
HEWLETT hp PACKARD
FJ
HEWLETT hp PACKARD
FRITZ JÖRN
CM

ENERGY

from \ to	Btu	cal	kgf m	ft lbf	joule	hp hr	kw hr
Btu	1	252.0	107.6	778.0	1055	3.93×10^{-4}	2.93×10^{-4}
cal	0.00397	1	0.4268	3.087	4.186	1.56×10^{-6}	1.16×10^{-6}
kgf m	0.00930	2.343	1	7.233	9.807	3.65×10^{-6}	2.72×10^{-6}
ft lbf	0.00129	0.3239	0.1383	1	1.356	5.05×10^{-7}	3.77×10^{-7}
joule	9.48×10^{-4}	0.2389	0.1020	0.7376	1	3.73×10^{-7}	2.78×10^{-7}
hp hr	2545	6.41×10^{5}	2.74×10^{5}	1.98×10^{6}	2.68×10^{6}	1	0.7457
kw hr	3413	8.60×10^{5}	3.67×10^{5}	2.66×10^{6}	3.60×10^{6}	1.341	1

1 erg = 1 dyne cm = 10^{-7} joule; 1 electron volt = 1 ev = 1.602×10^{-19} joule;
1 joule = 1 newton m = 1 kg mass m²/sec²

POWER

from \ to	watt	hp	Btu/min	ft lbf/sec	ft lbf/min
watt	1	0.00134	0.05688	0.7376	44.25
hp	745.7	1	42.42	550	3.30×10^{4}
Btu/min	17.58	0.02358	1	12.97	778.0
ft lbf/sec	1.356	0.00182	0.07712	1	60
ft lbf/min	0.02260	3.03×10^{-5}	0.00129	0.01667	1

1 watt = 1 joule/sec; 1 kw = 1000 watts
P = EI cos θ; cos θ = power factor
db = 10 $\log_{10}(P_1/P_2)$ = 20 $\log_{10}(V_1/V_2)$ = 20 $\log_{10}(I_1/I_2)$

GREEK ALPHABET

Α α	alpha	Η η	eta	Ν ν	nu	Τ τ	tau
Β β	beta	Θ θ	theta	Ξ ξ	xi	Υ υ	upsilon
Γ γ	gamma	Ι ι	iota	Ο ο	omicron	Φ φ	phi
Δ δ	delta	Κ κ	kappa	Π π	pi	Χ χ	chi
Ε ε	epsilon	Λ λ	lambda	Ρ ρ	rho	Ψ ψ	psi
Ζ ζ	zeta	Μ μ	mu	Σ σ	sigma	Ω ω	omega

VELOCITY

from \ to	cm/sec	km/hr	in/sec	ft/sec	ft/min	mph
cm/sec	1	0.03600	0.3937	0.03281	1.968	0.02237
km/hr	27.78	1	10.94	0.9113	54.68	0.6214
in/sec	2.540	0.09143	1	0.08333	5	0.05682
ft/sec	30.48	1.097	12	1	60	0.6818
ft/min	0.5080	0.01829	0.2000	0.01667	1	0.01136
mph	44.70	1.609	17.60	1.467	88	1

1 knot = 1 nautical mile/hr = 1.852 km/hr = 1.151 mph

FORCE, F = ma/g_c

F	m	g_c, conversion factor
nt.	kg	1 kg m/newton sec²
dyne	g	1 g cm/dyne sec²
lbf	slug	1 slug ft/lbf sec²
lbf	lbm	32.17 lbm ft/lbf sec²
gf	g	980.7 g cm/gf sec²

a = m/sec², cm/sec² or ft/sec²
1 dyne = 1 g mass cm/sec²;
1 newton = 1 kg mass m/sec² = 1 × 10⁵ dynes = 0.2248 lb force;
1 lb force = 1 slug ft/sec²

MASS

from \ to	g	kg	oz	lbm
g	1	0.001	0.03527	0.00220
kg	1000	1	35.27	2.205
oz	28.35	0.02835	1	0.0625
lbm	453.6	0.4536	16	1

1 slug = 32.17 lbm = 14.59 kg;
1 gram = 15.43 grains; 1 lbm = 7000 grains;
1 ton = 2000 lbm; 1 metric ton = 1000 kg
Density: 1 g/cm³ = 62.43 lbm/ft³;
1 lbm/ft³ = 0.1337 lbm/gal

VOLUME

from \ to	cm³	liter	in³	ft³	fl qt	gal
cm³	1	0.001	0.06102	3.53×10^{-5}	0.00106	2.64×10^{-4}
liter	1000	1	61.02	0.03532	1.057	0.2642
in³	16.39	0.01639	1	5.79×10^{-4}	0.01732	0.00433
ft³	2.83×10^{4}	28.32	1728	1	29.92	7.481
fl qt	946.4	0.9463	57.75	0.03342	1	0.2500
gal	3785	3.785	231.0	0.1337	4	1

1 fl qt = 2 fl pt = 32 fl oz; 1 gal (Br.) = 1.201 gal; 1 cord = 128 ft³ = 3625 liters;
1 m³ = 1000 liters = 35.31 ft³ = 1057 fl qt = 264.2 gal

