Engineering Fundamentals Review

Manual

HP49G

CHOTKEH

Engineering Fundamentals Review

Manual

HP49G

Eit-FE Review Software Package
Version (6.1)

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ABOUT THE MANUAL AND CALCULATOR

This is a two (2) part manual and contains over 900 core engineering fundamental equations all of which are programmed into the Library of HP49G.

Part 1: Is the original reference manual containing over 500 equations, SECTION 1 - 8:

Part 2: Is the quick reference to NCEES HANDBOOK. Most of the 400 core useable and programmable equations are programmed into the calculator. SECTION 9.

HOW TO USE THE CALCULATOR:
When using this software package, ensure that the calculator is in **RPN** and **DEG** mode.

1. The key board:
There are three (3) types of distinctive function keys in HP49G:

1.1 The hard keys with their functions showed on the face of the keys. They are activated by pressing the key. Throughout this manual, they are identified by bold letters and underlined, like **ON**, **ENTER**, **NXT**, **SIN**, **TOOL**, **MODE**, etc.

1.2 The same hard keys with their colored functions showed at the top of the keys. To activate the function, the corresponding color coded ↰ or ↱ must be pressed prior to the subject key. They are identified by underlined symbols (not bold), like LIB, EVAL, PREV, MATH, MTRW, etc.

1.3 The soft keys or screen menu keys. There are six (6), F1-F6, keys located just below the screen. To activate the menu item, press the corresponding F key. The screen menu items (Directories, Sub-directories and Equation's name) are identified with plain capital letters (no bold no underline), like PUMP, PIPE, FLME, EXPR=, THER, etc.

2. Useful keys and their functions:
The user must ensure to use the implied ↰ or ↱ key, as needed. Numbers in parenthesis (next to the following specified keys) represent the calculator key-board's row and column respectively. For more information refer to Chapter 1 of HP catalog.

ALPHA (7,1) Use to turn the calculator to alphabetical mode. If the key pressed twice, the calculator will stay in this mode. Press again when typing is finished. The key may also be pressed and hold during the typing. Then release when typing is over.

ANS (10,5) To recall the previous answer (in **ALG** mode) or last argument (in **RPN** mode).

BASE (9,4) To display the list of binary arithmetic objects.

ABOUT THE MANUAL AND CALCULATOR

CANCEL (10,1) To cancel the command line.

CLEAR (4,5) To clear the screen. This symbol is only underlined, means the corresponding ↱ key must be pressed first.

CMD (4,1) To display the last four (4) commands/calculations. Highlight and press OK to copy to stack.

DEL (5,5) To delete the object on level 1.

EVAL (4,4) To evaluate an expression, written on level 1.

ENTER (10,5) To obtain a result, select an option or duplicate the object on level 1 (**RPN** mode).

EXPR= This appears on the screen menu, when solving an equation or expression. It is used to calculate the expression. EXPR= is the last symbol on the screen menu. If it does not appear on the first page of the menu, there may be more than six (6) variables in the current equation.

Press **NXT** to ensure no variable is missing.

LASTARG At **RPN** mode, press ANS or type **LASTARG** press **ENTER**.

LAST MENU To get only one (1) step back and forth between the menus, press ↰ and hold, press PREV (**XXT**).

LIB (9,3) To get to the Library to use the Library program.

MODE (2,2) To set the mode like: **RPN/ALGEBRAIC, DEGREE/RADIAN, POLAR/RECTANGULAR, FLAGS, CAS** (Computer Algebra System), etc.

MTH (4,4) To display the mathematics menu.

MTRW (4,3) To write a matrix.

NUM To find the numeric value of the answer/object.

NUM.SLV (7,2) To get to numeric equation solver application.

NXEQ To rotate the list of related equations written under one name. The name of these equations are followed by → .

NXT (3,3) To go to the next page of multiple page screen menu.

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OFF (10,1)	To turn the calculator off.
ON (10,1)	To turn the calculator on.
PREV (3,3)	To return back to the previous page of screen menu.
SPC (10,4)	To create space between the keyed-in data.
STO (3,2)	To store a current object in a variable.
SWAP	At **RPN** mode: press **TOOL**, **F3** (STACK), **F2** (SWAP)
TOOL (2,3)	To display a menu of commands like: EDIT, VIEW, PURGE, etc.
UPDIR (3,1)	To get back to one (1) level higher directory.
UNITS (8,4)	To go to units conversion menu.
VAR (3,1)	To display the list of variables contained in the current directory.
WIN (1,2)	To display plotting parameters and draw the specific plot.
Y = (1,1)	To list the equation(s) and data to plot.
( ) (8,5)	Use to identify/enter the value as a complex number. The real and the imaginary part must be separated by "**comma**" or "**SPC**". When writing the expression, use "**comma**" only. But you may use either of them when entering components of complex numbers inside parenthesis.
' (4,3)	The inverted comma as ' '. Use to write an expression or equation (in **RPN** mode). Also use to specify the equation or variables name.
# (9,4)	To specify/enter a binary integer.
⇐ (4,5)	To delete the object on level 1 (drop) or to delete the character to the left of cursor.
∡	The symbol of angle, to retrieve, press CHARS (4,2), highlight the symbol, press ECHO **ENTER.** Or press **ALPHA** ↱ 6.

ABOUT THE MANUAL AND CALCULATOR

3. How to identify the name, retrieve, and solve the equation:

3.1 In the solution part of every problem, in Problems and Solutions Book, following statement is used to refer to the subject equation, i.e. Hazen Williams (HAZN) equation, in SI system. " Refer to equation (20) **SI** (FLME/FRICH/HAZN)" (20) is the number of equation in CHOTKEH manual, SI is the SI system, FLME is the main directory for Fluid Mechanic. FRICH is the sub-directory for friction head and HAZN is the name of the equation. Therefore after getting to LIB, press FLME FRICH HAZN SI. Now, by knowing what to look for, get to the Library (LIB).

3.2 Press LIB To get to the Library. You should see the menu on the screen.

3.3 Look up for the subject directory on the screen menu. You have to go to the subject directory first. If not found, press **NXT**. When found, press the corresponding F key.

3.4 Follow the same instruction for sub-directory(s). In few occasions there are more than three (3) sub-directories prior to equation's name.

3.5 Find the **equation/expression** name and press the corresponding soft key. The equations with their names followed by → , contain more than one equation. See NXEQ in page 2.

3.6 You should see the equation's variables listed on the screen menu and the equation, in whole or in part, at the top of the screen. If there are more than six (6) variables in the equation, press **NXT** to see the rest.

3.7 The "EXPR=" symbol is the last on the screen menu. If the equation has more than five (5) variables, press **NXT**.

NOTE: Throughout the CHOTKEH Manual, the equation's **directory/sub-directory** names are shown in parenthesis at the right side of the subject's title.

3.8 Enter the variable's value: Key in the value and press the corresponding variable's F key. You should see the variables symbol and its entered value at the top of the screen. If not correct, enter the correct value again. When finished, press ↰ and unknown variable's F key. The answer will appear.

The holders of HP49G may also use the solver's screen feature. Press ↱ NUMSLV **ENTER**. Highlight the variables and input the values. Then highlight the unknown variable and press SOLVE key. If the known variable's value needed to be calculated or unit conversion feature must be used, the user must quit the screen and get back, when the calculation or conversion was performed. This is a time consuming process. Press ON (CANCEL) to quit the screen.

ABOUT THE MANUAL AND CALCULATOR

IMPORTANT NOTE: For the equations with complex numbers, which are programmed in the expression form (only in ELECTRICITY SECTION), you will not find the unknown's symbol on the screen. To get the answer, you have to press EXPR= (on the screen menu) and then NUM, if necessary.

3.9 If you have to retrieve another equation in the same sub-directory, type **0MENU** press **ENTER** and continue as directed above. Otherwise press LIB for other directories.

3.10 After you retrieved the equation, if you observed any inconsistency between the variables in the equation and the ones on the screen menu, first ensure that you retrieved the right equation. If the answer is yes, refer to NOTE 3 below.

NOTE 1:

Except for the complex number contained equations/expressions, every equation can be solved for **any variable in the equation**, if the rest are known.

NOTE 2:

When using CHOTKEH's Library software, stay in HOME directory. If you are using you own created equations, with the units attached to the variables, a new directory must be created and subject equations must be stored in new directory.

To create a new directory, i.e. **AAA**:

Press ' type AAA, press PRG (4,2) MEM DIR CRDIR

Press **VAR**, AAA will appear on the screen menu. Press the corresponding soft (F) key, the { HOME AAA } will appear at the top of the screen, which means that the calculator is in AAA directory. Use AAA to write your own equations in this directory. To get back to HOME, press UPDIR.

NOTE 3:

Do not enter the variable's value accompanied with the unit sign, i.e. for L=2 feet, enter 2 not 2_ft. This may happen when using calculator's UNITS conversion feature. The variables' value must all be numeric and consistent. If by error the values are followed by unit signs or the values are represented by an expression, etc., you may get the "**Bad Guess**" error message or may lose the variable's name on the menu. If that happened:

a. Purge the variable: press ' type **variable's name** press **ENTER** **TOOL** F key under PURGE. If did not work:

b. Press **VAR** press **ALPHA** twice type CLVAR press **ENTER**. This process will purge all variables in the current directory.

NOTE 4:

Although enough care has been taken in compiling the contents of this Manual, writing the programs, and problems and solutions, mostly for educational purposes, the preparer assumes no responsibility resulting from any error or omission in this manual, program, or problems and solutions. The contents of this manual and the associated program are subject to change without prior notice.

FREQUENTLY ASKED QUESTIONS, HP49G

1. The screen is too dark/light, how do I adjust it?
Press the ON key and hold. Push the (+) or (-) key to adjust the shade of the screen.

2. How do I set the calculator to, i.e., three (3) decimal point?
Press **MODE** ▼ CHOOS ▼ OK ▶ key in : 3 OK. To reverse:
Press **MODE** ▼ CHOOS ▲ OK OK.

3. How do I display the clock?
Press **MODE** DISP Scroll down to Clock *✓CHK* OK OK

4. How do I turn the calculator's beeper off?
Press **MODE** Scroll down to Beep *✓CHK* OK

5. How can I see the entire current equation?
Press the **ALPHA** key and hold, type EQ, release **ALPHA** key, press ENTER. Current equation will appear on the screen.

6. How can I get to the previous Menu?
You may go only one step back to the previous menu. Press ↰ and hold, press PREV (**NXT**).

7. How can I SWAP the objects displayed on Level 1 and Level 2 of the screen?
At **RPN** mode, press **TOOL**, **F3** (STACK), **F2** (SWAP)

8. Although I am following the directions to solve for a variable, in the retrieved equation, why I am not getting the correct answer?
In the majority of cases, instead of pressing ↰ and soft key under the subject variable, the user is pressed EXPR=. Also check for the units and calculator mode, i.e. Radian vs Degree or Rectangular vs Polar, etc.

9. While using the program, what should I do if I notice the loss of a variable on the menu or getting error message?
Refer to CHOTKEH's Manual, page A-5, NOTEs 2 and 3 for answer. Then correct the condition as follows:

a. Purge the variable: key in ' type **variable's name** press **TOOL** PURGE. If did not work:
b. Press **ALPHA** twice, type CLVAR press **ENTER**. This process will purge all variables before the directory. If did not work:
c. Press **ON** **F1** **F6** keys simultaneously and release. Press soft key under NO. This will re-set the calculator and clears the entire memory. If you have any equation or Directory you want to keep. This is not a right approach.
   In this case, to get back to RPN, degree and MTH on the soft menu:
   Press **MODE** CHOOS RPN OK ▼ ▼ CHOOS degree OK FLAGS ▲ ▲ ▲ (highlight 117) *✓CHK* OK OK

10. Can I erase or change the data in the CHOTKEH program?
CHOTKEH's programs are built in the calculator, you may not erase it by mistake. Also resetting the calculator or removing the batteries shall not affect the program.

11. Am I allowed to use the HP49G in the examination site?
For permissibility, contact the State Board where you are registered to take the examination.

12. How do I obtain technical support for CHOTKEH products?
Upon the receipt of the package, fill out the Registration form and mail/facsimile to CHOTKEH. There is 120 days of free technical support for registered users. Facsimile your questions to (212)942-8105.

Thank you for purchasing CHOTKEH products.

EXAMPLES OF HP49G NUMERIC KEYBOARD CALCULATIONS

The following calculations are separately done in **RPN** and **ALG** modes. To get to these modes: Press **MODE** CHOOS, highlight **RPN** or **Algebraic**, press **F6** **F6**

Reverse Polish Notation (RPN)	**Algebraic (ALG)**
1. Calculate 13 x 96	
Key in: 13 **SPC** 96 × Answer: 1248	Key in: 13 × 96 **ENTER** Answer: 1248
2. Calculate $\frac{24}{1.5}$	
Key in: 24 **SPC** 1.5 ÷ Answer: 16	Key in: 24 ÷ 1.5 **ENTER** Answer: 16
3. Calculate 13 x 96 + 12	
Key in: 13 **SPC** 96 × 12 + Answer: 1260	Key in: 13 × 96 + 12 **ENTER** Answer: 1260
4. Calculate 2.5^4	
Key in: 2.5 **SPC** 4 y^x Answer: 39.0625	Key in: 2.5 y^x 4 **ENTER** Answer: 39.0625
5. Calculate 3.6^{-4}	
Key in: 3.6 **SPC** 4 +/- y^x Answer: 5.9537E-3	Key in: 3.6 y^x 4 +/- **ENTER** Answer: 5.9537E-3
6. Calculate 1/25	
Key in: 25 **1/X** Answer: .04	Key in: **1/X** 25 **ENTER** Answer: .04
7. Calculate $\sqrt{75}+\frac{1}{2.5^2}$	
Key in: 75 $\sqrt{x}$ 2.5 x^2 1/x + Answer: 8.82	'Key in: $\sqrt{x}$ 75 + 1 ÷ 2.5 y^x 2 **ENTER** Answer: 8.82

SAMPLES OF HP49G NUMERIC KEYBOARD CALCULATIONS

Reverse Polish Notation (RPN)	Algebraic (ALG)
8. Calculate $\sqrt{17^3-16^{2.5}}$	
Key in: `17` ***SPC*** `3` y^x `16` ***SPC*** `2.5` y^x `-` $\sqrt{x}$ Answer: 62.36	Key in: $\sqrt{x}$ `( )` `17` y^x `3 - 16` y^x `2.5` **ENTER** Answer: 62.36
9. Calculate $\sqrt{\frac{13^2-16^{1.5}}{(2.5+2)^2}}$	
Key in: `13` ***SPC*** `2` y^x `16` ***SPC*** `1.5` y^x `-` `2.5` ***SPC*** `2 + 2` y^x `+` $\sqrt{x}$ Answer: 2.28	**Key in:** $\sqrt{x}$ `( ) ( )` `13` y^x `2 - 16` y^x `1.5` `▸ + ( ) 2.5 + 2 ▸` y^x `2` **ENTER** Answer: 2.28
10. Given a voltage `(210, ∠0)` and current `(11, ∠15)` calculate the complex impedance.	
At **POLAR**: Key in: `( ) 210 ∠ 0 ▸` ***SPC*** `( ) 11 ∠ 15 ÷` Answer: (19.09, ∠-15)	At **POLAR**: Key in: `( ) 210 ∠ 0 ▸ ÷ ( ) 11 ∠ 15` **ENTER** Answer: (19.09, ∠-15)
11. Calculate the Rectangular and Polar equivalent of two (2) impedances, `(15 +4 i)` and `(12, ∠-5)`, in parallel. Ze=1/(1/Z1 + 1/Z2)	
At **Rectangular**: `( ) 15` ***SPC*** `4` **1/x** `( ) 12 ∠ 5 +/-` **1/x** `+` **1/x** Answer: (6.86, 0.44) At **POLAR** Answer: **(6.87, ∠3.68)**	At **Rectangular**: Key in: `1 ÷ ( ) 1 ÷ ( ) 15 , 4 ▸ +` `1 ÷ ( ) 12 ∠ 5 +/-` **ENTER** Answer: (6.86, 0.44) At **POLAR** Answer: **(6.87, ∠3.68)** If angle **-5** did not work, enter **355** (360-5)

NOTE: To enter the symbol of angel (∠): Press **ALPHA** ↱ 6

To get to POLAR (*R∠Z*) mode, press **MODE**, highlight Coord System, press CHOOS, highlight Polar, press OK OK. When using POLAR, make sure calculator is in DEG mode, unless the given angle is in Radian.

SELECTED BUILT-IN FUNCTIONS
HP49G

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BINARY ARITHMETIC

Example (1): Convert Hexadecimal 56AB to Decimal base.

Press ↰ MTH BASE HEX. May also press ↱ BASE HEX
Press ↰ # **56** **ALPHA** **ALPHA** **A** **B** **ENTER**
Press DEC Answer: # 22187d

*****

Example (2): Display the same in Octal base
Press OCT Answer : # 53253o

*****

Example (3): Display the same in Binary base
Press BIN Answer: # 101011010101011b

*****

Example (4): Divide the above answer by 10101b
At **RPN** mode: Press ↰ # 10101 ÷
At **ALG** mode: Press ÷ ↰ # 10101 **ENTER**
Answer: #10000100000b

COMBINATION

Example: Find combination (arrangement without order) (5,4)

At **RPN** mode: Press ↰ MTH NXT PROB
Type 5 SPC 4, pres COMB Answer: 5

At **ALG** mode: Press ↰ MTH **NXT** PROB
Press COMB, type 5, 4 **ENTER** Answer: 5

COMPLEX NUMBER

Example: Solve $\frac{(9+4i)+(-4+3i)}{(3+i)}$

At **RPN** mode:

Press: ' ( ) ( ) 9 , 4 ▸ + ( ) -4 , 3 ▸ ▸ ÷ ( ) 3 , 1

Press EVAL Answer: (2.2,1.6) or 2.2+1.6i

At **ALG** mode:

Press: ( ) ( ) 9 , 4 ▸ + ( ) -4 , 3 ▸ ▸ ÷ ( ) 3 , 1

Press **ENTER** Answer: (2.2,1.6) or 2.2+1.6i

DETERMINANT

Example: Solve $\begin{vmatrix} 1 & -1 & 4 \\ 2 & 11 & -3 \\ 6 & -7 & 10 \end{vmatrix}$

At RPN mode:

Press ↰ MTH MATRX NORM **NXT**. You should see DET on the screen Menu.

Press ↰ MTRW F5 (If necessary to make the GO with right arrow active.)

Key in 1 **SPC** -1 **SPC** 4 **ENTER** ▼ ↱ ◂

Key in 2 **SPC** 11 **SPC** -3 **ENTER**

Key in 6 **SPC** -7 **SPC** 10 **ENTER** **ENTER**

Press DET Answer: -193

ELECTRIC CIRCUITS

Example: For **(10, ∡ 0)** volt and **(2, ∡ 30)** amps: calculate the impedance.

At **RPN**, **DEG**, and **POLAR** mode:

Press: ' ( ) 10 , **ALPHA** ▸ 6 0 ▸ ÷ ( ) 2 , **ALPHA** ▸ 6 30 EVAL:

Answer: (**5, ∡-30**)

At **RPN**, **DEG**, and **RECT** mode:

Answer: (4.33, -2.5)

EXPRESSION

Example: Solve: $2^{(1.1*1.6)}+LOG22+1^{2.5}\sqrt{7}*SIN50$

At **RPN** and **DEG** mode: Press:

' 2 y^x ↰ () 1.1×1.6 ▸ + ↱ *LOG* (22) ▸ + ↱ $\sqrt{x}$ 2.5 → , 7 ▸ × *SIN* 50

Press EVAL — Answer: 6.3978

At **ALG** and **DEG** mode: Press:

2 y^x ↰ () 1.1×1.6 ▸ + ↱ *LOG* (22) ▸ + ↱ $\sqrt{x}$ 2.5 → , 7 ▸ × *SIN* 50

Press **ENTER** — Answer: 6.3978

FACTORIAL

Example: Solve 5!

At **RPN** mode: Press: ↰ MTH **NXT** PROB 5 !

Answer: 120

At **ALG** mode: Press: ↰ MTH **NXT** PROB 5 ! **ENTER**

Answer: 120

LINEAR (SIMULTANEOUS) EQUATIONS

Example: Solve

$2x+4y+z=9$
$-x-3y-z=-8$
$3x-y+z=-2$

for x, y, z

At **RPN** mode: Press ↰ MTRW

Key in 9 **SPC** -8 **SPC** -2 **ENTER** **ENTER**

Press ↰ MTRW F5 (If necessary to make the GO with right arrow active.)

Key in 2 **SPC** 4 **SPC** 1 **ENTER** ▼ ↱ ◂

Key in -1 **SPC** -3 **SPC** -1 **ENTER**

Key in 3 **SPC** -1 **SPC** 1 **ENTER** **ENTER**

Press ÷ — Answer: x=-1, y=2, z=3

PERMUTATION

Example: Find Permutation (arrangement with order) (5,4)

At **RPN** mode: Press ↰ MTH **NXT** PROB

Type 5 **SPC** 4, press PERM Answer: 120

At **ALG** mode: Press ↰ MTH **NXT** PROB

pres PERM, type 5, 4 **ENTER** Answer: 120

PLOTTING

Example: Plot x^2-2x-3 and find the roots. Calculator must be in **ALG** mode:

Press: ↰ Y= (F1) CLEAR ADD, key in $\boldsymbol{x^2-2x-3}$ **ENTER**

Press: ERASE DRAW. The curve will appear

Press FCN ROOT, read the first root: Answer: Root = -1

Press **NXT** x to locate the cursor. Move the cursor to the right close to intersection with x axis. Press ROOT, read the second root: Answer: Root = 3

Press **ON** **ON**

QUADRATIC/POLYNOMIAL EQUATIONS

Example 1: Solve $2X^2+5X-12=0$ (Quadratic Equation)
Press ↱ NUMSLV ▼ ▼ OK, key in: [2 **SPC** 5 **SPC** -12] OK SOLVE **ENTER**
Answer: 1.5,-4

Example 2: Solve $X^2-9=0$ (Quadratic Equation)
Press ↱ NUMSLV ▼ ▼ OK, key in: [1 **SPC** 0 **SPC** -9] OK SOLVE **ENTER**
Answer: -3, 3

Example 2: Solve $3X^3-1.5X^2-12X+6=0$ (Polynomial Equation)
Press ↱ NUMSLV ▼ ▼ OK
Key in: [3 **SPC** -1.5 **SPC** -12 SPC 6] OK SOLVE **ENTER**
Answer: .5, -2, 2

TIME ARITHMETIC

To set the time and date: Press ↱ TIME, select 3 OK. Move the cursor and choose the options.

Example (1): Determine the date 49 days after 7/9/00

For time arithmetic, calculator must be in **RPN**, **Fixed 6** decimal and **M/D/Y** mode.

Press ↱ TIME, select Tools OK **NXT**. Key in 7.092000 **ENTER**

Key in 49 press DATE+ Answer: 08.272000 or 8/27/00

Example (2): Calculate number of days between 7/9/00 and 8/27/00

Press ↱ TIME, select Tools OK **NXT**. Key in 7.092000 **ENTER**

Key in 8.272000 press DDAYS Answer: 49 days

UNIT CONVERSION

For unit conversion application, calculator must be in **RPN** mode.

Following is the UNITS catalog menu which converts to built-in units.

Press ↱ UNITS to reach to the menu:

TOOLS LENG AREA VOL TIME SPEED press **NXT**

MASS FORCE ENRG POWR PRESS TEMP press **NXT**

ELEC ANGL LIGHT RAD VISC

Example (1): Find equivalent of 8 gallon in cubic feet.

Press ↱ UNITS VOL **NXT** 8 gal PREV

Press ↰ ft^3 Answer: 1.069 ft^3

Example (2): Calculate 1.5 yards + 2.5 feet + 3 inches.

Press ↱ UNITS LENG 1.5 yd 2.5 ft 3 in

Press + + Answer (1): 87_in

Press ↰ ft Answer (2): 7.25_ft

Press ↰ yd Answer (3): 2.42_yd

<u>START UP</u>

<u>EIT-FE SOLVED PROBLEMS</u>

<u>HP49G</u>

Before practicing, please read pages A-1 through A-5 of CHOTKEH's Manual

GENERAL NOTE: The entire program is stored in the calculator's library, therefore, first, get to the library by pressing ↱ LIB. Calculator in **RPN** mode (No **ALG** on top of screen)

****

1- The repayment of a $100,000 loan during a 30 year period based on equal end-of-the-year installments, at an interest rate of 15% requires annual payments which is most nearly:

(A) $ 4,000

(B) 13,800

(C) 15,230

(D) 17,500

(E) 20,800

Solution:

This is an Engineering Economic (ENEC) problem. Refer to page 3-4 for Mortgage.

