter|cos|var|×|var| [5] C/CE

Execution: |θ exec|v_0 exec|

$y = -\frac{1}{2}g\,t^2 + v_0 \sin\theta t$

Program: B/E |enter|sto|+|var|enter|sin|var|×|rcl|×|x–m|+|×|"2"|÷|–|var|×|rcl|+|var| [23] C/CE

Execution: |t exec|θexec|v_0 exec|g exec|

$v_y = \frac{dy}{dt} = v_o \sin\theta - gt$

Program: B/E |enter|sin|var|×|sto|+|var|enter|var|×|–|rcl|+|var| [14] C/CE

Execution: |θ exec|v_0 exec|t exec|g exec|

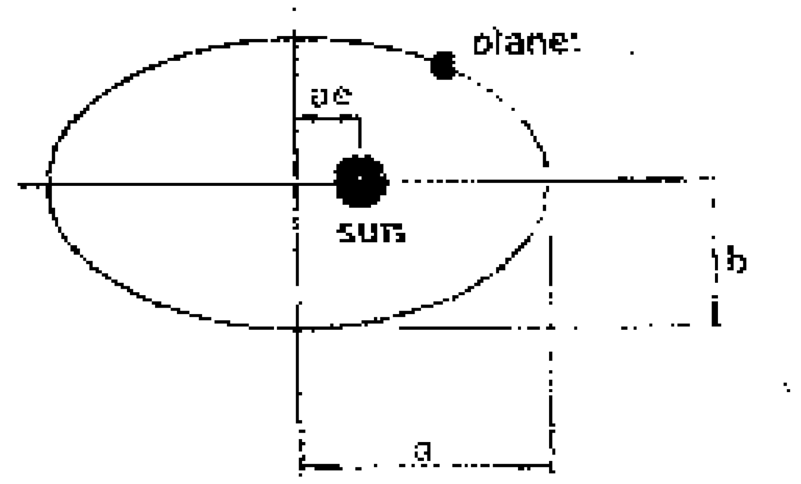
$y = -\frac{1}{2}g\left(\frac{x}{v_o\cos\theta}\right)^2 + x\tan\theta$

Program: B/E |enter|sto|cos|x–m|sin|rcl|÷|var|×|x–m|+|var|×|var|÷|÷|×|var|×|–|rcl|+|var| [23] C/CE

Execution: |θ exec|x exec|v_0 exec|x exec|$g/2$ exec|

PLANETARY MOTION

KEPLERS 1st LAW—orbit is an ellipse with sun at one of the foci



$$r = \frac{p}{1+e\cos\theta} = \frac{b\sqrt{1-e^2}}{1+e\cos\theta} \quad (i)$$

$$= \frac{b^2}{a(1+e\cos\theta)} \quad (ii)$$

Program: (i) B/E |enter|sto|+|var|cos|rcl|×|❛|1|❜|+|$x-m$|+|×|−|var|+|$\sqrt{x}$|rcl|÷|var|×|var| [23] C/CE

Execution: |e exec|θ exec|1 exec|b exec|

Program: (ii) B/E |enter|cos|var|×|❛|1|❜|+|var|×|sto|+|var|enter|×|rcl|÷|var| [18] C/CE

Execution: |θ exec|e exec|a exec|b exec|

INVERSE SQUARE LAW—Newtons Law of Universal Gravitation

$$F_R = \text{Radial force} = -4\pi^2 \frac{a^3}{T^2}\frac{m}{r^2}$$

$$= \frac{Gm_1 m_2}{r^2}$$

Program: B/E |enter|var|×|var|×|sto|+|var|enter|×|rcl|÷|÷|var| [14] C/CE

Execution: |G exec|m_1 exec|m_2 exec|r exec|

ELECTRON DYNAMICS

VELOCITY OF AN ACCELERATED ELECTRON (or particle)

$$v = \sqrt{\frac{2e}{m}\left(V_A - V_C\right)}$$

e = charge

m = mass

A = anode

C = cathode

Program: B/E |enter|var|−|“|2|”|×|var|×|var|÷|$\sqrt{x}$|var| {13} C/CE

Execution: |V_A exec|V_C exec|e exec|m exec| ×

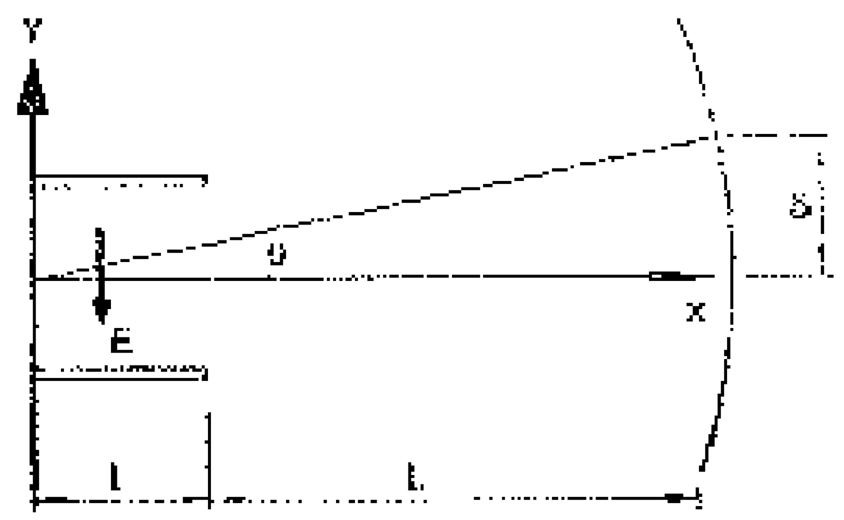
DEFLECTION IN A CATHODE RAY TUBE

$$\tan\theta = \frac{eEl}{mv^2}$$

e = charge

E = electric field

v = velocity in x – direction



Program: B/E |enter|×|var|×|sto|+|var|enter|var|×|var|×|rcl|÷|var| {15} C/CE

Execution: |v exec|m exec|e exec|E exec|l exec|

Deflection at screen $\delta = \frac{eEl}{mv^2}\left(\frac{l}{2} + L\right)$

Program: B/E |enter|×|÷|var|÷|var|×|var|×|var|×|sto|+|var|enter|“|2|”|÷|var|+|rcl|×|var| {24} C/CE

Execution: |v exec|m exec|e exec|E exec|l exec|l exec|L exec|

ESCAPE VELOCITY

$$v = \sqrt{\frac{2gR^2}{r_o}}$$

g = accn. due to gravity

R = planet radius

r_0 = orbit radius

Program: B/E |enter| × |var| ÷ |var| × |⁽|2|⁾| × |$\sqrt{x}$|var| [12] C/CE

Execution: |R exec|r_0 exec|g exec|

DOPPLER EFFECT

O = observer

S = source

f = frequency

f' = observed frequency

c = velocity of wave

v_0 = observer velocity

(i) $O \rightarrow S$

S stationary

$$f' = \left(\frac{c + v_o}{c}\right)f$$

Program: B/E |enter|var|÷|⁽|1|⁾|+|var|×|var| [10] C/CE

Execution: |v_0 exec|c exec|f exec|

(ii) O stationary

$S \rightarrow O$

$$f' = \left(\frac{c}{c - v_s}\right)f$$

v_s = source velocity

Program: B/E |enter|var|÷|−|⁽|1|⁾| + |÷|var|×|var| [12] C/CE

Execution: |v_s exec|c exec|f exec|

$O \rightarrow S$
$S \rightarrow O$

$$f' = \left(\frac{c + v_o}{c - v_s}\right)f$$

Program: B/E |enter|sto|+|var|−|$x-m$|+|var|+|rcl|÷|var|×|var| [14] C/CE

Execution: |c exec|v_s exec|v_o exec|f exec|

MIRRORS AND LENS $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$

f = focal length

u = object dist.

v = image dist.

$$f = \frac{1}{\frac{1}{u} + \frac{1}{v}}$$

Program: B/E |enter|÷|sto|+|var|enter|÷|rcl|+|÷|var| [11] C/CE

Execution: |u exec|v exec|

SUM OF 2 LENSES IN SERIES $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$

Program: B/E |enter|÷|sto|+|var|enter|÷|rcl|+|÷|var| [11] C/CE

Execution: |f_1 exec|f_2 exec|

VELOCITY OF SOUND

(i) in a solid $a_s = \sqrt{\frac{E}{p}}$

(ii) in a liquid $a_l = \sqrt{\frac{K}{p}}$

(iii) in a gas $a_g = \sqrt{\frac{\gamma P}{p}}$

(iv) $a_g = \sqrt{\gamma R T}$

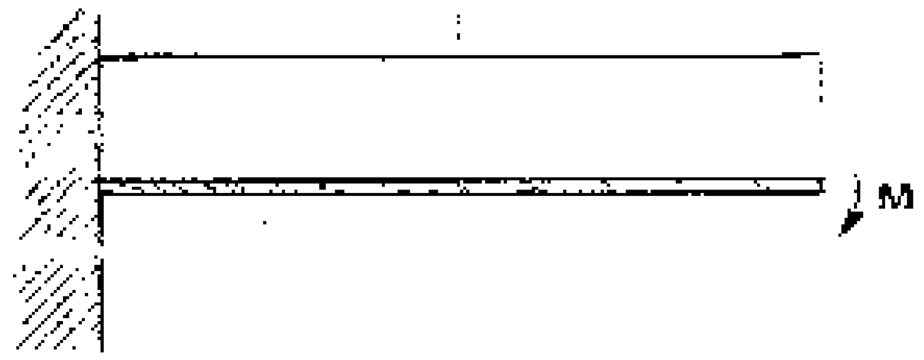
E = Youngs modulus
p = density
K = bulk modulus
γ = ratio specific heats
P = pressure
T = absolute temperature
R = universal gas constant

Program: (i) (ii) B/E |enter|var|÷|$\sqrt{x}$|var| [5] C/CE
Execution: (i) |E exec|p exec|
(ii) |K exec|p exec|

Program: (iii) B/E |enter|var|×|var|÷|$\sqrt{x}$|var| [7] C/CE
Execution: |γ exec|p exec|P exec|

Program: (iv) B/E |enter|var|×|var|×|$\sqrt{x}$|var| [7] C/CE
Execution: |γ exec|R exec|T exec|

BEAM DEFLECTION EQUATIONS—ELASTIC ANALYSIS



END SLOPE $= \dfrac{Ml}{EI}$

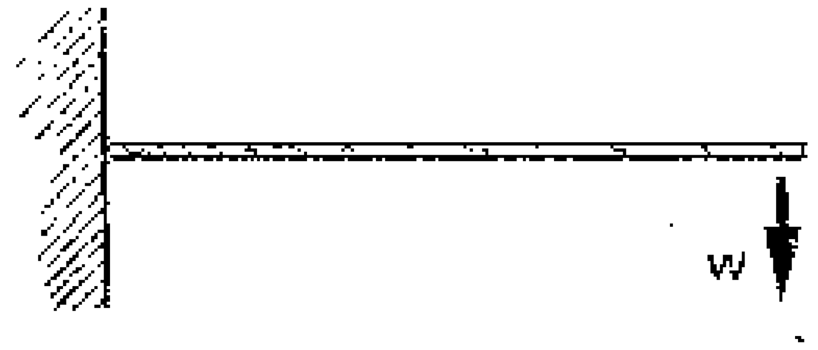
Program: B/E |enter|var|×|var|÷|var|÷|var| [8] C/CE

Execution: |*M* exec|*l* exec|*E* exec|*I* exec|

END DEFLECTION $= \dfrac{Ml^2}{2EI}$

Program: B/E |enter|×|var|×|var|÷|var|÷|(|2|)|÷|var| [13] C/CE

Execution: |*l* exec|*M* exec|*E* exec|*I* exec|



END SLOPE $= \dfrac{Wl^2}{2EI}$

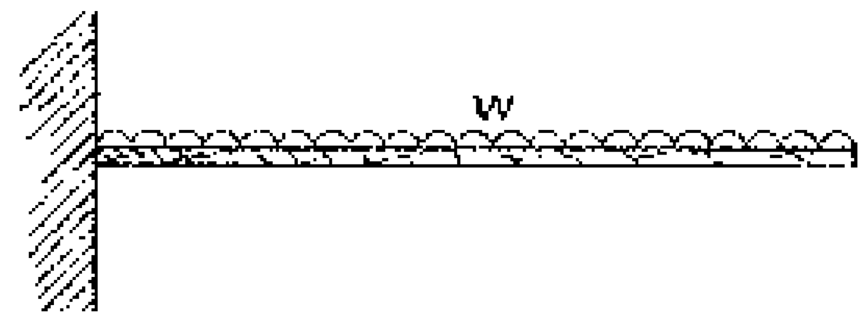
Program: B/E |enter|×|var|×|var|÷|var|÷|(|2|)|÷|var| [13] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec|

END DEFLECTION $= \dfrac{Wl^3}{3EI}$

Program: B/E |enter|sto|+|×|rcl|×|var|×|var|÷|var|÷|(|3|)|÷|var| [17] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec| [17] C/CE



