POCKET REF

Thomas J. Glover

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POCKET REF

Compiled by

Thomas J. Glover

First Edition

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Preface

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Many thanks to Georgia, Trish, and Carrie for all their help in making this book possible.

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PERSONAL INFORMATION

Name ⇒					
Birthday					
Anniversary					
Hat					
Suit/Dress					
Neck					
Shoulder to Waist					
Chest					
Shirt Size					
Sleeve Length					
Gloves					
Waist					
Hips					
Inseam					
Sock or Hose					
Shoe					

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REFERENCES, TRADE NAMES & TRADE MARKS

Index463The following are Trade Names and Trade Marks included in Pocket Ref. If we missed your Trade Name or Trade Mark, we apologize, please let us know and we will insert it in the next printing.

AWS – American Welding Society
ANSI – American National Standards Institute
ASCII – American Standard Code for Information Interchange
Brown & Sharp
Cedarapids – Iowa Manufacturing Co.
Commodore 64 – Commodore Computers
Diablo 630 – Xerox Corporation
Epson, FX–80 – Epson America Inc
Hayes – Hayes Microcomputer Products, Inc.
HP, HP-IB, Hewlett-Packard, Laserjet – Hewlett–Packard Company
Ibm , AT, XT, PC, PS/2, PC Convertible, PC Jr. - International Business Machines Corporation
ISO – International Standards Organization
Macintosh, Apple IIc, Apple – Apple Computer, Inc.
Metropolitan Life Insurance Company
Microsoft and MS–DOS – Microsoft Corporation
NCHS – National Center for Health Statistics
NEC, Pinwriter – NEC Corporation
NEMA – National Electrical Manufacturers Association
Pioneer – Portec Pioneer Division
ROMEX –
SAE – Society of Automotive Engineers

Some of the references used in writing Pocket Ref include the following (They are all excellent references and should be added to any good reference library):

Arco's New Complete Woodworking Handbook – J. T. Adams, Arco
Builders Vest Pocket Reference – W.J. Hornumg, Prentice–Hall,Inc
Cedarapids Reference Book – Iowa Manufacturing Company
Dana's Manual of Minerology – E.S. Dana, John Wiley & Sons
Electronic Engineers Master Catalog – Hearst Business Communications Inc.
Field Geologists Manual – Australian Institute of Mining and Met.
Graingers Catalog– W. W. Graingers, Inc
Handbook of Chemistry & Physics – The Chemical Rubber Co.
Handbook of Physical Calculations – Jan J. Tuma, McGraw–Hill
Machinery's Handbook – E.O. & F.D. Jones, Industrial Press Inc
Machinists' & Draftsmen's Handbook – A.M. Wagener & H.R. Arthur
Mechanical Engineers' Handbook – McGraw–Hill Book Co., Inc.
National Electrical Code – National Fire Protection Association
Pioneer Facts and Figures – Portec, Pioneer Division
Scientific Tables – Ciba–Geigy Ltd, New York
Standard Math Tables – The Chemical Rubber Co.
Technical Reference Handbook – E. P. Rasis, American Tech. Pub.
The World Almanac 1989 – Pharos Books
Water Well Handbook – K.E. Anderson, Missouri Water Well Assn.

NOTE: There are many more references, most of which are referenced on specific pages in Pocket Ref. If we have omitted a reference, we apologize, please let us know and we will include it in the next printing of Pocket Ref.

POCKET REF

AIR and GASES

(See WATER for Tank Volumes & Pollution, p. 377)

COMPOSITION OF AIR

Component of Air	Symbol	Content – %Volume
Nitrogen	N_2	78.084 percent
Oxygen	O_2	20.947 percent
Argon	Ar	0.934 percent
Carbon dioxide	CO_2	0.033 percent
Neon	Ne	18.2 parts/million
Helium	He	5.2 parts/million
Krypton	Kr	1.1 parts/million
Sulfur dioxide	SO_2	1.0 parts/million
Methane	CH_4	2.0 parts/million
Hydrogen	H_2	0.5 parts/million
Nitrous oxide	N_2O	0.5 parts/million
Hydrogen	H_2	0.5 parts/million
Xenon	Xe	0.09 parts/million
Ozone	O_3	0.0 to 0.07 parts/million
Ozone – Winter	O_3	0.0 to 0.02 parts/million
Nitrogen dioxide	NO_2	0.02 parts/million
Iodine	I_2	0.01 parts/million
Carbon monoxide	CO	0.0 to trace
Ammonia	NH_3	0.0 to trace

> 99.998% (Nitrogen, Oxygen, Argon, Carbon dioxide)

The above table is an average for clean, dry air at sea level.
1 part/million = 0.0001 percent.

PHYSICAL PROPERTIES OF AIR

Density of dry air at Standard Temperature and Pressure:
1.2929 kilograms/cu meter = 0.0807 pounds/cu foot

Universal Gas Constant (R): 0.0821 liter–atmosphere/ ^{o}K /mole

Standard Temperature & Pressure (STP):
Standard Temperature = 0^{o}C = 32^{o}F = 273.15^{o}K
Standard Pressure = 760 mm Hg =
14.70 pounds/sq inch = 2116.22 pounds/sq foot =
29.92 inch Hg = 1.01325×10^{5} N/m^{2}

Speed of sound in dry air at STP:
331.4 meters/sec = 1089 ft/sec = 742.5 miles/hr

ICAO Sea Level Air Standard Values:
Atmospheric pressure = 760 mm Hg = 14.7 lbs/sq inch
Temperature = 15^{o}C = 288.15^{o}K = 59^{o}F

WEIGHTS OF GASES

Gas	Weight (gms/liter)	Weight (lb/cu ft)
Air	1.2928	0.08071
Air @ 59°F	1.2256	0.07651
Argon	1.7840	0.111368
Carbon Dioxide	1.9770	0.123416
Carbon Monoxide	1.2500	0.078033
Helium	0.1785	0.011143
Hydrogen	0.0899	0.005612
Neon	0.9002	0.056196
Nitrogen	1.2506	0.075261
Oxygen	1.4290	0.089207

All weights listed above assume a dry gas at standard temperature and pressure (0°C and 760 mm Hg).

STANDARD ATMOSPHERE

The unit "1 Standard Atmosphere" is defined as the pressure equivalent to that exerted by a 76mm column of mercury at 0°C (32°F), at sea level, and at standard gravity (32.174 ft/sec^2). Atmospheric pressure is simply the weight of a column of air per area unit as measured from the top of the atmosphere to the reference point being measured. Atmospheric pressure decreases as altitude increases. Equivalents to 1 atmosphere are as follows:

76 centimeters of mercury
29.92 inches of mercury
10.33 meters of water
406.8 inches of water
39.9 feet of water
14.7 pounds per square inch
2.116 pounds per square foot

Perfect Gas Law:

$$PV = nRT$$

P = Pressure in atmospheres
V = Volume in liters n = Number of moles
R = Gas constant (0.0821 liter-atmospheres/°K/mole)
T = Temperature in degrees K

If constant pressure	$V1/V2 = T1/T2$
If constant temperature	$P1/P2 = V2/V1$
If constant volume	$P1/P2 = T1/T2$

Boyle's Law

If temperature is kept constant, the volume of a given mass of gas is inversely proportional to the pressure which is exerted upon it.

$$\frac{\text{Initial Pressure}}{\text{Initial Volume}} = \frac{\text{Pressure Change}}{\text{Volume Change}}$$

Charles' Law

If the pressure is constant, the volume of a given mass of gas is directly proportional to the absolute temperature.

$$\frac{\text{Initial Volume}}{\text{Initial Temperature }^\circ\text{K}} = \frac{\text{Volume Change}}{\text{Final Temperature }^\circ\text{K}}$$

Dalton's Law of Partial Pressures

The pressure which is exerted on the walls of a vessel is the sum of the pressures which each gas would exert if it were present alone.

Graham's Law of Diffusion

Relative rates of diffusion of two gases are inversely proportional to the square roots of their densities.

Avogadro's Law

Equal volumes of gases, measured under the same conditions of temperature and pressure, contain equal numbers of molecules.

Air Velocity in a Pipe:

$$V = \sqrt{\frac{25{,}000\ DP}{L}}$$

V = Air velocity in feet per second
D = Pipe inside diameter in inches
L = Length of pipe in feet
P = Pressure loss due to air friction in ounces/square inch
Approximate values of P are as follows:

Velocity Ft/Sec	Pipe Diameter in inches, 10 feet long 1	2	4	6	10
1	0.004	0.0002	0.0001	0.00006	0.00004
2	0.0016	0.0008	0.0004	0.0002	0.00016
5	0.0100	0.005	0.0025	0.0016	0.001
10	0.04	0.02	0.01	0.0066	0.004
15	0.09	0.45	0.0225	0.015	0.0089
20	0.16	0.08	0.04	0.026	0.016
25	0.25	0.125	0.0625	0.041	0.025
30	0.36	0.18	0.09	0.06	0.036

(Formula from B.F. Sturtevant Co)

Air Volume Discharged from Pipe:

$$CFM = 60VA$$

CFM = Air volume in cubic feet per minute
V = Air velocity in feet per second as determined in the equation at the top of this page.
A = Cross section area of pipe in square feet.

Theoretical Horsepower to Compress Air:

$$HP = CFM \times PSI \times 0.0007575$$

HP = Compressor Horsepower
CFM = Air flow in cubic feet per minute
PSI = Air pressure in pounds per square inch
(assumes Atmospheric Pressure = 14.7 psi, Temp = 60°F)

DENSITY OF MOIST AIR

mm Hg	Air Temperature (Dew Point = 10°C) 0°C	10°C	20°C	40°C	60°C
1000	1.695	1.635	1.579	1.479	1.390
975	1.653	1.594	1.540	1.441	1.355
950	1.610	1.553	1.500	1.404	1.320
925	1.568	1.512	1.461	1.367	1.285
900	1.525	1.471	1.421	1.330	1.250
875	1.482	1.430	1.381	1.293	1.215
850	1.440	1.389	1.342	1.256	1.181
825	1.397	1.348	1.302	1.219	1.146
800	1.355	1.307	1.262	1.182	1.111
775	1.312	1.266	1.223	1.145	1.076
760	1.287	1.241	1.199	1.122	1.055
750	1.270	1.225	1.183	1.108	1.041
725	1.227	1.184	1.144	1.071	1.006
700	1.185	1.143	1.104	1.033	0.971
675	1.142	1.102	1.064	0.996	0.937
650	1.100	1.061	1.025	0.959	0.902
625	1.057	1.020	0.985	0.922	0.867
600	1.015	0.979	0.945	0.885	0.832
575	0.972	0.938	0.906	0.848	0.797
550	0.930	0.897	0.866	0.811	0.762
525	0.887	0.856	0.827	0.774	0.727
500	0.845	0.815	0.787	0.737	0.692
475	0.802	0.774	0.747	0.700	0.658
450	0.760	0.733	0.708	0.663	0.623
425	0.717	0.692	0.668	0.625	0.588
400	0.674	0.651	0.628	0.588	0.553
375	0.632	0.610	0.589	0.551	0.518
350	0.589	0.569	0.549	0.514	0.483
325	0.547	0.528	0.510	0.477	0.448
300	0.504	0.487	0.470	0.440	0.414
275	0.462	0.446	0.430	0.403	0.379
250	0.419	0.405	0.391	0.366	0.344
225	0.377	0.363	0.351	0.329	0.309
200	0.334	0.322	0.311	0.292	0.274
175	0.292	0.281	0.272	0.254	0.239
150	0.249	0.240	0.232	0.217	0.204
125	0.207	0.199	0.193	0.180	0.169
100	0.164	0.158	0.153	0.143	0.135
75	0.122	0.117	0.113	0.106	0.100

Moist air density (gms/liter) = 1.2929 x (273.13/T) x ((P–Vp)/760)

T = Absolute air temperature (°Kelvin)

P = Barometric pressure (mm of mercury)

Vp = Vapor pressure of water (see table in WATER Chapter)

ELEVATION vs AIR & WATER

Elevation Meters	Elevation Feet	US Std Atmosphere Temp °F	US Std Atmosphere Pressure lbs/sq in	Boiling Point H_2O (°F)	Speed Sound m/sec
-1000	-3280	70.7	16.52	217.9	344.1
-500	-1640	64.9	15.59	215.1	342.2
0	0	59.0	14.70	212.0	340.3
250	820	56.1	14.26	210.6	339.3
500	1640	53.2	13.85	208.9	338.4
750	2461	50.2	13.44	207.5	337.4
1000	3281	47.3	13.03	206.1	336.4
1250	4101	44.4	12.64	204.4	335.5
1500	4921	41.5	12.26	203.0	334.5
1750	5742	38.5	11.89	201.6	333.5
2000	6562	35.6	11.53	199.9	332.5
2500	8202	29.8	10.83	197.1	330.6
3000	9843	23.9	10.17	194.0	328.6
3500	11483	18.1	9.54	190.4	326.6
4000	13123	12.2	8.94	188.1	324.6
4500	14764	6.4	8.38	184.8	322.6
5000	16404	0.5	7.84	181.9	320.5
5500	18045	-5.3	7.33	178.9	318.5
6000	19685	-11.1	6.85	175.8	316.5
6500	21325	-17.0	6.39	172.8	314.4
7000	22966	-22.8	5.96	169.7	312.3
7500	24606	-28.6	5.56	166.6	310.2
8000	26247	-34.5	5.17	163.6	308.1
8500	27887	-40.3	4.81	160.5	305.9
9000	29528	-46.2	4.47	157.5	303.8
9500	31168	-52.0	4.15	154.4	301.7
10000	32808	-57.8	3.84	151.3	299.5
11000	36089	-69.5	3.29	145.0	295.2
12000	39370	-69.5	2.81	138.9	295.1
13000	42651	-69.5	2.41	133.0	295.1
14000	45932	-69.5	2.06	127.0	295.1
15000	49212	-69.5	1.74	121.3	295.1
16000	52493	-69.5	1.50	115.7	295.1
17000	55774	-69.5	1.28	110.3	295.1
18000	59055	-69.5	1.10	104.7	295.1
19000	62336	-69.5	.94	99.7	295.1
20000	65617	-69.5	.80	94.5	295.1
25000	82021	-60.9	.37	70.5	298.4
30000	98425	-52.0	.17	49.3	301.7
32000	104986	-48.5	.13	41.5	303.0

1 mm Hg @ 0°C = 0.019336 lbs/sq in = 1 Torr

AIR TOOL REQUIREMENTS

Tool Category	Tool CFM	Tool Category	Tool CFM
Air Filter Cleaner	3	Hydr Lift 8000 lb	6*
Air Hammer	4	Hydr Floor Jack	6*
Air Hoist 1000#	5	Impact Wrenches: ...	
Air Motor 1 hp	6–10	1/4 inch drive	3
Air Motor 2 hp	12–15	3/8 inch drive	2–5
Air Motor 3 hp	18–20	1/2 inch drive	4–8
Bead Breaker	12*	3/4 inch drive	7–9
Bench Rammer	5	1 inch drive	10
Body Polisher	2	1 1/4 inch drive ...	14
Body Orbital Sander .	5	Nutsetter – 3/8 inch ..	3–6
Brake Tester	4	Nutsetter – 3/4 inch ..	5–8
Burr Tool – small	4	Pneu. Garage Door ..	3*
Burr Tool – large	5–6	Radiator Tester	1
Carbon Remover	3	Rammers – small	3
Chain Saw	7–22	Rammers – medium .	9
Circle Saw – 8 inch ..	12	Rammers – large	10
Circle Saw – 12 inch .	17	Sander – 5 in Pad ...	8–10
Compression Riviter .	1	Sander – 7 in Pad ...	15
Die Grinder	4–6	Sander – 9 in Pad ...	17–20
Drill 1/16–3/8 inch ...	4–6	Screwdriver #2–#6 ..	1–3
Drill 3/8–5/8 inch	7–8	Screwdriver #6–up ..	3–6
Dust blow gun	3	Spray Cleaner	5
File/Saw Machine ...	3–5	Spray Paint Guns: ...	
Floor Rammer	7	Standard	5
Grease Gun	3*	Production	9
Grinder – 2 in Horz ..	5–10	Touch–up	4
Grinder – 4 in Horz ..	15	Undercoat	19
Grinder – 6 in Horz ..	15–17	Tamper Backfill	6–15
Grinder – 8 in Horz ..	20	Tapper – 3/8 inch ...	3–5
Grinder – 5 in Vert ...	8–10	Tire Changer	1*
Grinder – 7 in Vert ...	14–15	Tire inflation	2*
Grinder – 9 in Vert ...	17–20	Tire Rim Stripper	6*
Hammer – Chip	8	Tire Spreader	1*
Hammer – Fender ...	9	Transmission Flusher	3
Hammer – Rivet	8–15		
Hammer – Scale	3–4		
Hammer – Tire	12		
Hoist – Cyl type	2		

NOTE: Most tools listed above are rated at 90 to 100 pounds/sq inch, however, those items with a "★" next to the cfm rating require 125 to 160 pounds/sq inch.

Always check the manufacturers recommendations for both air pressure (psi – pounds per sq inch) and air flow (cfm – cubic feet per minute) requirements. The ratings listed above are only averages based on a 25% load factor (running 25% of the time).

CFM vs PSI FOR NOZZLES

Gage PSI	CFM Free Air Flow @ Nozzle Diameter (inch) 1/64	1/32	3/64	1/16
1	0.03	0.11	0.2	0.4
5	0.06	0.24	0.5	1.0
10	0.08	0.34	0.8	1.4
15	0.10	0.42	0.9	1.6
20	0.12	0.48	1.1	1.9
25	0.13	0.54	1.2	2.2
30	0.16	0.63	1.4	2.5
40	0.19	0.77	1.7	3.1
50	0.22	0.91	2.0	3.6
60	0.26	1.05	2.3	4.2
70	0.29	1.19	2.7	4.8
80	0.33	1.33	3.0	5.3
90	0.36	1.47	3.3	5.9
100	0.40	1.61	3.7	6.4
110	0.43	1.76	3.9	7.0
120	0.47	1.90	4.3	7.6
130	0.50	2.04	4.6	8.1
140	0.54	2.17	4.9	8.7
150	0.57	2.33	5.2	9.2
175	0.66	2.65	5.9	10.6
200	0.76	3.07	6.9	12.2

PSI	3/32	1/8	3/16	1/4
1	1.0	1.7	3.9	6.8
5	2.2	3.9	8.7	15.4
10	3.1	5.4	12.3	21.8
15	3.7	6.6	15.0	26.7
20	4.2	7.7	17.1	30.8
25	4.7	8.6	19.4	34.5
30	5.6	10.0	22.5	40.0
40	6.8	12.3	27.5	49.1
50	8.2	14.5	32.8	58.2
60	9.4	16.8	37.5	67.0
70	10.7	19.0	43.0	76.0
80	11.9	21.2	47.5	85.0
90	13.1	23.5	52.5	94.0
100	14.5	25.8	58.3	103.0
110	15.7	28.0	63.0	112.0
120	17.0	30.2	68.0	121.0
130	18.2	32.4	73.0	130.0
140	19.5	34.5	78.0	138.0
150	20.7	36.7	83.0	147.0
175	23.8	42.1	95.0	169.0
200	27.5	48.7	110.0	195.0

PSI = pounds/square inch; CFM = cubic feet/minute

AIR HOSE FRICTION

Hose Size (inch)	CFM thru 50 ft Hose	Gage Pressure – Pounds/sq inch 50	70	90	110
		PSI Loss Over 50 foot Hose Length			
1/2	20	1.8	1.0	0.8	0.6
	30	5.0	3.4	2.4	2.0
	40	10.1	7.0	5.4	4.3
	50	18.1	12.4	9.5	7.6
	60	+	20.0	14.8	12.0
	70	+	28.4	22.0	17.6
	80	+	+	30.5	24.6
	90	+	+	41.0	33.3
	100	+	+	+	44.5
	110	+	+	+	+
3/4	20	0.4	0.2	0.2	0.1
	30	0.8	0.5	0.4	0.3
	40	1.5	0.9	0.7	0.5
	50	2.4	1.5	1.1	0.9
	60	3.5	2.3	1.6	1.3
	70	4.4	3.2	2.3	1.8
	80	6.5	4.2	3.1	2.4
	90	8.5	5.5	4.0	3.1
	100	11.4	7.0	5.0	3.9
	110	14.2	8.8	6.2	4.9
	120	+	11.0	7.5	5.9
	130	+	+	9.0	7.1
1	20	0.1	0.0	0.0	0.0
	30	0.2	0.1	0.1	0.1
	40	0.3	0.2	0.2	0.2
	50	0.5	0.4	0.3	0.2
	60	0.8	0.5	0.4	0.3
	70	1.1	0.7	0.6	0.4
	80	1.5	1.0	0.7	0.6
	90	2.0	1.3	0.9	0.7
	100	2.6	1.6	1.2	0.9
	110	3.5	2.0	1.4	1.1
	120	4.8	2.5	1.7	1.3
	130	7.0	3.1	2.0	1.5

PSI = Pressure in pounds/square inch
CFM = Air flow in cubic feet/minute

" + " means pressure loss is too great and therefore, the combination of Hose Size, CFM, and Gage Pressure is not recommended. Gage Pressure is the indicated air pressure, in pounds/square inch, at the source (ie, the air compressor receiver tank).

AIR LINE RECOMMENDED SIZES

Air Flow CFM	Length of Air Line in Feet 50	100	200	300
	Recommended Air Line Size in Inches			
1-5	1/2	1/2	1/2	1/2
6-10	1/2	3/4	3/4	3/4
11-15	3/4	3/4	3/4	3/4
16-20	3/4	3/4	3/4	3/4
21-25	3/4	3/4	1	1
26-30	3/4	3/4	1	1
31-35	3/4	1	1	1
36-40	1	1	1	1
41-59	1	1	1	1
60-79	1	1	1-1/4	1-1/4
80-100	1-1/4	1-1/4	1-1/2	1-1/2

AIR RECEIVER CAPACITIES

Tank Size (inches)	Tank Size (gallons)	Gauge Pressure on Tank (PSI) 0	100	150	200
		Cubic Feet Tank Capacity			
12 x 24	10	1.3	11	15	19
14 x 36	20	2.7	21	30	39
16 x 36	30	4.0	31	45	59
20 x 48	60	8.0	62	90	117
20 x 63	80	10.7	83	120	156
24 x 68	120	16.0	125	180	234
30 x 84	240	32.0	250	360	467

If your tank is not listed in the above table, use the following formula to calculate the Tank Size (gallons) and then estimate that Cubic Feet Tank Capacity at a given pressure from the table above.

$$\text{Tank Gallons} = \frac{\text{Tank Height} \times (\text{Tank Radius})^2}{73.53}$$

Height and Radius are in inches.

AIR POLLUTION SAFE LIMITS [1]

Pollutant	Safe Exposure 8hr/day, 5days/week
Asbestos	5 million parts/cubic foot
Benzene	80 mg/m^3
Bromine	0.7 mg/m^3
Cadmium	0.2 mg/m^3
Carbon dioxide	9,000 mg/m^3
Carbon disulfide	60 mg/m^3
Carbon monoxide	55 mg/m^3
Carbon tetrachloride	65 mg/m^3
Chlorine	1.5 mg/m^3
Chloroform	240 mg/m^3
Chromic acid	0.1 mg/m^3
Cresol	22 mg/m^3
Freon–12	4,950 mg/m^3
Freon–21	4,200 mg/m^3
Ethyl alcohol	1,900 mg/m^3
Ether	1,200 mg/m^3
Fluorine	0.02 mg/m^3
Formaldehyde	6 mg/m^3
Gasoline	1,800 to 2,000 mg/m^3
Hydrochloric acid	7 mg/m^3
Hydrogen cyanide	11 mg/m^3
Iodine	1 mg/m^3
Iron oxide	10 mg/m^3
Isopropyl alcohol	980 mg/m^3
Lead	0.2 mg/m^3
Manganese	5 mg/m^3
Mercury	0.01 mg/m^3
Methyl alcohol	260 mg/m^3
Naptha (coal tar)	400 mg/m^3
Naptha (petroleum)	2,000 mg/m^3
Nitric oxide	30 mg/m^3
Nitrogen dioxide	9 mg/m^3
Propane	1,800 mg/m^3
Selenium	0.2 mg/m^3
Sulfur dioxide	13 mg/m^3
Sulfuric acid	1 mg/m^3
Tellurium	0.1 mg/m^3
Tetraethyl lead	0.075 mg/m^3
Toluene	750 mg/m^3
Turpentine	560 mg/m^3
Vinyl chloride	1,300 mg/m^3
Zinc oxide	5 mg/m^3

(1) *American Industrial Hygiene Association*

See also WATER Chapter for pollution, page 386

POCKET REF

Automotive

(See ELECTRICAL for more wiring tables, p. 107)
(See HARDWARE for Bolt Torques, page 249)
(See also GLUE for paint types, page 235)

ANTIFREEZE TABLE

Cooling System Capacity Quarts	Temperature Rating °F at Quarts of Antifreeze Required: 3	4	5	6
8	-7	-34	-68	
9	0	-21	-50	-84
10	4	-12	-34	-62
11	8	-6	-23	-47
12	10	0	-15	-34
13	13	3	-9	-25
14	15	6	-5	-17
15	16	8	0	-12
16	17	10	2	-7
17	18	12	5	-4
18	19	14	7	0
19	20	15	9	2
20		16	10	4

Cooling System Capacity Quarts	Temperature Rating °F at Quarts of Antifreeze Required: 7	8	9	10
8				
9				
10	-84			
11	-69	-84		
12	-58	-74		
13	-45	-66	-84	
14	-34	-53	-74	-84
15	-26	-43	-62	-76
16	-19	-34	-53	-68
17	-14	-27	-43	-59
18	-10	-21	-34	-51
19	-7	-16	-28	-42
20	-3	-12	-22	-34

NOTE: Never use more that 70% antifreeze in a cooling system or the antifreeze and boiling properties of the mixture become unfavorable. Commercial automotive antifreeze is an ethylene glycol based solution that, when mixed with radiator water, lowers the temperature at which the radiator water will freeze and also increases the temperature at which the water will boil. A 50% solution of antifreeze and water will increase the boiling point to 265° F and a 70% solution will increase it to 276° F. Ethylene glycol is actually the chemical "1,2 Ethanediol" and has a chemical formula of $HOCH_2CH_2OH$. Antifreeze is poisonous and if swallowed, give two glasses of water, induce vomiting and call a physician. Portions of the above information are based on *Prestone Anti Freeze by Union Carbide Corp.*

SPARK PLUG TORQUE

Spark Plug Thread Size	Aluminum Head Ft Lbs	Aluminum Head Kg M	Iron Head Ft Lbs	Iron Head Kg M
10mm (Gasket)	8-11	1.1-1.5	8-12	1.1-1.7
12 mm (Gasket)	10-18	1.4-2.5	10-18	1.4-2.5
14 mm (Gasket)	18-22	2.5-3.0	26-30	3.6-4.1
14 mm (Taper seat)	7-15	1.0-2.1	7-15	1.0-2.1
18 mm (Gasket)	28-34	3.9-4.7	32-38	4.4-5.2
18 mm (Taper seat)	15-20	2.1-2.8	15-20	2.1-2.8
7/8-18 inch (Gasket)	31-39	4.3-5.4	31-39	4.3-5.4

NOTE: If the engine manufacturers' torque specification is available, it should always take precedence over the values in the above table. Even with the above torque ranges, exercise care when tightening the spark plugs, since condition of the head threads, length of the threads and temperature all have an effect on the maximum torque. If a torque wrench is not available, simply tighten spark plug down to finger tight and then wrench tighten an additional 1/4 turn with gasket type plugs or 1/16 turn with taper seat plugs. It is recommended that a small amount of antiseize compound be used on threads in aluminum heads and a small amount of light weight oil be used in cast iron heads.

For additional information on torque ratings of various bolt specifications, see the HARDWARE Chapter, page 249.

LEAD–ACID BATTERY SPECIFIC GRAVITY & CHARGE

Acids Specific Gravity	Charge Level
1.30 to 1.32	Overcharged
1.26 to 1.28	100%
1.24 to 1.26	75%
1.20 to 1.22	50%
1.15 to 1.17	25%
1.13 to 1.15	Very low capacity
1.11 to 1.12	Discharged

Battery Efficiency Changes with Temperature

80°F = 100% Charge	10°F = 50% Charge
50°F = 82% Charge	0°F = 40% Charge
30°F = 64% Charge	–10°F = 33% Charge
20°F = 58% Charge	–20°F = 18% Charge

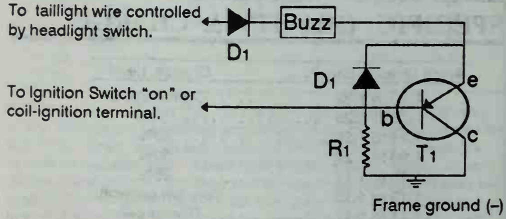
OIL VISCOSITY vs TEMPERATURE

Engine Oil SAE Viscosity	Outside Temperature °F -20	0	20	40	60	80	100
20W-20	no	no	yes	yes	yes	yes	yes
20W-40	no	no	yes	yes	yes	yes	yes
20W-50	no	no	yes	yes	yes	yes	yes
10W-30	no	yes	yes	yes	yes	yes	yes
10W-40	no	yes	yes	yes	yes	yes	yes
10W	no	yes	yes	yes	yes	no	no
5W-30	yes	yes	yes	yes	yes	no	no
5W-20	yes	yes	no	no	no	no	no

Gear Oil SAE Viscosity	Outside Temperature °F -20	0	20	40	60	80	100
75W	yes	yes	yes	yes	no	no	no
80W	yes	yes	yes	yes	yes	yes	no
80W-90	yes	yes	yes	yes	yes	yes	yes
85W	no	no	yes	yes	yes	yes	no
90	no	no	no	no	yes	yes	yes
140	no	no	no	no	yes	yes	yes

Note: Values listed above are for average conditions and may vary depending on the type of equipment being used. Manufacturers specifications should always take precedence over the above tables.

AUTO HEADLIGHT WARNING



This simple circuit will buzz if you leave your headlights turned on when the ignition switch is turned off!

R1 = 150 ohm resistor, 10 watt
D1 = Silicon rectifier, almost any size such as 50 volt, 3 amp
Buzz = Small 12 volt buzzer
T1 = PNP 35 watt silicon switching transistor
"To taillight" is the wire that has 12 volts when the lights are ON
"To Ignition" is the wire that has 12 volts when the ignition is ON.

AUTOMOTIVE AIR CONDITIONING

WARNING: Air conditioning systems can be dangerous. Make sure you know what you are doing ! Read directions for your gauges, freon, and the system you are recharging FIRST.

General Recharging Steps:

1. If the system is completely empty, you will probably have to use a vacuum pump to evacuate the lines down to 28–29.5 in. of vacuum (reduce those numbers by 1 in of vacuum for every 1000 feet of altitude where you live). Vacuum pumps are expensive, you may want to have this task done at a garage.

2. Attach a pressure gauge to the low pressure side of the system and run the air conditioner for 15 minutes to stabilize the system. (Leave the high pressure side alone unless absolutely necessary to check the compressor). Use the following table to establish the desired interior cooling value (column 1); normally you should use about 35 psi for a temp of 38°F:

Temperature / Gauge Pressure Chart for R-12 Freon

Evaporator Temp °F (Inside Car)	Low Pressure Reading in PSI (Evaporator side)	High Pressure Reading in PSI (Head side)	Condenser Temp °F
16	18	132	72
18	20	137	74
20	21	144	76
22	22	152	78
24	24	160	80
26	25	165	82
28	27	170	84
30	28	175	86
32	30	180	88
34	32	185	90
36	33	189	92
38	35	193	94
40	37	200	96
42	39	210	98
44	41	220	100
46	43	228	102
48	45	236	104

3. If one or both of the low pressure or high pressure readings are HIGHER than shown in the table above for the desired interior temperature, **DO NOT ADD REFRIGERANT!** If it is not cooling properly at this point, you should seek professional help from a qualified service representative. Overcharging the system can be dangerous not only to yourself but also to the system. If outside air temp is less than condenser temp, no air conditioning!

Automotive Air Conditioning by Boyce Dwiggins, 1983. Delmar Publishers, is an excellent reference for auto air conditioning work.

AUTOMOTIVE ELECTRIC WIRING

Wire Gauge AWG	Maximum Wire Length (feet) for Car Wiring (1) Current Load in Amps @ 12 Volts DC (2) 1	2	4	6	8	10
20	106	53	26	17	13	nr
18	150	75	37	25	18	15
16	224	112	56	37	28	22
14	362	181	90	60	45	36
12	572	286	143	95	71	57
10	908	454	227	151	113	90
8	1452	726	363	241	181	145
6	2342	1171	585	390	292	234
4	3702	1851	925	616	462	370
2	6060	3030	1515	1009	757	606
1	7692	3846	1923	1280	961	769
0	9708	4854	2427	1616	1213	970

Wire Gauge AWG	Maximum Wire Length (feet) for Car Wiring (1) Current Load in Amps @ 12 Volts DC (2) 12	15	20	50	100	200
20	nr	nr	nr	nr	nr	nr
18	12	nr	nr	nr	nr	nr
16	18	14	nr	nr	nr	nr
14	30	24	18	nr	nr	nr
12	47	38	28	nr	nr	nr
10	75	60	45	nr	nr	nr
8	120	96	72	29	nr	nr
6	194	155	117	46	23	nr
4	307	246	185	74	37	nr
2	503	403	303	121	60	30
1	638	511	384	153	76	38
0	805	645	485	194	97	48
000	1296	1039	781	312	156	78

(1) Maximum recommended wire lengths are based on a 1/2 volt maximum voltage drop over the length of the wire. If you want to determine lengths based on a different drop, simply multiply the table value by the appropriate factor (for example, if you want the values for a 1 volt drop, multiply the table value by 2).

(2) If you want the lengths for 6 volt or 24 volt systems, multiply the listed amperage by 0.5 for 6 volt or 2 for 24 volt and then select the wire length from the table.

"nr" means wire size is not recommended at selected current. To be safe, always pick one wire size larger than you need for the specified wire length at the required current level.

TIRE SIZE vs LOAD RATING

Tire Size (Bias, Bias-Belted, Radial)	Max Load lbs @ Cold Inflation 20 psi	32 psi
Passenger Car Tires:		
145R- 12 inch	600	780
6.00- 12 inch	605	845
155R- 12 inch	665	865
145/80R 12 inch	617	783
155/80R 12 inch	694	871
145R- 13 inch	660	825
145R- 13 inch	665	860
155R- 13 inch	730	950
155/80R- 13 inch	740	925
165/70R- 13 inch	750	880
6.00-, 165R-, 165/75R- 13 inch	770	1010
175/70R- 13 inch	845	980
165/80R- 13 inch	816	1025
195/60R- 13 inch	825	1035
215/50R- 13 inch	840	1050
175/75R- 13 inch	850	1060
A78-, A70-, AR78-, AR70-, 13 inch	810	1060
205/60R- 13 inch	835	1085
185/70R- 13 inch	870	1090
195/65R- 13 inch	880	1115
175/80R- 13 inch	905	1135
B13, 175R-, 205/60R- 13 inch	890	1150
6.50-,B78-,B70-,175R-,BR78-,BR70-,BR60-13	890	1150
185/75R- 13 inch	925	1170
195/70R- 13 inch	948	1190
195/70R- 13 inch	1045	1210
235/50R- 13 inch	970	1220
C-, C78-, C70-, CR78-, CR70-, 185/70R- 13 inch	950	1230
185/80R- 13 inch	990	1250
7.00-, 185R- 13 inch	980	1270
205/70R- 13 inch	1040	1300
D70-, DR78-, DR70- 13 inch	1010	1320
195R- 13 inch	1060	1370
E70-, ER78-, ER70-, ER60- 13 inch	1070	1400
155R- 14 inch	780	1010
A70-, AR70- 14 inch	810	1060
6.45-, 165R- 14 inch	860	1120
B78-, B70-, BR78-, BR70- 14 inch	890	1150
6.95- 14 inch	950	1230
C78-, C70-, CR78-, CR70- 14 inch	950	1230
D78-, D70-, DR78-, DR70-, 195/70- 14 inch	1010	1320
7.35-, 185R- 14 inch	1040	1360
E78-, E70-, ER78-, ER70-, 205/70- 14 inch	1070	1400
7.75-, 195R- 14 inch	1150	1500
F78-,F70-,F60-,FR78-,FR70-,FR60-,215/70-14	1160	1500
8.25-, 205R- 14 inch	1250	1620
G78-,G70-,G60-,GR78-,GR70-,GR60- 14 inch	1250	1620
8.55-, 215R- 14 inch	1360	1770
H78-, H70-, H60-, HR78-, HR70- 14 inch	1360	1770
8.85-, 225R- 14 inch	1430	1860
6.85-, C78-, C70-, 175R-, CR78-, CR70- 15 inch	950	1230
D78-, D70- 15 inch	1010	1320
7.35-, 185R- 15 inch	1070	1390
E78-,E70-,E60-,ER78-,ER70-,ER60-,205/70-15	1070	1400
7.75-, 195R- 15 inch	1150	1490
F78-,F70-,F60-,FR78-,FR70-,FR60-,215/70-15	1160	1500
205R- 15 inch	1240	1610
G78-,G70-,G60-,GR78-,GR70-,GR60-,225/70-15	1250	1620
8.25- 15 inch	1250	1620
215R- 15 inch	1340	1740

TIRE SIZE vs LOAD RATING

Tire Size (Bias, Bias-Belted, Radial)	Max Load lbs @ Cold Inflation 20 psi	32 psi
H78-,H70-,H60-,HR78-,HR70-,HR60- 15 inch	1360	1770
8.55- 15 inch	1360	1770
8.85-, 225R- 15 inch	1430	1860
J78-, J70-, J60-, JR78-, JR70- 15 inch	1430	1860
9.00- 15 inch	1460	1900
K70-, KR70- 15 inch	1460	1900
9.15-, 235R- 15 inch	1510	1970
L78-, L70-, L60-, LR78-, LR70-, LR60- 15 inch	1520	1970
205/55R- 16 inch	890	1150
225/50R- 16 inch	1000	1300
245/50R- 16 inch	1200	1510
255/50R- 16 inch	1280	1610

Light Truck Tires: (single tire) Tire Size (Bias, Bias-Belted, Radial)	Max Load lbs @ Cold Inflation 35 psi *Radial* / 30 psi *Bias*	60 psi / 75 psi
E-, ER78-14LT	1140	1620
G-, GR78-14LT	1260	—
G-, GR78-15LT	1310	1870
H-, HR78-15LT	1440	2060
L-, LR78-15LT	1600	2290
F-, FR78-16LT	1270	1820
H-, HR78-16LT	1510	2150
L-, LR78-16LT	1670	2380
6.70-15LT	1210	2060
7.00-15LT	1350	2320
6.50-16LT	1270	2160
7.50-16LT	1620	2780
8.00-16.5LT	1360	2330
8.75-16.5LT	1570	2680
9.50-16.5LT	1860	3170
10.00-16.5LT	1840	3135
12.00-16.5LT	2370	4045
LT195/75-14	1115	1625
LT195/75-15	1165	—
LT215/75-15	1345	1960
LT235/75-15	1530	2230
LT255/75-16	1920	2800
	30 psi *radial* / 20 psi *belted*	50 psi / 45 psi
27 x 8.50-14LT	940	1515
30 x 9.50-15LT	1240	1990
31 x 10.50-15LT	1400	2250
31 x 11.50-15LT	1455	2340
32 x 11.50-15LT	1575	2530
33 x 12.50-15LT	1755	—

NOTE: Always check the current manufacturers specifications on a tire to verify the above approximations. If you want detailed information on tires, sizes, recommendations for different cars, etc, use a book entitled *"1986 Tire Guide" (get one for the current year), published by Bennett Garfield Publishers, 1101-6 S. Rogers Circle, Boca Raton, FL, 33487, (407) 997-9229.* Cost of the book is only $5.00 and contains an abundance of information.

TIRE MANUFACTURER CODES

Manufacturer	Codes
Alliance Tire & Rubber (Israel)	CD
Armstrong Rubber	CE, CF, CH, CV
Avon Rubber (England)	AT
B.F. Goodrich	BA to BP
Bridgestone Tire	EH to EP
Carlisle Tire & Rubber	UU
CEAT (Italy)	HT, HU, HV
Continental Gummiwerke	CM to CU
Copper Tire & Rubber	UP, UT
Dayton Tire & Rubber	HX and HY
Denman Rubber Mfg	DY
Dunlop Tire & Rubber	DA to DU
Firestone Tire & Rubber	VA to VY, WA to WJ
Gates Rubber	BW, BX, BY
General Tire	AA to AH
Goodyear Tire & Rubber	MA to MY, NA to NY, PA to PF
Hung Ah Tire (Korea)	EF
Inoue Rubber (Japan)	CJ
IRI International Rubber	BV
Kelly–Springfield Tire	PH to PY, TA to TY, UA to UN
Kleber-Colombes	EV to EY
Kyowa Rubber Industry (Japan)	UV
Lee Tire & Rubber	JA to JY, KA to KY, LA to LF
Madras Rubber (India)	WT
Mansfield-Denman (Canada)	LV, WL
McCreary Tire & Rubber	CY
Metzeler A.G.	EA, EB, EC
Michelin Tire	FF to FY, HA to HP
Mitsuboshi Belting	LX, LY
Mohawk Rubber	CA, CB, CC
Nitto Tire (Japan)	EE
Okamoto Riken Gomu (Japan)	ED
Olympic Tire & Rubber (Aust.)	WM, WN
Phoenix Gummiwerke A.G.	AX, AY
Pirelli Tire	XA to XP
Samson Tire & Rubber	AW
Semperit Gummiwerke A.G.	BT, BU
Sieberling Tire and Rubber	AV
Sumitomo Rubber Industries	ET, EU
Toyo Rubber Industry	CW, CX
Trelleborg Rubber (Sweden)	LW
Uniroyal, Inc	AJ to AP, LH to LU, AU
Veith-Pirelli A.G.	XT
Vredestine (Netherlands)	DV, DW, DX
Yokohama Rubber	FA to FE

NOTE: The number–letter tire code is located on the sidewall, near the rim and the letters "DOT", the code is "XXYY MMM999". The "XX" is the Manufacturer, the "YY" is the tire size (another letter type code), "MMM" is an optional tire type code, and "999" is the Date of Manufacture. In the above coding system, the letters "G", "I", "O", "Q", "R", "S", "Z", and the number "0" are never used. If you need more specific information on Manufacturer Codes, you can obtain a detailed list *(PART 574–TIRE CODE)* of the codes from the *Department of Transportation (DOT)*.