The ID **NAME** for installment is equation (30) **INSTL** (ENEC/MORT):

Select LIB, Press ENEC **NXT** MORT INSTL. Enter values for variables:

Enter .15 for **I**; 30 for **n**; 100000 for **LOAN**

Press ↰ INSTL — Answer: **INSTL = 15230** (C)

****

2- A 2" diameter shaft is subject to a torque equal to 10,000 in-lbf. The shearing stress due to torsion is nearly:

(A) 0 psi

(B) 6370 psi

(C) 7650 psi

(D) 12770 psi

(E) 15900 psi

Solution:

This is a Mechanics of Material (MEMA) problem. Refer to page 7-1 for stress in the shaft.

The ID **NAME** for Sheer Stress, in a solid round shaft, is equation (11) **SOLID** (MEMA/SHAFT/SHEAR):

Select LIB, Press **NXT** MEMA SHAFT SHEAR SOLID

Enter 10000 for **T**; 1 for **r**

Press ↰ τ — Answer: τ **=6366** psi (B)

<u>GENERAL NOTE:</u> The entire program is stored in the calculator's library, therefore, first, get to the library by pressing ↱ <u>LIB</u>. Calculator in **RPN** mode (No **ALG** on top of screen)

****

3- If the interest rate is 12% compounded monthly, the effective rate per annum is most nearly:

(A) 12.00%

(B) 12.12%

(C) 12.34%

(D) 12.68%

(E) 12.96%

<u>Solution:</u>

This is an Engineering Economic (ENEC) problem. Refer to page 3-3 for Interest.

The ID <u>**NAME**</u> for Effective Interest Rate is equation (27) **EFFEC** (ENEC/INTER)

Select <u>LIB</u>, Press ENEC INTER EFFEC

Enter .12 for **I**; 12 for **m**

Press ↰ iEF   <u>Answer: **iEF=.1268** (D)</u>

****

4- What is the maximum efficiency of a Carnot cycle operating between temperatures of 980 oF and 500 oF

(A) 33%

(B) 50%

(C) 67%

(D) 75%

(E) 100%

<u>Solution:</u>

This is a Thermodynamics (THER) problem. Refer to page 8-2 for efficiency equations.

The ID <u>NAME</u> for Carnot Efficiency, with the given temperatures, is equation (15) **TEMP** (THER/EFFI/CARN)

Select <u>LIB</u>, Press <u>**NXT**</u> THER EFFI CARN TEMP. Enter values for variables.

Key in ' 980+460 <u>EVAL</u>=1440, enter for **Th**; ' 500+460 <u>EVAL</u>=960 enetr for **Tl**

Press ↰ **η**   <u>Answer: **η** =.333 or 33% (A)</u>

GENERAL NOTE: The entire program is stored in the calculator's library, therefore, first, get to the library by pressing ↱ LIB. Calculator in **RPN** mode (No **ALG** on top of screen)

****

5- Evaluate the following determinant:

$$y = \begin{vmatrix} 3 & 1 & -1 \\ 4 & -2 & 0 \\ 2 & 1 & 4 \end{vmatrix}$$

The answer is more nearly:

(A) 33

(B) 121

(C) -48

(D) 77

(F) -11

Solution:

This is a built-in function and shall be calculated as follows:

Press ↰ MTRW F5 (If necessary to make the "GO" with the right arrow active.

Key in 3 **SPC** 1 **SPC** -1 **ENTER** ▼ ↱ ◄

Key in 4 **SPC** -2 **SPC** 0 **ENTER**

Key in 2 **SPC** 1 **SPC** 4 **ENTER** **ENTER**

Press ↰ MTH MATRX NORM **NXT** DET Answer: **-48** (C)

****

6- What input horsepower required for a pump with 80% efficiency, inlet pressure of 10 psia, outlet pressure of 20 psig, and a flow of 5 cfs of water? Assume sea level condition.

(A) 2.90 hp

(B) 10.40 hp

(C) 14.00 hp

(D) 25.00 hp

(E) 40.00 hp

Solution:

This is a Fluid Mechanics (FLME) problem with specific equations in English and SI Systems.

Refer to FLUID MECHANIC SECTION, page 4-6 for pumps.

The ID **NAME** for **hp**, with the flow in cfs in English system, is equation (71) **CFS** (FLME/PUMP/HP/ENG):

Select LIB, Press FLME **NXT** PUMP HP ENG CFS. Enter the values

Press ' ↰ ( ) 20+14.7-10 ► *144/62.4 **EVAL** = 57, enter for **hA**; 5 for **cfs**; 62.4 for **ρ** , and .8 for **η**

Press ↰ hp Answer: **hp=40.4** (E)

<u>GENERAL NOTE:</u> The entire program is stored in the calculator's library, therefore, first, get to the library by pressing ↱ <u>LIB</u>. Calculator in **RPN** mode (No **ALG** on top of screen)

****

7- An industrial plant draws an average current of 600 amp. daily from a 3 phase, 440 volt, 60 HZ line, at a power factor of .75 lagging. If a condenser improved the power factor to .92 lagging, the new value of average daily current will be most nearly :

(A) 450 amp.
(B) 475 amp.
(C) 490 amp.
(D) 550 amp.
(E) 650 amp.

<u>Solution:</u>

This is an Electricity (ELEC) problem. Refer to gage 2-5 for power equations.
The ID <u>NAME</u> for three phase effective Power is equation (51) **3φ** (ELEC/POWR/EFEC):

Select <u>LIB</u>, Press ELEC <u>**NXT**</u> POWR EFEC 3φ. Enter values.
Enter 440 for **V**; 600 for **I**; .75 for **PF**; Press ↰ P
With the calculated power under old power factor; enter .92 for PF (new power factor)
Press ↰ I <u>Answer: **I=489** (C)</u>

****

8- Oil flows through a 6" diameter pipe at a rate of 150 gpm. Its viscosity is 0.001 pound-second per square foot, and its specific gravity is 0.8. Under these conditions, the Reynolds Number NR is most nearly:

(A) 1320
(B) 2000
(C) 3300
(D) 9900
(E) 12400

<u>Solution:</u>

This is a Fluid Mechanics (FLME) problem with specific equations in English and SI Systems.
Refer to FLUID MECHANIC SECTION, page 4-5 for pipes. Calculate the velocity first.
The ID <u>NAME</u> for velocity, flow in **gpm** in English system, is equation (60) **GPM** (FLME/PIPE/VELO/ENG):
Select <u>LIB</u>, Press FLME <u>**NXT**</u> PIPE VELO ENG GPM. Enter the values for variables.
Enter 150 for **gpm**; .5 for **D**; Press ↰ V <u>v=1.7 fps</u> (the value for **v** is stored in the calculator)
The ID <u>NAME</u> for Reynolds Number, with absolute viscosity, is equation (75) **ABSO** (FLME/REYN)
Select <u>LIB</u>, Press FLME <u>**NXT**</u> REYN ABSO. Enter the values.
Press ' 62.4x.8 <u>EVAL</u>= 49.92 for **ρ** ; .001 for **μ** ; 32.2 for **g** (values for **D** & **v** are stored before)
Press ↰ NRe <u>Answer **NRe=1319** (A)</u>

<u>GENERAL NOTE:</u> The entire program is stored in the calculator's library, therefore, first, get to the library by pressing ↦ <u>LIB</u>. Calculator in **RPN** mode (No **ALG** on top of screen)

****

9- A steel shaft 30" long an 2" in diameter is subjected to a torque equal to 60,000 in-lbf. If G is assumed to be 12EE6 psi, the angular rotation, in degree, at the end of the shaft is most near to:

(A) .7

(B) .11

(C) .56

(D) 5.70

(E) 45.00

<u>Solution:</u>

This is a Mechanics of Material (MEMA) problem. Refer to page 7-1 for angle of twist in the shaft.

The ID **<u>NAME</u>** for Angle of Twist, in solid bar is equation (06) **SOLID** (MEMA/SHAFT/ANGL)

Select <u>LIB</u>, Press **<u>NXT</u>** MEMA SHAFT ANGLE SOLID

Enter 60000 for **T**; 30 for **L**; 12E6 for **G**; 1 for **r**

Press ↰ **Ω** <u>Answer: **Ω =5.47** (D)</u>

****

10- Air is compressed in a frictionless manner with no transfer of heat from a condition of 70 oF and 14.7 psia to 1000 psia. What is the resulting air temperature in degree Fahrenheit?

(A) 70

(B) 234

(C) 990

(D) 1310

(E) 10340

<u>Solution:</u>

This is a Gas Properties (GASP) problem. Refer to page 5-3 for isentropic process.

The ID <u>NAME</u> for temperature, with the given pressure, is equation (27) ***ΔT/P*** (GASP/ISENT)

Select <u>LIB</u>, Press GASP ISENT *ΔT/P* . Enter the values for variables.

Key in ' 70+460 **<u>EVAL</u>**= 530, enter for **T1**, 1000 for **p2**; 14.7 for **p1**; and 1.4 for **k** (assumed)

Press ↰ T2 <u>Answer: **T2=1769.7 oR**</u>

Select <u>UNITS</u> **<u>NXT</u>** TEMP oR ↰ oF <u>Answer: **T2=1310 oF** (D)</u>

GENERAL NOTE: The entire program is stored in the calculator's library, therefore, first, get to the library by pressing ↱ **LIB**. Calculator in **RPN** mode (No **ALG** on top of screen)

****

11- Water flows through a 2' diameter drain pipe to a level such that a 60 degree arc at the top of the pipe is not wetted.
The hydraulic radius, in feet, is most nearly:

(A) 0.50
(B) 0.58
(C) 0.67
(D) 1.00
(E) 2.00

Solution:
This is a Mathematics (MATH) problem. Refer to page 6-1 for hydraulic radius.
The ID **NAME** for Hydraulic Radius, with the given angle, is equation (10) **ANGL** (MATH/HYD.R)

Select LIB, Press MATH HYD.R ANGL
Enter 1 for **r**; 360-60=300 for **Ω**
Press ↰ HR   Answer: **HR=.58** (B)

****

12- Ten pounds of helium at a constant pressure of 20 psia are heated for two hours at a constant rate of 100 btu/hr. The helium volume is allowed to increase in a frictionless manner from 700 cubic feet to 1000 cubic feet. How much work is done?

(A) 0 ft-lb/hr
(B) 550 Btu
(C) 1110 Btu
(D) 43,200 ft-lb/hr
(E) 86,400 ft-lb/hr

Solution:
This is a Gas Properties (GASP) problem. Refer to page 5-1 for constant pressure process.
The ID **NAME** for the Work Done is equation (07) **W** (GASP/PRESS).

Select LIB, Press GASP PRESS **NXT** W. Enter the values for variables.
Key in ' 20x144 **EVAL**=2880, enter for **p1**; 1000 for **v2**; 700 for **v1**
Press ↰ W   **W=864000** lb-ft
To convert the answer to Btu:
Select UNITS **NXT** ENRG ft*lb ↰ BTU   Answer: **W=1110 btu** (C)

DYNAMICS

DESCRIPTION	FORMULA	NAME

BANKING ANGLE: (*DYNA/BANK*)

ENGLISH System: (*DYNA/BANK/ENG*)

(01) For motion impeding down	$\Omega=ATAN\left(\frac{.0668*mph^2}{r}\right)+ATAN\mu$	*DOWN*
(02) For motion impeding up	$\Omega=ATAN\left(\frac{.0668*mph^2}{r}\right)-ATAN\mu$	*UP*
(03) Ideal	$\Omega=ATAN\left(\frac{.0668*mph^2}{r}\right)$	*IDEAL*
(04) Height of outside edge	$h=RW*Sin\Omega$	*HIGHT*

SI Units: (*DYNA/BANK/SI*)

(05) For motion impeding down	$\Omega=ATAN\left(\frac{.00786*kmh^2}{r}\right)+ATAN\mu$	*DOWN*
(06) For motion impeding up	$\Omega=ATAN\left(\frac{.00786*kmh^2}{r}\right)-ATAN\mu$	*UP*
(07) Ideal	$\Omega=ATAN\left(\frac{.00786*kmh^2}{r}\right)$	*IDEAL*
(08) Height of outside edge	$h=RW*Sin\Omega$	*HIGHT*

CIRCULAR MOTION, ACCELERATED: (*DYNA/CIRM*)

Angle subtended: (*DYNA/CIRM/* θ)

(09) With the given α and T	$\theta=\omega_o*t+\frac{1}{2}\alpha*t^2$	α. *T*
(10) With the given α and ω	$\theta=\frac{\omega^2-\omega_o^2}{2\alpha}$	α. ω
(11) With the given N	$\theta=2\pi N$	*N*

Angular acceleration: (*DYNA/CIRM/* α)

(12) With the given α and ω	$\alpha=\frac{\omega-\omega_o}{t}$	ω. *T*
(13) With the given θ and T	$\alpha=\frac{2(\theta-\omega_o*t)}{t^2}$	θ. *T*

DYNAMICS

DESCRIPTION	FORMULA	NAME
Angular velocity (***DYNA/CIRM/*** ω)		
(14) With the given α and **T**	$\omega=\omega_o+\alpha*t$	$\alpha.T$
(15) With the given α and θ	$\omega=\sqrt{\omega_o^2+2\alpha*\theta}$	$\alpha.\theta$
(16) With the given **RPM**	$\omega=\frac{2\pi*RPM}{60}$	*RPM*
Centrifugal force: (***DYNA/CIRM/ FC***)		
(17) With the given **w** and **an**	$F_c=\frac{w*a_n}{g}$	*W.AN*
(18) With the given **w** and **v**	$F_c=\frac{w*v^2}{g*r}$	*W.V*
(19) With the given **w** and ω	$F_c=\frac{w*r*\omega^2}{g}$	*W.*ω
Linear velocity: (***DYNA/CIRM/ V***)		
(20) With the given **RPM**	$v=\frac{2\pi*r*RPM}{60}$	*RPM*
(21) With the given ω	$v=\omega*r$	ω
Normal acceleration: (***DYNA/CIRM/ AN***)		
(22) With the given **v** and **r**	$a_n=\frac{v^2}{r}$	*V.R*
(23) With the given ω and **r**	$a_n=r*\omega^2$	ω*. R*
(24) Rotational speed	$RPM=\frac{30}{\pi}(\omega_o+\alpha*t)=RPM_o+\frac{30\alpha*t}{\pi}$	*RPM*→
Time: (***DYNA/CIRM/ T***)		
(25) With the given α and ω	$t=\frac{\omega-\omega_o}{\alpha}$	$\alpha.\omega$
(26) With the given α and θ	$t=\frac{\sqrt{2\alpha*\theta+\omega_o^2}-\omega_o}{\alpha}$	$\alpha.\theta$
(27) With the given θ and ω	$t=\frac{2\theta}{\omega+\omega_o}$	$\theta.\omega$

DYNAMICS

DESCRIPTION	FORMULA	NAME

ENERGY: (***DYNA/ENRG***)

(28) Potential	$E_p = m*g*h$	***POTEN***

Kinetic: (***DYNA/ENRG/KINET***)

(29) Linear system	$E_k = \frac{1}{2} m*v^2$	***LINER***
(30) Circular system	$E_k = \frac{1}{2} I*\omega^2$	***CIRCU***

LINEAR MOTION (***DYNA/LINM***)

Acceleration: (***DYNA/LINM/ A***)

(31) With the given v and t	$a = \frac{v - v_o}{t}$	***V.T***
(32) With the given s and t	$a = \frac{2(s - s_o) - 2v_o*t}{t^2}$	***S.T***
(33) With the given s and v	$a = \frac{v^2 - v_o^2}{2(s - s_o)}$	***S.V***

Displacement: (***DYNA/LINM/ S***)

(34) With the given a and t	$s = s_o + v_o*t + \frac{1}{2} a*t^2$	***A.T***
(35) With the given a and v	$s = s_o + \frac{v^2 - v_o^2}{2a}$	***A.V***
(36) With the given t and v	$s = s_o + \frac{1}{2} t(v_o + v)$	***T.V***

Initial velocity: (***DYNA/LINM/ VO***)

(37) With the given a, t, and v	$v_o = v - a*t$	***A.T.V***
(38) With the given a, s, and t	$v_o = \frac{s - s_o}{t} - \frac{1}{2} a*t$	***A.S.T***
(39) With the given a, s, and v	$v_o = \sqrt{v^2 - 2a(s - s_o)}$	***A.S.V***

DYNAMICS

DESCRIPTION	FORMULA	NAME
Velocity: (*DYNA/LINM/ V*)		
(40) With the given a and t	$v=v_o+a*t$	A.T
(41) With the given a and s	$v=\sqrt{v_o^2+2a(s-s_o)}$	A.S
(42) With the given a, s, and t	$v=\frac{2(s-s_o)}{t}-v_o$	S.T
Time: (*DYNA/LINM/ T*)		
(43) With the given a and v	$t=\frac{v-v_o}{a}$	A.V
(44) With the given a and s	$t=\frac{\sqrt{v_o^2+2a(s-s_o)}-v_o}{a}$	A.S
(45) With the given s and v	$t=\frac{2(s-s_o)}{v+v_o}$	S.V

PENDULUM: (*DYNA/PEND*)

Compound: (*DYNA/PEND/COMP*)		
(46) Angular frequency	$\omega=\sqrt{\frac{m*g*L}{I}}$	ω
(47) Frequency	$f=\frac{1}{2\pi}\sqrt{\frac{m*g*L}{I}}$	F
(48) Period	$T=2\pi\sqrt{\frac{I}{m*g*L}}$	T
Simple: (*DYNA/PEND/SIMP*)		
(49) Angular frequency	$\omega=\sqrt{\frac{g}{L}}$	ω
(50) Frequency	$f=\frac{1}{2\pi}\sqrt{\frac{g}{L}}$	F
(51) Period	$T=2\pi\sqrt{\frac{L}{g}}$	T

DYNAMICS

DESCRIPTION	FORMULA	NAME
PROJECTILE MOTION: (*DYNA/PROJ*)		
Horizontal: (*DYNA/PROJ/HORIZ*)		
(52) Altitude above the base	$y=H_b-\frac{1}{2}g*t^2$	ALTI
(53) Drop angle	$\Omega=ATAN(\frac{v_o}{H_b}\sqrt{\frac{2H_b}{g}})$	ANGL
(54) Flight time	$T=\sqrt{\frac{2H_b}{g}}$	TIME
(55) Horizontal displacement (Range)	$R=v_o\sqrt{\frac{2H_b}{g}}$	RANG
Vertical: (*DYNA/PROJ/VERTI*)		
Altitude: (*DYNA/PROJ/VERTI/ALTI*)		
(56) At time t	$y=v_o*t*Sin\Omega-\frac{1}{2}g*t^2$	AT:T
(57) Maximum	$H=\frac{v_o^2*Sin\Omega^2}{2g}$	MAX
Flight Time: (*DYNA/PROJ/VERTI/TIME*)		
(58) Total	$T=\frac{2v_o*Sin\Omega}{g}$	TOTL
(59) At altitude y	$t=\frac{v_o*Sin\Omega+\sqrt{v_o^2*Sin\Omega^2-2g*y}}{g}$	AT:Y
Horizontal Displacement: (*DYNA/PROJ/VERTI/DISP*)		
(60) At time t	$x=v_o*t*Cos\Omega$	AT:T
(61) At altitude y	$x=v_oCos\Omega\frac{v_oSin\Omega+\sqrt{v_o^2Sin\Omega^2-2g*y}}{g}$	AT:Y
(62) Range, total	$R=\frac{v_o^2*Sin(2\Omega)}{g}$	RANG

DYNAMICS

DESCRIPTION	FORMULA	NAME
Velocity: (*DYNA/PROJ/VERTI/VELO*)		
(63) Total	$v=\sqrt{v_o^2-2g*y}$	V
(64) Horizontal	$v_x=v_o*Cos\Omega$	VX
(65) Vertical	$v_y=v_o*Sin\Omega-g*t$	VY

SPRING: (*DYNA/SPRIN/MASS*)

Angular frequency: (*DYNA/SPRIN/MASS/* ω)

(66) With the given **k** and **w**	$\omega=\sqrt{\frac{k*g}{w}}$	K.W
(67) With the given **f**	$\omega=2\pi*f$	F
(68) With the given **T**	$\omega=\frac{2\pi}{T}$	T

Frequency: (*DYNA/SPRIN/ F*)

(69) With the given k and w	$f=\frac{1}{2\pi}\sqrt{\frac{k*g}{w}}$	K.W
(70) With the given ω	$f=\frac{\omega}{2\pi}$	ω
(71) With the given **T**	$f=\frac{1}{T}$	T

Period: (*DYNA/SPRIN/MASS/ T*)

(72) With the given **k** and **w**	$T=2\pi\sqrt{\frac{w}{k*g}}$	K.W
(73) With the given ω	$T=\frac{2\pi}{\omega}$	ω
(74) With the given **T**	$T=\frac{1}{f}$	F

DYNAMICS

DESCRIPTION	FORMULA	NAME
Torsional: ***(DYNA/SPRIN/TORS)***		
(75) Angular frequency	$\omega=\sqrt{\frac{k}{I}}$	ω
(76) Frequency	$f=\frac{1}{2\pi}\sqrt{\frac{k}{I}}$	*F*
(77) Period	$T=2\pi\sqrt{\frac{I}{k}}$	*T*

DYNAMICS EXAMPLES: ***(DYNA/XMPL)***

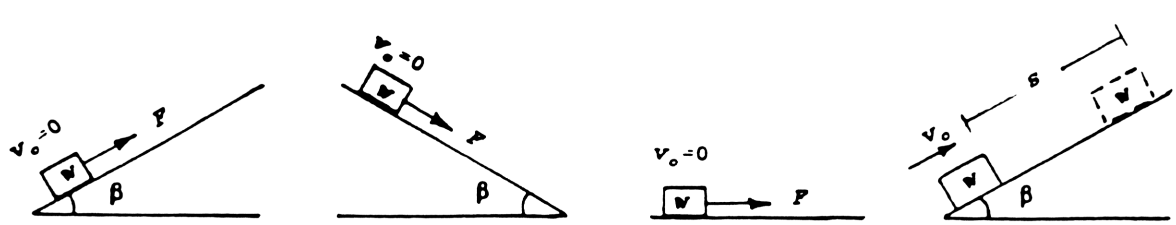
MOTION ON SLOPE: ***(DYNA/XMPL/SLOP)***

Acceleration: ***(DYNA/XMPL/SLOP/ACCEL)***

(78) (a) Moving uphill	$a=(\frac{F}{W}-Sin\beta-\mu Cos\beta)g$	*UPHIL*
(79) (b) Moving downhill	$a=(\frac{F}{W}+Sin\beta-\mu Cos\beta)g$	*DNHIL*
(80) (c) Moving horizontally	$a=(\frac{F}{W}-\mu)\,g$	*HORIZ*

Displacement: ***(DYNA/XMPL/SLOP/DISP)***

(81) (d) Moving uphill	$s=\frac{v_o^2}{2g(SIN\beta+\mu Cos\beta)}$	*UPHIL*



(a) (b) (c) (d)

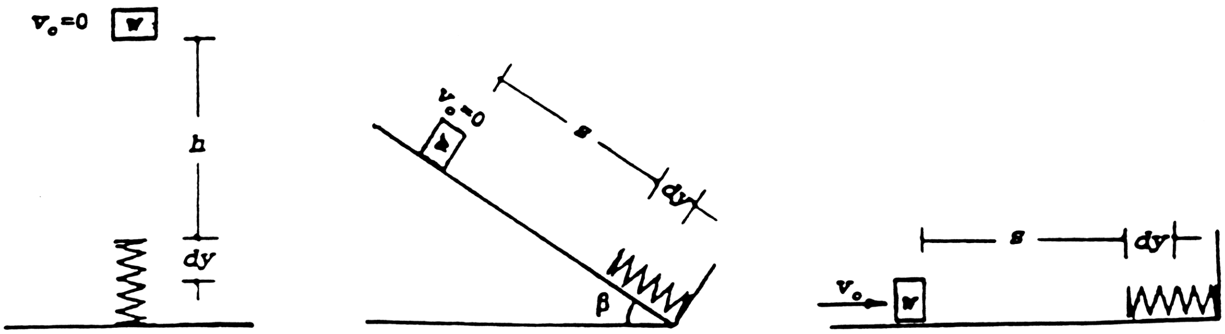
DYNAMICS

DESCRIPTION	**FORMULA**	**NAME**

SPRING DEFLECTION, WORK: ***(DYNA/XMPL/SPRIN)***

Deflection when an object hits over the spring: ***(DYNA/XMPL/SPRIN/DFLEC)***

(82) (e) Free drop	$dy=\frac{w+\sqrt{w^2+2k*w*h}}{k}$	*DROP*
(83) (f) Downhill	$dy=\frac{w(Sin\beta-\mu Cos\beta)+\sqrt{w^2(Sin\beta-\mu Cos\beta)^2+2k*w*s(Sin\beta-\mu Cos\beta)}}{k}$	*DNHIL*
(84) (g) Horizontal move	$dy=\frac{-\mu w+\left(\mu^2 w^2-k\left(2\mu w*s-\frac{w*v_o^2}{g}\right)\right)^{.5}}{k}$	*HORIZ*