END SLOPE $= \dfrac{Wl^2}{6EI}$

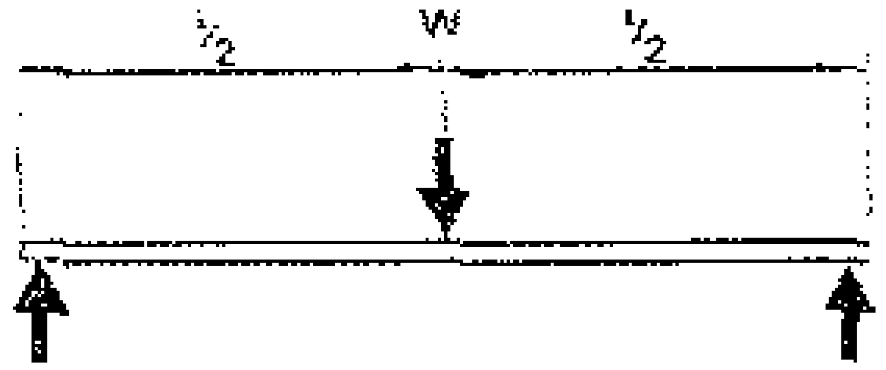
Program: B/E |enter|×|var|×|var|÷|var|÷|(|6|)|÷|var| [13] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec|

END DEFLECTION $= \dfrac{Wl^3}{8EI}$

Program: B/E |enter|sto|+|×|rcl|×|var|×|var|÷|var|÷|(|8|)|÷|var| [17] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec|



END SLOPE $= \dfrac{Wl^2}{16EI}$

Program: B/E |enter|×|var|×|var|÷|var|÷|(|1|6|)|÷|var| [14] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec|

CENTRAL DEFLECTION

$$\frac{Wl^3}{48EI}$$

Program: B/E |enter|sto|+|×|rcl|×|var|×|var|÷|var|÷|(|4|8|)|÷|var| [18] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec|

END SLOPE $= \dfrac{Wl^2}{24EI}$

Program: |enter|×|var|×|var|÷|var|÷|(|2|4|)|÷|var| [14] C/CE

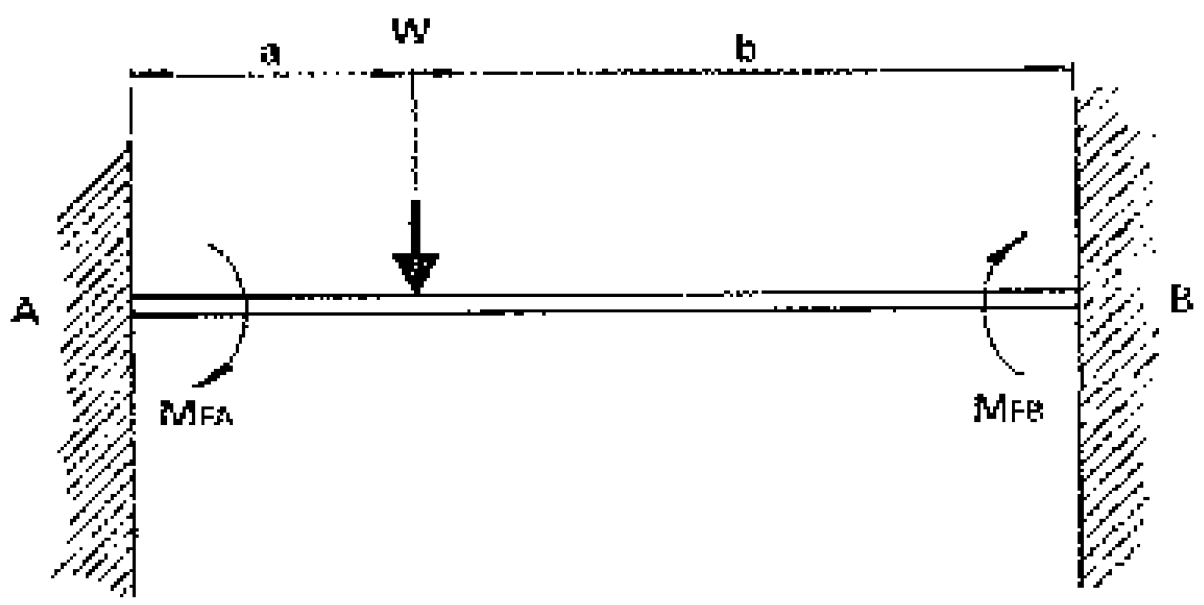
Execution: |*l* exec|*W* exec|*E* exec|*I* exec|

CENTRAL DEFLECTION $= \dfrac{5Wl^3}{384EI}$

Program: B/E |enter|sto|+|×|rcl|×|var|×|(|5|)|×|var|÷|var|÷|(|3|8|4|)|÷|var| [23] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec

FIXED END MOMENTS DUE TO LOAD *W*



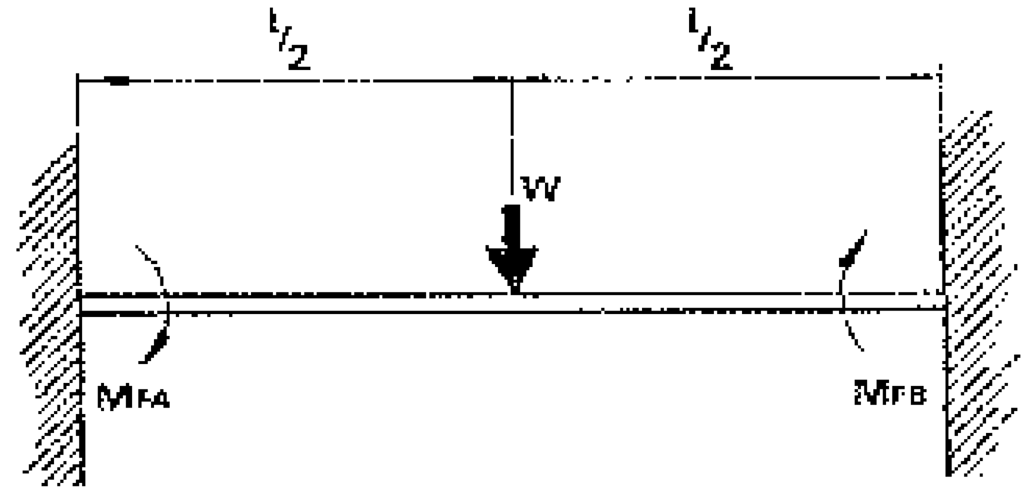
$$M_{FA} = -\frac{Wb^2a}{l^2} \qquad \text{(i)}$$

$$M_{FB} = \frac{Wa^2b}{l^2} \qquad \text{(ii)}$$

Program: B/E |enter| × |var| × |var| × |sto| + |var|enter| × |rcl| ÷ | ÷ |var| [15] C/CE

Execution: (i) |*b* exec| – *W* exec|*a* exec|*l* exec

Execution: (ii) |*a* exec| *W* exec|*b* exec|*l* exec|



$$M_{FA} = -\frac{Wl}{8} \qquad \text{(i)}$$

$$M_{FB} = +\frac{Wl}{8} \qquad \text{(ii)}$$

Program: B/E |enter|var| × |^{6}|8|^{9}| ÷ |var| [8] C/CE

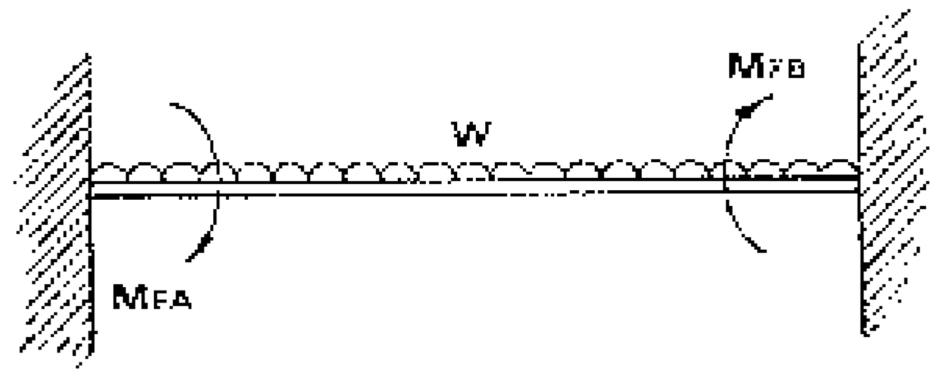
Execution: (i) | *W* exec| – *l* exec|

Execution: (ii) | *W* exec|*l* exec|

CENTRAL DEFLECTION — $Wl^3/192\,EI$

Program: B/E |enter|sto| + | × |rcl| × |var| × |^{6}|1|9|2|^{9}| ÷ |var| ÷ |var| ÷ |var| [19] C/CE

Execution: |*l* exec|*W* exec|*E* exec|*I* exec|



$$M_{FA} = -\frac{Wl}{12}$$

$$M_{FB} = +\frac{Wl}{12}$$

Program: B/E |enter|var| × |^{6}|1|2|^{9}| ÷ |var| [9] C/CE

Execution: (i) | *W* exec| – *l* exec|

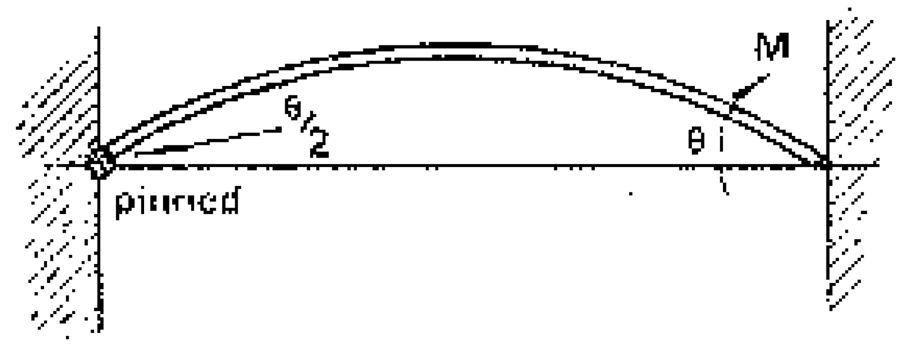
(ii) | *W* exec|*l* exec|

$$CENTRAL\ DEFLECTION = \frac{Wl^3}{384\ EI}$$

Program: B/E |enter|sto|+|×|rcl|×|var|×|var|÷|var|÷|[6]3|8|4|[9]|÷|var| [19] C/CE

Execution: |l exec|W exec|E exec|I exec|

EFFECT OF END ROTATION OR DISPLACEMENT

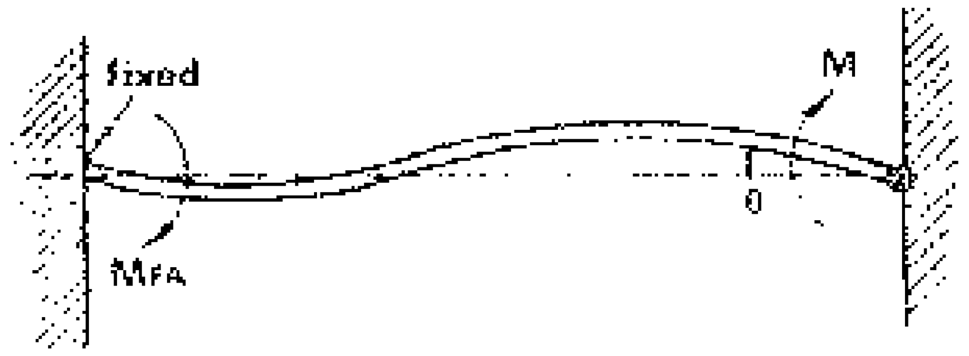


$$END\ SLOPE = \frac{Ml}{3EI}$$

Program: B/E |enter|var|×|var|÷|var|÷|[6]3|[9]|÷|var| [12] C/CE

Execution: |M exec|l exec|E exec|I exec|

$$M_{FA} = \frac{M}{2}$$

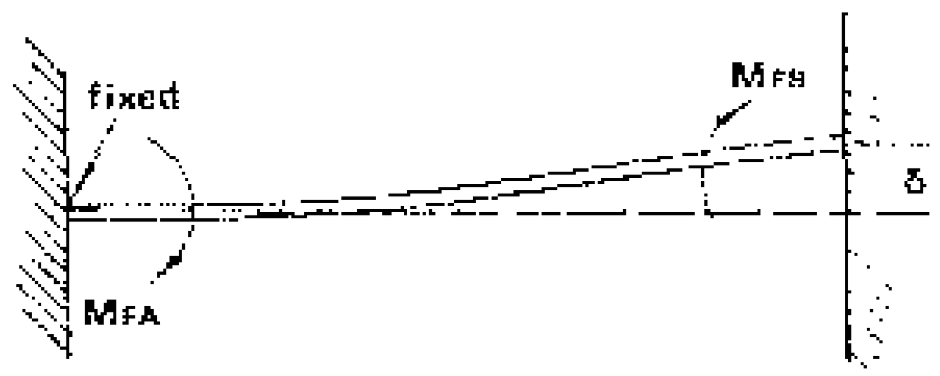


$$END\ SLOPE\ \theta = \frac{Ml}{4EI}$$

Program: B/E |enter|var|×|var| : |var|÷|[6]4|[9]|÷|var| [12] C/CE

Execution: |M exec|l exec|E exec|I exec|

$$M_{FA} = + \frac{6EI\delta}{l^2} \qquad \text{(i)}$$



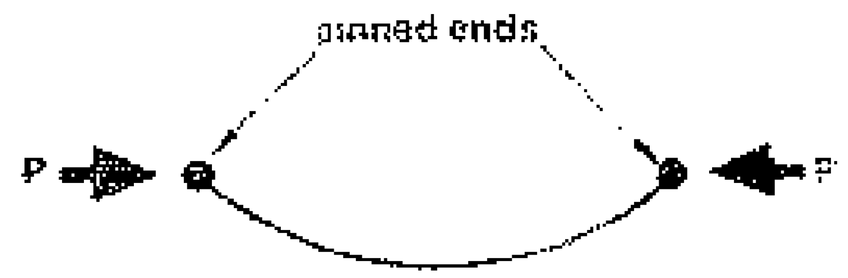
$$M_{FB} = + \frac{6EI\delta}{l^2} \qquad \text{(ii)}$$