TIRE SIZE CODES

Conventional Coding:

9.50R-15C

9.50 = Tire section width
R = Radial ply construction (no letter if Bias)
15 = Rim diameter in inches
C = Load Range

LR60-15B-HR

L = Load Range
R = Radial ply construction (no letter if Bias)
60 = Aspect ratio, 60 means the section height is 60% as great as the width
15 = Rim Diameter in inches
B = Load Range
HR = Speed rating: HR = 112 mph, SR = 130 mph, VR = 165 mph maximum allowable safe speed

Metric Coding:

P215/75R-15

P = P is passenger car, LT is light truck.
215 = Tire section width in millimeters
75 = Aspect ratio (see description above)
R = Radial ply construction (no letter if Bias)
15 = Rim diameter in inches

LOAD RANGE vs PLY RATING

Load Range	Ply Rating	Load Range	Ply Rating
A	2	G	14
B	4	H	16
C	6	J	18
D	8	L	20
E	10	M	22
F	12	N	24

AUTOMOTIVE FORMULAS

Engine Displacement = Stroke x Bore^2 x 0.7854 x Cylinders
Engine Displacement is in cubic inches if Bore and Stroke are in inches or cubic centimeters (cc's) if Bore and Stroke are in centimeters.
Cylinders is the number of engine cylinders (4, 6, 8, etc)

CFM Engine Carburetor Air Flow:

$$\text{4 Stroke Engine CFM} = \frac{\text{CID} \times \text{RPM} \times \text{VE}}{3456}$$

CFM is Cubic Feet per Minute air flow through the carburetor.
CID is the engine displacement in cubic inches.
RPM is the engine Revolutions Per Minute.
VE is the engine Volumetric Efficiency, use 1 for 100% efficient.
(For a **2 Stroke Engine**, divide by 1728, not 3456)

Carpentry and Construction

(See also HARDWARE on page 249)
(See also PLUMBING on page 317)
(See also GLUE on page 235)

SOFTWOOD LUMBER SIZES

Nominal Size (Inches)	Actual Size Dry (Inches)	Actual Size Green (Inches)
THICKNESS:		
1	3/4	25/32
1-1/4	1	1-1/32
1-1/2	1-1/4	1-9/32
2	1-1/2	1-9/16
2-1/2	2	2-1/16
3	2-1/2	2-9/16
3-1/2	3	3-1/16
4	3-1/2	3-9/16
4-1/2	4	4-1/16
6	5-1/2	5-9/16
8	7-1/2	7-9/16
FACE WIDTH:		
2	1-1/2	1-9/16
3	2-1/2	2-9/16
4	3-1/2	3-9/16
5	4-1/2	4-5/8
6	5-1/2	5-5/8
7	6-1/2	6-5/8
8	7-1/4	7-1/2
9	8-1/4	8-1/2
10	9-1/4	9-1/2
11	10-1/4	10-1/2
12	11-1/4	11-1/2
14	13-1/4	13-1/2
16	15-1/4	15-1/2

Dry lumber is defined as lumber with less than 19 percent moisture and green is greater than 19 percent. All sizes listed above, both nominal and actual, conform to standards set by the *American Softwood Lumber Standards*.

Lumber is sold by a "feet board measure" or "board foot" rating. 1 board foot = 244 square inches (12 inch x 12 inch x 1 inch).

Board feet = thickness (in) x face width (in) x length (in)/144
or = thickness (in) x face width (in) x length (ft)/12

The following are quick approximations for calculating board feet:
- for a 1 x 4, divide linear length (feet) by 3
- for a 1 x 6, divide linear length (feet) by 2
- for a 1 x 8, multiply linear length (feet) by 0.66
- for a 1 x 12, linear length (feet) = board feet
- for a 2 x 4, multiply linear length (feet) by 0.66
- for a 2 x 6, linear length (feet) = board feet
- for a 2 x 8, multiply linear length (feet) by 1.33
- for a 2 x 12, multiply linear length (feet) by 2

SOFTWOOD LUMBER GRADING

Softwood grading is based on the appearance, strength and stiffness of lumber. Grading systems are established by a variety of associations in different parts of the country but they all must follow the US Department of Commerce American Lumber Standards. The grading system is quite long and very detailed *If you want more detailed information on softwood grading, obtain the book "Western Lumber Grading Rules 88" by the Western Wood Products Association, 522 S.W. Fifth, Portland, Oregon, 97204, (503)224-3930. The cost is only $7.00 and it is an excellent pocket reference.*

Softwood lumber comes from "conifer" trees, which means they have needle shaped leaves that stay green all year. Hardwoods come from "deciduous" trees, which means they have broad leaves and loose their leaves in the cold months. A list of tree types and their characteristics is given later in this chapter.

The first broad softwood classification is as follows:

Rough Lumber – Sawn, trimmed, and edged, but the faces are rough and show saw marks.

Surfaced Lumber (dressed) – Rough lumber that has been smoothed by a surfacing machine. Sub-categories are based on the number of sides and edges that have been smoothed:

- **S1S** – Sawn 1 Side
- **S1E** – Sawn 1 Edge
- **S2S** – Sawn 2 Sides
- **S2E** – Sawn 2 Edges
- **S1S1E** – Sawn 1 Side and 1 Edge
- **S1S2E** – Sawn 1 Side and 2 Edges
- **S2S1E** – Sawn 2 Sides and 1 Edge
- **S4S** – Sawn 4 Sides
- **S/S** – Saw Sized (resawn)

Worked Lumber – Surfaced lumber that has been matched, patterned, shiplapped or any combination thereof.

Another broad softwood classification (which is not a subcategory of the first classification above) is as follows:

Shop and Factory Lumber – This is millwork lumber used for applications such as molding, door jambs, and window frames.

Yard Lumber – Lumber used for house framing, concrete forms, and sheathing. It is also known as structural lumber.

SOFTWOOD LUMBER GRADING

Yard or Structural softwood lumber is further subdivided into the following categories, based on size:

Boards – Lumber must be no more than 1 inch thick and 4 to 12 inches wide.

Planks – Lumber must be over 1 inch thick and more than 6 inches wide.

Timbers – Lumber width and thickness must both be greater than 5 inches.

The most common softwood grading system places lumber into three main categories. Once again, bear in mind that some of these categories are very detailed and long; for example, the specific description of "#2 Common Board" is almost 2 pages long and covers details such as degree of cupping, twist, wane, knots, and raising of grain. The following descriptions cover the primary system only, see a grading manual for more detail:

1. **Select and Finish Materials** – These are "Appearance" grades and are used primarily for interior and exterior trim work, moldings, cabinets, and interior walls. Select grades are based on the best face and Finish grades are based on the best face and 2 edges.
   - Select – B & BTR – 1 & 2 Clear
   - C Select
   - D Select
   - Superior Finish VG, FG or MG
   - Prime Finish VG, FG, MG
   - E Finish
2. **Boards** – Five grades referred to as "Commons" (1 Common through 5 Common) are used for general building, crafts, form lumber, flooring, sheathing, etc. "Alternate Board Grades" include the following (in order from best to worst):
   - Select Merchantable
   - Construction
   - Standard
   - Utility
   - Economy

   The final category of Boards is the "Stress Related Boards". These are special use products for light trusses, rafters, and box beams for factory built and mobile homes.

3. **Dimension Lumber** – This category is limited to surfaced softwood lumber that is 2 to 4 inches thick and is to be used as framing components. Category breakdowns are as follows:

Light Framing – General framing and stud walls. Up to 4 inch wide. Grades are as follows:
Construction (34% Bending Strength Ratio)
Standard (19% Bending Strength Ratio)

Structural Light Framing – This is suitable for higher stress applications such as roof trusses and concrete forms. Up to 4 inch wide. Grades are as follows:
Select Structural (67% Bending Strength Ratio)
No. 1 (55% Bending Strength Ratio)
No. 2 (45% Bending Strength Ratio)
No. 3 (26% Bending Strength Ratio)

Studs – Load bearing and stud walls of 2 x 4 and 2 x 6 construction. Lengths are less than 10 feet. Up to 4 inch wide and 5 inch and over. Stud grade is a 26% Bending Strength Ratio.

Structural Joists and Planks – Roof rafters, ceiling and floor joists. 5 inch and wider. Grades are as follows:
Select Structural (65% Bending Strength Ratio)
No. 1 (55% Bending Strength Ratio)
No. 2 (45% Bending Strength Ratio)
No. 3 (26% Bending Strength Ratio)

Timber – Heavy beam support and floor and ceiling supports.

Appearance Framing – High bend strength ratio, over 2 inch wide, and good appearance for special applications. Appearance Framing grade has a 55% Bending Strength Ratio.

If you are confused by the softwood grading scheme, don't feel bad, you're not alone! Grading is not an exact science since it deals with both visual and strength analysis. A maximum of 5% variation below grade is allowable between graders. Note that the above grading is only a small portion of the actual code, there are literally hundreds of different grades.

HARDWOOD LUMBER SIZE & GRADE

Hardwood comes from "deciduous" trees, which have broad leaves and loose their leaves in the cold months. Oak and walnut constitute 50% of all hardwood production. Other common hardwoods include Basswood, Beech, Birch, Butternut, Chestnut, Cherry, Elm, Gum, Hickory, Maple, Mahogany, and Yellow Poplar. See the section later in this chapter that describes wood types and their general characteristics.

HARDWOOD SIZES

Nominal Size (Fraction In)	Rough Size (Inches)	Surface 2 Sides Actual Size Dry (Inches)
4/4	1	13/16
5/4	1–1/4	1–1/16
6/4	1–1/2	1–5/16
7/4	1–3/4	1–1/2
8/4	2	1–3/4
10/4	2–1/2	2–1/4
12/4	3	2–3/4
14/4	3–1/2	3–1/4
16/4	4	3–3/4

HARDWOOD GRADES

Grading is simpler than that used for Softwood and appearance is the prime consideration. Grades are based on the appearance of the poorest side, assuming that the board will be cut into pieces that are 2 to 7 feet long, each of which will have one clear face. There are numerous other requirements for grades of each of the various tree species, but the general grades of hardwood as determined by the National Hardwood Lumber Association are as follows (Listed in order from best to worst):

First and Second (FAS) – The best grade. Normally required for a natural or stained finish. A FAS board must be at least 6 inches wide, 8 to 16 feet long, and 83.3% clear on the worst face.

Select – No. 1 Common – Minimum 3 inches wide, 4 to 16 feet long, 66.66% clear wood.

Select – No. 2 Common

Select – No. 3 Common

If you want detailed information on the grading of hardwood, obtain a copy of the Hardwood Rule Book, National Hardwood Association, P.O. Box 34518, Memphis, Tennessee, 38134. Cost of the book is $4.00. It is an excellent source book.

WOOD MOISTURE CONTENT

Moisture content in wood affects both the size and strength of lumber. In general, the physical properties of wood can be improved by seasoning or drying. Although dependent on the tree species type, the strength of wood decreases as the moisture content goes up. *The following table is from Circular 108 of the U.S. Forest Service.*

MOISTURE vs COMPRESSIVE STRENGTH

% Moisture	Red Spruce	Longleaf Pine	Douglas Fir
	Relative Maximum crushing strength compared to wood containing 2% moisture (compression parallel to the grain)		
2	1.000	1.000	1.000
4	0.926	0.894	0.929
6	0.841 (c)	0.790	0.850
8	0.756	0.702	0.774
10	0.681	0.623	0.714
12	0.617	0.552	0.643
14	0.554 (b)	0.488	0.589
16	0.505	0.431	0.535
18	0.463	0.377	0.494
20	0.426	0.328 (a)	0.458
22	0.394	0.278	0.428
24	0.362		0.398 (a)
26	0.335		
28	0.314		
30	0.292		
32	0.271		
34	0.255		

(a) Green wood
(b) Air dried
(c) Kiln dried

The above table clearly indicates that high moisture content in wood significantly decreases the woods strength. As an example, Longleaf Pine has half the strength (0.552) with 16% moisture as is does with 2% moisture.

Additional information can be obtained from U.S. Department of Agriculture Bulletin 282 and Technical Bulletin 479.

PLYWOOD & PANEL GRADING

Plywood is generally graded in terms of the quality of the veneer on both the front and back sides of the panel or by a "use type" name. Plywood is also grouped by the tree species type.

The American Plywood Association (APA) Veneer Grades

N..... Smooth surface "natural finish" veneer. Select, all heartwood or all sapwood. Free of open defects. Allows not more than 6 repairs, wood only, per 4 x 8 panel, made parallel to grain and well matched for grain and color.

A..... Smooth, paintable. Not more than 18 neatly made repairs, boat, sled, or router type, and parallel to grain, permitted. May be used for natural finish in less demanding applications.

B..... Solid surface. Shims, circular repair plugs and tight knots to 1 inch across grain permitted. Some minor splits permitted.

C..... **Plugged** Improved C veneer with splits limited to 1/8–inch width and knotholes and borer holes limited to 1/4 x 1/2 inch. Admits some broken grain. Synthetic repairs permitted.

C..... Tight knots to 1–1/2 inch. Knotholes to 1 inch across grain and some to 1–1/2 inch if total width of knots and knotholes is within specified limits. Synthetic or wood repairs. Discoloration and sanding defects that do not impair strength permitted. Limited splits allowed. Stitching permitted.

D..... Knots and knotholes to 2–1/2 inch width across grain and 1/2 inch larger within specified limits. Limited splits are permitted. Stitching permitted. Limited to Exposure 1 or Interior panels.

As an example, "C–D" grade panel would have one side conforming to the "C" grade and the other side conforming to the "D" grade. You must also specify the "Exposure Durability" (defined on the next page) to completely define the grade, e.g., EXTERIOR C–D.

NOTE: "CDX" is a very common grade of panel, but it does not have an "EXTERIOR" rating, it has an "EXPOSURE 1" rating.

A full description of the plywood and panel code can be obtained from the American Plywood Association P.O. Box 11700. Tacoma. Washington. 98411. (206) 565–6600.

EXPOSURE DURABILITY

EXTERIOR: Fully waterproof bond and designed for applications subject to permanent exposure to weather or moisture.

EXPOSURE 1: Fully waterproof bond but not for permanent exposure to weather or moisture.

EXPOSURE 2: Interior type with intermediate glue under PS 1. Intended for protected construction applications where slight moisture exposure can be expected.

INTERIOR: Interior applications only.

GROUP CLASSIFICATION OF SPECIES

Group 1	Group 2	Group 3	Group 4	Group 5
Apitong	Cedar–Port	Alder–Red	Aspen	Basswood
Beech–Amer.	Cedar-Oxford	Birch–Paper	Bigtooth	Poplar
Birch–Sweet	Cypress	Cedar-Alaska	Quaking	Balsam
Birch–Yellow	Douglas Fir 2	Fir-Subalpine	Cativo	
Fir 1-Douglas	Fir	Hemlock-East	Cedar	
Kapur	Balsam	Maple-Bigleaf	Incense	
Keruing	Calif. Red	Pine	West Red	
Larch–West.	Grand	Jack	Cottonwood	
Maple-Sugar	Noble	Lodgepole	Eastern	
Pine	Pacific-Silver	Ponderosa	Black	
Caribbean	White	Spruce	West Poplar	
Ocote	Hemlock	Redwood	Pine	
Pine South.	Lauan	Spruce	East White	
Loblolly	Almon	Engelmann	Sugar	
Longleaf	Bagtikan	White		
Shortleaf	Mayapis			
Slash	Red			
Tanoak-White	Tangile			
	Maple–Black			
	Mengkulang			
	Meranti–Red			
	Mersawa			
	Pine–Pond, Red, Virginia, Western White			
	Spruce–Black, Red, and Sitka			
	Sweetgum			
	Tamarack			
	Yellow Poplar			

Group numbers are used to define the strength and stiffness of the panel, Group 1 being the strongest, Group 5 the weakest.

WOOD CHARACTERISTICS

Wood Name	1988 Cost/ Brd Ft (1)	Density Lbs per Cubic Ft	Hard	Split Resist	Grain
Alder	$1.95	25–30	Med	Good	Low
Ash	$2.80	40–45	Hard	Good	Mod open
Aspen	$1.25	25	Soft	Good	Mild fine
Balsa	$2.50	8	V Soft	Good	Open
Basswood	$1.70	25–28	Soft	Good	Low, fine
Beech	$1.90	45	Hard	V Good	Mod, fine
Birch	$2.50	40–45	Hard	V Good	Mod, fine
Butternut		27	Med	Good	Mod
Cedar, East		29	M Hard	Poor	Fine, knots
Cedar, West	$0.85/1.80	25	Med	Poor	Fine
Cherry	$3.20	35	M Hard	V Good	Mod, fine
Chestnut		30	M Hard	Good	Mod, coarse
Cottonwood		25	Med	Good	Low, fine
Cypress	$2.30	35	M Hard	Poor	Wide, fine
Ebony	$24.00	50–65	V Hard	V Good	V Low, fine
Elm, American		35	M Hard	V Good	Mod, v fine
Elm, Rock		44	Hard	V Good	Mod, v fine
Fir, Douglas	$0.30/1.35	35	Med	Fair	Wide
Fir, White	$0.65	25	Med	Fair	Wide
Gum, Black		36	M Hard	V Good	Mod
Gum, Blue		50	Hard	V Good	Mod, open
Gum, Red	$3.15	35	M Hard	V Good	Mod
Hackberry		38	M Hard	Poor	Coarse
Hickory	$1.70	40–55	Hard	Good	Mod, pores
Holly		40	M Hard	V Good	None, fine
Ligum Vitae	$6.00 lb	80	V Hard	V Good	Mod, v fine
Madrone		45	Hard	Good	Mod, v fine
Magnolia	$1.70	35	M Hard	Good	Fine
Mahogany					
African		30	M Hard	Good	Open, figure
Cuban		40	Hard	Good	Open, figure
Honduras	$4.50	35	M Hard	Good	Open, figure
Phillippine			Not a Mahogany, see Phillippine.		
Maple (hard)	$1.85	35–44	M Hard	Good	Mod, fine
Myrtle		40	Hard	Good	Mod, fine
Oak	$3.75				
Amer. Red	$3.10	45	Hard	Good	Coarse, pores
Amer. White	$2.95	47	Hard	Good	Coarse, pores
English Brown		45	Hard	Good	Coarse, pores
Pecan	$1.70	47	Hard	Good	Fine, pores
Persimmon		55	Hard	V Good	V fine
Philippine:					
Red Luan	$2.60	36	M Hard	Good	Mod, coarse
Tanguile		39	M Hard	V Good	Mod, coarse

WOOD CHARACTERISTICS

Wood Name	1988 Cost/ Brd Ft (1)	Density Lbs per Cubic Ft	Hard	Split Resist	Grain
Pine, White:	0.40/2.35				
Northern		25	Soft	Poor	V coarse
Western		27	Soft	Poor	Mod, fine
Poplar, Yellow	$1.65	30	M Hard	Good	Mod, v fine
Redwood	$0.95/1.95	28	Med	Poor	Fine
Rosewood:					
Bolivian	$5.90	50	Hard	Good	Swirls,pores
East Indian	$11.00	55	Hard	Good	Mod
Satinwood	$6.20	67	V Hard	Good	Mod, fine
Spruce	$4.60	28	Med	Poor	Mod, fine
Sycamore	$1.20	35	M Hard	High	Mod, fine
Teak (Burma)	$8.00	45	Hard	High	Mod to High
Walnut:					
Amer Black	$4.20	38	Hard	Good	Mod, fine
Claro		30	M Hard	Good	Mod, open
European		35	M Hard	Good	Mod, open
Willow	$2.00	26	Soft	Good	Mod, fine
Zebrawood	$6.20	48	Hard	Good	High, fine

Hardness is a relative term between the different species. "V Soft" is an abbreviation for Very Soft, "V Hard" is Very Hard, and "M Hard" is moderately hard.

Split Resist refers to the susceptibility the lumber has to splitting. The scale ranges from "V Good" (Very Good) to "Good" to "Fair" to "Poor".

Grain defines the general appearance of the wood grain. "Mod" is moderate, "High" is very pronounced grain, "pores" is large open pores, "fine" is fine grained, "V fine" is very fine grained, and "coarse" is coarse grained.

(1) The cost per board foot column will sometimes contain two values instead of one. The first number represents the cost of relatively low grade lumber such as "#3 Common" and the second number represents the cost of the higher grades such as "Select 1" or "Select 2". Hardwood costs are for First & Seconds (FAS) and are sawn 2 sides (S2S). Thicker hardwood boards are usually more expensive, e.g. 4/4 (1 inch thick) Red Oak is $3.09/board foot whereas 8/4 (2 inch thick) is $4.63/board foot. Price increases of 10% to 40% are not uncommon for double the thickness.

An excellent book on woods is "Beautiful Woods", by the Frank Paxton Lumber Co. 4837 Jackson St. Denver, CO 80216. (303)399–6810. cost $5.00 (complete with color photos!). Also, "Know Your Woods" by Albert Constantine. 1959. ISBN 0–684–14115–9.

INSULATION VALUE OF MATERIALS

Insulation Material	Thickness (inches)	k	C	R Value
Ground surface			2.00	0.50
Concrete	1	12.00		0.08
Plaster	1	8.00		0.12
Face Brick	1	9.00		0.11
Brick – Low density	1	5.00		0.20
Hollow Concrete Block	8		0.90	1.11
Hollow Tile	4		1.00	1.00
Stucco	1	5.00		0.20
Metal Lath & Plaster	3/4		7.70	0.13
Rock cork	1	0.328		3.05
Celotex	1	0.330		3.03
Cork Board	1	0.30		3.33
Gypsum Board	1/2		2.20	0.45
Plywood	1/2		1.60	0.62
Most softwoods	1	0.80		1.25
Most hardwoods	1	1.10		0.91
Sawdust	1	0.410		2.44
Redwood	1	0.570		1.75
Asphalt Shingles			2.27	0.44
Built-up Roofing	3/8		3.00	0.33
Wood Shingles			1.06	0.94
Structural Insulation Bd	1/2		0.76	1.32
Glass wool	1	0.266		3.76
Mineral Wool Bat	3–4		0.09	11.00
Mineral Wool Bat	5–6		0.05	19.00
Mineral Wool Bat	6–7		0.05	22.00
Mineral Wool Bat	8–9		0.03	30.00
Sheep's wool	1	0.338		2.96
Balsam wool	1	0.27		3.70
Polystyrene	1		0.28	3.57
Air Space, nonreflective	3/4		1.00	1.01
Air Space, reflective	3/4			3.48

"k" is heat conductivity over a thickness of 1 inch and "C" is heat conductance over the specified thickness. "R Value" is the most common number used to compare the insulating properties of various material and is typically marked on the wrapper or container of the insulator. The "R Value" is effectively the materials resistance to heat-flow and is based on the "k" and "C" values. "R Values" based on "k" assume a thickness of 1 inch and "R Values" based on "C" are based on the thickness indicated above. *Values listed above are from the National Bureau of Standards and from the ASHRAE 1977 Fundamentals Handbook.* Refer to those references for more detailed information.

MAXIMUM FLOOR JOIST SPANS

S. Pine–Douglas Fir, Max Load **40** lbs/sq ft, uniformly distributed

Lumber Size (Inch)		Inches	Max Feet Between Supports	
Nominal	Actual	On Center	Unplastered	Plastered
2 x 6	1–5/8 x 5–5/8	12	12.00	10.00
		16	10.50	9.08
3 x 6	2–5/8 x 5–5/8	12	15.00	11.66
		16	13.08	10.66
2 x 8	1–5/8 x 7–1/2	12	15.92	13.25
		16	13.92	12.08
3 x 8	2–5/8 x 7–1/2	12	19.66	15.33
		16	17.33	14.00
2 x 10	1–5/8 x 9–1/2	12	19.92	16.66
		16	17.33	15.25
3 x 10	2–5/8 x 9–1/2	12	24.58	19.25
		16	21.66	17.66
2 x 12	1–5/8 x 11–1/2	12	23.92	20.08
		16	20.92	18.42
3 x 12	2–5/8 x 11–1/2	12	29.33	23.08
		16	25.92	21.25
2 x 14	1–5/8 x 13–1/2	12	27.66	23.42
		16	24.33	21.42
3 x 14	2–5/8 x 13–1/2	12	–	26.92
		16	–	24.83

S. Pine–Douglas Fir, Max Load **75** lbs/sq ft, uniformly distributed

Lumber Size (Inch)		Inches	Max Feet Between Supports	
Nominal	Actual	On Center	Unplastered	Plastered
2 x 8	1–5/8 x 7–1/2	12	12.00	11.33
		16	10.50	10.33
3 x 8	2–5/8 x 7–1/2	12	15.17	13.17
		16	12.17	12.08
2 x 10	1–5/8 x 9–1/2	12	15.25	14.25
		16	13.25	13.00
4 x 8	3–5/8 x 7–1/2	12	17.58	14.58
		16	15.42	13.33
3 x 10	2–5/8 x 9–1/2	12	19.00	16.66
		16	16.66	15.17
2 x 12	1–5/8 x 11–1/2	12	18.33	17.17
		16	16.00	12.75
4 x 10	3–5/8 x 9–1/2	12	22.08	18.33
		16	18.42	16.83
3 x 12	2–5/8 x 11–1/2	12	22.83	20.08
		16	20.08	18.33
3 x 14	2–5/8 x 13–1/2	12	26.58	23.42
		16	23.33	21.50

Data from the National Lumber Manufacturers Association.

MAXIMUM FLOOR JOIST SPANS

Western Hemlock, Max Load **40** lbs/sq ft, uniformly distributed

Lumber Size (Inch) Nominal	Actual	Inches On Center	Max Feet Between Supports Unplastered	Plastered
2 x 6	1-5/8 x 5-5/8	12	11.50	9.50
		16	10.00	8.66
3 x 6	2-5/8 x 5-5/8	12	14.33	11.17
		16	12.50	10.17
2 x 8	1-5/8 x 7-1/2	12	15.25	12.66
		16	13.33	11.58
3 x 8	2-5/8 x 7-1/2	12	18.83	14.66
		16	17.58	13.42
2 x 10	1-5/8 x 9-1/2	12	19.08	16.00
		16	16.66	14.58
3 x 10	2-5/8 x 9-1/2	12	23.50	18.42
		16	20.75	16.92
2 x 12	1-5/8 x 11-1/2	12	22.92	19.25
		16	20.08	17.58
3 x 12	2-5/8 x 11-1/2	12	28.08	22.08
		16	24.83	20.33
2 x 14	1-5/8 x 13-1/2	12	26.500	22.50
		16	23.33	20.50
3 x 14	2-5/8 x 13-1/2	12	–	29.75
		16	–	23.75

Western Hemlock, Max Load **75** lbs/sq ft, uniformly distributed

Lumber Size (Inch) Nominal	Actual	Inches On Center	Max Feet Between Supports Unplastered	Plastered
2 x 8	1-5/8 x 7-1/2	12	11.50	10.83
		16	10.00	9.83
3 x 8	2-5/8 x 7-1/2	12	14.50	12.66
		16	12.66	11.58
2 x 10	1-5/8 x 9-1/2	12	14.58	13.66
		16	12.66	12.42
4 x 8	3-5/8 x 7-1/2	12	16.92	14.00
		16	14.83	12.75
3 x 10	2-5/8 x 9-1/2	12	18.25	15.92
		16	15.92	14.58
2 x 12	1-5/8 x 11-1/2	12	17.50	16.42
		16	15.17	15.08
4 x 10	3-5/8 x 9-1/2	12	21.17	17.58
		16	18.58	16.17
3 x 12	2-5/8 x 11-1/2	12	21.92	19.17
		16	19.25	17.58
3 x 14	2-5/8 x 13-1/2	12	25.25	22.25
		16	22.33	20.50

Data from the National Lumber Manufacturers Association.

MAXIMUM FLOOR JOIST SPANS

Spruce, Max Load **40** lbs/sq ft, uniformly distributed

Lumber Size (Inch) Nominal	Actual	Inches On Center	Max Feet Between Supports Unplastered	Plastered
2 x 6	1-5/8 x 5-5/8	12	10.92	9.08
		16	9.50	8.25
3 x 6	2-5/8 x 5-5/8	12	13.66	10.50
		16	12.00	9.66
2 x 8	1-5/8 x 7-1/2	12	14.50	12.00
		16	12.66	11.00
3 x 8	2-5/8 x 7-1/2	12	17.92	13.92
		16	15.75	12.75
2 x 10	1-5/8 x 9-1/2	12	18.25	15.17
		16	15.92	13.83
3 x 10	2-5/8 x 9-1/2	12	22.42	17.50
		16	19.75	16.08
2 x 12	1-5/8 x 11-1/2	12	21.83	18.25
		16	19.25	16.75
3 x 12	2-5/8 x 11-1/2	12	25.42	20.92
		16	22.42	19.33
2 x 14	1-5/8 x 13-1/2	12	25.25	21.17
		16	22.25	19.50
3 x 14	2-5/8 x 13-1/2	12	30.00	24.42
		16	27.50	22.50

Spruce, Max Load **75** lbs/sq ft, uniformly distributed

Lumber Size (Inch) Nominal	Actual	Inches On Center	Max Feet Between Supports Unplastered	Plastered
2 x 8	1-5/8 x 7-1/2	12	11.00	10.25
		16	9.58	9.42
3 x 8	2-5/8 x 7-1/2	12	13.83	12.08
		16	12.42	11.00
2 x 10	1-5/8 x 9-1/2	12	13.92	12.92
		16	12.08	11.83
4 x 8	3-5/8 x 7-1/2	12	16.17	13.25
		16	14.08	12.17
3 x 10	2-5/8 x 9-1/2	12	17.42	15.17
		16	15.25	13.75
2 x 12	1-5/8 x 11-1/2	12	19.75	15.66
		16	14.58	14.25
4 x 10	3-5/8 x 9-1/2	12	20.08	16.66
		16	17.75	15.25
3 x 12	2-5/8 x 11-1/2	12	20.66	18.17
		16	18.33	16.66
3 x 14	2-5/8 x 13-1/2	12	24.25	21.25
		16	21.33	19.50

Data from the National Lumber Manufacturers Association.

STRENGTH OF WOOD BEAMS [1]

Wood	Stress in Pounds per Square Inch (PSI) Bending Horizontal Shear Dry	Wet	Compression Perpendicular to Grain Dry	Wet	Compression Parallel to Grain Dry	Wet
Cedar, red	900	800	200	150	700	700
Cedar, white	750	650	175	140	550	500
Chestnut	950	850	300	200	800	700
Cypress	1300	1100	350	250	1100	1100
Fir, Balsum	900	750	150	125	700	600
Fir, Douglas #1	1600	1400	350	250	1200	1100
Fir, Douglas #2	1300	1100	300	225	1000	900
Gum, red	1100	900	300	200	800	750
Hemlock, Eastern	1000	900	300	225	700	700
Hemlock, Western	1300	1100	300	225	900	900
Hickory	1900	1500	600	400	1500	1200
Maple, silver	1000	900	250	250	800	700
Maple, sugar	1500	1300	500	375	1200	1100
Oak, Red	1400	1200	500	375	1000	900
Pine, Eastern	900	800	250	150	750	750
Pine, Norway	1100	1000	250	175	800	800
Pine, Southern	1450	1250	325	235	1100	1000
Pine, Western	900	800	250	150	750	750
Redwood	1200	1000	250	150	1000	900
Spruce, red	1100	900	250	150	800	750

(1) *U.S. Government test*

Note from the above table, that all strength ratings of wood decrease dramatically when the wood is wet!

The above table should only be used as a general guide and that the values shown will vary greatly depending on the actual field conditions, moisture content (see the Wood Moisture Content page in this chapter), etc. For specific information on the wood you are using, contact the supplier of you wood and ask for items such as the exact grading specifications, moisture content, and stress specifications (if available).

Values for the above table were obtained from the Machinists and Draftsmen's Handbook by A.M. Wagener and H.R. Arthur, 1946. D. Van Nostrand Company, New York, page 423.

WOOD GLUING CHARACTERISTICS

Wood gluing is a very common practice today, but there are a large number of glue types from which to choose and each of the different types of wood have different gluing properties. See the chapter on GLUE, page 235, for specific information on each of the common glue types.

The following 4 groups define the relative difficulty with which various woods can be glued:

- **Easy: Works with many different types of glues and under many gluing conditions.** Aspen, Western Red Cedar, Chestnut, Cottonwood, Cypress, White Fir, Larch, Redwood, Spruce, Willow, Yellow Poplar.
- **Moderate: More restricted gluing conditions than the Easy category. Different types of glue work fine.** Red Alder, Basswood, Butternut, Eastern Red Cedar, Douglas Fir, American and Rock Elm, Hackberry, Western Hemlock, Magnolia, Mahogany, Pine, Sweet Gum.
- **Difficult: Well controlled gluing conditions are required but still works with many different glue types.** White Ash, Alaskan Cedar, Cherry, Dogwood, Silver Maple (soft), Red and White Oak, Pecan, Sycamore, Black and Water Typelo, Black Walnut.
- **Very Difficult: Requires special glues and very close control of gluing conditions.** American Beech. Sweet and Yellow Birch, Hickory, Sugar Maple (hard), Osage–orange, Persimmon.

"Gluing conditions" is a function of proper sanding, letting surfaces to be glued become tacky before joining, using clamps to hold glue positions, and drying in a warm, dry area. Heat lamps will sometimes aid in the drying process

In addition to the above, the following generalities are also true:

- Hardwoods are more difficult to glue than softwoods.
- Heartwood is more difficult to glue than sapwood.
- Heavy woods are more difficult to glue than lightweight woods.

CONCRETE

Concrete is a mixture of aggregate (typically sand and gravel), Portland cement, and water. Characteristics of each of these components are as follows:

Aggregate: A mixture of sand and gravel ranging in size from dust to 2–1/2 inches. Rounded fragments are generally better and do not use fragments larger than 1/4 the thickness of the concrete unit you are pouring (e.g. for a 4 inch slab, don't use greater than 1 inch gravel). The larger the gravel the more cost effective the concrete and there will be less problems from shrinkage.

Portland Cement: Cement comes in 1 cubic foot bags that weigh 94 lbs. It can also be purchased in bulk trailer loads. There are 5 basic types of cement:

- Type I: The most common type sold by building suppliers.
- Type II: A "sulfate resistant" variety used in bridges & pilings.
- Type III: Quick hardening, used for rush jobs and winter use.
- Type IV: Slow hardening, low heat for large structures.
- Type V: Very high "sulfate resistance". (near water)

Water: Use clean, impurity free water, not muddy water.

Air: A fourth component of some concrete is millions of tiny air bubbles entrained in the mixture. This component helps the concrete withstand the effects of freezing and thawing and also makes the concrete lighter. Machine mixing is a must.

The strength of concrete increases when:

1. The amount of cement in the mixture increases.
2. The amount of water relative to cement decreases.
3. The density of the concrete is higher.
4. The aggregate is coarser.

The most common problems encountered in making concrete are adding too much water or sand, and poor mixing.

Other factors affecting the quality of the finished product include mixing and curing. Thorough mixing of the concrete is absolutely necessary in order to produce the strongest, most durable pour. Curing of concrete is necessary in order for the material to harden properly. The concrete must be kept moist for a period of 7 days and the temperature must not drop below 50°F. Although after 28 days, there is normally very little increase in the strength of concrete, most concrete does not completely cure for years.

Typical Concrete Mixtures by Volume

Cement:Sand:Gravel Ratio	Application
1:3:6	Normal static loads, no rebar; not exposed
1:2.5:5	Normal foundations & walls; exposed
1:2.5:4	Basement walls
1:2.5:3.5	Waterproof basement walls
1:2.5:3	Floors (light duty), driveways
1:2.25:3	Steps, driveways, sidewalks
1:2:4	Lintels
1:2:4	Reinforced roads, buildings, walls; exposed
1:2:3.5	Retaining walls, drive ways
1:2:3	Swimming pools, fence posts
1:1.75:4	Floors (light duty)
1:1.5:3	Watertight, reinforced tanks & columns
1:1:2	High strength columns, girders, floors
1:1:1.5	Fence posts

When mixing concrete, mix the sand and cement first until a uniform color is obtained then mix in the aggregate. Adding the correct amount of water is a difficult task. In the above table, the portion for water is about 1/2 but this will vary depending on whether the sand is dry, damp, or wet (the 1/2 ratio component is equal to about 6 gallons of water per sack of cement). Simply remember that you only want to add enough water to make the concrete mixture workable and that the less water in relation to cement, the stronger the final concrete will be.

The strength of concrete can also be increased by compacting or working the mixture into place. This is accomplished by walking in the wet mixture or tamping or vibrating. If vibrators are used be careful that you do not cause segregation of the aggregate.

Recommended Thickness of Slabs

Thickness (inches)	Application
4	Home basement floors, farm building floors
4 to 5	Home garage floors, porches
5 to 6	Sidewalks, barn and granary floors, small shed floors
6 to 8	Driveways

Calculating Cubic Volumes

Concrete and mortar are normally sold and used on a cubic volume basis (either cubic feet or cubic yards). Use the following to calculate the amount of concrete you need for a slab:

Cubic feet of Concrete = Slab thickness in feet x Slab width in feet x Slab length in feet

1 cubic yard = 27 cubic feet
1 cubic foot = 1,728 cubic inches

In using the above equations, note that the volume of the final concrete mixture is approximately 2/3's the volume of the original cement–aggregate mixture. This occurs because the sand and cement fill in the void spaces between the gravel fragments.

Standard Steel Reinforcing Bar (re–bar)

Bar # Number	Diameter (inches)	Pounds per foot
2b	1/4	0.17
3	3/8	0.38
4	1/2	0.67
5	5/8	1.04
6	3/4	1.50
7	7/8	2.04
8	1	2.67
9	1–1/8	3.40
10	1–1/4	4.30
11	1.41	5.31

Coloring Concrete and Mortar

Color	Color material	lbs / sack Cement
Black	Black oxide or mineral Black	1 to 12
Blue	Ultramarine Blue	5 to 9
Brown–Red	Red iron oxide	5 to 9
Bright Red	Mineral Turkey Red	5 to 9
Purple–Red	Indian red	5 to 9
Brown	Metallic Brown Oxide	5 to 9
Buff to yellow	Yellow ocher or yellow oxide	2 to 9
Green	Chromium oxide or ultramarine	5 to 9

MORTAR

Mortar is composed of basically the same material as concrete, except that its composition has been altered to increase the ease of workability and decrease the setting time of the mixture. As with concrete, the strength of mortar is a function of the proportions of its ingredients.

Mortar is a mixture of Portland cement, hydrated lime, sand (well graded and in a size range of 1/8 inch to 100 mesh) and water. Masonry cement, which already contains the hydrated lime, can be used instead of Portland cement.

The strength of mortar increases when:

1. The amount of cement in the mixture increases.
2. The amount of water relative to cement decreases. Unfortunately, there is no rule for the amount of water since it is a function of workability. Just use as little as as possible.
3. The amount of hydrated lime decreases.
4. The amount of Portland cement relative to masonry cement increases.
5. Brick with low water absorption is used. If brick absorbs water readily, the bricks must be wetted before mortaring.
6. Clean sand is used. Organic matter and salts in the sand will drastically decrease the mortar strength. A higher percentage of coarse to fine sand increases strength.
7. Special epoxies are available that can be mixed with the mortar. These increase both the strength and bonding power of the mortar and in many cases will create mortar that is stronger that the brick. Note that this adds to the cost of the mortar.

The workability of mortar increases when:

1. The amount of hydrated lime in the mixture increases.
2. The amount of water increases.

As with concrete, thorough mixing of the mortar is imperative. A power mixer is best, but small quantities can be mixed by hand. Once the mortar has been mixed, it will begin to cure and stiffen. If the mortar begins to stiffen within 2 to 2.5 hours of mixing (above 80°F outside air temperature) you can add a small amount of water to increase workability. After the 2.5 hour time limit, the mortar should be thrown away and a new batch mixed. If the outside air temperatures are below 80°F, the 2.5 hour time limit can be increased to approximately 3.5 hours.

MORTAR

Type numbers are used to define the various mortar mixes. The following are the four common types with their volume proportions of Portland cement (see also concrete section for different types of Portland), masonry cement (Type II unless otherwise stated), lime, and sand:

Type M: General use for foundations, walls, sidewalks and other situations in contact with the ground or below grade. 28 day compression strength 4900–5400 psi, depending on amount of water used.
Portland Mix: 1 Portland; 1/4 hydrated lime; 3 sand
Masonry Mix: 1 Portland; 1 masonry, 6 sand

Type S: General use for high resistance to sideways or lateral stress. 28 day compression strength 2100–2800 psi, depending on amount of water used.
Portland Mix: 1 Portland; 1/2 hydrated lime; 4.5 sand.
Masonry Mix: 1/2 Portland; 1 masonry; 4.5 sand

Type N: General use above grade for severe exposure walls. 28 day compression strength 800–1200 psi, depending on amount of water used.
Portland Mix: 1 Portland; 1 hydrated lime, 6 sand
Masonry Mix: 1 masonry; 3 sand

Type O: Low strength load bearing walls where excessive moisture and freezing are not present. Compression strength must be below 100 psi.
Portland Mix: 1 Portland; 2 hydrated lime; 9 sand
Masonry Mix: 1 masonry (Types I or II); 3 sand

If you need a small amount of general use mortar, the following will make about 1 cubic foot: 16 lbs Portland cement, 8.5 lbs hydrated lime, 100 lbs dry sand, and 2 to 3 gallons of water.

The amount of mortar required for a job varies tremendously, but the following average quantities may be helpful:

Mortar required for Common Brick (8 in x 3-3/4 in x 2-1/4 in) assuming 20 bricks per cubic foot:

Joint Thickness Inches	Cu ft Mortar/ 1000 brick	Cu ft mortar/ Cu ft brick
1/4	9	0.2
3/8	14	0.3
1/2	20	0.4

With practice, you can lay 90–120 common bricks/hour.