AREA

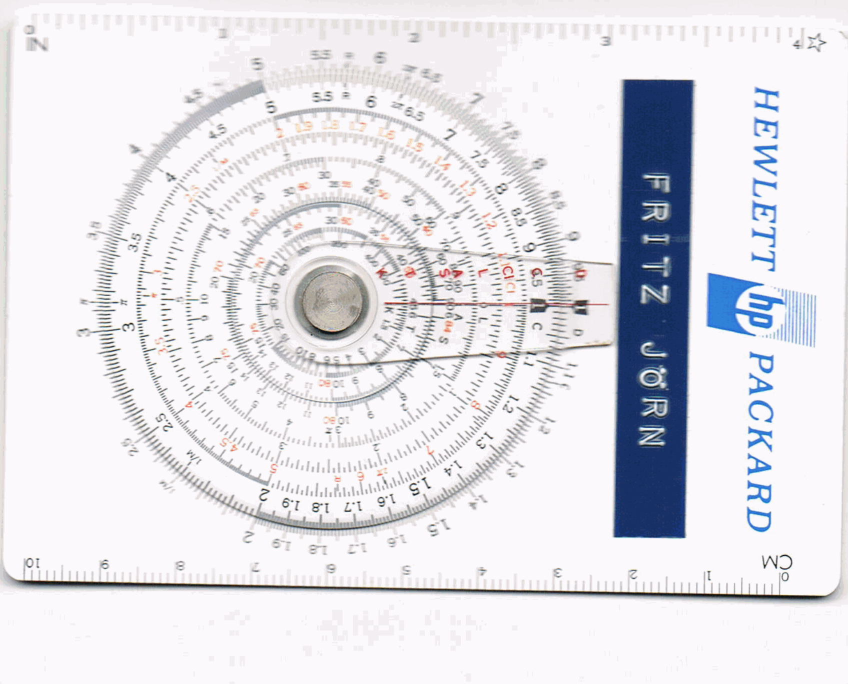
from \ to	cm²	m²	km²	in²	ft²	mile²
cm²	1	0.0001	1×10^{-10}	0.1550	0.00108	3.86×10^{-11}
m²	1×10^{4}	1	1×10^{-6}	1550	10.76	3.86×10^{-7}
km²	1×10^{10}	1×10^{6}	1	1.55×10^{9}	1.08×10^{7}	0.3861
in²	6.452	6.45×10^{-4}	6.45×10^{-10}	1	0.00694	2.49×10^{-10}
ft²	929.0	0.09290	9.29×10^{-8}	144	1	3.59×10^{-8}
mile²	2.59×10^{10}	2.59×10^{6}	2.590	4.01×10^{9}	2.79×10^{7}	1

1 cir mil = 0.7854 mil² = 7.85×10^{-7} in² = 5.067×10^{-6} cm²;
1 acre = 4047 m² = 43560 ft² = 0.00156 mile²

LENGTH

from \ to	cm	m	km	in	ft	mile
cm	1	0.01	1×10^{-5}	0.3937	0.03281	6.21×10^{-6}
m	100	1	0.001	39.37	3.281	6.21×10^{-4}
km	1×10^{5}	1000	1	3.94×10^{4}	3281	0.6214
in	2.54	0.0254	2.54×10^{-5}	1	0.08333	1.58×10^{-5}
ft	30.48	0.3048	3.05×10^{-4}	12	1	1.89×10^{-4}
mile	1.61×10^{5}	1609	1.609	6.34×10^{4}	5280	1

1 Angstrom = 1 Å = 1×10^{-8} cm; 1 micron = 1 μm = 1×10^{-6} m; 1 mil = 0.001 in;
1 m = 1.094 yd; 1 mile = 1760 yd; 1 nautical mile = 1.852 km = 6076 ft = 1.151 miles



UNIT CONVERSIONS

quantity	symbol	dimensions	mks (r) units	mks (nr)	cgs	esu	emu
				equivalent number of units			
capacitance	C	$C=q/V$	farad	1	1	9×10^{11}	10^{-9}
charge	q	q	coulomb	1	1	3×10^{9}	10^{-1}
conductivity	σ	$\sigma=1/\rho$	mho/m	1	10^{-2}	9×10^{9}	10^{-11}
current	I	$I=q/t$	ampere	1	1	3×10^{9}	10^{-1}
current density	J	$J=I/A$	amp/m²	1	10^{-4}	3×10^{5}	10^{-5}
e dipole moment	p	$p=ql$	coul-m	1	10^{2}	3×10^{11}	10
m dipole moment	m	$m=ml$	weber-m	$1/4\pi$	$10^{10}/4\pi$	$1/12\pi$	$10^{10}/4\pi$
displacement	D	$D=\epsilon E$	coul/m²	4π	$4\pi\times10^{-4}$	$12\pi\times10^{5}$	$4\pi\times10^{-5}$
electric field	E	$E=F/q$	volt/m	1	10^{-2}	$10^{-4}/3$	10^{6}
emf, potential	V	$V=El$	volt	1	1	$10^{-2}/3$	10^{8}
flux density	B	$B=\mu H$	weber/m²	1	10^{4}	$10^{-6}/3$	10^{4}
inductance	L	$L=\Phi/I$	henry	1	1	$10^{-11}/9$	10^{9}
magnetic field	H	$H=nI/l$	amp-turn/m	4π	$4\pi\times10^{-3}$	$12\pi\times10^{7}$	$4\pi\times10^{-3}$
magnetic flux	Φ	$\Phi=BA$	weber	1	10^{8}	$10^{-2}/3$	10^{8}
magnetization	M	$M=ml/v$	weber/m²	$1/4\pi$	$10^{4}/4\pi$	$10^{-6}/12\pi$	$10^{4}/4\pi$
mmf, potential	$\mathfrak{F}$	$\mathfrak{F}=Hl$	amp-turn	4π	$4\pi\times10^{-1}$	$12\pi\times10^{9}$	$4\pi\times10^{-1}$
permeability	μ	$F=m^2/4\pi\mu l^2$	henry/m	$1/4\pi$	$10^{7}/4\pi$	$10^{-13}/36\pi$	$10^{7}/4\pi$
permittivity	ϵ	$F=q^2/4\pi\epsilon l^2$	farad/m	4π	$4\pi\times10^{-9}$	$36\pi\times10^{9}$	$4\pi\times10^{-11}$
polarization	P	$P=p/v$	coul/m²	1	10^{-4}	3×10^{5}	10^{-5}
pole strength	m	m	weber	$1/4\pi$	$10^{8}/4\pi$	$10^{-2}/12\pi$	$10^{8}/4\pi$
reluctance	$\mathfrak{R}$	$\mathfrak{R}=\mathfrak{F}/\Phi$	amp-turn/w	4π	$4\pi\times10^{-9}$	$36\pi\times10^{11}$	$4\pi\times10^{-9}$
resistance	R	$R=V/I$	ohm	1	1	$10^{-11}/9$	10^{9}
resistivity	ρ	$\rho=RA/l$	ohm-m	1	10^{2}	$10^{9}/9$	10^{11}

