CORVUS
CORPORATION
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# OWNER'S MANUAL

**REFERENCE FORMULAS FOR**

- **MATHEMATICS • ENGINEERING • PHYSICS**
- **TRIG AND LOG TABLES**
- **CONVERSION TABLES**

SLIDE RULE
CALCULATOR
WITH MEMORY

# 411

CORVUS

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# INTRODUCTION AND FEATURES

The Corvus 411 — your personal slide rule with memory — is designed for the engineer, scientist, or student, to aid in accurately solving complex problems in a non-complex manner with features such as these:

- **Algebraic entry:** Problems are entered in the sequence in which they are normally written.
- **Constant:** Automatic on four functions.
- **Scientific notation:** Computes and displays numbers from $\pm 9.99999 \times 10^{99}$ to $\pm 1.00000 \times 10^{-99}$.
- **Memory:** Convenient storage of intermediate answers with easy recall and exchange features.

CORVUS: A Leader in Calculator Design

Each calculator in the CORVUS line features an MOS/LSI integrated circuit manufactured by MOSTEK Corporation. MOSTEK, the parent company of CORVUS, was the first in the world to design and market a single-chip integrated circuit for calculators. In less than ¼ square inch, this chip contained the complete capability of a four-function calculator. This breakthrough by MOSTEK in 1970 virtually revolutionized the calculator industry, allowing the design of compact, hand-held, portable units.

A similar, more advanced, MOS circuit developed by MOSTEK is used in the Model 411 to provide you with many extra calculation features and a useful memory.

Each CORVUS calculator is designed to provide extra capability to solve a wide variety of calculation applications in the home, business, office, and the field. Corvus' built-in reliability is backed by a full-year warranty on components and service.



# GUIDE TO THE 411

## POWER SOURCE

The 411 is powered by rechargeable nickel-cadmium batteries. The following precautions are advisable to ensure years of service from your 411:

(1) Recharge unit when the display becomes noticeably dimmer; always avoid total discharge of batteries.
(2) When charging unit:
   (a) Use the supplied charger *only*.
   (b) Turn the calculator "Off" and interconnect charger using standard household AC power.
(3) The 411 may be operated while the charger is interconnected; however, the charging circuit will be automatically disconnected when the power switch is "On," in order to protect against accidental overcharging.
(4) Limit charging time to 12 hours (or less if unit is used infrequently).

## KEYBOARD

### DATA ENTRY KEYS

0 through 9 — Number entry keys

• Decimal point entry key

π Enters Pi as 3.141592 with a display of 3.14159

### FUNCTION KEYS

C **Clear:** Performs either a *total clear* or a *clear entry* (clearing displayed number only) as described below.
1. Total clear following any function key.
2. Clear entry following any Data Entry key(s) or Memory key(s).
3. Clear entry of a blinking display resulting from a numeric entry overflow.
4. Total clear of a blinking display resulting from a misoperation.
5. Clears memory contents *only if* pressed before M/S (Memory Store).
6. Ensures a total clear when pressed *twice*.

+ **"Add" key:** Instructs the calculator to complete any previous calculations and add the next numeric entry.

− **"Subtract" key:** Instructs the calculator to complete any previous calculation and subtract the next numeric entry.

× **"Multiply" key:** Instructs the calculator to complete any previous calculation and multiply by the next numeric entry.

÷ **"Divide" key:** Instructs the calculator to complete any previous calculation and divide by the next numeric entry.

$\sqrt{x}$ **"Square Root" key:** Instructs the calculator to complete any previous calculation and obtain the square root of the resultant.

$1/x$ **"Reciprocal" key:** Instructs the calculator to complete any previous calculation and obtain the reciprocal of the result.

= **"Equals" key:** Instructs the calculator to complete any previous calculation. Note that when the = key is used, the previously-entered number and functional command automatically become available for use as a constant. See Page 7.

## MEMORY KEYS

**MS** **"Memory Store" key:** Instructs the calculator to store the displayed number. This automatically *replaces* any previously stored number.

**MR** **"Memory Recall" key:** Recalls and displays the number stored in the memory but does not "erase" the number from memory. (Non-destructive recall.)

**EX** **"Exchange" key:** Exchanges the displayed number with the number in memory, thus displaying the previously stored number — making it available for calculation.

NOTE: The use of any Memory key will automatically terminate any numeric entry and a "decimal point" will appear in the display.

Note that these keys *do not* complete any previous calculation and may therefore be used at any point in a chain calculation.

## SCIENTIFIC NOTATION KEY

**EE** **"Enter Exponent" key:** Instructs the calculator that the next numeric entry will be an exponent of 10. A number is entered in Scientific Notation by entering the mantissa, pressing EE, and entering the exponent. (If exponent is negative, press − prior to entering exponent.)

EXAMPLE: $1.2 \times 10^{-6}$ is entered: 1.2, EE, −, 6 .

Display will read 1.2 −06.

## DISPLAY DESCRIPTION

This display is a solid-state LED (Light-Emitting Diode) display. The display is formatted as follows:

−1.23456 −06

Mantissa Sign* | Mantissa | Exponent Sign* | Exponent

*NOTE: Sign of mantissa or exponent is understood to be positive unless negative sign appears.

## SYMBOL DESCRIPTION

− Indicates a negative mantissa or exponent. The negative sign will appear immediately to the left of mantissas of less than 5 digits.

⊓ Indicates positive Overflow (see Page 6)

□ Indicates negative Overflow (see Page 6)

## FLASHING DISPLAYS

A flashing display can result from two conditions:

**Entry Overflow:** A numeric entry of more than 6 digits in the mantissa. Display will flash 6 digits.

**Misoperation (or Illegal Operation):** Attempting an operation such as taking the square root of a negative number results in a flashing display of the last "legitimate" resultant or entry. For example: Attempting $\sqrt{6\ (-3)}$ will result in a flashing "−18".



## SCIENTIFIC NOTATION

"Scientific notation" is stating a number in terms of 10 raised to a power. For example, one million (1,000,000) can be stated as $1 \times 10^6$. Similarly, 1,200 is stated $1.2 \times 10^3$. You will note in both examples that the number in the exponent is the number of places that the decimal was moved. (Proof: 32,000 is $3.2 \times 10^4$ (decimal moved 4 places), or $3.2 \times 10{,}000 = 32{,}000$.)

Numbers less than one are conveniently expressed by using negative exponents. For example, one-millionth (commonly called one micro), 0.000001, can be expressed as $1 \times 10^{-6}$.

In the example of .00032, expressed as $3.2 \times 10^{-4}$, it is entered in the 411 as 3.2 EE − 4. In the resulting display, the "3.2" is called the mantissa, and the "− 4" the exponent. —— Note again that the exponent represents the number of places that the decimal was moved. Note also that positive and negative exponents move the decimal point in opposite directions.

Your Corvus 411 allows you to enter numbers in scientific notation with either negative or positive exponents. When entering a number in scientific notation, it is not necessary to reduce the mantissa to one "units" digit (standard scientific notation form). For example, 750 kHz is $750 \times 10^3$ Hz, since $k = 10^3$. It may be entered on the 411 as 750 EE 3. The 411 will automatically convert it to $7.5 \times 10^5$ on subsequent operations.

**Advantages:**

Scientific notation greatly reduces the number of keystrokes required and greatly increases the calculator's capacity for handling large numbers. For example, 1,600,000 is easily entered: 1.6 EE 6. Calculations can be made with numbers up to $9.99999 \times 10^{99}$. A standard calculator without *scientific notation* would require over 100 digit positions to display results within the capacity of the Model 411.

**Characteristics of Scientific Notation Use & Display:**

**Mantissa:** In standard form, the mantissa is fixed point: 1 digit with up to 5 decimal points as required. (Trailing zeros are not displayed).

**Exponent sign:** The sign of the exponent is understood to be positive unless the negative sign appears to its immediate left.

**Entry:** Entry of a problem in scientific notation is simple. Enter mantissa (see definitions above); press EE ; press − if negative; enter exponent.

**Automatic Conversion:** The 411 will automatically convert to and display results in scientific notation when the result is greater than 999,999 or less than .001.

**Reciprocals and Square Roots Less Than One:** All reciprocals ( $1/x$ ) and square roots ( $\sqrt{x}$ ) less than unity are always expressed in scientific notation to maintain accuracy.

**No "Sign Change" Required:** In the 411, it is not necessary to use a "sign change" key since negative exponents are entered with the negative key. For example, $6 \times 10^{-3}$ is entered 6 EE − 3. (See Negative Entry, Page 8.)

## OPERATING THE 411

### SIMPLE ALGEBRAIC ENTRY:

The Corvus 411 operates algebraically (rather than employing the so-called reverse Polish or arithmetic logic), so that you enter a problem in the same sequence that you would write it. Compare the problem 8 − 3 = 5 in the various logics:

**Arithmetic.** Problem is entered in this sequence:
8, +/=, 3, −/= (Display is "5.")

**Reverse Polish.** Problem is entered as follows:
8, +, 3, − (Display is "5.")

**Algebraic.** Entry is simplified.
8, −, 3, = (Display is "5.").

The greater the complexity of a problem, the more the simplicity of algebraic entry is appreciated.

### OPERATING MODES

The Model 411 has two operating modes:

**"Floating Point."** In this mode, calculations are entered and made just as on standard multifunction calculators, with six-digit capacity and floating decimal point. (Results exceeding this capacity are automatically converted to Scientific Notation.)

**"Scientific Notation."** Entries may be made directly in the scientific notation mode simply by using the EE ("Exponent Entry") key.

### ACCURACY

The 411 maintains an internal 7-digit accuracy. **Round-Off:** Resultant 6-digit displays are rounded off to the nearest correct digit; e.g., an internal answer of 1.343457 would be displayed as 1.34346.

Another exa..iple is $\pi$, which is displayed as 3.14159 but internally carried as 3.141592, so that 3 $\times$ $\pi$ results in a display of 9.42478.

### OVERFLOW

When a calculation results in an overflow (as noted by the appropriate symbol), the mantissa will display the most significant digits while the exponent will overflow past $10^{99}$.