POCKET REF

Chemistry & Physics

(See Oxide Conversions in GEOLOGY, page 212)
(See also WEIGHTS OF MATERIALS, page 389)

ELEMENT TABLES

Element Name	Symbol	Atomic Number	Atomic Weight	Valence	Redox Potential
Actinium	Ac	89	(227)	3	
Aluminum	Al	13	26.9815	3	$Al^{3+} = +1.66$
Americium	Am	95	(243)	3,4,5,6	$Am^{3+} = +2.32$
Antimony	Sb	51	121.75	3,5	
Argon	Ar	18	39.948	0	
Arsenic	As	33	74.9216	3,5	
Astatine	At	85	(210)	1,3,5,7	
Barium	Ba	56	137.34	2	$Ba^{2+} = +2.90$
Berkelium	Bk	97	(247)	3,4	
Beryllium	Be	4	9.0122	2	$Be^{2+} = +1.85$
Bismuth	Bi	83	208.980	3,5	
Boron	B	5	10.811	3	
Bromine	Br	35	79.904	1,3,5,7	$2Br^-, Br2 = -1.066$
Cadmium	Cd	48	112.40	2	$Cd^{2+} = +0.40$
Calcium	Ca	20	40.08	2	$Ca^{2+} = +2.87$
Californium	Cf	98	(252)		
Carbon	C	6	12.01115	2,4	
Cassiopeium	Cp	see Lutetium			
Cerium	Ce	58	140.12	3,4	$Ce^{3+} = +2.48$
Cesium	Cs	55	132.905	1	$Cs = +2.92$
Chlorine	Cl	17	35.453	1,3,5,7	$2Cl^-, Cl2 = -1.36$
Chromium	Cr	24	51.996	2,3,6	$Cr^{3+} = +0.74$
Cobalt	Co	27	58.9332	2,3	$Co^{2+} = +0.28$
Columbium	Cb	see Niobium			
Copper	Cu	29	63.546	1,2	$Cu^{2+} = -0.34$
Curium	Cm	96	(247)	3	
Dysprosium	Dy	66	162.50	3	
Einsteinium	Es	99	(254)		
Emanation	Em	see Radon			
Erbium	Er	68	167.26	3	
Europium	Eu	63	151.96	2,3	
Fermium	Fm	100	(257)		
Fluorine	F	9	18.9984	1	$2F^-F2 = -2.85$
Francium	Fr	87	(223)	1	
Gadolinium	Gd	64	157.25	3	$Gd^{3+} = +2.4$
Gallium	Ga	31	69.72	2,3	$Ga^{3+} = +0.53$
Germanium	Ge	32	72.59	4	
Glucinium	Gl	see Beryllium			
Gold	Au	79	196.967	1,3	$Au^{3+} = -1.50$
Hafnium	Hf	72	178.49	4	$Hf^{4+} = +1.70$

Element Name	Symbol	Atomic Number	Atomic Weight	Valence	Redox Potential
Hahnium	Ha	105	262		
Helium	He	2	4.0026	0	
Holmium	Ho	67	164.930	3	
Hydrogen	H	1	1.00797	1	$H^{+} = +2.10$
Illinium	Il	see Promethium			
Indium	In	49	114.82	3	$In^{3+} = +0.34$
Iodine	I	53	126.9044	1,3,5,7	$2I^{-}, I_2 = -0.54$
Iridium	Ir	77	192.2	3,4	
Iron	Fe	26	55.847	2,3	$Fe^{2+} = +0.44$
Krypton	Kr	36	83.80	0	
Lanthanum	La	57	138.91	3	$La^{3+} = +2.52$
Lawrencium	Lw/Lr	103	(256)		
Lead	Pb	82	207.19	2,4	$Pb^{2+} = +0.13$
Lithium	Li	3	6.939	1	$Li^{+} = +3.04$
Lutetium	Lu	71	174.97	3	$Lu^{3+} = +2.25$
Magnesium	Mg	12	24.305	2	$Mg^{2+} = +2.37$
Manganese	Mn	25	54.9380	2,3,4,6,7	$Mn^{2+} = +1.18$
Mendelevium	Md	101	(257)		
Mercury	Hg	80	200.59	1,2	$2Hg, 2+ = -0.79$
Molybdenum	Mo	42	95.94	3,4,6	$Mo^{3+} = +0.20$
Neodymium	Nd	60	144.24	3	$Nd^{3+} = +2.44$
Neon	Ne	10	20.179	0	
Neptunium	Np	93	(237)	4,5,6	$Np^{3+} = +1.86$
Nickel	Ni	28	58.71	2,3	$Ni^{2+} = +0.25$
Niobium	Nb	41	92.906	3,5	$Nb^{3+} = +1.1$
Niton	Nt		see Radon		
Nitrogen	N	7	14.0067	3,5	
Nobelium	No	102	(255)		
Osmium	Os	76	190.2	2,3,4,8	
Oxygen	O	8	15.9994	2	
Palladium	Pd	46	106.4	2,4,6	$Pd^{2+} = -0.99$
Phosphorus	P	15	30.9738	3,5	
Platinum	Pt	78	195.09	2,4	$Pt^{2+} = -1.2$
Plutonium	Pu	94	(244)	3,4,5,6	$Pu^{3+} = +2.07$
Polonium	Po	84	(210)		
Potassium	K	19	39.102	1	$K^{+} = +2.925$
Praseodymium	Pr	59	140.907	3	
Promethium	Pm	61	(147)	3	
Protactinium	Pa	91	(231)		
Radium	Ra	88	(226)	2	$Ra^{2+} = +2.92$
Radon	Rn	86	(222)	0	

Element Name	Symbol	Atomic Number	Atomic Weight	Valence	Redox Potential
Rhenium	Re	75	186.2		
Rhodium	Rh	45	102.905	3	$Rh^{3+} = -0.8$
Rubidium	Rb	37	85.47	1	$Rb^{+} = +2.92$
Ruthenium	Ru	44	101.07	3,4,6,8	
Rutherfordium	Rf	104	261		
Samarium	Sm	62	150.35	2,3	$Sm^{3+} = +2.41$
Scandium	Sc	21	44.956	3	$Sc^{3+} = +2.08$
Selenium	Se	34	78.96	2,4,6	$Se^{2-}Se = +0.78$
Silicon	Si	14	28.086	4	
Silver	Ag	47	107.868	1	$Ag^{+} = +0.799$
Sodium	Na	11	22.9898	1	$Na^{+} = +2.71$
Strontium	Sr	38	87.62	2	$Sr^{2+} = +2.89$
Sulphur	S	16	32.064	2,4,6	$S^{2-},S = +0.92$
Tantalum	Ta	73	180.948	5	
Technetium	Tc	43	(99)	6,7	
Tellurium	Te	52	127.60	2,4,6	$Te^{2+} = +0.51$
Terbium	Tb	65	158.924	3	
Thallium	Tl	81	204.37	1,3	$Tl^{+} = +0.34$
Thorium	Th	90	232.038	4	$Th^{4+} = +1.9$
Thulium	Tm	69	168.934	3	
Tin	Sn	50	118.69	2,4	$Sn^{2+} = +0.14$
Titanium	Ti	22	47.90	3,4	$Ti^{2+} = +1.63$
Tungsten	W	74	183.85	6	
Uranium	U	92	238.03	4,6	$U^{3+} = +1.80$
Vanadium	V	23	50.942	3,5	$V^{2+} = +1.18$
Wolfram	W	see Tungsten			
Xenon	Xe	54	131.30	0	
Ytterbium	Yb	70	173.04	2,3	
Yttrium	Y	39	88.905	3	
Zinc	Zn	30	65.37	2	$Zn = +0.76$
Zirconium	Zr	40	91.22	4	$Zr^{4+} = +1.53$

Table of atomic weights based on carbon isotope C^{12}. Numbers in parenthesis represent the mass (Atomic Weight) of the most stable isotope. "Redox Potential" lists the end product (or beginning and end product if two are given) and electrode potential.

ELEMENT PROPERTIES

Element Name	State	Atomic Number	Density gm/cc	Melting Point °C	Boiling Point °C
Actinium		89	10.07	1050	3200
Aluminum		13	2.6989	660	2467
Americium		95	11.7	850?	
Antimony		51	6.69	630	1380
Argon	gas	18	1.78	−189.2	−185.7
Argon	liquid	18	1.402(−185°)	−189.2	−185.7
Argon	solid	18	1.65(−223°)	−189.2	−185.7
Arsenic	xtal	33	5.73	817	
Arsenic	yellow	33	1.97	817	
Astatine		85			
Barium		56	3.5	725	1140
Berkelium		97			
Beryllium		4	1.848	1278	2970
Bismuth		83	9.747	271	1560
Boron		5	2.34	2300	2550
Bromine	gas	35	7.59	−7.2	58.78
Bromine	liquid	35	3.12	−7.2	58.78
Cadmium		48	8.65	321	765
Calcium		20	1.55	842	1487
Californium		98			
Carbon	amorph.	6	1.8-2.1	3550	4827
Carbon	graphite	6	1.9-2.3	3550	4827
Carbon	diamond	6	3.15-3.53	3550	4827
Cerium		58	6.66	795	3468
Cesium		55	1.87	28.5	690
Chlorine	gas	17	3.214	−100.98	−34.6
Chlorine	liquid	17	1.56(−33°)	−100.98	−34.6
Chromium		24	7.18	1890	2482
Cobalt		27	8.9	1492	2900
Copper		29	8.96	1083	2595
Curium		96	7?		
Dysprosium		66	8.536	1407	2600
Einsteinium		99			
Erbium		68	9.051	1497	2900
Europium		63	5.259	826	1439
Fermium		100			
Fluorine	gas	9	1.696	−219.6	−188.1
Fluorine	liquid	9	1.108(−188°)	−219.6	−188.1
Francium		87			
Gadolinium		64	7.89	1312	3000
Gallium		31	5.9	29.8	2403
Germanium		32	5.32(25°)	937	2830
Gold		79	19.32	1063.0	2966
Hafnium		72	13.29	2150	5400

ELEMENT PROPERTIES

Element Name	State	Atomic Number	Density gm/cc	Melting Point °C	Boiling Point °C
Helium	gas	2	0.177	–272.2	–268.6
Holmium		67	8.803	1461	2600
Hydrogen	gas	1	0.08988	–259.14	–252.5
Hydrogen	liquid	1	0.070(–252°)	–259.14	–252.5
Indium		49	7.31	156.6	2000
Iodine	gas	53	11.27	113.5	184.3
Iodine		53	4.93	113.5	184.3
Iridium		77	22.42	2443	4527
Iron		26	7.87	1535	3000
Krypton	gas	36	3.733	–156.6	–152.3
Lanthanum		57	5.98	920	3469
Lawrencium		103			
Lead		82	11.35	327	1744
Lithium		3	0.534	179	1317
Lithium	liquid	3	0.507(200°)	179	1317
Lutetium		71	9.842	1652	3327
Magnesium		12	1.738	651	1107
Manganese		25	7.21	1244	2097
Mendelevium		101			
Mercury		80	13.54	–38.87	356.58
Molybdenum		42	10.22	2610	5560
Neodymium		60	7.004	1024	3027
Neon	gas	10	0.8999	–248.7	–245.9
Neon	liquid	10	1.207(–245°)	–248.7	–245.9
Neptunium		93	18-20	640	
Nickel		28	8.9(25°)	1453	2732
Niobium		41	8.57	2468	4927
Nitrogen	gas	7	1.2506	–209.86	–195.8
Nitrogen	liquid	7	0.808(–195°)	–209.86	–195.8
Nitrogen	solid	7	1.026(–252°)	–209.86	–195.8
Nobelium		102			
Osmium		76	22.57	3000	5000
Oxygen	gas	8	1.429	–218.4	–182.9
Oxygen	liquid	8	1.14(–182°)	–218.4	–182.9
Palladium		46	12.02	1552	2927
Phosphorus	yellow	15	1.82	44.1	280
Phosphorus	red	15	2.20	44.1	280
Phosphorus	black	15	2.25-2.69	44.1	280
Platinum		78	21.45	1769	3827
Plutonium		94	19.84(25°)	639.5	3235
Polonium		84	9.32	254	962
Potassium		19	0.862	63.6	754
Praseodymium		59	6.78	935	3127
Promethium		61		1035	2730

ELEMENT PROPERTIES

Element Name	State	Atomic Number	Density gm/cc	Melting Point °C	Boiling Point °C
Protactinium		91	15.37	1230?	
Radium		88	5?	700	1737
Radon	gas	86	9.73	−71	−61.8
Radon	liquid	86	4.4(−62°)	−71	−61.8
Radon	solid	86	4	−71	−61.8
Rhenium		75	21.02	3180	5627
Rhodium		45	12.41	1960	3727
Rubidium	liquid	37	1.475(39°)	38.89	688
Rubidium	solid	37	1.532	38.89	688
Ruthenium		44	12.41	2250	3900
Samarium		62	7.54	1072	1900
Scandium		21	2.992	1539	2727
Selenium		34	4.79(25°)	217	685
Silicon		14	2.33	1410	2355
Silver		47	10.5	960	2112
Sodium		11	0.971	97.8	892
Strontium		38	2.54	769	1384
Sulphur		16	2.07	112.8	444.6
Tantalum		73	16.6	2996	5425
Technetium		43	11.5	2200	
Tellurium		52	6.24	449	989
Terbium		65	8.272	1356	2800
Thallium		81	11.85	303	1457
Thorium		90	11.66	1700	4000
Thulium		69	9.332	1545	1727
Tin		50	7.31	231.9	2270
Titanium		22	4.54	1675	3260
Tungsten		74	19.3	3380	5927
Uranium		92	18.95	1132	3818
Vanadium		23	6.11(18°)	1890	3000
Xenon	gas	54	5.88	−112	−107
Xenon	liquid	54	3.52	−112	−107
Ytterbium		70	6.977	824	1427
Yttrium		39	4.45	1495	2927
Zinc		30	7.13	419.5	907
Zirconium		40	6.53	1852	3578

The elements above are in a "solid" state unless otherwise noted. Density of gases are measured at 760mm Hg and 0°C and other elements are measured at 20°C (unless otherwise indicated).

PERIODIC TABLE OF ELEMENTS

IA	IIA	IIIB	IVB	VB	VIB	VIIB	VIII			IB	IIB	IIIB	IVA	VA	VIA	VIIA	VIIIA
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Ha	106												

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lw

pH OF COMMON ACIDS

Acids (pH < 7)	Molarity	pH
Acetic	N	2.4
Acetic	0.1N	2.9
Acetic	0.01N	3.4
Alum	0.1N	3.2
Arsenious	Saturated	5.0
Benzoic	0.1N	3.0
Boric	0.1N	5.3
Carbonic	Saturated	3.8
Citric	0.1N	2.1
Formic	0.1N	2.3
Hydrochloric	N	0.1
Hydrochloric	0.1N	1.1
Hydrochloric	0.01N	2.0
Hydrocyanic	0.1N	5.1
Hydrogen Sulfide	0.1N	4.1
Lactic	0.1N	2.4
Malic	0.1N	2.2
Orthophosphoric	0.1N	1.5
Oxalic	0.1N	1.3
Succinic	0.1N	2.7
Salicylic	Saturated	2.4
Sulfuric	N	0.3
Sulfuric	0.1N	1.2
Sulfuric	0.01N	2.1
Sulfurous	0.1N	1.5
Tartaric	0.1N	2.0
Trichloracetic	0.1N	1.2

pH OF COMMON BASES

Bases (pH > 7)	Molarity	pH
Ammonia	N	11.6
Ammonia	0.1N	11.1
Ammonia	0.01N	10.6
Barbital Sodium	0.1N	9.4
Borax	0.01N	9.2
Calcium Carbonate	Saturated	9.4
Calcium Hydroxide	Saturated	12.4
Ferrous Hydroxide	Saturated	9.5
Lime	Saturated	12.4
Magnesia	Saturated	10.5
Potassium Acetate	0.1N	9.7
Potassium Bicarbonate	0.1N	8.2
Potassium Carbonate	0.1	11.5
Potassium Cyanide	0.1N	11.0
Potassium Hydroxide	N	14.0
Potassium Hydroxide	0.1N	13.0
Potassium Hydroxide	0.01N	12.0
Sodium Acetate	0.1N	8.9
Sodium Benzoate	0.1N	8.0
Sodium Bicarbonate	0.1N	8.4
Sodium Carbonate	0.1N	11.6
Sodium Hydroxide	N	14.0
Sodium Hydroxide	0.1N	13.0
Sodium Hydroxide	0.01N	12.0
Sodium Metasilicate	0.1N	12.6
Sodium Sesquicarbonate	0.1N	10.1
Trisodium Phosphate	0.1N	12.0

pH INDICATORS

Indicator	Acid Color	pH	Base Color
Cresol red #1	red	0.2-1.8	yellow
Cresol purple #1	red	1.2-2.8	yellow
Thymol blue	red	1.2-2.8	yellow
Metanil yellow	red	1.2-2.3	yellow
Tropaeolin LL	red	1.4-3.2	yellow
2,6 Dinitrophenol	no color	1.7-4.4	yellow
Benzyl orange	red	1.9-3.3	yellow
2,4 Dinitrophenol	no color	2.0-4.7	yellow
Benzo Yellow	red	2.4-4.0	yellow
p-Dimethylaminoazobenzene	red	2.9-4.0	yellow
Bromophenol blue	red	3.0-4.6	violet
Congo red	blue	3.0-5.0	red
Bromochlorophenol blue	yellow	3.0-4.6	purple
Methyl orange	red	3.1-4.4	yellow
Bromocresol green	yellow	3.8-5.4	blue
2,5 Dinitrophenol	no color	4.0-5.8	yellow
Methyl red	red	4.4-6.0	yellow
Azolitmin (litmus)	red	4.4-6.6	blue
Propyl red	red	4.6-6.6	yellow
p-Nitrophenol	no color	4.7-7.9	yellow
Bromocresol purple	yellow	4.8-6.8	purple
Bromophenol red	yellow	4.8-6.8	purple
Chlorophenol red	yellow	5.0-6.9	purple
Bromothymol blue	yellow	6.0-7.6	blue
m-Nitrophenol	no color	6.6-8.6	yellow
Neutral red	red	6.8-8.0	yellow
Phenol red	yellow	6.8-8.4	red
Rosolic acid	brown	6.9-8.0	red
Cresol red #2	yellow	7.2-8.8	purple
a-Naphtholphthalein	brown	7.3-8.7	green
Orange I	yellow	7.6-8.9	rose
m-Cresol purple #2	yellow	7.6-9.2	purple
Thymol blue #2	yellow	8.0-9.6	blue
o-Cresolphthalein	no color	8.2-9.8	red
Phenolphthalein	no color	8.3-10.0	red
Phthalein red	yellow	8.6-10.2	red
Thymolphthalein	no color	9.3-10.5	blue
Tolyl red	red	10.0-11.6	yellow
b-Naphthol violet	yellow	10.0-12.0	violet
Alizarin yellow R	yellow	10.0-12.1	brown
Alizarin yellow GG	yellow	10.0-12.0	orange
Nitramine	no color	10.8-13.0	brown
Parazo orange	yellow	11.0-12.6	orange
Poirrier blue	blue	11.0-13.0	red
Tropaeolin O	yellow	11.1-12.7	orange
Acyl blue	red	12.0-13.6	blue

pH values are approximate values and have been rounded off to the nearest tenth. Values assume a temperature of 25°C (77°F).

RADIOISOTOPE HALF LIVES

Isotope	Half Life
Ag^{110}	252 days
Am^{241}	432 years
Am^{243}	7380 years
Au^{198}	2.69 days
Ba^{137}	11.2 years
Ba^{140}	12.79 days
Be^{7}	53.28 days
Bi^{210}	3.5 million years
Br^{82}	35.3 hours
C^{14}	5730 years
Ca^{45}	163 days
Cd^{113}	14.6 years
Ce^{144}	284.4 days
Cl^{36}	300,000 years
Cm^{242}	162.8 days
Cm^{244}	18.11 years
Co^{60}	5.27 years
Cr^{51}	27.71 days
Cs^{134}	2.06 years
Cs^{137}	30.17 years
Cu^{64}	12.71 hours
Fe^{55}	2.7 years
Fe^{59}	44.6 days
Ga^{72}	14.1 hrs
Ge^{68}	287 days
H^{3}	12.33 years
Hg^{203}	46.6 days
I^{131}	8.04 days
In^{115}	95.7 years
Ir^{192}	74.2 days
K^{40}	0.012 years
K^{42}	12.36 hrs
Kr^{85}	10.72 years
La^{140}	40.23 hours
Mn^{54}	312.5 days
Mo^{99}	66.02 hours
Na^{22}	2.6 years
Na^{24}	15.02 hours
Ni^{63}	100 years
Np^{237}	2.14 million yr
P^{32}	14.28 days
Pb^{210}	22.3 years
Pd^{106}	27.3 years
Pd^{109}	13.43 hours
Pm^{147}	2.62 years
Po^{210}	138.38 days
Pr^{144}	17.28 minute
Pu^{238}	87.74 years
Rb^{86}	18.65 days
Rb^{87}	27.83 years
Rh^{103}	100 years
Rh^{106}	29.9 seconds
Ru^{106}	368 days
S^{35}	87.2 days
Sb^{125}	2.73 years
Sc^{46}	83.8 days
Se^{75}	120 days
Si^{32}	280 years
Sn^{113}	115 days
Sr^{89}	50.52 days
Sr^{90}	29 years
Ta^{182}	115 days
Tc^{99}	213,000 years
Te^{123}	0.89 years
Tl^{201}	73 hours
Tm^{170}	129 days
U^{238}	45 billion year
(See more U on page 60)	
V^{50}	0.25 years
Y^{90}	64 hours
Zn^{65}	27.9 years
Zr^{95}	64 days

ELEMENTARY PARTICLES

Particle Name	Lifespan Seconds	Mass MeV	Charge	Spin
Baryons				
Proton	Stable	938.3	+1	1/2
Antiproton	Stable	938.3	−1	1/2
Neutron	9.18×10^{2}	939.6	0	1/2
Antineutron	9.19×10^{2}	939.6	0	1/2
Lambda hyperon	3×10^{-10}	1115.6	0	1/2
Lambda antihyperon	3×10^{-10}	1115.6	0	1/2
Positive sigma	8 x 10-9	1189.4	+1	1/2
Neutral sigma	10^{-11}	1192.5	0	1/2
Negative sigma	1.5×10^{-10}	1195.3	−1	1/2
Neutral xi	3×10^{-10}	1315	0	1/2
Negative xi	1.7×10^{-19}	1321	−1	1/2
Omega	1.3×10^{-10}	1672	−1	1/2
Gluons				
Red to blue	Stable	0	0	1
Red to green	Stable	0	0	1
Green to red	Stable	0	0	1
Green to blue	Stable	0	0	1
Blue to red	Stable	0	0	1
Blue to green	Stable	0	0	1
Neutral (1)	Stable	0	0	1
Neutral (2)	Stable	0	0	1
Leptons				
Neutrino	Stable	0	0	1/2
Antineutrino	Stable	0	0	1/2
Neutrino–muon	Stable	0	0	1/2
Antineutrino–muon	Stable	0	0	1/2
Neutrino–tau	Stable	0	0	1/2
Antineutrino–tau	Stable	0	0	1/2
Electron	Stable	0.511	−1	1/2
Positron	Stable	0.511	+1	1/2
Muon	2.2×10^{-6}	105.7	−1	1/2
Antimuon	2.2×10^{-6}	105.7	+1	1/2
Tau		1750	+1	1/2
Antitau		1750	−1	1/2

ELEMENTARY PARTICLES

Particle Name	Lifespan Seconds	Mass MeV	Charge	Spin
Mesons				
Positive pi	2.6×10^{-8}	139.6	+1	0
Negative pi	2.6×10^{-8}	189.6	−1	0
Neutral pi	8×10^{-17}	135	0	0
Positive K	1.2×10^{-8}	493.7	+1	0
K–zero–short	9×10^{-11}	497.7	0	0
K–zero–long	5.2×10^{-8}	497.7	0	0
Negative K	1.2×10^{-8}	493.7	−1	0
Rho		773	0	1
Omega		783	0	1
Eta		2980	0	0
Psi		3098		1
B meson		1228		1
D meson		1286		1
Quarks				
Up	Stable	1.0	+2/3	1/2
Down	Stable	3.0	−1/3	1/2
Strange	Stable	102.2	−1/3	1/2
Charm		1530	+2/3	1/2
Top		4600	+2/3	1/2
Bottom	$< 5 \times 10^{-12}$	4700	−1/3	1/2
Vector Bosons				
Photon	Stable	0	0	1
Positive W	10^{-20}	81000	+1	1
Negative W	10^{-20}	81000	−1	1
Neutral Z	10^{-20}	93800	0	1
Higgs particle		10^{6}	0	0
Graviton	Stable	0	0	0

Note that there are many more subatomic particles than those listed in this table, but the above list contains most of the "common" particles. For detailed information see references such as the *Handbook of Chemistry and Physics by The Chemical Rubber Company.*

URANIUM-238 DECAY SERIES

Rnuclide	Element	Half-Life	Energy (MeV)
^{238}U	Uranium	4.5 billion yrs	4.1-4.2 Alpha
^{234}Th	Thorium	24 days	0.06-0.2 Beta
^{234}Pa	Protactinium	2.1 minutes	2.3 Beta
^{234}U	Uranium	250,000 years	4.7-4.8 Alpha
^{230}Th	Thorium	80,000 years	4.6-4.7 Alpha
^{226}Ra	Radium	1,600 years	4.6-4.8 Alpha
^{222}Rn	Radon	3.82 days	5.5 Alpha
^{218}Po	Polonium	3.05 minutes	6.0 Alpha
^{214}Pb	Lead	26.8 minutes	0.7-1.0 Beta
^{214}Bi	Bismuth	19.7 minutes	0.4-3.3 Beta
^{214}Po	Polonium	16 milliseconds	7.7 Alpha
^{210}Pb	Lead	22 years	1 Beta
^{210}Bi	Bismuth	5 days	1.2 Beta
^{210}Po	Polonium	138 days	5.3 Alpha
^{206}Pb	Lead	Stable	

ALUMINUM TYPES

Class	Description
F	As fabricated, temper from shaping process only.
O	Annealed, recrystallized, softest temper for wrought.
H1	Strain hardened only.
H2	Strain hardened and then partially annealed.
H3	Strain hardened and then stabilized.
W	Solution heat–treated.
T2	Annealed, cast only, improved ductility & stability.
T3	Solution heat–treated and then cold worked, improved strength.
T4	Solution heat–treated and naturally aged to a substantially stable condition. Not cold worked.
T5	Artificially aged only. Rapid cool process like casting.
T6	Solution heat–treated and then artificially aged. Not cold worked after heat treated. Common class.
T7	Solution heat–treated and then stabilized, good growth control and residual stress.
T8	Solution heat–treated, cold worked, and artificially aged. Cold worked to improve strength.
T9	Solution heat–treated, artificially aged, and cold worked to improve strength.
T10	Artificially aged and then cold worked. Rapid cooling after heat treatment the cold worked for strength.
TX51	Stress–relieved by stretching.
TX52	Stress–relieved by compressing.
TX53	Stress–relieved by thermal treatment.
T42	Wrought only, properties of T4.
T62	Wrought only, properties of T6.

Computers

COMPUTER ASCII CODES

The following ASCII (American Standard Code for Information Interchange) tables are used by most of the microcomputer industry. The codes occur in two sets: the "low-bit" set, from Dec 0 to Dec 127, and the "high-bit" set, from Dec 128 to Dec 255. The "low-bit" set is standard for almost all microcomputers but the "high-bit" set varies between the different computer brands. For instance, in the case of Apple computers and Epson printers, the "high-bit" set repeats the "low-bit" set except that the alphanumeric characters are italic. In the case of IBM and many other MSDOS systems, the "high-bit" set is composed of foreign language and box drawing characters and mathematic symbols.

Hex	Dec	Description	Abbr	Character	Control
00	0	Null	Null		Control @
01	1	Start Heading	SOH		Control A
02	2	Start of Text	STX		Control B
03	3	End of Text	ETX		Control C
04	4	End Transmit	EOT		Control D
05	5	Enquiry	ENQ		Control E
06	6	Acknowledge	ACK		Control F
07	7	Beep	BEL		Control G
08	8	Back space	BS		Control H
09	9	Horizontal Tab	HT		Control I
0A	10	Line Feed	LF		Control J
0B	11	Vertical Tab	VT		Control K
0C	12	Form Feed	FF		Control L
0D	13	Carriage Ret.	CR		Control M
0E	14	Shift Out	SO		Control N
0F	15	Shift In	SI		Control O
10	16	Device Link Esc	DLE		Control P
11	17	Dev Cont 1 X-ON	DC1		Control Q
12	18	Dev Control 2	DC2		Control R
13	19	Dev Cont 3 X-OFF	DC3		Control S
14	20	Dev Control 4	DC4		Control T
15	21	Negative Ack	NAK		Control U
16	22	Synchronous Idle	SYN		Control V
17	23	End Trans Block	ETB		Control W
18	24	Cancel	CAN		Control X
19	25	End Medium	EM		Control Y
1A	26	Substitute	SUB		Control Z
1B	27	Escape	ESC		Control [

Hex	Dec	Description	Abbr	Character	Control
1C	28	Cursor Right	FS	→	Control /
1D	29	Cursor Left	GS	↔	Control]
1E	30	Cursor Up	RS	▲	Control ^
1F	31	Cursor Down	US	▼	Control –

Hex	Dec	Character	Description
20	32		Space (SP)
21	33	!	Exclamation Point
22	34	"	Double Quote
23	35	#	Number sign
24	36	$	Dollar sign
25	37	%	Percent
26	38	&	Ampersand
27	39	'	Apostrophe
28	40	(	Left parenthesis
29	41	)	Right parenthesis
2A	42	*	Asterisk
2B	43	+	Plus sign
2C	44	,	Comma
2D	45	–	Minus sign
2E	46	.	Period
2F	47	/	Right or Front slash
30	48	0	Zero
31	49	1	One
32	50	2	Two
33	51	3	Three
34	52	4	Four
35	53	5	Five
36	54	6	Six
37	55	7	Seven
38	56	8	Eight
39	57	9	Nine
3A	58	:	Colon
3B	59	;	Semicolon
3C	60	<	Less than
3D	61	>	Greater than
3E	62	=	Equal sign
3F	63	?	Question mark
40	64	@	"at" symbol

COMPUTER ASCII CODES

Hex	Dec	Character	Description
41	65	A	
42	66	B	
43	67	C	
44	68	D	
45	69	E	
46	70	F	
47	71	G	
48	72	H	
49	73	I	
4A	74	J	
4B	75	K	
4C	76	L	
4D	77	M	
4E	78	N	
4F	79	O	
50	80	P	
51	81	Q	
52	82	R	
53	83	S	
54	84	T	
55	85	U	
56	86	V	
57	87	W	
58	88	X	
59	89	Y	
5A	90	Z	
5B	91	[	Right bracket
5C	92	\	Left or Back Slash
5D	93	]	Left bracket
5E	94	^	Caret
5F	95	_	Underline
60	96	‘	Accent
61	97	a	
62	98	b	
63	99	c	
64	100	d	
65	101	e	
66	102	f	
67	103	g	

Hex	Dec	Standard Character	Description
68	104	h	
69	105	i	
6A	106	j	
6B	107	k	
6C	108	l	
6D	109	m	
6E	110	n	
6F	111	o	
70	112	p	
71	113	q	
72	114	r	
73	115	s	
74	116	t	
75	117	u	
76	118	v	
77	119	w	
78	120	x	
79	121	y	
7A	122	z	
7B	123	{	Left bracket
7C	124	|	Vertical line
7D	125	}	Right bracket
7E	126	~	Tilde
7F	127	DEL	Delete

Hex	Dec	Standard Character	IBM Set	Standard Description
80	128	Null	Ç	Null
81	129	SOH	ü	Start Heading
82	130	STX	é	Start of Text
83	131	ETX	â	End of Text
84	132	EOT	ä	End Transmit
85	133	ENQ	à	Enquiry
86	134	ACK	å	Acknowledge
87	135	BEL	ç	Beep
88	136	BS	ê	Back Space
89	137	HT	ë	Horiz Tab
8A	138	LF	è	Line Feed

Hex	Dec	Standard Character	IBM Set	Standard Description
8B	139	VT	ï	Vertical Tab
8C	140	FF	î	Form Feed
8D	141	CR	ì	Carriage Return
8E	142	SO	Ä	Shift Out
8F	143	SI	Å	Shift In
90	144	DLE	É	Device Link Esc
91	145	DC1	æ	Device Cont 1 X–ON
92	146	DC2	Æ	Device Control 2
93	147	DC3	ô	Device Cont 3 X–OFF
94	148	DC4	ö	Device Control 4
95	149	NAK	ò	Negative Ack
96	150	SYN	û	Synchronous Idle
97	151	ETB	ù	End Transmit Block
98	152	CAN	ÿ	Cancel
99	153	EM	Ö	End Medium
9A	154	SUB	Ü	Substitute
9B	155	ESC	¢	Escape
9C	156	FS	£	Cursor Right
9D	157	GS	¥	Cursor Left
9E	158	RS	Pt	Cursor Up
9F	159	US	ƒ	Cursor Down
A0	160	Space	á	Space
A1	161	*!*	í	Italic Exclamation point
A2	162	*"*	ó	Italic Double quote
A3	163	*#*	ú	Italic Number sign
A4	164	*$*	ñ	Italic Dollar sign
A5	165	*%*	Ñ	Italic Percent
A6	166	*&*	ª	Italic Ampersand
A7	167	*'*	º	Italic Apostrophe
A8	168	*(*	¿	Italic Left parenthesis
A9	169	*)*	⌐	Italic Right parenthesis
AA	170	*	¬	Italic asterisk
AB	171	+	½	Italic plus sign
AC	172	,	¼	Italic comma
AD	173	–	¡	Italic minus sign
AE	174	.	«	Italic period
AF	175	*/*	»	Italic right slash
B0	176	*0*	░	Italic Zero
B1	177	*1*	▒	Italic One

Hex	Dec	Standard Character	IBM Set	Standard Description
B2	178	*2*	▓	Italic Two
B3	179	*3*	│	Italic Three
B4	180	*4*	┤	Italic Four
B5	181	*5*	╡	Italic Five
B6	182	*6*	╢	Italic Six
B7	183	*7*	╖	Italic Seven
B8	184	*8*	╕	Italic Eight
B9	185	*9*	╣	Italic Nine
BA	186	*:*	║	Italic colon
BB	187	*;*	╗	Italic semicolon
BC	188	*<*	╝	Italic less than
BD	189	*=*	╜	Italic equal
BE	190	*>*	╛	Italic greater than
BF	191	*?*	┐	Italic question mark
C0	192	*@*	└	Italic "at" symbol
C1	193	*A*	┴	Italic A
C2	194	*B*	┬	Italic B
C3	195	*C*	├	Italic C
C4	196	*D*	─	Italic D
C5	197	*E*	┼	Italic E
C6	198	*F*	╞	Italic F
C7	199	*G*	╟	Italic G
C8	200	*H*	╚	Italic H
C9	201	*I*	╔	Italic I
CA	202	*J*	╩	Italic J
CB	203	*K*	╦	Italic K
CC	204	*L*	╠	Italic L
CD	205	*M*	═	Italic M
CE	206	*N*	╬	Italic N
CF	207	*O*	╧	Italic O
D0	208	*P*	╨	Italic P
D1	209	*Q*	╤	Italic Q
D2	210	*R*	╥	Italic R
D3	211	*S*	╙	Italic S
D4	212	*T*	╘	Italic T
D5	213	*U*	╒	Italic U
D6	214	*V*	╓	Italic V
D7	215	*W*	╫	Italic W
D8	216	*X*	╪	Italic X

Hex	Dec	Standard Character	IBM Set	Description
D9	217	*Y*	┘	Italic Y
DA	218	*Z*	┌	Italic Z
DB	219	*[*	█	Italic left bracket
DC	220	\	▄	Italic left or back slash
DD	221	*]*	▌	Italic right bracket
DE	222	^	▐	Italic caret
DF	223		▀	Italic underline
E0	224	`	α	Italic accent / alpha
E1	225	*a*	β	Italic a / beta
E2	226	*b*	Γ	Italic b / gamma
E3	227	*c*	π	Italic c / pi
E4	228	*d*	Σ	Italic d / sigma
E5	229	*e*	σ	Italic e / sigma
E6	230	*f*	μ	Italic f / mu
E7	231	*g*	γ	Italic g / gamma
E8	232	*h*	Φ	Italic h / phi
E9	233	*i*	θ	Italic i / theta
EA	234	*j*	Ω	Italic j / omega
EB	235	*k*	δ	Italic k / delta
EC	236	*l*	∞	Italic l / infinity
ED	237	*m*	Ø	Italic m / slashed zero
EE	238	*n*	∈	Italic n
EF	239	*o*	∩	Italic o
F0	240	*p*	≡	Italic p
F1	241	*q*	±	Italic q
F2	242	*r*	≥	Italic r
F3	243	*s*	≤	Italic s
F4	244	*t*	⌠	Italic t
F5	245	*u*	⌡	Italic u
F6	246	*v*	÷	Italic v
F7	247	*w*	≈	Italic w
F8	248	*x*	°	Italic x
F9	249	*y*	•	Italic y
FA	250	*z*	●	Italic z
FB	251	{	√	Italic left bracket
FC	252	|	^{n}	Italic vertical line
FD	253	}	^{2}	Italic right bracket
FE	254	~		Italic tilde
FF	255	Blank	Blank	Blank

GAME CONTROL CABLE - IBM PC

Joystick Pin Number	Signal Description	Function	Signal Direction At Joystk
1	+5 Volts	Supply voltage	Input
2	Button 1	Push Button 1	Output
3	Position 0	X Coordinate	Output
4	Ground	Ground	
5	Ground	Ground	
6	Position 1	Y Coordinate	Output
7	Button 2	Push Button 2	Output
8	+5 Volts	Supply voltage	Input
9	+5 Volts	Supply voltage	Input
10	Button 3	Push Button 3	Output
11	Position 2	X Coordinate	Output
12	Ground	Ground	
13	Position 3	Y Coordinate	Output
14	Button 4	Push Button 4	Output
15	+5 Volts	Supply voltage	Input

GAME CONTROL CABLE - APPLE IIe

Joystick Pin Number	Signal Description	Function	Signal Direction At Joystk
1	PB1	Push Button 1	Output
2	+5 Volt	Supply voltage	Input
3	Ground	Ground	
4	N.C.	No Connection	
5	PDL0	Paddle 0	Output
6	N.C.	No Connection	
7	PB0	Push Button 0	Output
8	PDL1	Paddle 1	Output
9	N.C.	No Connection	

GAME CONTROL - COMMODORE 64

Joystick Pin Number	Signal Description	Function	Signal Direction At Joystk
1	JOYA0 or BO	Control A0 or B0	Output
2	JOY A1 or B1	Control A1 or B1	Output
3	JOY A2 or B2	Control A2 or B2	Output
4	JOY A3 or B3	Control A3 or B3	Output
5	Pot AY or BY	Pot A or B Y axis	Output
6	Button A/LP or B	Button A or B or Light Pen	Output
7	+5 Volt, 50 ma	Supply Voltage	Input
8	Ground	Ground	
9	Pot AX or BX	Pot A or B X axis	Output

PARALLEL PRINTER INTERFACE

Printer Pin Number	Signal Description	Function	Signal Direction At Printer
1	STROBE	Reads in the data	Input
2	DATA Bit 0	Data line	Input
3	DATA Bit 1	Data line	Input
4	DATA Bit 2	Data line	Input
5	DATA Bit 3	Data line	Input
6	DATA Bit 4	Data line	Input
7	DATA Bit 5	Data line	Input
8	DATA Bit 6	Data line	Input
9	DATA Bit 7	Data line	Input
10	ACKNLG	Acknowledge receipt of data	Output
11	Busy	Printer is busy	Output
12	Paper Empty	Printer out of paper	Output
13	SLCT	Online mode indicator	Output
14	Auto Feed XT		Input
15	Not Used	Not Used	
16	Signal ground	Signal ground	
17	Frame ground	Frame ground	
18	+5 volts	+5 volts	
19-30	Ground	Return signals of pins 1–12, twisted pairs.	
31	Input Prime or INIT	Resets printer, clears buffer & initializes	Input
32	Fault or Error	Indicates offline mode	Output
33	Signal ground	External ground	
34	Not Used	Not Used	
35	+5 Volts	+5 Volts (3.3 K-ohm)	
36	SLCT IN	TTL high level	Input

The above pinout is at the printer plug, computer side pinouts are on the next page. The "Parallel" or "Centronics" configuration for printer data transmission has become the de facto standard in the personal computer industry. This configuration was developed by a printer manufacturer (Centronics) as an alternative to serial data transmission. High data transfer rates are the main advantage of parallel and are attained by simultaneous transmission of all bits of a binary "word" (normally an ASCII code). Disadvantages of the parallel transfer are the requirement for 8 separate data lines and computer to printer cable lengths of less than 12 feet.

PARALLEL PINOUTS @ COMPUTER

IBM/ MS DOS DB25 Systems

Computer Pin Number	Signal Description	Function	Signal Direction At Computer
1	STROBE	Reads in the data	Output
2	DATA Bit 0	Data line	Output
3	DATA Bit 1	Data line	Output
4	DATA Bit 2	Data line	Output
5	DATA Bit 3	Data line	Output
6	DATA Bit 4	Data line	Output
7	DATA Bit 5	Data line	Output
8	DATA Bit 6	Data line	Output
9	DATA Bit 7	Data line	Output
10	ACKNLG	Acknowledge receipt of data	Input
11	Busy	Printer is busy	Input
12	Paper Empty	Printer out of paper	Input
13	SLCT	Online mode indicator	Input
14	Auto Feed XT		Output
15	Fault or Error	Indicates offline mode	Input
16	Input Prime or INIT	Resets printer, clears buffer & initializes	Output
17	SLCT IN	TTL high level	Output
18-25	Ground	Return signals of pins 1–12, twisted pairs.	

IBM VIDEO CARD PINOUTS

Pin Number	Description
Monochrome Display Adapter	
1 & 2	Ground
3, 4, & 5	Not Used
6	+ Intensity
7	+ Video
8	+ Horizontal Drive
9	– Vertical Drive
Color/Graphics Display Adapter	
1 & 2	Ground
3	Red
4	Green
5	Blue
6	+ Intensity
7	Reserved
8	+ Horizontal Drive
9	– Vertical Drive

Standard DB25 Pin Connector

Serial Pin Number	Signal Description	Function	Signal Direction At Device
1	FG	Frame ground	
2	TD	Transmit Data	Output
3	RD	Receive Data	Input
4	RTS	Request to Send	Output
5	CTS	Clear to Send	Input
6	DSR	Data Set Ready	Input
7	SG	Signal Ground	
8	DCD	Data Carrier Detect	Input
9	+V	+ DC test voltage	Input
10	−V	− DC test voltage	Input
11	QM	Equalizer Mode	Input
12	(S)DCD	2nd Data Carrier Detect	Input
13	(S)CTS	2nd Clear to Send	Input
14	(S)TD	2nd Transmitted Data	Output
15	TC	Transmitter Clock	Input
16	(S)RD	2nd Received Data	Input
17	RC	Receiver Clock	Input
18	Not used	Not used	
19	(S)RTS	2nd Request to Send	Output
20	DTR	Data Terminal Ready	Output
21	SQ	Signal Quality Detect	Input
22	RI	Ring Indicator	Input
23		Data Rate Selector	Output
24	(TC)	External Transmitter Clk	Output
25	Not used	Not used	

IBM Standard DB9 Pin Connector

Serial Pin Number	Signal Description	Function	Signal Direction At Device
1	DCD	Data Carrier Detect	Input
2	RD	Receive Data	Input
3	SD	Transmit Data	Output
4	DTR	Data Terminal Ready	Output
5	SG	Signal Ground	
6	DSR	Data Set Ready	Input
7	RTS	Request to Send	Output
8	CTS	Clear to Send	Input
9	RI	Ring Indicator	Input

SERIAL I/O INTERFACES (RS232C)

Macintosh DB9 Pin Connector

Serial Pin Number	Signal Description	Function	Signal Direction At Device
1	GND	Ground	
2		No connection	
3	SG	Signal Ground	
4		No connection	
5	TD	Transmit Data	Output
6	DTR	Data Terminal Ready	Output
7	DSR	Data Set Ready	Input
8		No connection	
9	RD	Receive Data	Input

Apple IIc Round Connector

Serial Pin Number	Signal Description	Function	Signal Direction At Device
1	DTR	Data Terminal Ready	Output
2	TD	Transmit Data	Output
3	GND	Ground	
4	RD	Receive Data	Input
5	DSR	Data Set Ready	Input

Commodore 64 Round Connector

Serial Pin Number	Signal Description	Function
1	SRQIN	Serial SRQIN
2	GND	Signal Ground
3		Serial Attn I/O
4		Serial Clock I/O
5		Serial Data I/O
6		Reset

IBM LIGHT PEN INTERFACE

Pin #	Description
1	– Light Pen Input
2	No connection
3	– Light Pen Switch
4	Chassis Ground
5	+ 5 Volts
6	+ 12 Volts

NOTES ON SERIAL INTERFACING

Printers and asynchronous modems are relatively unsophisticated pieces of electronic equipment. Although all 25 pins of the **Standard DB25** serial connector are listed 2 pages back, only a few of the pins are needed for normal applications. The following list gives the necessary pins for each of the indicated applications.