F=force; l=length; t=time; v=volume; n = no of turns

ORDERS OF MAGNITUDE

order	prefix	symbol	order	prefix	symbol
10^{12}	tera	T	10^{-2}	centi	c
10^{9}	giga	G	10^{-3}	milli	m
10^{6}	mega	M	10^{-6}	micro	μ
10^{3}	kilo	k	10^{-9}	nano	n
10^{2}	hecto	h	10^{-12}	pico	p
10	deka	da	10^{-15}	femto	f
10^{-1}	deci	d	10^{-18}	atto	a

INSERT-EE

STANDARD COMPONENT VALUES

1% tolerance						5% tol	
100	147	215	316	464	681	10*+	36
102	150	221	324	475	698	11	39*
105	154	226	332	487	715	12*	43
107	158	232	340	499	732	13	47*+
110	162	237	348	511	750	15*+	51
113	165	243	357	523	768	16	56*
115	169	249	365	536	787	18*	62
118	174	255	374	549	806	20	68*+
121	178	261	383	562	825	22*+	75
124	182	267	392	576	845	24	82*
127	187	274	402	590	866	27*	91
130	191	280	412	604	887	30	100*+
133	196	287	422	619	909	33*+	
137	200	294	432	634	931	note:	
140	205	301	442	649	953	*10% tol exists	
143	210	309	453	665	976	+20% tol exists	

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COLOR CODE

color	figure	mult	tol (%)	voltage
black	0	1	—	—
brown	1	10	1*	100*
red	2	10^{2}	2*	200*
orange	3	10^{3}	3*	300*
yellow	4	10^{4}	4*	400*
green	5	10^{5}	5*	500*
blue	6	10^{6}	6*	600*
violet	7	10^{7}	7*	700*
gray	8	10^{8}	8*	800*
white	9	10^{9}	9*	900*
gold	—	10^{-1}	5	1000*
silver	—	10^{-2}	10	2000*
no color	—	—	20	500*

* capacitors only

h PARAMETERS

$V_1=h_{11}I_1+h_{12}V_2$ $\quad h_{11}=h_i \quad h_{12}=h_r$

$I_2=h_{21}I_1+h_{22}V_2$ $\quad h_{21}=h_f \quad h_{22}=h_o$

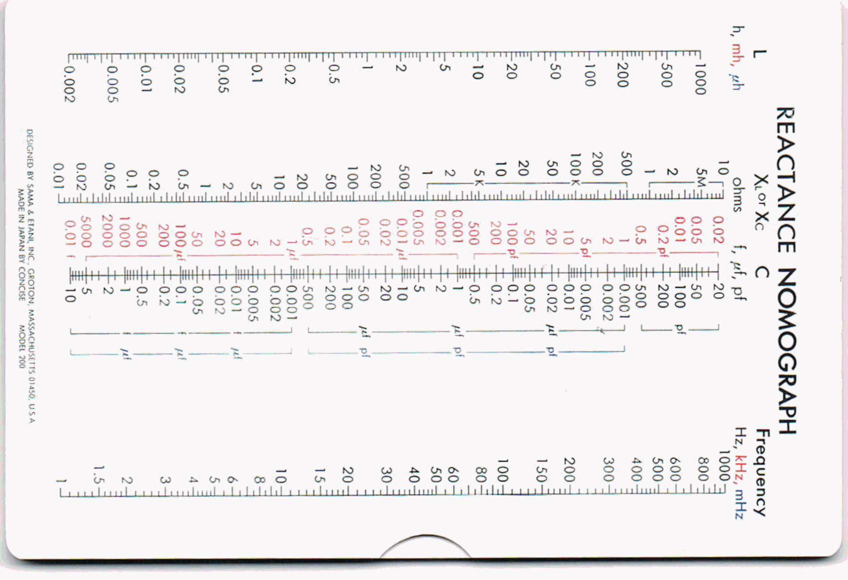
COPPER WIRE TABLE

wire size AWG (B&S)	circular mil area	ohms per 1000ft, 25°	current cap+ (amp)
8	16510	0.6405	23.6
10	10380	1.018	14.8
12	6530	1.619	9.33
14	4107	2.575	5.87
16	2583	4.094	3.69
18	1624	6.510	2.32
20	1022	10.35	1.46
22	642.4	16.46	0.918

+ figured at 700 cir mil/amp

USEFUL CONSTANTS & DATA

$c = 2.998\times10^{8}$ m/sec = 186272 miles/sec
Sound velocity, air 20°C, 1 atm:
344 m/sec = 1129 ft/sec = 769.5 mph
e = base, natural logs = 2.71828 18284 59045
γ = Euler's constant = 0.57721 56649
$\ln x = \log_e x = (\log_e 10)(\log_{10} x) = 2.3026 \log_{10} x$
1 electron = 1.602×10^{-19} coul; 9.109×10^{-31} kg
F = Faraday constant = 96500 coul/g equiv.
g_o = 9.807 m/sec² = 32.17 ft/sec²
h = Planck's constant = 6.626×10^{-34} joule sec
N_A = Avogadro's no. = 6.023×10^{23} molecules/g mole
π = 3.14159 26535 89793 23846 26433 83279 50288
σ = Stefan-Boltzmann constant =
5.670×10^{-8} watt/m² (°K)⁴
R = 1 radian = 57.3 deg.; 1 deg. = 0.01745 radian
Sphere: area = $4\pi r^2$; volume = $(4/3)\pi r^3$
Temperature conversion: °C = 5/9 (°F − 32)
°F = 9/5 °C + 32; °K = °C + 273.2; °R = °F + 459.7