Program: B/E |enter|×|sto|+|var|enter|var|×|var|×|[6]6|[9]|×|rcl|÷|var| [17] C/CE

Execution: |l exec|E exec|I exec|δ exec|

STRUTS

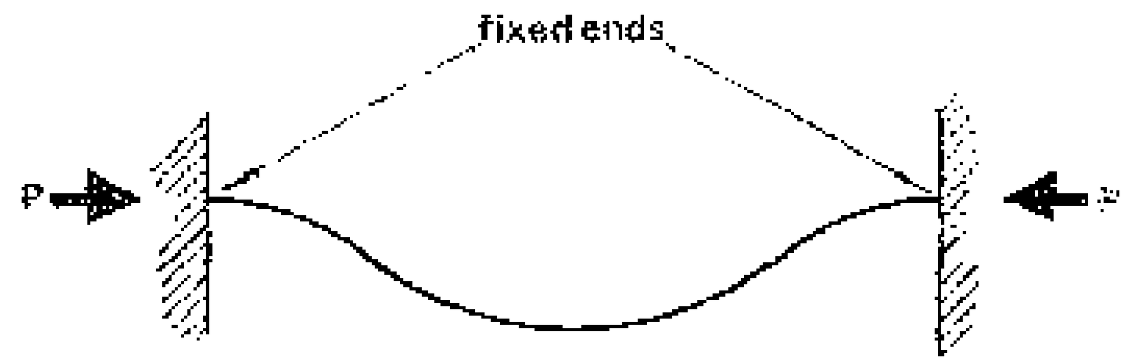
$P_{crit.} = CRITICAL\ LOAD = \frac{\pi^2 EI}{l^2}$



Program: B/E |enter| × |var| ÷ |var| ÷ | ÷ |[6]|2|2|7|[9]| × |[6]|2|3|[9]| ÷ |var| [19] C/CE

Execution: |*l* exec|*E* exec|*I* exec|

$P_{crit.} = \frac{\pi^2 EI}{(l/2)^2}$



Program: B/E |enter|[6]|2|[9]| ÷ | × |var| ÷ |var| ÷ | ÷ |[6]|2|2|7|[9]| × |[6]|2|3|[9]| ÷ |var| [23] C/CE

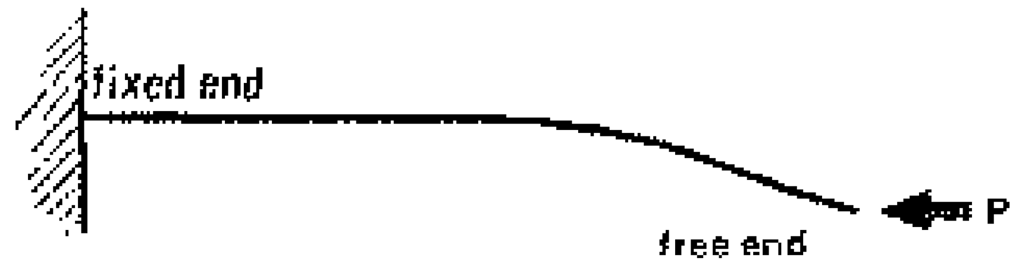
Execution: |*l* exec|*E* exec|*I* exec|

$P_{crit.} = \frac{\pi^2 EI}{(0.7\,l)^2}$

Program: B/E |enter|var| × | × |var| ÷ |var| ÷ | ÷ |[6]|2|2|7|[9]| × |[6]|2|3|[9]| ÷ |var| [21] C/CE

Execution: |*l* exec|0.7 exec|*E* exec|*I* exec|

$P_{crit.} = \frac{EI\,\pi^2}{(2l)^2}$



Program: B/E |enter|[6]|2|[9]| × | × |var| ÷ |var| ÷ | ÷ |[6]|2|2|7|[9]| × |[6]|2|3|[9]| ÷ |var| [23] C/CE

Execution: |*l* exec|*E* exec|*I* exec|

ELASTIC BENDING & TORSION FORMULAE

$$\frac{\sigma}{y} = \frac{M}{I} = \frac{E}{R}$$ *FOR BENDING ABOUT PRINCIPAL AXIS*

σ = stress
y = dist. from axis
M = Bending moment
I = Mom. of inertia
E = Youngs mod.
R = radius of curvature

τ = shear stress
r = radius
G = rigidity mod
θ = turning angle
L = length of shaft
T = torque
J = polar mom. of inertia

$$\frac{\tau}{r} = \frac{G\theta}{L} = \frac{T}{J}$$ for elastic torsion of a round shaft

ELASTIC STRAIN ENERGY

IN (i) *TENSION* $= \frac{\sigma^2}{2E}$

(ii) *TORSION* $= \frac{\tau^2}{2G}$

Program: B/E |enter| × |var| ÷ |(|2|)| ÷ |var| [9] C/CE

Execution: (i) |σ exec|E exec|

(ii) |τ exec|G exec|

TORSION OF THIN WALLED TUBE

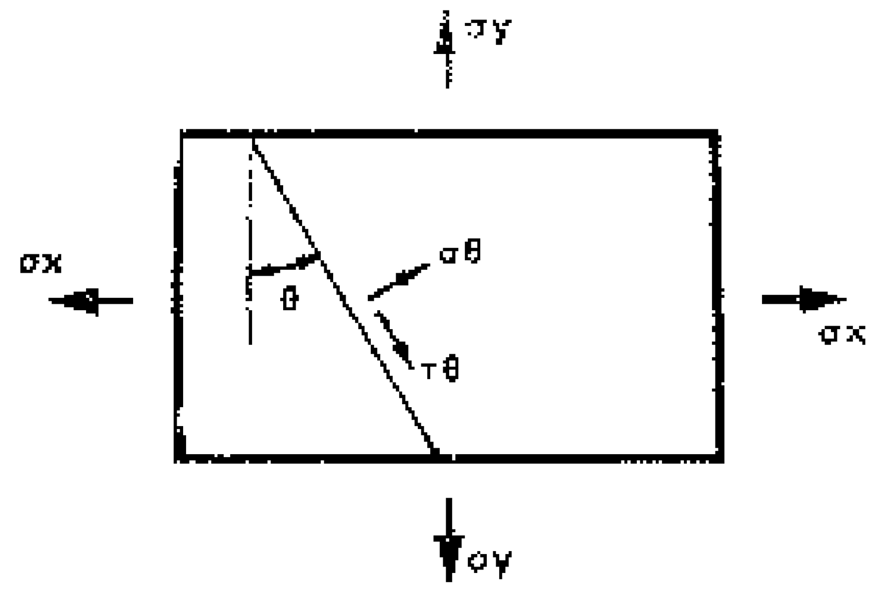
t = wall thickness

$\frac{\theta}{L}$ twist/length

TORQUE $= G\frac{\theta}{L}2\pi r^3 t$

Program: B/E |sto|enter| × |rcl| × |var| × |var| × |var| × |(|7|1|0|)| × |(|1|1|3|)| ÷ |var| [24] C/CE

Execution: |r exec|t exec|G exec| $\frac{\theta}{L}$ exec|



COMPLEX STRESSES

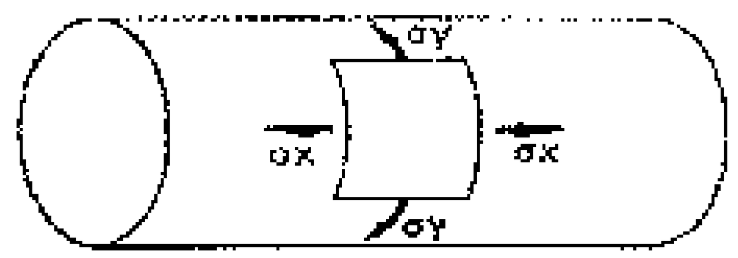
$$\sigma_\theta = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2}\cos 2\theta$$

Program: B/E |sto|cos|X|var|X|$x - m$|sin|X|var|X|rcl|+|var| [13] C/CE

Execution: |θ exec|σ_x exec|σ_y exec|

CYLINDRICAL PRESSURE VESSEL

LONGITUDINAL STRESS $\sigma_x = \frac{pd}{4t}$



p = pressure inside vessel (gauge)
d = diameter of vessel
t = wall thickness

Program: B/E |enter|var|×|var|÷|(|4|)|:|var| [10] C/CE

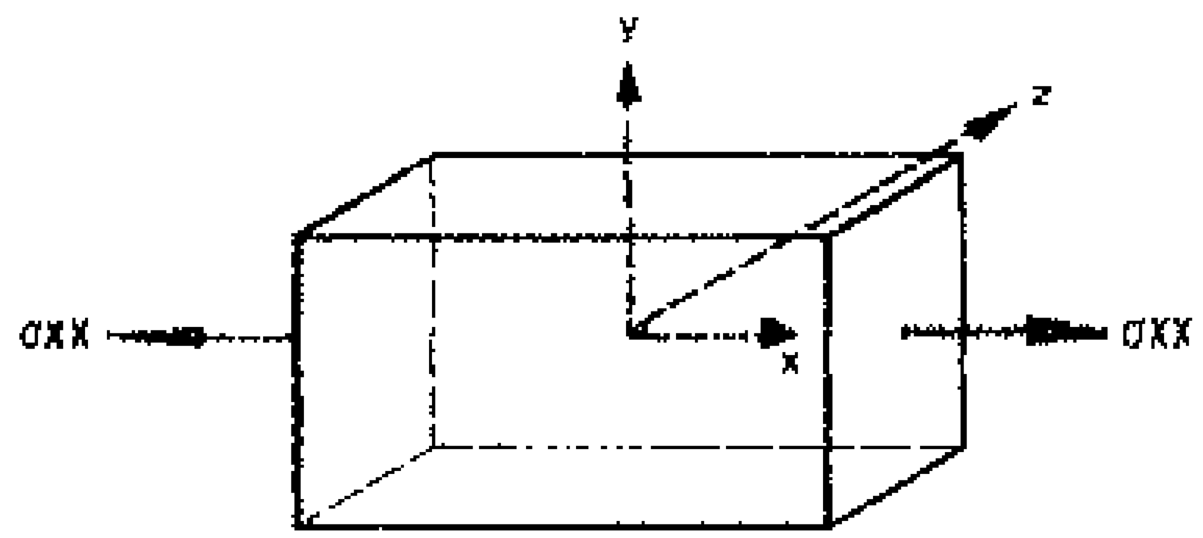
Execution: |p exec|d exec|t exec|

HOOP STRESS $\sigma_y = \frac{pd}{2t}$

Program: B/E |enter|var|×|var|÷|(|2|)|÷|var| [10] C/CE

Execution: |p exec|d exec|t exec|

STRAINS DUE TO STRESS σ_x



σ = stress
E = Youngs mod
γ = Poissons ratio

$$\varepsilon_{xx} = \frac{\sigma_{xx}}{E} \quad \text{(i)}$$

$$\varepsilon_{yy} = \varepsilon_{zz} = -\frac{\gamma\sigma_{xx}}{E} \quad \text{(ii)}$$

Program: (ii) B/E |enter|var|×|var|÷|−|var| [7] C/CE

Execution: |γ exec|σ_{xx} exec|E exec|

DEGREE OF REDUNDANCY IN TRUSSES

(a) 2—*DIMENSIONS*

Degree of redundancy = $D = b + r - 2j$

b = no. of bars

r = no. of restraints

j = no. of joints

Program : B/E |enter|var|+|sto|+|var|enter|⁽|2|⁾|×|−|rcl|+|var| [15] C/CE

Execution: |b exec|r exec|j exec|

(b) 3—*DIMENSIONS*

$D = b + r - 3j$

Program: B/E |enter|var|+|sto|+|var|enter|⁽|3|⁾|×|−|rcl|+|var| [15] C/CE

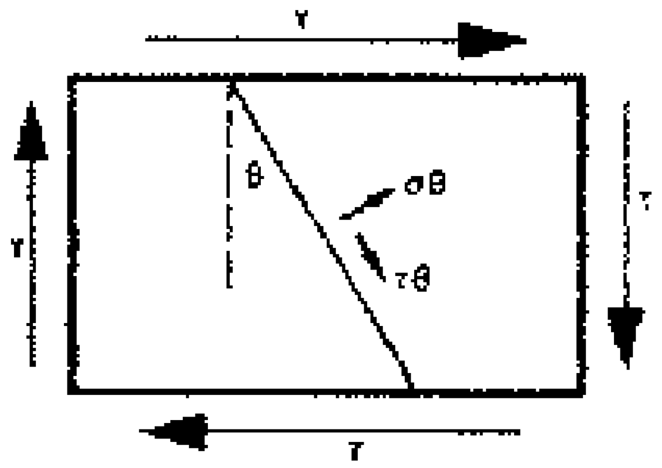
Execution: |b exec|r exec|j exec|

$$\tau\theta = \frac{\sigma_x - \sigma_y}{2}\sin 2\theta$$

Program: B/E |enter|var|−|⁽|2|⁾|÷|sto|+|var|enter|⁽|2|⁾|×|sin|rcl|×|var| [19] C/CE