(e) (f) (g)

PULLEYS: ***(DYNA/XMPL/PULY)***

(85) (h) Acceleration on slope	$a=g\frac{w_1(Cos\beta-\mu Sin\beta)-w_2}{w_1+w_2}$	*ACCEL*
(86) (i) Tension on cables	$T=2w_1\left(1-\frac{w_1-w_2}{w_1+w_2}\right)$	*TNSN*

DYNAMICS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
a	Linear acceleration; ft/s2, m/s2 (1 ft/s2 = 0.3048 m/s2).
an	Normal acceleration; ft/s2, m/s2 (1 ft/s2 = 0.3048 m/s2).
dy	Deflection; ft, m (1 ft = 0.3048 m).
Ek	Kinetic energy; ft-lbf, J (1 ft-lbf = 1.3558 J(N.m)).
Ep	Potential energy; ft-lbf, J (1 ft-lbf = 1.3558 J(N.m)).
f	Frequency; cps (cycle per second)
F	Force; lbf, N (1 lbf = 4.4482 N).
Fc	Centrifugal force; lbf, N (1 lbf = 4.4482 N).
g	Acceleration of gravity; (g = 32.2 ft/s2 = 9.81 m/s2).
h	Height; ft, m (1 ft = 0.3048 m).
Hh	Launch base altitude from the target; ft, m (1 ft = 0.3048 m).
I	Mass moment of inertia; lbm-ft2, Nm-m2 (1 lbm-ft2 = 0.04214 kg.m2).
k	Spring constant; lbf/ft, N/m (1 lbf/ft = 14.5939 N/m).
kph	Kilometer per hour; (1 kph = 0.62137 mph).
l	Length, pendulum; ft, m (1 ft = 0.3048 m).
m	Mass; lbm, kg (1 lbm = 0.4536 kg).
mph	Mile per hour; (1 mph = 1.609344 kph).
N	Number of rotations; None.
R	Maximum projectile range on horizontal plane; ft, m (1 ft = 0.3048 m)
r	Radius; ft, m (1 ft = 0.3048 m).
RPM	Revolution per minute.
RPMo	Initial revolution per minute.
RW	Road's width; ft, m (1 ft = 0.3048 m).
s	Linear displacement; ft, m (1 ft = 0.3048 m).
T	Total flight time; sec. : Period; spc. : Tension; lbf, N (1 lbf = 4.4482 N).
t	Time; sec.
Th	Flight time; sec.
v	Velocity; ft/s, m/s (1 ft/s = 0.3048 m/s).
vx	Horizontal velocity; fps, m/s (1 ft/s = 0.3048 m/s).
vy	Vertical velocity; fps, m/s (1 ft/s = 0.3048 m/s).
w	Weight; lb, kg (1 lb = 0.4536 kg).
x	Projectile's horizontal displacement; ft, m (1 ft = 0.3048 m).
xh	Horizontal displacement; ft, m (1 ft = 0.3048 m).
y	Projectile altitude above the base; ft, m (1 ft = 0.3048 m).
yh	Altitude above the base; ft, m (1 ft = 0.3048 m).

DYNAMICS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT
α	Angular acceleration; **rad/s**.
β	Angle with horizontal plane; **deg**.
μ	Coefficient of friction; **decimal**.
Ω	Banking, Launch, or Drop angle; **deg**.
ω	Angular velocity; **rad/s**.
ω_o	Initial angular velocity; **rad/s**.
θ	Angle subtended; **rad**.

ELECTRICITY

DESCRIPTION	FORMULA	NAME
BATTERIES IN PARALLEL: (*ELEC/BATT*)		
(01) Current through battery #1	$I_1=\frac{V_1-V_2+I*R_2}{R_1+R_2}$	I_1
(02) Current through battery #2	$I_2=\frac{V_2-V_1+I*R_1}{R_1+R_2}$	I_2

CAPACITORS: (*ELEC/CAPAC*)

Equivalent Capacitance: (*ELEC/CAPAC/EQUIV*)

(03) Parallel, 2 or 3	$C_e=C_1+C_2+C_3$	*PARA*
Series: (*ELEC/CAPAC/EQUIV/SERI*)		
(04) Two in Series	$C_e=\frac{C_1*C_2}{C_1+C_2}$	*TWO*
(05) Three in Series	$C_e=\frac{C_1*C_2*C_3}{C_1*C_2+C_1*C_3+C_2*C_3}$	*THREE*

Capacitance Reactance: (*ELEC/CAPAC/REAC*)

(06) With f and C	$X_c=\frac{1}{2\pi*f*C}$	F.C
(07) With V and I	$X_c=\frac{V}{I}$	V.I
(08) With w and C	$X_c=\frac{1}{\omega*C}$	ω.C

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(09) Coulomb Law (*ELEC*)	$F=\frac{q_1*q_2}{4\pi*\epsilon*r^2}$	*CULMB*

IMPEDANCE: (*ELEC/IMPED*)

(10) Magnitude	$Z=\frac{V}{I}$	*MAG*

ELECTRICITY

DESCRIPTION	FORMULA	NAME

Magnitude: R, L, and C in Parallel (*ELEC/IMPED/PARA*)

(11) With **R** and **C**	$Z=\frac{R*X_C}{\sqrt{R^2+X_C^2}}$	*R.C*
(12) With **R** and **L**	$Z=\frac{R*X_L}{\sqrt{R^2+X_L^2}}$	*R.L*
(13) With **L** and **C**	$Z=\frac{X_L*X_C}{X_L-X_C}$	*L.C*
(14) With **R** , **L**, and **C**	$Z=\frac{R*X_L*X_C}{\sqrt{X_L^2*X_C^2+R^2(X_L-X_C)^2}}$	*R.L.C*

Magnitude of R, L, and C in Series (*ELEC/IMPED/SERI*)

(15) With **R** and **C**	$Z=\sqrt{R^2+X_C^2}$	*R.C*
(16) With **R** and **L**	$Z=\sqrt{R^2+X_L^2}$	*R.L*
(17) With **C** and **L**	$Z=X_L-X_C$	*C.L*
(18) With **R** , **L**, and **C**	$Z=\sqrt{R^2+(X_L-X_C)^2}$	*R.L.C*

INDUCTORS: (*ELEC/INDUC*)

Equivalent Inductance: (*ELEC/INDUC/EQUIV*)

Parallel: (*ELEC/INDUC/EQUIV/PARA*)

(19) Two in Parallel	$L_e=\frac{L_1*L_2}{L_1+L_2}$	*TWO*
(20) Three in Parallel	$L_e=\frac{L_1*L_2*L_3}{L_1*L_2+L_1*L_3+L_2*L_3}$	*THREE*
(21) Two or three in Series	$L_e=L_1+L_2+L_3$	*SERI*

Inductive Reactance: (*ELEC/INDUC/REAC*)

(22) With **f** and **L**	$X_L=2\pi*f*L$	*F.L*
(23) With **V** and **I**	$X_L=\frac{V}{I}$	*V.I*
(24) With **w** and **L**	$X_L=L*\omega$	*ω.L*

ELECTRICITY

DESCRIPTION	**FORMULA**	**NAME**

KIRCHOFF'S LAW: ***(ELEC/KIRC)***

Two (2) MESH network: ***(ELEC/KIRC/2LOOP)***

The format of the equations resulted from applying the Kirchoff's Law, are as follow:

$$\begin{vmatrix} A_1 I_1 + B_1 I_2 = C_1 \\ A_2 I_1 + B_2 I_2 = C_2 \end{vmatrix}$$

(25) Current in MESH #1 $\quad I_1 = EXPR = \dfrac{C_1B_2 - B_1C_2}{A_1B_2 - A_2B_1}$ $\quad$ *I1*

(26) Current in MESH #2 $\quad I_2 = EXPR = \dfrac{C_1A_2 - A_1C_2}{A_2B_1 - A_1B_2}$ $\quad$ *I2*

Three (3) MESH network: ***(ELEC/KIRC/3LOOP)***

The format of the equations, resulted from applying the Kirchoff's Law, are as follow:

$$\begin{vmatrix} A_1 I_1 + B_1 I_1 + C_1 I_3 = D1 \\ A_2 I_1 + B_2 I_1 + C_2 I_3 = D2 \\ A_3 I_1 + B_3 I_1 + C_3 I_3 = D3 \end{vmatrix}$$

Current in MESH #1

(27) $\quad I_1 = EXPR = \dfrac{(C_3B_2 - C_2B_3)(C_2D_1 - C_1D_2) - (C_2B_1 - C_1B_2)(C_3D_2 - C_2D_3)}{(C_3B_2 - C_2B_3)(C_2A_1 - C_1A_2) - (C_2B_1 - C_1B_2)(C_3A_2 - C_2A_3)}$ $\quad$ *I1*

Current in MESH #2

(28) $\quad I_2 = EXPR = \dfrac{(A_3C_2 - A_2C_3)(A_2D_1 - A_1D_2) - (A_2C_1 - A_1C_2)(A_3D_2 - A_2D_3)}{(A_3C_2 - A_2C_3)(A_2B_1 - A_1B_2) - (A_2C_1 - A_1C_2)(A_3B_2 - A_2B_3)}$ $\quad$ *I2*

Current in MESH #3

(29) $\quad I_3 = EXPR = \dfrac{(A_3B_2 - A_2B_3)(A_2D_1 - A_1D_2) - (A_2B_1 - A_1B_2)(A_3D_2 - A_2D_3)}{(A_3B_2 - A_2B_3)(A_2C_1 - A_1C_2) - (A_2B_1 - A_1B_2)(A_3C_2 - A_2C_3)}$ $\quad$ *I3*

MOTORS: ***(ELEC/MOTR)***

Elevators: ***(ELEC/MOTR/ELEV)***

English System: ***(ELEC/MOTR/ELEV/ENG)***

(30) Power in **kW** $\quad kW = \dfrac{w \times fpm}{44254 \times \eta}$ $\quad$ *KW*

(31) Power in **hp** $\quad hp = \dfrac{w \times fpm}{33000 \times \eta}$ $\quad$ *HP*

ELECTRICITY

DESCRIPTION	FORMULA	NAME
SI System: (*ELEC/MOTR/ELEV/SI*)		
(32) Power in **kW**	$kW=\frac{w\times mpm}{6118.33\times\eta}$	*KW*
(33) Power in **hp**	$hp=\frac{w\times mpm}{4562.4\times\eta}$	*HP*
Power: (*ELEC/MOTR/POWR*)		
Single Phase: (*ELEC/MOTR/POWR/* **1ϕ**)		
(34) Power in **kW**	$kW=\frac{V\times I\times PF\times\eta_M}{1000}$	*KW*
(35) Power in **hp**	$hp=\frac{V\times I\times PF\times\eta_M}{745.7}$	*HP*
Three Phase: (*ELEC/MOTR/POWR/* **3ϕ**)		
(36) Power in **kW**	$kW=\frac{\sqrt{3}\times V\times I\times PF\times\eta_M}{1000}$	*KW*
(37) power in **hp**	$hp=\frac{\sqrt{3}\times V\times I\times PF\times\eta_M}{745.7}$	*HP*
Pumps: (*ELEC/MOTR/PUMP*)		
Horsepower: (*ELEC/MOTR/PUMP/HP*)		
English System: (*ELEC/MOTR/PUMP/HP/ENG*)		
(38) Flow in **gpm**	$hp=\frac{h\times gpm\times SG}{3960\times\eta}$	*GPM*
(39) Flow in **lbps**	$hp=\frac{h\times lbps}{550\times\eta}$	*LBPS*
(40) Flow in **cfs**	$hp=\frac{h\times cfs\times SG}{8.814\times\eta}$	*CFS*
SI System: (*ELEC/MOTR/PUMP/HP/SI*)		
(41) Flow in **m3ps**	$hp=\frac{h\times m3ps\times SG}{.07615\times\eta}$	*M3PS*
(42) Flow in **lps**	$hp=\frac{h\times lps\times SG}{76.15\times\eta}$	*LPS*
(43) Flow in **kgps**	$hp=\frac{h\times kgps}{76.15\times\eta}$	*KGPS*
Speed: (*ELEC/MOTR*)		
(44) Rotational speed	$RPM=\frac{120\times f(1-S)}{P}$	*RPM*
Torque: (*ELEC/MOTR/TORQ*)		
(45) English System	$T=\frac{5252.1\times hp}{RPM}$	*ENG*
(46) SI System	$T=\frac{7120.8\times hp}{RPM}$	*SI*

ELECTRICITY

DESCRIPTION	FORMULA	NAME
POWER: (*ELEC/POWR*)		
Apparent: (*ELEC/POWR/APAR*)		
(47) Single phase	$P_a = V*I$	1ϕ
(48) Three phase	$P_a = \sqrt{3}*V*I$	3ϕ
Effective: (*ELEC/POWR/EFEC*)		
(49) Instantaneous	$P_i = V*I(COS\phi + COS(2\omega*t+\phi))$	INST
(50) Average, single phase	$P = V*I*PF$	1ϕ
(51) Average, three phase	$P = \sqrt{3}*V*I*PF$	3ϕ
Reactive: (*ELEC/POWR/REAC*)		
(52) Average, single phase	$P_r = V*I*SIN(ACOS(PF))$	1ϕ
(53) Average, three phase	$P_r = \sqrt{3}*V*I*SIN(ACOS(PF))$	3ϕ

DESCRIPTION	FORMULA	NAME
POWER FACTOR: (*ELEC/PFAC*)		
Power Factor Equations: (*ELEC/PFAC/EQUA*)		
(54) Power Factor with ϕ	$PF = COS(\phi)$	ϕ
(55) Power Factor with X and R	$PF = COS(ATAN\frac{X}{R})$	X.R
(56) Power Factor with **W** and **VA**	$PF = \frac{kW}{kVA}$	W.VA
(57) Power Factor (**Single phase**)	$PF = \frac{1000 \times kW}{V \times I}$	1ϕ
(58) Power Factor (**Three phase**)	$PF = \frac{1000 \times kW}{\sqrt{3} \times V \times I}$	3ϕ
(59) Power Factor with **I1** and **I2**	$PF_2 = PF_1 \times \frac{I_1}{I_2}$	I1.I2
Power Factor Correction: (*ELEC/PFAC/COREC*)		
(60) System Power Factor	$PF_1 = \frac{R.KW + M.KW}{\sqrt{(M.KW \times Tan(ACOS(M.PF)))^2 + (R.KW + M.KW)^2}}$	SYSPF
(61) Capacitors kVAR	$kVAR = (R.KW + M.KW) \times (TAN(ACOS(PF1)) - TAN(ACOS(PF2)))$	KVAR
(62) Capacitors Value, in Farad.	$C = \frac{159.15 \times kVAR}{f \times V^2}$	FARAD

ELECTRICITY

DESCRIPTION	FORMULA	NAME
RESISTORS: ***(ELEC/RESIS)***		
Equivalent Resistance: ***(ELEC/RESIS/EQUIV)***		
Parallel: ***(ELEC/RESIS/EQUIV/PARA)***		
(63) Two in parallel	$R_e=\frac{R_1*R_2}{R_1+R_2}$	*TWO*
(64) Three in parallel	$R_e=\frac{R_1*R_2*R_3}{R_1*R_2+R_1*R_3+R_2*R_3}$	*THREE*
(65) Series, 2 or 3	$R_e=R_1+R_2+R_3$	*SERI*
(66) Resistance, general equation	$R=\frac{\rho*L}{A}$	*GNRL*
(67) Resistance variance with temperature	$R_2=R_1(1+\alpha*dt)$	*ΔT*
(68) Thermal Coefficient of resistant	$\alpha=\frac{R_2-R_1}{dt*R_1}$	*ΔT*

DESCRIPTION	FORMULA	NAME
RESONANCE: ***(ELEC/RESO)***		
(69) Angular velocity	$\omega_r=\sqrt{\frac{1}{L*C}}$	*ANG.V*
Capacitance: ***(ELEC/RESO/CAPAC)***		
(70) With L and w	$C_r=\frac{1}{L*\omega^2}$	*L.ω*
(71) With L and f	$C_r=\frac{1}{L(2\pi*f)^2}$	*L.F*
Frequency: ***(ELEC/RESO/FREQ)***		
(72) With w and R	$f_r=\frac{\omega_r}{2\pi}$	*ω.R*
(73) With L and C	$f_r=\frac{1}{2\pi}\sqrt{\frac{1}{L*C}}$	*L.C*
(74) With f and X	$f_r=f\sqrt{\frac{X_C}{X_L}}$	*F.X*
Inductance: ***(ELEC/RESO/INDUC)***		
(75) With C and f	$L_r=\frac{1}{C(2\pi*f)^2}$	*C.F*
(76) With C and w	$L_r=\frac{1}{C*\omega^2}$	*C.ω*

ELECTRICITY

DESCRIPTION	**FORMULA**	**NAME**

VOLTAGE DROP: (***ELEC/VDRP***)

Line Current: (***ELEC/VDRP/CURR***)

(77) Single phase load	$I=\frac{1000 \times kW}{V \times PF}$	**1ϕ**
(78) Three phase load	$I=\frac{1000 \times kW}{\sqrt{3} \times V \times PF}$	**3ϕ**

Voltage drop, across a copper conductors: (***ELEC/VDRP/DROP***)

(79) AWG size Conductors: 14 AWG - 1 AWG, 20 amps - 130 amps:

$$VD=.001 \times L \times I(.1257e^{(.2285 \times AWG)} \times PF+(.0552+.00121 \times AWG) \times Sin(Acos(PF)))$$ *AWG*

(80) AUGHT size Conductors: 1/0 - 4/0, 150 amps - 230 amps:

$$VD=.001 \times L \times I(.1512e^{(-.2169 \times AUT)} \times PF+(.0565-.0014 \times AUT) \times Sin(Acos(PF)))$$ *AUT*

(81) KCMIL size Conductors: 250 KCM - 1000 KCM, 255 amps - 545 amps:

$$VD=.001 \times L \times I(4.322 \times KCM^{-.8} \times PF+.0835 \times KCM^{-.0876} \times SIN(ACOS(PF)))$$ *KCM*

ELECTRICITY

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
A	Section area of wire; CM, m2 (1 CM = 5.067EE-10 m2).
C	Capacitance, Capacitor value; farad, Charge; Coulomb.
Ce	Equivalent Capacitance; farad.
cfs	Cubic feet per second (1 cfs = 448.83 gpm = 0.02832 m3/s).
CM	Circular Mill ($CM = d^2 \times 1EE6$, d=diameter of wire in inch).
cps	Cycle per second.
dt	Temperature difference; oC.
F	Force; N (Newton) (1 N = 0.22481 lbf).
f	Frequency; cps.
fpm	Feet per minute (1 fpm = 0.3048 mpm).
gpm	Gallon per minute (1 gpm = 0.002228 cfs = 6.309EE-5 m3/s).
h	Head; ft, m (1 ft = 0.3048 m).
I	Current; Amp.
kgps	Kilogram per second (1 kgps = 2.2046 lbps).
L	Inductance; henry : Length; ft, m (1 ft = .3048 m).
Le	Equivalent Inductance; henry.
lbps	Pound per second (1 lbps = .4536 kgps).
lps=L/s	Liter per second (1 L/s = 15.85 gpm = 0.035315 cfs).
m3ps=m3/s	Cubic meter per second (1 m3/s = 15850 gpm = 35.315 cfs).
M.KW	Motor/Inductive load; kW.
M.PF	Motor/Induction's load Power Factor; None.
mpm	Meters per minute.
p	Number of poles; none.
P	Effective Power; watt.
Pa	Apparent Power; volt amp.
PF	Power Factor; None.
Pi	Instantaneous effective Power; watt.
Pr	Reactive Power; var.
q	Charge; C (coulomb).

ELECTRICITY

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
r	Distance; ft, m (1 ft = .3048 m).
R	Resistance; ohm.
R.KW	Resistive load; kW.
Ro	Original resistance (at 20 Oc); ohm.
RPM	Revolution Per Minute.
S	Slip; decimal.
SG	Specific Gravity; None.
T	Period of cycle; sec : Torque; ft-lbf, N-m (1 ft-lbf = 1.3558 N.m = .13826 kg.m).
t	Temperature; oC : Time; sec.
V	Voltage; volt
VD	Voltage Drop; volt
w	Weight; lbf, kg (1 lbf = .4536 kg).
X	Reactance; ohm.
Xc	Capacitive reactance; ohm.
XL	Inductive reactance; ohm.
Z	Impedance; ohm
α	Thermal coefficient of resistance; 1/oC.
ϵ	Permittivity; C2/N-m2.
η	Efficiency; decimal.
η_M	Motor's efficiency; decimal.
ω	Angular velocity; rad/sec. or deg./sec.
ϕ	Phase angle; deg.
ρ	Resistivity; ohm-CM/ft, ohm.m (1 ohm-CM/ft = 1.66243E-9 ohm.m).