DESIGNED BY SAMA & ETANI, INC., GROTON, MASSACHUSETTS 01450, U.S.A.
MADE IN JAPAN BY CONCISE MODEL 200

The COPPER WIRE TABLE lists important constants for commonly used sizes of copper wire. The current capacity limits, figured at 700 circular mils of cross sectional area per ampere, are conservative ratings, often used in the design of inductors or transformers. When single wires are to be run in free air, or when a group of wires are to be run in a cable or conduit, more liberal figures may apply. For example, the following table (from MIL-W-5088B [ASG]) is often used.

Wire Size	Continuous-duty current (Amperes) Single wire in free air	Wires and cables in conduit or bundles*
8	73	46
10	55	33
12	41	23
14	32	17
16	22	13
18	16	10
20	11	7.5
22	—	5

*Based upon bundles of 15 or more wires carrying no more than 20% of the total carrying capacity of the bundle.

SPECIAL INSTRUCTIONS FOR MODEL 200 EE

USE OF REACTANCE NOMOGRAPH

Four scales are provided on the Reactance Nomograph side of the slide rule representing inductance (L), reactance (X_L or X_C), capacitance (C), and frequency. The scales are color coded to permit rapid identification of corresponding units. The nomograph is used by aligning any two known quantities, and reading the two remaining quantities from the other two scales.

Example: Find the reactance of a 0.1μf capacitor at a frequency of 60 hertz (cycles per second).

Procedure: Since frequency in Hz appears in black, capacitance should be located on the C scale in the black column. Withdraw the reference table insert and use it as a straightedge to intersect 0.1 μf on the black C scale and 60 Hz on the frequency scale. A pencil line may be drawn directly on the nomograph if a temporary record is desired. The reactance on the X scale which lies on this straight line is approximately 27 kohms. (By actual computation: $X_C = \dfrac{1}{2\pi fC} = 26.5K\Omega$)

The pencil line, if drawn, may now be erased with your thumb.

Quality . . . by Design

Designers, Importers and Distributors
SAMA & ETANI, INC., Groton, Massachusetts 01450, U.S.A.
Telephone—617-448-6500, 6501, Cable—SAMET, Telex—928423

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SAMA & ETANI

REFERENCE TABLES

AND CIRCULAR SLIDE RULE

Example: Find a capacitor which will resonate with a 2 mh inductor at 8 kilohertz.

Procedure: Frequency in kHz indicates that the red scale should be used. Line up 8 kHz on the frequency scale with 2 mh on the L scale using the edge of the reference table insert.

The answer read on the red C scale is approximately 0.2 μf.

(By actual computation:

$$X_L = X_C,\ 2\pi fL = \frac{1}{2\pi fC},\ C = \frac{1}{4\pi^2 f^2 L} = 0.198\ \mu f)$$

USE OF REFERENCE TABLES

The UNIT CONVERSIONS table allows rapid conversion to rationalized MKS units from any of the following systems: Non-rationalized MKS, CGS, ESU or EMU.

The numbers in the STANDARD COMPONENT VALUES table represent the "preferred values" for many resistors and small capacitors. In this system, the numbers represent only the significant figures and must be multiplied by the appropriate power of ten to obtain the actual value.

Example: 162 in the 1% tolerance table could represent 1.62, 16.2, 162, 1620, 16200, etc., ± 1%.

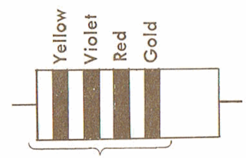
This table allows rapid selection of resistors, capacitors and inductors for particular circuit applications.

For example, if calculations called for a 420 ohm resistor, the table shows the following possibilities:

470 ± 20%	430 ± 5%
390 ± 10%	422 ± 1%

The particular resistor could then be chosen to conform to the other design considerations.

The COLOR CODE table may be used to identify resistors or capacitors. For example, the resistor shown in the figure is identified as follows:



Colored Bands

4700 Ω ± 5%

1. Start with the colored band nearest to the end of the resistor.
2. The first and second bands indicate figures as listed in the color code table (4 and 7 in this example).
3. The third band indicates a multiplier for the first two figures (10^2 in this example). This colored band can also be interpreted as specifying the number of zeros following the first two figures.
4. The last band indicates the resistor tolerance as tabulated in the color code table (5% in this example).

Note: The distortion temperature of the vinyl construction material is 150°F; therefore, exposure of the instrument to such temperatures should be avoided.

Telephone—617-448-6500, 6501

Telex—928423

CONTENTS

INTRODUCTION

The SAMA & ETANI reference tables and circular slide rule series was designed and constructed to facilitate calculations encountered daily by engineers, scientists and students. The tables provide handy reference to many frequently used conversion factors and physical data, while the slide rule is sufficiently accurate for all but the most precise calculations.

The circular slide rule has the following characteristics:

1. The outer scales have a circumference of approximately 7½ inches and as many subdivisions as a 10-inch linear slide rule.

2. Problems involving multiplication, division, squares, square roots, cubes, cube roots, logarithms and trigonometric functions can be easily solved.