Execution: |σ_x exec|σ_y exec|θ exec|

σ_θ $-\tau \sin 2\theta$



Program: B/E |enter|⁽|2|⁾|×|sin|var|×|var| [9] C/CE

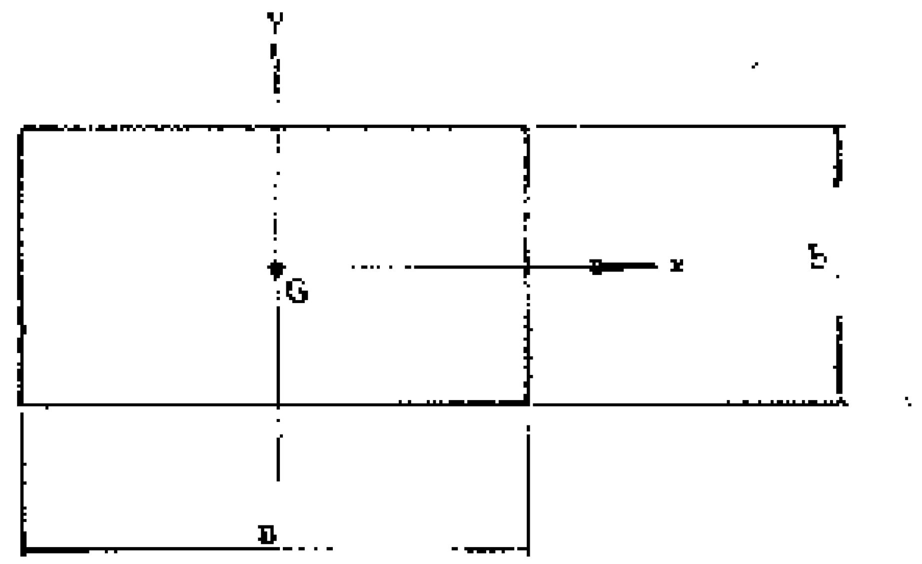
Execution: |θ exec|τ exec|

$\tau_\theta = -\tau\cos 2\theta$

Program: B/E |enter|⁽|2|⁾|×|cos|var|×|−|var| [10, C/CE

Execution: |θ exec|τ exec|

LAMINAE



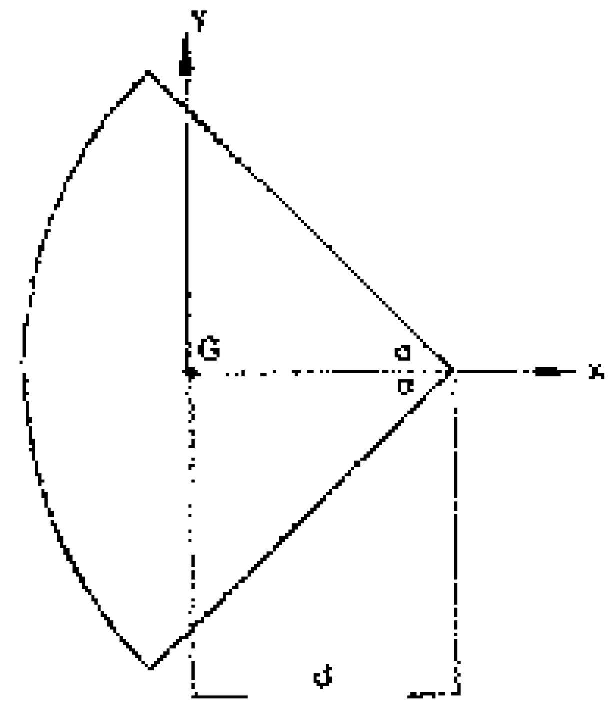
$$k_{xx}^2 = \frac{1}{12}b^2 \qquad \text{(i)}$$

$$k_{yy}^2 = \frac{1}{12}a^2 \qquad \text{(ii)}$$

Program: B/E |enter| × |⁽|12|⁾| ÷ |var| [7] C/CE

Execution: (i) |b exec|

(ii) |a exec|



$$d = \frac{2}{3}a\frac{\sin\alpha}{\alpha}$$

Program: B/E |enter|sto|sin|rcl| ÷ |var| × |⁽|2|⁾| × |⁽|3|⁾| ÷ |var| [16] C/CE

Execution: |α exec|a exec|

$$k_{xx}^2 = \frac{a^2}{4}\left(1 - \frac{\sin 2\alpha}{2\alpha}\right)$$

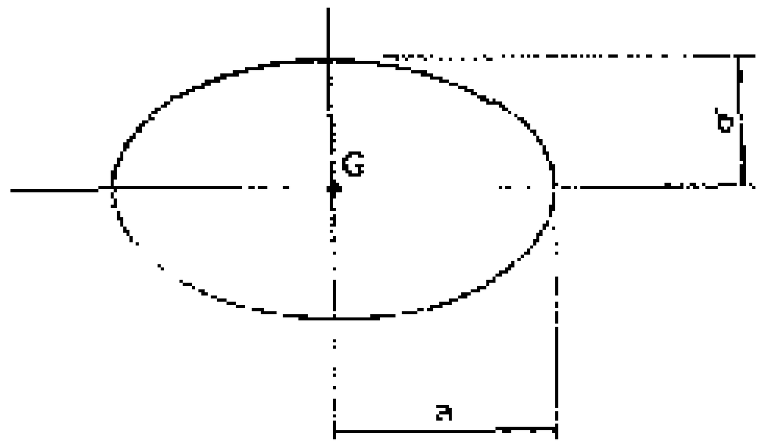
Program: B/E |enter|sto|sin|rcl| ÷ | − |⁽|1|⁾| + |sto| + |var|enter| × |⁽|4|⁾| ÷ |rcl| × |var| [22] C/CE

Execution: |2α exec|a exec|

$AREA = \pi ab$

Program: B/E |enter|var| × |^{6}|3|5|5|^{9}| × |^{6}|1|1|3|^{9}| ÷ |var| [16] C/CE

Execution: |a exec|b exec|



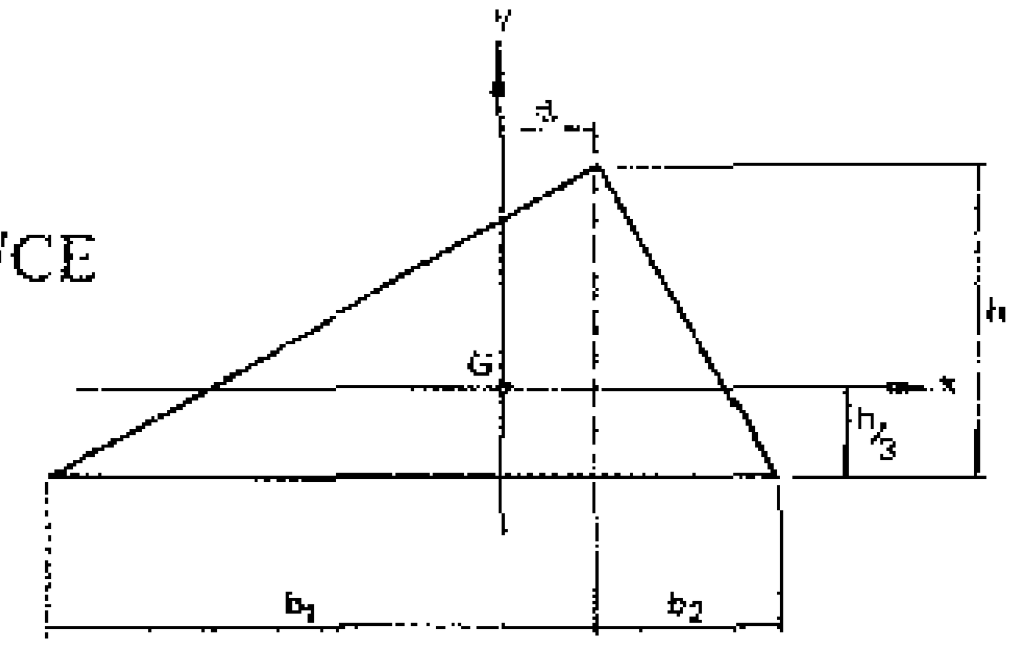
$$k_{xx}^2 = \frac{1}{4} b^2 \qquad \text{(i)}$$

$$k_{yy}^2 = \frac{1}{4} a^2 \qquad \text{(ii)}$$

Program: B/E |enter| × |^{6}|4|^{9}| ÷ |var| [7] C/CE

Execution: (i) |b exec|

(ii) |a exec|



$AREA = \frac{1}{2} h (b_1 + b_2)$

Program: B/E |enter|var| + |var| × |^{6}|2|^{9}| ÷ |var| [10] C/CE

Execution: |b_1 exec|b_2 exec|h exec|

$$d = \tfrac{1}{3} (b_1 - b_2)$$

Program: B/E |enter|var| − |^{6}|3|^{9}| ÷ |var| [8] C/CE

Execution: |b_1 exec|b_2 exec|

$$k_{xx}^2 = \frac{1}{18} h^2$$

Program: B/E |enter| × |^{6}|18|^{9}| ÷ |var| [8] C/CE

Execution: |h exec|

$$k_{yy}^2 = \frac{1}{18} (b_1{}^2 + b_1 b_2 + b_2{}^2)$$

Program: B/E |enter|sto| + | × |x-m| + |var| × |rcl| + |sto| + |var|enter| × |rcl| + |^{6}|1|8|^{9}| ÷ |var| [23] C/CE

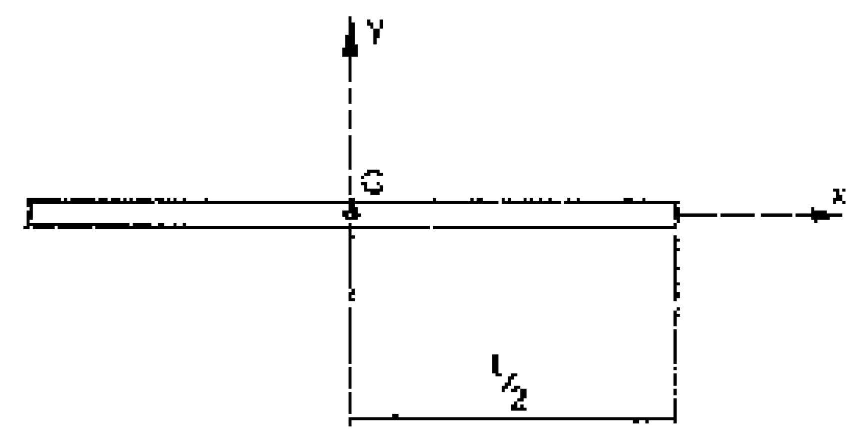
Execution: |b_1 exec|b_2 exec|b_2 exec|

RODS

NOTATION G = position of centre of gravity

k_{xx} = radius of gyration about x-axis

k_{yy} = radius of gyration about y-axis

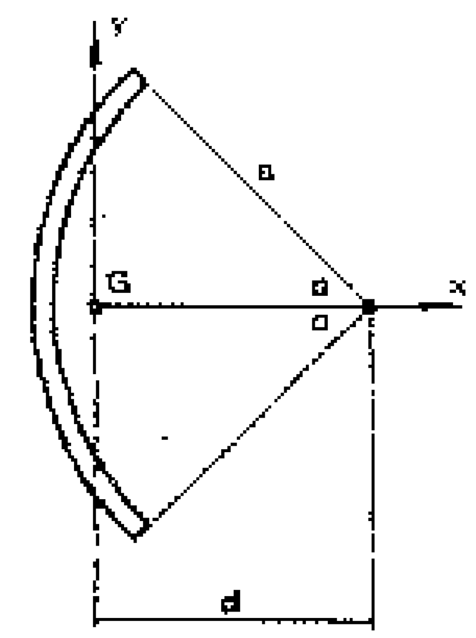


$$k_{xx}^2 = 0$$

$$k_{yy}^2 = \frac{1}{12}\, l^2$$

Program: B/E |enter| × |‘|1|2|’| ÷ |var| [8] C/CE

Execution: |l exec|



$$d = \frac{a \sin \alpha}{\alpha}$$

Program: B/E |enter|sto|sin|rcl| ÷ |var| × |var| [8] C/CE

Execution: |α exec|a exec|

$$k_{xx}^2 = \frac{1}{2}\, a_2 \left(1 - \frac{\sin 2\alpha}{2\alpha}\right)$$

Program: B/E |enter|sto|sin| − |rcl| ÷ |‘|1|’| + |sto| + |var|enter| × |‘|2|’| ÷ |rcl| × |var| [22] C/CE