ENGINEERING ECONOMICS

ANNUAL COST, EQUIVALENT UNIFORM: (*ENEC/ANNU*)

(01) With Sinking Fund depreciation, SF $$A=\frac{i(P-L)(1+i)^n}{(1+i)^n-1}+L*i+AE$$ **SF**

(02) With SF & uniform gradient, G $$A=\frac{i(P-L)(1+i)^n}{(1+i)^n-1}+L*i+AE+G(A/G,i,n)$$ **SF+G**

(03) With Straight Line depreciation, SL $$A=\frac{P-L}{n}+\frac{i}{2*n}(n+1)(P-L)+L*i+AE$$ **SL**

(04) Equalized Annual Cost/Income (For up to five (5) years, same interest rate.)

$$A_{eq}=\frac{i(1+i)^n}{(1+i)^n-1}(A_1(1+I)^{-1}+A_2(1+I)^{-2}+A_3(1+I)^{-3}+A_4(1+I)^{-4}+A_5(1+I)^{-5})$$ **AEQ**

BONDS: (*ENEC/BOND*)

(05) Present Worth $$PW=BSV(1+R)^{-N}+\frac{i*BFV}{2}\frac{(1+R)^N-1}{R(1+R)^N}$$ **PW**

(06) Rate of Return (approximate) $$ROR=\frac{\frac{BSV-PW}{n}+i*BFV}{\frac{BSV+PW}{2}}$$ **ROR**

CAPITALIZED COST: (*ENEC/CAPIT*)

(07) With no periodical replacement $$CC=P+\frac{A}{i}$$ **N.REP**

With periodical replacement/cost: (*ENEC/CAPIT/W.REP*)

(08) With in-kind periodical replacement $$CC=P+\frac{P-L}{(1+i)^n-1}+\frac{A}{i}$$ **KIND**

(09) With other periodical cost $$CC=P+\frac{PC}{(1+i)^n-1}+\frac{A}{i}$$ **OTHER**

ENGINEERING ECONOMICS

COMPOUND FACTORS/VALUES: (*ENEC/FACTR*)

(10) Future to Annual/Annual to Future $$A=\frac{i}{(1+i)^n-1}*F$$ ***AF***

(11) Gradient to Annual/Annual to Gradient $$A=\left(\frac{1}{i}-\frac{n}{(1+i)^n-1}\right)*G$$ ***AG***

(12) Present to Annual/Annual to Present $$A=\frac{i(1+i)^n}{(1+i)^n-1}*P$$ ***AP***

(13) Present to Future/Future to Present $$F=(1+i)^n*P$$ ***FP***

(14) Gradient to Present/Present to Gradient $$P=\left(\frac{(1+i)^n-1}{i^2(1+i)^n}-\frac{n}{i(1+i)^n}\right)*G$$ ***PG***

DEPRECIATION: (*ENEC/DEPRI*)

Double Declining Balance: (*ENEC/DEPRI/DDB*)

(15) For the xth year $$D_x=\frac{2P}{n}\left(1-\frac{2}{n}\right)^{(x-1)}$$ ***DX***

(16) Book value after x year(s) $$BV_x=P\left(1-\frac{2}{n}\right)^x$$ ***BVX***

(17) After Tax Depreciation Recovery (ATDR)

$$ATDR=TAX.R\left(\frac{2P}{n\left(1-\frac{2}{n}\right)}\;\frac{\left(\frac{(1+i)n}{n-2}\right)^n-1}{\left(\frac{(1+i)n}{n-2}\right)^n\left(\frac{(1+i)n}{n-2}-1\right)}\right)$$ ***RECOV***

Sinking Fund: (*ENEC/DEPRI/SF*)

(18) For the xth year $$D_x=(P-L)\frac{i}{(1+i)^n-1}(1+i)^{(x-1)}$$ ***DX***

(19) Book value after x year(s) $$BV_x=P-(P-L)\frac{i}{(1+i)^n-1}\;\frac{(1+i)^x-1}{i}$$ ***BVX***

ENGINEERING ECONOMICS

DEPRECIATION: (*ENEC/DEPRI*)

Straight line: (*ENEC/DEPRI/SL*)

(20) For the xth year $D_x = \frac{P-L}{n}$ *DX*

(21) Book value after x year(s) $BV_x = \frac{(P-L)(n-x)}{n} + L$ *BVX*

(22) After Tax Depreciation Recovery (ATDR) $ATDR = TAX.R \frac{P-L}{n} \frac{(1+i)^n-1}{i(1+i)^n}$ *RECOV*

Sum Of the Years' Digits: (*ENEC/DEPRI/SOYD*)

(23) For the xth year $D_x = \frac{2(P-L)(n-x+1)}{n(n+1)}$ *DX*

(24) Book value after x year(s) $BV_x = P-2(P-L)(n-\frac{x-1}{2})\frac{x}{n(n+1)}$ *BVX*

(25) After Tax Depreciation Recovery (ATDR)

$$ATDR = TAX.R(\frac{2n}{n(n+1)} \frac{(1+i)^n-1}{i(1+i)^n} - \frac{2}{n(n+1)}(\frac{(1+i)^n-1}{i^2(1+i)^n} - \frac{n}{i(1+i)^n}))$$ *RECOV*

INTEREST RATE, COMPOUNDED/INFLATION: (*ENEC/INTER*)

(26) Continuous (yield) $iCO = e^{i \cdot y} - 1$ *YIELD*

(27) Effective $iEF = (1+\frac{i}{m})^m - 1$ *EFECT*

(28) Equivalent $iEQ = e^{(\frac{\ln(1+i)}{m})} - 1$ *EQUIV*

(29) **Interest** and **Inflation** combined $iINF = i + r(1+i)$ *INFLT*

ENGINEERING ECONOMICS

MORTGAGE: (*ENEC/MORT*)

(30) Installment (Periodical Payment) $$INSTL=\frac{I(1+I)^n}{(1+I)^n-1}LOAN$$ *INSTL*

(31) Number of payments $$NP=\frac{-\ln((1-I*LV)/INSTL)}{\ln(1+I)}$$ *NUMB*

(32) Balance after xth payment $$BAL_x=\frac{INSTL}{I}(1-(1+I)^{(x-n)})$$ *BALAN*

Interest Paid: (*EN'FC/MORT/INTER*)

(33) As a part of xth payment $$I_x=INSTL(1-(1+I)^{x-1-n})$$ *XTH*

(34) Total, after xth payment $$I_t=INSTL*x-LOAN+\frac{INSTL}{I}(1-(1+I)^{(x-n)})$$ *TOTAL*

Principal Paid: (*ENEC/MORT/PRINC*)

(35) As a part of xth payment $$P_x=INSTL(1+I)^{(x-1-n)}$$ *XTH*

(36) Total, after xth payment $$P_t=LOAN-\frac{INSTL}{I}(1-(1+I)^{(x-n)})$$ *TOTAL*

PRESENT WORTH (No depreciation): (*ENEC/PW*)
Before Tax: (*ENEC/PW/B.TAX*)

(37) With Uniform Annual Expanses

$$PW=-P+(AR-AE)\frac{(1+i)^n-1}{i(1+i)^n}+\frac{L}{(1+i)^n}$$ *UNIF*

(38) With Uniform Gradient on Annual Expenses

$$PW=-P+(AR-AE-(A/G,i,n)G)\frac{(1+i)^n-1}{i(1+i)^n}+\frac{L}{(1+i)^n}$$ *GRADI*

ENGINEERING ECONOMICS

PRESENT WORTH (No depreciation): *(ENEC/PW)*
After Tax: *(ENEC/PW/A.TAX)*

(39) With Uniform Annual Expanses

$$PW=-P+(AR-AE)(1-TAX.R)\frac{(1+i)^n-1}{i(1+i)^n}+\frac{L}{(1+i)^n} \qquad UNIF$$

(40) With Uniform Gradient on Annual Expenses

$$PW=-P+(AR-AE-(A/G,i,n)G)(1-TAX.R)\frac{(1+i)^n-1}{i(1+i)^n}+\frac{L}{(1+i)^n} \qquad GRADI$$

Rate Of Return on Investment: *(ENEC/ROR)*

(41) With salvage value

$$\frac{((1+ROR)^n-1)AAR}{ROR(1+ROR)^n}+\frac{L}{(1+ROR)^n}=P \qquad SAL>0$$

(42) Without salvage value

$$\frac{((1+ROR)^n-1)AAR}{ROR(1+ROR)^n}=P \qquad SAL=0$$

ENGINEERING ECONOMICS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT
A	Annuity; **amount**.
AAR	Annual Average Revenue; **amount**.
A1	A2, A3, A4, or A5= Annual expense/income for different years; **amount**.
AE	Annual Uniform Expense; **amount**.
Aeq	Equalized Annual Cost/Income; **amount**.
AI	Annual Income; **amount**.
APR	Annual Percentage Rate; **decimal**.
AR	Annual Revenue; **amount**.
ATDR	After Tax Depreciation Recovery (Present Worth); **amount**.
BFV	Bond's Face Value; **amount**.
BSV	Bond's Sale Value; **amount**.
BVx	Book value at the end of xth year; **amount**.
CC	Capitalized Cost; **amount** (Initial capital investment to perpetually support project from the interest earned).
F	Future Value; **amount**.
G	Uniform Gradient; **amount**.
I	Interest rate per period; APR/12 for monthly payment in case of mortgage; **decimal**.
i=I	Interest rate per period; **decimal**. ("i" is HP48 designated variable. It should not be used for programming.)
INSTL	Installment (Payment per period); **amount**.
L	Salvage Value; **amount**.
LOAN	Loan Value; **amount**.
m	Compound number; **None**.
N	N=2n (R=ROR/2); **none**. (Number of payments for bonds with semi annually interest payment. In case of annual interest payment, R=ROR and N=n).
n	Number of Payments or Periods; **none**.
P	Present Value; **amount**.
PC	Periodical Uniform Costs; **amount**.
PW	Present Worth; **amount**.
r	Inflation rate per period; **decimal**.
R	ROR/2 (N=2n); **decimal** (Rate for bonds with semi annually interest payment. In case of annual interest payment R=ROR and N=n).
ROR	Rate of Return; **decimal**.
TAX.R	Tax rate; **decimal**.
x	Period number; **none**.
y	Period; **years**.

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME
BERNOULLI EQUATIONS: (*FLME/BERN*)		
English System: (*FLME/BERN/ENG*)		
(01) No friction loss	$\frac{P_1}{\rho}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho}+\frac{v_2^2}{2g}+z_2$	*NO.HF*
(02) With friction loss	$\frac{P_1}{\rho}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho}+\frac{v_2^2}{2g}+z_2+hf$	*W.HF*
(03) Friction & minor loss	$\frac{P_1}{\rho}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho}+\frac{v_2^2}{2g}+z_2+h_f+h_{FIT}$	*HF+*
SI System: (*FLME/BERN/SI*)		
(04) No friction loss	$\frac{P_1}{\rho\times g}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho\times g}+\frac{v_2^2}{2g}+z_2$	*NO.HF*
(05) With friction loss	$\frac{P_1}{\rho\times g}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho\times g}+\frac{v_2^2}{2g}+z_2+hf$	*W.HF*
(06) Friction & minor loss	$\frac{P_1}{\rho\times g}+\frac{v_1^2}{2g}+z_1=\frac{P_2}{\rho\times g}+\frac{v_2^2}{2g}+z_2+h_f+h_{FIT}$	*HF+*

CAPILLARITY AND SURFACE TENSION: (*FLME/CAPIL*)		
Capillary rise: (*FLME/CAPIL/RISE*)		
(07) English System	$h=\frac{4\sigma*COS\beta}{\rho*d}$	*ENG*
(08) SI System	$h=\frac{0.40788*\sigma*COS\beta}{\rho*d}$	*SI*
Surface Tension: (*FLME/CAPIL/TENS*)		
(09) Surface Tension (General)	$\sigma=\frac{P}{L}$	*GENER*
(10) Surface Tension (In bulb surrounded by air)	$\sigma=\frac{P*D}{8}$	*AIR*
(11) Surface Tension (In a droplet or bubble in liquid)	$\sigma=\frac{P*D}{4}$	*LIQID*

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME

FRICTION FACTOR (MOODY CHART): (*FLME/FRIC.F*)

(12) Laminar flow, **NRe<2000**	$f=\frac{64}{NRe}$	*LAMI*
(13) Turbulent flow, **NRe>4000**	$\frac{1}{\sqrt{f}}=-2LOG(\frac{\epsilon/D}{3.7}+\frac{2.51}{NRe\sqrt{f}})$	*TURBU*

FRICTION HEAD/LOSS IN PIPE: (*FLME/FRIC.H*)

Darcy Equations: (*FLME/FRIC.H/DARCY*)

(14) General, with the given velocity, in **fps**	$h_f=\frac{f*L_e*v^2}{2*g*D}$	*GENER*

English System: (*FLME/FRIC.H/DARCY/ENG*)

(15) With the given flow, in **gpm**	$h_f=\frac{f*L_e*gpm^2}{248528*g*D^5}$	*GPM*
(16) With the given flow, in **cfs**	$h_f=\frac{f*L_e*cfs^2}{1.2337*g*D^5}$	*CFS*

SI System: (*FLME/FRIC.H/DARCY/SI*)

(17) With the given flow, in **lps**	$h_f=\frac{f*L_e*lps^2}{1233700*g*D^5}$	*LPS*
(18) With the given flow, in **m3ps**	$h_f=\frac{f*L_e*m3ps^2}{1.2337*g*D^5}$	*M3PS*

Hazen-Williams equation (*FLME/FRIC.H/HAZN*)

(19) English System	$h_f=\frac{3.012*v^{1.85}*L_e}{C_{HW}{}^{1.85}\cdot D^{1.165}}$	*ENG*
(20) Si System	$h_f=\frac{6.797*v^{1.85}*L_e}{C_{HW}{}^{1.85}*D^{1.165}}$	*SI*
(21) Fittings, Valves, Entrances	$h_f=\frac{K*v^2}{2*g}$	*FITIN*
(22) Nozzle, Orifice, Ventury	$h_f=(\frac{1}{C_v^2}-1)\frac{v^2}{2*g}$	*NOZL*
(23) Sudden Contraction	$h_f=\frac{K_c*v_2^2}{2*g}$	*CONT*

Enlargement: (*FLME/FRIC.H/NLRG*)

(24) Gradual	$h_f=\frac{K_e(v_1-v_2)^2}{2*g}$	*GRAD*
(25) Sudden	$h_f=(1-(\frac{D_1}{D_2})^2)^2\frac{v_1^2}{2*g}$	*SUDD*
(26) Scaled pipe	$h_f=h_{fnew}(\frac{D_{new}}{D_{scal}})^5$	*SCALE*

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME
HYDROSTATIC PRESSURE: (*FLME/HYD.P*)		
English System: (*FLME/HYD.P/ENG*)		
Horizontal plate: (*FLME/HYD.P/ENG/HORIZ*)		
(27) Density	$\rho=\frac{P}{h}$	*DENSI*
(28) Gage pressure	$p=\rho*h$	*PRESS*
(29) Vertical force	$F=\rho*h*A$	*FORCE*
Inclined rectangular plate: (*FLME/HYD.P/ENG/INCLN*)		
Pressure: (*FLME/HYD.P/ENG/INCLN/PRESS*)		
(30) Gage pressure	$p=\rho*L*SIN\Omega$	*GAGE*
(31) Gage pressure, average	$p_A=.5*\rho(L_1+L_2)SIN\Omega$	*AVER*
(32) Location of Center of Gravity	$C_G=.5(L_1+L_2)$	*CEN.G*
(33) Location of Center of Pressure	$C_P=\frac{2}{3}(L_1+L_2-\frac{L_1*L_2}{L_1+L_2})$	*CEN.P*
(34) Normal force on plane	$F=.5*\rho(L_1+L_2)SIN\Omega*A$	*FORCE*
SI System: (*FLME/HYD.P/SI*)		
Horizontal plate: (*FLME/HYD.P/SI/HORIZ*)		
(35) Density	$\rho=\frac{P}{h*g}$	*DENSI*
(36) Gage pressure	$p=\rho*h*g$	*PRESS*
(37) Vertical force	$F=\rho*h*g*A$	*FORCE*
Inclined rectangular plate: (*FLME/HYD.P/SI/INCLN*)		
Pressure: (*FLME/HYD.P/SI/INCLN/PRESS*)		
(38) Gage pressure	$p=\rho*L*g*SIN\Omega$	*GAGE*
(39) Gage pressure, average	$p_A=.5*\rho*g(L_1+L_2)SIN\Omega$	*AVER*
(40) Location of Center of Gravity	$C_G=.5(L_1+L_2)$	*CEN.G*
(41) Location of Center of Pressure	$C_P=\frac{2}{3}(L_1+L_2-\frac{L_1*L_2}{L_1+L_2})$	*CEN.P*
(42) Normal force on plane	$F=.5*\rho*g(L_1+L_2)SIN\Omega*A$	*FORCE*

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME
OPEN CHANNEL: (*FLME/CHAN*)		
(43) Flow	$V=v*A$	*FLOW*
Roughness Constant: (*FLME/CHAN/ROGH*)		
(44) English System	$n=\frac{1.4859*HR^{\frac{2}{3}}*SLP^{.5}}{v}$	*ENG*
(45) SI System	$n=\frac{HR^{\frac{2}{3}}*SLP^{.5}}{v}$	*SI*
Velocity: (*FLME/CHAN/VELO*)		
(46) English System	$v=\frac{1.4859*HR^{\frac{2}{3}}*SLP^{.5}}{n}$	*ENG*
(47) SI System	$v=\frac{HR^{\frac{2}{3}}*SLP^{.5}}{n}$	*SI*

DESCRIPTION	FORMULA	NAME
ORIFICE: (*FLME/ORIF*)		
Coefficient: (*FLME/ORIF/COEF*)		
(48) Contraction	$C_c=\frac{C_d*v_i}{v_a}$	*CONT*
(49) Discharge	$C_d=\frac{4*V}{\pi*D^2*\sqrt{2*g*h}}$	*DISCH*
(50) Velocity	$C_v=\frac{C_d}{C_c}$	*VELO*
Discharge Velocity: (*FLME/ORIF/VELO*)		
(51) Actual	$v_a=\frac{x}{\sqrt{2*y/g}}$	*ACTU*
(52) Ideal	$v_i=\sqrt{2*g*h}$	*IDEAL*
Flow quantity: (*FLME/ORIF/FLOW*)		
(53) Gage height	$V=\frac{C_d*\pi*D^2}{4}(2*g*h)^{.5}$	*H*
(54) Height difference	$V=\frac{C_d*\pi*D^2}{4}(2g*dh(SG_1-SG_2))^{.5}$	*ΔH*

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME
PIPE: (*FLME/PIPE*)		
(55) Area (full flow)	$A=\frac{\pi*D^2}{4}$	***AREA***
Flow quantity: (*FLME/PIPE/FLOW*)		
English System: (*FLME/PIPE/FLOW/ENG*)		
(56) Flow in **gpm**	$gpm=\frac{v*\pi*D^2}{.00891}$	***GPM***
(57) Flow in **cfs**	$cfs=\frac{v*\pi*D^2}{4}$	***CFS***
SI System: (*FLME/PIPE/FLOW/SI*)		
(58) Flow in **lps**	$lps=785.4*v*D^2$	***LPS***
(59) Flow in **m3ps**	$m3ps=\frac{v*\pi*D^2}{4}$	***M3PS***
Velocity: (*FLME/PIPE/VELO*)		
English System: (*FLME/PIPE/VELO/ENG*)		
(60) Flow in **gpm**	$v=\frac{.00891*gpm}{\pi*D^2}$	***GPM***
(61) Flow in **cfs**	$v=\frac{4*cfs}{\pi*D^2}$	***CFS***
SI System: (*FLME/PIPE/VELO/SI*)		
(62) Flow in **lps**	$v=\frac{lps}{785.4*D^2}$	***LPS***
(63) Flow in **m3ps**	$v=\frac{4*m3ps}{\pi*D^2}$	***M3PS***
Hydraulic Radius: (*FLME/PIPE/HYD.R*)		
(64) General	$HR=\frac{Flow\ Area(FA)}{Wet\ Perimeter(WP)}$	***GENER***
(65) Central angle given	$HR=\frac{r(.5*\pi*\Omega-90*SIN\Omega)}{\pi*\Omega}$	***ANGL***
(66) Height of liquid given	$HR=.5*r-\frac{90(r-h)*SIN(ACOS(\frac{r-h}{r}))}{\pi*ACOS(\frac{r-h}{r})}$	***HIGHT***

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME
PUMP: (*FLME/PUMP*)		
Head added by: (*FLME/PUMP/HEAD*)		
English System: (*FLME/PUMP/HEAD/ENG*)		
(67) Flow in **gpm**	$hA=\frac{246858\times hp\times\eta}{gpm\times\rho}$	*GPM*
(68) Flow in **cfs**	$hA=\frac{550\times hp\times\eta}{cfs\times\rho}$	*CFS*
SI System: (*FLME/PUMP/HEAD/SI*)		
(69) Flow in **lps**	$hA=\frac{76150\times hp\times\eta}{lps\times\rho}$	*LPS*
(70) Flow in **m3ps**	$hA=\frac{76.15\times hp\times\eta}{m3ps\times\rho}$	*M3PS*
Horsepower: (*FLME/PUMP/HP*)		
English System: (*FLME/PUMP/HP/ENG*)		
(71) Flow in **gpm**	$hp=\frac{hA\times gpm\times\rho}{246858\times\eta}$	*GPM*
(72) Flow in **cfs**	$hp=\frac{hA\times cfs\times\rho}{550\times\eta}$	*CFS*
SI System: (*FLME/PUMP/HP/SI*)		
(73) Flow in **lps**	$hp=\frac{hA\times lps\times\rho}{76150\times\eta}$	*LPS*
(74) Flow in **m3ps**	$hp=\frac{hA\times m3ps\times\rho}{76.15\times\eta}$	*M3PS*

REYNOLDS NUMBER: (*FLME/REYN*)		
(75) With Absolute Viscosity	$NR_e=\frac{D*v*\rho}{\mu*g}$	*ABSO*
(76) With Kinematic Viscosity	$NR_e=\frac{D*V}{\nu}$	*KINET*

SPEED OF SOUND: (*FLME/SOUND/ENG*)		
Gas: (*FLME/SOUND/ENG/GAS*)		
(77) With variables **K**, **R**, **T**	$c_g=\sqrt{k*g*R*T}$	*K.R.T*
(78) With variables **K**, **p**, **ρ**	$c_g=\sqrt{\frac{k*p*g}{\rho}}$	*K.P.ρ*
Liquid: (*FLME/SOUND/ENG/LIQID*)		
(79) With Bulk Modules	$c_l=\sqrt{\frac{BM*g}{\rho}}$	*BULK*
(80) With Coefficient of compressibility	$c_l=\sqrt{\frac{g}{CM*\rho}}$	*COMP*

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME
THIN CYLINDER: ***(FLME/CYLIN)***		
(81) Hoop stress	$f=\frac{P*r}{t}$	*STRES*
(82) Thickness of cylinder	$t=\frac{P*r}{f}$	*THICK*
TURBINE HORSEPOWER: ***(FLME/TURB/HP)***		
English System: ***(FLME/TURB/HP/ENG)***		
(83) Flow in **gpm**	$hp=\frac{gpm*\rho*h*\eta}{246858}$	*GPM*
(84) Flow in **cfs**	$hp=\frac{cfs*\rho*h*\eta}{550}$	*CFS*
SI System: ***(FLME/TURB/HP/SI)***		
(85) Flow in **lps**	$hp=\frac{h\times lps\times\rho\times\eta}{76150}$	*LPS*
(86) Flow in **m3ps**	$hp=\frac{h\times m3ps\times\rho\times\eta}{76.15}$	*M3PS*
VENTURI: ***(FLME/VENT)***		
(87) Flow quantity (with **h**)	$V=\frac{\pi*C_d*D_1^2*D_2^2}{4}\left(\frac{2g*dh(SG_1-SG_2)}{D_1^4-D_2^4}\right)^{.5}$	*HEAD*
(88) Flow quantity (with **p**)	$V=\frac{\pi*C_d*D_2^2}{4(1-D_2^4/D_1^4)^{.5}}+\left(2g\left(\frac{p_1-p_2}{\rho}\right)+z_1-z_2\right)^{.5}$	*PRESS*
(89) Velocity head	$h_v=\frac{V^2(D_1^4-D_2^4)}{2g(SG_1-SG_2)\left(\frac{\pi}{4}C_d*D_1^2*D_2^2\right)^2}$	*VEL.H*
WATER HAMMER: ***(FLME/HAMR)***		
(90) Pressure increase	$dp=\frac{\rho*C*dv}{g}$	ΔP
(91) Time for shock wave to travel	$t=\frac{2*L}{C}$	*TIME*

FLUID MECHANICS

DESCRIPTION	FORMULA	NAME
WEIR, RECTANGULAR, SUPPRESSED: (*FLME/WEIR*)		
Flow quantity: (*FLME/WEIR/FLOW*)		
(92) English System	$V=3.33*b*h^{\frac{2}{3}}$	*ENG*
(93) SI System	$V=1.838*b*h^{\frac{2}{3}}$	*SI*
Head: (*FLME/WEIR/HEAD*)		
(94) English System	$h=(\frac{V}{3.33*b})^{\frac{2}{3}}$	*ENG*
(95) SI System	$h=(\frac{V}{1.838*b})^{\frac{2}{3}}$	*SI*
(96) Velocity	$v=\frac{V}{b(h+PH)}$	*VELO*

FLUID MECHANICS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
A	Area; ft2, m2 (1 ft2 = .0929 m2.)
b	Weir's width; ft, m (1 ft = 0.3048 m.)
BM(E)	Bulk Modules; lbf/ft2.
c	Speed of sound; ft/s, m/s (1 ft/s = .3048 m/s, not given, assume: air: 1130 ft/s, 344.4 m/s water: 4880 ft/s, 1487 m/s.)
Cc	Contraction Coefficient; None.
Cd	Discharge Coefficient; None.
cfs=ft3/s	Cubic foot per second (1 cfs = 448.83 gpm = 0.028317 m3/s = 28.317 L/s.)
cg	Speed of sound in gas; ft/s, m/s (1 ft/s = 0.3048 m/s.)
CG	Location of Center of gravity; ft, m (1 ft = 0.3048 m.)
C.HW	Hazen-William Coefficient; None (Assumed same value for ENG and SI Systems.)
cl	Speed of sound in liquid; ft/s, m/s (1 ft/s = 0.3048 m/s.)
CM	Compressibility; ft2/lbf.
Cp	Location of Center of pressure; ft, m (1 ft = 0.3048 m.)
Cv	Velocity Coefficient; None.
D	Diameter; ft, m : Diameter of droplet, bubble; ft, m (1 ft = .3048 m.)
d	Depth; ft, m : Diameter; ft, m : Diameter of capillary tube ; ft, m (1 ft = .3048 m.)
dh	Height difference; ft, m (1 ft = 0.3048 m.)
dp	Pressure difference; lbf/ft2, Pa (1 lbf/ft2 = 47.88 Pa.)
dv	Velocity difference; ft/s, m/s (1 ft/s = 0.3048 m/s.)
F	Force; lbf, N (1 lbf = 4.4482 N.)
f	Friction Factor; None : Hoop stress; lbf/s2, Pa (1 lbf/in2 = 6894.8 Pa.)
g	Gravity acceleration; ft/s2, m/s2 (g=32.2 ft/s2, g=9.8067 (9.81) m/s2.)
gpm	Gallon per minute (1 gpm = 0.002228 cfs = 6.309EE-5 m3/s = 0.06309 L/s.)
hA	Added head; ft, m (1 ft = .3048 m.)
hf	Friction head; ft, m (1 ft = .3048 m.)
hFIT	Fittings friction head; ft, m (1 ft = .3048 m.)
HR	Hydraulic Radius; ft, m (1 ft = .3048 m.)
hv	Velocity head; ft, m (1 ft = .3048 m.)
K/Ke	Coefficient; None.
k	Specific Heat Ratio; None.
L	Length; ft, m : Distance; ft, m (1 ft = .3048 m.)
Le	Equivalent length; ft, m (1 ft = .3048 m.)
lps=L/s	Liter per second (1 L/s = 15.85 gpm = 0.035315 cfs = 1 EE-3 m3/s.)
m3ps=m3/s	Cubic meter per second (1 m3/s = 15850 gpm = 35.315 cfs = 1000 L/s.)
n	Manning roughness constant; None (If not given, assume the design values as: copper: 140, plastic: 130, cast iron/concrete/steel: 100. Assumed same value for ENG and SI)

FLUID MECHANICS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
N_{Re}	Reynold's number; **None**.
P	Pressure; **lbf/in2**, **Pa** (1 lbf/in2 = 6894.8 Pa.)
p	Pressure; **lbf/ft2**, **Pa** (1 lbf/ft2 = 47.88 Pa.)
PH	Plate's height; **ft**, **m** (1 ft = .3048 m.)
r	Radius of pipe; **ft**, **m** (1 ft = .3048 m.) : Radius of cylinder; **in**, **m** (1 in = .0254 m.)
SG	Specific Gravity; **None** : subscript 1 = heavier, 2 = lighter.
SLP	Slope; **ft/1000ft**.
t	Thickness; **in**. : Time; **sec**.
T	Absolute temperature; **oR**.
V	Flow quantity; **ft3/s**, **m3/s** (1 ft3/s = .028317 m3/s.)
v	Velocity; **ft/s**, **m/s** (1 ft/s = .3048 m/s.)
va	Actual velocity; **ft/s**, **m/s** (1 ft/s = .3048 m/s.)
vi	Ideal velocity; **ft/s**, **m/s** (1 ft/s = .3048 m/s.)
x	x coordinate from orifice; **ft**, **m** (1 ft = .3048 m.)
y	y coordinate from orifice; **ft**, **m** (1 ft = .3048 m.)
z	Elevation above datum; **ft**, **m** (1 ft = .3048 m.)
α	Blade's angle with x axis; **degree**.
β	Liquid's angle with the wetted tube wall; **degree**.
ϵ	Specific roughness; **ft** (If not given, assume the design values as; copper/plastic: 0.000005, cast iron: 0.0008, steel: 0.0002, concrete: 0.004)
η	Efficiency; **decimal**.
μ	Absolute viscosity; **lbf-sec/sf**.
ν	Kinematic viscosity, **ft2/sec**.
Ω	Inclination or central angle; **deg**.
ρ	Density; **lb/ft3**, **kg/m3** (If not given for water, assume: 62.4 lb/ft3, 1000 kg/m3.)
σ	Surface tension; **lbf/ft**, **N/m** (1 lbf/ft = 14.594 N/m.)