1. "Dumb Terminals" – 1,2,3, & 7
2. Printers and asynchronous modems – 1,2,3,4,5,6,7,8, & 20
3. "Smart" and synchronous modems – 1,2,3,4,5,6,7,8,13,14, 15,17,20,22, & 24

Cable requirements also differ, depending on the particular hardware being used. The asynchronous modems normally use the 9 pin or 25 pin cables and are wired 1 to 1 (ie, pin 1 on one end of the cable goes to pin 1 on the other end of the cable.) Serial printers, however, have several wires switched in order to accommodate "handshaking" between computer and printer. The rewired junction is called a "Modem Eliminator". In the case of Standard DB25 the following are typical rewires:

Standard IBM PC

DB25 @ Computer	DB25 @ Printer
1	1
3	2
2	3
8	4
4	8
5 & 6	20
20	5 & 6
7	7

Second Standard PC

DB25 @ Computer	DB25 @ Printer
1	1
3	2
2	3
20	5, 6 & 8
7	7
5, 6 & 8	20

PC to Terminal

1	1
2	3
3	2
4	5
5	4
6 & 8	20
20	6 & 8
7	7

Std Hewlett-Packard

1	1
2	3
3	2
4 & 5	8
8	4 & 5
6	20
7 & 22	7 & 22
17	15
11	12
12	11
15 & 24	17
20	6

HAYES COMPATIBLE MODEM SWITCH SETTINGS

Switch	Position	Function
1	Off	Supports DTR line, RS232C
	On	Ignores DTR line, RS232C
2	Off	Word Result Codes
	On	Digital Result Codes: Ø = OK, 1 = Connect, 2 = Ring, 3 = No Carrier, 4 = Error, 5 = Connect 1200 (Extended Code Set)
3	Off	Display no result codes (Q1 Command)
	On	Display result codes (Q0 Command)
4	Off	Echo characters in command state (E1)
	On	No Echo unless 1/2 duplex (EØ)
5	Off	Auto Answer on 1st Ring
	On	Do not answer a call
6	Off	Read Status of Carrier Detect, RS232C
	On	Set Carrier Detect line TRUE at all times.
7	Off	Single Phone Line Jack, R11
	On	Multiline Phone Line Jack, RJ12 or RJ13
8	Off	Disable Smartmodem 1200 Command Recognition (Dumb Mode)
	On	Enable Smartmodem 1200 Command Recognition (Smart Mode)

HAYES COMPATIBLE MODEM COMMAND SETTINGS

Command	Function
A	Immediate answer on ring
A /	Repeat last command line (Replaces AT)
Cn	n = Ø is Transmitter off, n = 1 is on, (1 = default)
Bn	n = Ø is CCITT answer tone, n = 1 is US/Canada Tone
Dn	Dial telephone number n = Ø to 9 for phone numbers n = T is Touch Tone Dial, P is Pulse Dial n = R is Originate Only, n = , is Pause n = ! is xfer call to following extension n = " is dial letters that follow n = @ is Dial, Wait for answer, & continue n = ; is Return to command mode after dialing
En	n = Ø is no character echo in command state n = 1 is echo all characters in command state
Fn	n = Ø is Half Duplex: n = 1 if Full Duplex
Hn	n = Ø is On Hook (Hang Up), n = 1 is Off Hook n = 2 is Special Off Hook
In	n = Ø is Display product code, n = 1 show Check Sum n = 2 is show RAM test, n = 3 is show call time length n = 4 is show current modem settings
Kn	n = Ø at AT13 show last call length, n = 1 show time

(1) Courtesy of *Hayes Microcomputer Products, Inc. Norcross, GA*

HAYES COMPATIBLE MODEM COMMAND SETTINGS

Command	Function
Mn	n = Ø is Speaker always on, n = 2 is always off n = 1 is Speaker on until carrier detected (default) n = 3 is Speaker on after dial through CONNECT
O	Return to on–line state
P	Pulse Dial
Qn	n = Ø is send Result Codes, n = 1 is do not send code
R	Reverse mode (Originate Only)
SØ = n ..	n = Ø to 255 rings before answer (see switch 5)
S1 = n ...	Counts rings from Ø to 255
S2 = n ...	Set escape code character, n = Ø to 127, 43 default
S3 = n ...	Set carriage return character, n = Ø to 127, 13 default
S4 = n ...	Set line feed character, n = Ø to 127, 10 default
S5 = n ...	Set backspace character, n = Ø to 127, 8 default
S6 = n ...	Wait time for dial tone, n = 2 to 255 seconds
S7 = n ...	Wait time for carrier, n = 2 to 255 seconds
S8 = n ...	Set duration of "," pause character, n = Ø to 255 sec.
S9 = n ...	Carrier detect response time, n = 1 to 255 1/10 secs.
S10 = n ..	Delay time carrier loss to hang-up, n = 1 to 255 1/10 s.
S11 = n ..	Duration & space of Touch Tones, n = 50 to 255 ms.
S12 = n ..	Escape code guard time, n = 50 to 255 1/50 seconds
S13 = n ..	UART Status Register Bit Mapped (reserved)
S14 = n ..	Option Register, Product code returned by AT1Ø
S15 = n ..	Flag Register (reserved)
S16 = n ..	Self test mode. n = Ø is data mode (default), n = 1 is Analog Loopback, n = 2 is dial test, n = 4 is Test Pattern, n = 5 is Analog Loopback and Test Pattern.
Sn ?	Send contents of Register n (Ø to 16) to Computer
T	Touch Tone Dial
Vn	n = Ø is send result codes as digits, n = 1 is words
Xn	n = Ø send basic result codes Ø to 4 n = 1 to 6 send extended result codes Ø to 12
Z	Software reset and reset to default values
&Cn	n = Ø is carrier detect always active, n = 1 active
&Dn	n = Ø is DTR always ignored, = 1 DTR causes return to command, = 2 DTR disconnects, = 3 disconnect/reset
&F	Get Factory Configuration
&Gn	n = Ø Disable Guard Tone, = 1 is 550hz, = 2 is 1800hz
&Ln	n = Ø or 1 Speaker Volume Low, = 2 medium, = 3 high
&Pn	n = Ø Pulse Make/Break Ratio USA 39% / 61% n = 1 Pulse Make/Break Ratio UK 33% / 67%
&Rn	n = Ø is CTS always active, n = 1 CTS always active
&Sn	n = Ø is DSR always active, n = 1 DSR active at connect
&Tn	Test Commands: n = Ø end test, = 1 local analog loopback, = 3 local digital loopback, = 4 enable Rmt digital loopback, = 5 disable digital loopback, = 6 request Rmt digital loop, = 7 request Rmt dig loop & enter self test, = 8 local analog loop & self test
&W	Write Configuration to Memory
&Zn	Store Phone Number

GPIB I/O INTERFACE (IEEE-488)

The HPIB/GPIB/IEEE–488 standard is a very powerful interface developed originally by Hewlett–Packard (HP–IB). The interface has been adopted by a variety of groups, such as IEEE, and is known by names such as HP–IB, GPIB, IEEE–488 and IEC Standard 625–1 (outside the US). Worldwide use of this standard has come about due to its ease of use, handshaking protocol, and precisely defined function.

Information management is handled by three device types, Talkers, Listeners, and Controllers. Talkers send information, Listeners receive data, and Controllers manage the interactions. Up to 15 devices can be interconnected, but are usually located within 20 feet of the computer. Additional extenders can be used to access more than 15 devices.

GPIB 24 Line Bus

Pin Number	Signal Description	Function
1	DATA I/O 1	Data line I/O bus
2	DATA I/O 2	Data line I/O bus
3	DATA I/O 3	Data line I/O bus
4	DATA I/O 4	Data line I/O bus
5	EIO	End or Identify
6	DAV	Data valid
7	NRFD	Not Ready For Data
8	NDAC	Data Not Accepted
9	SRQ	Service Request
10	IFC	Interface Clear
11	ATN	Attention
12	Shield	or wire ground
13	DATA I/O 5	Data line I/O bus
14	DATA I/O 6	Data line I/O bus
15	DATA I/O 7	Data line I/O bus
16	DATA I/O 8	Data line I/O bus
17	REN	Remote Enable
18	Ground	Ground
19	Ground	Ground
20	Ground	Ground
21	Ground	Ground
22	Ground	Ground
23	Ground	Ground
24	Logic Ground	Logic Ground

Devices can be set up in star, linear or other combinations and are easily set up using male/female stackable connectors.

IBM PC MEMORY MAP

Address Range	Size	Description
ØØØØØ-ØØ3FF ...	1K ...	Interrupt Vectors
ØØ4ØØ-7FFFF	512K .	Bios, DOS, 512K RAM Expansion
8ØØØØ-9FFFF	128K .	128K RAM Expansion (Top of 640K)
AØØØØ-AFFFF	64K ..	EGA Video Buffer
BØØØØ-B7FFF	32K ..	Monochrome & other screen buffers
B8ØØØ-B8FFF	32K ..	CGA and EGA Buffers
AT LIM Expanded Memory 64K page is between 768K and 896K		
CØØØØ-C3FFF	16K ..	EGA Video Bios
C4ØØØ-C7FFF	16K ..	ROM Expansion Area
XT LIM Expanded Memory 64K page is between 800K and 960K		
C8ØØØ-CCFFF	20K ..	XT Hard Disk Controller Bios
CDØØØ-CFFFF	12K ..	User PROM, Memory mapped I/O
DØØØØ-DFFFF ...	64K ..	User PROM, normal LIM Location for Expanded Memory
EØØØØ-EFFFF	64K ..	ROM expansion, I/O for XT
FØØØØ-FDFFF	56K ..	ROM BASIC
FEØØØ-FFFD9	8K ...	BIOS
FFFFØ-FFFF4	4	1st Code run after system power on
FFFF5-FFFFC	8	BIOS Release Date
FFFFE-FFFFF	2	Machine ID (Top of 1 Meg RAM)
1ØØØØØ-FFFFFF ..	15Meg	AT Extended Memory

IBM PC HARDWARE INTERRUPTS

NMI .... Non-Maskable Interrupt (Parity)

Interrupt Controller 1:

IRQØ .... Timer Output
IRQ1 .... Keyboard
IRQ2 .... XT – Reserved
AT – Route to Interrupt Controller 2, IRQ8 to 15
IRQ3 .... Serial Port COM2: or SDLC
IRQ4 .... Serial Port COM1: or SDLC
IRQ5 .... XT – Hard Disk Controller
AT – Parallel Printer Port 2
IRQ6 .... Floppy Disk Controller
IRQ7 .... Parallel Printer Port LPT1:

Interrupt Controller 2 (AT Only):

IRQ8 .... Real Time Clock
IRQ9 .... Software redirect to IRQ2 (Int ØA Hex)
IRQ10 ...... Reserved
IRQ11 ...... Reserved
IRQ12 ...... Reserved
IRQ13 ...... 80287 Math Coprocessor
IRQ14 ...... Hard Disk Controller
IRQ15 ...... Reserved

IBM PC HARDWARE I/O MAP

8088 Class Systems

Address	Function
ØØØ–ØØF	DMA Controller (8237A)
Ø2Ø–Ø21	Interrupt controller (8259A)
Ø4Ø–Ø43	Timer (8253)
Ø6Ø–Ø63	PPI (8255A)
Ø8Ø–Ø83	DMA page register (74LS612)
ØAØ–ØAF	NMI – Non Maskable Interrupt
2ØØ–2ØF	Game Port Joystick controller
21Ø–217	Expansion Unit
2E8–2EF	COM4: Serial Port
2F8–2FF	COM2: Serial Port
3ØØ–31F	Prototype Card
32Ø–32F	Hard Disk
378–37F	Parallel Printer Port 1
38Ø–38F	SDLC
3BØ–3BF	MDA – Monochrome Adapter and printer
3DØ–3D7	CGA – Color Graphics Adapter
3E8–3EF	COM3: Serial Port
3FØ–3F7	Floppy Diskette Controller
3F8–3FF	COM1: Serial Port

80286 Class Systems

Address	Function
ØØØ–Ø1F	DMA Controller #1 (8237A–5)
Ø2Ø–Ø3F	Interrupt controller #1 (8259A)
Ø4Ø–Ø5F	Timer (8254)
Ø6Ø–Ø6F	Keyboard (8Ø42)
Ø7Ø–Ø7F	NMI – Non Maskable Interrupt & CMOS RAM
Ø8Ø–Ø9F	DMA page register (74LS612)
ØAØ–ØBF	Interrupt controller #2 (8259A)
ØCØ–ØDF	DMA Controller #2 (8237A)
ØFØ–ØFF	8Ø287 Math Coprocessor
1FØ–1F8	Hard Disk
2ØØ–2ØF	Game Port Joystick controller
258–25F	Intel Above Board
278–27F	Parallel Printer Port 2
2E8–2EF	COM4: Serial Port
2F8–2FF	COM2: Serial Port
3ØØ–31F	Prototype Card
378–37F	Parallel Printer Port 1
38Ø–38F	SDLC or Bisynchronous Comm Port 2
3AØ–3AF	Bisynchronous Comm Port 1
3BØ–3BF	MDA – Monochrome Adapter
3BC–3BE	Parallel Printer on Monochrome Adapter
3CØ–3CF	EGA – Reserved
3DØ–3D7	CGA – Color Graphics Adapter
3E8–3EF	COM3: Serial Port
3FØ–3F7	Floppy Diskette Controller
3F8–3FF	COM1: Serial Port

IBM PC SOFTWARE INTERRUPTS

Address	Int #	Interrupt Name
ØØØ–ØØ3	Ø	Divide by zero
ØØ4-ØØ7	1	Single Step IRET
ØØ8–ØØB	2	NMI Non Maskable Interrupt
ØØC–ØØF	3	Breakpoint
Ø1Ø–Ø13	4	Overflow IRET
Ø14–Ø17	5	Print Screen
Ø18–Ø1F	6	Reserved Ø18–Ø1B and Ø1C–Ø1F
Ø2Ø–Ø23	8	Time of Day Ticker IRQØ
Ø24–Ø27	9	Keyboard IRQ1
Ø28–Ø2B	A	XT Reserved, AT IRQ2 direct to IRQ9
Ø2C–Ø2F	B	COM2 communications, IRQ3
Ø3Ø–Ø33	C	COM1 communications, IRQ4
Ø34–Ø37	D	XT Hard disk, AT Parallel Printer, IRQ5
Ø38–Ø3B	E	Floppy Diskette, IRQ6
Ø3C–Ø3F	F	Parallel Printer 1, IRQ7, slave 8259, IRET
Ø4Ø–Ø43	1Ø	ROM Handler – Video
Ø44–Ø47	11	ROM Handler – Equipment Check
Ø48–Ø4B	12	ROM Handler – Memory Check
Ø4C–Ø4F	13	ROM Handler – Diskette I/O
Ø5Ø–Ø53	14	ROM Handler – COMM I/O
Ø54–Ø57	15	XT Cassette, AT ROM Catchall Handlers
Ø58–Ø5B	16	ROM Handler – Keyboard I/O
Ø5C–Ø5F	17	ROM Handler – Printer I/O
Ø6Ø–Ø63	18	ROM Handler – Basic Startup
Ø64–Ø67	19	ROM Handler – Bootstrap
Ø68–Ø6B	1A	ROM Handler – Time of Day
Ø6C–Ø6F	1B	ROM Handler – Keyboard Break
Ø7Ø–Ø73	1C	ROM Handler – User Ticker
Ø74–Ø77	1D	ROM Pointer, Video Initialization
Ø78–Ø7B	1E	ROM Pointer, Diskette Parameters
Ø7C–Ø7F	1F	ROM Pointer, Graphics Characters Set 2
Ø8Ø–Ø83	2Ø	DOS – Terminate Program
Ø84–Ø87	21	DOS – Function Call
Ø88–Ø8B	22	DOS – Program's Terminate Address
Ø8C–Ø8F	23	DOS – Program's Control–Break Address
Ø9Ø–Ø93	24	DOS – Critical Error Handler
Ø94–Ø97	25	DOS – Absolute Disk Read
Ø98–Ø9B	26	DOS – Absolute Disk Write
Ø9C–Ø9F	27	DOS – TSR Terminate & Stay Ready
ØAØ–ØFF	28–3F	DOS – Idle Loop, IRET
1ØØ–1Ø3	4Ø	Hard Disk Pointer – Original Floppy Handler
1Ø4–1Ø7	41	ROM Pointer, XT Hard Disk Parameters
1Ø8–1ØB	42–45	Reserved
1ØC–1ØF	46	ROM Pointer, AT Hard Disk Parameters
11Ø–17F	47–5F	Reserved
18Ø–19F	6Ø–67	Reserved for User (67 is Expanded Mem)
1AØ–1BF	68–6F	Not Used
1CØ–1C3	7Ø	AT Real Time Clock, IRQ8
1C4–1C7	71	AT Redirect to IRQ2, IRQ9, LAN Adapter 1
1C8–1CB	72	AT Reserved, IRQ1Ø
1CC–1CF	73	AT Reserved, IRQ11
1DØ–1D3	74	AT Reserved, IRQ12
1D4–1D7	75	AT 8Ø287 Error to NMI, IRQ13
1D8–1DB	76	AT Hard Disk, IRQ14
1DC–1DF	77	AT Reserved, IRQ15
1EØ–1FF	78–7F	Not Used
2ØØ–217	8Ø–85	Reserved for BASIC
218–21B	86	NetBIOS, Relocated Interrupt 18H
218–3C3	87–FØ	Reserved for BASIC Interpreter
3C4–3FF	F1–FF	Not Used

IBM XT/AT CLASS ERROR CODES

A variety of tests are executed automatically when XT/AT class computers are first turned on. Initially, the "Power-On Self Test" (POST). The POST process provides error or warning messages whenever a faulty component is encountered. Typically, two types of messages are issued: **audio codes** and **display screen** messages or codes.

Audio codes consist of a series of beeps that identify a faulty component. If your computer is functioning normally, you will hear one short beep when the system is turned on. However, if a problem is detected, a series of beeps will occur. These audio codes define the problem and are typically the following:

Beep Code	Problem
No beep, continuous beep, or repeating short beeps	Power Supply
1 long beep and 1 short beep	System Board
1 long beep and 2 short beeps, or 1 short beep and blank	Monitor adapter card and/or monitor cable and/or wrong display.
1 short beep and either the red drive LED staying on or Personal Computer BASIC statement	Drive and/or drive adapter card

If the system completes the POST process, then additional errors are reported in the form of display error messages. See the next page for typical codes and their descriptions.

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MEGABYTES AND KILOBYTES

1 kilobyte = 2^{10} bytes = exactly 1,024 bytes

1 megabyte = 2^{20} bytes = exactly 1,048,576 bytes

1 gigabyte = 1 billion bytes   1 terabyte = 1 trillion bytes

1 byte = 8 bits (bit is short for binary digit)

8 bit computers (such as the 8088) move data in 1 byte chunks

16 bit computers (such as the 80286) move data in 2 byte chunks

32 bit computers (such as the 80386) move data in 4 byte chunks

IBM XT/AT CLASS ERROR CODES

Code	Description
01x	Undetermined problem errors
02x	Power supply errors
1xx	**System board error**
101	Interrupt failure
102	Timer failure
103	Timer interrupt failure
104	Protected mode failure
105	Last 8042 command not accepted
106	Converting logic test
107	Hot NMI test
108	Timer bus test
109	Direct memory access test error
121	Unexpected hardware interrupts occurred
131	Cassette wrap test failed
152	
161	System Options Error-(Run SETUP) [Battery failure]
162	System options not set correctly-(Run SETUP)
163	Time and date not set-(Run SETUP)
164	Memory size error-(Run SETUP)
199	User indicated configuration not correct
2xx	**Memory (RAM) errors**
201	Memory test failed
202	Memory address error
203	Memory address error
3xx	**Keyboard errors**
301	Keyboard did not respond to software reset correctly or a stuck key failure was detected. If a stuck key was detected, the scan code for the key is displayed in hexadecimal. For example, the error code 49 301 indicates that key 73, the PgUp key has failed (49 Hex = 73 decimal)
302	User indicated error from the keyboard test or AT system unit keylock is locked
303	Keyboard or system unit error
304	Keyboard or system unit error; CMOS does not match system
4xx	**Monochrome monitor errors**
401	Monochrome memory test, horizontal sync frequency test, or video test failed
408	User indicated display attributes failure
416	User indicated character set failure
424	User indicated 80X25 mode failure
432	Parallel port test failed (monochrome adapter)

IBM XT/AT CLASS ERROR CODES

Code	Description
5xx	**Color monitor errors**
501	Color memory test failed, horizontal sync frequency test, or video test failed
508	User indicated display attribute failure
516	User indicated character set failure
524	User indicated 80X25 mode failure
532	User indicated 40X25 mode failure
540	User indicated 320X200 graphics mode failure
548	User indicated 640X200 graphics mode failure
6xx	**Diskette drive errors**
601	Diskette power on diagnostics test failed
602	Diskette test failed; boot record is not valid
606	Diskette verify function failed
607	Write protected diskette
608	Bad command diskette status returned
610	Diskette initialization failed
611	Time-out - diskette status returned
612	Bad NEC - diskette status returned
613	Bad DMA - diskette status returned
621	Bad seek - diskette status returned
622	Bad CRC - diskette status returned
623	Record not found - diskette status returned
624	Bad address mark - diskette status returned
625	Bad NEC seek - diskette status returned
626	Diskette data compare error
7xx	**8087 or 80287 math coprocessor errors**
9xx	**Parallel printer adapter errors**
901	Parallel printer adapter test failed
10xx	**Reserved for parallel printer adapter**
11xx	**Asynchronous communications adapter errors**
1101	Async communications adapter test failed
12xx	**Alternate asynchronous communications adapter errors**
1201	Alternateasynchronous communications adapter test failed
13xx	**Game control adapter errors**
1301	Game control adapter test failed
1302	Joystick test failed
14xx	**Printer errors**
1401	Printer test failed
1404	Matrix printer failed
15xx	**Synchronous data link control (SDLC) comm adapter errors**
1510	8255 port B failure
1511	8255 port A failure

Code	Description
1512	...... 8255 port C failure
1513	...... 8253 timer 1 did not reach terminal count
1514	...... 8253 timer 1 stuck on
1515	...... 8253 timer 0 did not reach terminal count
1516	...... 8253 timer 0 stuck on
1517	...... 8253 timer 2 did not reach terminal count
1518	...... 8253 timer 2 stuck on
1519	...... 8273 port B error
1520	...... 8273 port A error
1521	...... 8273 command/read time-out
1522	...... Interrupt level 4 failure
1523	...... Ring Indicate stuck on
1524	...... Receive clock stuck on
1525	...... Transmit clock stuck on
1526	...... Test indicate stuck on
1527	...... Ring indicate not on
1528	...... Receive clock not on
1529	...... Transmit clock not on
1530	...... Test indicate not on
1531	...... Data set ready not on
1532	...... Carrier detect not on
1533	...... Clear to send not on
1534	...... Data set ready stuck on
1536	...... Clear to send stuck on
1537	...... Level 3 interrupt failure
1538	...... Receive interrupt results error
1539	...... Wrap data mis-compare
1540	...... DMA channel 1 error
1541	...... DMA channel 1 error
1542	...... Error in 8273 error checking or status reporting
1547	...... Stray interrupt level 4
1548	...... Stray interrupt level 3
1549	...... Interrupt presentation sequence time-out
16xx	...... **Display emulation errors (327x, 5520, 525x)**
17xx	...... **Fixed disk errors**
1701	...... Fixed disk POST error
1702	...... Fixed disk adapter error
1703	...... Fixed disk drive error
1704	...... Fixed disk adapter or drive error
1780	...... Fixed disk 0 failure
1781	...... Fixed disk 1 failure
1782	...... Fixed disk controller failure
1790	...... Fixed disk 0 error
1791	...... Fixed disk 1 error
18xx	...... **I/O expansion unit errors**

Code	Description
1801	I/O expansion unit POST error
1810	Enable/Disable failure
1811	Extender card warp test failed (disabled)
1812	High order address lines failure (disabled)
1813	Wait state failure (disabled)
1814	Enable/Disable could not be set on
1815	Wait state failure (disabled)
1816	Extender card warp test failed (enabled)
1817	High order address lines failure (enabled)
1818	Disable not functioning
1819	Wait request switch not set correctly
1820	Receiver card wrap test failure
1821	Receiver high order address lines failure
19xx	**3270 PC attachment card errors**
20xx	**Binary synchronous communications (BSC)** adapter errors
2010	8255 port A failure
2011	8255 port B failure
2012	8255 port C failure
2013	8253 timer 1 did not reach terminal count
2014	8253 timer 1 stuck on
2016	8253 timer 2 did not reach terminal count or timer 2 stuck on
2017	8251 Data set ready failed to come on
2018	8251 Clear to send not sensed
2019	8251 Data set ready stuck on
2020	8251 Clear to send stuck on
2021	8251 hardware reset failed
2022	8251 software reset failed
2023	8251 software "error reset" failed
2024	8251 transmit ready did not come on
2025	8251 receive ready did not come on
2026	8251 could not force "overrun" error status
2027	Interrupt failure - no timer interrupt
2028	Interrupt failure - transmit, replace card or planar
2029	Interrupt failure - transmit, replace card
2030	Interrupt failure - receive, replace card or planar
2031	Interrupt failure - receive, replace card
2033	Ring indicate stuck on
2034	Receive clock stuck on
2035	Transmit clock stuck on
2036	Test indicate stuck on
2037	Ring indicate stuck on
2038	Receive clock not on
2039	Transmit clock not on

Code	Description
2040	...... Test indicate not on
2041	...... Data set ready not on
2042	...... Carrier detect not on
2043	...... Clear to send not on
2044	...... Data set ready stuck on
2045	...... Carrier detect stuck on
2046	...... Clear to send stuck on
2047	...... Unexpected transmit interrupt
2048	...... Unexpected receive interrupt
2049	...... Transmit data did not equal receive data
2050	...... 8251 detected overrun error
2051	...... Lost data set ready during data wrap
2052	...... Receive time-out during data wrap
21xx	...... **Alternate binary synchronous communications adapter errors**
2110	...... 8255 port A failure
2111	...... 8255 port B failure
2112	...... 8255 port C failure
2113	...... 8253 timer 1 did not reach terminal count
2114	...... 8253 timer 1 stuck on
2115	...... 8253 timer 2 did not reach terminal count or timer 2 stuck on
2116	...... 8251 Data set ready failed to come on
2117	...... 8251 Clear to send not sensed
2118	...... 8251 Data set ready stuck on
2119	...... 8251 Clear to send stuck on
2120	...... 8251 hardware reset failed
2121	...... 8251 software reset failed
2122	...... 8251 software "error reset" failed
2123	...... 8251 transmit ready did not come on
2124	...... 8251 receive ready did not come on
2125	...... 8251 could not force "overrun" error status
2126	...... Interrupt failure - no timer interrupt
2128	...... Interrupt failure - transmit, replace card or planar
2129	...... Interrupt failure - transmit, replace card
2130	...... Interrupt failure - receive, replace card or planar
2131	...... Interrupt failure - receive, replace card
2133	...... Ring indicate stuck on
2134	...... Receive clock stuck on
2135	...... Transmit clock stuck on
2136	...... Test indicate stuck on
2137	...... Ring indicate stuck on
2138	...... Receive clock not on
2139	...... Transmit clock not on

IBM XT/AT CLASS ERROR CODES

Code	Description
2140	Test indicate not on
2141	Data set ready not on
2142	Carrier detect not on
2143	Clear to send not on
2144	Data set ready stuck on
2145	Carrier detect stuck on
2146	Clear to send stuck on
2147	Unexpected transmit interrupt
2148	Unexpected receive interrupt
2149	Transmit data did not equal receive data
2150	8251 detected overrun error
2151	Lost data set ready during data wrap
2152	Receive time-out during data wrap
22xx	**Cluster adapter errors**
24xx	**Enhanced graphics adapter errors**
29xx	**Color matrix printer errors**
2901	
2902	
2904	
33xx	**Compact printer errors**

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IBM HARDWARE RELEASES

Date	Code	Hardware Release
04-24-81	FF	PC (the original!)
10-19-81	FF	PC (fixed bugs)
08-16-81	FE	XT
10-27-82	FF	PC with hard drive support and 640k
11-08-82	FE	PC-XT portable
06-01-83	FD	PC jr
01-10-84	FC	AT
06-10-85	FC	AT revision 1
09-13-85	F9	PC Convertible
11-15-85	FC	AT w/speed control, 30 meg hard disk
01-10-86	FB	XT revision 1
04-21-86	FC	XT-286 model 2
05-09-86	FB	XT revision 2
09-02-86	FA	PS/2 Model 30
02-13-87	FC	PS/2 Model 50 model 4
02-13-87	FC	PS/2 Model 60 model 5
03-30-87	F8	PS/2 Model 80 16 mhz
10-07-87	F8	PS/2 Model 80 20 mhz

STANDARD 80286 HARD DISK TYPES

Drive Type	# of Cylinders	# of Heads	Write Precomp	Land Zone	Size in Megabytes
1	306	4	128	305	10
2	615	4	300	615	21
3	615	6	300	615	31
4	940	8	512	940	63
5	940	6	512	940	47
6	615	4	65535	615	21
7	462	8	256	511	31
8	733	5	65535	733	31
9	900	15	65535	901	112
10	820	3	65535	820	21
11	855	5	65535	855	36
12	855	7	65535	855	50
13	306	8	128	319	21
14	733	7	65535	733	43
15	0	0	0	0	0
16	612	4	0	663	21
17	977	5	300	977	41
18	977	7	65535	977	57
19	1024	7	512	1023	60
20	733	5	300	732	31
21	733	7	300	732	43
22	733	5	300	733	31
23	306	4	0	336	10
24	698	7	300	732	42
25	615	4	0	615	21
26	1024	4	65535	1023	34
27	1024	5	65535	1023	43
28	1024	8	65535	1023	68
29	512	8	256	512	34
30	615	2	615	615	10
31	732	7	300	732	44
32	1023	5	65535	1023	44
33	306	4	0	340	10
34	976	5	488	977	42
35	1024	9	1024	1024	77
36	1024	5	512	1024	43
37	830	10	65535	830	69
38	823	10	256	824	68
39	615	4	128	664	21
40	615	8	128	664	41
41	917	15	65535	918	114
42	1023	15	65535	1024	127
43	823	10	512	823	68
44	820	6	65535	820	41
45	1024	8	65535	1024	68
46	925	9	65535	925	69
47	699	7	256	700	41

Note: Drive types over #24 vary between computer manufacturers

DIABLO 630 PRINTER CODES

Code	Hex	Decimel	Command
Page Format Control:			
ESC 9	1B 39	27 57	Set left margin at current position
ESC Ø	1B 3Ø	27 48	Set right margin at current position
ESC T	1B 54	27 84	Set top margin at current position
ESC L	1B 4C	27 76	Set bottom margin at current posit.
ESC C	1B 43	27 67	Clear top and bottom margins
ESC FF #	1B ØC #	27 12 #	Set lines/page, # is 1 to 126 lines
Horizontal Movement and Spacing Control:			
CR	ØD	13	Carriage return
ESC M	1B 4D	27 77	Enable auto justify
ESC =	1B 3D	27 61	Enable auto center
ESC ?	1B 3F	27 63	Enable auto carriage return
ESC !	1B 21	27 33	Disable auto carriage return
ESC /	1B 2F	27 47	Enable auto backward printing
ESC \	1B 5C	27 92	Disable auto backward printing
ESC <	1B 3C	27 6Ø	Enable reverse printing
ESC >	1B 3E	27 62	Disable reverse printing
ESC 5	1B 35	27 53	Enable forward printing
ESC 6	1B 36	27 54	Enable backward printing
SP	2Ø	32	Space
BS	Ø8	Ø8	Backspace
ESC BS	1B Ø8	27 Ø8	Backspace 1/12Ø inch
HT	Ø9	Ø9	Horizontal tab
ESC HT #	1B Ø9 #	27 Ø9 #	Absolute horizontal tab, # is column 1 to 126
ESC DC1 #	1B 11 #	27 17 #	Spacing offset, # is 1 to 126 (1/12Ø" units), where # 1 = offset 1 to # 63 = offset 63, # 64 = offset Ø, # 65 = offset –1 to # 126 = offset –62
ESC 1	1B 31	27 49	Set horizontal tab stop at current position
ESC 8	1B 38	27 56	Clear horizontal tab at current position

Code	Hex	Decimel	Command
Horizontal Movement and Spacing Control: (Continued)			
ESC 2	1B 32	27 5Ø	Clear all vertical and horizontal tab stops
ESC US #	1B 1F #	27 31 #	Set horizontal motion index, # is 1 to 126, where (#−1)/12Ø inch is the column spacing.
ESC S	1B 53	27 83	Return HMI control to spacing switch
Vertical Movement and Spacing Control:			
LF	ØA	1Ø	Line feed
ESC LF	1B ØA	27 1Ø	Reverse line feed
ESC U	1B 55	27 85	Half line feed
ESC D	1B 44	27 68	Reverse half line feed
FF	ØC	12	Form feed
VT	ØB	11	Vertical tab
ESC VT #	1B ØB #	27 11 #	Absolute vertical tab, # is line 1 to 126
ESC _	1B 2D	27 45	Set vertical tab stop at current position
ESC 2	1B 32	27 5Ø	Clear all vertical and horizontal tab stops
ESC RS #	1B 1E #	27 3Ø #	Set vertical motion index, # is 1 to 126, where (#-1)/48 inch is the line spacing.
Character Selection:			
ESC P	1B 5Ø	27 8Ø	Enable proportional print spacing
ESC Q	1B 51	27 81	Disable proportional print spacing
ESC SO DC2	1B ØE 12	27 14 18	Enable printwheel down-load mode
DC4	14	28	Exit printwheel down-load
SO	ØE	14	Enable ESC mode, supplementary characters
SI	ØF	15	Disable ESC mode, primary characters
ESC A	1B 41	27 65	Select red ribbon (secondary font)
ESC B	1B 42	27 66	Select black ribbon (primary font)
ESC X	1B 58	27 88	Cancel all WP modes except Proportional
ESC Y	1B 59	27 89	Printwheel Spoke Ø char.

DIABLO 630 PRINTER CODES

Code	Hex	Decimel	Command
Character Selection: (Continued)			
ESC Z	1B 5A	27 9Ø	Printwheel Spoke 95 char.
Character Highlight Selection:			
ESC E	1B 45	27 69	Enable underscore print
ESC R	1B 52	27 82	Disable underscore print
ESC O	1B 4F	27 79	Enable bold printing
ESC W	1B 57	27 87	Enable shadow printing
ESC &	1B 26	27 38	Disable bold and shadow printing
Graphics:			
ESC 3	1B 33	27 51	Enable graphics mode
ESC 4	1B 34	27 52	Disable graphics mode
ESC G	1B 47	27 71	Enable HyPLOT mode
Miscellaneous:			
ESC CR P	1B ØD 5Ø	27 13 8Ø	Reset all modes to default
ESC SUB I	1B 1A 49	27 27 73	Reset all modes to default
ESC EM	1B 19	27 25	Enable auto sheet feeder
ESC SUB	1B 1A	27 26	Enable remote diagnostics
ESC N	1B 4E	27 78	Restore normal carriage settling time
ESC %	1B 25	27 37	Increase carriage settling time
ESC 7	1B 37	27 55	Enable print suppression
ESC SO M	1B ØE 4D	27 14 77	Enable program mode

EPSON FX–80 PRINTER CODES

Code	Hex	Decimel	Command
Page Format Control:			
ESC l #	1B 6C #	27 1Ø8 #	Set Left Margin at Col #
ESC Q #	1B 51 #	27 81 #	Set Right Margin at Col #
ESC C #	1B 43 #	27 67 #	Set Form Length to # Lines (or n inches)
ESC C Ø #	1B 43 ØØ #	27 67 Ø #	Set Form Length to # inches
ESC N #	1B 4E #	27 78 #	Set Skip–over Perforation to # lines
ESC O	1B 4F	27 79	Turn Skip–over Perforation Off

EPSON FX-80 PRINTER CODES

Code	Hex	Decimel	Command
Horizontal Movement and Spacing Control:			
CR	ØD	13	Carriage return
BS	Ø8	Ø8	Backspace
HT	Ø9	Ø9	Horizontal tab
ESC a Ø	1B 61 ØØ	1B 61 Ø	Alignment Left Justified
ESC a 1	1B 61 Ø1	1B 61 1	Alignment Auto Centering
ESC a 2	1B 61 Ø2	1B 61 2	Alignment Right Justified
ESC a 3	1B 61 Ø3	1B 61 3	Alignment Auto Justified
ESC D#Ø	1B 44 # Ø	27 68 # ØØ	Set Horizontal Tab(s), # can be 1 or a series of tabs (columns)
ESC D Ø	1B 44 Ø	27 68 ØØ	Release Horizontal Tab
ESC eØ#	1B 44 Ø #	27 68 ØØ #	Set Horizontal Unit Tab(s), # is repeating Tab distance in columns
ESC e ØØ	1B 44 Ø Ø	27 68 ØØ ØØ	Release Horiz Tab Unit
ESC f Ø #	1B 66 ØØ #	27 1Ø2 Ø #	Move print position # cols
ESC \ #1#2	1B 5C #1#2	27 92 #1#2	Move print position in increments of 1/12Ø inch
ESC $ #1#2	1B 24 #1#2	27 36 #1#2	Move print position in 1/6Ø inch increments from left margin
ESC SP #	1B 2Ø #	27 32 #	Add space after each character in units of 1/24Ø inch where # is from 1 to 63
ESC <	1B 3C	27 6Ø	One Line Unidirectional Printing Mode On
ESC U	1B 55	27 85	Select Continuous Print Unidirectional Mode
Vertical Movement and Spacing Control:			
LF	ØA	1Ø	Line feed
ESC j #	1B 6A #	27 1Ø6 #	Reverse Line Feed of #/216 Inch
ESC J #	1B 4A #	27 74 #	Forward Line Feed of #/216 inches
ESC f 1 #	1B 66 Ø1 #	27 1Ø2 1 #	Forward Line Feed # lines
FF	ØC	12	Form feed
ESC Ø	1B 3Ø	27 48	Set Line Spacing to 1/8" (9 points or 8 lpi)
ESC 1	1B 31	27 49	Set Line Spacing to 7/72" (7 points)
ESC 2	1B 32	27 5Ø	Set Line Spacing to 1/6" (12 points, 6 lpi)
ESC 3 #	1B 33 #	27 51 #	Set Line Spacing to #/216"
ESC A #	1B 41 #	27 65 #	Set Line Spacing to # Points (#/72 inch)

EPSON FX-80 PRINTER CODES

Code	Hex	Decimel	Command
Vertical Movement and Spacing Control: (Continued)			
VT	ØB	11	Vertical tab
ESC b#1#2#3 Ø	1B 62 #1#2#3 ØØ	27 98 #1#2#3 Ø	Set Vertical Tabs Format Units in Specific Channel, see the manual for details
ESC b #1 Ø	1B 62 #1 ØØ	27 98 #1 Ø	Release Vertical Tab Format Unit
ESC / #	1B 2F #	27 47 #	Select Vertical Tab Channel #
ESC B#1#2Ø	1B 42 #1#2 Ø	27 66 #1 #2 Ø	Set Vertical Tabs for Channel #1, #2 etc
ESC B Ø	1B 42 Ø	27 66 Ø	Release Vertical Tabs for Channels
ESC e 1 #	1B 65 Ø1 #	27 1Ø1 1 #	Set Vertical Tab Unit at # of equal space intervals
ESC e 1 1	1B 65 Ø1 Ø1	27 1Ø1 1 1	Release Vertical Tab Unit of equal space intervals
Character Selection:			
ESC I 1	1B 49 Ø1	27 73 1	Select Characters (Ø–31, 128–159) to Print
ESC I Ø	1B 49 ØØ	27 73 Ø	Disable Characters (Ø–31, 128–159) from Printing
ESC M	1B 4D	27 77	Enable Elite Pitch Mode
ESC P	1B 5Ø	27 8Ø	Enable Pica Pitch Mode
ESC o	1B 6F	27 111	Enable Elite Pitch Mode
ESC n	1B 6E	27 11Ø	Enable Pica Pitch Mode
ESC w #	1B 77 #	27 119 #	Direct Pitch Selection, # = Ø is 1Øcpi, # = 1 is 12cpi, # = 2 is 15cpi, # = 3 is 17cpi, # = 4 is proport.
ESC p 1	1B 7Ø Ø1	27 112 1	Select Proportional Spac
ESC p Ø	1B 7Ø ØØ	27 112 Ø	Release Proportional Spa
ESC W 1	1B 57 Ø1	27 87 1	Select Expanded Pitch
ESC W Ø	1B 57 ØØ	27 87 Ø	Release Expanded Pitch
SO or ESC SO	ØE	14	Enable 1–line Expanded Print Mode
DC4	14	28	Disable one–line Expanded Print Mode
SI or ESC SI	ØF	15	Enable Compressed Print
DC2	12	18	Disable Compressed Print
ESC :	1B 3A	27 58	Duplicate Internal Font
ESC ! #	1B 21 #	27 33 #	Print Mode Selection, # determines mode, # = 128 is underline, # = 64 is italic, # = 32 is double wide, # = 16 is double strike,

EPSON FX-80 PRINTER CODES

Code	Hex	Decimel	Command
Character Selection: (Continued)			
	# = 8 is bold, # = 4 is compressed, # = 2 is proportional, # = 1 is Elite, # = Ø is Pica. Add numbers for multiples, eg, 129 is Underlined Elite		
ESC %	1B 25	27 37	Select Character Set Bank
ESC &	1B 26	27 38	Define User Font
ESC 6	1B 36	27 54	Enable printing High Bit Symbols (Dec128–Dec159)
ESC 7	1B 37	27 55	Disable printing High Bit Symbols (Dec128–Dec159)
ESC 4	1B 34	27 52	Enable Italics printing
ESC 5	1B 35	27 53	Disable Italics printing
ESC R #	1B 52 #	27 82 #	Select International Character Set, # = Ø is USA, 1 is France, 2 is Germany, 3 is England, 4 is Denmark A, 5 is Sweden, 6 is Italy, 7 is Spain, 8 is Japan, 9 is Norway, 1Ø is Denmark B
ESC S 1	1B 53 Ø1	27 83 1	Select Subscripting
ESC S Ø	1B 53 ØØ	27 83 Ø	Select Superscripting
ESC T	1B 54	27 84	Release Super or Subscripting
Character Highlight Selection:			
ESC – 1	1B 2D Ø1	27 45 1	Turn underline mode on
ESC – Ø	1B 2D ØØ	27 45 Ø	Turn underline mode off
ESC E	1B 45	27 69	Enable Bold Print Mode
ESC F	1B 46	27 7Ø	Disable Bold Print Mode
ESC G	1B 47	27 71	Enable Double–strike
ESC H	1B 48	27 72	Disable Double–strike
Graphics:			
	For values for #1 and #2 below, see printer manuals		
ESC K#1#2	1B 4B #1#2	27 75 #1#2	Enable Single–density Graphics Mode, 6Ø dpi
ESC L#1#2	1B 4C #1#2	27 76 #1#2	Enable Double–density Graphics Mode, 12Ø dpi
ESC Y#1#2	1B 59 #1#2	27 89 #1#2	Enable Double–density, 12Ø dpi, High–speed Graphics Mode
ESC Z#1#2	1B 5A #1#2	27 9Ø #1#2	Enable Quadruple – density Graphics Mode, 24Ø dpi
ESC *#1#2#3	1B 2A #1#2#3	27 42 #1#2#3	Set Graphics Mode
ESC ^#1#2#3	1B 5E #1 #2 #3	27 94 #1#2#3	9 pin Graphics Mode
ESC ?#1#2	1B 3F #1#2	27 63 #1#2	Bit Image Mode Reassignment

EPSON FX-80 PRINTER CODES

Code	Hex	Decimel	Command
Miscellaneous:			
CAN	18	24	Cancel
DC1	11	17	Remote Printer Select
DC3	13	19	Remote Printer Deselect
DEL	7F	127	Delete
ESC @	1B 4Ø	27 64	Master Reset
ESC #	1B 23	27 35	Read Bit 7 of Received Word Normally
ESC =	1B 3D	27 61	Set Received Bit 7 to Ø
ESC >	1B 3E	27 62	Set Received Bit 7 to 1
ESC 8	1B 38	27 56	Out of Paper Sensor Off
ESC 9	1B 39	27 57	Out of Paper Sensor On
ESC i	1B 69	27 1Ø5	Enable Immediate Printing
ESC s	1B 73	27 115	Half Speed Printing
ESC EM #	1B 19 #	27 25 #	Paper Cassette Selection, # = E is envelope, # = 1 is Lower Cassette, # = 2 is Upper Cassette, # = R is eject page

HP LASERJET PRINTER CODES

Code	Hex	Decimel	Command
Page Format Control:			
ESC & l ØO	1B 26 6C 3Ø 4F	27 38 1Ø8 48 79	Portrait Orient.
ESC & l 1O	1B 26 6C 31 4F	27 38 1Ø8 49 79	Landscape Orient.
ESC & l #P	1B 26 6C # 5Ø	27 38 1Ø8 # 8Ø	Page length, # of lines
ESC & l #E	1B 26 6C # 45	27 38 1Ø8 # 69	Top Margin, # of lines
ESC & l #F	1B 26 6C # 46	27 38 1Ø8 # 7Ø	Text Length, # of lines
ESC & l 1L	1B 26 6C 31 4C	27 38 1Ø8 49 76	Skip Perforation, Set on
ESC & l ØL	1B 26 6C 3Ø 4C	27 38 1Ø8 48 76	Skip Perforation, Set off
ESC & l #D	1B 26 6C # 44	27 38 1Ø8 # 68	Lines Per Inch, # of lines/inch
ESC & l #C	1B 26 6C # 43	27 38 1Ø8 # 67	Vertical Motion Index, # of 1/48 inch
ESC &k#H	1B 26 6B # 48	27 38 1Ø7 # 72	Horizontal Motion Index, # of 1/12Ø inch
ESC &a#L	1B 26 61 # 4C	27 38 97 # 76	Left Margin, Left column #

HP LASERJET PRINTER CODES

Code	Hex	Decimel	Command
Page Format Control: (Continued)			
ESC &a#M	1B 26 61 # 4D	27 38 97 # 77	Right Margin, Right column #
ESC 9	1B 39	27 57	Clear Margins
Horizontal Movement and Spacing Control:			
BS	Ø8	8	Backspace
CR	ØD	13	Carriage Return
ESC &k#G	1B 26 6B # 47	27 38 1Ø7 # 71	CR/LF/FF Line Termination Action

#	Line Termination Action CR	LF	FF
Ø	CR	LF	FF
1	CR + LF	LF	FF
2	CR	CR + LF	CR + FF
3	CR + LF	CR + LF	CR + FF

Code	Hex	Decimel	Command
ESC &sØC	1B 26 73 3Ø 43	27 38 115 48 67	Set Wrap Around
ESC &s1C	1B 26 73 31 43	27 38 115 49 67	Release Wrap Around
ESC &a#C	1B 26 61 # 43	27 38 97 # 67	Move Print Position to Column #
ESC &a#H	1B 26 61 # 48	27 38 97 # 72	Move Print Position Horizontal # of Decipoints
ESC *p#X	1B 2A 7Ø # 58	27 42 112 # 88	Move Print Position Horizontal # of Dots
Vertical Movement and Spacing Control:			
LF	ØA	1Ø	Line Feed
FF	ØC	12	Formfeed
ESC =	1B 3D	27 61	Half Line Feed
ESC &a#R	1B 26 61 # 52	27 38 97 # 82	Move Print Position to Row #
ESC &a#V	1B 26 61 # 56	27 38 97 # 86	Move Print Position Vertical # of Decipoints
ESC *p#Y	1B 2A 7Ø # 59	27 42 112 # 89	Move Print Position Vertical # of Dots
Font Selection:			
ESC (#ID	1B 28 # ID	27 4Ø # ID	Symbol Set, Primary, # is Character ID
ESC)#ID	1B 29 # ID	27 41 # ID	Symbol Set, Secondary, # is Character ID

Character ID's: Roman-8bit = 8U, Kana-8bit = 8K,

HP LASERJET PRINTER CODES

Code	Hex	Decimel	Command
Font Selection: (Continued)			
	Math-8bit = 8M, ANSI-8bit = 9U, USASCII = ØU, Line Draw = ØB, Math Symbols = ØA, US Legal = 1U, Roman Ext = ØE, ISO Denmark = ØD, ISO Italy = ØI, ISO United Kingdom = 1E, ISO France = ØF, ISO Germany = ØG, ISO Sweden = ØS, ISO Spain = 1S		
ESC (sØP	1B 28 73 3Ø 5Ø	27 4Ø 115 48 8Ø	Spacing, Primary Fixed
ESC (s1P	1B 28 73 31 5Ø	27 4Ø 115 49 8Ø	Spacing, Primary Proportional
ESC)sØP	1B 29 73 3Ø 5Ø	27 41 115 48 8Ø	Spacing, Secondary Fixed
ESC)s1P	1B 29 73 31 5Ø	27 41 115 49 8Ø	Spacing, Secondary Proportional
ESC (s#H	1B 28 73 # 48	27 4Ø 115 # 72	Print Pitch, Primary, # is characters/inch
ESC)s#H	1B 29 73 # 48	27 41 115 # 72	Print Pitch, Secondary, # is characters/inch
ESC &k#S	1B 26 6B # 53	27 38 1Ø7 # 83	Print Pitch, Prim. & Secondary, # = Ø is 1Ø cpi, # = 1 is 16.66 cpi
ESC (s#V	1B 28 73 # 56	27 4Ø 115 # 86	Print Point Size, Primary, # is points
ESC)s#V	1B 29 73 # 56	27 41 115 # 86	Print Point Size, Secondary, # is points
ESC (sØS	1B 28 73 3Ø 53	27 4Ø 115 48 83	Print Style, Primary, Upright
ESC (s1S	1B 28 73 31 53	27 4Ø 115 49 83	Print Style, Primary, Italic
ESC)sØS	1B 29 73 3Ø 53	27 41 115 48 83	Print Style, Secondary, Upright
ESC)s1S	1B 29 73 31 53	27 41 115 49 83	Print Style, Secondary, Italic
ESC (s#B	1B 28 73 # 42	27 4Ø 115 # 66	Stroke Weight, Primary, # is −7 to +7
ESC)s#B	1B 29 73 # 42	27 41 115 # 66	Stroke Weight, Secondary, # is −7 to +7, −1 to −7 = light, Ø = Medium, 1 to 7 = Bold
ESC (s#T	1B 28 73 # 54	27 4Ø 115 # 84	Typeface, Primary, # is typeface
ESC)s#T	1B 29 73 # 54	27 41 115 # 84	Typeface, Secondary, # is typeface: Ø = Line printer, 1 = Pica, 2 = Elite, 3 = Courier, 4 = Swiss 721, 5 = Dutch, 6 = Gothic, 7 = Script, 8 = Prestige, 9 = Caslon, 1Ø = Orator, 23 = Century 7Ø.