Execution: |2α exec|a exec|

$VOLUME = 2\pi alt$

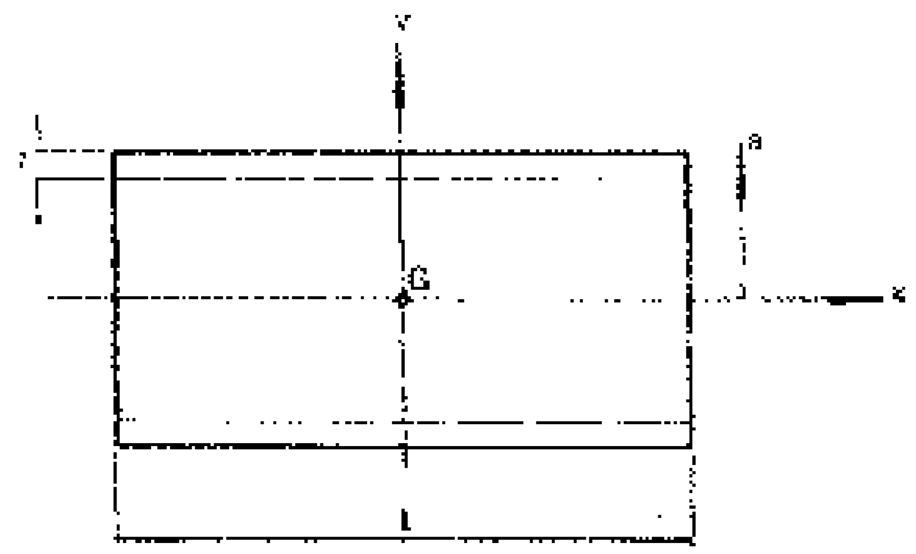
Program: B/E |enter|var| × |var| × |⁽|7|1|0|⁾| × |⁽|1|1|3|⁾| ÷ |var| [18] C/CE

Execution: |a exec|l exec|t exec|

$k_{xx}^2 = a^2$

Program: B/E |enter| × |var| [3] C/CE

Execution: |a exec|



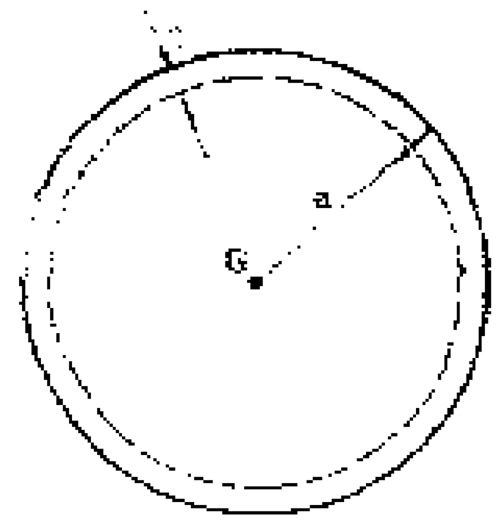
$$k_{yy}^2 = k_{zz}^2 = \frac{1}{2}a^2 + \frac{1}{12}l^2$$

Program: B/E |enter| × |⁽|2|⁾| ÷ |sto| + |var|enter| × |⁽|1|2|⁾| ÷ |rcl| + |var| [19] C/CE

Execution: |a exec|l exec|

SHELLS OF REVOLUTION

SPHERE



VOLUME $= 4\pi a^2 t$

Program: B/E |enter|×|var|×|❛|1|4|2|0|❜|×|❛|1|1|3|❜|÷|var| [18] C/CE

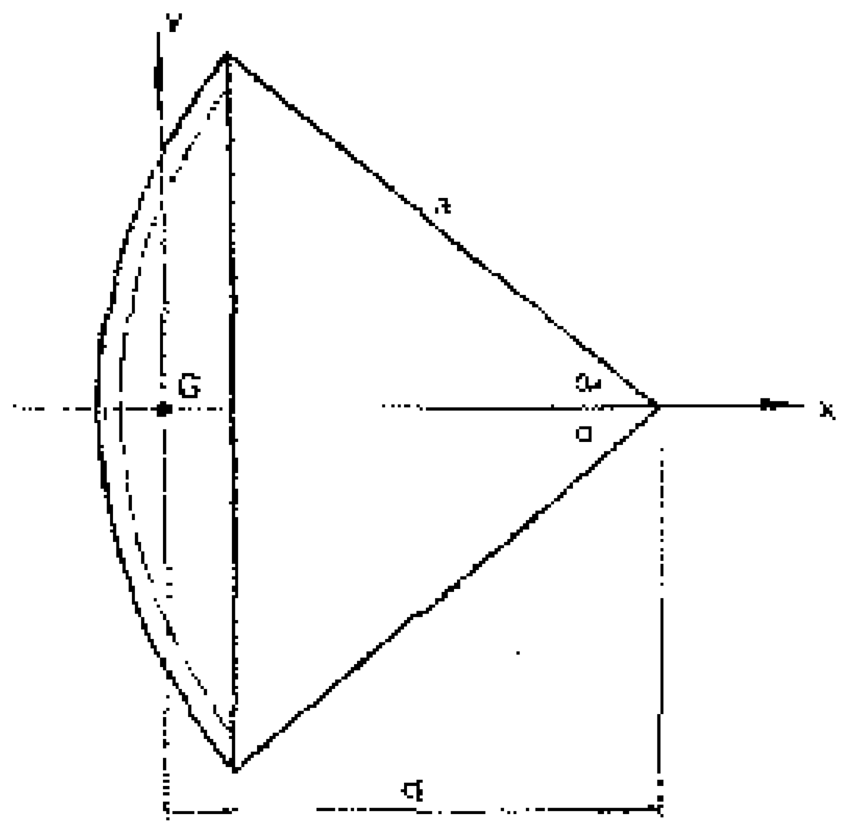
Execution: |a exec|t exec|

$k_{xx}^2 = k_{yy}^2 = k_{zz}^2 = \frac{2}{3}a^2$

Program: B/E |enter|×|❛|2|❜|×|❛|3|❜|÷|var| [11] C/CE

Execution: |a exec|

SPHERICAL CAP



VOLUME $= 2\pi a^2 t(1 - \cos\alpha)$

Program: B/E |arctan|❛|8|❜|×|sto|+|var|enter|×|var|×|rcl|×|sto|+|
|var|cos|−|var|+|rcl|×|var| [24] C/CE

Execution: |1 exec|a exec|t exec|α exec|1 exec|

$k_{xx}^2 = \frac{1}{3}a^2(1-\cos\alpha)\ (2 + \cos\alpha)$

Program: B/E |enter|cos|sto|+|var|+|x–m|−|❛|1|❜|+|
|rcl|×|sto|+|var|enter|×|var|÷|rcl|×|var| [24] C/CE

Execution: |α exec|2 exec|a exec|3 exec|

$$k_{yy}^2 = \frac{1}{12}\, a^2(1-\cos\alpha)\ (5+\cos\alpha)$$

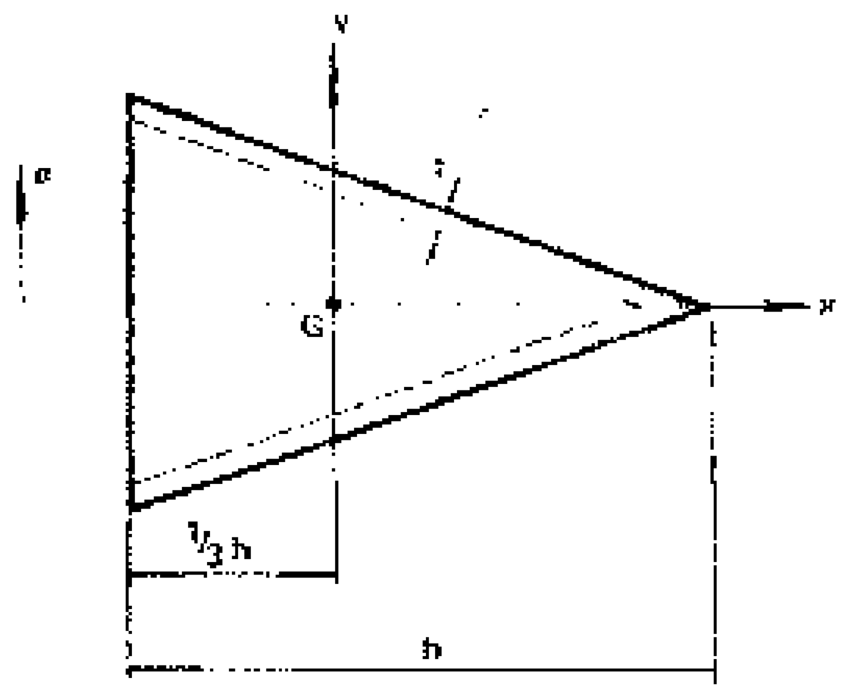
Program: B/E |enter|cos|sto|+|var|+|x–m|–|(|1|)|÷|
|rcl|×|sto|+|var|enter|×|var|÷|rcl|×|var| [24] C/CE

Execution: |α exec|5 exec|a exec|12 exec|

$$a' = \frac{1}{2}\, a\,(1+\cos\alpha)$$

Program: B/E |enter|cos|(|1|)|+|var|×|(|2|)|÷|var| [13] C/CE

Execution: |α exec|a exec|



CONE

$VOLUME = \pi$ at $(a^2 + h^2)^{\frac{1}{2}}$

Program: B/E |enter|×|sto|+|var|enter|×|rcl|+|$\sqrt{x}$|x–m|+|$\sqrt{x}$|var|×|rcl|×|var|×|var|
[20] C/CE

Execution: |a exec|h exec|t exec|3.1416 exec|

$$k_{xx}^2 = \frac{1}{2}a^2$$

Program: B/E |enter|×|(|2|)|÷|var| [7] C/CE

Execution: |a exec|

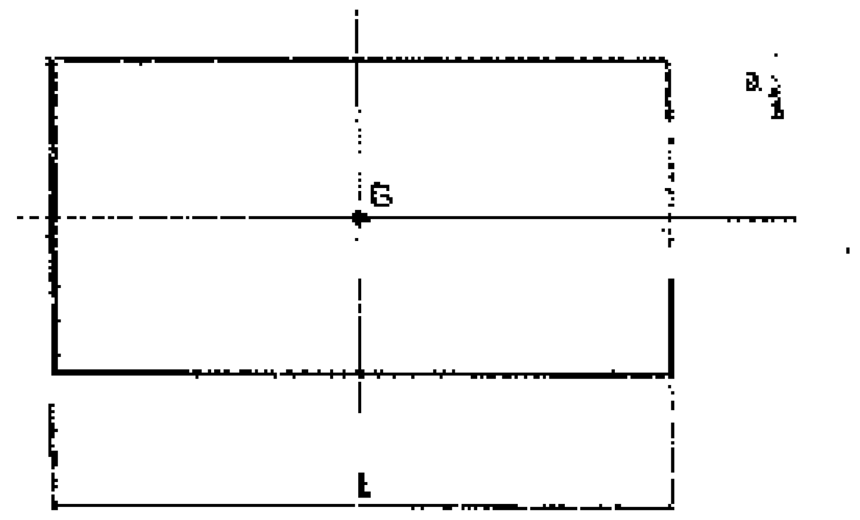
$$k_{yy}^2 = \frac{1}{4}a^2 + \frac{1}{18}h^2$$