When the result *first* goes into overflow the exponent is understood to be three digits with the "hundreds" digit not shown, so that a display of ⊓ 8.12345 06 is interpreted as 8.12345 $\times$ $10^{106}$.

This overflow condition can be further calculated if desired, but by multiplication or division only and with the necessary mental corrections of the displayed exponent, since the 411 will assume the display as 8.12345 $\times$ $10^{6}$ during secondary calculations.

Addition or subtraction during overflow will not calculate since either is an illegal operation. The display will be restored to the previous overflow, and flash on and off. A single pressing of the C key, in this case, performs a clear-all function.



### TOTAL CHAIN/COMBINATION CAPABILITY

The Model 411 features total chain/combination capability. Each function key serves as an "equals" key to the previously entered portion of the problem. For example, in the problem (2 + 3) $\times$ 4, the $\times$ key completes the addition of 2 and 3 and sets up multiplication of the displayed "5" by the next entry, which will be 4. The reciprocal $1/x$ and square root $\sqrt{x}$ keys not only complete their previous calculation, but also complete their respective functions. For example, $\sqrt{5+4}$ is entered 5, +, 4, $\sqrt{x}$. (Note = is not necessary to complete calculation.)

### AUTOMATIC CLEAR

The following function keys, =, $\sqrt{x}$, and $1/x$ result in complete termination of the calculation in process; therefore, it is not necessary to "clear" the calculator with the C key before beginning a new calculation. (See also use of = key in Automatic Constant Functions, below.)

Since previous calculations cannot be assumed, each sample problem illustrated throughout this manual begins with a double depression of the C key, to ensure an "all clear."

### FUNCTION KEY ENTRY ERROR CORRECTION

Each functional key supersedes a previously depressed function key, for simplicity of entry corrections. The calculator will perform according to the last received instruction; for example an inadvertent striking of the − key can be simply overridden by striking the + key and vice versa. $\times$ and ÷ act similarly as well as overriding + or −. The − command is accepted when it follows a $\times$ or ÷ command, in order to allow division or multiplication by negative numbers.

E.g., 12, −, $\times$, 6 = 72. (411 has ignored − command)
but 144, ÷, −, 6 = −24. (411 has accepted the entry as a negative number for division.)

An error in Exponent Entry can be corrected simply by entering the correct exponent, as the calculator accepts only the last two digits received. E.g., exponent "6" is mistakenly entered EE, 5. To correct, press 0, 6. Also, re-pressing the EE key serves as an exponent "clear."

E.g., − 12 entered as EE, 12. To correct: EE, −, 12.

### AUTOMATIC CONSTANT FUNCTIONS

Any of the basic four functions ( +, −, ÷, and $\times$ ) can provide automatic constant operation when us·d in conjunction with the "equals" key. The second or latest, entry becomes the constant. For example, following the calculation of 2 $\times$ 12 = 24, the 12 is automatically available as a constant multiplier, if desired. Thus to multiply any other number of 12, such as 4, it is merely necessary to enter that number and depress the "equals" key.

Examples of using a constant divisor:

(a) 12 ÷ 5
(b) 15 ÷ 5
(c) 40 ÷ 5 $\times$ 6 − 14

| Enter | Press | Display | Note |
|---|---|---|---|
| | C, C | | |
| 12 | ÷ | 12. | |
| 5 | = | 2.4 | Answer (a) |
| 15 | = | 3. | Answer (b) |
| 40 | = | 8. | |
| | $\times$ | 8. | |
| 6 | − | 48. | |
| 14 | = | 34. | Answer (c) |

The constant is useful when a repetitive number appears in a *chain calculation, e.g.,* 12.5 + 8.5 + 7.0 + 7.0 + 7.0

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 12.5 | + | 12.5 |
| 8.5 | + | 21. |
| 7.0 | = | 28. |
| | = | 35. |
| | = | 42. |

## RAISING NUMBERS TO POWERS

This automatic constant feature makes it extremely easy to multiply a number by itself as many times as desired; that is, to raise it to the desired power, $3^4$, therefore, is simply calculated as:

| Enter | Press | Display | Note |
|---|---|---|---|
| | C, C | | |
| 3 | ×, = | 9 | Second power |
| | = | 27 | Third power |
| | = | 81 | Fourth power |

## NEGATIVE ENTRY

The − key instructs the calculator that the next entry will be a negative number. For example, 6(−3) is entered:

6 × − 3 =

This key is also used to enter negative exponents. See "Scientific Notation," Page 5.

## MEMORY

To store a displayed positive or negative number in the memory, press the MS ("Memory Store") key. (This number will replace any previously stored number.)

To recall without "erasing," (non-destructive recall) a number in the memory, press the MR ("Memory Recall") key. The memory contents will be displayed.

If it is desired to perform a calculation with the contents of the memory, depress the EX ("Exchange") key. This automatically exchanges the displayed number with the contents of the memory, allowing you to temporarily "pigeon-hole" a resultant, as well as performing calculations with the number previously stored in the memory.

To Clear Memory, press C , MS .

## APPLICATION OF MEMORY KEYS MS, MR

(1) Product of Sums: (5 + 4) × (2 + 3) × (6 + 7) =

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 5 | + | 5. |
| 4 | =, MS | 9. |
| 2 | + | 2. |
| 3 | ×, MR | 9. |
| | =, MS | 45. |
| 6 | + | 6. |
| 7 | ×, MR | 45. |
| | = | 585. |



(2) Credits/Debits: Total (add) all debits and store in memory; next, total credits; subtract debits (memory) from credits for positive or negative balance (net amount). Note that debits are still retained in memory for reference.

Example: Credits, \$18.80, \$5.35
Debits: \$9.95, \$3.94, \$7.50, \$2.98, \$4.29

| Enter | Press | Display | Note |
|---|---|---|---|
| | C, C | | |
| 9.95 | + | 9.95 | |
| 3.94 | + | 13.89 | |
| 7.50 | + | 21.39 | |
| 2.98 | + | 24.37 | |
| 4.29 | =, MS | 28.66 | Debits stored |
| 18.80 | + | 18.8 | |
| 5.35 | − | 24.15 | Credit total |
| → | MR | 28.66 | Debit total |
| | = | −4.51 | Net balance |
| | EX | 28.66 | Debit (check) |
| or | | | |
| → | EX | 28.66 | Credits in memory |
| | = | −4.51 | Net balance |
| | EX | 24.15 | Credits (check) |

(3) Storing Constant in Memory: Example of metric conversion. Known, .03937 inches = 1 mm; to solve:
(a) Convert 250 mm to inches: in. = constant × mm
(b) Convert 99 mm to inches: in. = constant × mm
(c) Convert 16 in. to mm: mm = in. ÷ constant

| Enter | Press | Display | Note |
|---|---|---|---|
| | C, C | | |
| .03937 | MS, × | 0.03937 | |
| 250 | = | 9.8425 | Answer (a) |
| 99 | ×, MR | 0.03937 | |
| | = | 3.89763 | Answer (b) |
| 16 | ÷, MR | 0.03937 | |
| | = | 406.401 | Answer (c) |

(4) Division of memory contents by displayed number: Assume calculation in process; 8.4 in memory; latest display is 2.8.

| Enter | Press | Display |
|---|---|---|
| | | 2.8 |
| | EX | 8.4 |
| | ÷ | 8.4 |
| | MR | 2.8 |
| | = | 3. |

## APPLICATION OF EXCHANGE KEY EX

EX has many practical uses, some of which follow:

(1) Memory check: allows reference back to memory without affecting calculation. E.g., assume calculation in process, 4.5 in memory:

| Enter | Press | Display | Note |
|---|---|---|---|
| 12 | X | 12. | |
| | EX | 4.5 | Memory check & |
| | EX | 12. | restored |
| 4 | = | 48. | |

(2) Update memory: Solve $a^3 + (ab) =$
Since the term a is repetitively used, it is first stored in memory as a constant. Note EX minimizes entries.

Let a = 1.6, b = 1.2

| Enter | Press | Display | Note |
|---|---|---|---|
| | C, C | | |
| 1.6 | MS, × | 1.6 | a in memory |
| | = | 2.56 | $a^2$ |
| | = | 4.096 | $a^3$ |
| | EX | 1.6 | $a^3$ in memory |
| | × | 1.6 | |
| 1.2 | + | 1.92 | (ab) |
| | MR | 4.096 | $a^3$ recalled |
| | = | 6.016 | Solution |

(3) Item Accumulation: Example: (a) 4 items @ $2.50; (b) 8 items @ $3.75; (c) 5 items @ $1.26. Determine each item cost (total) and total quantity of items.

| Enter | Press | Display | Note |
|---|---|---|---|
| | C, C | | |
| 4 | MS, × | 4. | |
| 2.5 | = | 10. | Cost of (a) |
| 8 | +, EX, = | 12. | |
| | EX, × | 8. | |
| 3.75 | = | 30. | Cost of (b) |
| 5 | +, EX, — | 17. | |
| | EX, × | 5. | |
| 1.26 | = | 6.3 | Cost of (c) |
| | MR | 17. | Total items |

Note also the sample problem for geometry shown on Page 17.