GAS PROPERTY CHANGE (IDEAL GAS)

DESCRIPTION	FORMULA	NAME
CONSTANT PRESSURE: (*GASP/PRESS*)		
dp=0, Q=dh, c=cp		
(01) Volume change	$v_2=v_1\frac{T_2}{T_1}$	ΔV
(02) Temperature change	$T_2=T_1\frac{v_2}{v_1}$	ΔT
(03) Enthalpy change	$dh=c_p(T_2-T_1)$	ΔH
(04) Entropy change	$ds=c_p*\ln\frac{T_2}{T_1}$	ΔS
(05) Internal energy change	$du=c_v(T_2-T_1)$	ΔU
(06) Heat	$Q=c_p(T_2-T_1)$	Q
(07) Work	$W=p_1(v_2-v_1)$	W

CONSTANT TEMPERATURE: (*GASP/TEMP*)

dT=0, dh=0, du=0, W=Q, n=1

(08) Pressure change	$p_2=p_1\frac{v_1}{v_2}$	ΔP
(09) Volume change	$v_2=v_1\frac{p_1}{p_2}$	ΔV

Entropy change: (*GASP/TEMP/* ΔS)

(10) English System	$ds=\frac{R}{778}*\ln\frac{v_2}{v_1}$	*ENG*
(11) SI System	$ds=R*\ln\frac{v_2}{v_1}$	*SI*

Heat: (*GASP/TEMP/HEAT*)

With P and V: (*GASP/TEMP/HEAT/P.V*)

(12) English System	$Q=\frac{p_1*v_1}{778}*\ln\frac{v_2}{v_1}$	*ENG*
(13) SI System	$Q=p_1*v_1*\ln\frac{v_2}{v_1}$	*SI*

GAS PROPERTY CHANGE (IDEAL GAS)

DESCRIPTION	FORMULA	NAME

CONSTANT TEMPERATURE (continued): (*GASP/TEMP*)

With R, T, and V: (*GASP/TEMP/HEAT/R.T.V*)

14) English System	$Q=\frac{R*T}{778}*\ln\frac{v_2}{v_1}$	*ENG*
(15) SI System	$Q=R*T*\ln\frac{v_2}{v_1}$	*SI*

Work: (*GASP/TEMP/WORK*)

(16) With P and V	$W=p_1*v_1*\ln\frac{v_2}{v_1}$	*P.V*
(17) With R, T, and V	$W=R*T*\ln\frac{v_2}{v_1}$	*R.T.V*

CONSTANT VOLUME: (*GASP/VOLM*)

dv=0, W=0, Q=du, c=cv

(18) Pressure change	$p_2=p_1\frac{T_2}{T_1}$	ΔP
(19) Temperature change	$T_2=T_1\frac{p_2}{p_1}$	ΔT
(20) Enthalpy change	$dh=c_p(T_2-T_1)$	ΔH
(21) Entropy change	$ds=c_v*\ln\frac{T_2}{T_1}$	ΔS
(22) Internal energy change	$du=c_v(T_2-T_1)$	ΔU
(23) Heat	$Q=c_v(T_2-T_1)$	*Q*

GAS PROPERTY CHANGE (IDEAL GAS)

DESCRIPTION	FORMULA	NAME
ISENTROPIC PROCESS: ***(GASP/ISENT)***		
ds=0, Q=0		
(24) Pressure change (change in volume)	$P_2 = P_1 (\frac{V_1}{V_2})^k$	$\Delta P/V$
(25) Pressure change (change in temperature)	$P_2 = P_1 (\frac{T_2}{T_1})^{\frac{k}{k-1}}$	$\Delta P/T$
(26) Temperature change (change in volume)	$T_2 = T_1 (\frac{V_1}{V_2})^{k-1}$	$\Delta T/V$
(27) Temperature change (change in pressure)	$T_2 = T_1 (\frac{P_2}{P_1})^{\frac{k-1}{k}}$	$\Delta T/P$
(28) Volume change (change in pressure)	$V_2 = V_1 (\frac{P_1}{P_2})^{\frac{1}{k}}$	$\Delta V/P$
(29) Volume change (change in temperature)	$V_2 = V_1 (\frac{T_1}{T_2})^{\frac{1}{k-1}}$	$\Delta V/T$
(30) Enthalpy change	$dh = c_p (T_2 - T_1)$	ΔH
(31) Internal energy change	$du = c_v (T_2 - T_1)$	ΔU
Work: ***(GASP/ISENT/WORK)***		
Closed System: ***(GASP/ISENT/WORK/CLOSE)***		
(32) With P and V	$W = \frac{P_1 * V_1 - P_2 * V_2}{k-1}$	P.V
With CV and T: ***(GASP/ISENT/WORK/CLOSE/CV.T)***		
(33) English System	$W = 778 * c_v (T_1 - T_2)$	ENG
(34) English System	$W = c_v (T_1 - T_2)$	SI
Steady Flow System: ***(GASP/ISENT/WORK/FLOW)***		
With CP and T: ***(GASP/ISENT/WORK/FLOW/CP.T)***		
(35) English System	$W = 778 * c_p * T_1 (1 - (\frac{P_2}{P_1})^{\frac{k-1}{k}})$	ENG
(36) SI System	$W = c_p * T_1 (1 - (\frac{P_2}{P_1})^{\frac{k-1}{k}})$	SI

GAS PROPERTY CHANGE (IDEAL GAS)

DESCRIPTION	FORMULA	NAME

ISENTROPIC PROCESS: (*GASP/ISENT*)

Work: (*GASP/ISENT/WORK*)

Steady Flow System (continued): (*GASP/ISENT/WORK/FLOW*)

DESCRIPTION	FORMULA	NAME
(37) With P and V	$W=\frac{k}{k-1}(p_2v_2-p_1v_1)$	P.V

Specific Heat Ratio: (*GASP/ISENT/K*)

DESCRIPTION	FORMULA	NAME
(38) With P and V	$k=\ln\frac{p_2}{p_1}/\ln\frac{v_1}{v_2}$	P.V
(39) With P and T	$k=\frac{\ln(p_2/p_1)}{\ln(p_2/p_1)-\ln(T_2/T_1)}$	P.T

POLYTROPIC PROCESS: (*GASP/POLYT*)

DESCRIPTION	FORMULA	NAME
(40) Pressure change (change in volume)	$p_2=p_1(\frac{v_1}{v_2})^n$	ΔP/V
(41) Pressure change (change in temperature)	$p_2=p_1(\frac{T_2}{T_1})^{\frac{n}{n-1}}$	ΔP/T
(42) Temperature change (change in volume)	$T_2=T_1(\frac{v_1}{v_2})^{n-1}$	ΔT/V
(43) Temperature change (change in pressure)	$T_2=T_1(\frac{p_2}{p_1})^{\frac{n-1}{n}}$	ΔT/P
(44) Volume change (change in pressure)	$v_2=v_1(\frac{p_1}{p_2})^{\frac{1}{n}}$	ΔV/P
(45) Volume change (change in temperature)	$v_2=v_1(\frac{T_1}{T_2})^{\frac{1}{n-1}}$	ΔV/T

Enthalpy change: (*GASP/POLYT/* ΔH)

DESCRIPTION	FORMULA	NAME
(46) With CP and T	$dh=c_p(T_2-T_1)$	CP.T

With P and V: (*GASP/POLYT/* ΔH */P.V*)

DESCRIPTION	FORMULA	NAME
(47) English System	$dh=\frac{n(p_2*v_2-p_1*v_1)}{778(n-1)}$	ENG
(48) SI System	$dh=\frac{n(p_2*v_2-p_1*v_1)}{n-1}$	SI

GAS PROPERTY CHANGE (IDEAL GAS)

DESCRIPTION	FORMULA	NAME
POLYTROPIC PROCESS (continued): (*GASP/POLYT*)		
(49) Entropy change	$ds=\frac{c_v(n-k)*\ln(T_2/T_1)}{n-1}$	ΔS
(50) Internal energy change	$du=c_v(T_2-T_1)$	ΔU
(51) Heat	$Q=\frac{c_v(n-k)(T_2-T_1)}{n-1}$	Q
Work: (*GASP/POLYT/WORK*)		
Closed System: (*GASP/POLYT/WORK/CLOSE*)		
(52) With P and V	$W=\frac{p_1*v_1-p_2*v_2}{n-1}$	P.V
(53) With R and T	$W=\frac{R*(T_1-T_2)}{n-1}$	R.T
Steady Flow System: (*GASP/POLYT/WORK/FLOW*)		
With H: (*GASP/POLYT/WORK/FLOW/H*)		
(54) English System	$W=778*(h_1-h_2)$	ENG
(55) SI System	$W=(h_1-h_2)$	SI
(56) With P and V	$W=\frac{n}{n-1}(p_2*v_2-p_1*v_1)$	P.V
Specific Heat Ratio: (*GASP/POLYT/N*)		
(57) With P and V	$n=\ln\frac{p_2}{p_1}/\ln\frac{v_1}{v_2}$	P.V
(58) With P and T	$n=\frac{\ln(p_2/p_1)}{\ln(p_2/p_1)-\ln(T_2/T_1)}$	P.T

GAS PROPERTY CHANGE (IDEAL GAS)

THROTTLING, STEADY FLOW: (*GASP/THROT*)

dP < 0, dv > 0, dT = 0, dh = 0, du = 0, Q = W = 0

(59) Pressure change $p_2 = p_1 \frac{v_1}{v_2}$ **ΔP**

Entropy change: (*GASP/THROT/* **Δs**)

With R and P: (*GASP/THROT/* **Δs** */R.P*)

(60) English System $ds = \frac{R}{778} * \ln \frac{P_1}{P_2}$ ***ENG***

(61) SI System $ds = R * \ln \frac{P_1}{P_2}$ ***SI***

With R and V: (*GASP/THROT/* **Δs** */R.V*)

(62) English System $ds = \frac{R}{778} * \ln \frac{V_2}{V_1}$ ***ENG***

(63) SI System $ds = R * \ln \frac{V_2}{V_1}$ ***SI***

(64) Volume change $v_2 = v_1 \frac{P_1}{P_2}$ **ΔV**

GENERAL: IDEAL GAS, WORK, HP EQUATIONS:

GAS, IDEAL: (*GASP/IDEAL*)

(65) With the given **mass** $pV = mRT$ ***MASS***

(66) With the given **mole** $pV = nR'T$ ***MOLE***

WORK: (*GASP/WORK*)

(67) English System $W = 778(dh+Q) + Z_1 - Z_2 + \left(\frac{v_1^2 - v_o^2}{2g}\right)$ ***ENG***

(68) SI System $W = dh + Q + (Z_1 - Z_2) * g + \left(\frac{v_1^2 - v_o^2}{2}\right)$ ***SI***

HORSEPOWER: (*GASP/HP*)

(69) English System $hp = \frac{M}{550}\left(778(dh+Q) + Z_1 - Z_2 + \left(\frac{v_1^2 - v_o^2}{2g}\right)\right)$ ***ENG***

(70) SI System $hp = \frac{M}{745.7}\left(dh + Q + (Z_1 - Z_2) * g + \left(\frac{v_1^2 - v_o^2}{2}\right)\right)$ ***SI***

GAS PROPERTY CHANGE (IDEAL GAS)

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
cp	Specific heat, Constant Pressure; **BTU/lbm-oR**, **J/kg.K** (1 BTU/lbm-oR=4186.8 J/kg.K).
cv	Specific Heat, Constant Volume; **BTU/lbm-oR**, **J/kg.K** (1 BTU/lbm-oR=4186.8 J/kg.K).
g	Gravitational acceleration; **ft/s2**, **m/s2** (1 ft/s2=0.3048 m/s2).
h	Enthalpy; **BTU/lbm**, **J/kg** (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
k	Ratio of Specific Heat; **None**.
M	Mass in flow; **lbm/s**, **kg/s** (1 lbm=0.4536 kg).
m	Mass; **lbm**, **kg** (1 lbm=0.4536 kg).
n	Polytropic Exponent; **None**, Number of moles; **pmole**, **kgmole**.
p	Pressure; **lb/ft2** **Pa** (1 lb/ft2=47.88 Pa).
Q	Heat; **BTU/lbm**, **J/kg** (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
R	Specific Heat Constant; **ft-lbf/lbm-oR**, **J/kg.K** (1 ft-lbf/lbm-R=5.3803 J/kg.K, 1 ft.lbf=1.3558 J).
R'	Universal Gas Constant; **1545.3 ft-lbf/pmole-oR**, **8314 J/kgmole.K**.
s	Entropy; **BTU/lbm-oR**, **J/kg.K** (1 BTU/lbm-oR=4186.8 J/kg.K).
T	Temperature; **oR**, **K**.
u	Internal energy; **BTU/lbm**, **J/kg** (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
V	Volume; **ft3**, **m3** (1 ft3=0.0283 m3).
v	Specific volume; **ft3/lbm**, **m3/kg** (1 ft3/lbm=0.06243 m3/kg).
vi	Velocity at inlet; **ft/s**, **m/s** (1 ft/s=0.3048 m/s).
vo	Velocity at outlet; **ft/s**, **m/s** (1 ft/s=0.3048 m/s).
W	Work; **ft-lbf/lbm**, **J/kg** (1 ft-lb/lbm=2.989 J/kg).
z	Elevation; **ft**, **m** (1 ft=0.3048 m).

MATHEMATICS

DESCRIPTION	FORMULA	NAME
AREA: (*MATH/AREA*)		
(01) Circle	$A=\pi*r^2$	*CIRCL*
Circular segment: (*MATH/AREA/SEGM*)		
(02) With the given central angle	$A=.5*r^2(\pi*\frac{\Omega}{180}-SIN\Omega)$	*ANGL*
(03) With the given height	$A=.5*r^2(\frac{\pi ACOS(\frac{r-h}{r})}{90}-SIN(2ACOS(\frac{r-h}{r})))$	*HGHT*
(04) Circular sector	$A=\pi*\frac{\Omega}{360}*r^2$	*SECTR*
(05) Ellipse	$A=\pi*a*b$	*ELIPS*
(06) Ring section	$A=\pi(r_o^2-r_i^2)$	*RING*
DETERMINANT: (*MATH/DETER*)		
(07) Second order $\begin{vmatrix} a1 & b1 \\ a2 & b2 \end{vmatrix}$	$DT2=a_1b_2-b_1a_2$	*DT2*
(08) Third order $\begin{vmatrix} a1 & b1 & c1 \\ a2 & b2 & c2 \\ a3 & b3 & c3 \end{vmatrix}$	$DT3=a_1b_2c_3+b_1c_2a_3+c_1a_2b_3-a_3b_2c_1-b_3c_2a_1-c_3a_2b_1$	*DT3*
HYDRAULIC RADIUS: (*MATH/HYD.R*)		
(09) General	$HR=\frac{FA\ (Flow\ Area)}{WP\ (Wet\ Perimeter)}$	*GENER*
(10) Pipe, with the given central angle	$HR=\frac{r(.5*\pi*\Omega-90*SIN\Omega)}{\pi*\Omega}$	*ANGL*
(11) Pipe, with the given height	$HR=.5*r-\frac{90(r-h)*SIN(ACOS(\frac{r-h}{r}))}{\pi*ACOS(\frac{r-h}{r})}$	*HGHT*

MATHEMATICS

DESCRIPTION	FORMULA	NAME
(12) Interpolation	$A_m=\frac{A_1-A_2}{B_1-B_2}(B_m-B_1)+A_1$	*INTRP*

POLAR/RECTANGULAR COORDINATES: (*MATH/PL-RC*)

(13) Angle	$\Omega=ATAN(\frac{y}{x})$	*ANGL*
(14) Radius	$R=(x^2+y^2)^{.5}$	*RDIUS*
(15) x Coordinate	$x=R*COS\Omega$	*X.COR*
(16) y Coordinate	$y=R*SIN\Omega$	*Y.COR*

(17) Quadratic equation	$x=\frac{-b\pm(b^2-4a*c)^{.5}}{2a}$	*QAD→*

(18) Simultaneous (Linear) equation	$x=\frac{c_1*b_2-b_1*c_2}{a_1*b_2-a_2*b_1},\ y=\frac{a_2*c_1-a_1*c_2}{a_2*b_1-a_1*b_2}$	*SIM→*

SURFACE: (*MATH/SURF*)

Cones, Circular: (*MATH/SURF/CONE*)

(19) base included	$S=\pi*r(r^2+h^2)^{.5}+\pi*r^2$	*FULL*
(20) Cone, circular, w/o base	$S=\pi*r(r^2+h^2)^{.5}$	*FACE*

Cylinder: (*MATH/SURF/CYLIN*)

(21) Cylinder, ends included	$S=2*\pi*r*h+2\pi*r^2$	*FULL*
(22) Cylinder, w/o ends	$S=2*\pi*r*h$	*FACE*
(23) Sphere	$S=4*\pi*r^2$	*SPHER*

MATHEMATICS

DESCRIPTION	FORMULA	NAME
TRIANGLE LAW: (***MATH/ΔLAW***)		
Law of Cosine: (***MATH/ΔLAW/COS***)		
(24) Side of triangle	$a=(b^2+c^2-2*b*c*COSA°)^{.5}$	*SIDE*
(25) Angle of triangle	$A° = ACOS(\frac{b^2+c^2-a^2}{2*b*c})$	*ANGL*
Law of Sine: (***MATH/ΔLAW/SIN***)		
(26) Side of triangle	$a=\frac{b*SINA°}{SINB°}$	*SIDE*
(27) Angle of triangle	$A° = ASIN(\frac{a*SINB°}{b})$	*ANGL*

VOLUME: (***MATH/VOLM***)		
(28) Cone, right, circular	$V=\frac{\pi*r^2*h}{3}$	*CONE*
(29) Cylinder, circular	$V=\pi*r^2*h$	*CYLIN*
(30) Sphere	$V=\frac{4*\pi*r^3}{3}$	*SPHER*

MATHEMATICS, HP49G BUILT-IN FUNCTIONS

DIFFERENTIATION:

The following is the procedure to differentiate a symbolic expression where:

f(x) = Expression to be differentiated and **X** = variable of differentiation. Please notice that no variable **X** is stored in the calculator. Otherwise you will get the numerical value of differential. To ensure:

Key in ' X **ENTER** **TOOL** PURGE

* Key in ' $f(x)$ **ENTER**
* Key in ' X **ENTER**
* Press ∂ You will get the symbolic answer.

Note 1. The answer may need to be simplified.

Note 2. If you store a value for **X** and then press NUM, while the differential still located in level 1 of the screen, you will get the numeric value of the differential.

Note 3. You may do the second differentiation:
While the first differential is still in level 1 of the screen key in:
'X **ENTER** ∂ . Ensure no variable **X** existed in the calculator.

INTEGRATION:

The following is the procedure to find the value of an integral with numeric limits, where:

X1 = lower limit, **X2** = higher limit, **f(X)** = Expression to be integrated, and **X** = variable of integration.

* Key in ' $\int(x_1,\ x_2,\ f(x)\ ,\ x)$ **ENTER** NUM

MATHEMATICS, HP49G BUILT-IN FUNCTIONS

LINEAR (SIMULTANEOUS) EQUATIONS:

The built-in MATRIX Application in HP49G is used to solve the linear equations. Following is the procedure for a three (3) variable linear equation. Same rule applies to others.

Equations format:

$$\begin{cases} a_1x + b_1y + c_1z = d_1 \\ a_2x + b_2y + c_2z = d_2 \\ a_3x + b_3y + c_3z = d_3 \end{cases}$$

Step 1. Write matrix for **d1**, **d2**, **d3**

Press ↰ MTRW, key in d1 **SPC** d2 **SPC** d3 **ENTER** **ENTER**

Step 2. Write matrix for **a1**, **b1**, **c1**; **a2**, **b2**, **c2**; and **a3**, **b3**, **c3**:

Press ↰ MTRW, F5 (If necessary to make the "GO" right arrow active)

Key in a1 **SPC** b1 **SPC** c1 **ENTER** ▼ ↱ ◄

Key in a2 **SPC** b2 **SPC** c2 **ENTER**

Key in a3 **SPC** b3 **SPC** c3 **ENTER** **ENTER**

Step 3. Press ÷ . You will get the answer values in the form of [**x** **y** **z**]

PLOTTING AND CALCULATING ROOTS AND AREAS:

The simplified plotting, root calculation, and area calculation which are performed by the PLOT Application in HP49G, are described below:

Calculator must be in **ALG** mode.

* 1. Press ↰ Y= CLEAR ADD

* 2. Key in the expression, f(X) **ENTER**.

* 3. Press ERASE (to erase the previous plots.)

* 4. Press DRAW (to plot the function.)

Press ON ON

MATHEMATICS, HP49G BUILT-IN FUNCTIONS

Calculating Roots:

You should be in the screen with the plotted function.

To find the roots:

* 1. Press FCN ROOT. Read the first root
* 2. Press NXT ✕ (to locate the cursor).
* 3. Move the cursor to get close to the point next curve's intersection with **X** axis.
* 4. Press ROOT. Read the second value.
* 5. Follow the above steps (2 to 4) for the next root(s), if any.
* 6. Press ON ON (to get back to the normal mode). The roots are on the screen too.