Program: B/E |enter|×|(|4|)|÷|sto|+|var|enter|×|(|1|8|)|÷|rcl|+|var| [19] C/CE

Execution: |a exec|h exec|

SOLIDS OF REVOLUTION

CYLINDER



VOLUME $= \pi a^2 l$

Program: B/E |enter|×|var|×|“|3|5|5|”|×|“|1|1|3|”|÷|var| [17] C/CE

Execution: |*a* exec|*l* exec|

$k_{xx}^2 = \frac{1}{2} a^2$

Program: B/E |enter|×|“|2|”|÷|var| [7] C/CE

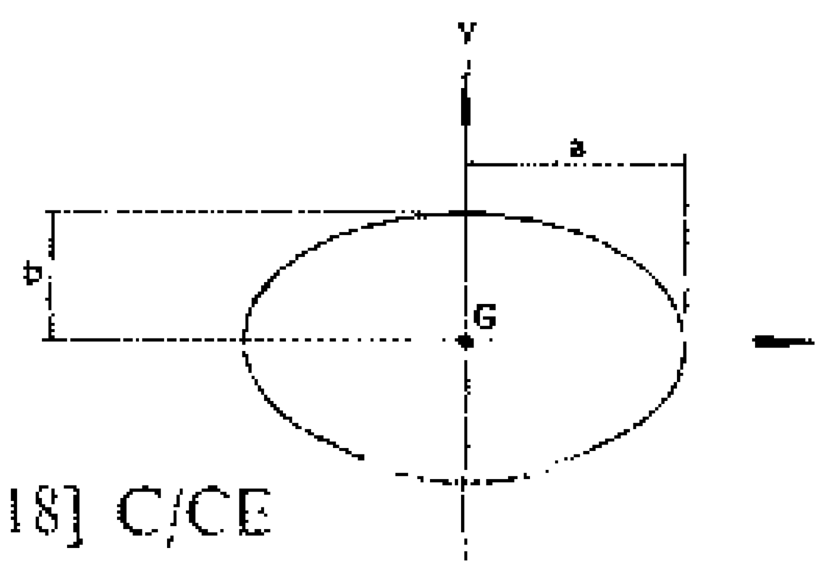
Execution: |*a* exec|

$k_{yy}^2 = \frac{1}{4} a^2 + \frac{1}{12} l^2$

Program: B/E |enter|×|“|4|”|÷|sto|+|var|enter|×|“|1|2|”|÷|rcl|+|var| [19] C/CE

Execution: |*a* exec|*l* exec|

SPHEROID



VOLUME $= \frac{4}{3}\pi\ ab^2$

Program: B/E |enter|×|var|×|“|1|4|2|0|”|×|“|3|3|9|”|÷|var| [18] C/CE

Execution: |*b* exec|*a* exec|

$$k_{xx}^2 = \frac{2}{5}\, b^2$$

Program: B/E |enter| × |❛|2|❜| × |❛|5|❜| ÷ |var| [11] C/CE

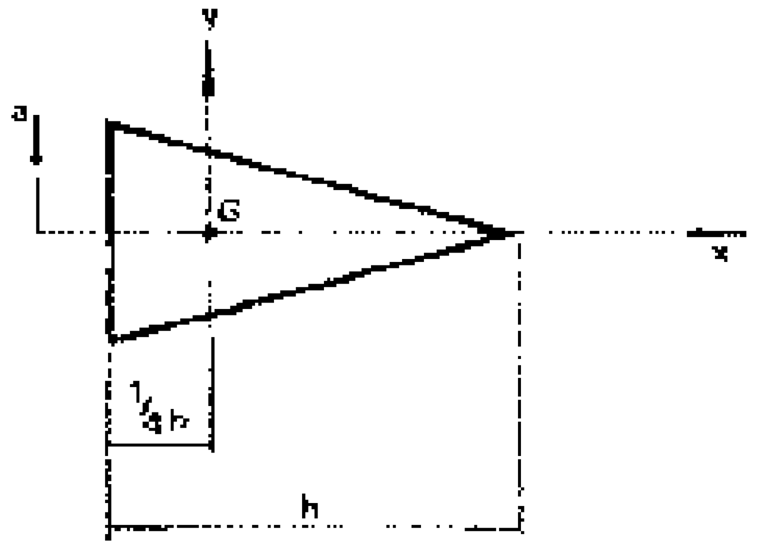
Execution: |*b* exec|

$$k_{yy}^2 = \frac{1}{5}\,(a^2 + b^2)$$

Program: B/E |enter| × |sto| + |var|enter| × |rcl| + |❛|5|❜| ÷ |var| [14] C/CE

Execution: |*a* exec|*b* exec|

CONE



$VOLUME = \frac{1}{3}\pi a^2 h$

Program: B/E |enter| × |var| × |❛|3|5|5|❜| × |❛|3|3|9|❜| ÷ |var| [17] C/CE

Execution: |*a* exec|*h* exec|

$$k_{xx}^2 = \frac{3}{10}\, a^2$$

Program: B/E |enter| × |❛|3|❜| × |❛|1|0|❜| ÷ |var| [12] C/CE

Execution: |*a* exec|

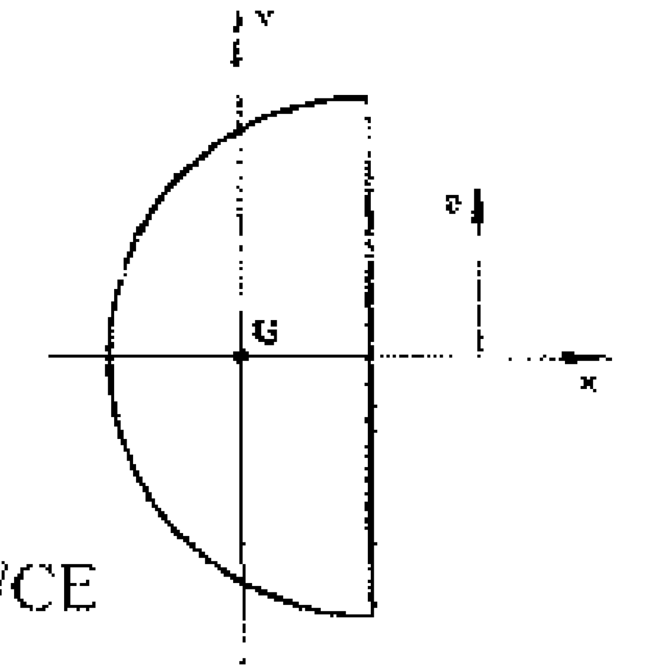
$$k_{yy}^2 = \frac{3}{80}\,(4a^2 + h^2)$$

Program: B/E |enter| × |❛|4|❜| × |sto| + |var|enter| × |rcl| + |❛|3|❜| × |❛|8|0|❜| ÷ |var| [23] C/CE

Execution: |*a* exec|*h* exec|

SOLIDS OF REVOLUTION

HEMISPHERE



$VOLUME = \frac{2}{3}\pi a^3$

Program: B/E |sto|enter| × |rcl| × |❛|7|1|0|❜| × |❛|3|3|9|❜| ÷ |var| [18] C/CE

Execution: |a exec|

$k_{xx}^2 = \frac{2}{5}a^2$

Program: B/E |enter| × |❛|2|❜| × |❛|5|❜| ÷ |var| [11] C/CE

Execution: |a exec|

$k_{yy}^2 = \frac{83a^2}{320}$

Program: B/E |enter| × |❛|8|3|❜| × |❛|3|2|0|❜| ÷ |var| [14] C/CE

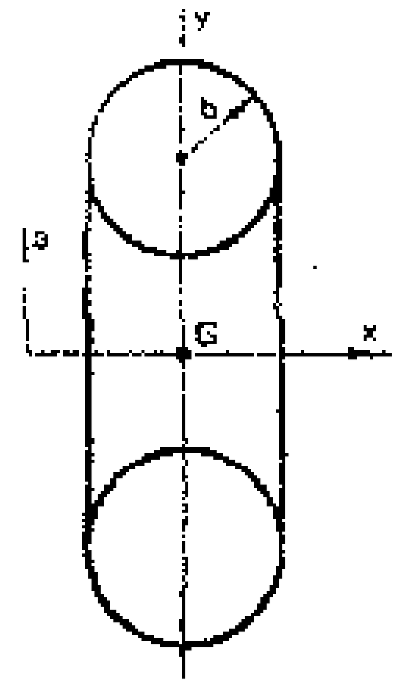
Execution: |a exec|

TOROID—CIRCULAR SECTION

$VOLUME = 2\pi^2 ab^2$

Program: B/E |enter| × |var| × |❛|4|5|4|❜| × |❛|2|3|❜| ÷ |var| [16] C/CE

Execution: |b exec|a exec|



$$k_{xx}^2 = a^2 + \frac{3}{4} b^2$$

Program: B/E |enter| × |sto| + |var|enter| × |❛|3|❜| × |❛|4|❜| ÷ |rcl| + |var| [18]

Execution: |*a* exec|*b* exec|

$$k_{yy}^2 = \frac{1}{2} a^2 + \frac{5}{8} b^2$$

Program: B/E |enter| × |❛|2|❜| ÷ |sto| + |var|enter| × |❛|5|❜| × |❛|8|❜| ÷ |rcl| + |var| [22] C/CE

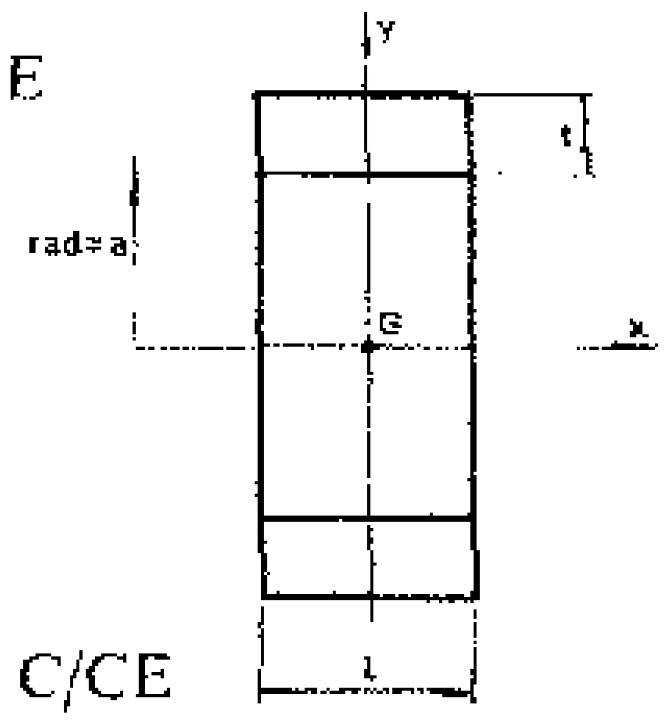
Execution: |*a* exec|*b* exec|

TOROID—SQUARE SECTION

VOLUME $2\pi atl$

Program: |enter|var| × |var| × |❛|7|1|0|❜| × |❛|1|1|3|❜| ÷ |var| [18] C/CE

Execution: |*a* exec|*t* exec|*l* exec|



$$k_{xx}^2 = a^2 + \frac{1}{4} t^2$$

Program: B/E |enter| × |sto| + |var|enter| × |❛|4|❜| ÷ |rcl| + |var| [14] C/CE

Execution: |*a* exec|*t* exec|

$$k_{yy}^2 = \frac{1}{2} a^2 + \frac{1}{8} t^2 + \frac{1}{12} l^2$$

Program: B/E |enter| × |var| ÷ |sto| + |var|enter| × |var| ÷ |rcl| + |
|sto| + |var|enter| × |var| ÷ |rcl| + |var| [23] C/CE

Execution: |*a* exec|2 exec|*t* exec|8 exec|*l* exec|12 exec|

DRYNESS FRACTION

$x = kg$ of saturated vapour/kg wet vapour

$1-x = kg$ sat. liquid/kg wet vapour

$u = (1-x)u_f + xu_g$

u = internal energy
x = dryness fraction
u_g = int. energy of sat. vapour
u_f = int energy of sat. vapour

Program: B/E |enter|sto|+|var|×|x–m|–|❛|1|❜|+|var|×|rcl|+|var| [16] C/CE

Execution: |x exec|u_g exec|u_f exec|

POLYTROPIC PROCESS

pv^n = const.

$$WORK = \frac{p_2v_2 - p_1v_1}{1-n} \quad \text{(i)}$$

$$= \frac{R}{1-n}(T_2 - T_1) \quad \text{(ii) for a perfect gas}$$

p = pressure
v = volume
n = index
T = abs. temp.
R = gas const.

Program: B/E |enter|var|×|sto|+|var|enter|var|×|rcl|–|sto|+|❛|1|❜|enter|var|–|rcl|
|÷|÷|var| [23] C/CE

Execution: (i) |p_1 exec|v_1 exec|p_2 exec|v_2 exec|n exec|

Program: B/E |enter|var|–|var|×|sto|+|❛|1|❜|enter|var|–|rcl|÷|÷|var| [17] C/CE

Execution: (ii) |T_2 exec|T_1 exec|R exec|n exec|

HEAT CONDUCTION

FOURIERS LAW

$$Q = -kA\frac{dT}{dx} \quad \text{(i)}$$

$$= -kA\frac{T_2 - T_1}{x_{12}} \quad \text{(ii)}$$

Q = heat flow
A = area
T = temperature
x = dist. into body
k = conductivity

Program: (i) B/E |enter|var| × |var| × | − |var| [7] C/CE

(ii) B/E |enter|var| − |var| × |var| × |var| ÷ | − |var [11] C/CE

Execution (i) |$\frac{dT}{dx}$ exec|A exec|k exec|

(ii) |T_2 exec|T_1 exec|A exec|k exec|x_{12} exec|

HEAT TRANSFER COEFFICIENT

$$h = \frac{Q}{A(T_w - T_F)}$$

T_w = wall temp.
T_F = fluid temp.