3. All scales and tables are engraved to ensure a lifetime of accurate readability.

4. As with all circular slide rules, the answer can never be off scale.

The size of the instrument is such that it will fit easily into a shirt pocket. For the measurement of small lengths, inch and centimeter scales are provided on the front face. The instrument is made of plastic and can be safely washed with lukewarm water and mild soap.

USE OF CONVERSION TABLES

Many reference and conversion tables and frequently used data are included on three surfaces of the instrument for the user's quick reference. Note that there are stars on the face of the instrument and on the sliding insert near the AREA table. By keeping the two stars in the same relative position, the user's speed will be enhanced as he becomes familiar with the locations of the various tables of the instrument.

Each conversion table consists of a matrix of numbers which are the multiplication factors for converting from one unit of measurement to another.

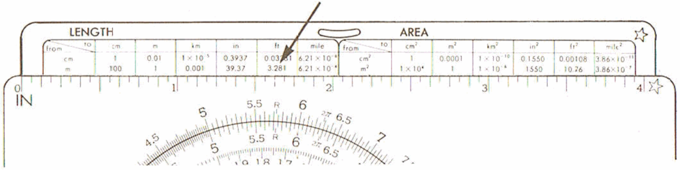


Figure 1

Example: Convert 3 meters into feet (Figure 1)

Procedure: Pull the sliding insert out to the left. On the front of this insert the LENGTH table can be found. Pull the insert out to the **m** row in the **from** column. Locate the **ft** column in the **to** row. The number found in the **m** row and the **ft** column is 3.281. When 3 is multiplied by 3.281, the answer 9.843 is the number of feet in 3 meters.

For convenience in writing and manipulation, numbers are often expressed in the tables as factors of the appropriate power of 10, for instance: 1.23×10^{6} denotes 1,230,000
1.23×10^{-6} denotes 0.00000123

Squares and cubes are expressed by exponents of 2 and 3.

UNITS OF FORCE AND MASS

The tables have been compiled with a view toward eliminating any possible confusion between force and mass. Wherever confusion might arise, an "f" to indicate force, or an "m" to indicate mass is used. For example, gf represents grams force and lbm represents pounds mass. Since the use of g and kg as units of mass is very common, it was not deemed necessary to add "m" after them when so used.

A special force table is also included in which the units of force, mass, acceleration and the conversion factor g_c are listed. This conversion factor is used with Newton's Law in the form $F=ma/g_c$. For example to calculate the gravitational force exerted on a pound mass (1 lbm) at a location where the gravitational acceleration is 30.0 ft/sec^2:

$$F=\frac{ma}{g_c}=\frac{1 \text{ lbm} \times 30.0 \text{ ft/sec}^2}{32.17 \text{ lbm ft/lbf sec}^2}=0.9325 \text{ lbf}$$

At or near sea level, where the earth's gravitational acceleration is 32.17 ft/sec^2, a one pound mass will be attracted to the earth by a one pound force, i.e., its weight will be 1 lbf.

Even when the conversion factor has a magnitude of 1, its use makes Newton's Law dimensionally consistent. For example, to determine the mass of an object whose weight is 2 newtons in a gravitational field of 5 meters/second^2:

$$m=\frac{Fg_c}{a}=\frac{2 \text{ newtons} \times 1 \text{ kg m/newton sec}^2}{5 \text{ m/sec}^2}=0.4 \text{ kg}$$

ABBREVIATIONS

a—acceleration
abs—absolute
acc.—acceleration
alt.—altitude
amp—ampere
atm—atmosphere
AWG—American Wire Gauge
B&S—Brown and Sharp
bbl—barrel
Br.—British
Btu—British thermal unit
c—speed of light
cal—calorie
cap—capacity
cent.—center
cgs—centimeter, gram, second unit
cir—circular
cm—centimeter
comp.—complex
coul—coulomb
db—decibels
deg.—degree
°C—degree Centigrade
°F—degree Fahrenheit
°K—degree Kelvin
°R—degree Rankine
dist.—distance
e—electric
E—potential in volts
elect.—electron
elem. ch.—elementary charge
emf—electromotive force
emu—electromagnetic unit
equiv—equivalent
esu—electrostatic unit
F—force
fl—fluid
ft—foot
fus.—fusion
g—gram mass
g_c—conversion factor in Newton's Law
g_0—gravitational acceleration at sea level
gal—gallon
gf—gram force
grav.—gravitational
Hg—mercury
hp—horsepower

h parameters—hybrid parameters
hr—hour
H_2O—water
I—current in amperes
in—inch
kg—kilogram mass
kgf—kilogram force
km—kilometer
kw—kilowatt
lbf—pound force
lbm—pound mass
lit—liter
ln—*logarithm base e*
log—logarithm base 10
m—magnetic
m—mass
m—meter
min—minute
mks—meter, kilogram, second unit
mks (nr)—non rationalized mks
mks (r)—rationalized mks
mm—millimeter
mmf—magneto-motive force
mph—miles per hour
mult—multiplier
no.—number
nos.—numbers
nt.—newton
ozm—ounce mass
P—power
pos.—positive
press.—pressure
pt—pint
π—ratio of circumference of a circle *to its diameter*
quad.—quadrant
qt—quart
r—radius
R—radian
rad.—radian
sec—second
S_n—sum of n terms
stand.—standard
temp.—temperature
tol—tolerance
trans.—transverse
vap.—vaporization
vert.—vertex
w—weber
yd—yard

INSTRUCTIONS FOR THE BEGINNER

CIRCULAR SLIDE RULE

The slide rule is a mechanical equivalent of a table of logarithms. The addition or subtraction of scale lengths corresponding to logarithms of numbers results in the *multiplication* or division of these numbers.

Although slide rules are available in many forms, such as cylindrical, spiral or linear, the *circular* slide rule is the simplest and most convenient to use.