Code	Hex	Decimel	Command
Font Control:			
SI	ØF	15	Shift In Primary
SO	ØE	14	Shift In Secondary
ESC (#X	1B 28 # 58	27 4Ø # 88	Define Font, Primary, # is the Font ID number
ESC)#X	1B 29 # 58	27 41 # 88	Define Font, Secondary, # is the Font ID numbr
ESC *c#F	1B 2A 63 # 46	27 42 99 # 7Ø	Font/Character Control, see printer manual
ESC (#@	1B 28 # 4Ø	27 4Ø # 64	Primary Font Default, see printer manual
ESC)#@	1B 29 # 4Ø	27 41 # 64	Secondary Font Default, see printer manual
ESC *c#D	1B 2A 63 # 44	27 42 99 # 68	Define Font ID, # is the ID
ESC)s#W	1B 29 73 # 57	27 41 115 # 87	Font Header, # is byte number of font attribute
ESC *c#E	1B 2A 63 # 45	27 42 99 # 69	Define Character Code to downloaded, # is Ø to 255
ESC (s#W	1B 28 73 # 57	27 4Ø 115 # 87	Produce Down-load Character, see printer manual
Character Highlight Selection:			
ESC &dD	1B 26 64 44	27 38 1ØØ 68	Turn underline on
ESC &d@	1B 26 64 4Ø	27 38 1ØØ 64	Turn underline off
Graphics:			
ESC *t#R	1B 2A 74 # 52	27 42 116 # 82	Resolution, # is 75, 1ØØ, 15Ø, or 3ØØ Dots/inch
ESC *r#A	1B 2A 72 # 41	27 42 114 # 65	Graphics Start, # = Ø is start vertical from left end of print area, # = 1 is start from present position.
ESC *b#W	1B 2A 62 # 57	27 42 98 # 87	Sending Graphics data, # is number of bytes of bit image data.
ESC *rB	1B 2A 72 42	27 42 114 66	End Raster Graphics Mode
ESC *c#A	1B 2A 63 # 41	27 42 99 # 65	Set Horizontal Rule Width to # dots (1 dot = 1/3ØØ inch)
ESC *c#H	1B 2A 63 # 48	27 42 99 # 72	Set Horizontal Rule Width to # decipoints (1 decipoint = 1/72Ø inch)
ESC *c#B	1B 2A 63 # 42	27 42 99 # 66	Set Vertical Rule Width to # dots (1 dot = 1/3ØØ inch)
ESC *c#V	1B 2A 63 # 56	27 42 99 # 86	Set Vertical Rule Width to # decipoints (1 decipoint = 1/72Ø inch)

HP LASERJET PRINTER CODES

Code	Hex	Decimel	Command
Graphics: (Continued)			
ESC *c#G	1B 2A 63 # 47	27 42 99 # 71	Set Gray Scale or Hatch Pattern ID #, see printer manual for a sample of each pattern/hatch and its associated ID #
ESC *c#P	1B 2A 63 # 5Ø	27 42 99 # 8Ø	Set Print Pattern #
Macro's:			
ESC &f#Y	1B 26 66 # 59	27 38 1Ø2 # 89	Set Macro ID #
ESC &fØX	1B 26 66 3Ø 58	27 38 1Ø2 48 88	Start Macro
ESC &f1X	1B 26 66 31 58	27 38 1Ø2 49 88	End Macro
ESC &f2X	1B 26 66 32 58	27 38 1Ø2 5Ø 88	Jump to Macro
ESC &f3X	1B 26 66 33 58	27 38 1Ø2 51 88	Call Macro
ESC &f4X	1B 26 66 34 58	27 38 1Ø2 52 88	Set Overlay Macro
ESC &f5X	1B 26 66 35 58	27 38 1Ø2 53 88	Release Overlay Macro
ESC &f6X	1B 26 66 36 58	27 38 1Ø2 54 88	Release all Macro
ESC &f7X	1B 26 66 37 58	27 38 1Ø2 55 88	Release all temporary Macro
ESC &f8X	1B 26 66 38 58	27 38 1Ø2 56 88	Release current Macro
ESC &f9X	1B 26 66 39 58	27 38 1Ø2 57 88	Assign temporary attribute to Macro
ESC &f1ØX	1B 26 66 31 3Ø 58	27 38 1Ø2 49 48 88	Assign permanent attribute to Macro
Miscellaneous:			
ESC Y	1B 59	27 89	Set Display Function of control codes
ESC Z	1B 5A	27 9Ø	Release Display Function of control codes
ESC & p # X	1B 26 7Ø # 58	27 38 112 # 88	Transparent Print Data (no ESC commands exist)
ESC &fØS	1B 26 66 3Ø 53	27 38 1Ø2 48 83	Push Printing Position. Puts present printing position on the top of the stack
ESC &f1S	1B 26 66 31 53	27 38 1Ø2 49 83	Pop Printing Position. Recall stored printing position and put on the top of the stack
ESC & l #X	1B 26 6C # 58	27 38 1Ø8 # 88	Set Number of Copies to #
ESC & l #H	1B 26 6C # 48	27 38 1Ø8 # 72	Paper Input Control. # = Ø is Feed out current page, # = 1 is Lower Cassette supplies paper, # = 3 is Envelope

HP LASERJET PRINTER CODES

Code	Hex	Decimel	Command
Miscellaneous: (Continued)			
	feeder supplies envelope, # = 4 is Upper Cassette supplies paper		
ESC E	1B 45	27 69	Reset Printer
ESC z	1B 7A	27 122	Start Printer Self Test

IBM PROPRINTER PRINTER CODES

Code	Hex	Decimel	Command
Page Format Control:			
ESC C Ø #	1B 43 ØØ #	27 67 Ø #	Page Length, # is in Inch
ESC C #	1B 43 #	27 67 #	Page Length, # is in Lines
ESC X #1#2	1B 58 #1#2	27 88 #1#2	Left/Right Margins Set, #1 is left inches, #2 is right inches
ESC N #	1B 4E #	27 78 #	Skip Perforation Set, # is Top + Bottom
ESC O	1B 4F	27 79	Skip Perforation Release
ESC 4	1B 34	27 52	Top of Page Set
Horizontal Movement and Spacing Control:			
BS	Ø8	8	Backspace
CR	ØD	13	Carriage Return
ESC D # Ø	1B 44 # ØØ	27 68 # Ø	Horizontal Tab Set, # is the column, can use more than one #
ESC D Ø	1B 44 ØØ	27 68 Ø	Horizontal Tab Release
HT	Ø9	9	Horizontal Tab, moves to next preset tab
ESC R	1B 52	27 82	Reset all Tabs
Vertical Movement and Spacing Control:			
ESC Ø	1B 3Ø	27 48	Set Line Spacing to 1/8 inch (9 points or 8 lpi)
ESC 1	1B 31	27 49	Set Line Spacing to 7/72 inch (7 points)
ESC 2	1B 32	27 5Ø	Execute a Line Feed, must follow ESC A # command
ESC 3 #	1B 33 #	27 51 #	Set Line Spacing to #/216 inch
ESC A #	1B 41 #	27 65 #	Set Line Spacing to # Points (#/72 inch)
LF	ØA	1Ø	Line feed
ESC 5 1	1B 35 Ø1	27 53 1	Set Auto Line Feed

IBM PROPRINTER PRINTER CODES

Code	Hex	Decimel	Command
Vertical Movement and Spacing Control (Continued):			
ESC 5 Ø	1B 35 ØØ	27 53 Ø	Release Auto Line Feed
ESC j #	1B 6A #	27 1Ø6 #	Reverse Line Feed of #/216 Inches
ESC J #	1B 4A #	27 74 #	Forward Line Feed of #/216 Inches
FF	ØC	12	Form feed
ESC B # Ø	1B 42 # ØØ	27 66 # Ø	Vertical Tab Set, # is the line, can use more than one #
ESC B Ø	1B 42 ØØ	27 66 Ø	Vertical Tab Release
VT	ØB	11	Vertical Tab, moves to next preset tab
ESC R	1B 52	27 82	Reset all Tabs
Character Selection:			
DC2	12	18	Pica Pitch (12 pt,1Ø cpi)
ESC :	1B 3A	27 58	Elite Pitch (1Ø pt, 12 cpi)
SI	ØF	15	Compressed Print
ESC SI	1B ØF	27 15	Compressed Print
SO	ØE	14	Set Double Width for a single line
ESC SO	1B ØE	27 14	Set Double Width for a single line
DC4	14	2Ø	Release Double Width for a single line
ESC WØ	1B 57 ØØ	27 87 Ø	Release Double Wide Line
ESC W1	1B 57 Ø1	27 87 1	Set Double Width Line
ESC SØ	1B 53 ØØ	27 83 Ø	Set Superscript Mode On
ESC S1	1B 53 Ø1	27 83 1	Set Subscript Mode On
ESC T	1B 54	27 84	Release Superscript and Subscript
ESC 7	1B 37	27 55	Set IBM Character Set 1
ESC 6	1B 36	27 54	Set IBM Character Set 2
ESC ^	1B 5E	27 94	Select 1 Character from the All Character Chart
ESC \ #1 #2	1B 5C	27 92	Select Print Continuously from All Character Chart for a total of (#2 X 256) + #1
Character Highlight Selection:			
ESC – 1	1B 2D Ø1	27 45 1	Turn Underline Mode On
ESC – Ø	1B 2D ØØ	27 45 Ø	Turn Underline Mode Off
ESC _ 1	1B 5F Ø1	27 95 1	Enable Overline Mode
ESC _ Ø	1B 5F ØØ	27 95 Ø	Disable Overline Mode
ESC E	1B 45	27 69	Enable Bold Print Mode
ESC F	1B 46	27 7Ø	Disable Bold Print Mode

IBM PROPRINTER PRINTER CODES

Code	Hex	Decimel	Command
Character Highlight Selection: (Continued)			
ESC G	1B 47	27 71	Enable Double–strike
ESC H	1B 48	27 72	Disable Double–strike
Graphics:			
For values of #1 and #2 below, see printer manuals			
ESC K#1#2	1B 4B #1#2	27 75 #1#2	Enable Single–density Graphics Mode, 6Ø dpi
ESC L#1#2	1B 4C #1#2	27 76 #1#2	Enable Double–density Graphics Mode, 12Ø dpi
ESC Y#1#2	1B 59 #1#2	27 89 #1#2	Enable Double–density, 12Ø dpi, High–speed Graphics Mode
ESC Z#1#2	1B 5A #1#2	27 9Ø #1#2	Enable Quad–density Graphics Mode, 24Ø dpi
Miscellaneous:			
CAN	18	24	Cancel
DC1	11	17	Remote Printer Select
ESC Q3	1B 51 Ø3	27 8 3	Remote Printer Deselect
ESC EM #	1B 19 #	27 25 #	Paper Cassette Selection, # = E is envelope, # = 1 is Lower Cassette, # = 2 is Upper Cassette, # = R is eject page
NUL	ØØ	Ø	Null
BEL	Ø7	7	Sound Beeper

NEC PINWRITER PRINTER CODES

Code	Hex	Decimel	Command
Pinwriters use most of the same codes as the Epson LQ1500 except for the following FS Codes:			
FS 3 #	1C	28	Line space Ø-255 #/360
FS C #	1C	28	Set Font Cartridge, # = Ø is resident font, # = 1 is slot 1, # = 2 is slot 2
FS E #	1C	28	Ø = Cancel horiz enlarge., 1 = 2X horiz enlargement, 2 = 3X horiz enlargement
FS F	1C	28	Release Enhanced Print
FS I #	1C	28	Ø = Italic Set, 1 = IBM Set
FS R	1C	28	Set Reverse Line Feed
FS S #	1C	28	Ø = Draft 12,1 = high speed
FS V 1	1C	28	Set double vertical enlarge
FS V Ø	1C	28	Release double vertical enlargement
FS Z #1 #2	1C	28	Set 360 dpi graphics
FS @	1C	28	Initialize except user buffer

POCKET REF

Constants

CONSTANT	SYMBOL	VALUE
Acceleration due to gravity	g	32.174 ft/sec^2
		980.665 cm/sec^2
		386.09 in/sec^2
		21.94 miles/hr–sec
Air, density @ 0^{o}C, 760mm Hg		1.2929 gm/liter
AMU		1.6605×10^{-27} kg
Astronomic unit	AU	149.600×10^{6} m
Atomic mass constant, unified	m_u	1.66043×10^{-27} *kg*
Atomic specific heat constant	h/k	4.79928×10^{-11} *sec deg*
Avogadro constant	N_A	6.02252×10^{23} mol^{-1}
Barn Cross Section		10^{-24} cm^2
Bohr Magneton	μ_B	9.2732×10^{-24} Am^2
Bohr radius	a_o	5.29177×10^{-9} cm
Equation for above		$\alpha / 4\pi R_\infty$
Boltzmann entropy constant	k	1.38054×10^{-23} JK^{-1}
Earth, equatorial radius		6378.39 km, 3969.34 mi
Earth, polar radius		6356.91km, 3949.99 mi
Earth, mass	M	5.983×10^{24} kg
		6.595×10^{21} tons
Earth, mean density		344.7 lbs / ft^3
Electric field constant	ε_o	$8.8541853 \times 10^{-12}$ Fm^{-1}
Equation for above		$1 / \mu_o c^2$
Electron, Atomic mass	Nm	5.48598×10^{-4} amu
Electron charge to mass ratio	e/m_e	1.758796×10^{-11} Ckg^{-1}
Electron radius	γ_e	2.81777×10^{-15} m
Electron, magnetic moment	μ_e	9.28389×10^{-21} erg gauss^{-1}
Electron mass at rest	m_e	9.1091×10^{-31} kg
Electron, Compton wave length	λ_c	2.42621×10^{-12} *m*
Electron–volt	eV	1.60210×10^{-19} *J*

CONSTANT	SYMBOL	VALUE
Euler's constant	γ	0.57721566490153386O
Faraday constant	F	9.64870 x 10^4 Cmol $^{-1}$
Gas constant, Universal	R	8.3143 $JK^{-1}mol^{-1}$
Gas constant, Universal	R_o	8.20545x10^{-2}lit-Atm/^{o}K-mole
Gas constant, Universal	R	1546 lbf–ft / lb mole-^oR
Golden Ratio	ϕ	1.618033988749894848
Gravitational constant	G	6.670 x 10^{-11} Nm^2kg^{-2}
Hydrogen, Atomic mass	H	1.00782522 amu
Hydrogen atom, mass		1.67339 x 10^{-24} gm
Ice–point temperature	T_{ice}	2.731500 x 10^2 K
Impedance of free space	Z_o	376.731 ohms
Light, speed of in a vacuum	C_o	2.997925 x 10^{10}cm/sec
Logarithmic constant	e	2.718281828459045235
Loschmidt's number	n_o	2.68702 x x 10^{19} cm^{-3}
Magnetic field constant	μ_o	1.256637 x $10^{-6}$$Hm^{-1}$
Equation for above		$4\pi 10^{-7}Hm^{-1}$
Mercury, density @ 0^oC		13.5955 gm/cm^3
Neutron rest mass	m_n	1.67482 x 10^{-27} kg
Parsec	pc	206.265 AU
Permeability of free space	μ_o	12.5664 x 10^{-7} henry/m
Permittivity of free space	ε_o	8.8542 x 10^{-12} farad/m
Pi (ratio circle circum/diameter)	π	3.141592653589793238
	2π	6.283185
	π^2	9.869604
	$\sqrt{\pi}$	1.772454
	$\pi/4$	0.785398
Planck constant	h	6.6256 x 10^{-34} Js

CONSTANT	SYMBOL	VALUE
Planck constant		6.6252×10^{-27} erg–sec
Planck – 1st radiation constant	c_1	3.7418×10^{-5} erg $cm^2 s^{-1}$
Planck – 2nd radiation constant	c_2	1.4388 cm K
Proton, Atomic mass	Nm_p	1.00727663 amu
Proton rest mass	m_p	1.67252×10^{-27} kg
Proton, Compton wave length	$\lambda_{c \bullet p}$	1.32140×10^{-15} m
Quantum charge ratio	h/e	4.13556×10^{15} Js/C
Radiation constant, 1st	c1	4.99208×10^{-15} erg-cm
Radiation constant, 2nd	c2	1.43879 cm–deg
Rydberg constant, infinite mass	R_∞	1.0973731×10^{7} m^{-1}
Sound, velocity in air @ STP		331.7 m/sec 1087.1 ft/sec
Sound, velocity in water @ 20°C		1470 m/sec 4823 ft/sec
Sefan-Boltzmann Constant	σ	5.6686×10^{-5} erg/cm^2–sec–$(^oK)^4$
Vacuum permeability	μ_o	$4\pi \times 10^{-7}$ $kgms^{-2}A^{-2}$
Water, density @ 3.98°C		1.000000 gm/ml 0.03613 lb/in^3 62.43 lb/ft^3
Water, heat of fusion @ 0°C		79.71 cal/gm
Water, heat of vaporization @ 100°C		539.55 cal/gm
Water, viscosity @ 20°C		1.002 centipoise 0.01002 dyne–sec/cm^2
Wave length, krypton 86 orange-red line		6057.802Å
Wien displacement constant	$\lambda_{max}T$	0.289779 cm deg
Zeeman displacement	μ_1/hc	(see next line) $4.668583 \times 10^{-5} cm^{-1} gauss^{-1}$

POCKET REF

Electrical

(See also ELECTRONICS Chapter on page 129)

COPPER WIRE CURRENT CAPACITY
Single wire in open air, ambient temp 86°F

Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts

Wire Size AWG	RUW, T, TW (140°F)	FEPW, RH, RHW RUH, THW, THWN XHHW, ZW (167°F)	V, MI (185°F)	TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH (194°F)
0000	300	360	390	405
000	260	310	335	350
00	225	265	290	300
0	195	230	250	260
1	165	195	215	220
2	140	170	185	190
3	120	145	160	165
4	105	125	135	140
6	80	95	100	105
8	60	70	75	80
10	40	50	55	55
12	30	35	40	40
14	25	30	30	35
16	–	–	23	24
18	–	–	–	18

Note: Types **T** and **TW** are the most common for house wiring. **T** is for dry conditions only and **TW** is for dry or wet conditions; both are single layer plastic covered.

If the ambient temperature(1) is over 86°F (30°C), then the following corrections should be applied by multiplying the above ampacities by the correction factor below.

Ambient(1)	*Ampacity Correction for above Wire types*			
Temp °F	140°F	167°F	185°F	194°F
87-104	0.82	0.88	0.90	C.91
105-113	0.71	0.82	0.85	0.87
114-122	0.58	0.75	0.80	0.82
123-141	...	0.58	0.67	0.71
142-158	...	0.35	0.52	0.58
159-176	...	...	0.30	0.41

NOTE: The above information has been extracted from the National Electrical Code ®, National Fire Protection Association, Quincy, Massachusetts 02269, Copyright 1983 and does not represent the complete code.

(1) Ambient temperature is the temperature of the material (air, earth, etc) surrounding the wire.

COPPER WIRE CURRENT CAPACITY
Three wires in cable, ambient temp 86°F

Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts				
Wire Size AWG	RUW, T, TW UF (140°F)	FEPW, RH, RHW RUH, THW, THWN XHHW, ZW, USE (167°F)	V, MI (185°F)	TA, TBS, SA, AVB, SIS, FEP, FEPB, RHH (194°F)
0000	195	230	250	260
000	165	200	215	225
00	145	175	190	195
0	125	150	165	170
1	110	130	145	150
2	95	115	125	130
3	85	100	110	110
4	70	85	95	95
6	55	65	70	75
8	40	50	55	55
10	30	35	40	40
12	25	25	30	30
14	20	20	25	25
16	–	–	18	18
18	–	–	–	14

Note: All notes on ambient temperature and T and TW types on the previous page also apply to this Three Wire section.

STANDARD LAMP & EXTENSION CORD CURRENT CAPACITIES

Wire Size AWG	Wire Types SP, SPT, S, SJ, SV, ST, SJT, SVT		
	2 Conductor	3 Conductor	4 Conductor
10	28	25	20
12	23	20	15
14	18	15	10
16	13	10	15
18	10	7	20

NOTE: The above information has been extracted from the National Electrical Code ®, National Fire Protection Association, Quincy, Massachusetts 02269, Copyright 1983 and does not represent the complete code.

ALUMINUM WIRE AMP CAPACITY

Single wire in open air, ambient temp 86°F

Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts				
Wire Size AWG	RUW, T, TW (140°F)	RH, RHW RUH, THW, THWN XHHW (167°F)	V, MI (185°F)	TA, TBS, SA, AVB, SIS, RHH, THHN, XHHW (194°F)
500MCM	405	485	525	545
400MCM	355	425	465	480
300MCM	290	350	380	395
0000	235	280	305	315
000	200	240	265	275
00	175	210	225	235
0	150	180	195	205
1	130	155	165	175
2	110	135	145	150
3	95	115	125	130
4	80	100	105	110
6	60	75	80	80
8	45	55	60	60
10	35	40	40	40
12	25	35	30	35

Note: Types **T** and **TW** are the most common for house wiring. **T** is for dry conditions only and **TW** is for dry or wet conditions; both are single layer plastic covered.

If the ambient(1) temperature is over 86°F (30°C), then the following corrections should be applied by multiplying the above ampacities by the correction factor below.

Ambient(1) Temp °F	*Ampacity Correction for above Wire Types* 140°F	167°F	185°F	194°F
87-104	0.82	0.88	0.90	0.91
105-113	0.71	0.82	0.85	0.87
114-122	0.58	0.75	0.80	0.82
123-141	...	0.58	0.67	0.71
142-158	...	0.35	0.52	0.58
159-176	...	...	0.30	0.41

NOTE: The above information has been extracted from the National Electrical Code ®, National Fire Protection Association, Quincy, Massachusetts 02269, Copyright 1983 and does not represent the complete code.

(1) Ambient temperature is the temperature of the material (air, earth, etc) surrounding the wire.

ALUMINUM WIRE AMP CAPACITY
Three wires in cable, ambient temp 86°F

Ampacities of Wire Types (w/ Temp Rating) @ 0–2000 Volts				
Wire Size AWG	RUW, T, TW UF (140°F)	RH, RHW RUH, THW, THWN XHHW, USE (167°F)	V, MI (185°F)	TA, TBS, SA, AVB, SIS, RHH, THHN, XHHW (194°F)
500MCM	260	310	335	350
400MCM	225	270	295	305
300MCM	190	230	250	255
0000	150	180	195	205
000	130	155	170	175
00	115	135	145	150
0	100	120	130	135
1	85	100	110	115
2	75	90	100	100
3	65	75	85	85
4	55	65	75	75
6	40	50	55	60
8	30	40	40	45
10	25	30	30	35
12	20	20	25	25

Note: All notes on ambient temperature and T and TW types on the previous page also apply to this Three Wire section.

CURRENT ADJUSTMENT FOR MORE THAN 3 WIRES IN A CABLE

Number of Conductors	Percentage of amperage value listed in amperage tables on the previous 4 pages.
4 to 6	80%
7 to 24	70%
25 to 42	60%
over 43	50%

Basically, the above table reflects the rule that the higher the temperature (more wires = higher temperature) the lower the current carrying capacity of the wire.

NOTE: The above information has been extracted from the National Electrical Code ®, National Fire Protection Association, Quincy, Massachusetts 02269, Copyright 1983 and does not represent the complete code.

COPPER WIRE RESISTANCE

Gauge A.W.G.*	Feet per Ohm @ 77°F	Ohms per 1000 ft @ 77°F	Feet per Ohm @ 149°F	Ohms per 1000 ft @ 149°F
0000	20000	0.050	17544	0.057
000	15873	0.063	13699	0.073
00	12658	0.079	10870	0.092
0	10000	0.100	8621	0.116
1	7936	0.126	6849	0.146
2	6289	0.159	5435	0.184
3	4975	0.201	4310	0.232
4	3953	0.253	3425	0.292
5	3135	0.319	2710	0.369
6	2481	0.403	2151	0.465
7	1968	0.508	1706	0.586
8	1560	0.641	1353	0.739
9	1238	0.808	1073	0.932
10	980.4	1.02	847.5	1.18
11	781.3	1.28	675.7	1.48
12	617.3	1.62	534.8	1.87
13	490.2	2.04	423.7	2.36
14	387.6	2.58	336.7	2.97
15	307.7	3.25	266.7	3.75
16	244.5	4.09	211.4	4.73
17	193.8	5.16	167.8	5.96
18	153.6	6.51	133.2	7.51
19	121.8	8.21	105.5	9.48
20	96.2	10.4	84.0	11.9
21	76.3	13.1	66.2	15.1
22	60.6	16.5	52.6	19.0
23	48.1	20.8	41.7	24.0
24	38.2	26.2	33.1	30.2
25	30.3	33.0	26.2	38.1
26	24.0	41.6	20.8	48.0
27	19.0	52.5	16.5	60.6
28	15.1	66.2	13.1	76.4
29	12.0	83.4	10.4	96.3
30	9.5	105	8.3	121
31	7.5	133	6.5	153
32	6.0	167	5.2	193
33	4.7	211	4.1	243
34	3.8	266	3.3	307
35	3.0	335	2.6	387
36	2.4	423	2.0	488
37	1.9	533	1.6	616
38	1.5	673	1.3	776
39	1.2	848	1.0	979
40	0.93	1070	0.81	1230

* *American Wire Gauge (formerly Brown & Sharp)*

STANDARD COPPER WIRE SPECS

Gauge A.W.G	Diameter in mils (1000th in)	Diameter Millimeters	Area in Circular Mils	Weight Lbs per 1000 feet	Turns / inch Enamel
0000	460.0	11.684	212000	641.0	2.2
000	410.0	10.414	168000	508.0	2.4
00	365.0	9.271	133000	403.0	2.7
0	325.0	8.255	106000	319.0	3.0
1	289.0	7.348	83700	253.0	3.3
2	258.0	6.544	66400	201.0	3.8
3	229.0	5.827	52600	159.0	4.2
4	204.0	5.189	41700	126.0	4.7
5	182.0	4.621	33100	100.0	5.2
6	162.0	4.115	26300	79.5	5.9
7	144.0	3.665	20800	63.0	6.5
8	128.0	3.264	16500	50.0	7.6
9	114.0	2.906	13100	39.6	8.6
10	102.0	2.588	10400	31.4	9.6
11	91.0	2.305	8230	24.9	10.7
12	81.0	2.053	6530	19.8	12.0
13	72.0	1.828	5180	15.7	13.5
14	64.0	1.628	4110	12.4	15.0
15	57.0	1.450	3260	9.86	16.8
16	51.0	1.291	2580	7.82	18.9
17	45.0	1.150	2050	6.2	21.2
18	40.0	1.024	1620	4.92	23.6
19	36.0	0.912	1290	3.90	26.4
20	32.0	0.812	1020	3.09	29.4
21	28.5	0.723	810	2.45	33.1
22	25.3	0.644	642	1.94	37.0
23	22.6	0.573	509	1.54	41.3
24	20.1	0.511	404	1.22	46.3
25	17.9	0.455	320	0.970	51.7
26	15.9	0.405	254	0.769	58.0
27	14.2	0.361	202	0.610	64.9
28	12.6	0.321	160	0.484	72.7
29	11.3	0.286	127	0.384	81.6
30	10.0	0.255	101	0.304	90.5
31	8.9	0.227	79.7	0.241	101
32	8.0	0.202	63.2	0.191	113
33	7.1	0.180	50.1	0.152	127
34	6.3	0.160	39.8	0.120	143
35	5.6	0.143	31.5	0.095	158
36	5.0	0.127	25.0	0.0757	175
37	4.5	0.113	19.8	0.0600	198
38	4.0	0.101	15.7	0.0476	224
39	3.5	0.090	12.5	0.0377	248
40	3.1	0.080	9.9	0.0200	282

** American Wire Gauge (formerly Brown & Sharp)*

WIRE CLASSES & INSULATION

Standard cable, as used in home and general construction, is classified by the wire size, number of wires, insulation type and dampness condition of the wire environment. Example: a cable with the code "12/2 with Ground – Type UF – 600V – (UL)" has the following specifications:

- Wire size is 12 gauge (minimum required size for homes today; see the National Electric Code).
- The " / 2 " indicates there are two wires in the cable.
- "Ground" indicates there is a third wire in the cable to be used as a grounding wire.
- "Type UF" indicates the insulation type and acceptable dampness rating.
- "600V" means the wire is rated at 600 volts maximum.
- "UL" indicates the wire has been certified by Underwriters Laboratory to be safe.

Cables are dampness rated as follows:

- DRY: No dampness normally encountered. Indoor location above ground level.
- DAMP: Partially protected locations. Moderate amount of moisture. Indoor location below ground level.
- WET: Water saturation probable, such as underground or in concrete slabs or outside locations exposed to weather.

There are literally hundreds of different types of insulation used in wire and cable. To make things simple, the following descriptions are for wires commonly used in home wiring:

"BX" Armor covered with flexible, galvanized steel. Normally used in dry locations. Not legal to use in some states such as California.

"ROMEX" Although actually a trade name, it is used to describe a general class of plastic coated cable. Each wire is plastic wrapped except possibly the ground wire, which is sometimes bare or paper covered. Very flexible. There are three general types:
"NM" – Dry only, 2 or 3 wire, ground wire plastic wrapped.
"NMC" – Dry, 2 or 3 wire, all wires in solid plastic.
"UF" – Wet, 2 or 3 wire, all wires in solid, water resistant plastic. Use also instead of conduit.

NEVER put ROMEX or BX inside conduit.

WIRE CLASSES & INSULATION

Wire types are typically coded by the type of insulation, temperature range, dampness rating, and type and composition of the jacket. The following are some of the "Type Codes":

"T..."	Very common, dry only, full current load temperature must be less than 60°C (140°F).
"F"	Fixture wire. CF has cotton insulation (90°C), AF has asbestos insulation (150°C), SF has silicone insulation (200°C).
"R..."	Rubber (natural, neoprene, etc) covered
"S..."	Appliance cord, stranded conductors, cotton layer between wire and insulation, jute fillers, rubber outer jacket. S is extra hard service, SJ lighter service, SV light service.
"SP..."	Lamp cord, rubber insulation.
"SPT..."	Lamp cord, plastic insulation.
"X..."	Insulation is a cross linked synthetic polymer. Very tough and heat and moisture resistant.
"FEP..."	Fluorinated ethylene propylene insulation. Rated over 90°C (194°F). Dry only.
"...B"	Suffix indicating a outer braid is used, such as glass.
"...H"	Suffix indicating Higher loaded current temperatures may be used, up to 75°C (167°F).
"...HH"	Suffix indicating much higher loaded current temperatures may be used, up to 90°C (194°F).
"...L"	Suffix indicating a seamless lead jacket.
"...N"	Suffix indicating the jacket is extruded nylon or thermoplastic polyester and is very resistant to gas and oil and is very tough.
"...O"	Suffix indicating neoprene jacket.
"...W"	Suffix indicating WET use type.

Examples of some of the more common wire types are "T", "TW", "THWN", "THHN", "XHHW", "RHH", and "RHW".

STANDARD WIRING COLOR CODES

Standard wire color codes are very different between electronic circuitry and household 110 Volt AC wiring.

Household wiring (or other AC applications in the 100+ volt range) uses the following color codes:

Wire Color	Circuit type
Black	"Hot" wire. In an outlet, it is always wired to the narrow spade or brass colored terminal.
Green	"Ground" wire, always wired to the green terminal. Also called chassis ground. This wire is also sometimes green w/ yellow stripe.
Red	"Traveler" wire used in connecting 3–way switches. Connects power between the 3–way switches.
White	"Neutral" wire. In an outlet, it is always wired to the wide spade or silver colored terminal.

Typically, the following color codes are used for **electronic applications** (as established by the Electronic Industries Association – EIA):

Wire Color (solid)	Circuit type
Black	Chassis grounds, returns, primary leads
Blue	Plate leads, transistor collectors, FET drain
Brown	Filaments, plate start lead
Gray	AC main power leads
Green	Transistor base, finish grid, diodes, FET gate
Orange	Transistor base 2, screen grid
Red	B plus dc power supply
Violet	Power supply minus
White	B–C minus of bias supply, AVC–AGC return
Yellow	Emitters-cathode and transistor, FET source

Stereo Audio Channels are color coded as follows:

Wire Color (solid)	Circuit type
White	Left channel high side
Blue	Left channel low side
Red	Right channel high side
Green	Right channel low side

STANDARD WIRING COLOR CODES

Power Transformers are color coded as follows:

Wire Color (solid)	Circuit type
Black	If a transformer does not have a tapped primary, both leads are black.
Black	If a transformer does have a tapped primary, the black is the common lead.
Black & Yellow	Tap for a tapped primary.
Black & Red	End for a tapped primary.

AF Transformers (audio) are color coded as follows:

Wire Color (solid)	Circuit type
Black	Ground line.
Blue	Plate, collector, or drain lead. End of primary winding.
Brown	Start primary loop, Opposite to blue lead.
Green	High side, end secondary loop.
Red	B plus, center tap push–pull loop.
Yellow	Secondary center tap.

IF Transformers (Intermediate Frequency) are color coded as follows:

Wire Color (solid)	Circuit type
Blue	Primary high side of plate, collector, or drain lead.
Green	Secondary high side for output.
Red	Low side of primary returning B plus.
Violet	Secondary outputs.
White	Secondary low side.

WIRE SIZE vs VOLTAGE DROP

Voltage drop is the amount of voltage lost over the length of a piece of wire. Voltage drop changes as a function of the resistance of the wire and should be less than 2% if possible. If the drop is greater than 2%, efficiency of the appliance is severely decreased and life of the equipment will be decreased. As an example, if the voltage drop on an incandescent light bulb is 10%, the light output of the bulb decreases over 30%!

Voltage drop can be calculated using Ohm's Law, which is Voltage Drop = Current in amps x Resistance in ohms. For example, the voltage drop over a 200 foot long, 14 gauge power line supplying a 1000 watt floodlight is calculated as follows:

Current = 1000 watts / 120 volts = 8.4 amps
Resistance of #14 wire = 2.58 ohms / 1000 feet @ 77°F
Resistance of power line = 200 feet X 0.00258 ohms/foot
= 0.516 ohms
Voltage drop = 8.4 amps X 0.516 ohms = 4.33 volts
Percent voltage drop = 4.33 volts / 120 volts = 3.6 %

The 4.2% drop is over the maximum 2% so either the wattage of the bulbs must be decreased or the diameter of the wire must be increased (a decrease in wire gauge number). If #12 wire were used in the above example, the voltage drop would have only been 2.2%. The wire resistance values for various size wire are contained in the Copper Wire table on page 112.

An interesting corollary to the above example is that if the line voltage doubles (240 volts instead of 120 volts) the voltage drop decreases by 50%. That means that a line can carry the same power 2 times further! Higher voltage lines are more efficient.

A more commonly used method of calculating voltage drop is as follows:

$$\text{Voltage drop} = \frac{22 \times \text{Wire length in feet} \times \text{current in amps}}{\text{Circular Mils}}$$

Circular mils are given in the Standard Copper Wire Specs table on page 113. Note that the 22 value applies to copper wire only, if aluminum is used, change the value to 36.

WIRE SIZE vs VOLTAGE DROP

Max Wire Feet @ 120 Volts, 1 Phase, 2% Max Voltage Drop

Amps	Volt-Amps	#14	#12	#10	#8	#6
1	120	450	700	1100	1800	2800
5	600	90	140	225	360	575
10	1200	45	70	115	180	285
15	1800	30	47	75	120	190
20	2400	...	36	57	90	140
25	3000	...	...	45	72	115
30	3600	...	...	38	60	95
40	4800	...	...	...	45	72
50	6000	...	...	...	...	57

Amps	Volt-Amps	#4	#2	1/0	2/0	3/0
1	120	4500	7000	...	...	...
5	600	910	1400	2250	2800	...
10	1200	455	705	1100	1400	1800
15	1800	305	485	770	965	1200
20	2400	230	365	575	725	900
25	3000	180	290	460	580	720
30	3600	150	240	385	490	600
40	4800	115	175	290	360	440
50	6000	90	145	230	290	360
60	7200	76	120	190	240	305
70	8400	65	105	165	205	260
80	9600	...	90	144	180	230

Max Wire Feet @ 240 Volts, 1 Phase, 2% Max Voltage Drop

Amps	Volt-Amps	#14	#12	#10	#8	#6
1	240	900	1400	2200	3600	5600
5	1200	180	285	455	720	1020
10	2400	90	140	225	360	525
15	3600	60	95	150	240	350
20	4800	...	70	110	180	265
25	6000	...	...	90	144	210
30	7200	...	...	75	120	175
40	5600	...	...	...	90	130
50	12000	...	...	...	...	105

Amps	Volt-Amps	#4	#2	1/0	2/0	3/0
1	240	9000	...	...	...	...
5	1200	1750	2800	4500	5600	7000
10	2400	910	1400	2200	2800	3600
15	3600	605	965	1500	1900	2400
20	4800	455	725	1100	1400	1800
25	6000	365	580	920	1100	1440
30	7200	300	485	770	970	1200
40	5600	230	360	575	725	880
50	12000	180	290	460	580	720
60	14400	150	240	385	485	600
70	16800	130	205	330	415	520
80	19200	...	180	290	365	440
100	24000	...	...	230	280	360
150	36000	...	...	185	190	240
200	48000	...	...	...	...	180

CONDUIT SIZE vs WIRE SIZE

Wire Size AWG	Minimum Conduit Size (inches) per Number of Type T & TW Wires. Number of Wires Inside Conduit 2	3	4	5	6
14	1/2	1/2	1/2	1/2	1/2
12	1/2	1/2	1/2	1/2	1/2
10	1/2	1/2	1/2	1/2	3/4
8	1/2	1/2	3/4	3/4	1
6	3/4	1	1	1-1/4	1-1/4
4	1	1	1-1/4	1-1/4	1-1/2
2	1	1-1/4	1-1/4	1-1/2	2
1/0	1-1/4	1-1/2	2	2	2-1/2
2/0	1-1/2	1-1/2	2	2	2-1/2
3/0	1-1/2	2	2	2-1/2	2-1/2

See the National Electric Code for conduit sizes when using wire types other than Type T & TW.