Program: B/E |enter|var| − |var| × |var| ÷ | ÷ |var| [9] C/CE

Execution: |T_w exec|T_F exec|A exec|Q exec| F = A/W

HEAT CONDUCTION---SHAPE FACTORS. F

PLANE WALL *area* = A
thickness = W

CYLINDER inside rad r_i
outside r_o
length L

$$F = \frac{2\pi L}{ln(r_o/r_i)}$$

Program: B/E |enter|var|÷|log|÷|var|×|◂|1|0|7|9|2|▸|×|◂|3|9|5|5|▸|÷|var| [23] C/CE

Execution: |r_0 exec|r_1 exec|L exec|

SPHERE

$$F = \frac{4\pi r_o r_i}{r_o - r_i}$$

Program: B/E |sto|enter|var|−|$x-m$|+|var|×|◂|1|4|2|0|▸|×|◂|1|1|3|▸|÷|rcl|÷|var|
[24] C/CE

Execution: |r_0 exec|r_1 exec|r_1 exec|

HORIZONTAL DISC radius r
centre line depth D

$$F = \frac{2.22\,r}{1 - \dfrac{r}{2.83D}}$$

Program B/E |enter|sto| − |var| ÷ |var| ÷ |⁽|1|⁾| + |$x-m$| + |var| × |rcl| ÷ |var| [18] C/CE

Execution: |r exec|D exec|2.83 exec|2.22 exec|

BURIED SPHERE radius r
centre line depth D

$$F = \frac{\pi r}{1 - \dfrac{r}{2D}}$$

Program: B/E |enter|sto| + |var|arctan|⁽|4|⁾| × |rcl| × |$x-m$| + |var| ÷ |var| ÷ | − |var| + |
|rcl| ÷ | ÷ |var| [24] C/CE

Execution: |r exec|1 exec|D exec|2 exec|1 exec|

RADIATION

STEPHAN BOLZMANN LAW $Q = \sigma T^4$

Q = heat transfer
T = absolute temp.
σ = Stephan-Bolzmann contant

Program: B/E |enter| × | × |var| × |var| [6] C/CE

Execution: |T exec|σ exec|

HYDROSTATICS

$F \;=\; \rho g A \bar{y} \cos\alpha$

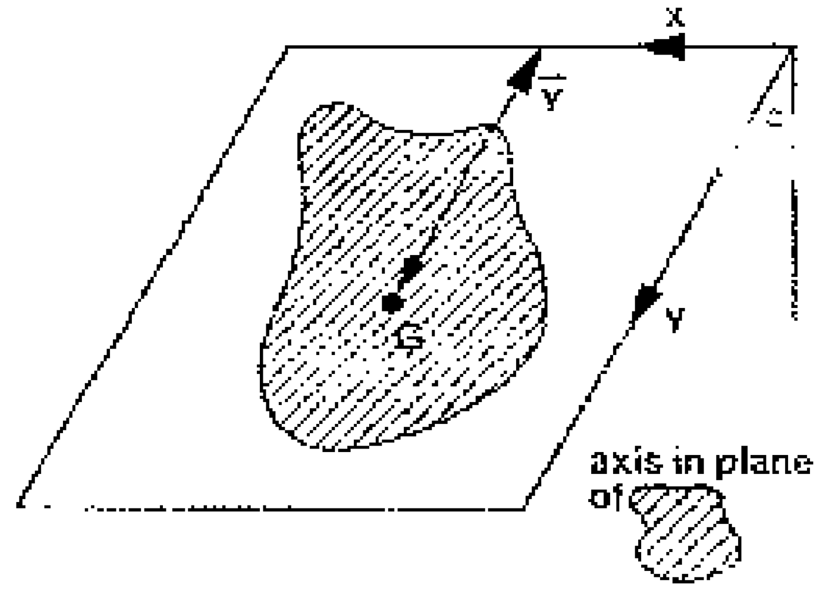
Program: B/E |enter|cos|var| × |var| × |var| × |‹|9|8|1|›| × |‹|1|0|0|›|÷|var| [21] C/CE

Execution: |α exec|ρ exec|A exec|$\bar{y}$ exec|

CENTRE OF PRESSURE ON ABOVE BODY (x_p, y_p)

$$x_p = \frac{I_{yy}}{\text{first moment of area}}$$

$$y_p = \frac{I_{xy}}{\text{first moment of area}}$$



FORCE ON SUBMERGED CURVED SURFACE

A_x = projected area in $y-z$ plane

z_c = position of centroid of this area

$F_x \;=\; A_x \rho g z_b$

Program: B/E |enter|var| × |var| × |‹|9|8|1|›| × |‹|1|0|0|›|÷|var| [18] C/CE

Execution: |A_x exec|ρ exec|z_c exec|

BASIC FLOW EQUATIONS

CONTINUITY $Y \rho A V = \text{const.}$

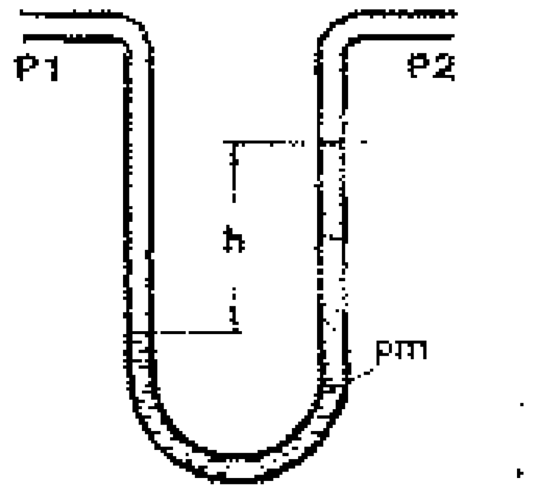
CONTINUITY $\dfrac{du}{dx} + \dfrac{dv}{dy} = 0$

EULERS EQUATION $\displaystyle\int \frac{dp}{\rho} + \frac{V^2}{2} + gz = \text{const. along a streamline}$

BERNOULLI'S EQUATION $p + \tfrac{1}{2}\rho V^2 + \rho g_z = \text{const.}$

ENERGY $h_0 = h + \tfrac{1}{2}v^2$

MANOMETER $p_1 - p_2 = gh(\rho_m - \rho)$



Program: B/E |enter|var|−|var|×|‘|9|8|1|’|×|‘|1|0|0|’|÷|var| [18] C/CE

Execution: |ρ_m exec|ρ exec|h exec|

FLOW RATES

PITOT—STATIC TUBE

$$u = \sqrt{\frac{2(P-p)}{\rho}}$$

u = velocity of fluid
P = total pressure
p = static pressure
ρ = density

Program: B/E |enter|var|−|var|÷|‘|2|’|×|$\sqrt{x}$|var| [11] C/CE

Execution: |P exec|p exec|ρ exec|

VENTURI

$$u = \sqrt{\frac{2(p_1-p_2)}{\rho[(\frac{a1}{a2})^2-1]}}$$

1 refers to tube
2 refers to throat
p = static pressure
a = area

Program: B/E |enter|var|÷|×|‘|1|’|−|var|×|sto|+|var|enter|var|−|‘|2|’|×|rcl|÷|
|$\sqrt{x}$|var| [24] C/CE

Execution: |a_1 exec|a_2 exec|ρ exec|p_1 exec|p_2 exec|

SHARP EDGED ORIFICE

$$Q = A_d C\sqrt{2gh}$$

A = area
Q = volume flow rate
C_d = discharge coeff.

Program: B/E |enter|‘|1|9|6|2|’|×|‘|1|0|0|’|÷|$\sqrt{x}$|var|×|var|×|var| [20] C/CE

Execution: |h exec|A exec|C_d exec|

PIPE FLOW

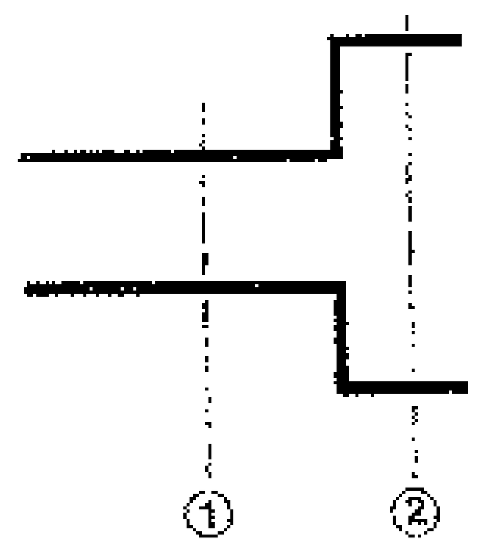
PRESSURE DROP $\Delta p = 2 \frac{L}{D} C_f \rho U_m^2$

L — length
D = diameter
C_f = skin inertia coefficient
ρ = density
U_m = mean velocity

Program: B/E |enter| × |var| × |var| × |var| × |var| ÷ |‘|2|’| × |var| [15] C/CE

Execution: |U_m exec|ρ exec|C_f exec|L exec|D exec|

SUDDEN EXPANSION



$$\text{Head loss} = \frac{(u_1 - u_2)^2}{2g} \qquad \text{(i)}$$

$$= \frac{u_1^2}{2g}\left(1 - \frac{A_1}{A_2}\right)^2 \qquad \text{(ii)}$$

Program: (i) B/E |enter|var| − | × |‘|1|9|6|2|’| ÷ |‘|1|0|0|’| × |var| [18] C/CE

Execution: |u_1 exec|u_2 exec|

Program: (ii) B/E |enter var| ÷ | − |‘|1|’| + | × |sto| + |var|enter| × |rcl| × |var| ÷ |‘|2|’| ÷ |
|var| [23] C/CE

Execution: |A_1 exec|A_2 exec|u_1 exec|g exec|

IDEAL PRESSURE RISE IN A DIFFUSER

$$\Delta p = \frac{1}{2}\rho u^2\left(1 - \left(\frac{A_1}{A^2}\right)^2\right) \qquad A = \text{area}$$

Program: B/E |enter|var| ÷ | × | − |‘|1|’| ÷ |sto| + |var|enter| × |var| × |rcl| × |‘|2|’| ÷ |
|var| [23] C/CE

Execution: |A_1 exec|A_2 exec|u_1 exec|ρ exec|

USEFUL NON DIMENSIONAL GROUP: FROUDE NO. $= \frac{u}{\sqrt{gh}}$

Program: B/E |enter|⁶|9|8|1|⁹| × |⁶|1|0|0|⁹| ÷ |√x|var| ÷ | ÷ |var| [18] C/CE

Execution: |h exec|u exec|

u = velocity
h = depth of flow

WAVE VELOCITY FOR INFINITESIMAL DISTURBANCE

$C = \sqrt{gh}$

Program: B/E |enter|⁶|9|8|1|⁹| × |⁶|1|0|0|⁹| ÷ |√x|var| [15] C/CE

Execution: |h exec|

SPEED OF FLOW DOWN CHANNEL OF CONSTANT L/S AREA

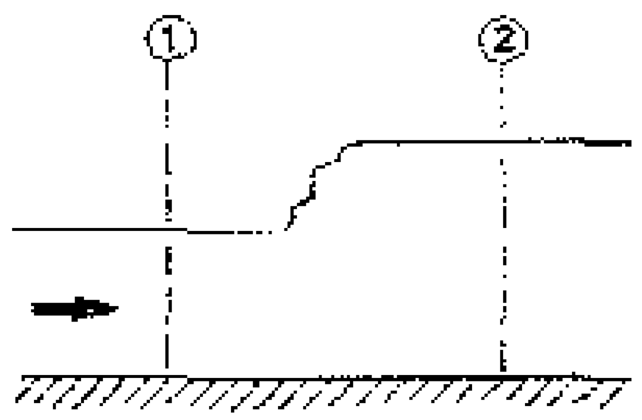
$$u = \frac{2g}{C_F}\sqrt{m \sin\theta}$$

$m = \frac{\text{area}}{\text{wetted perimeter}}$
C_f = skin friction coeff.
θ = angle of channel to horizontal

Program: B/E |enter|sin|var| × |√x|var| ÷ |⁶|1|9|6|2|⁹| × |⁶|1|0|0|⁹| ÷ |var| [21] C/CE

Execution: |θ exec|m exec|C_f exec|

HYDRAULIC JUMP



$$F_1^2 = \frac{h_2(h_1 + h_2)}{2h_1^2} \quad \text{(i)}$$

F = froude no.
h = depth of flow

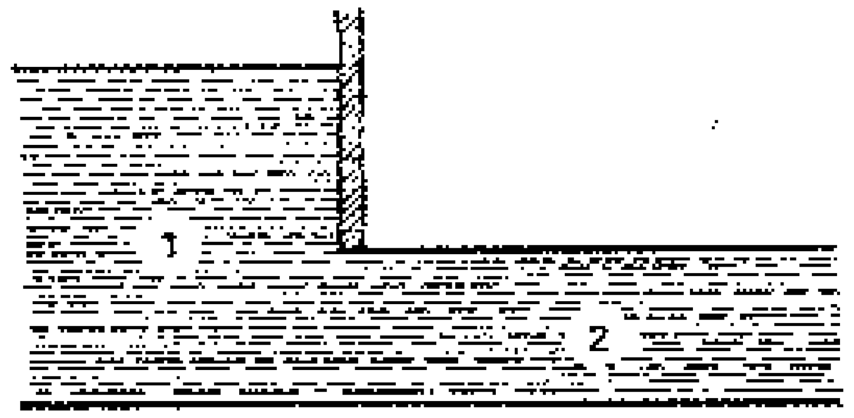
$$F_2^2 = \frac{h_1(h_1 + h_2)}{2h_2^2} \quad \text{(ii)}$$

Program: B/E |enter|var| ÷ |sto| + | × |rcl| + |⁶|2|⁹| ÷ |var| [13] C/CE

Execution: (i) |h_2 exec|h_1 exec|

(ii) |h_1 exec|h_2 exec|

SLUICE GATE



$$F_2^2 = \frac{u_2^2}{gh_2} \qquad \text{(i)}$$

$$= \frac{2h_1^2}{h_2(_1 + h_2)} \qquad \text{(ii)}$$

Program: (i) B/E |enter| × |var| ÷ |‘|9|8|1|’| ÷ |‘|8|0|0|’| × |var| [17] C/CE

Execution: (i) |u_2 exec|h_2 exec|

Program: (ii) B/E |enter|var| ÷ |sto| + | × |rcl| + |‘|2|’| ÷ | ÷ |var| [14] C/CE

Execution: (ii) |h_2 exec|h_1 exec|

VENTURI CHANNEL

$$Q = B_t\left(\frac{8}{27}\, gH^3\right)^{1/2}$$

B_t = throat width
H = depth at throat
Q = volume flow rate

Program: B/E |enter|sto| + | × |rcl| × |var| × |‘|8|’| × |‘|2|7|’| ÷ |$\sqrt{x}$|var| × |var| [21] C/CE