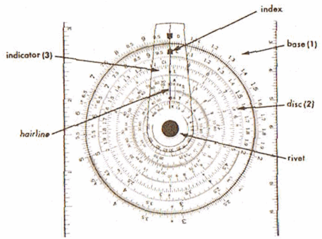


Figure 2

The circular slide rule has three major elements, the base (1), the disc (2) and indicator (3) (or cursor) attached to the base by *a rivet* (see Figure 2). The hairline is inscribed on the indicator. Index marks 1 and 1 are located at the beginning of the C and D scales.

LOCATING NUMBERS ON THE SCALES

The decimal point has no bearing upon the position of the number on the slide rule scale. Thus 0.00128, 1.28, 1280, etc., are located at the same position on the scales.

To use the slide rule it is necessary to understand the term "significant digit of a number." The "first significant digit" is the first digit in a number that is not zero. The "first significant digit" in the number 0.00128, 1.28 or 1280 is therefore 1. If the "first significant digit" is 1, then the number will be located on the slide rule scale between the primary divisions 1 and 2. If the "first significant digit" is 2, then the number will be between primary divisions 2 and 3, and so on up the scale.

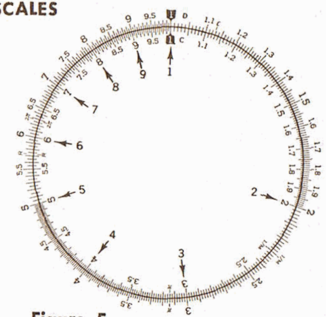


Figure 5

Single-digit numbers fall on primary divisions (see Figure 5). Two-

digit numbers fall on the secondary divisions (see Figure 6). Three-digit numbers fall on or within the subdivisions of the secondary divisions.

Example: To locate 2.68

Procedure: Move the indicator to primary division 2 (which is the "first significant digit"). Digit 6 is the sixth secondary division to the right of primary division 2. Since the finest subdivisions have a value of 0.02 each, digit 8 is the fourth finest subdivision to the right (see Figure 7).

When the number is not found to fall exactly on a division, it is necessary to interpolate visually between divisions. For example, 2.87 is located one-half of the way from 2.86 to 2.88 as shown in Figure 7.

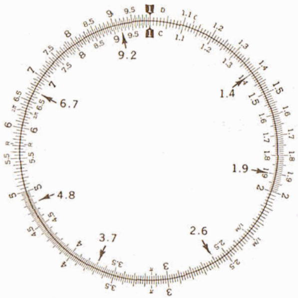


Figure 6

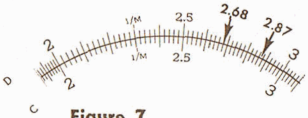


Figure 7

By visual interpolation between the finest divisions, it is possible to locate a number to 4 significant figures between 1 and 2 and to 3 significant figures between 2 and 10.

DECIMAL POINTS

During slide rule calculations, numbers should be set on the slide rule without regard to decimal points.

When answers are obtained on the slide rule, the correct position of the decimal point must be determined separately. Often this is immediately apparent, i.e., 2 x 32.0 is easily understood to be 64.0 and not 6.40 or 640. For complicated calculations, the location of the decimal point is determined by doing the calculations mentally in steps with rounded-off figures. For example, to determine the decimal point for the calculation 899 x 21.0 ÷ 342, note that 899/342 is between 2 and 3. When this is multiplied by 21.0 or the rounded-off figure of 20, the answer must be greater than 10 and less than 100; thus, the position of the decimal in the answer is after the second digit.

USE OF CIRCULAR SLIDE RULE

The slide rule has D, C, CI, L, A, S, T and K scales. The C, D, and CI scales are used for multiplication and division. Scales A and C are used to calculate squares and square roots, and K and C scales are used for cubes and cube roots. Logarithms are obtained with the L and C scales. The remaining scales, S and T, are used in conjunction with the D, C, and CI scales to obtain and manipulate trigonometric functions. The circular slide rule is used in much the same manner as the conventional straight slide rule.

In order to simplify explanation of the use of the circular slide rule the following symbols are used in the booklet:

↗ ....setting of the scales
↑ ....setting of the indicator
* ....answer

Letters designating scales are imprinted in red on the indicator. These letters will be helpful to the user in locating the scales. Note that these letters are positioned over the numerical figures in the respective scales, rather than over the divisions, for ease in reading the divisions.

MULTIPLICATION

Example: 1.8 x 2.5=4.5 (Figure 8)

Procedure: Locate 1.8 on the D scale, and line up the index on the C scale with it. Set the indicator to 2.5 on the C scale. The indicator shows the answer 4.5 on the D scale.

Figure 8a

Figure 8b

Figure 8a shows the detailed subdivisions while 8b is shown schematically. For greater clarity, schematic diagrams are used for all subsequent examples.

Example: 3 x 2=6, 3 x 5=15, 3 x 7=21 (Figure 9)

Procedure: Locate 3 on the D scale, and line up on the C scale with it. Set the indicator to the values 2, 5 and 7 on the C scale, and read the answers 6, 15 and 21 respectively, on the D scale.

Figure 9

Example: 3 x 4 x 5=60 (Figure 10)

Procedure: Locate 3 on the D scale, and line up 4 on the CI scale with it. Move the indicator to 5 on the C scale, which gives the answer 60 on the D scale.

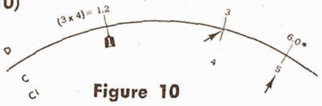


Figure 10

DIVISION

Example: 850÷25=34 (Figure 11)

Procedure: Locate 850 on the D scale, and line up 25 on the C scale with it. The index on the C scale points to answer 34 on the D scale.

Figure 11

Example: 850÷25÷8=4.25 (Figure 12)

Procedure: Locate 850 on the D scale and line up 25 on the C scale with it. Move the indicator to 8 on the CI scale and read the answer 4.25 on the D scale.