Calculating the Area:

To find the area bounded by the curve, **X** axis, lower limit (**X1**), and the higher limit (**X2**):

* 1. Plot the expression as described above. But take the following exception for the better vision to the selected area:
* 2. Press ↰ Y= CLEAR ADD
* 3. Key in the expression, f(X) **ENTER** **ENTER**.
* 4. Press ↰ WIN
* 5. Key in value of **X1** **ENTER** and value of **X2**
* 3. Press AUTO ERASE (to erase the previous plots) DRAW. The curve will appear.
* 5. Press (x,y)
* 4. Press ↱ ◄ . X coordinate should read the value of **X1**
* 4. Press ✕ to set the lower limit.
* 4. Press ↱ ► . X coordinate should read the value of **X2**
* 6. Press NXT FCN AREA. Read the area.
* 7. When finished, press ON ON (to get back to the normal mode.)

NOTE:

If you have to calculate the area between two (2) curves within the **X** limits, you have to calculate the area of each curve and **X** axis and subtract them.

VECTORS:

To perform the vector operations by HP49G, take the following points into consideration:

1. Calculator in **RPN** and = (= or exact answer is located at the top of the screen next to **R**).
2. The functions are built in calculator's Mathematic (**MTH**) section, **MTH/VECTR**.

3. Vectors must be entered in the form of [a **SPC** b] for two (2) dimension and [a **SPC** b **SPC** c] for three (3) dimension vectors.

Unit Vector:

To find a Unit Vector, parallel to a given vector:

* Press **MTH** VECTR
* Key in the vector **ENTER** **ENTER** (to duplicate the vector on the screen.)
* Press ABS (to find the magnitude.)
* Press ÷ NUM.

Angle Between vectors:

To find the Vectors' angle:

* Press **MTH** VECTR
* Key in the first vector **ENTER**, key in the second vector **ENTER**
* Press DOT (to calculate the dot product.)
* Press ANS (to bring the two (2) vectors back to the screen.)
* Press ABS type **SWAP**, press **ENTER** ABS (to calculate the magnitude of both vectors.)
* Press × (to multiply the magnitudes.)
* Press ÷ (to divide the dot product by the products of magnitudes, This is the ACOS of the angle.)
* Press NUM ACOS (to find the angle.)

Dot Product of vectors:

To find the Dot Product of vectors (**V1.V2**):

* Press **MTH** VECTR
* Key in the first vector **ENTER**, key in the second vector
* Press DOT.

Cross Product of vectors:

To find the Cross Product of vectors (**V1xV2**):

* Press **MTH** VECTR
* Key in the first vector **ENTER**, key in the second vector
* Press CROSS.

Absolute value (magnitude) of vectors:

To find the magnitude of vectors:

* Press **MTH** VECTR
* Key in the vector
* Press ABS.

Addition and subtraction of vectors:

To add or subtract the vectors:

* Key in the first vector **ENTER**, key in the second vector **ENTER**, the third, etc.
* Apply the arithmetic operation keys (+ or −) as needed.

MECHANICS OF MATERIALS

DESCRIPTION	FORMULA	NAME
COLUMNS: (*MEMA/CLMN*)		
Load: (*MEMA/CLMN/LOAD*)		
(01) Euler load, with given **E** and **I**	$F_e=\frac{\pi^2*E*I}{(C*L)^2}$	*E.I*
(02) Euler load, with given **E** , **A**, and **K**	$F_e=E*A(\frac{\pi*k}{C*L})^2$	*E.A.K*
Stress: (*MEMA/CLMN/STRES*)		
(03) Euler stress, with given **F** and **A**	$\sigma_e=\frac{F_e}{A}$	*F.A*
(04) Euler stress, with given **E** and **K**	$\sigma_e=\frac{\pi^2*E}{(L*\frac{C}{k})^2}$	*E.K*

DESCRIPTION	FORMULA	NAME
SHAFT IN TORSION: (*MEMA/SHAFT*)		
Angle of twist: (*MEMA/SHAFT/ANGL*)		
(05) General equation	$\Omega=\frac{180*T*L}{\pi*G*J}$	*GENER*
(06) Solid round	$\Omega=\frac{360*T*L}{\pi^2*G*r^4}$	*SOLID*
(07) Hollow round	$\Omega=\frac{360*T*L}{\pi^2*G*(r_o^4-r_i^4)}$	*HOLLO*
(08) Energy stored	$U=\frac{T^2*L}{2*G*J}$	*ENRG*
(09) Horsepower, English System	$hp=\frac{T*RPM}{63025}$	*HP/ENG*
(09a) Horsepower, SI System	$hp=\frac{T*RPM}{7120.9}$	*HP/SI*
Shear Stress: (*MEMA/SHAFT/SHEAR*)		
(10) General	$\tau=\frac{T*r}{J}$	*GENER*
(11) Solid round	$\tau=\frac{2T}{\pi*r^3}$	*SOLID*
(12) Hollow round	$\tau=\frac{2*T*r_o}{\pi(r_o^4-r_i^4)}$	*HOLLO*
(13) Torque, English System	$T=\frac{63025*hp}{RPM}$	*TORQ/ENG*
(13a) Torque, SI System	$T=\frac{7120.9*hp}{RPM}$	*TORQ/SI*

MECHANICS OF MATERIALS

DESCRIPTION	FORMULA	NAME
STRESS: (*MEMA/STRES*)		
(14) Allowable stress	$\sigma_A=\frac{\sigma_u}{FS}$	*ALOW*
Bending stress: (*MEMA/STRES/BEND*)		
(15) General	$\sigma_b=\frac{M*y}{I_c}$	*GENER*
(16) Maximum	$\sigma_b=\frac{M*c}{I_c}$	*MAX*
Bending plus Normal stress: (*MEMA/STRES/BND+*)		
(17) Maximum	$\sigma=\frac{F}{A}+\frac{M*c}{I_c}$	*MAX*
(18) Minimum	$\sigma=\frac{F}{A}-\frac{M*c}{I_c}$	*MIN*
Combined stress: (*MEMA/STRES/COMB*)		
Normal stress: (*MEMA/STRES/COMB/NORM*)		
(19) Maximum	$\sigma_{max}=\frac{\sigma_x+\sigma_y}{2}+\sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$	*MAX*
(20) Minimum	$\sigma_{min}=\frac{\sigma_x+\sigma_y}{2}-\sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$	*MIN*
Shear stress: (*MEMA/STRES/COMB/SHEAR*)		
(21) Maximum	$\tau_{max}=\sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$	*MAX*
(22) Minimum	$\tau_{min}=-\sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2+\tau_{xy}^2}$	*MIN*
(23) Normal	$\sigma=E*\epsilon,\ \sigma=F/A$	*NRM→*
Shear stress: (*MEMA/STRES/SHEAR*)		
(24) General	$\tau=\frac{M_s*F_s}{I_c*b}$	*GENER*
Shear stress, Maximum: (*MEMA/STRES/SHEAR/MAX*)		
(25) In a circular section	$\tau_{mx}=\frac{4*F_s}{3*\pi*r^2}$	*CIRC*
(26) In a rectangular section	$\tau_{mx}=\frac{3*F_s}{2*b*h}$	*RECT*

MECHANICS OF MATERIALS

DESCRIPTION	FORMULA	NAME
THERMAL DEFORMATION: (*MEMA/DEFOR*)		
(27) Linear expansion	$d_L=\alpha * L_o(t_2-t_1)$	*EXPN*
Strain: (*MEMA/DEFOR/STRN*)		
(28) Axial, with elongation	$\epsilon=\frac{d_L}{L_o}$	*ΔL*
(29) Axial, with change in temperature	$\epsilon=\alpha(t_2-t_1)\ ,\ \epsilon=\sigma/E$	*AXL→*
(30) Lateral, with change in temperature	$\epsilon=\mu\alpha(t_2-t_1)\ ,\ \epsilon=\mu\sigma/E$	*LAT→*
Stress: (*MEMA/DEFOR/STRES*)		
(31) With the given **E** and ϵ	$\sigma=E*\epsilon$	*E.ε*
(32) With change in temperature	$\sigma=E*\alpha(t_2-t_1)$	*ΔT*
(33) With elongation	$\sigma=dL*E/L$	*ΔL*

DESCRIPTION	FORMULA	NAME
MISCELLANEOUS (*MEMA/MSCL*)		
(34) Elongation	$d_L=\frac{F*L}{A*E}$	*ELNG*
(35) Energy stored in loaded member	$U=\frac{F^2*L}{2A*E}$	*ENRG*
Polar moment of inertia (*MEMA/MSCL/POLR*)		
(36) Round hollow shaft	$J=\frac{\pi(r_o^4-r_i^4)}{2}$	*HOLLO*
(37) Round solid shaft	$J=\frac{\pi*r^4}{2}$	*SOLID*
(38) Radius of Gyration	$k=(\frac{I}{A})^{.5}$	*GYRA*
(39) Shear/Elasticity Modulus	$G=\frac{E}{2(1+\mu)}$	*MDUL*
(40) Strain	$\epsilon=\frac{d_L}{L_o}$	*STRN*

MECHANICS OF MATERIALS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
A	Area; in2, m2 (1 in2=0.000645 m2).
b	Width of section; in, m (1 in=0.0254 m).
C	End resistant coefficient; None. (Both end built in = 0.5, both end pinned = 1, one end built-in and one end pinned = 0.7, one end built-in and one end free = 2.)
c	Distance of extreme fiber from neutral axis; in, m (1 in=0.0254 m).
dL	Elongation; in, m (1 in=0.0254 m).
E	Modules of Elasticity; psi, Pa (1 psi=6894.8 Pa).
F	Force or load; lbf, N (1 lbf=4.4482 N).
Fe	Euler load; lbf, N (1 lbf=4.4482 N).
FS	Factor of Safety; None.
Fs	Shear force; lbf, N (1 lbf=4.4482 N).
G	Shear Modules; psi, Pa (1 psi=6894.8 Pa).
h	Height of beam section; in, m (1 in=0.0254 m).
hp	Horsepower.
I	Moment of Inertia; in4, m4 (1 in4=4.1623EE-7 m4).
Ic	Centeroidal Moment of Inertia; in4, m4 (1 in4=4.1623EE-7 m4).
J	Polar Moment of Inertia; in4, m4 (1 in4=4.1623EE-7 m4).
k	Radius of Gyration; in, m (1 in=0.0254 m).
L	Length; in, m (1 in=0.0254 m).
M	Moment; in-lbf, N.m (1 in-lbf=0.1129848 N.m).
Ms	Statistical Moment; in3, m3 (1 in3=1.6387EE-5 m3).
P	Pressure; psi, Pa (1 psi=6894.8 Pa).
r	Radius; in, m (1 in=0.0254 m).
ri	Inside radius; in, m (1 in=0.0254 m).
ro	Outside radius; in, m (1 in=0.0254 m).
RPM	Revolution Per Minute.
T	Torque; in-lbf, N.m (1 in-lbf=0.1129848 N.m).
t	Temperature; oF : Thickness; in, m (1 in=0.0254 m).
U	Energy stored in a load member; in-lbf, N.m (1 in-lbf=0.1129848 N.m).
y	Distance of fiber from neutral axis; in, m (1 in=0.0254 m).
α	Coefficient of linear thermal deformation; 1/oF, 1/oC.
ϵ	Strain; None.
μ	Poisson's Ratio; None.
Ω	Angle of twist; degree.
σ	Stress; psi, Pa (1 psi=6894.8 Pa).
σ_A	Allowable Stress; psi, Pa (1 psi=6894.8 Pa).
σ_b	Bending Stress; psi, Pa (1 psi=6894.8 Pa).
σ_e	Euler Stress; psi, Pa (1 psi=6894.8 Pa).
σ_u	Ultimate/Yield Stress; psi, Pa (1 psi=6894.8 Pa).
τ	Shear Stress; psi, Pa (1 psi=6894.8 Pa).

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME

ATMOSPHERIC AIR: (*THER/ATM.A*)

(01) Pressure, dry air	$P_{da}=P_{at}-P_{wv}$	*P.DRY*
(02) Pressure, total	$P_{at}=P_{da}+P_{wv}$	*P.TOT*

Pressure, water vapor: (*THER/ATM.A/P.WV*)

(03) With the given **Hs** and **P**	$P_{wv}=\frac{H_s*P_{at}}{.621+H_s}$	*HS.P*
(04) With the given **RH** and **P**	$P_{wv}=RH*P_{swv}$	*RH.P*

Relative Humidity: **(*THER/ATM.A/REL.H*)**

(05) With the given **Pwv**	$RH=\frac{P_{wv}}{P_{wsv}}$	*PWV*
(06) With the given **Pda**	$RH=\frac{1.61*H_s*P_{da}}{P_{swv}}$	*PDA*

Specific Humidity: **(*THER/ATM.A/SPC.H*)**

(07) With the given **Pda**	$H_s=\frac{.621*P_{wv}}{P_{da}}$	*PDA*
(08) With the given **Pat**	$H_s=\frac{.621*P_{wv}}{P_{at}-P_{wv}}$	*PAT*

COMPRESSORS: (*THER/COMP*)

Enthalpy: (*THER/COMP/ENTH*)

Compression Enthalpy: (*THER/COMP/ENTH/COMP*)

(09) English System	$h=\frac{v_f(p_2-p_1)}{778}$	*ENG*
(10) SI System	$h=v_f(p_2-p_1)$	*SI*
(11) Actual discharge enthalpy	$h_{2A}=h_1+\frac{h_{2I}-h_1}{\eta}$	*ACTU*
(12) Ideal discharge enthalpy	$h_{2I}=\eta(h_{2A}-h_1)+h_1$	*IDEAL*
(13) Efficiency	$\eta=\frac{h_{2I}-h_1}{h_{2A}-h_1}$	*EFFI*

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME
EFFICIENCY: (***THER/EFFI***)		
Carnot (***THER/EFFI/CARN***)		
(14) With the given **heats**	$\eta = \frac{q_{in} - q_{out}}{q_{in}}$	*HEAT*
(15) With the given **temperatures**	$\eta = \frac{T_h - T_l}{T_h}$	*TEMP*
Rankin (***THER/EFFI/RANK***)		
(16) With the given **heats**	$\eta = \frac{q_{in} - q_{out}}{q_{in}}$	*HEAT*
With the given works: (***THER/EFFI/RANK/WORK***)		
(17) English System	$\eta = \frac{W_{turb} - W_{pump}}{778 q_{in}}$	*ENG*
(18) SI System	$\eta = \frac{W_{turb} - W_{pump}}{q_{in}}$	*SI*

DESCRIPTION	FORMULA	NAME
GAS: (***THER/GAS***)		
Enthalpy: (***THER/GAS/H***)		
With the given **P** and **V**: (***THER/GAS/H/P.V***)		
(19) English System	$h = u + \frac{p * v}{778}$	*ENG*
(20) SI System	$h = u + p * v$	*SI*
With the given **R** and **T**: (***THER/GAS/H/R.T***)		
(21) English System	$h = u + \frac{R * T}{778}$	*ENG*
(22) SI System	$h = u + R * T$	*SI*
Ratio of Specific Heat (***THER/GAS/K***)		
(23) With the given **cp** and **cv**	$k = \frac{c_p}{c_v}$	*CP.CV*
With the given **R** and **cv**: (***THER/GAS/K/R.CV***)		
(24) English System	$k = \frac{R}{778 * c_v} + 1$	*ENG*
(25) SI System	$k = \frac{R}{c_v} + 1$	*SI*

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME

GAS (continued): (***THER/GAS***)

With the given **R** and **cp**: (***THER/GAS/K/R.CP***)

(26) English System	$k=\frac{c_p}{c_p-\frac{R}{778}}$	*ENG*
(27) SI System	$k=\frac{c_p}{c_p-R}$	*SI*

Specific Heat Constant: (***THER/GAS/R***)

With the given **cp** and **cv**: (***THER/GAS/R/CP.CV***)

(28) English System	$R=778(c_p-c_v)$	*ENG*
(29) SI System	$R=c_p-c_v$	*SI*

With the given Molecular Weight **MW**: (***THER/GAS/R/MW***)

(30) English System	$R=\frac{1545.3}{MW}$	*ENG*
(31) SI System	$R=\frac{8314}{MW}$	*SI*

Specific Heat, Constant Pressure: (***THER/GAS/CP***)

(32) With the given **k** and **cv**	$c_p=k*c_v$	*K.CV*

With the given **k** and **R**: (***THER/GAS/CP/K.R***)

(33) English System	$c_p=\frac{k*R}{778(k-1)}$	*ENG*
(34) SI System	$c_p=\frac{k*R}{(k-1)}$	*SI*

Specific Heat, Constant Volume: (***THER/GAS/CV***)

(35) With the given **k** and **cp**	$c_v=\frac{c_p}{k}$	*K.CP*

With the given **k** and **R**: (***THER/GAS/CV/K.R***)

(36) English System	$c_v=\frac{R}{778(k-1)}$	*ENG*
(37) SI System	$c_v=\frac{R}{k-1}$	*SI*

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME
Gas, Ideal: (*THER/GAS/IDEAL*)		
(38) With the given **mass**	$pV=mRT$	***MASS***
(39) With the given **mole**	$pV=nR'T$	***MOLE***
(40) Gas, Real	$pV=mRTZ$	***REAL***

HEAT EXCHANGER: (*THER/HTEXC*)

Heat Flow: (*THER/HTEXC/HTFLO*)

DESCRIPTION	FORMULA	NAME
(41) Multiple pass	$q=F_c*U*A*LMTD$	***MULTI***
Single pass: (*THER/HTEXC/HTFLO/SINGL*)		
(42) With the given **U** and **A**	$q=U*A*LMTD$	***U.A***
(43) With the given **m** and **cp**	$q=m*c_p(t_2-t_1)$	***M.CP***

Logarithmic Mean Temperature Difference: (*THER/HTEXC/LMTD*)

DESCRIPTION	FORMULA	NAME
Counter flow: (*THER/HTEXC/LMTD/COUNT*)		
(44) English System	$LMTD=\frac{(T_i-t_o)-(T_o-t_i)}{\ln\frac{T_i-t_o}{T_o-t_i}}$	***ENG***
(45) SI System	$LMTD=\frac{(T_i-t_o)-(T_o-t_i)}{\ln\frac{T_i-t_o}{T_o-t_i}}$	***SI***
Parallel flow: (*THER/HTEXC/LMTD/PARAL*)		
(46) English System	$LMTD=\frac{(T_o-t_o)-(T_i-t_i)}{\ln\frac{T_o-t_o}{T_i-t_i}}$	***ENG***
(47) SI System	$LMTD=\frac{(T_o-t_o)-(T_i-t_i)}{\ln\frac{T_o-t_o}{T_i-t_i}}$	***SI***

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME

HEAT FLOW THROUGH: *(THER/HTFLO)*

(48) A film	$q=h*A(t_1-t_2)$	*FILM*

Pipe: *(THER/HTFLO/PIPE)*

(49) Un-insulated w/o film	$q=\dfrac{2\pi*K*l*(t_1-t_2)}{\ln\dfrac{r_o}{r_i}}$	*BARE*
(50) Insulated w/o film	$q=\dfrac{2\pi*l*(t_1-t_2)}{\dfrac{\ln(\frac{r_o}{r_i})}{K_{pipe}}+\dfrac{\ln(\frac{r_{ins}}{r_o})}{K_{ins}}}$	*INSUL*

Slab: *(THER/HTFLO/SLAB)*

Single Section, no film: *(THER/HTFLO/SLAB/SINGL)*

(51) With the given **K** and **L**	$q=\dfrac{K*A(t_1-t_2)}{L}$	*K.L*
(52) With the given **U**	$q=U*A(t_1-t_2)$	*U*

Composite Sections: *(THER/HTFLO/SLAB/COMP)*

(53) With up to 3 sections, no film, **3K**	$q=\dfrac{A(t_1-t_2)}{\dfrac{L_1}{K_1}+\dfrac{L_2}{K_2}+\dfrac{L_3}{K_3}}$	3*K*
(54) With 1 film and 1 section, **1h + 1K**	$q=\dfrac{A(t_1-t_2)}{\dfrac{L_1}{K_1}+\dfrac{1}{h_1}}$	1*H*1*K*
(55) With 2 film and 2 sections, **2h + 2K**	$q=\dfrac{A(t_1-t_2)}{\dfrac{1}{h_1}+\dfrac{L_1}{K_1}+\dfrac{L_2}{K_2}+\dfrac{1}{h_2}}$	2*H*2*K*
(56) With 2 film and 3 sections, **2h + 3K**	$q=\dfrac{A(t_1-t_2)}{\dfrac{1}{h_1}+\dfrac{L_1}{K_1}+\dfrac{L_2}{K_2}+\dfrac{L_3}{K_3}+\dfrac{1}{h_2}}$	2*H*3*K*

Radiation: *(THER/HTFLO/RADIA)*

(57) English System	$q_r=.1713EE{-}8*A*F_e*F_a(T_1^4-T_2^4)$	*ENG*
(58) SI System	$q_r=5.6724EE{-}8*A*F_e*F_a(T_1^4-T_2^4)$	*SI*

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME
INTERNAL COMBUSTION ENGINES: (*THER/NGIN*)		
Engine displacement: (*THER/NGIN/DISP*)		
(59) English System	$disp=\frac{\pi*BORE^2*STRK*NCYL}{4}$	*ENG*
(60) SI System	$disp=\frac{\pi*BORE^2*STRK*NCYL}{4EE3}$	*SI*
Indicated horsepower: (*THER/NGIN/HP*)		
With the given power strokes, NPST: (*THER/NGIN/HP/NPST*)		
(61) English System	$hp=\frac{\pi*P_m*BORE^2*STRK*NPST}{1.584EE6}$	*ENG*
(62) SI System	$hp=\frac{\pi*P_m*BORE^2*STRK*NPST}{1.82496EE6}$	*SI*
With the given cycle strokes, NCST: (*THER/NGIN/HP/NCST*)		
(63) English System	$hp=\frac{\pi*P_m*BORE^2*STRK*RPM*NCYL}{7.92EE5*NCST}$	*ENG*
(64) SI System	$hp=\frac{\pi*P_m*BORE^2*STRK*RPM*NCYL}{9.1248EE5*NCST}$	*SI*
(65) Number of power strokes/min	$NPST=\frac{2*RPM*NCYL}{NCST}$	*NPST*
Thermal efficiency: (*THER/NGIN/ η_{TH}*)		
With the given fuel consumption, FC: (*THER/NGIN/ η_{TH} /FC*)		
(66) English System	$\eta_{th}=\frac{2545*hp}{FC*HV}$	*ENG*
(67) SI System	$\eta_{th}=\frac{2684975*hp}{FC*HV}$	*SI*
With the given fuel consumption, SFC: (*THER/NGIN/ η_{TH} /SFC*)		
(68) English System	$\eta_{th}=\frac{2545}{SFC*HV}$	*ENG*
(69) SI System	$\eta_{th}=\frac{2684975}{SFC*HV}$	*SI*

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME

INTERNAL COMBUSTION ENGINES: (*THER/NGIN*)

Volumetric efficiency: (*THER/NGIN/ ηV*)

With the given engine displacement, **DISP**: (*THER/NGIN/ ηV /DISP*)

(70) English System	$\eta_v=\frac{3456*INAIR}{RPM*disp}$	*ENG*
(71) SI System	$\eta_v=\frac{120*INAIR}{RPM*disp}$	*SI*

With the given engine bore and stroke: (*THER/NGIN/ ηV /BR.ST*)

(72) English System	$\eta_v=\frac{13824*INAIR}{\pi*RPM*BORE^2*STRK*NCYL}$	*ENG*
(73) SI System	$\eta_v=\frac{4.8EE5*INAIR}{\pi*RPM*BORE^2*STRK*NCYL}$	*SI*

REFRIGERATION: (*THER/REFRI*)

Coefficient Of Performance: (*THER/REFRI/COP*)

(74) With the given tons of refrigeration, **tonR:**	$COP=\frac{4.715*ton_R}{hp}$	*TONR*
(75) With the given **heats**	$COP=\frac{q_{in}}{q_{out}-q_{in}}$	*HEAT*
(76) With the given **temperatures**	$COP=\frac{T_{low}}{T_{high}-T_{low}}$	*TEMP*

Energy Efficiency Ratio: (*THER/REFRI/EER*)

(77) With the given **hp**	$EER=\frac{12000*ton_R}{745.7*hp}$	*HP*
(78) With the given **watt**	$EER=\frac{12000*ton_R}{watt}$	*WATT*

Horsepower: (*THER/REFRI/HP*)

(79) With the given **COP**	$hp=\frac{4.715*ton_R}{COP}$	*COP*
(80) With the given **EER**	$hp=\frac{16.09*ton_R}{EER}$	*EER*