Execution: |H exec|g exec|B_t exec|

TOTAL CONDITIONS

$$h_o = h + \tfrac{1}{2}u^2 \qquad \text{(i)}$$

$$p_o = p + \tfrac{1}{2}u^2 \qquad \text{(ii)}$$

$$T_o = T + \tfrac{1}{2}\frac{u^2}{Cp} \qquad \text{(iii)}$$

h_o = stagnation enthalpy
p_o = stagnation pressure
T_o = stagnation temperature
h = static enthalpy
p = static pressure
T = static temperature
u = fluid velocity
Cp = specific heat at constant pressure

Program: (i), (ii) B/E |enter| × |‘|2|’| ÷ |var| + |var| [9]

(iii) B/E |enter| × |‘|2|’| ÷ |var| ÷ |var| + |var| [11] C/CE

Execution: (i) |u exec|h exec|

(ii) |u exec|p exec|

(iii) |u exec|C_p exec|T exec|

MACH NUMBER $= \mathrm{M} = \frac{v}{a}$

v = gas velocity
a = speed of sound in the gas

VELOCITY OF SOUND $= \sqrt{\frac{\gamma p}{\rho}}$ (i) } for a perfect gas

$= \sqrt{\gamma R T}$ (ii) } for a perfect gas

$= 20.03\sqrt{T}$ (iii) *IN AIR*

Program: (i) B/E |enter|var| × |var| ÷ |√x|var| [7]

(ii) B/E |enter|var| × |var| × |√x|var| [7] C/CE

(iii) B/E |enter|√x|❛|2|0|0|3|❜| × |❛|1|0|0|❜| ÷ |var| [16] C/CE

Execution: (i) |γ exec|p exec|ρ exec|

(ii) |γ exec|R exec|T exec|

(iii) |T exec|

γ = ratio of specific heats
p = pressure
ρ = density
T = absolute temp.
R = gas constant

COMPRESSIBLE FLOW

PERFECT GAS RELATIONSHIPS

$$\frac{T_o}{T} = \left(1 + \frac{\gamma - 1}{2} M^2\right)$$

Program: B/E |enter| × |❛|2|❜| ÷ |sto| + |var|enter|❛|1|❜| − |rcl| × |❛|1|❜| + |var| [21] C/CE

Execution: |M exec|γ exec|

$$\frac{p_o}{p} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{\frac{\gamma-1}{\gamma}}$$

Program: B/E |enter| × |❛|2|❜| ÷ |sto| + |var|enter|❛|1|❜| − |rcl| × |var| + |log|var| × |antilog|
|var| [23] C/CE

Execution: |M exec|γ exec|1 exec|$\frac{\gamma-1}{\gamma}$ exec| For $\gamma = 1.4$ $\frac{\gamma-1}{\gamma} = 0.2857$

$$\frac{I_o}{I} = \left(1 + \frac{\gamma - 1}{2} M^2\right)^{-(\gamma-1)}$$

Program: B/E |enter| × |❛|2|❜| ÷ |sto| + |var|enter|❛|1|❜| − |rcl| × |var| + |log| − |var| × |
|antilog|var [24] C/CE

Execution: |M exec|γ exec|1 exec|$(\gamma - 1)$ exec|

VORTICES

FLOW WITH CIRCULAR STREAMLINES

$$\frac{dp}{dv} = \frac{\rho u^2}{R}$$

Program: B/E |enter| × |var| × |var| ÷ |var| [7] C/CE

Execution: |u exec|ρ exec|R exec|

$\frac{dp}{dv}$ = variation of pressure with radius
u = velocity
R = radius of curvature

FREE VORTEX

ur = const.

Shape of face surface $z - z_o = \frac{u_o^2}{2g}\left[1 - \left(\frac{r_o}{r}\right)^2\right]$

Program: B/E |enter|var| ÷| × | − |⁽|1|⁾| + |sto| + |var|enter| × |var| ÷ |⁽|2|⁾| ÷ |rcl| × |var| [23] C/CE

Execution: |r_o exec|r exec|u_o exec|g exec|

FORCED VORTEX

wr = u

Shape of face surface $z - z_o = \frac{w^2}{2g} \quad (r^2 + r_o^2)$

Program: B/E |enter| × |sto| + |var|enter| × |rcl| − |var| ÷ |⁽|2|⁾| ÷ |sto| + |var|enter| × |rcl| | × |var| [23] C/CE

Execution: |r_o exec|r exec|g exec|w exec|

GENERAL

REYNOLDS NUMBER $= \frac{\rho v l}{\mu}$

ρ = density
v = velocity
l = length
μ = viscosity

Program: B/E |enter|var| × |var| × |var| ÷ |var| [8] C/CE

Execution: |ρ exec|v exec|l exec|μ exec|

SKIN FRICTION COEFFICIENT $- C_f = \frac{\tau w}{\frac{1}{2}\rho U_m^2}$

Program: B/E |enter| × |var| × |⁽|2|⁾| ÷ |var| ÷ | ÷ |var| [12] C/CE

Execution: |U_m exec|ρ exec|τw exec|

τw = wall shear stress
U_m = mean velocity

ATOMIC PHYSICS

$$E = h\upsilon$$

E = energy
h = planks constant
υ = frequency

Program: B/E |enter|var|×|var| [4] C/CE

Execution: |h exec|υ exec|

DE BROGLIE – wave/particle duality

$$\lambda = \frac{h}{m\upsilon}$$

λ = wavelength
h = planks constant
m = mass
υ = velocity

Program: B/E |enter|var|÷|var|÷|var| [6] C/CE

Execution: |h exec|m exec|υ exec|

ENERGY GIVEN OUT IN ELECTRON ORBITAL CHANGES

$$E = -13.5\, z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

z = atomic No.
n = quantum No.

Program: B/E |enter|×|÷|sto|+|var|enter|×|÷|rcl|−|sto|
|+|var|enter|×|rcl|×|var|×|var| [21] C/CE

Execution: |n_1 exec|n_2 exec|z exec|13.5 exec|

MEAN FREE PATH = $\dfrac{1}{\sqrt{2\pi d^2 n}}$

d = molecule diameter
n = No. molecules/vol.

Program: B/E |enter|×|var|×|^{6}|7|1|0|^{9}|×|^{6}|1|1|3|^{9}|÷|$\sqrt{x}$|÷|var| [19] CC/E

Execution: | d exec| n exec|

KINETIC THEORY OF GASES

$$pv = \tfrac{1}{3}mN\overline{c^2}$$

$$p = \tfrac{1}{3}m\frac{N\overline{c^2}}{v} \qquad (i)$$

$$= \tfrac{1}{3}\rho\overline{c^2} \qquad (ii)$$

p = pressure
v = volume
m — mass of molecule
N = No. molecules
$\overline{c^2}$ = mean square velocity

Program: (i) B/E |enter|var|÷|var|×|var|×|⁶|3|⁹|÷|var| [12] C/CE

Execution: |$\overline{c^2}$ exec| v exec|N exec|m exec|

Program: (ii) B/E |enter|var|×|⁶|3|⁹|÷|var| [8] C/CE

Execution: |$\overline{c^2}$ exec|ρ exec|

TRANSPORT PROPERTIES

THERMAL CONDUCTIVITY

$$k = \tfrac{1}{3}\rho\bar{c}\lambda\, Cv$$

λ = mean free path
$\bar{c}$ = Root mean square vel.
Cv = specific heat capacity at constant volume.

Program: B/E |enter|var|×|var|×|var|×|⁶|3|⁹|÷|var| [12] C/CE

Execution: |ρ exec|$\bar{c}$ exec|λ exec|Cv exec|

VISCOSITY

$$\mu = \tfrac{1}{3}\rho\bar{c}\lambda$$

Program: B/E |enter|var|×|var|×|⁶|3|⁹|÷|var| [10] C/CE

Execution: |ρ exec|$\bar{c}$ exec|λ exec|

DIFFUSIVITY

$$D = \tfrac{1}{3}\bar{c}\lambda$$

Program: B/E |enter|var|×|⁶|3|⁹|÷|var| [8] C/CE

Execution: |$\bar{c}$ exec|λ exec|

FORCE BETWEEN ATOMS IN IONIC BOND

$$F = \frac{q^2}{4\pi\varepsilon r^2}$$

ε = permitivity
q = charge
r = distance

Program: B/E |enter|var|÷|×|var|÷|‘|1|4|2|0|’|÷|‘|1|1|3|’|×|var| [20] C/CE

Execution: |q exec|r exec|ε exec|

ELASTIC PROPERTIES

$$E = 2G(1+v)$$

E = Youngs mod
G = rigidity mod
v = Poissons ratio

Program: B/E |enter|‘|1|’|+|var|×|‘|2|’|×|var| [12] C/CE

Execution: |v exec|G exec|

$$E = 3k(1-2v)$$

k = bulk mod

Program: B/E |enter|‘|2|’|×|–|‘|1|’|+|var|×|‘|3|’|×|var| [17] C/CE

Execution: |v exec|k exec|

$$E = \frac{9Gk}{G+3k}$$

Program: B/E |sto|enter|‘|3|’|×|var|+|x–m|+|‘|9|’|×|var|×|rcl|÷|var| [19] C/CE

Execution: |k exec|G exec|G exec|

STRESSES AND STRAINS

σ_n = nominal stress
F = force applied
A_0 = initial area
ε_n = nominal strain = $\frac{l-l_0}{l_0}$

TRUE STRESS $\sigma_t = \sigma_n(1+\varepsilon_n)$ $\qquad \sigma_n = \frac{F}{A_0}$

Program: B/E |enter|‘|1|’|+|var|×|var| [8] C/CE

Execution: |ε_n exec|σ_n exec|

TRUE STRAIN = log $(1+\varepsilon_n)$

Program: B/E |enter|‘|1|’|+|log|‘|1|7|5|’|×|‘|7|6|’|÷|var| [18] C/CE

Execution: |ε_n exec|

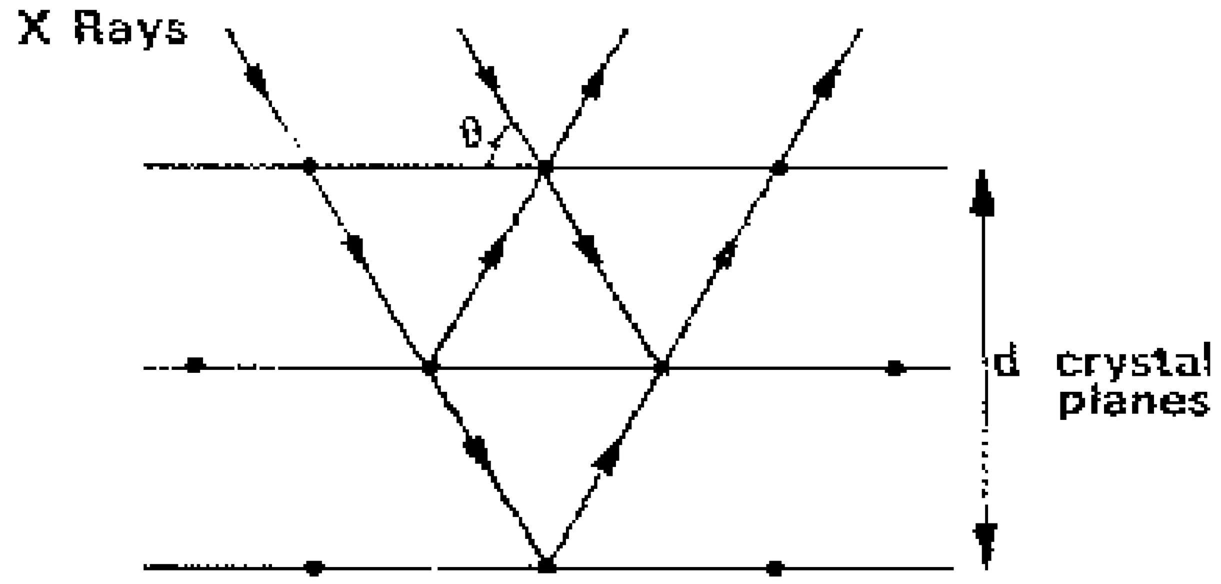
ELASTIC STRAIN ENERGY = $\frac{1}{2}\frac{\sigma^2}{E}$

σ = stress (nominal)

Program: B/E |enter|×|var|÷|‘|2|’|÷|var| [9] C/CE

Execution: |σ exec|E exec|

BRAGGS LAW OF X-RAY DIFFRACTION



$$d = \frac{n\lambda}{2\sin\theta}$$

n = integer
λ = wavelength

Program: B/E |enter|sin|‘|2|’|×|sto|+|var|enter|var|×|rcl|÷|var| [15] C/CE

Execution: |θ exec|λ exec|n exec|

DISLOCATIONS

STRAIN ENERGY/LENGTH

FOR SCREW $= Gb^2$ (i)

EDGE $= \frac{Gb^2}{1-v}$ (ii)

b = Burgers vector
G = rigidity modulus
v = Poissons ratio

Program: (i) B/E |enter|×|var|×|var| [5] C/CE

Execution: |b exec|G exec|

Program: (ii) B/E |enter|−|‘|1|’|+|sto|+|var|enter|×|var|×|rcl|÷|var| [16] C/CE

Execution: |v exec|b exec|G exec|

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THERMODYNAMICS

FLUID MECHANICS

MATERIALS

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