BOX SIZE vs NUMBER OF WIRES

Box Size in inches	Maximum Number of Wires in a Junction Box Wire Size AWG #14	#12	#10	#8
Outlet Boxes				
3-1/4 X 1-1/2 octagon	5	4	4	3
3-1/2 X 1-1/2 octagon	5	5	4	3
4 X 1-1/2 octagon	8	7	6	5
4 X 2-1/8 octagon	11	10	9	7
4 X 4 X 1-1/2	11	10	9	7
4 X 4 X 2-1/8	15	14	12	10
4 X 2-1/8 X 1-1/2	3	3	3	2
4 X 2-1/8 X 1-7/8	5	4	4	3
4 X 2-1/8 X 2-1/8	5	5	4	3
Switch Boxes				
3 X 2 X 1-1/2	6	5	5	4
3 X 2 X 2	7	6	5	4
3 X 2 X 2-1/4	9	8	7	6
3 X 2 X 2-1/2	5	4	4	3
3 X 2 X 2-3/4	6	6	5	4
3 X 2 X 3-1/2	7	6	6	5

The above number are maximums and you should deduct 1 wire if an outlet, switch, cable clamp, fixture stud, or similar part is also installed in the box.

AVERAGE ELECTRIC MOTOR SPECS

NOTE: Use the following table as a general guide only! These numbers are for normal fan, furnace, appliance, pump, and normal duty applications. The exact specifications for any given motor can vary greatly from those listed below. For 230V motors simply divide the indicated amps by 2.

Specs for 115 volt, 60 Hz, 1 Phase, AC Electric Motors

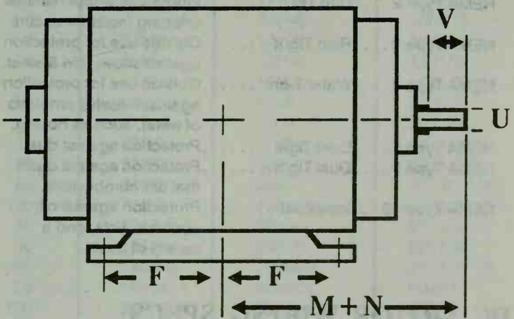
Motor Horsepower	RPM	Full Load Amps
1/20	1550	2.5
1/15	1550	2.8
1/12	1725	2.2–2.8
	1550	4.1
	850	3.2
1/10	1550	3.5
	1050	3.4–4.2
1/8	1725	1.8–2.7
	1140	3.8
	1075	1.8–5.0
1/6	1725	3.3–4.7
	1550	4.0–4.8
	1140	4.0–4.9
	1075	2.4–5.0
1/4	1725	4.4–6.3
	1625	3.1–3.6
	1140	5.6–6.8
	1075	3.4–6.8
	850	6.9
1/3	3450	5.6–6.5
	1725	5.3–6.8
	1140	5.0–7.2
	1075	5.1
1/2	3450	9.8
	1725	7.0–9.2
	1075	7.3
3/4	3450	11.8
	1725	11.6
	1075	9.5
1	3450	13.0–15.0
	1725	13.6–16.0
1-1/2	3450	16.4–19.6
	1725	19.6
2	3450	19–23

The above general specifications are based on motor data from the *1988 Graingers Catalog, Chicago, Illinois.*

NEMA ELECTRIC MOTOR FRAMES

Motor Frame	NEMA Frame Dimension - Inches D	E	F	U	V	M + N	Keyway
42	2-5/8	1-3/4	27/32	3/8	...	4-1/32	...
48	3	2-1/8	1-3/8	1/2	...	5-3/8	...
56	3-1/2	2-7/16	1-1/2	5/8	...	6-1/8	3/16x3/32
66	4-1/8	2-15/16	2-1/2	3/4	...	7-7/8	3/16x3/32
143T	3-1/2	2-3/4	2	7/8	2	6-1/2	3/16x3/32
145T	3-1/2	2-3/4	2-1/2	7/8	2	7	3/16x3/32
182	4-1/2	3-3/4	2-1/4	7/8	2	7-1/4	3/16x3/32
182T	4-1/2	3-3/4	2-1/4	1-1/8	2-1/2	7-3/4	1/4x1/8
184	4-1/2	3-3/4	2-3/4	7/8	2	7-3/4	3/16x3/32
184T	4-1/2	3-3/4	2-3/4	1-1/8	2-1/2	8-1/4	1/4x1/8
213	5-1/4	4-1/4	2-3/4	1-1/8	2-3/4	9-1/4	1/4x1/8
213T	5-1/4	4-1/4	2-3/4	1-3/8	3-1/8	9-5/8	5/16x5/32
215	5-1/4	4-1/4	3-1/2	1-1/8	2-3/4	10	1/4x1/8
215T	5-1/4	4-1/4	3-1/2	1-3/8	3-1/8	10-3/8	5/16x5/32
254T	6-1/4	5	4-1/8	1-5/8	3-3/4	12-3/8	3/8x3/16
254U	6-1/4	5	4-1/8	1-3/8	3-1/2	12-1/8	5/16x5/32
256T	6-1/4	5	5	1-5/8	3-3/4	13-1/4	3/8x3/16
256U	6-1/4	5	5	1-3/8	3-1/2	13	5/16x5/32
284T	7	5-1/2	4-3/4	1-7/8	4-3/8	14-1/8	1/2x1/4
284TS	7	5-1/2	4-1/4	1-5/8	3	13-1/2	3/8x3/16
284U	7	5-1/2	4-3/4	1-5/8	4-5/8	14-2/8	3/8x3/16
286T	7	5-1/2	5-1/2	1-7/8	4-3/8	14-7/8	1/2x1/4
286U	7	5-1/2	5-1/2	1-5/8	4-5/8	15-1/8	3/8x3/16
324T	8	6-1/4	5-1/4	2-1/8	5	15-3/4	1/2x1/4
324U	8	6-1/4	5-1/4	1-7/8	5-3/8	16-1/8	1/2x1/4
326T	8	6-1/4	6	2-1/8	5	16-1/2	1/2x1/4
326TS	8	6-1/4	6	1-7/8	3-1/2	15	1/2x1/4
326U	8	6-1/4	6	1-7/8	5-3/8	16-7/8	1/2x1/4
364T	9	7	5-5/8	2-3/8	5-5/8	17-3/8	5/8x5/16
364U	9	7	5-5/8	2-1/8	6-1/8	17-7/8	1/2x1/4
365T	9	7	6-1/8	2-3/8	5-5/8	17-7/8	5/8x5/16
365U	9	7	6-1/8	2-1/8	6-1/8	1-3/8	1/2x1/4
404T	10	8	6-1/8	2-7/8	7	20	3/4x3/8
404U	10	8	6-1/8	2-3/8	6-7/8	19-7/8	5/8x5/16
405T	10	8	6-7/8	2-7/8	7	20-3/4	3/4x3/8
405U	10	8	6-7/8	2-3/8	6-7/8	20-5/8	5/8x5/16
444T	11	9	7-1/4	3-3/8	8-1/4	23-1/4	7/8x7/16
444U	11	9	7-1/4	2-7/8	8-3/8	23-3/8	3/4x3/8
445T	11	9	8-1/4	3-3/8	8-1/4	24-1/4	7/8x7/16
445U	11	9	8-1/4	2-7/8	8-3/8	24-3/8	3/4x3/8

The above standards were established by the *National Electrical Manufacturers Association (NEMA)*



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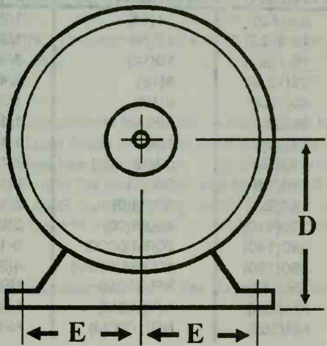


NEMA ELECTRIC ENCLOSURES

Enclosure Type	Class	Description
NEMA Type 1	General Purpose	Indoor use where no oil, water or dust is present.
NEMA Type 2	Drip Tight	Indoor use where minimal dripping moisture occurs.
NEMA Type 3	Rain Tight	Outside use for protection against snow, rain & sleet.
NEMA Type 4	Water Tight	Outside use for protection against massive amounts of water, such as hosing.
NEMA Type 5	Dust Tight	Protection against dust.
NEMA Type 9	Dust Tight	Protection against dusts that are combustible.
NEMA Type 12	Industrial	Protection against oil, coolants, lints, and a variety of dusts.

DC MOTOR WIRING SPECS

HP	Full Load Amps 115V(230V)	Wire Size Minimum (AWG–Rubber) 115V(230V)	Conduit Size Inches 115V(230V)
1	8.4(4.2)	14(14)	1/2(1/2)
1.5	12.5(6.3)	12(14)	1/2(1/2)
2	16.1(8.3)	10(14)	3/4(1/2)
3	23(12.3)	8(12)	3/4(1/2)
5	40(19.8)	6(10)	1(3/4)
7.5	58(28.7)	3(6)	1-1/4(1)
10	75(38)	1(6)	1-1/2(1)
15	112(56)	00(4)	2(1-1/4)
20	140(74)	000(1)	2(1-1/2)
25	184(92)	300M(0)	2-1/2(2)
30	220(110)	400M(00)	3(2)
40	292(146)	700M(0000)	3-1/2(2-1/2)
50	360(180)	1000M(300M)	4(2-1/2)
60	NR(215)	NR(400M)	NR(3)
75	NR(268)	NR(600M)	NR(3-1/2)
100	NR(355)	NR(1000M)	NR(4)

NR indicates "Not Recommended" and M indicates M.C.M (1000 Circular Mils). The above specifications are based on data from the *National Electrical Code.*

3 PHASE ELECTRIC MOTOR SPECS

HP	Full Load Amps 230V(460V)	Wire Size Minimum (AWG–Rubber) 230V(460V)	Conduit Size Inches 230V(460V)
1	3.3(1.7)	14(14)	1/2(1/2)
1.5	4.7(2.4)	14(14)	1/2(1/2)
2	6(3.0)	14(14)	1/2(1/2)
3	9(4.5)	14(14)	1/2(1/2)
5	15(7.5)	12(14)	1/2(1/2)
7.5	22(11)	8(14)	3/4(1/2)
10	27(14)	8(12)	3/4(1/2)
15	38(19)	6(10)	1-1/4(3/4)
20	52(26)	4(8)	1-1/4(3/4)
25	64(32)	3(6)	1-1/4(1-1/4)
30	77(39)	1(6)	1-1/2(1-1/4)
40	101(51)	00(4)	2(1-1/4)
50	125(63)	000(3)	2(1-1/4)
60	149(75)	200M(1)	2-1/2(1-1/2)
75	180(90)	0000(0)	2-1/2(2)
100	245(123)	500M(000)	3(2)
125	310(155)	750M(0000)	3-1/2(2-1/2)
150	360(180)	1000M(300M)	4(2-1/2)
200	480(240)	NR(500M)	NR(3)
250	580(290)	NR(NR)	NR(NR)
300	696(348)	NR(NR)	NR(NR)

NR indicates "Not Recommended" and "M" indicates M.C.M (1000 Circular Mils).

Note that starting currents for the above motors can be many times the Full Load Amps and fuses must be adjusted accordingly. If the powerline becomes too long, voltage drop will exceed safe limits and the wire size should be adjusted to the next larger (smaller AWG number) gauge wire. See the Copper Wire Specifications table in this chapter for more specific information on wire.

The above specifications are from the *National Electrical Code.*

HP vs TORQUE vs RPM - MOTORS

	Torque in Inch Pounds @ Motor R.P.M.					
HP	3450	2000	1725	1550	1140	1050
1	18	32	37	41	55	60
1.5	27	47	55	61	83	90
2	37	63	73	81	111	120
3	55	95	110	122	166	180
5	91	158	183	203	276	300
7.5	137	236	274	305	415	450
10	183	315	365	407	553	600
15	274	473	548	610	829	900
20	365	630	731	813	1106	1200
25	457	788	913	1017	1382	1501
30	548	945	1096	1220	1659	1801
40	731	1261	1461	1626	2211	2401
50	913	1576	1827	2033	2764	3001
60	1096	1891	2192	2440	3317	3601
70	1279	2206	2558	2846	3870	4202
80	1461	2521	2923	3253	4423	4802
90	1644	2836	3288	3660	4976	5402
100	1827	3151	3654	4066	5529	6002
125	2284	3939	4567	5083	6911	7503
150	2740	4727	5480	6099	8293	9004
175	3197	5515	6394	7116	9675	10504
200	3654	6303	7307	8132	11057	12005
225	4110	7090	8221	9149	12439	13505
250	4567	7878	9134	10165	13821	15006
275	5024	8666	10047	11182	15203	16507
300	5480	9454	10961	12198	16586	18007
350	6394	11029	12788	14231	19350	21008
400	7307	12605	14614	16265	22114	24010
450	8221	14181	16441	18298	24878	27011
500	9134	15756	18268	20331	27643	30012
550	10047	17332	20095	22364	30407	33013
600	10961	18908	21922	24397	33171	36014

$$\text{Torque in Inch Pounds} = \frac{\text{Horsepower} \times 63025}{\text{Motor RPM}}$$

To convert to Foot Pounds, divide the torque by 12.

HP vs TORQUE vs RPM – MOTORS

HP	Torque in Inch Pounds @ Motor R.P.M. 1000	850	750	600	500	230
1	63	74	84	105	126	274
1.5	95	111	126	158	189	411
2	126	148	168	210	252	548
3	189	222	252	315	378	822
5	315	371	420	525	630	1370
7.5	473	556	630	788	945	2055
10	630	741	840	1050	1261	2740
15	945	1112	1261	1576	1891	4110
20	1261	1483	1681	2101	2521	5480
25	1576	1854	2101	2626	3151	6851
30	1891	2224	2521	3151	3782	8221
40	2521	2966	3361	4202	5042	10961
50	3151	3707	4202	5252	6303	13701
60	3782	4449	5042	6303	7563	16441
70	4412	5190	5882	7353	8824	19182
80	5042	5932	6723	8403	10084	21922
90	5672	6673	7563	9454	11345	24662
100	6303	7415	8403	10504	12605	27402
125	7878	9268	10504	13130	15756	34253
150	9454	11122	12605	15756	18908	41103
175	11029	12976	14706	18382	22059	47954
200	12605	14829	16807	21008	25210	54804
225	14181	16683	18908	23634	28361	61655
250	15756	18537	21008	26260	31513	68505
275	17332	20390	23109	28886	34664	75356
300	18908	22244	25210	31513	37815	82207
350	22059	25951	29412	36765	44118	95908
400	25210	29659	33613	42017	50420	109609
450	28361	33366	37815	47269	56723	123310
500	31513	37074	42017	52521	63025	137011
550	34664	40781	46218	57773	69328	150712
600	37815	44488	50420	63025	75630	164413

$$\text{Torque in Inch Pounds} = \frac{\text{Horsepower} \times 63025}{\text{Motor RPM}}$$

NOTE: Ratings below 500 RPM are for gear motors.
To convert to Foot Pounds, divide the torque by 12.

HP vs TORQUE vs RPM - MOTORS

HP	Torque in Inch Pounds @ Motor R.P.M. 190	155	125	100	84	68
1	332	407	504	630	750	927
1.5	498	610	756	945	1125	1390
2	663	813	1008	1261	1501	1854
3	995	1220	1513	1891	2251	2781
5	1659	2033	2521	3151	3751	4634
7.5	2488	3050	3782	4727	5627	6951
10	3317	4066	5042	6303	7503	9268
15	4976	6099	7563	9454	11254	13903
20	6634	8132	10084	12605	15006	18537
25	8293	10165	12605	15756	18757	23171
30	9951	12198	15126	18908	22509	27805
40	13268	16265	20168	25210	30012	37074
50	16586	20331	25210	31513	37515	46342
60	19903	24397	30252	37815	45018	55610
70	23220	28463	35294	44118	52521	64879
80	26537	32529	40336	50420	60024	74147
90	29854	36595	45378	56723	67527	83415
100	33171	40661	50420	63025	75030	92684
125	41464	50827	63025	78781	93787	115855
150	49757	60992	75630	94538	112545	139026
175	58049	71157	88235	110294	131302	162197
200	66342	81323	100840	126050	150060	185368
225	74635	91488	113445	141806	168817	208539
250	82928	101653	126050	157563	187574	231710
275	91220	111819	138655	173319	206332	254881
300	99513	121984	151260	189075	225089	278051
350	116099	142315	176470	220588	262604	324393
400	132684	162645	201680	252100	300119	370735
450	149270	182976	226890	283613	337634	417077
500	165855	203306	252100	315125	375149	463419
550	182441	223637	277310	346638	412664	509761
600	199026	243968	302520	378150	450179	556103

$$\text{Torque in Inch Pounds} = \frac{\text{Horsepower} \times 63025}{\text{Motor RPM}}$$

NOTE: Ratings below 500 RPM are for gear motors.
To convert to Foot Pounds, divide the torque by 12.

POCKET REF

Electronics

(See also Frequency Spectrum on page 192)
(See also ELECTRIC Chapter on page 107)

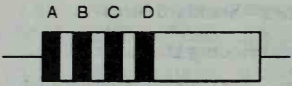
RESISTOR COLOR CODES

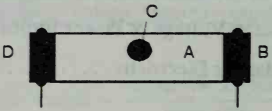
Color	1st Digit(A)	2nd Digit(B)	Multiplier(C)	Tolerance(D)
Black	0	0	1	
Brown	1	1	10	
Red	2	2	100	
Orange	3	3	1,000	
Yellow	4	4	10,000	
Green	5	5	100,000	
Blue	6	6	1,000,000	
Violet	7	7	10,000,000	
Gray	8	8	100,000,000	
White	9	9	10^9	
Gold			0.1 (EIA)	5%
Silver			0.01 (EIA)	10%
No Color				20%

Example: Red–Red–Orange = 22,000 ohms, 20%

Additional information concerning the Axial Lead resistor can be obtained if Band A is a wide band. Case 1: If only Band A is wide, it indicates that the resistor is wirewound. Case 2: If Band A is wide and there is also a blue fifth band to the right of Band D on the Axial Lead Resistor, it indicates the resistor is wirewound and flame proof.

Axial Lead Resistor





Radial Lead Resistor

RESISTOR STANDARD VALUES

Standard Resistor Values for 5% class

1	62	3.9k	240k
1.1	68	4.3k	270k
1.2	75	4.7k	300k
1.3	82	5.1k	330k
1.5	91	5.6k	360k
1.6	100	6.2k	390k
1.8	110	6.8k	430k
2.0	120	7.5k	470k
2.2	130	8.2k	510k
2.4	150	9.1k	560k
2.7	160	10k	620k
3.0	180	11k	680k
3.3	200	12k	750k
3.6	220	13k	820k
3.9	240	15k	910k
4.3	270	16k	1.0M
4.7	300	18k	1.1M
5.1	330	20k	1.2M
5.6	360	22k	1.3M
6.2	390	24k	1.5M
6.8	430	27k	1.6M
7.5	470	30k	1.8M
8.2	510	33k	2.0M
9.1	560	36k	2.2M
10	620	39k	2.4M
11	680	43k	2.7M
12	750	47k	3.0M
13	820	51k	3.3M
15	910	56k	3.6M
16	1.0k	62k	3.9M
18	1.1k	68k	4.3M
20	1.2k	75k	4.7M
22	1.3k	82k	5.1M
24	1.5k	91k	5.6M
27	1.6k	100k	6.2M
30	1.8k	110k	6.8M
33	2.0k	120k	7.5M
36	2.2k	130k	8.2M
39	2.4k	150k	9.1M
43	2.7k	160k	10.0M
47	3.0k	180k	
51	3.3k	200k	
56	3.6k	220k	

k = kohms = 1,000 ohms M = megohms = 1,000,000 ohms

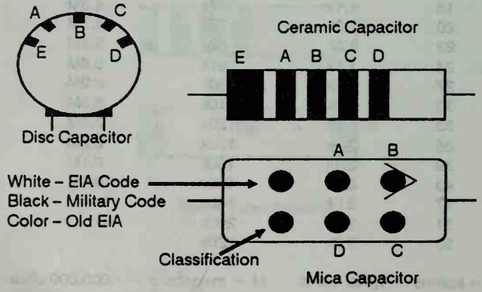
CAPACITOR COLOR CODES

Color	1st Digit(A)	2nd Digit(B)	Multiplier(C)	Tolerance(D)
Black	0	0	1	20%
Brown	1	1	10	1%
Red	2	2	100	2%
Orange	3	3	1,000	3%
Yellow	4	4	10,000	4%
Green	5	5	100,000	5%
Blue	6	6	1,000,000	6%
Violet	7	7	10,000,000	7%
Gray	8	8	100,000,000	8%
White	9	9	10^9	9%
Gold			0.1 (EIA)	5%
Silver			0.01 (EIA)	10%
No Color				20%

Color Codes for Ceramic Capacitors

	Decimal	Tolerance (D)		Temp Coef
Color	Multiplier(C)	Above 10pf	Below 10pf	ppm/°C (E)
Black	1	20	2.0	0
Brown	10	1		–30
Red	100	2		–80
Orange	1000			–150
Yellow				–220
Green		5	0.5	–330
Blue				–470
Violet				–750
Gray	0.01		0.25	30
White	0.1	10	1.0	500

Ceramic disc capacitors are usually labeled. If the number is < 1 then the value is picofarads, if > 1 the value is microfarads. The letter R is sometimes used as a decimal, eg, 4R7 is 4.7.



CAPACITOR STANDARD VALUES

pF	mF	mF	mF	mF
10	0.001	0.1	10	1000
12	0.0012			
13	0.0013			
15	0.0015	0.15	15	
18	0.0018			
20	0.002			
22	0.0022	0.22	22	2200
24				
27				
30				
33	0.0033	0.33	33	3300
36				
43				
47	0.0047	0.47	47	4700
51				
56				
62				
68	0.0068	0.68	68	6800
75				
82				
100	0.01	1.0	100	10,000
110				
120				
130				
150	0.015	1.5		
180				
200				
220	0.022	2.2	220	22,000
240				
270				
300				
330	0.033	3.3	330	
360				
390				
430				
470	0.047	4.7	470	47,000
510				
560				
620				
680	0.068	6.8		
750				
820				82,000
910				

pf = picofarads = 1×10^{-12} farads
mf = micro farads = 1×10^{-6} farads

PILOT LAMPS

Lamp Number	Bead Color	Base Type	Bulb Volts	Amps	Type
12		2 Pin	6.3	0.15	G3-1/2
12PSB5		Slide	12	0.17	T2
13		Screw	3.7	0.30	G3-1/2
14		Screw	2.47	0.30	G3-1/2
19		2 Pin	14.4	0.10	G3-1/2
24PSB5		Slide	24	0.073	T2
27		Screw	4.9	0.30	G4-1/2
28PSB5		Slide	28	0.04	T2
31		Screw	6.15	0.30	G4-1/2
40	Brown	Screw	6-8	0.15	T3-1/4
40A	Brown	Bayonet	6-8	0.15	T3-1/4
41	White	Screw	2.5	0.5	T3-1/4
42	Green	Screw	3.2	0.35/0.5	T3-1/4
43	White	Bayonet	2.5	0.5	T3-1/4
44	Blue	Bayonet	6-8	0.25	T3-1/4
45	White/Grn	Bayonet	3.2	0.35/0.5	T3-1/4
46	Blue	Screw	6-8	0.25	T3-1/4
47	Brown	Bayonet	6-9	0.15	T3-1/4
48	Pink	Screw	2.0	0.06	T3-1/4
49	Pink	Bayonet	2.0	0.06	T3-1/4
49A	White	Bayonet	2.1	0.12	T3-1/4
50	White	Screw	6-8	0.2	G3-1/2
51	White	Bayonet	6-8	0.2	G3-1/2
53		Bayonet	14.4	0.12	G3-1/2
55	White	Bayonet	6-8	0.4	G4-1/2
57	White	Bayonet	14	0.24	G4-1/2
63		Bayonet	7.0	0.63	G6
67		Bayonet	13.5	0.59	G6
73		Wedge	14	0.08	T1-3/4
81		Bayonet	6.5	1.02	G6
82		Dbl Bayonet	6.5	1.02	G6
85		Wedge	28	0.04	T1-3/4
86		Wedge	6.3	0.20	T1-3/4
87		Bayonet	6.8	1.91	S8
88		Dbl Bayonet	6.8	1.90	S8
89		Bayonet	13.0	0.58	G6
93		Bayonet	12.8	1.04	S8
112	Pink	Screw	1.1	0.22	TL-3
120MB		Min. Bayonet	120.0	0.025	T2
123		Screw	1.25	0.30	G3-1/2
136		Screw	1.25	0.60	G4-1/2
158		Wedge	14.0	0.24	T3-1/4
161		Wedge	14.0	0.19	T3-1/4
168		Wedge	14.0	0.35	T3-1/4
194		Wedge	14.0	0.27	T3-1/4
222	White	Screw	2.2	0.25	GTL-3
292	White	Screw	2.9	0.17	T3-1/4
292A	White	Bayonet	2.9	0.17	T3-1/4
301		Bayonet	28.0	0.17	G5
302		Dbl Bayonet	28.0	0.17	G5
303		Bayonet	28.0	0.30	G6
305		Bayonet	28.0	0.51	S8
307		Bayonet	28.0	0.66	S8
308		Dbl Bayonet	28.0	0.67	S8
309		Bayonet	28.0	0.90	S11
313		Min. Bayonet	28.0	0.17	T3-1/4
327		Mig. Flanged	28.0	0.04	T1-3/4

PILOT LAMPS

Lamp Number	Bead Color	Base Type	Bulb Volts	Amps	Type
328		Mig. Flanged	6.0	0.20	T1-3/4
330		Mig. Flanged	14.0	0.08	T1-3/4
331		Mig. Flanged	1.35	0.06	T1-3/4
334		Mig. Grooved	28.0	0.04	T1-3/4
335		Mig. Screw	28.0	0.04	T1-3/4
344		Mig. Flanged	10.0	0.014	T1-3/4
381		Mig. Flanged	6.3	0.02	T1-3/4
382		Mig. Flanged	14.0	0.08	T1-3/4
385		Mig. Flanged	28.0	0.04	T1-3/4
387		Mig. Flanged	28.0	0.04	T1-3/4
388		Mig. Grooved	28.0	0.04	T1-3/4
656		Wedge	28.0	0.06	T3-1/4
680		Wires	5.0	0.06	T1
682		Mig. Flange	5.0	0.06	T1
683		Wires	5.0	0.06	T1
683AS15		Wires	5.0	0.06	T1
685		Mig. Flange	5.0	0.06	T1
713		Wires	5.0	0.075	T1
714		Mig. Flange	5.0	0.075	T1
715		Wires	5.0	0.115	T1
715AS15		Wires	5.0	0.115	T1
718		Mig. Flange	5.0	0.115	T1
755		Min. Bayonet	6.3	0.15	T3-1/4
756		Min. Bayonet	14.0	0.08	T3-1/4
757		Min. Bayonet	28.0	0.08	T3-1/4
1003		Bayonet	12.8	0.94	B6
1004		Dbl Bayonet	12.8	0.94	B6
1034		Bayonet	12.8	1.80	S8
1076		Dbl Bayonet	12.8	1.80	S8
1133			6.2	3.91	RP11
1156		Bayonet	12.8	2.10	S8
1157		DC Bayonet	12.8	2.10	S8
1176		Dbl Bayonet	12.8	1.34	S8
1195			12.5	3.0	RP11
1251		Bayonet	28.0	0.23	G6
1445		Bayonet	14.4	0.135	G3-1/2
1447		Screw	18	0.15	G3-1/2
1455	Brown	Screw	18.0	0.25	G5
1455A	Brown	Bayonet	18.0	0.25	G5
1458		Bayonet	20.0	0.25	G5
1487		Screw	12-16	0.2	T3-1/4
1488		Bayonet	14	0.15	T3-1/4
1490	White	Bayonet	3.2	0.15	T3-1/4
1495		Bayonet	28.0	0.30	T4-1/2
1705		Wires	14.0	0.08	T1-3/4
1764		Wires	28.0	0.04	T1-3/4
1784		Wires	6.0	0.20	T1-3/4
1813		Bayonet	14.4	0.10	T3-1/4
1815		Bayonet	12-16	0.20	T3-1/4
1816		Bayonet	13.0	0.33	T1-3/4
1819		Min. Bayonet	28.0	0.04	T3-1/4
1820		Min. Bayonet	28.0	0.10	T3-1/4
1822		Min. Bayonet	36.0	0.10	T3-1/4
1829		Min. Bayonet	28.0	0.07	T3-1/4
1847		Bayonet	6.3	0.15	T1-3/4
1864		Min. Bayonet	28.0	0.17	T3-1/4
1891	Pink	Bayonet	14	0.23	T3-1/2

PILOT LAMPS

Lamp Number	Bead Color	Base Type	Bulb Volts	Amps	Type
1892	White	Screw	14	0.12	T3-1/2
1895		Min. Bayonet	14.0	0.27	G4-1/2
2181		Wires	6.3	0.20	T1-3/4
2182		Wires	6.3	0.20	T1-3/4
2187		Wires	28.0	0.04	T1-3/4
3150		Mig. Flange	5.0	0.06	T1-3/4
6838		Wires	28.0	0.024	T1
6839		Mig. Flange	28.0	0.024	T1
7327		Bi Pin	28.0	0.04	T1-3/4
7333		Mig. Flange	5.0	0.06	T1-3/4
7361		Bi Pin	5.0	0.06	T1-3/4
7381		Bi Pin	6.3	0.20	T1-3/4
7382		Bi Pin	14.0	0.08	T1-3/4
7387		Bi Pin	28.0	0.04	T1-3/4
7632		Bi Pin	28.0	0.04	T1-3/4
7839		Bi Pin	28.0	0.024	T1
8623		Thr. Knurled	28.0	0.04	T1-1/4
8627		Wires	28.0	0.04	T1-1/4
PR-2	Blue	Flange	2.4	0.50	B3-1/2
PR-3	Green	Flange	3.6	0.50	B3-1/2
PR-4	Yellow	Flange	2.3	0.27	B3-1/2
PR-6	Brown	Flange	2.5	0.30	B3-1/2
PF-7		Flange	3.7	0.30	B3-1/2
PR-12	White	Flange	5.95	0.50	B3-1/2
PR-13		Flange	4.75	0.50	B3-1/2
PR-18		Flange	7.2	0.55	B3-1/2

Neon Number	**Resistor Required**	**Base Type**	**Bulb Volts**	**Milli-amps**	**Type**
NE-2 (A1A)	150K	Wire	110VAC	0.5	T2
NE-2A (A2A)	220K	Wire	110VAC	0.3	T2
A1B	220K	Wire	110VAC	0.3	T2
A1C	47K	Wire	110VAC	1.2	T2
NE-2D (C7A)	100K	Midg. Flange	110VAC	0.6	T2
NE-2E (A9A)	100K	Wire	110VAC	0.6	T2
NE-2H (C2A)	30K	Wire	110VAC	1.7	T2
NE-2J (C9A)	30K	Flange	110VAC	1.7	T2
NE-2M	150K	Wire	110VAC	0.5	T2
NE-2P	30K	Wire	110VAC	1.7	T2
NE-7 (B4A)	30K	Wire	110VAC	2.0	
NE-17(B5A)	30K	DC Bayonet	110VAC	2.0	T4-1/2
NE-21 (B6A)	30K		110VAC	2.0	
NE-30	None	Screw	110VAC	12.0	S11
NE-34		Screw	110VAC	18.0	S14
NE-42			110VAC	30.0	
NE-45 (B7A)	30K	Candelabra S	110VAC	2.0	T4-1/2
NE-47 (B8A)	30K	SC Bayonet	110VAC	2.0	T4-1.2
NE-48	30K	DC Bayonet	110VAC	2.0	T4-1/2
NE-51 (B1A)	200K	Min. Bayonet	110VAC	0.3	T3-1/4
NE-51H (B2A)	45K	Min. Bayonet	110VAC	1.2	T3-1/4
NE-56	None	Screw	220VAC	5.0	S11
NE-57	None	Candelabra S	110VAC	2.0	T4-1/4
NE-58 (F4A)	100K	Candelabra S	220VAC	2.0	T4-1/4
NE-79	7.5K	DC Bayonet	110VAC	12.0	S7
6S6DC		Dbl Bayonet	120V	6 watt	S6
7C7		Candelabra S	115-0125	7 watt	S7

FUSES – SMALL TUBE TYPE

TYPE	Description	Diameter Inches	Length Inches
3AB	Ceramic body, normal, 200% 15sec	1/4	1-1/4
1AG	Auto Glass, fast blow, 200% 5sec	1/4	5/8
2AG	Auto Glass, fast blow, 200% 10sec	0.177	0.57
3AG	Auto Glass, fast blow, 200% 5sec	1/4	1-1/4
4AG	Auto Glass, fast blow, 200% 5sec	9/32	1-1/4
5AG	Auto Glass, fast blow, 200% 5sec	13/32	1-1/2
7AG	Auto Glass, fast blow, 200% 5sec	1/4	7/8
8AG	Auto Glass, fast blow, 200% 5sec	1/4	1
9AG	Auto Glass, fast blow, 200% 5sec	1/4	1-7/16
216	Metric, fast blow, high int.,210% 30m	5mm	20mm
217	Glass, Metric, fast blow, 210% 30m	5mm	20mm
218	Glass, Metric, slow blow, 210% 2 min	5mm	20mm
ABC	No Delay, Ceramic, 110% rating, Will blow at 135% load in one hour	1/4	1-1/4
AGC	Fast Acting, glass tube, 110% rating, Will blow at 135% load in one hour	1/4	1-1/4
AGX	Fast Acting, glass tube	1/4	1
BLF	No delay, 200% 15sec	13/32	1-1/2
BLN	No delay, military, 200% 15sec	13/32	1-1/2
BLS	Fast clearing, 600V, 135% 1hr	13/32	1-3/8
FLA	Time delay, indicator pin, 135% 1hr	13/32	1-1/2
FLM	Dual element, delay, 200% 12 sec	13/32	1-1/2
FLQ	Dual element, delay,500V,200%12sec	13/32	1-1/2
FNM	Slow Blow Time Delay	13/32	1-1/4
FNA	Slow Blow, Indicator, silver pin pops out when blown, Dual Element	13/32	1-1/2
GBB	Rectifier Fuse, Fast, low let through	1/4	1-1/4
GLD	Indicator Fuse, silver pin pops out to show blown fuse. 110% rating	1/4	1-1/4
GGS	Metric, fast acting	5mm	20mm
KLK	Fast, current limiting, 600V, 135% 1hr	13/32	1-1/2
KLW	Fast, protect solid state, 250% 1sec	13/32	1-1/2
MDL	Dual Element, Time Delay, glass tube	1/4	1-1/4
MDX	Dual Element, glass tube	1/4	1-1/4
MDV	Dual Element, glass tube, Pigtail	1/4	1-1/4
SC	Slow Blow, Time Delay Size rejection also	13/32	1-5/16to 2-1/4
218000	Slow blow, glass body, 200% 5sec	0.197	0.787
251000	Pico II™ Subminiature, fast blow	Wire lead	
273000	Microfuse, fast blow, 200% 5sec	Wire lead	
313000	Slow Blow, glass body, 200% 5sec	1/4	1-1/4
326000	Slow Blow, ceramic, 200% 5sec	1/4	1-1/4

Note: The 200% 10 sec figures above indicate that a 200% overload will blow the fuse in 10 seconds.

BATTERY CHARACTERISTICS

Battery (1)	Anode	Cathode	Voltage(2)	Amp-hrs/kg
Ammonia	Mg	m–DNB	2.2 (1.7)	1,400
Cadmium–Air (C)	Cd	O_2	1.2 (0.8)	475
Cuprous chloride	Mg	CuCl	1.5 (1.4)	240
Edison (C)	Fe	NiO	1.5 (1.2)	195
H_2–O_2 (C)	H_2	O_2	1.23 (0.8)	3,000
Lead–Acid (C)	Pb	PbO_2	2.1 (2.0)	55
Leclance (NC)	Zn	MnO_2	1.6 (1.2)	230
Lithium–High Temp, 350°C, with fused salt				
	Li	S	2.1 (1.8)	685
Magnesium (NC)	Mg	MnO_2	2.0 (1.5)	270
Mercury (NC)	Zn	HgO	1.34 (1.2)	185
Mercad (NC)	Cd	HgO	0.9 (0.85)	165
MnO_2 alkaline (NC)	Zn	MnO_2	1.5 (1.15)	230
NiCad (C)	Cd	NiO	1.35 (1.2)	165
Organic Cath.(NC)	Mg	m–DNB	1.8 (1.15)	1,400
Silver Cadmium (C)	Cd	AgO	1.4 (1.05)	230
Silver Chloride	Mg	AgCl	1.6 (1.5)	170
Silver Oxide	Zn	AgO	1.85 (1.5)	285
Silver–Poly	Ag	Polyiodide	0.66 (0.6)	180?
Sodium – High Temp, 300°C, with β–alumina electrolyte				
	Na	S	2.2 (1.8)	1,150
Thermal	Ca	Fuel	2.8 (2.6)	240
Zinc-Air (NC)	Zn	O_2	1.6 (1.1)	815
Zinc–Nickel (C)	Zn	Ni oxides	1.75 (1.6)	185
Zinc-Silver Ox	Zn	AgO	1.85 (1.5)	285

Fuel Cells:

Hydrogen	H_2	O_2	1.23 (0.7)	26,000
Hydrazine	N_2H_4	O_2	1.5 (0.7)	2,100
Methanol	CH_2OH	O_2	1.3 (0.9)	1,400

(1) (NC) after the name indicates the cell is a Primary Cell and cannot be recharged. (C) indicates the cell is a Secondary Cell and can be recharged.

(2) The first voltage is the theoretical voltage developed by the cell and the value in parenthesis is the typical voltage generated by a working cell. Amp–hrs/kg is the theoretical capacity of the cell.

Battery data listed above was obtained from the *Electronic Engineers Master Catalog, Hearst Business Communications Inc., 1986–1987.*

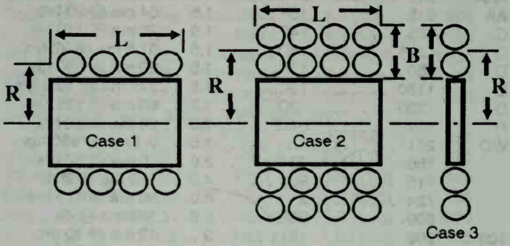
BATTERIES – STANDARD SIZES

Size	Eveready #	NEDA #	Voltage	Capacity
Carbon Zinc Cells:				
AAA	912	24F	1.5	20 ma @ 21 hrs
AA	915	15F	1.5	54 ma @ 20 hrs
C	935	14F	1.5	20 ma @ 140 hrs
C	1235	14D	1.5	37.5 ma @ 97 hrs
D	950	13F	1.5	20 ma @ 360 hrs
D	1150	13C	1.5	375 ma @ 15.8 hrs
D	1250	13D	1.5	60 ma @ 139 hrs
N	904	910F	1.5	20 ma @ 22 hrs
WO	201		1.5	0.1 ma @ 650 hrs
	750	704	3.0	20 ma @ 37 hrs
	715	903	4.5	120 ma @ 90 hrs
	724	2	6.0	60 ma @ 175 hrs
	509	908	6.0	187 ma @ 40
109	206	1611	9	12 ma @ 40 hrs
127	226	1600	9	12 ma @ 61 hrs
	276	1603	9	20 ma @ 350 hrs
117	216	1604	9	9 ma @ 50 hrs
	228	1810	12	12 ma @ 59 hrs
	420	225	22.5	5 ma @ 60 hrs
	482	207	45	40 ma @ 125 hrs
	490	204	90	10 ma @ 63
Alkaline–Manganese:				
AAA	E92	24A	1.5	37.5 ma @ 25 hrs
AA	E91	15A	1.5	20 ma @ 107 hrs
C	E93	14A	1.5	37.5 ma @ 160 hrs
D	E95	13A	1.5	50 ma @ 270 hrs
G	520	930A	6.0	375 ma @ 59 hrs
N	E90	910A	1.5	9 ma @ 90 hrs
	532	1308AP	3.0	20 ma @ 35 hrs
	531	1307AP	4.5	20 ma @ 35 hrs
	522	1604A	9.0	18 ma @ 33 hrs
	539		6.0	18 MA @ 30.5
Ni Cad Rechargeable:				
AAA	CH12ABP-2	10024	1.2	180 milliamp–hours
AA	CH15	10015	1.2	500 milliamp–hours
C	CH35	10014	1.2	1.2 ampere–hours
Sub C	CH1.2	10022	1.2	1.2 ampere–hours
D	CH50	10013	1.2	1.2 ampere–hours
D	CH4	10013HC	1.2	4 ampere–hours
N	CH150	10910	1.2	150 milliamp–hours
	CH22		8.4	80 milliamp–hours

(CF series rechargeable is Fast Charge, CH is Standard Charge)

RF COIL WINDING DATA

The inductance (I), in microhenrys, of air–core coil can be calculated to within 1% or 2% with the following formulas:



CASE 1: Single Layer Coil

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

CASE 2: Multiple Layer Coil

$$I = \frac{0.8\,(R^2N^2)}{6R + 9L + 10B}$$

CASE 3: Single Layer, Single Row Coil

$$I = \frac{R^2N^2}{8R + 11B}$$

In all of the above equations, N = number of turns and I is the inductance in microhenrys. L and R are distances in inches.

WIRE SIZE vs TURNS/INCH

Gauge AWG	Number of Turns Per Inch of Length Enamel	S.S.C.	D.C.C.
1	...	...	3.3
2	...	...	3.6
3	...	...	4.0
4	...	...	4.5
5	...	...	5.0
6	...	...	5.6
7	...	...	6.2
8	7.6	...	7.1
9	8.6	...	7.8
10	9.6	...	8.9
11	10.7	...	9.8
12	12.0	...	10.9
13	13.5	...	12.0
14	15.0	...	13.8
15	16.8	...	14.7
16	18.9	18.9	16.4
17	21.2	21.2	18.1
18	23.6	23.6	19.8
19	26.4	26.4	21.8
20	29.4	29.4	23.8
21	33.1	32.7	26.0
22	37.0	36.5	30.0
23	41.3	40.6	31.6
24	46.3	45.3	35.6
25	51.7	50.4	38.6
26	58.0	55.6	41.8
27	64.9	61.5	45.0
28	72.7	68.6	48.5
29	81.6	74.8	51.8
30	90.5	83.3	55.5
31	101.0	92.0	59.2
32	113.0	101.0	62.6
33	127.0	110.0	66.3
34	143.0	120.0	70.0
35	158.0	132.0	73.5
36	175.0	143.0	77.0
37	198.0	154.0	80.3
38	224.0	166.0	83.6
39	248.0	181.0	86.6
40	282.0	194.0	89.7

The above values will vary slightly depending the manufacturer of the wire and thickness of enamel.