## FORMULAS & EXAMPLES

ALGEBRA

**I. Fractions: General Rules**

**Addition:** Add numerators only (after making all denominators common).
E.g., 2/7 + 3/7 = 5/7 ; 1/3 + 3/7 = 7/21 + 9/21 = 16/21

**Subtraction:** Subtract numerators only (as with addition).

**Multiplication:** Multiply numerators; multiply denominators; divide resultant numerators by resultant denominators.
E.g., 3/4 × 2/3 = 6/12 = 1/2

**Division:** Invert the fractional divisor and proceed as in multiplication:
E.g., 3/4 ÷ 2/3 = 3/4 × 3/2 = 9/8 = 1 1/8

**II. Powers & Exponents: General Rules**

**Addition:** When adding numbers with exponents, it is only possible to add to those numbers which have the same exponent: Add base numbers; do not change exponents.
E.g., $x^2 + 3x^2 + x^3 = 4x^2 + x^3$

**Subtraction:** Same rules apply as addition. Subtract base numbers with like exponents only:
E.g., $2x^2 - x - x^2 = x^2 - x$

**Multiplication:**

(a) Add exponents of *like bases* and *like signs:*
E.g., $x^2 \cdot x^3 \cdot y^3 = x^5 \cdot y^3$
$x^{-2} \cdot x^{-5} = x^{-7}$

(b) Subtract exponents of *like bases* and *unlike signs:*
E.g., $x^2 \cdot x^{-5} = x^{-3}$
$x^{-2} \cdot x^5 = x^3$

(c) Multiply exponents of exponents:
E.g., $(x^2)^3 = x^6$



**Division:** Subtract denominator (dividend) exponent from numerator (divisor) exponent (like bases only):

E.g., $x^6 \div x^2 = x^4$
$x^6 \div x^{-2} = x^8$ [Since $6-(-2) = 6 + 2 = 8$]
Similarly, $x^{-6} \div x^2 = x^{-8}$ [Since $(-6) - 2 = -8$]

**Negative Exponents:** A number raised to a negative power may also be expressed as the reciprocal of that number to a positive power. Thus:

$$x^{-3} = \frac{1}{x^3} \text{ and } 2^{-3} = \frac{1}{2^3} = \frac{1}{8} = .125$$

**Non-Integer Exponents:** The following expressions are true:

(a) $x^{.5} = \sqrt{x}$ (b) $x^{2.5} = (x^2)(\sqrt{x})$
(c) $x^{3/4} = (x^{2/4})(x^{1/4}) = (x^{.5}) \times (\sqrt[4]{x}) = (\sqrt{x})(\sqrt{\sqrt{x}})$
(d) $x^{1/n} = \sqrt[n]{x}$

**III. Roots**

Extracting a root is the reverse of raising a number to a power. For roots involving powers of 2, the following expressions are true:
(a) $\sqrt[.5]{x} = x^2$ (b) $\sqrt{x} = \sqrt[2]{x}$
(c) $\sqrt[4]{x} = \sqrt{\sqrt{x}}$ (d) $\sqrt[8]{x} = \sqrt{\sqrt{\sqrt{x}}}$

**Extracting Non-Integer Roots:** A unique approach is proposed allowing extraction of any root $\sqrt[n]{N}$ without guesswork or approximation. Normally, the resultant is within ½% of the correct answer. Note that the number of $\sqrt{x}$ steps and X , = steps must be the same. The number of steps taken determines the degree of accuracy; where less accuracy is required, fewer steps may be used.

(a) Enter number, N
(b) Perform 9 sequential $\sqrt{x}$ operations
(c) Subtract the number 1.
(d) Divide by the desired root, n
(e) Add the number 1
(f) Square the display 9 times using × , = repetitively.

To demonstrate the accuracy of this method, test by comparison with known cube root of 27 = 3 (3 • 3 • 3 = 27):

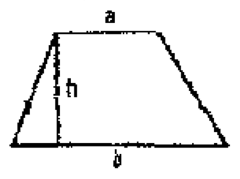
| Enter | Press | Display | Note |
|---|---|---|---|
| 27 | $\sqrt{x}$ (9 times) | 1.00646 | |
| | — | 1.00646 | |
| 1 | ÷ | 0.00646 | |
| 3 | + | 0.0215 | 3 is desired root |
| 1 | ×, = | 1.00431 | |
| | ×, = (9th time) | 3.00689 | Answer is "off" by .007 |

Another example: Extract $\sqrt[.5]{2}$ ($\doteq 2^2 = 4$)

| Enter | Press | Display |
|---|---|---|
| 2 | $\sqrt{x}$ (9 times) | 1.00135 |
| | — | 1.00135 |
| 1 | ÷ | 0.00135 |
| .5 | + | 0.0027 |
| 1 | ×, = (9 times) | 3.98134 |

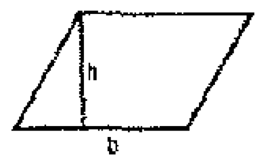
## I. Plane Figures:

**Trapezoid**



Area $= \frac{(a+b)\,h}{2}$

**Parallelogram**

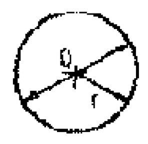


Area $= bh$

**Reg. Hex.**

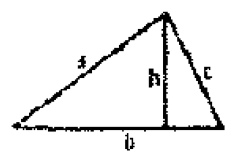
$A = 2.598\,s^2 = 3.464\,r^2$
$R = s = 1.155r$
$r = 0.866\,s = 0.866\,R$

**Circle**



Area $= \pi r^2$
Cir. $= 2\,\pi r$

**Triangle**

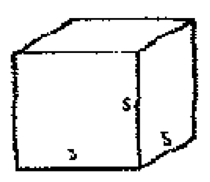


Area $= \frac{bh}{2} = \sqrt{s\,(s-a)\,(s-b)\,(s-c)}$

where term $s = \frac{a+b+c}{2}$

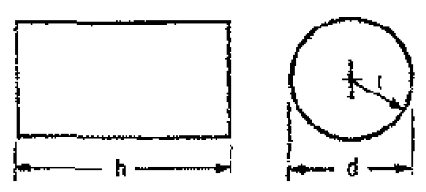
## II. Solid Figures:

**Cube**



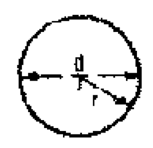
$V = s^3$
$A = 6\,s^2$

**Cylinder**



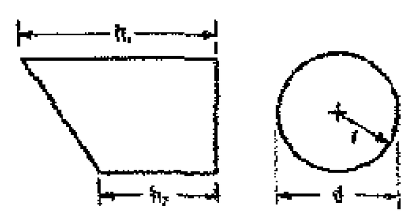
$V = \pi\,r^2h = 0.7854\,d^2h$
$S_C = 6.2832\,rh = \pi\,dh$

**Sphere**



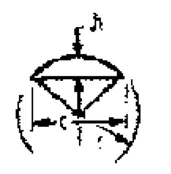
$V = \frac{4\pi r^3}{3} = \frac{\pi d^3}{6}$
$A = 4\pi r^2 = \pi d^2$

**Portion of Cylinder**



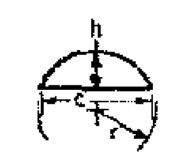
$V = 1.5708\,r^2\,(h_1 + h_2)$
$S_C = \pi\,r\,(h_1 + h_2)$

**Spherical Sector**



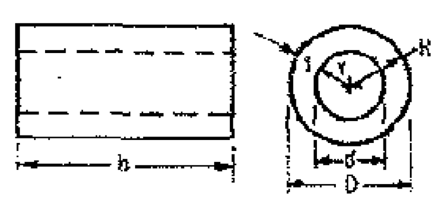
$V = \frac{2\,\pi r^2 h}{3}$
$A = \pi\,r\,(2\,h + \frac{1}{2}\,c)$
$c = 2\,\sqrt{h\,(2\,r - h)}$

**Spherical Segment**



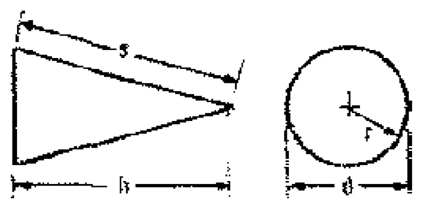
$V = \pi\,h^2\left(r - \frac{h}{3}\right) = \pi\,h\left(\frac{c^2}{8} + \frac{h^2}{6}\right)$
$A = 2\,\pi rh = \pi\left(\frac{c^2}{4} + h^2\right)$
$c = 2\,\sqrt{h\,(2r - h)} \quad r = \frac{c^2 + 4\,h^2}{8\,h}$

**Hollow Cylinder**



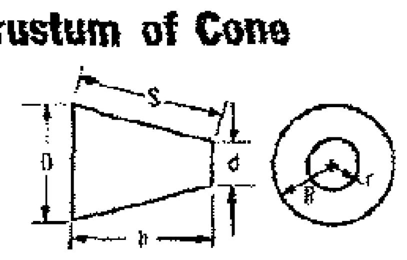
$V = \pi\,h\,(R^2 - r^2) = 0.7854\,h\,(D^2 - d^2)$
$= \pi\,ht\,(2\,R - t) = \pi\,ht\,(D - t)$
$= \pi\,ht\,(2\,r + t) = \pi\,ht\,(d + t)$
$= \pi\,ht\,(R + r) = 1.5708\,ht\,(D + d)$

**Cone**



$V = 1.0472\,r^2h = 0.2618\,d^2h$
$A = \pi\,r\,\sqrt{r^2 + h^2} = \pi\,rs$
$s = \sqrt{r^2 + h^2}$

**Frustum of Cone**



$V = 1.0472\,h\,(R^2 + Rr + r^2)$
$A = \pi\,s\,(R + r)$
$s = \sqrt{(R - r)^2 + h^2}$

**Torus**

$V = 2\pi^2Rr^2 = \frac{\pi^2}{4}Dd^2$
$A = 4\,\pi^2Rr = \pi^2Dd$





## I. For any acute angle $\phi$ lying in a right triangle:

(1) $\sin\phi = \frac{\text{opp}}{\text{hyp}}$

(2) $\cos\phi = \frac{\text{adj}}{\text{hyp}}$

(3) $\tan\phi = \frac{\text{opp}}{\text{adj}}$

## II. For angle $\phi$, the following fundamental relationships are given:

(1) $\csc\phi = \frac{1}{\sin\phi}$

(2) $\sec\phi = \frac{1}{\cos\phi}$

(3) $\cot\phi = \frac{1}{\tan\phi}$

(4) $\tan\phi = \frac{\sin\phi}{\cos\phi}$

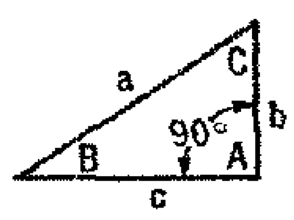
(5) $\cot\phi = \frac{\cos\phi}{\sin\phi}$