Figure 12

MULTIPLICATION AND DIVISION

Example: $3 \times 6 \div 5 = 3.6$ (Figure 13)

Procedure: Locate 3 on the D scale and line up 5 on the C scale with it. Set the indicator to 6 on the C scale. Read answer 3.6 on the D scale.

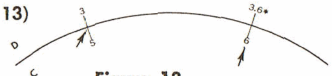


Figure 13

PROPORTIONS

Example: $2.4:5 = x:8 \quad x = 3.84$ (Figure 14)

Procedure: Locate 2.4 on the D scale and line up 5 on the C scale with it. Set the indicator to 8 on the C scale and read answer 3.84 on the D scale.

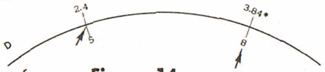


Figure 14

SQUARES AND SQUARE ROOTS

Example: $3^2 = 9$ (Figure 15)

Procedure: Set the indicator to 3 on the C scale. Read the answer 9 on the A scale.

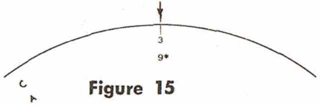
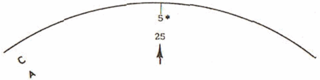


Figure 15

Example: $\sqrt{25} = 5$ (Figure 16)

Procedure: Set the indicator to 25 on the A scale. Read the answer 5 on the C scale.

Figure 16

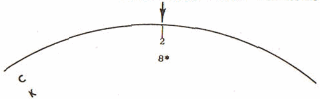


CUBES AND CUBE ROOTS

Example: $2^3 = 8$ (Figure 17)

Procedure: Move the indicator to 2 on the C scale. Read the answer 8 on the K scale.

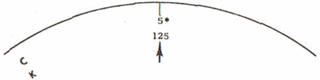
Figure 17



Example: $\sqrt[3]{125} = 5$ (Figure 18)

Procedure: Move the indicator to 125 on the K scale. Read the answer 5 on the C scale.

Figure 18



LOGARITHMS

Example: log 78=1.892 (Figure 19)

Procedure: Set the indicator to 78 on the C scale. The mantissa 0.892 is read on the L scale. Since the characteristic number is 1, the logarithm of 78 is 1.892.

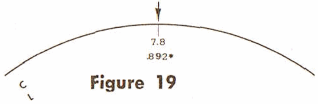


Figure 19

POWERS

Example: $(2)^4=16.0$ (Figure 20)

Procedure: Set the indicator to 2.0 on the C scale. Read log 2.0= 0.301 on the L scale. Line up the index 1 on the C scale with 0.301 on the D scale. Move the indicator to 4 on the C scale and read 4 log 2.0=1.204 on the D scale. This is the log of the answer since log $(2.0)^4=4$ log 2.0; therefore, set the indicator to 0.204 on the L scale. The answer 16.0 is read on the C scale.

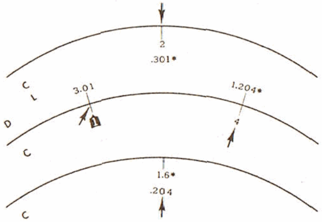


Figure 20

NOTE: Only the mantissas of logarithms are found on the L scale. The characteristic, in this case 1, is used to locate the decimal.

SINES AND COSINES

The S scale is used to determine sines of angles between 6 and 90 degrees. Since the cosine of an angle is equal to the sine of its complement, i.e. cos $\theta=\sin(90-\theta)$, these same scales can be used to find cosines of angles. For convenience when working with cosines, the complements of the angles are shown in orange on the S scale.

Example: sin 30°=0.500 (Figure 21)

Procedure: Set the indicator to the black 30° marking on the S scale. The answer 0.500 is read on the C scale.

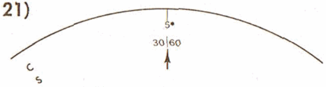


Figure 21

Example: cos 40°=0.766 (Figure 22)

Procedure: Set the indicator to the orange 40° marking on the S scale. The answer 0.766 is read on the C scale.

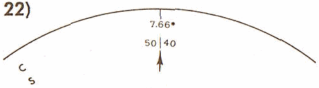


Figure 22

TANGENTS AND COTANGENTS

The tangent scale, T, is used to determine tangents of angles from 6 to 45 degrees, and 45 to 84 degrees. Between 6 and 45 degrees the angles are in black on the T scale and their tangents are found on the C scale (also black). Between 45 degrees and 84 degrees the angles are in orange on the T scale and their tangents are found on the CI scale (also orange).

Example: Tan 42° = 0.900 (Figure 23)

Procedure: Set the indicator to the black 42° marking on the T scale. Answer 0.900 is read on the C scale.

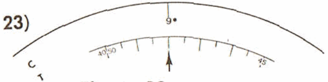


Figure 23

Example: Tan 60° = 1.732 (Figure 24)

Procedure: Set the indicator to the orange 60° on the T scale. The answer 1.732 is read on the CI scale.

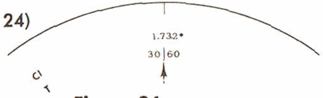


Figure 24

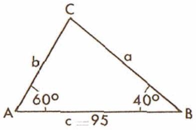
The cotangent of an angle θ is obtained by determining the tangent of $(90-\theta)$. Thus the cotangent 48° and the contangent 30° are obtained by determining tan 42° and tan 60° as in the preceding examples.