THERMODYNAMICS

DESCRIPTION	FORMULA	NAME

REFRIGERATION: (*THER/REFRI*)

Refrigerant rate: (*THER/REFRI/RATE*)

(81) English System	$M=\frac{10*ton_R}{3(h_2-h_1)}$	ENG
(82) SI System	$M=\frac{3517.2*ton_R}{h_2-h_1}$	SI

STEAM: (*THER/STIM*)

(83) Enthalpy, **h**	$h=h_f+X*h_{fg}$	H
(84) Entropy, s	$s=s_f+X*s_{fg}$	S

Quality (*THER/STIM/X*)

(85) With the given **h**	$X=\frac{h-h_f}{h_{fg}}$	H
(86) With the given s	$X=\frac{s-s_f}{s_{fg}}$	S
(87) Specific volume, v	$v=v_f+X*v_{fg}$	V

Steam rate: (*THER/STIM/RATE*)

(88) English System	$M=\frac{q}{3600(h_1-h_2)}$	ENG
(89) SI System	$M=\frac{W}{(h_1-h_2)}$	SI

TURBINE: (*THER/TURB*)

Enthalpy at Discharge: (*THER/TURB/ENTH*)

(90) Actual discharge enthalpy	$h_{2A}=h_1-\eta(h_1-h_2I)$	ACTU
(91) Ideal discharge enthalpy	$h_2I=h1+\frac{h_2A-h_1}{\eta}$	IDEAL
(92) Efficiency	$\eta=\frac{h_1-h_2A}{h_1-h_2I}$	EFFI

THERMODYNAMICS

DESCRIPTION	**FORMULA**	**NAME**
TURBINE: (***THER/TURB***)		
Horsepower: (***THER/TURB/HP***)		
(93) English System	$hp=\frac{M*\eta}{550}(778(h_i-h_o)+\frac{v_i^2-v_o^2}{2g})$	*ENG*
(94) SI System	$hp=\frac{M*\eta}{745.7}(h_i-h_o+\frac{v_i^2-v_o^2}{2})$	*SI*
Specific Steam Rate: (***THER/TURB/RATE***)		
(95) English System	$SSR=\frac{3413}{3600(h_i-h_o)}$	*ENG*
(96) SI System	$SSR=\frac{1000}{h_i-h_o}$	*SI*

THERMODYNAMICS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
A	Surface area; ft2, m2 (1 ft2=0.0929 m2).
BORE	Piston's bore; in, cm (1 in=2.54 cm).
COP	Coefficient Of Performance; None.
cp	Specific heat, Constant Pressure; BTU/lbm-oR, J/kg.K (1 BTU/lbm.oR=4186.8 J/kg.K).
cv	Specific Heat, Constant Volume; BTU/lbm-oR, J/kg.K (1 BTU/lbm.oR=4186.8 J/kg.K).
disp	Engine's displacement; in3/cyc, L/cyc (1 in3/cyc=0.01639 L/cyc).
EER	Energy Efficiency Ratio; BTU/watt.
Fa	Shape Factor; None.
Fc	Correction Factor; None.
FC	Fuel Consumption; lbm, kg (1 lbm=0.4563 kg).
Fe	Emissivity Factor; None.
g	Gravitational acceleration; ft/s2, m/s2 (1 ft/s2=0.3048 m/s2).
h	Enthalpy; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
h	Film coefficient; BTU/hr-ft2.oR, W/m2.K (1 BTU/hr-ft2-oR=5.68 W/m2.K).
hf	Enthalpy of Saturated liquid; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
hfg	Enthalpy of vaporization; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
hg	Enthalpy of Saturated vapor; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
hp	Horsepower.
Hs	Specific Humidity;None; lbw/lbda, kgw/kgda (1 lbm=0.4536 kg).
HV	Heating Value; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
h2A	Discharge Actual Enthalpy; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
h2I	Discharge Ideal Enthalpy; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
INAIR	Intake air quantity; cfm, L/s (1 cfm=0.47195 L/s).
K	Thermal Conductivity; BTU/hr-ft-oR, W/m.K (1 BTU/hr-ft-oR=1.731 W/m.K).
k	Ratio of Specific Heat; None.
L	Thickness; ft, m (1 ft=0.3048 m).
l	Length; ft, m (1 ft=0.3048 m).
LMTD	Logarithmic Mean Temperature Difference; oF, oC.
M	Mass in flow; lbm/s, kg/s (1 lbm=0.4536 kg).
MW	Molecular Weight.
NCST	Number of strokes per each cycle; stroke/cycle.
NCYL	Number of Cylinders; None.
NPST	Number of engine's power strokes per minute; stroke/minute.
m	Mass; lbm, kg (1 lbm=0.4536 kg).
n	Polytropic Exponent; None, Number of moles; pmole, kgmole.
p	Pressure; lbf/ft2, Pa (1 lb/ft2=47.88 Pa).
Pat	Atmospheric Pressure; psi, Pa (1 psi=6894.76 Pa).
Pda	Dry Air Partial Pressure; psi, Pa (1 psi=6894.76 Pa).

THERMODYNAMICS

VARIABLES IDENTIFICATION

SYMBOL	DESCRIPTION; UNIT (ENG, SI)
Pm	Engine's Mean Effective Pressure; psi, kg/cm2 (1 psi=0.07031 kg/cm2).
Pswv	Saturated Water Vapor Pressure; psi, Pa (1 psi=6894.76 Pa).
Pwv	Water Vapor Pressure; psi (1 psi=6894.76 Pa).
Q	Heat/unit of weight; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
q	Heat flow quantity; BTU/hr, W (1 BTU/hr=0.2931 W=0.252 kcal/hr).
qr	Radiation Heat flow; BTU/hr, W (1 BTU/hr=0.2931 W=0.252 kcal/hr).
R	Specific Heat Constant; ft-lbf/lbm-oR, J/kg.K (1 ft-lbf/lbm.oR=5.3803 J/kg.K, 1 ft.lbf=1.3558 J).
R'	Universal Gas Constant; 1545.3 ft-lbf/pmole-oR, 8314 J/kgmole.K.
r	Radius; ft, m subscript i = inside, o = outside (1 ft=0.3048 m).
RH	Relative Humidity; decimal.
RPM	Revolutions Per Minute.
s	Entropy; BTU/lbm-oR, J/kg.K (1 BTU/lbm-oR=4186.8 J/kg.K).
sf	Entropy of Saturated Liquid; BTU/lbm-oR, J/kg.K (1 BTU/lbm-oR=4186.8 J/kg.K).
SFC	Specific Fuel Consumption; lbm/hp, kg/hp (1 lbm=0.4536 k).
sfg	Entropy of vaporization; BTU/lbm-oR, J/kg.K (1 BTU/lbm-oR=4186.8 J/kg.K).
sg	Entropy of Saturated Vapor; BTU/lbm-oR, J/kg.K (1 BTU/lbm-R=4186.8 J/kg.K).
SSR	Specific Steam Rate; lbm/kw, kg/kw (1 lbm=0.4536 kg).
STRK	Piston's stroke; in, cm (1 in=2.54 cm).
T	Temperature; oR, K.
Ti	Hot fluid inlet temperature; oF, oC.
ti	Cold fluid inlet temperature; oF, oC.
To	Hot fluid outlet temperature; oF, oC.
to	Cold fluid inlet temperature; oF, oC.
tonR	Ton of refrigeration; 12,000 BTU/hr, 3517 W, 3024 kcal/hr.
U	Overall coefficient of heat transfer; BTU/hr-sf-oR, W/m2.K (1 BTU/hr-ft2-oR=5.68 W/m2.K).
u	Internal energy; BTU/lbm, J/kg (1 BTU/lbm=2326 J/kg, 1 BTU=1055 J).
V	Volume; ft3, m3 (1 ft3=0.02832 m3).
v	Specific volume; ft3/lbm, m3/kg (1 ft3/lbm=0.06243 m3/kg).
vf	Specific volume of saturated liquid; ft3/lbm, m3/kg (1 ft3/lbm=0.06243 m3/kg).
vfg	Specific volume of vaporization; ft3/lbm, m3/kg (1 f 3/lbm=0.06243 m3/kg).
vg	Specific volume of saturated vapor; ft3/lbm, m3/kg (1 ft3/lbm=0.06243 m3/kg).
vi	Velocity at inlet; ft/s, m/s (1 ft/s=0.3048 m/s).
vo	Velocity at outlet; ft/s, m/s (1 ft/s=0.3048 m/s).
W	Work; ft-lbf/lbm, J/kg (1 ft-lbf/lbm=2.9891 J/kg).
X	Quality of steam; decimal.
Z	Compressibility Factor; None.
η	Efficiency; decimal.
ρ	Density; lbm/ft3, kg/m3 (1 lbm/ft3=16.0185 kg/m3).

QUICK REFERENCE TO NCEES FE REFERENCE HANDBOOK

This part is prepared to summarize and highlight the more common, useful, and calculator accepted equations in NCEES FE Reference Handbook (January 1996 issue). Subject equations are programmed in ROM card.
By learning the overall concept, the user may retrieve the selected equation and solve it for an unknown variable in a faster and more accurate way without even any need to refer to this part of the manual.

Read the following notes and memorize the naming procedure for an easy access to stored equations:

1. Acquaint yourself with the subjects, equations, and the nomenclature of variables and their units in NCEES FE Reference Handbook. Ensure to use the proper unit to get the proper answer.

2. Following are the general rules for naming and retrieving the equations, except for Chemical, Civil, and Mechanical Engineering Sections, which are named by the subjects:

   a. The main directories are representing the following sections in NCEES FE Reference Handbook:

DYNAMICS	DY
ELECTRICITY	EL
ENGINEERING **E**CONOMICS	EE
FLUID **M**ECHANICS	FM
HEAT **T**RANSFER	HT
MATHEMATICS	MA
MECHANICS OF **M**ATERIALS	MM
THERMODYNAMICS	TH
CHEMICAL ENGINEERING	CHEM
CIVIL ENGINEERING	CIVIL
MECHANICAL ENGINEERING	MECH

   b. The subdirectories are representing the main subjects covered in the Handbook.

   c. The **NAME** of the equation which will appear on the screen menu, generally, is either the variable's (at the left side of the equation) symbol or other sub-directories recognizable abbreviation.

DYNAMICS

DIRECTORY (*DY*)

TO FIND	SUB DIR.	SYMB	NAME
Circular motion:			
(01) Tangential velocity	CIRCU	vt	**VT**
(02) Tangential acceleration		at	**AT**
(03) Normal acceleration (2 equations)		an	***AN→***
Linear motion:			
(04) Distance	LINER	s	**S**
(05) Velocity		v	**V**
(06) Velocity		v	**V^2**
Projectile:			
(07) Horizontal velocity	PROJ	vx	**VX**
(08) Vertical velocity (2 equations)		vy	***VY→***
(09) Horizontal distance (2 equations)		x	***X→***
(10) Vertical distance (2 equations)		y	***Y→***
(11) Weight	--	W	**WGHT**
(12) Newton's 2nd law (2 equations)	--	ΣF	***ΣF→***
Energy:			
(13) Kinetic Energy	ENRG	KE	**KE**
(14) Kinetic Energy Change		any	***ΔKE***
(15) Potential Energy		PE	**PE**
(16) Spring/Potential Energy Stored	ENRG/SPRIN	PE	**PE**
(17) Spring/Change in Potential Energy		any	***ΔPE***
(18) Centrifugal Force (2 equations)	--	Fc	***FC→***
(19) Tangent of Banking angle	--	tanθ	***TANθ***

ELECTRICITY

DIRECTORY (*EL*)

TO FIND	SUB DIR.	SYMB	NAME
Resistivity and Resistors:			
(01) Resistance	RESIS	R	**GENER**
(02) Resistivity, change in temperature		ρ	**ρ.ΔT**
(03) Resistance, change in temperature		R	**R.ΔT**
(04) Resistance (total), 3 in series		RT	**SERI**
(05) Resistance (total), 3 in parallel		RT	**PAR3**
(06) Resistance (total), 2 in parallel		RT	**PAR2**
Power in Resistive element			
(07) With **V** and **I**	POWR	P	**V.I**
(08) With **V** and **R**		P	**V.R**
(09) With **I** and **R**		P	**I.R**
Capacitors in series and parallel:			
(10) Capacitance, 3 in parallel	CAPAC	Ceq	**PARA**
(11) Capacitance, 2 in series		Ceq	**SER2**
(12) Capacitance, 3 in series		Ceq	**SER3**
Inductors in series and parallel:			
(13) Inductance, 2 in parallel	INDUC	Leq	**PAR2**
(14) Inductance, 3 in parallel		Leq	**PAR3**
(15) Inductance, 3 in series		Leq	**SERI**

ELECTRICITY

DIRECTORY (*EL*)

TO FIND	SUB DIR.	SYMB	NAME
RC Transients:			
(16) Voltage across capacitor	TRNSI/RC	Vct	VCT
(17) Current		it	IT
(18) Voltage across resistor (2 equations)		VRt	*VRT*→
RL Transients:			
(19) Current	TRNSI/RL	it	IT
(20) Voltage across resistor		VRt	*VRT*→
(21) Voltage across inductor		VLt	*VLT*→
Amplifiers:			
(22) Output voltage	--	vo	AMPLI
Reactance:			
(23) Capacitive reactance (2 equations)	REAC	Xc	*XC*→
(24) Inductive reactance (2 equations)		XL	*XL*→
Resonance:			
(25) Radiant resonance frequency (2 equations)	RESO	ω_o	*ωO*→
(26) Series Resonance		ω_o	*ωOL*
(27) Quality Factor, Series (2 equations)		Q	*QS*→
(28) Quality Factor, Parallel (2 equations)		Q	*QP*→

ENGINEERING ECONOMICS

DIRECTORY (*EE*)

TO FIND	SUB DIR.	SYMB	NAME
Discount Factor, Discrete Compound:			
(01) F/P Factor		F	**F/P**
(02) P/F Factor		P	**P/F**
(03) A/F Factor		A	**A/F**
(04) A/P Factor		A	**A/P**
(05) F/A Factor	FCTR	F	**F/A**
(06) P/A Factor		P	**P/A**
(07) P/G Factor		P	**P/G**
(08) F/G Factor		F	**F/G**
(09) A/G Factor		A	**A/G**
(10) Non-Annual Compounding	--	ie	**COMP**
Discount Factor, Continuous Compound:			
(11) Continuous Compounding F/P		F	**F/P**
(12) Continuous Compounding P/F		P	**P/F**
(13) Continuous Compounding A/F	CONTI	A	**A/F**
(14) Continuous Compounding F/A		F	**F/A**
(15) Continuous Compounding A/P		A	**A/P**
(16) Continuous Compounding P/A		P	**P/A**
Depreciation:			
(17) Depreciation, Straight Line	--	Dj	**DEPRI**
Inflation:			
(18) Combined interest and inflation rate	--	d	**INFLA**

FLUID MECHANICS
DIRECTORY (*FM*)

TO FIND	SUB DIR.	SYMB	NAME
Surface Tension:			
(01) General	CAPIL/TENS	σ	**GENE**
(02) In bulb surrounded by air		σ	**AIR**
(03) In a droplet or bubble in liquid		σ	**LIQID**
(04) Capillary rise	CAPIL	h	**RISE**
Pressure Field in a Static Liquid:			
(05) Simple manometer equation	PRESS	Po	**PO**
(06) Atmospheric pressure (2 equations)		Patm	***PA*→2**
Forces on submerged Surfaces:			
(07) Pressure on submerged surface	FORCE	p	**P**
(08) y coord. of Center of Pressure		y	**Y1**
(09) z coord. of Center of Pressure		z	**Z1**
(10) y coord. of Center of Pressure		y	**Y2**
(11) z coord. of Center of Pressure		z	**Z2**
(12) Force on the plate		F	**F**
(13) Mass flow rate (2 equations)	MASS	m	***M*→2**
(14) Bernoulli equation, no friction	BERN	any	**NO.HF**
(15) Bernoulli equation, + hf		any	**W.HF**
(16) Bernoulli equation, + hf		any	**HF+**

FLUID MECHANICS

DIRECTORY (*FM*)

TO FIND	SUB DIR.	SYMB	NAME
Fluid flow:			
(17) Velocity distribution for laminar flow	FLOW	v	**V**
(18) Shear stress distribution		τ	$\boldsymbol{\tau}$
(19) Drag force		FD	**FD**
(20) Drag coefficient (2 equations)		CD	***CD→***
Reynolds Number:			
(21) Newtonian fluid	REYN	Re	***RE→***
(22) Power law fluid		Re'	RE'
(23) Friction head (Darcy equation)	FRIC.H	hf	**DARCY**
(24) Minor loss, with the given **C**	FRIC.H/MINO	hf	**C**
(25) Minor loss, with **C=.04**		hf	**C=.04**
(26) Pump power equation	-	W	**pump**
Jet Propulsion:			
(27) Flow quantity	JET	Q	**Q**
(28) Velocity		V2	**V2**
Deflection Blades:			
Fixed blades:			
(29) x component	BLADE	Fx	**FX**
(30) y component		Fy	**FY**

FLUID MECHANICS

DIRECTORY (*FM*)

TO FIND	SUB DIR.	SYMB	NAME
Deflection Blades:			
Moving blades:			
(31) x component (2 equations)	BLADE	Fx	***FX→***
(32) y component (2 equations)		Fy	***FY→***
Impulse Turbine:			
(33) Power of turbine	TURB	W	**W**
(34) Maximum power of turbine		Wmax	**WMX**
Open Channel Flow:			
(35) Manning's equations English System	CHAN/MANI	V	**ENG**
(36) Manning's equations SI System		V	**SI**
(37) Hazen-Williams equation English System	CHAN/HAZN	V	**ENG**
(38) Hazen-Williams equation SI System		V	**SI**
(39) Speed of sound	SOUND	c	**C**
(40) Velocity, Pitot Tube (2 equations)	*PITO→*	V	***V→2***
(41) Venturi meter, Flow quantity	-	Q	**VENT**
Orifice:			
(42) Flow quantity		Q	**Q**
(43) Coefficient of orifice	ORIF	C	**C**
(44) Submerged flow quantity (2 equations)		Q	**SUB →**
(45) Free discharge flow		Q	**FREE**

HEAT TRANSFER

DIRECTORY (*HT*)

TO FIND	SUB DIR.	NAME
CONDUCTION:	COND	
Through a plane wall:	COND/WALL	
(01) Rate of heat transfer		**Q**
(02) Thermal resistance		**R**
(03) Total resistance		**RTTL**
(04) Thermal resistance, R1		**R1**
(05) Thermal resistance, R2		**R2**
(06) Intermediate temperature		**T2**
(07) Surface temperature		**T3**
Through a cylindrical wall:	COND/CYLIN	
(08) Rate of heat transfer		**Q**
(09) Thermal resistance		**R**
CONVECTION:	CONV	
(10) Rate of heat transfer		**Q**
(11) Thermal resistance		**R**
Through a straight fin:	CONV/FIN	
(12) Rate of heat transfer		**Q**
(13) Equation for **m**		**M**
(14) Equation for **Lc**		**LC**

HEAT TRANSFER

DIRECTORY (*HT*)

TO FIND	SUB DIR.	NAME
RADIATION:	RADIA	
(15) Radiation emitted by a body		**Q**
Radiation heat transfer between two bodies:	RADIA/Q12	
(16) Small to a large body		**SMAL**
(17) Two (2) black bodies		**BLAK**
HEAT EXCHANGERS:	HTEX	
Shell and Tube:	HTEX/SHEL	
(18) Overall heat transfer coefficient		**U**
Log Mean Temperature Difference:	HTEX/LMTD	
(19) Counter current flow in tubular		**CONTR**
(20) Parallel flow in tubular		**PARAL**
(21) Heat Transfer/Section Area equation	HTEX	**Q/A**
Tubular Heat Exchanger:	HTEX/TUBUL	
(22) Rate of Heat Transfer		**Q**

HEAT TRANSFER

DIRECTORY (***HT***)

TO FIND	SUB DIR.	NAME
HEAT EXCHANGERS:	HTEX	
Tubular Heat Exchanger:	HTEX/TUBUL	
Nusselt number:	HTEX/TUBUL/NU	
(23) Laminar flow		**LAMI**
(24) Turbulent flow (2 equations)		***TUR→***
Liquid Metals:	HTEX/TUBUL	
(25) Constant heat flux	/LIQID	**HEAT**
(26) Constant wall temperature		**TEMP**
(27) Condensation of pure vapor	HTEX/TUBUL	**VAPR**
HEAT TRANSFER TO/FROM		
IMMERSED BODY:	IMERS	
Nusselt Number:	IMERS/NU	
Flow parallel to constant temp. flat plate:	IMERS/NU/PLATE	
(28) For Re<10^5		**RE<.1M**
(29) For Re>10^5		**RE>.1M**
(30) Of a constant temperature of cylinder	IMERS/NU	**CYLIN**
(31) Of a constant temperature of sphere		**SPHER**

HEAT TRANSFER

DIRECTORY (*HT*)

TO FIND	SUB DIR.	NAME
CONDUCTIVE HEAT TRANSFER:	COND'	
Steady Conduction With Internal Energy	COND'/ENRG	
Generation:	COND'/ENRG	
Plane wall:	/WALL	
(32) Intermediate temperature at point x		TX
	COND'/ENRG	
Long Circular Cylinder:	/CYLIN	T
(33) Temperature		Q
(34) Heat transfer per unit length		
Transient Conduction, Lump Capacitance	COND'/TRNSI	
Method:		Q
(35) Heat transfer		T
(36) Temperature variation		QTTL
(37) Total temperature transfered up to time t		BI
(38) Biot number		
NATURAL (FREE) CONVECTION:	CONV'	
Vertical flat plate/cylinder:	CONV'/VERTI	
(39) Heat transfer coefficient		H
(40) Raleigh Number		RAL
Long Horizontal Cylinder and large body:	CONV'/HORIZ	
(41) Heat transfer coefficient		H
(42) Raleigh Number		RAD

HEAT TRANSFER

DIRECTORY (*HT*)

TO FIND	SUB DIR.	NAME
RADIATION:	RADI'	
(43) Two-body problem		**2BODY**
(44) Radiation Shields		**SHILD**
(45) Reradiating surface		**SURF**

MATHEMATICS

DIRECTORY (*MA*)

TO FIND	SUB DIR.	SYMB	NAME
Straight Line:			
(01) Slope between two (2) points	LINE	m	**SLOP**
(02) Angle between two (2) lines		α	**ANGL**
(03) Distance between two (2) points		d	**DIST**
Quadratic Equations:			
(04) Root 1, **x1**	QUAD	x1	**X1**
(05) Root 2, **x2**		x2	**X2**
Conic Sections:			
(06) Parabola		any	**PARAB**
(07) Ellipse, equation and eccentricity (2 equ.)	CONIC	any	***ELIP→***
(08) Hyperbola, equation and eccentricity (2 equ.)		any	***HYP→***
(09) Circle, equation		any	**CIRCL**
Trigonometry:			
(10) Law of Sines (3 equations)	TRIGO	any	***SIN→***
(11) Law of Cosines (3 equations)		any	***COS→***
(12) Determinant, 2nd order	DETER	DT	**DT2**
(13) Determinant, 3rd order		DT	**DT3**
(14) Probability, Permutation	PROB	Pnr	**PERM**
(15) Probability, Combination		Cnr	**COMB**
Ellipse:			
(16) Area	ELIPS	A	**AREA**
(17) Perimeter		p	**PERI**
Circular Segment:	CIRCL		
(18) Area	SEGM	A	**AREA**
(19) Angle		ϕ	**ANGL**

MATHEMATICS

DIRECTORY (*MA*)

TO FIND	SUB DIR.	SYMB	NAME
Circular Sector:	CIRCL		
(20) Area	SECT	A	**AREA**
(21) Angle		φ	**ANGL**
Sphere:			
(22) Volume	SPHER	V	**VOLM**
(23) Area		A	**AREA**
Parallelogram:			
(24) Periphery		p	**PERI**
(25) d1	PARAL	d1	**D1**
(26) d2		d2	**D2**
(27) d1d2/ab		d1d2	**D1D2**
(28) Area (2 equations)		A	**AREA→**
Regular Polygon (n equal sides):			
(29) Angle		φ	**φ**
(30) Angle	POLIG	θ	**θ**
(31) Side		s	**S**
(32) Perimeter		p	**P**
(33) Area		A	**A**
(34) Prismoid Volume	PRISM	V	**VOLM**
Right Circular Cone:			
(35) Volume		V	**VOLM**
(36) Area	CONE	A	**AREA**
(37) Ax/Ab ratio		Ax/Ab	**AXAB**
Right Circular Cylinder:			
(38) Volume	CYLIN	V	**VOLM**
(39) Area		A	**AREA**
Parabola of Revolution:			
(40) Area of parabola (2 equations)	PARAB	A	**AREA**
(41) Volume		V	**VOLM**