(6) $\sin^2\phi + \cos^2\phi = 1$

(7) $1 + \tan^2\phi = \sec^2\phi$

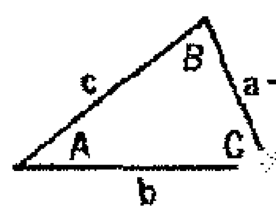
(8) $1 + \cot^2\phi = \csc^2\phi$

## III. Solution of Right-angled Triangles




| Sides and Angles Known | Formulas for Sides and Angles to be Found | | |
|---|---|---|---|
| Sides a and b | $c = \sqrt{a^2 - b^2}$ | $\sin B = \frac{b}{a}$ | $C = 90° - B$ |
| Sides b and c | $a = \sqrt{b^2 + c^2}$ | $\tan B = \frac{b}{c}$ | $C = 90° - B$ |
| Side a; angle B | $b = a \sin B$ | $c = a \cos B$ | $C = 90° - B$ |
| Side b; angle B | $a = \frac{b}{\sin B}$ | $c = b \cot B$ | $C = 90° - B$ |
| Side b; angle C | $a = \frac{b}{\cos C}$ | $c = b \tan C$ | $B = 90° - C$ |

## IV. Solution of Oblique-angled Triangles




| | |
|---|---|
| One side and two angles known. a, A, B | $b = \frac{a \sin B}{\sin A}$ $c = \frac{a \sin C}{\sin A} = \frac{a \sin (A+B)}{\sin A}$ <br> Area $= \frac{a\,b \sin C}{2}$ |
| Two sides and angle between them known. a, b, C | $\tan A = \frac{a \sin C}{b - a \cos C}$ $c = \frac{a \sin C}{\sin A}$ <br> Area $= \frac{a\,b \sin C}{2}$ |
| Two sides and angle opposite one side known. a, b, A | $\sin B = \frac{b \sin A}{a}$ $c = \frac{a \sin C}{\sin A}$ <br> Area $= \frac{a\,b \sin C}{2}$ |
| Three sides known. a, b, c <br> Note: $C = 180° - (A + B)$ | $\cos A = \frac{b^2 + c^2 - a^2}{2\,bc}$ $\sin B = \frac{b \sin A}{a}$ <br> Area $= \frac{a\,b \sin C}{2}$ |

## ELECTRICAL

**I. Definition of Terms:**

| Symbol | Definition | Units |
|---|---|---|
| C | Capacitance | Farads |
| E | Voltage | Volts |
| F | Frequency | Hertz |
| I | Current | Amps |
| L | Inductance | Henries |
| P | Power | Watts |
| Q | Charge | Coulombs |
| R | Resistance | Ohms |
| t | Time | Seconds |
| Z | Impedance | Ohms |

**II. Ohm's Law (Direct Current):**

$$E = IR = \frac{P}{I} = \sqrt{RP} \qquad R = \frac{E}{I} = \frac{P}{I^2} = \frac{E}{P}$$

$$I = \frac{E}{R} = \frac{P}{E} = \sqrt{\frac{P}{R}} \qquad P = EI = I^2R = \frac{E^2}{R}$$

**III. Alternating Current:**

Voltage: $RMS = \frac{E\ max}{\sqrt{2}}$

Current: $RMS = \frac{I\ max}{\sqrt{2}}$

Power: P peak = (E max) (I max)
P *effective* = (E *effective*) (I *effective*)

**IV. Series/Parallel Formulas**

| | Series | Parallel |
|---|---|---|
| $E_{total}$ | $E_1 + E_2 + E_n$ | $E_1 = E_2 = E_n$ |
| $I_{total}$ | $I_1 = I_2 = I_n$ | $I_1 + I_2 + I_n$ |
| $R_{total}$ | $R_1 + R_2$ | $\frac{R_1R_2}{R_1+R_2}$ |
| $R_{total}$ | $R_1 + R_2 + R_n$ | $\frac{1}{1/R_1 + 1/R_2 + 1/R_n}$ |
| $P_{total}$ | $P_1 + P_2 + P_n$ | $P_1 + P_2 + P_n$ |
| $C_{total}$ | $\frac{1}{1/C_1 + 1/C_2 + 1/C_n}$ | $C_1 + C_2 + C_n$ |
| $L_{total}$ | $L_1 + L_2 + L_n$ | $\frac{1}{1/L_1 + 1/L_2 + 1/L_n}$ |

**V. Capacitors/Inductors**

Inductance (L) $= \frac{X_L}{2\pi f}$

Inductive Reactance $(X_L) = 2\pi fL$

Capitance Reactance $(X_C) = \frac{1}{2\pi fC}$

Time Constants (t) = RC; $(t) = \frac{L}{R}$

Resonant Circuits: $X_L = X_C$

$$f_O = \frac{1}{2\pi\sqrt{LC}}$$

Charge (Q) = CE = It
Q total (series) $= Q_1 = Q_2 = Q_n$
Q total (parallel) $= Q_1 + Q_2 + Q_n$

Figure of Merit (Q) $= \frac{X_L}{R}$ or $\frac{X_C}{R}$



## KINEMATICS/ACCELERATION

**I. Terms:**
a = acceleration
g = 32.17 ft/sec²
s = distance covered in t sec.
t = time
v = velocity after t sec.
$v_O$ = initial velocity

**II. Linear Motion (uniform):**

s = vt

**III. Linear Motion** $(v_O>0)$: $s = \frac{t}{2}(v_O + v) = v_Ot \pm \frac{1}{2}at^2$
(accelerated, +) (retarded, −)

**IV. Projection:**

$v = v_O \pm gt$ (downward, +; upward, −)

$s = v_Ot \pm \frac{1}{2}gt^2$ (downward, +; upward, −)

$s = \frac{vt}{2}$ where $v_O = 0$

$t = \frac{2s}{v_O + v}$

$t = \frac{\sqrt{25}}{g}$ where $v_O = 0$

**V. Sliding motion on incline** (excluding friction):

$v = \sqrt{2gs}$

## DYNAMICS

**I. Terms:**

| | | | |
|---|---|---|---|
| a | = acceleration | v | = tangential velocity |
| F | = force | w | = energy |
| G | = weight | $w_k$ | = kinetic energy |
| g | = gravity | $w_p$ | = *potential energy* |
| h | = height | p | = performance |
| m | = mass | $\omega$ | = angular velocity |
| Fa | = accelerated force | r | = radius |
| s | = distance | n | = revs. per. min. |
| t | = time | | |

**II. Linear Motion:**

Fa = ma
w = Fs
$w_k = \frac{1}{2}mv^2$
P = w/t
$W_p$ = Gh

**III. Calculation of Mass:** m = G/g

**IV. Centrifugal Force:** $(F_z)$

$$F_z = m\omega^2 r = \frac{mv^2}{r}$$

$$v = \omega r$$

## HYDRAULICS

**I. Specific weight** $\gamma$ = G/V (G = weight, V = volume)

**II. Density** Q = m/V = $\gamma$/g (m = mass; g = gravity)

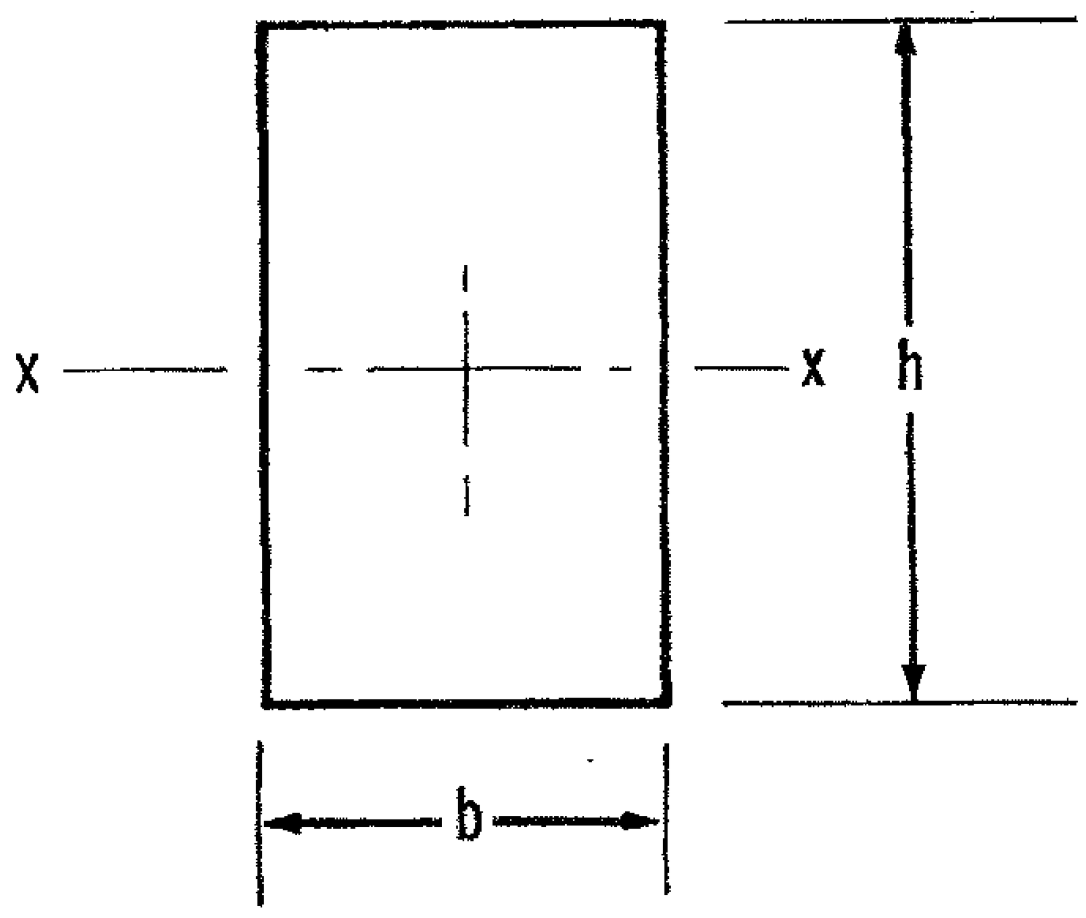
**III. Buoyancy** $F_a = \gamma V$

### Definition of Symbols

L = Length
M = Bending moment
F = Concentrated load
f = Deflection
E = Tensile modulus
I = Moment of inertia