DECIBELS vs VOLT & POWER RATIOS

Voltage	Power	+ DB −	Voltage	Power
1.000	1.000	0.0	1.000	1.000
1.059	1.122	0.5	0.891	0.944
1.122	1.259	1.0	0.794	0.891
1.189	1.413	1.5	0.708	0.841
1.259	1.585	2.0	0.631	0.794
1.334	1.778	2.5	0.562	0.750
1.413	1.995	3.0	0.501	0.708
1.496	2.239	3.5	0.447	0.668
1.585	2.512	4.0	0.398	0.631
1.679	2.818	4.5	0.355	0.596
1.778	3.162	5.0	0.316	0.562
1.884	3.548	5.5	0.282	0.531
1.995	3.981	6.0	0.251	0.501
2.113	4.467	6.5	0.224	0.473
2.239	5.012	7.0	0.200	0.447
2.371	5.623	7.5	0.178	0.422
2.512	6.310	8.0	0.158	0.398
2.661	7.079	8.5	0.141	0.376
2.818	7.943	9.0	0.126	0.355
2.985	8.913	9.5	0.112	0.335
3.162	10.000	10.0	0.100	0.316
3.350	11.220	10.5	0.089	0.299
3.548	12.589	11.0	0.079	0.282
3.758	14.125	11.5	0.071	0.266
3.981	15.849	12.0	0.063	0.251
4.217	17.783	12.5	0.056	0.237
4.467	19.953	13.0	0.050	0.224
4.732	22.387	13.5	0.045	0.211
5.012	25.119	14.0	0.040	0.200
5.309	28.184	14.5	0.035	0.188
5.623	31.623	15.0	0.032	0.178
5.957	35.481	15.5	0.028	0.168
6.310	39.811	16.0	0.025	0.158
6.683	44.668	16.5	0.022	0.150
7.079	50.119	17.0	0.020	0.141
7.499	56.234	17.5	0.018	0.133
7.943	63.096	18.0	0.016	0.126
8.414	70.795	18.5	0.014	0.119
8.913	79.433	19.0	0.013	0.112
9.441	89.125	19.5	0.011	0.106
10.0	100	20.0	0.010	0.100
31.6	1000	30.0	0.001	0.0316
100.0	10000	40.0	0.0001	0.01
316.2	10^5	50.0	0.00001	0.00316
1000	10^6	60.0	10^{-6}	0.001
3162	10^7	70.0	10^{-7}	0.000316
10000	10^8	80.0	10^{-8}	0.001
31620	10^9	90.0	10^{-9}	0.0000316
10^5	10^{10}	100.0	10^{-10}	10^{-5}
316200	10^{11}	110.0	10^{-11}	0.0000031
10^6	10^{12}	120.0	10^{-12}	10^{-6}

FORMULAS FOR ELECTRICITY

(1) Ohms Law (DC Current):

$$\text{Current in amps} = \frac{\text{Voltage in volts}}{\text{Resistance in ohms}} = \frac{\text{Power in watts}}{\text{Voltage in volts}}$$

$$\text{Current in amps} = \sqrt{\frac{\text{Power in watts}}{\text{Resistance in ohms}}}$$

Voltage in volts = Current in amps x Resistance in ohms

Voltage in volts = Power in watts / Current in amps

Voltage in volts = $\sqrt{\text{Power in watts x Resistance in ohms}}$

Power in watts = (Current in watts)^2 x Resistance in ohms

Power in watts = Voltage in volts x Current in amps

Power in watts = (Voltage in volts)^2 / Resistance in Ohms

Resistance in ohms = Voltage in volts / Current in amps

Resistance in ohms = Power in watts / (Current in amps)^2

(2) Resistors in Series (values in Ohms):

Total Resistance = $\text{Resistance}_1 + \text{Resistance}_2 + \ldots\text{Resistance}_n$

(3) Two Resistors in Parallel (values in Ohms):

$$\text{Total Resistance} = \frac{\text{Resistance}_1 \times \text{Resistance}_2}{\text{Resistance}_1 + \text{Resistance}_2}$$

(4) Multiple Resistors in Parallel (values in Ohms):

Total Resistance =

$$\frac{1}{1/\text{Resistance}_1 + 1/\text{Resistance}_2 + \ldots\ 1/\text{Resistance}_n}$$

(5) Ohms Law (AC Current):

In the following AC Ohms Law formulas, θ is the phase angle in degrees by which current lags voltage (in an inductive circuit) or by which current leads voltage (in a capacitive circuit). In a resonant circuit (such as normal household 120VAC) the phase angle is 0° and Impedance = Resistance.

$$\text{Current in amps} = \frac{\text{Voltage in volts}}{\text{Impedance in ohms}}$$

$$\text{Current in amps} = \sqrt{\frac{\text{Power in watts}}{\text{Impedance in ohms} \times \cos\theta}}$$

$$\text{Current in amps} = \frac{\text{Power in watts}}{\text{Voltage in volts} \times \cos\theta}$$

$$\text{Voltage in volts} = \text{Current in amps} \times \text{Impedance in ohms}$$

$$\text{Voltage in volts} = \frac{\text{Power in watts}}{\text{Current in amps} \times \cos\theta}$$

$$\text{Voltage in volts} = \sqrt{\frac{\text{Power in watts x Impedance ohm}}{\cos\theta}}$$

$$\text{Impedance in ohms} = \text{Voltage in volts / current in ohms}$$

$$\text{Impedance in ohms} = \text{Power in watts / (Current amps}^2 \times \cos\theta)$$

$$\text{Impedance in ohms} = (\text{Voltage in volts}^2 \times \cos\theta) \text{ / Power in watts}$$

$$\text{Power in watts} = \text{Current in amps}^2 \times \text{Impedance in ohms} \times \cos\theta$$

$$\text{Power in watts} = \text{Current in amps} \times \text{Voltage in volts} \times \cos\theta$$

$$\text{Power in watts} = \frac{(\text{Voltage in volts})^2 \times \cos\theta}{\text{Impedance in ohms}}$$

(6) Resonance: – *f*

Resonant frequency in hertz (where $XL = X_C$) =

$$\frac{1}{2\pi\sqrt{\text{Inductance in henrys} \times \text{Capacitance in farads}}}$$

(7) Reactance: – X

Reactance in ohms of an inductance is X_L
Reactance in ohms of a capacitance is X_C

$X_L = 2\pi$(frequency in hertz x Inductance in henrys)

$XC = 1 / (2\pi$(frequency in hertz x Capacitance in farads)

(8) Impedance: – Z

Impedance in ohms (series) $= \sqrt{\text{Resistance in ohms}^2 \times (X_L - X_C)^2}$

Impedance in ohms (parallel) $= \dfrac{\text{Resistance in ohms} \times \text{Reactance}}{\sqrt{\text{Resistance in ohms}^2 \times \text{Reactance}^2}}$

(9) Susceptance: – B

Susceptance in mhos =

$$\frac{\text{Reactance in ohms}}{\text{Resistance in ohms}^2 + \text{Reactance in ohms}^2}$$

(10) Admittance: – Y

Admittance in mhos =

$$\frac{1}{\sqrt{\text{Resistance in ohms}^2 \times \text{Reactance in ohms}^2}}$$

Admittance in mhos = 1 / Impedance in ohms

(11) Power Factor: – pf

Power Factor = cos (Phase Angle)
Power Factor = True Power / Apparent Power
Power Factor = Power in watts / (volts x current in amps)
Power Factor = Resistance in ohms / Impedance in ohms

(12) Q or Figure of Merit: – Q

Q = Inductive Reactance in ohms / Series Resistance in ohms
Q = Capacitive Reactance in ohms / Series Resistance in ohms

(13) Efficiency of any Device:

Efficiency = Output / Input

(14) Sine Wave Voltage and Current:

Effective (RMS) value = 0.707 x Peak value
Effective (RMS) value = 1.11 x Average value
Average value = 0.637 x Peak value
Average value = 0.9 x Effective (RMS) value
Peak Value = 1.414 x Effective (RMS) value
Peak Value = 1.57 x Average value

(15) Decibels: – db

db = 10 Log10 (Power in Watts #1 / Power in Watts #2)
db = 10 Log10 (Power Ratio)
db = 20 Log10 (Volts or Amps #1 / Volts or Amps #2)
db = 20 Log10 (Voltage or Current Ratio)
Power Ratio = $10^{(db/10)}$
Voltage or Current Ratio = $10^{(db/20)}$

If impedances are not equal:

$$db = 20 \log_{10} \left[(\text{Volt1}\sqrt{Z_2}) / (\text{Volt2}\sqrt{Z_1}) \right]$$

(16) Capacitors in Parallel (values in any farad):

$$\text{Total Capacitance} = \text{Capacitance}_1 + \text{Capacitance}_2 + \ldots \text{Capacitance}_n$$

(17) Two Capacitors in Serial (values in any farad):

$$\text{Total Capacitance} = \frac{\text{Capacitance}_1 \times \text{Capacitance}_2}{\text{Capacitance}_1 + \text{Capacitance}_2}$$

(18) Multiple Capacitors in Series (values in farads):

$$\text{Total Capacitance} = \frac{1}{1/\text{Capacitance}_1 + 1/\text{Capacitance}_2 + \ldots\ldots 1/\text{Capacitance}_n}$$

(19) Quantity of Electricity in a Capacitor: – Q

Q in coulombs = Capacitance in farads x Volts

(20) Capacitance of a Capacitor: – C

Capacitance in picofarads =

$$0.0885 \times \frac{\text{Dielectric constant} \times \text{area in cm}^2 \times (\text{\# of plates} - 1)}{\text{thickness of dielectric in cm}}$$

(21) Self Inductance:

Use the same formulas as those for Resistance, substituting inductance for resistance. When including the effects of coupling, add 2 x mutual inductance if fields are adding and subtract 2 x mutual inductance if the fields are opposing. e.g.

Series: $Lt = L1 + L2 + 2M$ or $Lt = L1 + L2 - 2M$

Parallel: $Lt = 1 / \left[(1/L1 + M) + (1/L2 + M) \right]$

(22) Frequency and Wavelength: f and λ

Frequency in kilohertz = (3×10^5) / wavelength in cm
Frequency in megahertz = (3×10^4) / wavelength in cm
Frequency in megahertz = (984) / wavelength in feet
Wavelength in cm = (3×10^4) / frequency in megahertz
Wavelength in meters = (3×10^5) / frequency in kilohertz
Wavelength in feet = (984) / frequency in megahertz

(23) Length of an Antenna:

Quarter–wave antenna:

Length in feet = 234 / frequency in megahertz

Half–wave antenna:

Length in feet = 468 / frequency in megahertz

(24) LCR Series Time Circuits:

Time in seconds =
Inductance in henrys / Resistance in ohms

Time in seconds =
Capacitance in microfarads x Resistance in ohms

(25) 70 Volt Loud Speaker Matching Transformer:

Transformer Primary Impedance =
(Amplifier output volts)^2 / Speaker Power

(26) Time Duration of One Cycle:

10 megahertz = 100 nanoseconds cycle
4 megahertz = 250 nanoseconds cycle
1 megahertz = 1 microsecond cycle
250 kilohertz = 4 microsecond cycle
100 kilohertz = 10 microsecond cycle

POCKET REF

General Information

(See also GENERAL SCIENCE on page 177)

HOLIDAYS

Holiday	Date (listed in chronological order)
New Years Day	January 1
Epiphany	Sunday on or before January 6
Martin Luther King Day	3rd Monday January or January 15
Robert E. Lee Day	January 18
National Freedom Day	February 1
Groundhog Day	February 2
Lincoln's Birthday	February 12
Presidents Day	3rd Monday February
Valentine's Day	February 14
Susan B. Anthony Day	February 15
Ash Wednesday	47 days before Easter
St Patrick's Day	March 17
St. Joseph's Day	March 19
Juarez' Birthday	March 21 (Mexico)
Palm Sunday	Sunday before Easter
Maundy Thursday	Thursday before Easter
Good Friday	Friday before Easter
Easter	1st Sunday after 1st full moon after the Spring equinox.
Pan American Day	April 14
Secretaries Day	4th Wednesday in April
Arbor Day	Last Friday in April
Loyalty Day	May 1
Cinco de Mayo	May 5 (Mexico)
Ascension	40 days after Easter
Pentecost	50 days after Easter
Mother's Day	2nd Sunday in May
Armed Forces Day	3rd Saturday in May
National Maritime Day	May 22
Victoria Day	1st Monday before May 25
Memorial Day	Last Monday in May
Flag Day	June14
Father's Day	3rd Sunday in June
Independence Day(US)	July 4
Assumption Day	August 15
Labor Day	1st Monday in September
Grandparent's Day	1st Sunday after Labor Day
Citizenship Day	September 17
Child Health Day	1st Monday in October
Columbus Day	2nd Monday in October
World Poetry Day	October 15
Boss Day	October 16
United Nations Day	October 24
Mother-in-Law's Day	4th Sunday in October
Halloween	October 31

HOLIDAYS

Holiday	Date (listed in chronological order)
Reformation Day	October 31 (Protestant)
All Saints' Day	November 1
Election Day	1st Tuesday in November
Veterans' Day	November 11
Sadie Hawkins Day	1st Saturday after November 11
Thanksgiving Day	4th Thursday in November
Immaculate Conception	December 8
Bill of Rights Day	December 15
Wright Brothers Day	December 17
Christmas Eve	December 24 (in some states)
Christmas Day	December 25
National Day of Prayer	Set by president, any day but Sunday

Most Jewish holidays are not included because they are difficult to calculate (not on the same date) and require the Jewish calendar.

STATE SPECIFIC HOLIDAYS

Three Kings Day, Puerto Rico	January 6
Confederate Heroes Day, in the South	January 19
Kentucky, F. D. Roosevelt's Bday	January 30
Texas Independence Day	March 2
Alabama, Thomas Jefferson Bday	March 12
Louisiana & Alabama, Mardi Gras	Tuesday before Ash Wed.
Alaska, Seward's Day	March 28
Alabama, Confederate Memorial Day	April 1
San Jacinto Day, Texas	April 21
Arbor Day, Nebraska	April 22
Mississippi, Confederate Memorial Day	April 24
Maine & Massachusetts, Patriots Day	3rd Monday in April
Missouri, Harry S. Truman's Bday	May 8
Mississippi, Jefferson Davis' Bday	May 29
Alabama, Jefferson Davis' Bday	1st Monday in June
Kentucky, Jefferson Davis' Bday	June 3
Kentucky, Confederate Memorial Day	June 3
Hawaii, King Kamehameha I Day	June 11
Texas, Emancipation Day	June 19
West Virginia Day	June 20
Vermont, Bennington Battle Day	June 16
Utah, Pioneer Day	July 24
Puerto Rico Constitution Day	July 25
Colorado, Colorado Day	August 1
Victory Day, Rhode Island	August 14
Defender's Day, Maryland	September 12
Alaska, Alaska Day	October 18
Nevada, Nevada Day	October 30
New York, Verrazano Day	April 7

SEASON & CLOCK DATES

Season	Date
Spring Equinox (Spring begins & day and night are equal lengths)	March 20
Daylight Savings Time, Start, move 1 hour ahead, 2 a.m. on the first Sunday in April	
Summer Solstice (Summer begins & sun is furtherest north of the equator ..	June 20
Autumn Equinox (Fall begins & day and night are equal lengths)	September 22
Daylight Savings Time, End, move 1 hour back, 2 a.m. on the last Sunday in October	
Winter Solstice (Winter begins & the sun is furtherest south of the equator ..	December 21

SIGNS OF THE ZODIAC

Name	Symbol	Dates
Aries	Ram	March 21–April 19
Taurus	Bull	April 20–May 20
Gemini	Twins	May 21–June 20
Cancer	Crab	June 21–July 22
Leo	Lion	July 23–Aug 22
Virgo	Virgin	Aug 23–Sept 22
Libra	Balance	Sept 23–Oct 22
Scorpio	Scorpion	Oct 23–Nov 21
Sagittarius	Archer	Nov 22–Dec 21
Capricorn	Goat	Dec 22–Jan 19
Aquarius	Water Bearer	Jan 20–Feb 18
Pisces	Fish	Feb 19–March 20

FLOWERS FOR EACH MONTH

Month	Flower
January	Carnation
February	Violet
March	Jonquil
April	Sweet Pea
May	Lily of the Valley
June	Rose
July	Larkspur
August	Gladiola
September	Aster
October	Calendula
November	Chrysanthemum
December	Narcissus

BIRTHSTONES

Month	Stone	Significance
January	Garnet	Constancy
February	Amethyst	Sincerity
March	Jasper, bloodstone, aquamarine	Wisdom
April	Diamond	Innocence
May	Emerald, chrysoprase	Love
June	Pearl, moonstone, alexandrite	Wealth
July	Ruby, carnelian	Freedom
August	Sardonyx, peridot	Friendship
September	Sapphire, lapis lazuli	Truth
October	Opal, tourmaline	Hope
November	Topaz	Loyalty
December	Turquoise, zircon, Lapis Lazuli	Success

ANNIVERSARY NAMES

Anniversary Year	Traditional	Modern
1	paper	clocks
2	cotton, straw, calico	china
3	leather	crystal or glass
4	flowers, fruit, books	appliances
5	wood	silverware
6	iron or sugar (sweets)	wood
7	copper, wool, brass	desk sets
8	bronze, rubber	linens & laces
9	pottery,	leather
10	tin or aluminum	diamond jewelry
11	steel	fashion jewelry
12	silk or fine linen	pearls
13	lace	textiles or furs
14	ivory or agate	gold jewelry
15	crystal, glass	watches
20	china	platinum
25	silver	silver
30	pearl	diamond
35	coral	jade
40	ruby or garnet	ruby
45	sapphire	sapphire
50	gold	gold
55	emerald, turquoise	emerald
60	diamond	diamond
75	diamond	diamond

ENGLISH – GREEK ALPHABET

English	Greek	Greek Name
A, a	Α, α	alpha
B, b	Β, β	beta
G, g	Γ, γ	gamma
D, d	Δ, δ	delta
E, e	Ε, ε	epsilon
Z, z	Ζ, ζ	zeta
E, e	Η, η	eta
Th, th	Θ, θ	theta
I, i	Ι, ι	iota
K, k	Κ, κ	kappa
L, l	Λ, λ	lambda
M, m	Μ, μ	mu
N, n	Ν, ν	nu
X, x	Ξ, ξ	xi
O, o	Ο, o	omicron
P, p	Π, π	pi
R, r	Ρ, ρ	rho
S, s	Σ, σ	sigma
T, t	Τ, τ	tau
U, u	Υ, υ	upsilon
Ph, ph	Φ, ϕ	phi
Ch, ch	Χ, χ	chi
Ps, ps	Ψ, ψ	psi
O, o	Ω, ω	omega

RADIO ALPHABET

Letter	Word	Pronunciation
A	Alfa	Al Fah
B	Bravo	Bra Voh
C	Charlie	Char Lee
D	Delta	Del Tah
E	Echo	Ek Oh
F	Foxtrot	Foks Trot
G	Golf	Golf
H	Hotel	Ho Tell
I	India	In Dee Ah
J	Juliett	Jew Lee Ett
K	Kilo	Key Loh
L	Lima	Lee Mah
M	Mike	Mike
N	November	No Vem Ber
O	Oscar	Oss Cahr
P	Papa	Pah Pah
Q	Quebec	Ke Beck
R	Romeo	Row Me Oh
S	Sierra	See Air Rah
T	Tango	Tang Go
U	Uniform	You Nee Form
V	Victor	Vick Ter
W	Whiskey	Wiss Key
X	X-Ray	Ecks Ray
Y	Yankee	Yang Key
Z	Zulu	Zoo Loo

MORSE CODE

Letter	Code	Letter	Code	Letter	Code
A	• –	Q	– – • –	1	• – – – –
B	– • • •	R	• – •	2	• • – – –
C	– • – •	S	• • •	3	• • • – –
D	– • •	T	–	4	• • • • –
E	•	U	• • –	5	• • • • •
F	• • – •	V	• • • –	6	– • • • •
G	– – •	W	• – –	7	– – • • •
H	• • • •	X	– • • –	8	– – – • •
I	• •	Y	– • – –	9	– – – – •
J	• – – –	Z	– – • •	0	– – – – –
K	– • –	Error	• • • • • • • •	.	• – • – • –
L	• – • •	Wait	• – • • •	,	– – • • – –
M	– –	End Msg	• – • – •	:	– – – • •
N	– •	End Wrk	• • • – • –	–	– • • • –
O	– – –	Inv Xmit	– • –	(	– • – – • –
P	• – – •	/	– • • – •	?	• • – – • •

"TEN" RADIO CODES

10–1	Receiving poorly, bad signal
10–2	Receiving OK, signal strong
10–3	Stop transmitting
10–4	Message received
10–5	Relay message
10–6	Busy, please stand by
10–7	Out of service
10–8	In service
10–9	Repeat message
10–10	Finished, standing by
10–11	Talk slower
10–12	Visitors present
10–13	Need weather or road conditions
10–16	Pickup needed at ________
10–17	Urgent Business
10–18	Is there anything for us
10–19	Nothing for you, return to base
10–20	My location is ________
10–21	Use a telephone
10–22	Report in person to ________
10–23	Stand by
10–24	Finished last assignment
10–25	Can you contact ________?
10–26	Disregard last information
10–27	I'm changing to channel ________
10–28	Identify your station
10–29	Your time is up for contact
10–30	Does not conform to FCC rules
10–32	I'll give you a radio check
10–33	Emergency traffic at this station
10–34	Help needed at this station
10–35	Confidential information
10–36	The correct time is ________
10-37	Wrecker needed at ________
10-38	Ambulance needed at ________
10-39	Your message has been delivered
10-41	Please change to channel ________
10-42	Traffic accident at ________
10-43	Traffic congestion at ________
10-44	I have a message for ________
10-45	All units within range please report in
10-50	Break channel
10-60	What is the next message number
10-62	Unable to copy, please call on the phone
10-63	Net directed to ________
10-64	Net clear
10-65	Standing by, awaiting your next message
10-67	All units comply
10-70	Fire at ________
10-71	Proceed with transmission in sequence
10-73	Speed trap at ________
10-75	Your transmission is causing interference
10-77	Negative contact
10-81	Reserve hotel room for ________
10-82	Reserve room for ________
10-84	My telephone number is ________
10-85	My address is ________
10-89	Radio repairman is needed at ________
10-90	I have TVI
10-91	Talk closer to the microphone
10-92	Your transmitter needs adjustment
10-93	Check my frequency on this channel
10-94	Please give me a long count
10-95	Transmit dead carrier for 5 seconds
10-99	Mission completed, all units secure
10-200	Police needed at ________

PAPER SIZES

Paper Size	Standard	Millimeters	Inches
Eight Crown	IMP	1461 x 1060	57-1/2 x 41-3/4
Antiquarian	IMP	1346 x 533	53 x 21
Quad Demy	IMP	1118 x 826	44 x 32-1/2
Double Princess	IMP	1118 x 711	44 x 28
Quad Crown	IMP	1016 x 762	40 x 30
Double Elephant	IMP	1016 x 686	40 x 27
B0	ISO	1000 x 1414	39.37 x 55.67
Arch-E	USA	914 x 1219	36 x 48
Double Demy	IMP	889 x 572	35 x 22-1/2
E	ANSI	864 x 1118	34 x 44
A0	ISO	841 x 1189	33.11 x 46.81
Imperial	IMP	762 x 559	30 x 22
Princess	IMP	711 x 546	28 x 21-1/2
B1	ISO	707 x 1000	27.83 x 39.37
Arch-D	USA	610 x 914	24 x 36
A1	ISO	594 x 841	23.39 x 33.11
Demy	IMP	584 x 470	23 x 18-1/2
D	ANSI	559 x 864	22 x 34
B2	ISO	500 x 707	19.68 x 27.83
Arch-C	USA	457 x 610	18 x 24
C	ANSI	432 x 559	17 x 22
A2	ISO	420 x 594	16.54 x 23.39
B3	ISO	353 x 500	13.90 x 19.68
Brief	IMP	333 x 470	13-1/8 x 18-1/2
Foolscap folio	IMP	333 x 210	13-1/8 x 8-1/4
Arch-B	USA	305 x 457	12 x 18
A3	ISO	297 x 420	11.69 x 16.54
B	ANSI	279 x 432	11 x 17
Demy quarto	IMP	273 x 216	10-3/4 x 8-1/2
B4	ISO	250 x 353	9.84 x 13.90
Crown quarto	IMP	241 x 184	9-1/2 x 7-1/4
Royal octavo	IMP	241 x 152	9-1/2 x 6
Arch-A	USA	229 x 305	9 x 12
Demy octavo	IMP	222 x 137	8-3/4 X 5-3/8
A	ANSI	216 x 279	8.5 x 11
A4	ISO	210 x 297	8.27 x 11.69
Foolscap quarto	IMP	206 x 165	8-1/8 x 6-1/2
Crown Octavo	IMP	181 x 121	7-1/8 x 4-3/4
B5	ISO	176 x 250	6.93 x 9.84
A5	ISO	148 x 210	5.83 x 8.27
	USA	140 x 216	5.5 x 8.5
	USA	127 x 178	5 x 7
A6	ISO	105 x 148	4.13 x 5.83
	USA	102 x 127	4 x 5
	USA	76 x 102	3 x 5
A7	ISO	74 x 105	2.91 x 4.13
A8	ISO	52 x 74	2.05 x 2.91
A9	ISO	37 x 52	1.46 x 2.05
A10	ISO	26 x 37	1.02 x 1.46

Abbreviations for the above table are:

ISO	International Standards Organization
ANSI	American National Standards Institute
USA	United States
IMP	Imperial paper and plan sizes
Arch	United States architectural standards

MILITARY RANK & GRADE

Grade	Air Force	Navy & Coast Guard
E1	Airman	Seaman Recruit
E2	Airman 3rd Class	Seaman Apprentice
E3	Airman 2nd Class	Seaman
E4	Airman 1st Class	Petty Officer 3rd Class
E5	Staff Sergeant	Petty Off 2nd Class
E6	Technical Sergeant	Petty Off 1st Class
E7	Master Sergeant	Chief Petty Officer
E8	Senior Master Sergeant	Sr Chief Petty Officer
E9	Chief Master Sergeant	Mst Chief Petty Officer
W1	Warrant Officer	Warrant Officer
W234	Chief Warrant Officers	Chief Warrant Officers
O1	2nd Lieutenant	Ensign
O2	1st Lieutenant	Lieutenant Jr Grade
O3	Captain	Lieutenant
O4	Major	Lieutenant Commander
O5	Lieutenant Colonel	Commander
O6	Colonel	Captain
O7	Brigadier General *	Commodore *
O8l	Major General **	Rear Admiral **
O8	Lieutenant General ***	Vice Admiral ***
O8	General ****	Admiral ****
O8	General of the Air Force 5*	Fleet Admiral 5*

Grade	Army	Marines
E1	Private	Private
E2	Private	Private 1st Class
E3	Private 1st Class	Lance Corporal
E4	Corporal Specialist 4	Corporal
E5	Sergeant Specialist 5	Sergeant
E6	Staff Sergeant Specialist 6	Staff Sergeant
E7	Sergeant 1st Class Specialist 7	Gunnery Sergeant
E8	1st/Mst Sergeant Specialist 8	1st/Master Sergeant
E9	Sergeant Major Specialist 9	Sgt Major/ Mgy Sergeant
W1	Warrant Officer	Warrant Officer
W234	Chief Warrant Officer	Chief Warrant Officer
O1	2nd Lieutenant	2nd Lieutenant
O2	1st Lieutenant	1st Lieutenant
O3	Captain	Captain
O4	Major	Major
O5	Lieutenant Colonel	Lieutenant Colonel
O6	Colonel	Colonel
O7	Brigadier General *	Brigadier General *
O8l	Major General **	Major General **
O8	Lieutenant General ***	Lieutenant General ***
O8	General ****	General ****
O8	Gen of Army 5*	--

STATE INFORMATION

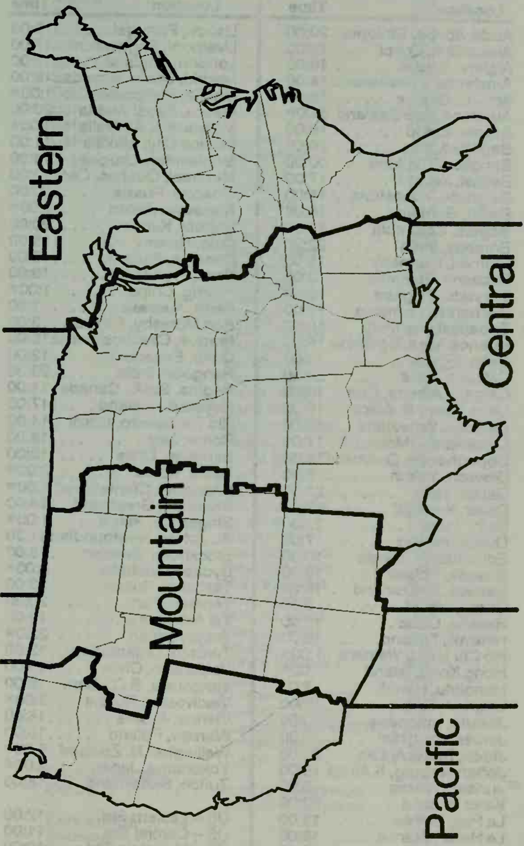
State	Abbreviation	Population (1980)	Capital
United States	USA	226,549,000	Washington, DC
Alabama	AL	3,894,000	Montgomery
Alaska	AK	402,000	Juneau
Arizona	AZ	2,719,000	Phoenix
Arkansas	AR	2,287,000	Little Rock
California	CA	23,668,000	Sacramento
Colorado	CO	2,890,000	Denver
Connecticut	CT	3,108,000	Hartford
Delaware	DE	595,000	Dover
Florida	FL	9,747,000	Tallahassee
Georgia	GA	5,463,000	Atlanta
Hawaii	HI	965,000	Honolulu
Idaho	ID	944,000	Boise
Illinois	IL	11,428,000	Springfield
Indiana	IN	5,491,000	Indianapolis
Iowa	IA	2,914,000	Des Moines
Kansas	KS	2,365,000	Topeka
Kentucky	KY	3,661,000	Frankfort
Louisiana	LA	4,206,000	Baton Rouge
Maine	ME	1,125,000	Augusta
Maryland	MD	4,217,000	Annapolis
Massachusetts	MA	5,737,000	Boston
Michigan	MI	9,262,000	Lansing
Minnesota	MN	4,076,000	St. Paul
Mississippi	MS	2,521,000	Jackson
Missouri	MO	4,917,000	Jefferson City
Montana	MT	787,000	Helena
Nebraska	NE	1,570,000	Lincoln
Nevada	NV	801,000	Carson City
New Hampshire	NH	921,000	Concord
New Jersey	NJ	7,365,000	Trenton
New Mexico	NM	1,304,000	Santa Fe
New York	NY	17,558,000	Albany
North Carolina	NC	5,882,000	Raleigh
North Dakota	ND	653,000	Bismarck
Ohio	OH	10,798,000	Columbus
Oklahoma	OK	3,026,000	Oklahoma City
Oregon	OR	2,633,000	Salem
Pennsylvania	PA	11,865,000	Harrisburg
Rhode Island	RI	947,000	Providence
South Carolina	SC	3,123,000	Columbia
South Dakota	SD	691,000	Pierre
Tennessee	TN	4,591,000	Nashville
Texas	TX	14,228,000	Austin
Utah	UT	1,461,000	Salt Lake City
Vermont	VT	512,000	Montpelier
Virginia	VA	5,347,000	Richmond
Washington	WA	4,133,000	Olympia
West Virginia	WV	1,951,000	Charleston
Wisconsin	WI	4,706,000	Madison
Wyoming	WY	470,000	Cheyenne

CLIMATE DATA IN U.S. CITIES

State, City	Temperature (°F) Winter	Summer	Avg Precipitation (in.) Rain	Snow
AL, Mobile	52.5	81.5	64.6	0.1
AK, Juneau	25.5	54.3	53.1	102.3
AZ, Phoenix	53.9	89.6	7.1	trace
AR, Little Rock	42.4	80.5	49.2	5.6
CA, Los Angeles	52.1	68.3	12.1	trace
CO, Denver	31.9	70.6	15.3	59.9
CT, Hartford	27.3	71.1	44.4	49.4
DC, Washington	37.2	77.0	39.0	16.7
DE, Wilmington	33.3	74.0	41.4	20.9
FL, Miami	67.8	82.0	57.5	0
GA, Atlanta	43.8	77.5	48.6	2.0
HI, Honolulu	73.2	80.0	23.5	0
ID, Boise	32.7	70.8	11.7	21.8
IL, Chicago	25.0	71.2	33.3	40.1
IN, Indianapolis	29.1	73.4	39.1	23.3
IA, Des Moines	22.9	73.9	30.8	35.0
KS, Wichita	33.0	79.0	28.6	16.3
KY, Louisville	35.2	75.9	43.6	17.3
LA, New Orleans	53.9	81.3	59.7	0.2
ME, Portland	23.4	65.6	43.5	72.0
MD, Baltimore	34.6	74.8	41.8	21.6
MA, Boston	31.3	71.1	43.8	41.6
MI, Detroit	25.9	70.0	31.0	41.3
MN, Minneapolis-St.Paul	16.0	70.6	26.4	49.9
MS, Jackson	47.8	80.7	52.8	1.1
MO, St. Louis	32.3	76.9	33.9	19.7
MT, Great Falls	23.7	66.2	15.2	59.1
NE, Omaha	24.9	75.3	30.3	31.1
NV, Reno	34.0	66.2	7.5	25.3
NH, Concord	22.2	67.1	36.5	64.4
NJ, Atlantic City	33.6	72.2	41.9	16.4
NM, Albuquerque	36.6	76.4	8.1	10.6
NY, New York	33.8	74.5	44.1	28.8
NC, Raleigh	41.1	76.2	41.8	7.5
ND, Bismarck	12.2	67.8	15.4	40.7
OH, Cleveland	28.0	69.8	35.4	54.0
OK, Oklahoma City	38.9	80.0	30.9	9.0
OR, Portland	41.0	63.8	37.4	7.0
PA, Pittsburgh	29.0	70.2	36.3	44.7
RI, Providence	29.9	70.1	45.3	36.6
SC, Columbia	46.2	79.6	49.1	1.9
SD, Sioux Falls	17.1	71.4	24.1	40.3
TN, Nashville	39.5	77.8	48.5	11.3
TX, Houston	53.3	82.1	44.8	0.4
UT, Salt Lake City	31.0	73.5	15.3	59.4
VT, Burlington	19.1	67.3	33.7	78.3
VA, Richmond	38.5	76.0	44.1	14.5
WA, Seattle	41.0	63.0	38.6	12.9
WV, Charleston	35.1	73.0	42.4	32.2
WI, Milwaukee	22.3	68.2	30.9	47.3
WY, Cheyenne	28.2	65.9	13.3	54.4

Temperature is average daily temperature (°F) in Dec, Jan, & Feb (Winter) and June, July, & Aug (Summer).
Rain is average annual rain plus snow, etc water equivalent.
Snow is the average depth of unmelted snow.
Data from U.S. NOAA, Climatography of the United States

TIME ZONES IN THE U.S.



TIME ZONES IN THE WORLD

The following times are based on a starting point of 12:00 Noon, Eastern Standard Time in the United States. "★" means Next Day

Location	Time
Addis Ababa, Ethiopia	20:00
Alexandria, Egypt	19:00
Algiers, Algeria	18:00
Amsterdam, Netherland	18:00
Athens, Greece	19:00
Auckland,New Zealand	5:00★
Azores, Island	16:00
Baghdad, Iraq	20:00
Bangkok, Thailand	00:00
Belfast, Ireland	17:00
Belgrade, Yugoslavia	18:00
Berlin, Germany	18:00
Bogota, Columbia	12:00
Bombay, India	22:30
Bremen, Germany	18:00
Brisbane, Australia	3:00
Brussels, Belgium	18:00
Bucharest, Rumania	19:00
Budapest, Hungary	18:00
Buenos Aires,Argentina	14:00
Cairo, Egypt	19:00
Calcutta, India	22:30
Calgary, Alberta, Can.	10:00
Cape Town, S. Africa	19:00
Caracas, Venezuela	13:00
Casablanca, Morocco	17:00
Copenhagen, Denmark	18:00
Dawson, Yukon	9:00
Dacca, India	23:00
Dakar, Senegal	17:00
Delhi, India	22:30
Dublin, Ireland	17:00
Edmonton, Canada	10:00
Gdansk, Poland	18:00
Geneva, Switzerland	18:00
Guam, Island	3:00
Havana, Cuba	12:00
Helsinki, Finland	19:00
Ho Chi Minh, Vietnam	1:00★
Hong Kong, Island	1:00★
Honolulu, Hawaii	7:00
Istanbul, Turkey	19:00
Jakarta, Indonesia	00:00
Jerusalem, Israel	19:00
Jidda, Saudi Arabia	20:00
Johannesburg, S.Africa	19:00
Juneau, Alaska	8:00
Karachi, India	22:00
La Paz, Bolivia	13:00
Le Havre, France	18:00
Leningrad, Russia	20:00
Lima, Peru	12:00
Lisbon, Portugal	18:00
Liverpool, England	17:00
London, England	17:00
Madrid, Spain	19:00
Manila, Philippines	1:00★
Mecca, Saudi Arabia	20:00
Melbourne, Australia	3:00★
Mexico City, Mexico	11:00
Montevideo, Uruguay	14:00
Montreal, Quebec, Can.	12:00
Moscow, Russia	20:00
Nagasaki, Japan	2:00★
Nairobi, Kenya	20:00
Oslo, Norway	18:00
Panama, Panama	12:00
Paris, France	18:00
Peking, China	1:00★
Perth, Australia	1:00
Port Moresby, Papua	3:00
Prague, Czechoslovakia	18:00
Quito, Ecuador	12:00
Rangoon, India	23:30
Regina, Sask., Canada	11:00
Reykjavik, Iceland	17:00
Rio De Janeiro, Brazil	14:00
Rome, Italy	18:00
Santiago, Chile	13:00
Seoul, Korea	2:00★
Shanghai, China	1:00★
Shannon, Greenland	14:00
Singapore, Island	1:00★
St. Johns, Newfoundland	1:30
Stockholm, Sweden	18:00
Sydney, Australia	3:00★
Tashkent, Russia	23:00
Teheran, Iran	20:30
Tel Aviv, Israel	19:00
Tokyo, Japan	2:00★
Toronto, Ontario, Can.	12:00
Valparaiso, Chile	13:00
Vancouver, B.C., Can.	9:00
Vladivostok, Russia	3:00★
Vienna, Austria	18:00
Warsaw, Poland	18:00
Wellington,N. Zealand	5:00★
Yokohama, Japan	2:00★
Zurich, Switzerland	18:00
US – Eastern Std	12:00
US – Central Std	11:00
US – Mountain Std	10:00
US – Pacific Std	9:00

TELEPHONE AREA CODES by STATE

State	City	Code
Alabama		205
Alaska		907
Anguilla		809
Antigua		809
Arizona		602
Arkansas		501
Bahamas		809
Barbados		809
Bequia		809
Bermuda		809
California	Anaheim	714
	Bakersfield	805
	Barstow	619
	Bishop	619
	El Centro	619
	Eureka	707
	Fresno	209
	Los Angeles	213
	Modesto	209
	Monterey	408
	Oakland	415
	Orange	714
	Palm Springs	619
	Pasadena	818
	Redding	916
	Riverside	714
	Sacramento	916
	San Diego	619
	San Francisco	415
	San Jose	408
	Santa Barbara	805
	Santa Rosa	707
Canada	Alberta	403
	Brit Columbia	604
	London	519
	Manitoba	204
	New Brunswick	506
	Newfoundland	709
	NW Territories	403
	Nova Scotia	902
	Ontario, West	807
	Ontario, East	705
	Ottawa	613
	Prince Edward I	902
	Toronto	416
	Quebec, Montreal	514
	Quebec, Quebec	418
	Quebec, Sherbrooke	819
	Saskatchewan	306
	Yukon	403
Cayman Islands		809
Colorado	Northern Colorado	303
	Southern Colorado	719
Connecticut		203
Delaware		302
District of Columbia	Washington	202
Dominica		809

TELEPHONE AREA CODES by STATE

State	City	Code
Dominican Republic		809
Florida	Ft. Lauderdale	305
	Ft. Myers	813
	Jacksonville	904
	Miami	305
	Pensacola	904
	Tallahassee	904
Georgia	Atlanta	404
	Savannah	912
Hawaii		808
Idaho		208
Illinois	Centralia	618
	Champaign	217
	Chicago	312
	Peoria	309
	Rockford	815
	Springfield	217
	Waukegan	312
Indiana	Evansville	812
	Indianapolis	317
	South Bend	219
Iowa	Council Bluffs	712
	Dubuque	319
	Des Moines	515
Jamaica		809
Kansas	Dodge City	316
	Topeka	913
	Wichita	316
Kentucky	Covington	606
	Frankfort	502
	Louisville	502
Louisiana	Baton Rouge	504
	Lake Charles	318
	New Orleans	504
	Shreveport	318
Maine		207
Maryland		301
Massachusetts	West state	413
	Boston	617
Mexico	Northwest Mexico	706
	Mexico City	905
Michigan	Ann Arbor	313
	Battle Creek	616
	Detroit	313
	Escanaba	906
	Flint	313
	Grand Rapids	616
	Lansing	517
Minnesota	Duluth	218
	Minneapolis	612
	Rochester	507
	St. Paul	612
Mississippi		601
Missouri	Jefferson City	314
	Kansas City	816
	Springfield	417
	St. Louis	314

TELEPHONE AREA CODES by STATE

State	City	Code
Montana		406
Montserrat		809
Mustique		809
Nebraska	Lincoln	402
	North Platte	308
	Omaha	402
Nevada		702
Nevis		809
New Hampshire		603
New Jersey	Newark	201
	Trenton	609
New Mexico		505
New York	Albany	518
	Binghamton	607
	Bronx	212
	Brooklyn	718
	Buffalo	716
	Elmira	607
	Hempstead	516
	Long Island	516
	Manhattan	212
	New York City	212
	Niagra Falls	716
	Queens	718
	Rochester	716
	Stanton Island	718
	Syracuse	315
	White Plains	914
	Yonkers	914
North Carolina	Charlotte	704
	Raleigh	919
North Dakota		701
Ohio	Cincinnati	513
	Cleveland	216
	Columbus	614
	Toledo	419
Oklahoma	Oklahoma City	405
	Tulsa	918
Oregon		503
Palm Island		809
Pennsylvania	Altoona	814
	Harrisburg	717
	Philadelphia	215
	Pittsburgh	412
Puerto Rico		809
Rhode Island		401
South Carolina		803
South Dakota		606
Sts. Kitts & Lucia		809
St. Vincent		809
Tennessee	Memphis	901
	Nashville	615
Texas	Abilene	915
	Amarillo	806
	Austin	512
	Corpus Christi	512
	Dallas	214

TELEPHONE AREA CODES by STATE

State	City	Code
Texas	El Paso	915
	Fort Worth	817
	Galveston	409
	Houston	713
	Lubbock	806
	San Antonio	512
	Sweetwater	915
	Waco	817
Trinidad		809
Tobago		809
Union Island		809
Utah		801
Vermont		802
Virgin Islands		809
Virginia	Arlington	703
	Norfolk	804
	Richmond	804
Washington	Olympia	206
	Seattle	206
	Spokane	509
West Virginia		304
Wisconsin	Eau Claire	715
	Green Bay	414
	Madison	608
	Milwaukee	414
Wyoming		307