TRIANGLES

Problems involving triangles can be solved easily on this slide rule. The slide rule is particularly well suited for Sine Law calculations:

Sine Law: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$ where $A+B+C=180°$

Example: Find a and b in following triangle:



$$\frac{a}{\sin 60°} = \frac{b}{\sin 40°} = \frac{95}{\sin[180-(60+40)]}$$

a = 83.5; b = 62 (Figure 25)

Procedure: Locate 95 on the D scale, and line up 80° on the S scale with it. Set the indicator to 60° and 40° on the S scale, and read the answers 83.5 and 62 respectively, on the D scale.

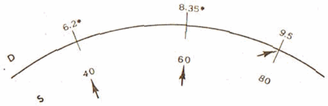


Figure 25

COORDINATE CONVERSIONS

A very important use of this slide rule is the conversion between rectangular and polar coordinate forms of complex numbers.

Example: $3 + j4 = 5 \angle 53^\circ$ *(Figure 26)

Procedure: Line up the index on the C scale with the larger rectangular component (4 in this example) on the D scale. Set the indicator to the other component on the D scale (3 in the example). Determine mentally whether the angle will be larger or smaller than 45°. If larger, read the angle (53°) using the orange numerals on the T scale. If smaller, read the black numerals on the T scale. Next, without moving the indicator, rotate the S scale until the angle just determined (orange 53°) falls under the hairline on the S scale. The magnitude of this number, 5, can now be read on the D scale opposite the index on the C scale.

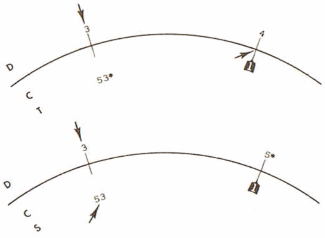


Figure 26

*Note: $5 \angle 53^\circ$ represents a vector of magnitude 5 at an angle of 53° with the plus x axis.

Example: $4 + j3 = 5 \angle 37^\circ$ (Figure 27)

Procedure: Line up on the C scale with 4 on the D scale. Set the indicator to 3 on the D scale. Since the angle is less than 45°, read the black numerals on the T scale, 37°. Next, without moving the indicator, rotate the S scale until the angle just determined (black 37°) falls under the hairline on the S scale. The magnitude of the number, 5, can now be read on the D scale opposite on the C scale.

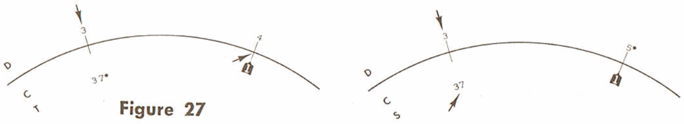


Figure 27

Example: $15\angle 30^\circ = 13.0 + j\,7.5$ (Figure 28)

Procedure: Line up 1 on the C scale with 15 on the D scale. Set the indicator to the angle designated on the S scale (30°). Use black numerals if the angle is smaller than 45°, orange if the angle is larger than 45°. The smaller rectangular component ($j\,7.5$) now lies under the hairline on the D scale. Next, without moving the indicator, rotate the T scale until the angle on the T scale (same number and color as just read) falls under the hairline. The larger component 13.0 now is on the D scale opposite 1 on the C scale.

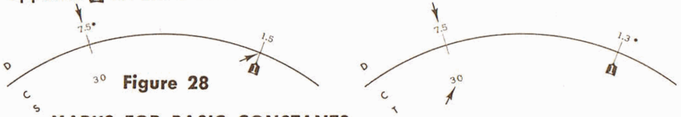


Figure 28

MARKS FOR BASIC CONSTANTS

The C, D, CI and A scales of the circular slide rule include several locating marks to facilitate computations involving frequently used basic constants. On the C, D, CI and A scales appear the mark "π" at 3.142 and a tick mark designating $\pi/4$ at 0.7854. The mark "2π" at 6.283 appears on the C, D and CI scales. The use of these marks makes it unnecessary to recall the numerical values when multiplying or dividing by π, 2π or $\pi/4$, and also insures a more accurate setting.

Three other marks are also provided on the slide rule. They are summarized as follows:

Mark	Scales	Numerical value	Usage
c	D	$\sqrt{4/\pi} = 1.128$	To find the area of a circle with a given diameter. **Procedure:** Line up diameter on the C scale with mark "c" on the D scale. Move the indicator to 1 on the D scale. The answer is found on the A scale.
1/M	C, D, CI	2.3026	To convert $\log_{10} x$ to $\log_e x$, i.e., $\log_e x = 2.3026 \log_{10} x$
R	C, D, CI	57.296°	To convert angles from radians to degrees or vice versa. **Procedure:** Line up 1 on the C scale with "R" on the D scale. Opposite any value on the C scale in radians read same angle in degrees on the D scale.

SAMA & ETANI Reference Tables and Circular Slide Rules

MODEL 600 SERIES

CONCISE CHEMICAL TABLES and CIRCULAR SLIDE RULE with INSERT-CE recommended for chemical and mechanical engineers, and chemists

CONCISE SCIENCE TABLES and CIRCULAR SLIDE RULE with INSERT-ST recommended for high school and college science students

MODEL 200-EE CONCISE ELECTRICAL TABLES and CIRCULAR SLIDE RULE with INSERT-EE recommended for electrical and electronic engineers, and physicists

CIBA MEDICAL TABLES and CALCULATOR

recommended for medical students and nurses

SAMA & ETANI Multi-Calculators and Reference Tables

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ADDING-SUBTRACTING INSTRUMENT and CIRCULAR SLIDE RULE

with INSERT-CE *recommended for chemical and mechanical* engineers, and chemists

with INSERT-ST recommended for high school and college science students

with INSERT-EE recommended for electrical and electronic engineers, and physicists

Other SAMA & ETANI Products

AUTO-CAL

Combination slide rule-mileage calculator and 22-year calendar in leather case with key ring

MODEL 90

90 mm diameter circular slide rule with conversion tables of length, area, volume, force, mass and temperature on the rear face

recommended for engineers, and high school and college students