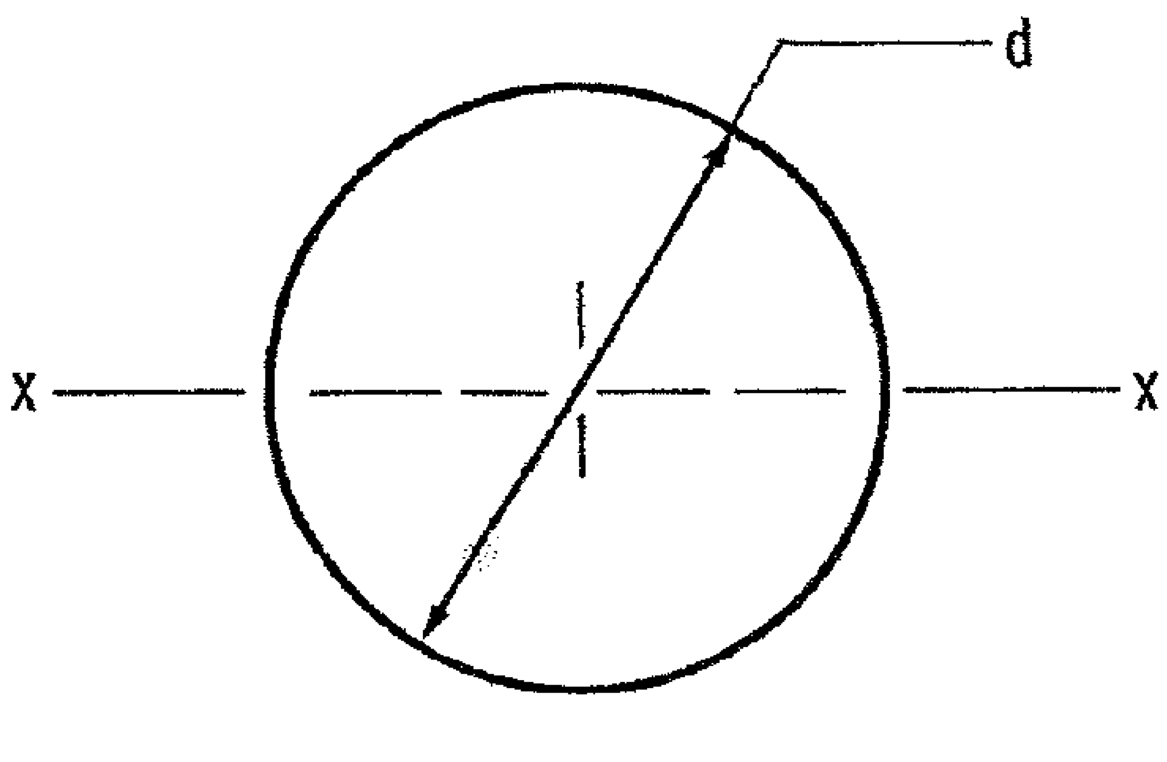
## MOMENT OF INERTIA OF SECTIONS

### Rectangle




$$I_{x-x} = \frac{bh^3}{12}$$

### Circle

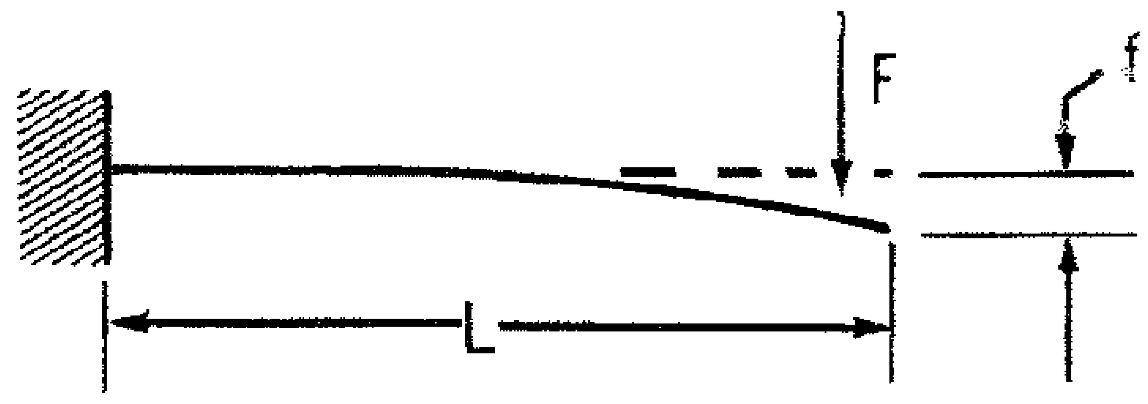



$$I_{x-x} = \frac{\pi d^4}{64}$$



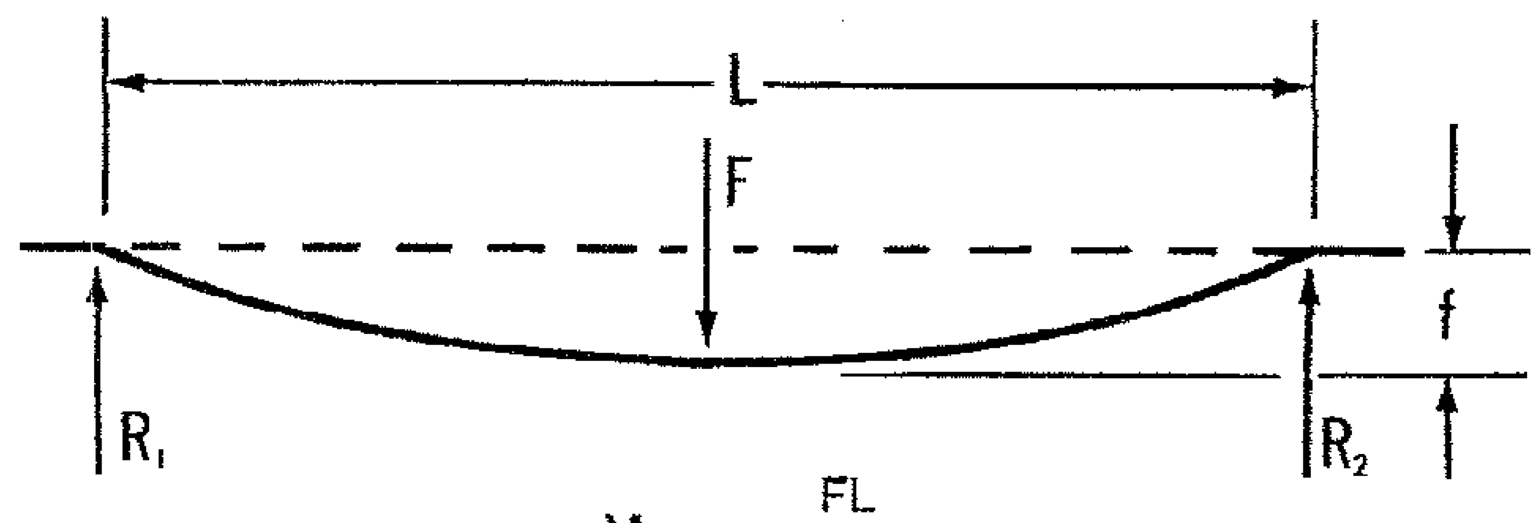
## BENDING MOMENTS AND DEFLECTIONS OF UNIFORM BEAMS

### 1. Cantilever Beam with End Load



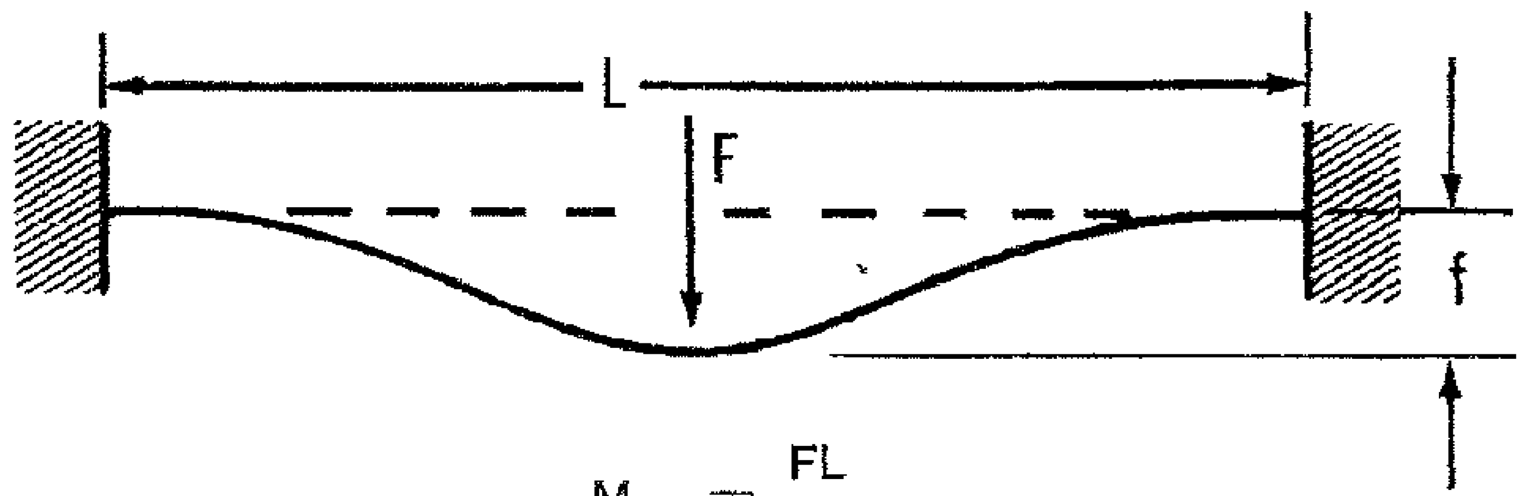

$$M_{max} = FL$$
$$f_{max} = \frac{FL^3}{3EI}$$

### 2. Simple Beam, Load at Center




$$M_{max} = \frac{FL}{4}$$
$$f_{max} = \frac{FL^3}{48EI}$$

### 3. Fixed-End Beam, Load at Center



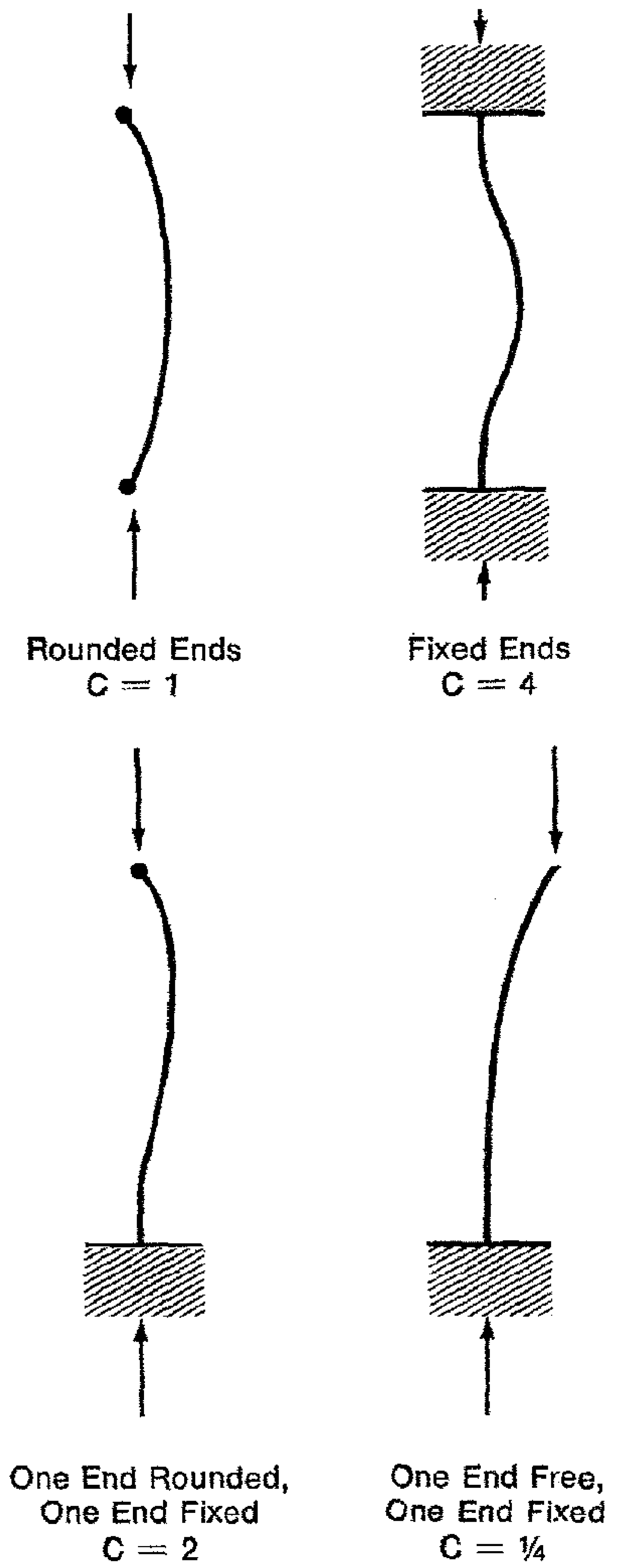

$$M_{max} = \frac{FL}{8}$$
$$f_{max} = \frac{FL^3}{192EI}$$