MECHANICS OF MATERIALS

DIRECTORY (*MM*)

TO FIND	SUB DIR.	SYMB	NAME
Engineering strain:			
(01) Engineering strain	STRN/ENGI	ϵ	**ϵ**
(02) Force/Deformation equation		F	**F**
Shear stress strain:			
(03) Shear Strain	STRN/SHEAR	γ	**γ**
(04) Shear Modulus		G	**G**
Loading and Deformation:			
(05) Stress	DEFOR/LOAD	σ	**σ**
(06) Strain		ϵ	**ϵ**
(07) Modulus of Elasticity (2 equations)		E	***E→***
(08) Elongation		δ	**δ**
Thermal deformations:			
(09) Deformation caused by temp. difference	DEFOR/THER	δt	**δ*T***
Cylindrical Pressure, Stress:	CYLIN/STRES		
Stress in Wall, internal pressure:			
(10) Tangential (Hoop) stress	WALL/INSID	σt	**σ*T***
(11) Radial stress		σr	**σ*R***
Stress in Wall, external pressure:			
(12) Tangential (Hoop) stress	WALL/OUTSI	σt	**σ*T***
(13) Radial stress		σr	**σ*R***
(14) Stress in caps	--	σa	***CAPS***
(15) Stress in thin wall cylinders	--	σt	***THIN***

MECHANICS OF MATERIALS

DIRECTORY (*MM*)

TO FIND	SUB DIR.	SYMB	NAME
Mohr's Circle, Stress:			
(16) Principle, maximum	MOHR	σ1. 2	σMAX
(17) Principle, minimum		σ1. 2	σMIN
(18) Shear stress, maximum		τmax	τMAX
Hook's Law:			
Three dimensional stress case:			
(19) Strain, x axis	HOOK/3DIM	εx	εx
(20) Strain, y axis		εy	εy
(21) Strain, z axis		εz	εz
Plane stress case:			
(22) Strain, x axis	HOOK/PLANE	εx	εx
(23) Strain, y axis		εy	εy
(24) Strain, z axis		εz	εz
Torsion:			
(25) Twisting moment per radian of twist	TORS	T/φ	T/φ
(26) Shear stress, hollow thin wall shaft		τ	τ
Stresses in Beams			
(27) Radius of curvature, deflected shaft	BEAM	ρ	1/ρ
(28) Normal Stress in beam, at y distance		σx	σx1
(29) Stress in beam, at c distance (2 equations)		σx	σx2→
(30) Stress in beam, with S (2 equations)		σx	σx3→
(31) Shear flow		q	Q
(32) Shear stress		τxy	τxy

MECHANICS OF MATERIALS

DIRECTORY (*MM*)

TO FIND	SUB DIR.	SYMB	NAME
Columns/Beams:			
(33) Euler's critical load, equation 1	CLMN	Pcr	**PCR1**
(34) Euler's critical load, equation 2		Pcr	**PCR2**
Elastic Strain Energy:			
(35) Energy stored in beam	ENRG	U	**U**
(36) Strain energy/unit vol.(2 equations)		u	***U→***

THERMODYNAMICS

DIRECTORY (*TH*)

TO FIND	SUB DIR.	SYMB	NAME
Properties of Single component systems:			
(01) Quality of vapor		x	**X**
(02) Specific volume (2 equations)		v	***V→***
(03) Internal energy		u	**U**
(04) Enthalpy	PROP	h	**H**
(05) Entropy		s	**S**
Ideal gas:			
(06) P, V equations	PROP/IDEAL	any	**PV**
(07) P, V, T equations		any	**PVT**
(08) Gas constant	PROP	R	**R**
For cold air standard, constant heat capacity:			
(09) Change in internal energy	AIR	Δu	**ΔU**
(10) Change in enthalpy		Δh	**ΔH**
(11) Change in entropy (T & P) (2 equations)		Δs	**ΔS→**
For constant entropy process:			
(12) P1, v1, P2, v2 equation		any	**P/V**
(13) T1, P1, T2, P2 equation	ΔS=0	any	**T/P**
(14) T1, v1, T2, v2 equation		any	**T/V**
(15) Ratio of Specific Heat		k	**K**
Closed Thermodynamic Systems:			
Work performed, ideal gas:			
(16) Constant Pressure	CLOSE	w	**ΔP=0**
(17) Constant Volume, w=0		-	--
(18) Constant Temperature (2 equations)		w	**ΔT=0**

THERMODYNAMICS

DIRECTORY (*TH*)

TO FIND	SUB DIR.	SYMB	NAME
Closed Thermodynamic Systems:			
Work performed, ideal gas:	CLOSE		
(19) Isentropic (2 equations)		w	***ISEN→***
(20) Polytropic		w	***POLY***
Open Thermodynamic Systems:			
Work performed, ideal gas:			
(21) Constant Pressure, w=0		-	-
(22) Constant Volume	OPEN	w	**Δ*V*=0**
(23) Constant Temperature (2 equations)		w	**Δ*T*=0→**
(24) Isentropic (2 equations)		w	***ISEN→***
(25) Isentropic, steady flow		Wis	***WIS***
(26) Polytropic		w	***POLY***
Nozzles, Diffusors:			
(27) Velocity term	**NOZL**	any	**HI**
(28) Efficiency of nozzle		η	**EFFI**
Turbines:	TURB		
(29) Efficiency		η	**EFFI**
Pump:	PUMP		
(30) Efficiency		η	**EFFI**
Compressor:	COMP		
(31) Efficiency		η	**EFFI**
Heat Exchanegrs:	HTEX		
(32) m1,h1,m2,h2 equation		any	**HTEX**
Heat Engines:			
(33) Efficiency	H.ENG	η	**η→**
(34) Efficiency of Carnot Cycle.		η_c	**η*C***

THERMODYNAMICS

DIRECTORY (***TH***)

TO FIND	SUB DIR.	SYMB	NAME
Coefficient Of Performance:			
(35) Heat Pump	COP	COPc	**HPMP**
(36) Refrigerator		COPc	**REFR**
Ideal Gas Mixture:			
(37) Partial Pressure	MIXT	Pi	**PRES**
(38) Partial Volume		Vi	**VOLM**
Psychometric:			
(39) Total air pressure		P	**P**
(40) Specific Humidity, mv, ma	PSYC	ω	**ω**
(41) Specific Humidity, Pv, Pa(2 equations)		ω	**ω→**
(42) Relative Humidity, Pv, Pg		φ	**φ→**
(43) Enthalpy		h	**H**

CHEMICAL ENGINEERING

DIRECTORY (*CHEM*)

TO FIND	SUB DIR.	NAME
Chemical Thermodynamics:	THER	
(01) Activity Coefficients	THER/ACTIV	**γIV**
Ideal solutions, Fugacities Coefficients:	THER/IDEAL	
(02) In term of pressure		**FI**
(03) mixture		**VIV**
Chemical Equilibrium:	THER/EQUIL	
For Reaction:	THER/EQUIL/REACT	
(04)		**ΔG**
(05)		**KA**
For mixtures:	THER/EQUIL/MIXTR	
(06)		**KA**
(07)		**KP**
Chemical Reaction Engineering:	REACT	
Rate of Reaction:	REACT/RATE	
(08) Rate (2 equations)		**RA→**
(09) Rate Constant		**K**
(10) Moles of A, reacted/fed		**XA**
Reaction Order:	REACT/ORDER	
Zero Order Reaction:	REACT/ORDER/ZERO	
(11) Rate		**RA**
(12) Concentration of Component A		**CA**
(13) Moles of A, reacted/fed		**XA**
First Order Reaction:	REACT/ORDER/FIRST	
(14) Rate		**RA**
(15) Concentration of Component A		**CA**
(16) Moles of A, reacted/fed		**XA**
Second Order Reaction:	REACT/ORDER/SCND	
(17) Rate		**RA**
(18) Concentration of Component A		**CA**
(19) Moles of A, reacted/fed		**XA**

CHEMICAL ENGINEERING

DIRECTORY (*CHEM*)

TO FIND	SUB DIR.	NAME
Reactors:	RACTR	
Batch:	RACTR/BATCH	
(20) Rate		**RA**
(21) Volume		**V**
Flow:	RACTR/FLOW	
(22) Plug-Flow Reactor		**PLUG**
Continuous:	RACTR/FLOW/CONTI	
(23) Continuous Stirred Tank Reactor (CSTR)		**CSTR**
(24) Stirred Tank Reactors in series (2 equations)		***SER→***
Distillation:	DISTIL	
Flash (or equilibrium) Distillation:	DISTIL/FLASH	
(25) Component material balance		**FZF**
(26) Overall material Balance		**F**
Differential (simple or Rayleigh) Distillation:	DISTIL/DIFER	
(27) y, when relative volatility is constant		**Y**
(28) Differential Distillation equation		**W/Wo**
Continuous (binary system) Distillation:	DISTIL/CONTI	
Total Material Balance:	DISTIL/CONTI/T.MAT	
(29)		**F**
(30)		**FZF**
Operating Lines:	DISTIL/CONTI/OPER	
Rectifying Section:	DISTIL/CONTI/OPER/RECTI	
(31) Total Material		**T.MAT**
(32) Component A (2 equations)		***CMP.A→***
Stripping Section:	DISTIL/CONTI/OPER/STRIP	
(33) Total Material		**T.MAT**
(34) Component A (2 equations)		***CMP.A→***
Reflux Ratio:	DISTIL/CONTI/OPER/RFLUX	
(35) Ratio of Reflux to overhead product		***RD→***
(36) Feed condition line		**SLOPE**
(37) Murphree Plate Efficiency		**EME**

CHEMICAL ENGINEERING

DIRECTORY (*CHEM*)

TO FIND	SUB DIR.	NAME
Diffusors:	DIFFU	
Molecular Diffusion:	DIFFU/MOLEC	
(38) Gas		**GAS**
(39) Liquid		**LIQID**
(40) Unidirectional of a Gas:	DIFFU	**UNIDI**
(41) Equimolar Counter Diffusion		**EQUI**
Convection:	CONV	
Two Film Theory (for equimolar Counter-Diffusion):	CONV/2FILM	
(42) First Equation		**EQ1**
(43) Second Equation		**EQ2**
(44) Third Equation		**EQ3**
(45) Fourth Equation		**EQ4**
Overall Coefficient:	CONV/COEF	
(46)		**K'G**
(47)		**K'L**
Transfer Unit:	CONV/TRNS	
(48) Height of Transfer Unit		**HOG**
(49) Height of Transfer Unit		**HOL**
(50) Height of Tower (2 equations)		***Z→***
(51) Dimension-less Group Equation	CONV	**KM**

CIVIL ENGINEERING

DIRECTORY (*CIVIL*)

TO FIND	SUB DIR.	NAME
GEOTECHNICAL DEFINITIONS:	GEOT/DEFIN	
(01) Coefficient of Curvature or Gradation		CC
(02) Uniformity Coefficient		CU
(03) Void Ratio		E
(04) Water Content (%)		W
(05) Compression Index		CC
(06) Relative Density (%) (2 equations)		*DD*→
(07) Specific Gravity		G
(08) Settlement		ΔH
(09) Plasticity Index		PI
(10) Degree of Saturation (%)		S
(11) Shrinkage Index		SI
(12) For flow nets		Q
(13) Total Unit Weight of Soil		γ
(14) Dry Unit Weight of Soil (2 equations)		γD→
(15) Unit Weight of Solids		γS
(16) Prosperity (2 equations)		η→
(17) Normal Stress		σ
(18) General Shear Stress		τ
(19) Coefficient of Active Earth Pressure		KA
(20) Coefficient of Passive Earth Pressure		KP
(21) Active Resultant Force		PA
(22) Bearing Capacity Equation		QULT
(23) Factor of Safety (Slope Stability)		FS
(24) Coefficient of Consolidation		CV
(25) Effective Stress		σ'
STRUCTURAL ANALYSIS:	STRUC	
Deflection of Trusses and Frames:	STRUC/DFLEC	
Deflection of Trusses:	STRUC/DFLEC/TRUS	GNRL
(26) General Equation		TEMP
(27) For temperature		LOAD
(28) For Load		

CIVIL ENGINEERING

DIRECTORY (*CIVIL*)

TO FIND	SUB DIR.	NAME
TRANSPORTATION:	TRANS	
Distance:	TRANS/DIST	
(29) Braking Distance:		**BRAKE**
Sight Distance:	TRANS/DIST/SIGHT	
Crest, Vertical Curve:	TRANS/DIST/SIGHT/CREST	
(30) S<L		**S<L**
(31) S>L		**S>L**
Sag, Vertical Curve:	TRANS/DIST/SIGHT/SAG	
(32) S<L		**S<L**
(33) S>L		**S>L**
(34) Riding Comfort on sag vertical curve	TRANS/DIST	**COMF**
Adequate Sight Distance:	TRANS/DIST/ADEQ	
(35) S<L		**S<L**
(36) S>L		**S>L**
(37) Horizontal Curve	TRANS/DIST	**HORIZ**
Super elevation:		
(38) Highways (General and SI system)	TRANS/SUPER/H.WAY	**GEN,SI**
(39) Railroads	TRANS/SUPER	**RAIL**
Spirals:		
(40) Highways	TRANS/SPIRA/H.WAY	**ENG,SI**
(41) Railroads (2 equations)	TRANS/SPIRA	***RAIL→***
Modified Davis Equation:		
(42) Level tangent Resistance		**R**
(43) Tractive Effort	TRANS/DAVIS	**TE**

CIVIL ENGINEERING

DIRECTORY (*CIVIL*)

TO FIND	SUB DIR.	NAME
REINFORCED CONCRETE:	CONC	
Ultimate Strength Design:	CONC/DESIN	
Moment Design:	CONC/DESIN/MMNT	
(44) Nominal Moment (2 equations)		**ϕMN→**
(45) Height of stress block		**A**
(46) Factored Moment		**MU**
Shear Design:	CONC/DESIN/SHEAR	
(47) Factored Shear Force		**VU**
(48) Nominal Concrete Shear Stress		**VC**
(49) Nominal Shear Stress provided by Reinforcement		**VS**
(50) Maximum Shear Stress provided by Reinforcement		**VSMX**
(51) Minimum Shear Reinforcement		**AV**
T-Beams:	CONC/T.BIM	
(52) Moment Capacity		**ϕMN**
Columns:	CONC/CLMN	
(53) Nominal axial load (tied)		**TIED**
(54) Nominal axial load (spiral)		**SPIRA**
(55) Nominal axial load for axially loaded columns		**PO**
(56) Concrete cross sectional area		**ACON**
(57) Reinforcement Ratio		**ρG**

CIVIL ENGINEERING

DIRECTORY (*CIVIL*)

TO FIND	SUB DIR.	NAME
STRUCTURAL STEEL DESIGN:	STEEL	
Tension Members:	STEEL/TENS	
Allowable Stress Design (ASD):	STEEL/TENS/ASD	
(58) For yielding		YIELD
(59) For fracture		FRACT
Load Resistance Factor Design (LRFD):	STEEL/TENS/LRFD	
(60) For yielding		YIELD
(61) For fracture		FRACT
Member Connections:	STEEL/CONEC	
Allowable Stress Design (ASD):	STEEL/CONEC/ASD	
(62) Shear Stress		FV
(63) Allowable Stress		FT
Load Resistance Factor Design (LRFD):	STEEL/CONEC/LRFD	
(64) Nominal Strength		ϕRN→
Compression Members:	STEEL/COMP	
(65) Maximum stress		σMAX
(65a) Minimum stress		σMIN
(65b) Euler formula (1)		PCR1
(65c) Euler formula (2)		PCR2
(65d) Slenderness Ratio		SR
(66) Cc value		CC
Allowable Stress Design (ASD):	STEEL/COMP/ASD	
Allowable Axial Compressive Stress (Fa):		
(67) If SR > Cc		SR>CC
(68) If SR < = Cc		SR≤CC
Load Resistance Factor Design (LRFD):	STEEL/COMP/LRFD	
Critical Stress (Fcr):		
(69) If $0 \le \lambda_c \le 1.5$		λ≤1.5
(70) If $\lambda_c > 1.5$		λ>1.5
(71) Column Slenderness parameter		λC
(72) Required Axial Strength		PU

CIVIL ENGINEERING

DIRECTORY (*CIVIL*)

TO FIND	SUB DIR.	NAME
CURVE FORMULAS:	CURVE	
Vertical Curves:	CURVE/VERTI	
(73) Horiz. Distance to min/max Elev. on Curve (3 eq.)		*XM→*
Elevation:	CURVE/VERTI/ELEV	
(74) Tangent Elevation (2 equations)		TANG
(75) Curve Elevation (2 equations)		CURV
(76) Tangent offset	CURVE/VERTI	Y
(77) Parabola Constant		A
(78) Tangent offset at PVI		E
(79) Rate of change of grade		R
Horizontal Curves:	CURVE/HORIZ	
(80) Radius		R
(81) Length of curve from P.C. to P.T. (2 equations)		*T→*
(82) Radius (2 equations)		*R→*
(83) Length of curve from P.C. to P.T.		L
(84) Length of Middle Ordinate		M
(85) Angle between two Tangents (2 equations)		*I/2→*
(86) Length of curve from P.C. to P.T. (2 equations)		*L→*
(87) Length of Sub-Chord		C
(88) Angle of Sub-Chord		D
(89) External Distance		*E*
BEAM FIXED-END MOMENT:	BEAM	
Situation 1:	BEAM/SITU1	
(90) AB moment		MAB
(91) BA moment		MBA
Situation 2:	BEAM/SITU2	
(92) AB moment		MAB
(93) BA moment		MBA
Situation 3:	BEAM/SITU3	
(94) AB moment		MAB
(95) BA moment		MBA

MECHANICAL ENGINEERING

DIRECTORY (*MECH*)

TO FIND	SUB DIR.	NAME
REFRIGERATION:	REFRI	
Two-Stage Cycle:	REFRI/CYCLE/TWO	
(01) Coefficient of Performance, Refrigeration (2 equations)		***COPR→***
(02) Coefficient of Performance, Heat Pump (2 equations)		***COPH→***
Air Refrigeration Cycle:	REFRI/CYCLE/AIR	
(03) Coefficient of Performance, Refrigeration		***COPR***
(04) Coefficient of Performance, Heat Pump		***COPH***
HVAC:	HVAC	
Pure Heating and Cooling:	HVAC/H&C	
(05) Heat in/out		***Q→***
Cooling and Dehumidification:	HVAC/C&DH	
(06) Heat out		**QOUT**
(07) Mass of water out		**MW**
Heating and Humidification:	HVAC/H&HU	
(08) Heat in		**QIN**
(09) Mass of water in		**MW**
Adiabatic Humidification:	HVAC/ADIAB/HUMI	
(10) Exit enthalpy		**H2**
(11) Mass of water in		**MW**
Adiabatic Mixing:	HVAC/ADIAB/MIX	
(12) Mass of mixture		**MA3**
(13) Enthalpy of mixture		**H3**
(14) Specific Humidity (Humidity Ratio) of mixture		**ω3**

MECHANICAL ENGINEERING

DIRECTORY (*MECH*)

TO FIND	SUB DIR.	NAME
HVAC	HVAC	
Heating Load:	HVAC/LOAD/HEAT	
(15) Heat loss (R is given)		**Q**
(16) Thermal Resistance		**R"**
(17) Heat loss (U is given)		**Q**
Cooling Load:	HVAC/LOAD/COOL	
(18) Heat gain		**Q**
Infiltration:		
(19) Heat loss, Air Change Method	HVAC/INFIL	**CHNG**
(20) Heat loss, Crack Method		**CRAK**
FANS:	FAN	
(21) Power		**POWR**
PUMPS:	PUMP	
(22) Net Positive Suction Head		**NPSH**
(23) Power		**POWR**
COMPRESSORS:	COMP	
(24) Input Power (2 equations)		***W*→**
(25) Exit enthalpy		**HE**
(26) Exit temperature		**TE**
ENERGY CONSERVATION:		
Internal Combustion Engines:	INTER	
DIESEL cycle:	INTER/DISEL	
(27) Compression Ratio		**R**
(28) Cut-Off Ratio		**RC**
(29) Efficiency		**η**
(30) Ratio of Specific Heat		**K**

MECHANICAL ENGINEERING

DIRECTORY (*MECH*)

TO FIND	SUB DIR.	NAME
ENERGY CONSERVATION:		
Internal Combustion Engines:	INTER	
Brake, Power:	INTER/BRAKE/POWR	
(31) General		***WB→***
(32) Indicated		**WI**
Brake, Efficiency:	INTER/BRAKE/EFFI	
(33) Thermal		**η*B***
(34) Indicated		**η*I***
(35) Mechanical		**η*M→***
(36) Displacement Volume	INTER	**VD**
(37) Compression Ratio		**RC**
(38) Mean Effective Pressure		**MEP**
(39) Volumetric Efficiency		**η*V***
(40) Specific Efficiency		***SFC→***
GAS TURBINE, Brayton Cycle:	TURB	
Steady Flow Cycle:	TURB/STIDY	
(41) w12 (2 equations)		***W12→***
(42) w34 (2 equations)		***W34→***
(43) wnet		**WNET**
(44) q23 (2 equations)		***Q23→***
(45) q41 (2 equations)		***Q41→***
(46) qnet		**QNET**
(47) Efficiency		**η**

MECHANICAL ENGINEERING

DIRECTORY (*MECH*)

TO FIND	SUB DIR.	NAME
GAS TURBINE, Brayton Cycle:	TURB	
With Regenerator:	TURB/RGEN	
(48) h3		**H3**
(49) T3		**T3**
(50) q34		***Q34→***
(51) q56		***Q56→***
(52) Efficiency		**η**
(53) Regenerated efficiency		***ηRG→***
STEAM POWER PLANTS:	STIM	
Feed Water Heater:	STIM/HETER	
(54) Open system		**OPEN**
(55) Closed system		**CLOSE**
(56) Junction	STIM	**JUNC**
Pump:	STIM/PUMP	
(57) Work		**W**
(58) h2s		**H2S**
(59) Work		**W**
SHAFT AND AXLES:	SHAFT	
Static Loading:	SHAFT/STAT	
(60) Maximum Shear stress		***τMX***
(61) Von Mises stress		**σ'**
Fatigue Loading:	SHAFT/FATIG	
(62) Shaft diameter		**D**

MECHANICAL ENGINEERING

DIRECTORY (*MECH*)

TO FIND	SUB DIR.	NAME
SCREWS:	SCRW	
(63) Torque required to raise		**TR**
(64) Torque required to lower		**TL**
(65) Efficiency of power screw		**η**
(66) Total bolt load		**FB**
(67) Total material load		**FM**
(68) Bolt stiffness		**KB**
(69) Member stiffness		**KM**
FASTENERS:	FASTE	
(70) Bolt load factor		**NB**
(71) Factor of safety		**NS**
(72) Alternating stress		**σA**
(73) Mean stress		**σM**
SPRINGS:	SPRIN	
Helical Linear Springs:	SPRIN/LINER	
(74) Shear stress		**τ**
(75) Correction factor		**KS**
(76) Spring rate (spring factor)		**K**
Helical Torsion Springs:	SPRIN/TORS	
(77) Bending stress		**σ**
(78) Correction factor		**KI**
(79) Deflection, Moment equation		**FR**
(80) Spring rate (spring factor)		**K**
(81) Endurance limit	SPRIN	**SE**

MECHANICAL ENGINEERING

DIRECTORY (*MECH*)

TO FIND	SUB DIR.	NAME
PRESS/SHRINK FITS:	FITS	
(82) Interface induced pressure		**PRESS**
(83) Torque, maximum by press/shrink fits		**TORQ**
COLUMNS:	CLMN	
Intermediate columns:	CLMN/INTER	
(84) Slenderness ratio		**SRD**
(85) Critical Load		**PCR**
Long columns:	CLMN/LONG	
(86) Critical Load		**PCR**
GEARS, STRAIGHT SPUR:	GEAR	
(87) Radial Force		**WR**
Transmitted Load (Tangential Force):	GEAR/WT	
(88) With the given torque (2 equations)		***TRQ→***
(89) With the given power (2 equations)		***PWR→***
(90) Bending stress	GEAR	***σB***
(91) Surface stress		***σC***