## CRITICAL COLUMN LOADS

**Definition of Symbols**

$F_c$ = Critical load at which buckling occurs
E = Tensile modulus
A = Cross-section area
L = Length
I = Moment of inertia
k = $\sqrt{I/A}$

$$\text{Euler's Formula: } F_c = \frac{C\pi^2 EA}{(L/k)^2}$$

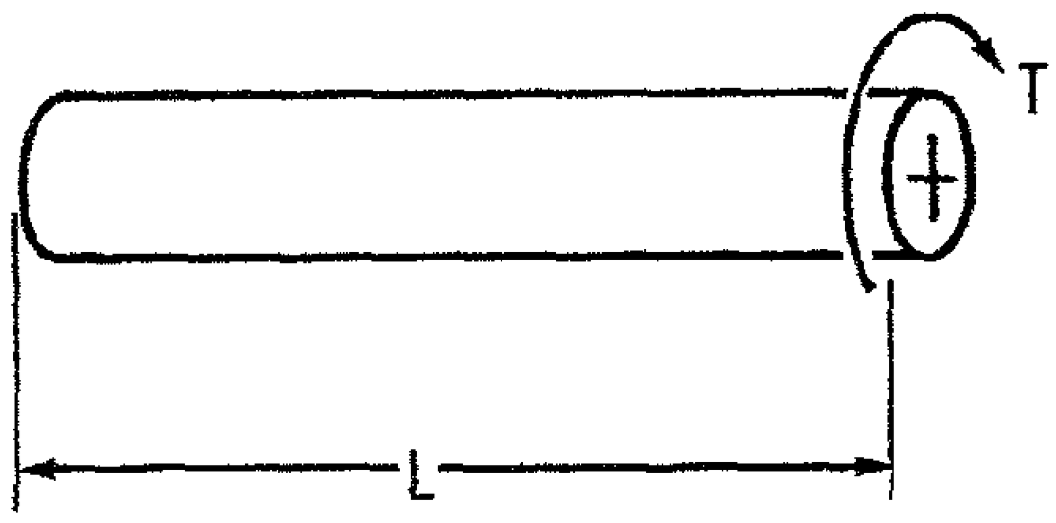





## TORSIONAL DEFLECTIONS OF SHAFTS

**Definition of Symbols**

T = Torque
J = Polar moment of inertia
G = Shear modulus



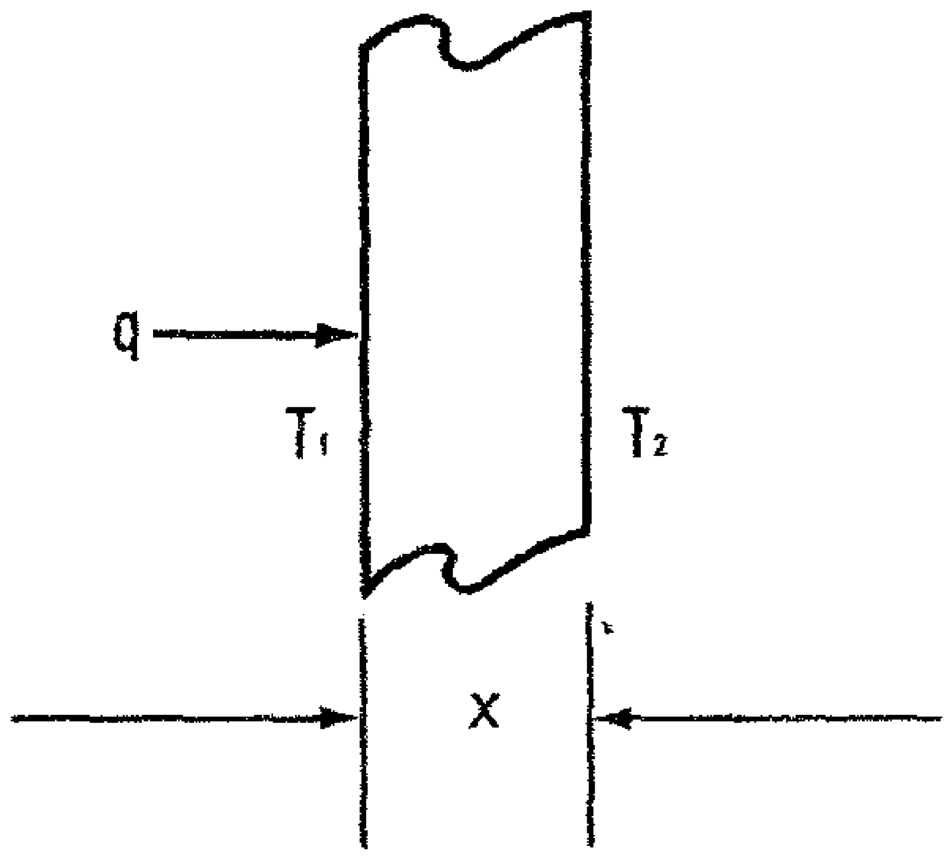

$$\theta = \frac{TL}{JG}\text{ Radians}$$

## HEAT TRANSFER

**Definition of Symbols**

k = Thermal conductivity of material BTU/Ft.²/hr./°F/ft.
A = *Surface area* Ft.²
$T_1$ = Temperature on one side of wall °F
$T_2$ = Temperature on other side of wall °F
q = BTU/Hr.

**Steady-state conduction through a homogeneous plane wall**




$$q = kA\,\frac{T_1 - T_2}{x}$$

## SAMPLE CALCULATIONS USING THE 411

### ALGEBRA

1. Determine: ¾ • ⅔

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 3 | × | 3. |
| 2 | ÷ | 6. |
| 4 | ÷ | 1.5 |
| 3 | = | 0.5 |

2. Determine: $[(17 + 9)6]^{.5} = \sqrt{(17 + 9)6}$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 17 | + | 17. |
| 9 | × | 26. |
| 6 | $\sqrt{x}$ | 12.49 |

### GEOMETRY

1. Determine area of triangle with sides a = 2.5, b = 3, c = 4 where term $s = \frac{a + b + c}{2}$

$A = \sqrt{s\ (s\text{-}a)\ (s\text{-}b)\ (s\text{-}c)}$

| Enter | Press | Display | Note |
|---|---|---|---|
| | C, C | | |
| 2.5 | + | 2.5 | |
| 3 | + | 5.5 | |
| 4 | ÷ | 9.5 | = sum of sides |
| 2 | −, MS | 4.75 | s, solved, in memory |
| 2.5 | X | 2.25 | = (s-a) |
| | MR, = | 10.6875 | = [s(s-a)] |
| | EX, − | 4.75 | Brings up s |
| 3 | X | 1.75 | = (s-b) |
| | EX, = | 18.7031 | = [s(s-a) (s-b)] |
| | EX, + | 1.75 | Brings up (s−b) |
| 3 | − | 4.75 | s restored by adding b |
| 4 | X | 0.75 | (s-c) |
| | MR, $\sqrt{x}$ | 3.74531 | $\sqrt{x}$ has simultaneously completed multiplication by 18.7031, obtaining internal (not displayed) result of 14.0273, and determined the square root |

2. Determine area of a circle with a 4.5" radius where $a = \pi r^2$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 4.5 | X, = | 20.25 |
| | X | |
| $\pi$ | = | 63.6173 |



### TRIGONOMETRY

1. Determine the hypotenuse (c) of a right triangle with side a = 3, b = 4
From geometry:
$c = \sqrt{a^2 + b^2}$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 3 | X, =, MS | 9. |
| 4 | X, =, + | 16. |
| | MR, $\sqrt{x}$ | 5. |

2. Determine sine of the angle formed by a and c above:
$\sin\theta = \frac{b}{c}$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 4 | ÷ | 4. |
| 5 | = | 0.8 |

3. Convert 36° to radians where 1 radian $= \frac{180°}{\pi}$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 36 | X | 36. |
| 180 | ÷ | 6480. |
| $\pi$ | = | 2062.65 |

### ELECTRICAL

1. Determine total resistance ($R_t$) of $R_1 = 390\Omega$ in parallel with $R_2 = 570\Omega$ where:
$R_t = \frac{R_1 R_2}{R_1 + R_2}$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 390 | + | 390. |
| 570 | 1/$x$, X | 0.00104 |
| 390 | X | 0.40625 |
| 570 | = | 231.563 |

2. Determine capacitive reactance ($X_C$) of a 750 kHz (f) circuit with .01$\mu$F capacitance (C) where:
$X_C = \frac{1}{2\pi fC}$

| Enter | Press | Display | |
|---|---|---|---|
| | C, C | | |
| 2 | X | 2. | |
| $\pi$ | X | 6.28319 | |
| 750 | EE | 750 | 00 |
| 3 | | 750 | 03 |
| | X | 4.71239 | 06 |
| .01 | EE | 0.01 | 00 |
| | − | 0.01 | −00 |
| 6 | | 0.01 | −06 |
| | 1/$x$ | 2.12207 | 01 (= 21Ω) |

3. Determine resonant frequency ($f_o$) of a .033 mH inductor (L) and a 47$\mu$F capacitor (C) where:

$$f_o = \frac{1}{2\pi\sqrt{LC}}$$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| .033 | EE, − | 0.033 −00 |
| 3 | | 0.033 −03 |
| | X | 3.3 −05 |
| 47 | EE, − | 47 −00 |
| 6 | | 47 −06 |
| | $\sqrt{x}$ | 3.93827 −05 |
| | X | 3.93827 −05 |
| $\pi$ | X | 1.23724 −04 |
| 2 | $1/x$ | 4.04124 03 (= 4kHz) |

## KINEMATICS

Use of Quadratic Equation

An object dropped from 5000′ is given an initial velocity of 20′/sec. Determine time to reach the ground where:

$s = \frac{1}{2}gt^2 + v_ot$
$s$ = distance = 5000′
$g$ = gravity 32.2 ft/sec²
$v_o$ = initial velocity = 20 ft/sec.

then,
$5000 = 16.1\,t^2 + 20t$, and
$16.1t^2 + 20 - 5000 = 0$

Quadratic Equation:
$ax^2 + bx + c = 0$; then

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

where $a = 16.1$
$b = 20$
$c = -5000$

$$t = \frac{-20 \pm \sqrt{20^2 - 4(16.1)(-5000)}}{2(16.1)} = 17.0125 \text{ seconds}$$

Proof: $5000 = 16.1(17.0125)^2 + 20(17.0125)$

| Enter | Press | Display |
|---|---|---|
| | C, C | |
| 4 | X | 4. |
| 16.1 | X, − | 64.4 |
| 5000 | =, MS | −322000. |
| 20 | X, =, −, | 400 |
| | MR, $\sqrt{x}$, MS, − | 567.803 |
| 20 | ÷ | 547.803 |
| 2 | ÷ | 273.902 |
| 16.1 | = | 17.0125 |
| | (solving negative root) | |
| | C, − | |
| | MR, − | −567.803 |
| 20 | ÷ | −587.803 |
| 2 | ÷ | −293.902 |
| 16.1 | = | −18.2548 |



## TABLES

**I Trigonometry**

Natural functions of angles

| Deg. | Sine | Cosine | Tangent | Cotangent | Deg. |
|---|---|---|---|---|---|
| 0 | 0.0000 | 1.0000 | 0.0000 | ∞ | 90 |
| 1 | 0.0175 | 0.9998 | 0.0175 | 57.2900 | 89 |
| 2 | 0.0349 | 0.9994 | 0.0349 | 28.6363 | 88 |
| 3 | 0.0523 | 0.9986 | 0.0524 | 19.0811 | 87 |
| 4 | 0.0698 | 0.9976 | 0.0699 | 14.3007 | 86 |
| 5 | 0.0872 | 0.9962 | 0.0875 | 11.4301 | 85 |
| 6 | 0.1045 | 0.9945 | 0.1051 | 9.5144 | 84 |
| 7 | 0.1219 | 0.9925 | 0.1228 | 8.1443 | 83 |
| 8 | 0.1392 | 0.9903 | 0.1405 | 7.1154 | 82 |
| 9 | 0.1564 | 0.9877 | 0.1584 | 6.3138 | 81 |
| 10 | 0.1736 | 0.9848 | 0.1763 | 5.6713 | 80 |
| 11 | 0.1908 | 0.9816 | 0.1944 | 5.1446 | 79 |
| 12 | 0.2079 | 0.9781 | 0.2126 | 4.7046 | 78 |
| 13 | 0.2250 | 0.9744 | 0.2309 | 4.3315 | 77 |
| 14 | 0.2419 | 0.9703 | 0.2493 | 4.0108 | 76 |
| 15 | 0.2588 | 0.9659 | 0.2679 | 3.7321 | 75 |
| 16 | 0.2756 | 0.9613 | 0.2867 | 3.4874 | 74 |
| 17 | 0.2924 | 0.9563 | 0.3057 | 3.2709 | 73 |
| 18 | 0.3090 | 0.9511 | 0.3249 | 3.0777 | 72 |
| 19 | 0.3256 | 0.9455 | 0.3443 | 2.9042 | 71 |
| 20 | 0.3420 | 0.9397 | 0.3640 | 2.7475 | 70 |
| 21 | 0.3584 | 0.9336 | 0.3839 | 2.6051 | 69 |
| 22 | 0.3746 | 0.9272 | 0.4040 | 2.4751 | 68 |
| 23 | 0.3907 | 0.9205 | 0.4245 | 2.3559 | 67 |
| 24 | 0.4067 | 0.9135 | 0.4452 | 2.2460 | 66 |
| 25 | 0.4226 | 0.9063 | 0.4663 | 2.1445 | 65 |
| 26 | 0.4384 | 0.8988 | 0.4877 | 2.0503 | 64 |
| 27 | 0.4540 | 0.8910 | 0.5095 | 1.9626 | 63 |
| 28 | 0.4695 | 0.8829 | 0.5317 | 1.8807 | 62 |
| 29 | 0.4848 | 0.8746 | 0.5543 | 1.8040 | 61 |
| 30 | 0.5000 | 0.8660 | 0.5774 | 1.7321 | 60 |
| 31 | 0.5150 | 0.8572 | 0.6009 | 1.6643 | 59 |
| 32 | 0.5299 | 0.8480 | 0.6249 | 1.6003 | 58 |
| 33 | 0.5446 | 0.8387 | 0.6494 | 1.5399 | 57 |
| 34 | 0.5592 | 0.8290 | 0.6745 | 1.4826 | 56 |
| 35 | 0.5736 | 0.8192 | 0.7002 | 1.4281 | 55 |
| 36 | 0.5878 | 0.8090 | 0.7265 | 1.3764 | 54 |
| 37 | 0.6018 | 0.7986 | 0.7536 | 1.3270 | 53 |
| 38 | 0.6157 | 0.7880 | 0.7813 | 1.2799 | 52 |
| 39 | 0.6293 | 0.7771 | 0.8098 | 1.2349 | 51 |
| 40 | 0.6428 | 0.7660 | 0.8391 | 1.1918 | 50 |
| 41 | 0.6561 | 0.7547 | 0.8693 | 1.1504 | 49 |
| 42 | 0.6691 | 0.7431 | 0.9004 | 1.1106 | 48 |
| 43 | 0.6820 | 0.7314 | 0.9325 | 1.0724 | 47 |
| 44 | 0.6947 | 0.7193 | 0.9657 | 1.0355 | 46 |
| 45 | 0.7071 | 0.7071 | 1.0000 | 1.0000 | 45 |
| Deg. | Cosine | Sine | Cotangent | Tangent | Deg. |

## II Logarithms

Three-Place Common Log Table

| Log X | .0 | .1 | .2 | .3 | .4 | .5 | .6 | .7 | .8 | .9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .000 | .041 | .079 | .114 | .146 | .176 | .204 | .230 | .255 | .279 |
| 2 | .301 | .322 | .342 | .362 | .380 | .398 | .415 | .431 | .447 | .462 |
| 3 | .477 | .491 | .505 | .519 | .531 | .544 | .556 | .568 | .580 | .591 |
| 4 | .602 | .613 | .623 | .633 | .643 | .653 | .663 | .672 | .681 | .690 |
| 5 | .699 | .708 | .716 | .724 | .732 | .740 | .748 | .756 | .763 | .771 |
| 6 | .778 | .785 | .792 | .799 | .806 | .813 | .820 | .826 | .833 | .839 |
| 7 | .845 | .851 | .857 | .863 | .869 | .875 | .881 | .886 | .892 | .898 |
| 8 | .903 | .908 | .914 | .919 | .924 | .929 | .934 | .939 | .944 | .949 |
| 9 | .954 | .959 | .964 | .968 | .973 | .978 | .982 | .987 | .991 | .996 |

Explanation of Table: Whole numbers are listed in left-hand vertical column with tenths of numbers in top heading, e.g., log 2.5 is derived by finding whole number 2 in left column, then moving laterally under .5 heading so that log 2.5 = .398.

Since $1 = 10^0$ and $10 = 10^1$, then any number between 1 and 10 may be expressed as a power of ten whose exponent is between 0 and 1 (or fractional); as is the case with log 2.5 = .398, then $2.5 = 10^{.398}$.

With this in mind any number may be derived from the table:

(1) log 25 is broken down to powers of ten or
log 25 = log 2.5 × log 10, then
log 2.5 = .398 and log 10 = 1.000, so
$25 = 10^{.398} \times 10^{1} = 10^{.398+1} = 10^{1.398}$

(2) log 250 = log 2.5 × log 100 = log 2.5 × log 10 × log 10 = $10^{.398+1+1} = 10^{2.398}$

(3) log .25 = log 2.5 × $10^{-1} = 10^{.398-1} = 10^{-.602}$

(4) log X = 3.881
$X = 10^{3.881}$
$X = 10^{3} \times 10^{.881}$
$X = 1000 \times 7.6$
$X = 7600$



## CONVERSION TABLES

In the following tables, first look up either of the units to be converted in the left-hand column (alphabetical order). Note that the top headings indicate conversion left to right by multiplying the lefthand unit by the factor. The bottom headings convert right to left by dividing the righthand unit by the factor. Example: 35 HP = X Watts; then, 35 HP x 746 (factor) = 26,110 Watts.

### METRIC CONVERSIONS

| To Convert | Multiply By | To Obtain |
|---|---|---|
| Acres | 4047 | Sq. meters |
| Acres | 160 | Rods |
| Ares | 100 | Sq. meters |
| Centimeter | .3937 | Inches |
| Cm./sec. | 1.969 | Feet/min. |
| Cubic feet | 28.32 | Liters |
| Cubic inches | .01639 | Liters |
| Cubic meters | 1,000 | Liters |
| Drams | 1.7718 | Grams |
| Fathoms | 1.8288 | Meters |
| Feet | 30.48 | Cm. |
| Furlongs | .125 | Miles |
| Gallons | 3.785 | Liters |
| Gallons (Imp.) | 1.20095 | Gal. (U.S.) |
| Grams | .03527 | Oz. |
| Grams | .03215 | Oz. (troy) |
| Hectares | 2.471 | Acres |
| Inches | 2.54 | Cm. |
| Kilometer | .6214 | Miles (st.) |
| Knots | 1.8532 | Kilometer/hr. |
| League | 3.0 | Miles |
| Quarts (liq.) | 946.4 | Cu. cms. |
| Rods | 5.029 | Meters |
| Rods | 16.5 | Feet |
| Sq. inches | 6.452 | Sq. cms. |
| Tons (metric) | 2205 | Pounds |
| **To Obtain** | **Divide By** | **To Convert** |

### Orders of Magnitude

| Prefix | | | Abbreviation |
|---|---|---|---|
| Pico | = | $10^{-12}$ | p |
| Nano | = | $10^{-9}$ | n |
| Micro | = | $10^{-6}$ | $\mu$ |
| Milli | = | $10^{-3}$ | m |
| Centi | = | $10^{-2}$ | c |
| Deci | = | $10^{-1}$ | d |
| Deka | = | 10 | da |
| Hecto | = | $10^{2}$ | h |
| Kilo | = | $10^{3}$ | k |
| Mega | = | $10^{6}$ | M |

Therefore, a centimeter is one-hundredth of a meter, etc.

## ELECTRO-MECHANICAL CONVERSIONS

| To Convert | Multiply By | To Obtain |
|---|---|---|
| Atmosphere | 14.7 | Pounds/Sq. In |
| Ampere-hours | 3,600 | Coulombs |
| Ampere-turns | 2.257 | Gilberts |
| BTU | $2.930 \times 10^{-4}$ | Kilowatt-hours |
| Centimeters | 393.7 | Mils |
| Candle/sq. cm. | 3.1416 | Lamberts |
| Degrees | 60 | Minutes |
| Dynes | $1.020 \times 10^{-3}$ | Grams |
| Dynes | $1.0 \times 10^{-7}$ | Joules/cm. |
| Ergs | $7.376 \times 10^{-8}$ | Foot-pounds |
| Ergs/sec. | $1.0 \times 10^{-10}$ | Kilowatts |
| Horsepower | $3.3 \times 10^{4}$ | Foot-pounds/min. Ft.-pounds/min. |
| Horsepower | 550 | Foot-pounds/sec. |
| Horsepower | 745.7 | Watts |
| Horsepower | 42.44 | Btu/min. |
| Horsepower (metric) | .9863 | Horsepower |
| Inches | 2.54 | Centimeters |
| Inches | $10 \times 10^{-3}$ | Mils |
| Joule | .7376 | Foot-pounds |
| Kilohertz | $1.0 \times 10^{3}$ | Hz |
| Kilowatts | 1.341 | Horsepower |
| Kilowatt-hours | $3.6 \times 10^{6}$ | Joules |
| Radians | $5.7296 \times 10^{1}$ | Degrees |
| Revolutions | 6.283 | Radians |
| Sq. Centimeters | $1.973 \times 10^{5}$ | Circular mils |
| Sq. Inches | $1.273 \times 10^{6}$ | Circular mils |
| Sq. Inches | 6.452 | Sq. centimeters |
| Sq. mils | 1.273 | Circular mils |
| Watt hours | $3.6 \times 10^{3}$ | Joules |
| **To Obtain** | **Divide By** | **To Convert** |

## TEMPERATURE CONVERSION

1. Degrees Fahrenheit = F°
2. Degrees Celcius (Centigrade) = C°
3. $\frac{F^\circ - 32}{180} = \frac{C^\circ}{100}$

(a) To convert F° to C°: $C^\circ = \frac{5}{9}(F^\circ - 32)$

(b) To convert C° to F°: $F^\circ = \frac{9}{5}(C^\circ) + 32$

4. Degrees Kelvin = K°
   $K^\circ = C^\circ + 273$



## AMERICAN CONVERSIONS

| To Convert | Multiply By | To Obtain |
|---|---|---|
| Angstrom | $3.937 \times 10^{-9}$ | Inches |
| Acres | 43,560 | Sq. feet |
| Acres | .00156 | Sq. miles |
| Acre feet | 325,900 | Gallons |
| Barrels (dry) | 3.281 | Bushels |
| Barrels (liquid) | 31.5 | Gallons |
| Bushels | 4 | Pecks |
| Cubic feet | 1728 | Cu. inches |
| Cubic feet | 7.48052 | Gallons (liq.) |
| Fathoms | 6 | Feet |
| Gallons | .1337 | Cu. feet |
| Knots | 1.0 | Naut. mi/hr |
| Knots | 1.151 | St. mi/hr |
| Light year | $5.88 \times 10^{12}$ | Miles |
| Miles (naut.) | 6,076 | Feet |
| Miles (naut.) | 1.1508 | Miles (st.) |
| Miles (st.) | 5280 | Feet |
| Pounds | 16 | Ounces |
| Pounds/sq. in. | 2.309 | Feet of water |
| Pounds/sq. in. | 144 | Pounds/sq. ft. |
| Tons (long) | 2,240 | Pounds |
| Tons (short) | 2,000 | Pounds |
| **To Obtain** | **Divide By** | **To Convert** |

## USEFUL CONSTANTS & DATA

c = speed of light = $2.907925 \times 10^{8}$ m/sec

Sound velocity: air 20°C, 1 atm: 34400 cm/sec = 1129 ft/sec = 769.5 mph

e = base, natural logs = 2.71828

$\gamma$ = Euler's constant = 0.57721

Ln x = 2.30259 Log x

1 electron = $1.60218 \times 10^{-19}$ coul

f = Faraday constant = $9.64870 \times 10^{4}$ C/mol

g = gravity = 980.7 cm/sec = 32.17 ft/sec²

h = Planck constant = $6.624 \times 10^{-27}$ erg sec

N = Avogadro no. = $6.02262 \times 10^{23}$/mol$^{-1}$

$\sigma$ = Stefan-Boltzmann constant: $0.56687 \times 10^{-4}$ ergs cm$^{-2}$ deg$^{-4}$ sec$^{-1}$

## NOTES:

## SERVICE CERTIFICATE

*Your electronic calculator is a precision electronic instrument which will serve you for many years with normal care.*

CORVUS CORPORATION guarantees this calculator against defects in materials or workmanship for a period of one year from date of purchase. This guarantee applies only to the original owner registered on the attached card which must be completed and mailed, postage paid, within ten (10) days from date of purchase. *Any unit that has been repaired by an unauthorized party, tampered with, or abused is not covered under this warranty.*

IN-WARRANTY SERVICE. Unit requiring repair should be returned, postage prepaid and fully insured, to the Corvus Service Center, listed below.

OUT-OF-WARRANTY SERVICE. When out of warranty, Corvus will repair the unit for a *minimum* service charge of Nine Dollars ($9.00). Owner will be notified of additional charges, if any. Unit should be returned, prepaid and insured, with check or money order for $9.00 to the Corvus Service Center.

*Unit should be returned in the original or a similarly* constructed packaging container, via U.P.S. where possible. Receipt will be acknowledged. Enclose a letter explaining the problem, with place and date of purchase.

**Corvus Service Center**

**13030 Branchview Lane**

**Dallas, Texas 75234**

MODEL NO.____________________

DATE OF PURCHASE____________________

DEALER'S NAME____________________

SERIAL NO.____________________