TELEPHONE AREA CODES by CODE

State	City	Code
New Jersey	Newark	201
District of Columbia	Washington	202
Connecticut		203
Canada	Manitoba	204
Alabama		205
Washington	Olympia	206
Washington	Seattle	206
Maine		207
Idaho		208
California	Fresno	209
California	Modesto	209
New York	Bronx	212
New York	Manhattan	212
New York	New York City	212
California	Los Angeles	213
Texas	Dallas	214
Pennsylvania	Philadelphia	215
Ohio	Cleveland	216
Illinois	Champaign	217
Illinois	Springfield	217
Minnesota	Duluth	218
Indiana	South Bend	219
Maryland		301
Delaware		302
Colorado	Northern Colorado	303
West Virginia		304

TELEPHONE AREA CODES by CODE

State	City	Code
Florida	Fort Lauderdale	305
Florida	Miami	305
Canada	Saskatchewan	306
Wyoming		307
Nebraska	North Platte	308
Illinois	Peoria	309
Illinois	Chicago	312
Illinois	Waukegan	312
Michigan	Ann Arbor	313
Michigan	Detroit	313
Michigan	Flint	313
Missouri	Jefferson City	314
Missouri	St. Louis	314
New York	Syracuse	315
Kansas	Dodge City	316
Kansas	Wichita	316
Indiana	Indianapolis	317
Louisiana	Lake Charles	318
Louisiana	Shreveport	318
Iowa	Dubuque	319
Rhode Island		401
Nebraska	Lincoln	402
Nebraska	Omaha	402
Canada	Alberta	403
Canada	Northwest Territories	403
Canada	Yukon	403
Georgia	Atlanta	404
Oklahoma	Oklahoma City	405
Montana		406
California	Monterey	408
California	San Jose	408
Texas	Galveston	409
Pennsylvania	Pittsburgh	412
Massachusetts	West state	413
Wisconsin	Green Bay	414
Wisconsin	Milwaukee	414
California	Oakland	415
California	San Francisco	415
Canada	Toronto	416
Missouri	Springfield	417
Canada	Quebec, Quebec	418
Ohio	Toledo	419
Arkansas		501
Kentucky	Frankfort	502
Kentucky	Louisville	502
Oregon		503
Louisiana	Baton Rouge	504
Louisiana	New Orleans	504
New Mexico		505
Canada	New Brunswick	506
Minnesota	Rochester	507
Washington	Spokane	509
Texas	Austin	512
Texas	Corpus Christi	512
Texas	San Antonio	512
Ohio	Cincinnati	513
Canada	Quebec, Montreal	514

TELEPHONE AREA CODES by CODE

State	City	Code
Iowa	Des Moines	515
New York	Hempstead	516
New York	Long Island	516
Michigan	Lansing	517
New York	Albany	518
Canada	London	519
Mississippi		601
Arizona		602
New Hampshire		603
Canada	Brit Columbia	604
South Dakota		605
Kentucky	Covington	606
New York	Binghamton	607
New York	Elmira	607
Wisconsin	Madison	608
New Jersey	Trenton	609
Minnesota	Minneapolis	612
Minnesota	St. Paul	612
Canada	Ottawa	613
Ohio	Columbus	614
Tennessee	Nashville	615
Michigan	Battle Creek	616
Michigan	Grand Rapids	616
Massachusetts	Boston	617
Illinois	Centralia	618
California	Barstow	619
California	Bishop	619
California	El Centro	619
California	Palm Springs	619
California	San Diego	619
North Dakota		701
Nevada		702
Virginia	Arlington	703
North Carolina	Charlotte	704
Canada	Ontario, East	705
Mexico	Northwest Mexico	706
California	Eureka	707
California	Santa Rosa	707
Canada	Newfoundland	709
Iowa	Council Bluffs	712
Texas	Houston	713
California	Anaheim	714
California	Orange	714
California	Riverside	714
Wisconsin	Eau Claire	715
New York	Buffalo	716
New York	Niagra Falls	716
New York	Rochester	716
Pennsylvania	Harrisburg	717
New York	Brooklyn	718
New York	Queens	718
New York	Staten Island	718
Colorado	Southern Colorado	719
Utah		801
Vermont		802
South Carolina		803
Virginia	Norfolk	804

TELEPHONE AREA CODES by CODE

State	City	Code
Virginia	Richmond	804
California	Bakersfield	805
California	Santa Barbara	805
Texas	Amarillo	806
Texas	Lubbock	806
Canada	Ontario, West	807
Hawaii		808
Anguilla		809
Antigua		809
Bahamas		809
Barbados		809
Bequia		809
Bermuda		809
Cayman Islands		809
Dominica		809
Domin. Republic		809
Jamaica		809
Montserrat		809
Mustique		809
Nevis		809
Palm Island		809
Puerto Rico		809
Sts. Kitts & Lucia		809
St. Vincent		809
Trinidad		809
Tobago		809
Union Island		809
Virgin Islands		809
Indiana	Evansville	812
Florida	Ft. Myers	813
Pennsylvania	Altoona	814
Illinois	Rockford	815
Missouri	Kansas City	816
Texas	Fort Worth	817
Texas	Waco	817
California	Pasadena	818
Canada	Quebec, Sherbrooke	819
Tennessee	Memphis	901
Canada	Nova Scotia	902
Canada	Prince Edward Island	902
Florida	Jacksonville	904
Florida	Pensacola	904
Florida	Tallahassee	904
Mexico	Mexico City	905
Michigan	Escanaba	906
Alaska		907
Georgia	Savannah	912
Kansas	Topeka	913
New York	White Plains	914
New York	Yonkers	914
Texas	Abilene	915
Texas	El Paso	915
Texas	Sweetwater	915
California	Redding	916
California	Sacramento	916
Oklahoma	Tulsa	918
North Carolina	Raleigh	919

MAJOR WORLD AIRPORTS

Airport City	Airport Name	Elevation, Feet
Addis–Ababa, Ethiopia	Haile Selassi II Intl.	7625
Algiers, Algeria	Dar el Beida	82
Amsterdam, Netherlands	Schiphol	– 13
Anchorage, Alaska	Anchorage Intl.	124
Athens, Greece	Athens Central	90
Atlanta, Georgia	Hartsfield Atlanta Intl.	1026
Auckland, New Zealand	Auckland Intl.	23
Azores, Island	Santa Maria	305
Baghdad, Iraq	Baghdad Intl.	113
Bangkok, Thailand	Bangkok	12
Beirut, Lebanon	Beirut Intl.	85
Belgrade, Yugoslavia	Belgrade Intl.	331
Berlin, Germany	Tegel	121
Berlin, Germany	Tempelhof	164
Bermuda, Island	Kindley AFB	11
Bogota, Columbia	El Dorado	8355
Bombay, India	Bombay	27
Boston, Massachusetts	Logan Intl.	20
Brisbane, Australia	Brisbane	7
Bucharest, Rumania	Otopeni	31
Budapest, Hungary	Ferihegy	440
Buenos Aires, Argentina	Ezeiza	66
Cairo, Egypt	Cairo Intl.	366
Calcutta, India	Calcutta	17
Calgary, Canada	Calgary Intl.	3557
Capetown, South Africa	D.F. Malan	151
Caracas, Venezuela	Maiquetia	230
Casablanca, Morocco	Nouasser	656
Chicago, Illinois	O'Hare Intl.	667
Copenhagen, Denmark	Kastrup	17
Dakar, Senegal W. Africa	Yoff	89
Dallas, Texas	Dallas/Ft. Worth	596
Damascus, Syria	Damascus Intl.	2020
Darwin, Australia	Darwin	94
Denver, Colorado	Stapleton Intl.	5330
Dublin, Ireland	Dublin	222
Edmonton, Canada	Edmonton Intl.	2373
Fairbanks, Alaska	Fairbanks Intl.	434
Frankfurt, Germany	Rhein/Main	368
Geneva, Switzerland	Geneva–Cointrin	1411
Guam, Island	Agana	298
Halifax, Canada	Halifax Intl.	477
Hamburg, Germany	Hamburg	53
Hartford, Connecticut	Bradley Intl.	173
Helsinki, Finland	Helsinki Airport	167
Ho Chi Minh City, Viet Nam	Tan Son Nhut	33
Hong Kong, Island	Hong Kong Intl.	15
Honolulu, Hawaii	Honolulu Intl.	13
Houston, Texas	Intercontinental	98
Istanbul, Turkey	Yesilkoy	92
Jakarta, Indonesia	Halim	86
Jidda, Saudi Arabia	Jidda Intl.	157
Johannesburg, South Africa	Jan Smuts	5557
Kansas City, Missouri	Kansas City Intl.	1025
Karachi, India	Karachi	100

MAJOR WORLD AIRPORTS

Airport City	Airport Name	Elevation, Feet
Khartoum, Sudan	Khartoum	1256
Kinshasa, Zaire	Ndjili	1014
La Paz, Bolivia	Kennedy	13354
Lima, Peru	Lima–Callao Intl.	105
Lisbon, Portugal	Lisbon	374
London, England	Heathrow Intl.	80
Los Angeles, California	Los Angeles Intl.	126
Madrid, Spain	Barajas	1998
Manila, Philippines	Manila Intl.	74
Melbourne, Australia	Tullamarine	392
Mexico City, Mexico	Mexico City Intl.	7341
Miami, Florida	Miami Intl.	10
Montreal, Canada	Montreal Intl.	117
Moscow, Russia	Sheremetyevo	623
Moscow, Russia	Vnukovo	669
Nairobi, Kenya	Nairobi	5327
New Delhi, India	Palam	776
New Orleans, Louisiana	Moisant Intl.	4
New York, New York	Kennedy Intl.	12
Osaka, Japan	Osaka Intl.	39
Panama, Panama	Tocumen National	135
Paris, France	Charles B. deGaulle	387
Paris, France	Le Bourget	217
Paris, France	Orly	292
Peking, China	Peking Intl.	15
Perth, Australia	Perth	53
Port Moresby, Papua	Jacksons Aero	125
Quito, Ecuador	Mariscal Sucre	9228
Rangoon, India	Mingaladon	109
Recife, Brazil	Guararepes	36
Reykjavik, Iceland	Keflavik NAS	169
Rio de Janeiro, Brazil	Galeao	16
Rome, Italy	Leonardo da Vinci	7
San Francisco, California	San Francisco Intl.	12
Santiago, Chili	Pudahuel	1554
Seattle, Washington	Seattle–Tacoma Intl.	428
Seoul, Korea	Kimpo Intl.	58
Shanghai, China	Shanghai Intl.	15
Shannon, Greenland	Shannon	47
Singapore, Island in Asia	Singapore	65
Stockholm, Sweden	Arlanda	123
Sydney, Australia	Kingsford–Smith	6
Taipei, Taiwan	Taipei Intl.	21
Teheran, Iran	Mehrabad	3949
Tel Aviv, Israel	Ben Gurion Intl.	135
Tokyo, Japan	Tokyo Intl.	8
Toronto, Canada	Toronto Intl.	569
Tunis, Algeria	Carthage	20
Vancouver, Canada	Vancouver Intl.	8
Wake, Island	Wake Island	14
Warsaw, Poland	Okecie	361
Washington, D.C.	Dulles Intl.	313
Zurich, Switzerland	Zurich	1416

AIRLINE TWO LETTER CODES

Code	Airline
AA	American
AC	Air Canada
AE	Air Ceylon
AF	Air France
AH	Air Algerie
AI	Air India
AL	Allegheny
AM	Aeromexico
AN	Ansett-Australia
AO	Aviaco
AQ	Air Anglia
AR	Aerolineas Argentinas
AS	Alaska
AT	Royal Air Maroc
AU	Austral
AV	Avianca
AW	Air Niger
AX	Air Togo
AY	Finnair
AZ	Alitalia
BA	British Airways BAOD
BB	Balair
BD	British Midland
BE	British Airways BAED
BG	Bangladesh Biman
BH	Turks & Caicos
BI	Royal Brunei
BJ	Bakhtar Afghan
BL	Air BVI
BM	Aero Tras. Italiani
BN	Braniff Intl.
BO	Bouraq Indonesia
BP	Air Botswana
BQ	Business Jets
BR	British Caledonian
BS	Burnett
BU	Braathens
BV	Bavaria
BW	British W. Indian
BX	Spantax
BY	Britannia
CA	Caac
CE	Central Australian
CF	Faucett
CG	Ciba-Pilatus
CI	China Airlines
CK	Connair
CL	Capitol Intl.
CM	Copa
CO	Continental
CP	CP Air
CS	Cambrian (British)
CU	Cubana
CV	Cargolux
CX	Cathay Pacific
CY	Cyprus
DA	Dan-Air

Code	Airline
DE	Delta Intl.
DF	Condor
DG	Affretair
DJ	Air Djibouti
DK	Scanair
DL	Delta
DM	Maersk
DO	Dominicana
DS	Air Senegal
DT	Taag-Angola
DV	Germanair
DX	Danair
DY	Alyemda
EA	Eastern
EC	East African
EF	Far Eastern
EI	Aer Lingus-Irish
EQ	Tame
ET	Ethiopian
EU	Ecuatoriana
EW	East-West
EX	Air Champagne Ardennes
EY	Europe Aero
FF	Intl Aviation
FG	Ariana Afghan
FI	Flugfelag Iceland
FJ	Air Pacific
FL	Frontier
FT	Flying Tiger
FU	Air Littoral
GA	Garuda Indonesia
GB	Air Inter Gabon
GC	Linacongo
GD	Air North
GF	Gulf Air
GH	Ghana
GI	Air Guinee
GJ	Ansett-S. Australia
GK	Laker
GL	Greenland Air
GN	Air Gabon
GP	Hadag General
GQ	General Air
GR	Aurigny Air
GS	Air Vosges
GT	Gibraltar
GU	Aviateca
GV	Territory
GW	Gambia
GX	Great Lakes
GY	Guyana
HA	Hawaiian
HB	Air Melanesiae
HE	Trans European
HF	Hapag-Lloyd-Flug
HH	Somali

AIRLINE TWO LETTER CODES

Code	Airline
HI	Hong Kong Air
HJ	Air Haiti
HN	NLM-Dutch
HT	Air Tchad
HV	Transavia
IA	Iraqi
IB	Iberia
IC	Indian
IE	Solomon Islands
IF	Interflug
IG	Alisarda
IH	Itavia
IJ	Touraine Air
IM	Invicta
IN	Aerlinte Eireann
IO	Air Paris
IQ	Intl. Caribbean
IR	Iran Air
IT	Air Inter
IV	Guinea Ecuatorial
IW	Intl. Air Bahama
IX	In Air
IY	Yemen
IZ	Arkia-Israel Inland
JA	Air Spain
JD	Toa Domestic
JH	Pan Adria
JJ	Aviogenex
JK	Tae
JL	Japan Air Lines
JM	Air Jamaica
JP	Inex-Adria
JR	Air Yugoslavia
JU	Yugoslav -JAT
JW	Trek
KA	Kalinga
KB	Kenya Air Charters
KD	Kendell
KE	Korean
KH	Cook Island
KL	KLM
KM	Air Malta
KR	Kar Air
KS	Saturn
KU	Kuwait
KW	KLM Air Charter
LA	LAN
LB	LAB
LC	Logan Air
LD	Lade-Lineas Aer-eas Del Estado
LE	Air Lowveld
LF	Linjeflyg
LG	Lux Air
LH	Lufthansa
LI	Leeward Islands
LJ	Sierra Leone
LL	Loftleidir Icelandic
LM	Alm-Dutch Antil.
LO	Lot Polish
LP	Air Alpes
LR	Lacsa
LT	Lufttransport Unter.
LU	Saeta
LV	Lav
LY	El Al
LZ	Balkan Bulgarian
MA	Malev Hungarian
MD	Air Madagascar
ME	Middle East
MG	Melanesian
MH	Malaysian
MK	Air Mauritius
MM	Sociedad Aero-nautica Medellin
MN	Commercial
MP	Martin Air
MR	Air Mauritanie
MS	Egypt Air
MU	Misr Air
MV	Macrobertson Miller
MW	Maya
MX	Mexicana
MY	Air Mali
MZ	Merpati Nusantara
NA	National
NB	Sterling
NC	North Central
ND	Nord Air
NE	Air New England
NH	All Nippon
NI	Lancia
NJ	Namakwaland Lugdiens
NL	Air Liberia
NM	Mt. Cook
NS	Northeast (Brit. Airways)
NU	Southwest
NW	Northwest Orient
NZ	New Zealand National
OA	Olympic
OB	Austrian Air Transport
OC	Air California
OD	Aero Condor
OG	Air Guadeloupe
OH	SFO Helicopters
OI	Slov Air
OK	Czechoslovak
OL	Ostfriesische Luft Transcontinental
OM	Monarch

AIRLINE TWO LETTER CODES

Code	Airline
ON	Air Nauru
OO	Sobel Air
OP	Air Panama
OR	Air Comores
OS	Austrain
OU	Aerial Tours
OV	Overseas National
OY	Conair
OZ	Ozark
PA	Pan American
PC	Fiji Air
PH	Polynesian
PI	Piedmont
PK	Pakistan Intl.
PL	Aero Peru
PR	Philippine
PS	Pacific Southwest
PV	Eastern Provincial
PW	Pacific Western
PX	Air Niugini
PY	Surinam
PZ	Lap
QB	Quebec Air
QC	Air Zaire
QD	Transbrazil
QE	Air Tahiti
QF	Qantas
QM	Air Malawi
QN	Bush Pilots
QP	Casp Air
QQ	Aerovias Quisqueyana
QR	Air Centrafique
QS	African Safari
QU	Air Limousin
QZ	Zambia
RA	Royal Nepal
RB	Syrian Arab
RC	Air Cambodge
RD	Airlift Intl
RF	Air Samoa
RG	Varig
RH	Air Rhodesia
RJ	Alia-Royal Jordan.
RK	Air Afrique
RM	Aerolineas Tao
RN	Royal Air Inter
RO	Tarom
RT	Transportes Aereos De Timor
RU	Rousseau
RW	Hughes Airwest
RY	Royal Air Laos
RZ	Tarca
SA	South African
SB	Seaboard World
SC	Cruzeiro
SD	Sudan
SG	Sabah Air
SH	Sahsa
SK	SAS
SL	Southeast
SN	Sabena
SO	Southern
SP	Sata
SQ	Singapore
SR	Swiss Air
SU	Aeroflot
SV	Saudi Arabian
SW	Suidwes Lugdiens
TA	Taca
TB	Trans Air (Sweden)
TD	Transportes Aereos De Carga
TE	Air New Zealand
TF	Avia Taxi France
TG	Thai Airways Intl
TH	Thai Airways Co
TK	Thy-Turk Hava Yollari
TL	Trans Mediterranean
TM	Deta
TN	Trans Australia
TO	Tempair
TP	Tap
TQ	Trans Oceanic
TR	Trans Europa
TS	Aloha
TT	Texas Intl
TU	Tunis Air
TV	Trans International
TW	Transworld
TX	TAN
TY	Air Caledonie
TZ	Transair Ltd
UA	United
UB	Burma
UC	Ladeco
UE	United Air Serivces
UF	Tonga
UK	British Island
UL	Lansa-Honduras
UM	Air Manila
UO	Trans Union
UP	Bahamas Air
UR	Trans Africa Air
UT	UTA
UY	Cameroon
UZ	Air Rouergue
VA	Viasa
VC	Laco
VE	Avensa
VF	British Air Ferries
VG	Air Siam

AIRLINE TWO LETTER CODES

Code	Airline
VH	Air Volta
VK	Crowley
VP	Vasp
VQ	Air Pacific
VS	Sata
VT	Air Polynesie
VU	Air Ivoire
VY	Alas Del Caribe
VX	Transval Air
WA	Western
WB	San
WC	Wien Air Alaska
WD	Ward Air
WF	Wideroes Flyvesel.
WG	ALAG–Alpine Lufttransport
WK	Western Alaska
WM	Windward Islands
WN	Southwest
WO	World
WQ	Bahamas World
WT	Nigeria
WU	AVNA
WW	Westwing
WX	Ansett–New South Wales
WZ	Swazi Air
YD	Pyren Air Gaspe
YK	Cyprus Turkish
YO	Brit Airways Helico.
YP	Pagas
ZT	Satena

LOST CREDIT CARD PHONE #'S

Carrier	USA Number	World Wide Number
American Express	800-227-2639	402-392-2429
Amoco	800-226-4100	515-226-4100
Chevron Oil Co	800-243-8766	415-827-6000
Conoco	Call collect	405-467-3456
Diamond Shamrock	800-333-3560	806-378-3601
Diners Club Int.	800-525-9150	
Discovery Card	800-858-5588	602-272-9012
Exxon Oil Co	800-231-4674	713-680-6500
Joslins	800-333-2878	303-779-3596
May D & F/ May Co	800-456-2933	303-620-7500
Mastercard	800-826-2181	416-232-8020
Montgomery Ward	800-367-0468	913-676-4025
J.C. Penney	Any Store	303-779-6900
Phillips 66	800-331-0961	918-661-5000
Sears & Roebuck	800-877-8691	303-450-1670
Shell Oil Co	800-331-3703	918-496-4300
Texaco Oil Co	800-552-7827	713-666-1050
Visa Worldwide	800-336-8472	414-574-7700

NOTE: MOST of the above carriers require that you have your credit card number in order to report it lost or stolen. You should carry a list of all you card numbers somewhere other than your wallet or purse (use the inside cover of POCKET REF if you want).

When calling the world wide number, try calling collect first. Many carriers, such as Visa, will accept a collect call to report a lost or stolen card. Some of the world wide numbers listed above are regional numbers, but they will be able to direct you to the correct number if they can't help.

AIRLINE 1-800 PHONE NUMBERS

Airline	Phone #
Air Canada	422–6232
Air France	237–2747
Air Midwest	835–2953
Air Nevada	634–6377
Air New Zealand	262–1234
Air Panama	272–6262
Alaska Airlines	426–0333
Alitalia Airlines	223–5730
Aloha Airlines	367–5250
Amer. Airlines	433–7300
Amer. Eagle Air.	446–7834
Australian Air.	922–5122
Austrian Air	872–4282
Bar Harbor Air	343–3210
Big Sky Air.	225–2525
British Airways	247–9297
British Caledonian	231–0270
Canadian Air.	552–7576
Cannonball Air	323–6850
Capitol Air Cargo	221–4468
Cayman Air. Ltd	422–9626
Christman Air Sys.	245–4966
Continental Air.	525–0280
CSA Czech. Air.	223–2365
Data Air Courier	323–6808
Delta Air. Dash	638–7333
Delta Air. Inc.	221–1212
DHL Worldwide	225–5345
Eastern Air.	327–8376
El Al Israel Air.	223–6700
Faucett Peruvian	334–3356
Finnair	223–5700
Gulf Air/Arabian	223–1740
Guyana Airways	242–4210
Havasu Air.	528–8047
Hawaiian Air.	525–5511
Horizon Air Frt.	547–9308
Iberia Air.	221–6002
Icelandair	223–5500
Japan Air.	525–3663
Jet America Air.	421–7574
KLM Royal Dutch	556–7777
Korean Air.	421–8200
Lacsa Air.	225–2272
LAN Chile Air.	225–5526
Lloyd Aero Boliv.	327–7407
Lufthansa Air.	645–3880
Malaysian Air.	421–8641
Malev Hungarian	223–6884
Mexicana Air.	531–7921
Midstate Air.	826–0522
Midway Air.	621–5700
New York Air	525–0280
Northwest Air.	225–2525
Olympic Airways	223–1226
Pacific SW Air.	345–9772
Pan Am World Aw.	221–1111
Piedmont Air.	251–5720
Priority Air Courier	821–7938
Quantas Airways	227–4500
SAS Scandinavian	221–2350
Saudi Arabian Air.	472–8342
Singapore Air.	742–3333
Sky Air Sys. Cour.	223–6795
Skywest Air.	801–628–2655
S. African Air.	722–9675
Southwest Air.	214–353–6100
Summit Air.	932–2636
Swissair	221–4750
TAP Air Portugal	221–7890
Telerad Air Cour.	621–7774
Texas Air.	713–658–9588
Thai Airways Int	426–5204
Trans World Air.	221–2000
United Air.	241–6522
United Air. Cargo	722–5243
USAir	428–4322
Varig Brasilian	468–2744
Viasa–Venezuelan	327–5454

POCKET REF

General Science

(See also GEOLOGY for Richter Earthquake scales)

TEMPERATURE CONVERSIONS

°C	°F	°C	°F	°C	°F
10000	18032	430	806	200	392.0
9500	17132	420	788	195	383.0
9000	16232	410	770	190	374.0
8500	15332	400	752	185	365.0
8000	14432	395	743	180	356.0
7500	13532	390	734	175	347.0
7000	12632	385	725	170	338.0
6500	11732	380	716	165	329.0
6000	10832	375	707	160	320.0
5500	9932	370	698	155	311.0
5000	9032	365	689	150	302.0
4500	8132	360	680	145	293.0
4000	7232	355	671	140	284.0
3500	6332	350	662	135	275.0
3000	5432	345	653	130	266.0
2500	4532	340	644	125	257.0
2000	3632	335	635	120	248.0
1500	2732	330	626	115	239.0
1000	1832	325	617	110	230.0
950	1742	320	608	105	221.0
900	1652	315	599	100	212.0
850	1562	310	590	99	210.2
800	1472	305	581	98	208.4
750	1382	300	572	97	206.6
700	1292	295	563	96	204.8
650	1202	290	554	95	203.0
600	1112	285	545	94	201.2
590	1094	280	536	93	199.4
580	1076	275	527	92	197.6
570	1058	270	518	91	195.8
560	1040	265	509	90	194.0
550	1022	260	500	89	192.2
540	1004	255	491	88	190.4
530	986	250	482	87	188.6
520	968	245	473	86	186.8
510	950	240	464	85	185.0
500	932	235	455	84	183.2
490	914	230	446	83	181.4
480	896	225	437	82	179.6
470	878	220	428	81	177.8
460	860	215	419	80	176.0
450	842	210	410	79	174.2
440	824	205	401	78	172.4

°C = Degrees Centigrade (Celsius scale). 1 unit is 1/100 of the difference between the temperature of melting ice and boiling water at standard temperature and pressure.

°F = Degrees Fahrenheit. 1 unit is 1/180 of the difference between the temperature of melting ice and boiling water at standard temperature and pressure.

TEMPERATURE CONVERSIONS

°C	°F	°C	°F	°C	°F
77	170.6	34	93.2	−9	15.8
76	168.8	33	91.4	−10	14.0
75	167.0	32	89.6	−11	12.2
74	165.2	31	87.8	−12	10.4
73	163.4	30	86.0	−13	8.6
72	161.6	29	84.2	−14	6.8
71	159.8	28	82.4	−15	5.0
70	158.0	27	80.6	−16	3.2
69	156.2	26	78.8	−17	1.4
68	154.4	25	77.0	−18	−0.4
67	152.6	24	75.2	−19	−2.2
66	150.8	23	73.4	−20	−4.0
65	149.0	22	71.6	−21	−5.8
64	147.2	21	69.8	−22	−7.6
63	145.4	20	68.0	−23	−9.4
62	143.6	19	66.2	−24	−11.2
61	141.8	18	64.4	−25	−13.0
60	140.0	17	62.6	−26	−14.8
59	138.2	16	60.8	−27	−16.6
58	136.4	15	59.0	−28	−18.4
57	134.6	14	57.2	−29	−20.2
56	132.8	13	55.4	−30	−22.0
55	131.0	12	53.6	−31	−23.8
54	129.2	11	51.8	−32	−25.6
53	127.4	10	50.0	−33	−27.4
52	125.6	9	48.2	−34	−29.2
51	123.8	8	46.4	−35	−31.0
50	122.0	7	44.6	−36	−32.8
49	120.2	6	42.8	−37	−34.6
48	118.4	5	41.0	−38	−36.4
47	116.6	4	39.2	−39	−38.2
46	114.8	3	37.4	−40	−40.0
45	113.0	2	35.6	−50	−58.0
44	111.2	1	33.8	−60	−76.0
43	109.4	0	32.0	−70	−94.0
42	107.6	−1	30.2	−80	−112.0
41	105.8	−2	28.4	−90	−130.0
40	104.0	−3	26.6	−100	−148.0
39	102.2	−4	24.8	−125	−193.0
38	100.4	−5	23.0	−150	−238.0
37	98.6	−6	21.2	−200	−328.0
36	96.8	−7	19.4	−250	−418.0
35	95.0	−8	17.6	−273	−459.4

$^{o}C = 5/9\ (^{o}F - 32)$ $\quad$ $^{o}F = 9/5\ ^{o}C + 32$

Absolute Zero = $0^{o}K = -273.16^{o}C = -459.69^{o}F$

^{o}K = Degrees Kelvin (Absolute temperature). This scale is based on the average kinetic energy per molecule of a perfect gas and uses the same size degrees as the Centigrade scale. Zero ($0^{o}K$) on the scale is the temperature at which a perfect gas has lost all of its energy.

SOUND INTENSITIES

Decibels	Degree	Loudness or Feeling
225	Deafening	12" cannon @ 12 ft, in front & below
140		Jet Aircraft
		Artillery fire
130		Threshold of Pain
		> 130 causes immediate ear damage
		Propeller aircraft at 5 meters
		Hydraulic press, pneumatic rock drill
120		Thunder, Diesel engine room
		Nearby riviter
110		Close to a train, ball mill
100	Very Loud	Boiler factory, home lawn mower
		Car horn at 5 meters, wood saw
90		Symphony or a band
		>90 regularly can cause ear damage
		Noisy factory
		Truck with out muffler
80	Loud	Inside a high speed auto
		Police whistle, electric shaver
		Noisy office, alarm clock
70		Average radio
		Normal street noise
60	Moderate	Normal conversation, close up
50		Normal office noise, quiet stream
45		To awaken a sleeping person
40	Faint	Normal private office noise
		Residential neighborhood, no cars
30		Quiet conversation
20	Very Faint	Inside an empty theater
		Ticking of a watch
		Rustle of leaves
		Whisper
10		Sound proof room
		Threshold of Hearing
0		Absolute silence

Sound intensities are typically measured in decibels (db). A decibel is defined as 10 times the logarithm of the power ratio (power ratio is the ratio of the intensity of the sound to the intensity of an arbitrary standard point.) Normally a change of 1 db is the smallest volume change detectable by the human ear.

Sound intensity is also defined in terms of energy (ergs) transmitted per second over a 1 square centimeter surface. This energy is proportional to the velocity of propagation of the sound.

$$\text{Ergs/cm3} = 2\pi^2 \times \text{density in gm/cm}^3 \times \text{frequency}^2 \text{ in hz} \times \text{amplitude in cm}$$

SOUND INTENSITIES

Permissible Noise Exposures

Hours Duration per Day	Sound Level in Decibels (Slow Response)
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25	115

The above restrictions are based on the *Occupational Safety and Health Act of 1970.* That Code basically states that if the above exposures are exceeded, then hearing protection must be worn. Note that these are based on the "A scale" of a standard sound level meter at slow response and will change if some other standard is used. See the *OSHA Section 1910.95* for additional details on the differences.

Perception of Changes in Sound

Sound Level Change in Decibels	Perception
3	Barely perceptible
5	Clearly perceptible
10	Twice as loud

Note that the sound level scale in decibels is a logarithmic rather than linear scale. This means that as the sound level goes up, the effective increase is much more. For example, by changing from 5 up to 10 decibels, the sound is twice as loud but a change from 90 up to 100 yields a sound that is three times as intense.

The human ear can hear sounds in the frequency range from 20 hz (cycles/second) up to 20,000 hz (cycles/second).

HUMAN BODY COMPOSITION

Element	Percent (1)
Oxygen	.65
Carbon	.18
Hydrogen	.10
Nitrogen	.3
Calcium	1.5
Phosphorus	1.0
Sulphur	0.25
Potassium	0.20
Chlorine	0.15
Sodium	0.15
Magnesium	0.05
Fluorine	0.02
Iron	0.006
Zinc	0.0033
Silicon	0.0020
Rubidium	0.00170
Zirconium	0.00035
Strontium	0.00020
Aluminum	0.00014
Niobium	0.00014
Copper	0.00014
Antimony	<0.00013
Lead	0.00011
Cadmium	0.000043
Tin	0.000043
Iodine	0.00004
Manganese	0.00003
Vanadium	0.00003
Barium	0.000023
Arsenic	0.00002
Titanium	<0.00002
Boron	0.000014
Nickel	<0.000014
Chromium	<0.000009
Cobalt	<0.000004
Molybdenum	<0.000007
Silver	<0.000001
Gold	<0.000001
Uranium	3×10^{-8}
Cesium	$< 1.4 \times 10^{-8}$
Radium	1.4×10^{-13}

(1) Scientific Tables. Ciba–Geigy Ltd
Basle, Switzerland 1971

BODY WEIGHT vs HEIGHT

MEN

Height in Feet–Inches	Small Frame (lbs)	Medium Frame (lbs)	Large Frame (lbs)
5–2	128–134	131–141	138–150
5–3	130–136	133–143	140–153
5–4	132–138	135–145	142–156
5–5	134–140	137–148	144–160
5–6	136–142	139–151	146–164
5–7	138–145	142–154	149–168
5–8	140–148	145–157	152–172
5–9	142–151	148–160	155–176
5–10	144–154	151–163	158–180
5–11	146–157	154–166	161–184
6–0	149–160	157–170	164–188
6–1	152–164	160–174	168–192
6–2	155–168	164–178	172–197
6–3	158–172	167–182	176–202
6–4	162–176	171–187	181–207

WOMEN

Height in Feet–Inches	Small Frame (lbs)	Medium Frame (lbs)	Large Frame (lbs)
4–10	102–111	109–121	118–131
4–11	103–113	111–123	120–134
5–0	104–115	113–126	122–137
5–1	106–118	115–129	125–140
5–2	108–121	118–132	128–143
5–3	111–124	121–135	131–147
5–4	114–127	124–138	134–151
5–5	117–130	127–141	137–155
5–6	120–133	130–144	140–159
5–7	123–136	133–147	143–163
5–8	126–139	136–150	146–167
5–9	129–142	139–153	149–170
5–10	132–145	142–156	152–173
5–11	135–148	145–159	155–176
6–0	138–151	148–162	158–179

Based on data from *Metropolitan Life Insurance Company*

PHYSICAL GROWTH % – BOYS

Select the age in years, read the weight/height on the same row and then read the top line for the Percentile category.

Age in Years	Boys Weight (Pounds) Percentile						
	5%	10%	25%	50%	75%	90%	95%
2	24	25	27	29	31	33	35
3	27	28	30	33	35	38	39
4	31	32	34	37	40	43	45
5	34	35	38	41	45	48	51
6	37	39	42	46	50	54	58
7	41	43	46	51	55	61	66
8	45	47	51	56	62	68	76
9	49	52	56	62	69	79	87
10	54	56	62	70	78	90	99
11	59	62	69	78	89	103	113
12	66	69	77	88	101	116	127
13	74	79	88	99	114	130	143
14	84	89	99	112	128	144	158
15	95	102	113	126	143	159	174
16	105	112	123	136	154	171	188
17	113	121	132	145	162	183	200
18	118	126	136	150	166	192	208

Age in Years	Boys Height (Inches) Percentile						
	5%	10%	25%	50%	75%	90%	95%
2	32.2	32.5	33.2	33.8	34.6	35.8	36.6
3	35.0	35.5	36.5	37.4	38.4	39.5	40.2
4	37.7	38.2	39.4	40.6	41.6	42.6	43.4
5	40.2	40.9	42.0	43.4	44.4	45.5	46.1
6	42.5	43.2	44.4	45.7	47.0	48.0	48.6
7	44.5	45.4	46.5	47.9	49.2	50.4	51.0
8	46.5	47.3	48.5	50.0	51.4	52.6	53.4
9	48.4	49.3	50.5	52.0	53.5	54.8	55.7
10	50.3	51.2	52.5	54.0	55.6	57.2	58.2
11	52.1	53.1	54.5	56.4	58.0	59.6	60.8
12	54.1	55.2	56.7	58.8	60.6	62.6	63.8
13	56.0	57.2	59.1	61.5	63.4	65.5	66.5
14	58.5	59.6	61.5	64.1	66.2	68.2	69.2
15	61.0	62.0	64.1	66.4	68.4	70.3	71.5
16	63.4	64.4	66.2	68.2	70.0	71.6	72.9
17	64.8	66.0	67.6	69.4	70.9	72.5	73.6
18	65.2	66.4	67.8	69.5	71.2	73.0	73.8

Data from the *National Center for Health Statistics (NCHS) Hyattsville, Maryland.*

PHYSICAL GROWTH % – GIRLS

Select the age in years, read the weight/height on the same row and then read the top line for the Percentile category.

Age in Years	Girls Weight (Pounds) Percentile 5%	10%	25%	50%	75%	90%	95%
2	22	23	25	27	29	31	32
3	26	27	29	31	34	37	38
4	29	31	33	36	39	42	44
5	32	33	36	39	43	47	50
6	36	37	39	43	47	53	57
7	39	41	44	48	53	60	71
8	43	45	49	55	61	71	76
9	48	50	55	63	71	82	89
10	53	57	63	72	82	96	103
11	60	64	71	81	94	109	118
12	67	71	80	91	105	123	134
13	75	80	89	101	116	134	147
14	83	88	97	110	125	144	160
15	90	95	105	118	132	152	170
16	95	100	110	123	137	157	177
17	98	103	112	124	138	158	180
18	99	104	113	124	138	159	181

Age in Years	Girls Height (Inches) Percentile 5%	10%	25%	50%	75%	90%	95%
2	31.6	31.7	32.5	33.8	34.8	36.0	36.5
3	34.7	35.1	36.0	37.0	38.0	39.0	39.5
4	37.4	38.0	38.9	40.0	41.0	42.0	42.6
5	39.8	40.4	41.5	42.7	43.9	44.8	45.5
6	42.0	42.7	43.9	45.2	46.5	47.6	48.4
7	44.0	44.8	46.0	47.5	49.0	50.2	51.0
8	46.0	46.7	48.1	49.8	51.4	52.8	53.6
9	48.0	48.9	50.3	52.1	53.7	55.3	56.2
10	50.1	51.0	52.5	54.5	56.1	57.9	61.4
11	52.5	53.3	55.1	57.0	58.6	60.5	62.8
12	55.0	56.0	57.8	59.6	61.3	63.0	64.0
13	57.1	58.2	60.0	61.8	63.4	65.0	66.0
14	58.5	59.5	61.4	63.0	64.8	66.4	67.3
15	59.2	60.3	61.8	63.6	65.4	67.0	68.0
16	59.6	60.6	62.0	64.0	65.6	67.3	68.1
17	60.2	61.0	62.4	64.2	65.8	67.3	68.2
18	60.4	61.4	62.7	64.4	65.9	67.3	68.2

Data from the *National Center for Health Statistics (NCHS) Hyattsville, Maryland.*

ACCELERATION DUE TO GRAVITY

Degrees Latitude	Acceleration Due to Gravity at Sea Level Feet/second^2	Cm/second^2
0	32.0878	978.039
5	32.0891	978.078
10	32.0929	978.195
15	32.0991	978.384
20	32.1076	978.641
25	32.1180	978.960
30	32.1302	979.329
31	32.1327	979.407
32	32.1353	979.487
33	32.1380	979.569
34	32.1407	979.652
35	32.1435	979.737
36	32.1463	979.822
37	32.1491	979.908
38	32.1520	979.995
39	32.1549	979.083
40	32.1578	980.171
41	32.1607	980.261
42	32.1636	980.350
43	32.1666	980.440
44	32.1696	980.531
45	32.1725	980.621
46	32.1755	980.711
47	32.1785	980.802
48	32.1814	980.892
49	32.1844	980.981
50	32.1873	981.071
51	32.1902	981.159
52	32.1931	981.247
53	32.1960	981.336
54	32.1988	981.422
55	32.2016	981.507
56	32.2044	981.592
57	32.2071	981.675
58	32.2098	981.757
59	32.2125	981.839
60	32.2151	981.918
65	32.2272	982.288
70	32.2377	982.608
75	32.2463	982.868
80	32.2525	983.059
85	32.2564	983.178
90	32.2577	983.217

BEAUFORT WIND STRENGTH SCALE

Beaufort Number	Wind Speed Miles/hour	Description
Ø	< 1	**Calm:** Still: Smoke will rise vertically.
1	1–5	**Light Air**: Rising smoke drifts, weather vane is inactive.
2	6–11	**Light Breeze**: Leaves rustle, can feel wind on your face, weather vane is active.
3	12–19	**Gentle Breeze:** Leaves and twigs move around. Light weight flags extend.
4	20–28	**Moderate Breeze**: Moves thin branches, raises dust and paper.
5	29–38	**Fresh Breeze:** Small trees sway.
6	39–49	**Strong Breeze**: Large tree branches move, open wires (such as telegraph wires) begin to "whistle", umbrellas are difficult to keep under control.
7	50–61	**Moderate Gale**: Large trees begin to sway, noticeably difficult to walk.
8	62–74	**Fresh Gale**: Twigs and small branches are broken from trees, walking into the wind is very difficult.
9	75–88	**Strong Gale**: Slight damage occurs to buildings, shingles are blown off of roofs.
10	89–102	**Whole Gale**: Large trees are uprooted, building damage is considerable.
11	103–117	**Storm**: Extensive widespread damage, These typically occur only at sea, and rarely inland.
12	> 117	**Hurricane:** Extreme destruction.

NOTE: The Beaufort Number is also referred to as a "Force" number, for example, "Force 10 Gale".

WIND CHILL FACTORS

In order to determine a "Wind Chill Factor", locate the measured outside temperature column and then the wind speed row and then read the corresponding "Wind Chill Factor" at the intersection of the row and column. "Wind Chill Factor" is the combined effect of actual temperature and wind speed that increases heat loss in the body and makes the measured outside temperature "feel" colder.

Wind Speed	Measured Outside Temperature °F				
Miles/hour	50	45	40	35	30
4	50	45	40	35	30
6	46	41	35	30	24
8	43	37	31	25	20
10	40	34	28	22	16
12	38	32	26	19	13
14	37	30	23	17	10
16	35	28	21	15	8
18	34	27	20	13	6
20	32	25	18	11	4
22	31	24	17	10	2
24	30	23	16	8	1
26	30	22	15	7	0
28	29	21	14	6	–1
30	28	21	13	5	–2
35	27	19	11	3	–4
40	26	18	10	2	–6
45	25	17	9	1	–7

Wind Speed	Measured Outside Temperature °F				
Miles/hour	25	20	15	10	5
4	25	20	15	10	5
6	19	13	8	2	–3
8	14	8	2	–4	–10
10	10	4	–3	–9	–15
12	6	0	–7	–13	–19
14	3	–3	–10	–17	–23
16	1	–6	–13	–20	–26
18	–1	–8	–15	–22	–29
20	–3	–10	–18	–25	–32
22	–5	–12	–19	–27	–34
24	–6	–14	–21	–29	–36
26	–8	–15	–23	–30	–38
28	–9	–17	–24	–32	–39
30	–10	–18	–25	–33	–41
35	–12	–20	–28	–36	–43
40	–14	–22	–29	–37	–45
45	–15	–23	–31	–39	–47

WIND CHILL FACTORS

Wind Speed Miles/hour	Measured Outside Temperature °F 0	-5	-10	-15	-20
4	0	-5	-10	-15	-20
6	-9	-14	-20	-25	-31
8	-16	-21	-27	-33	-39
10	-21	-27	-33	-40	-46
12	-26	-32	-39	-45	-51
14	-30	-36	-43	-50	-56
16	-33	-40	-47	-54	-60
18	-36	-43	-50	-57	-64
20	-39	-46	-53	-60	-67
22	-41	-48	-56	-63	-70
24	-43	-51	-58	-65	-73
26	-45	-53	-60	-68	-75
28	-47	-54	-62	-69	-77
30	-48	-56	-64	-71	-79
35	-51	-59	-67	-75	-82
40	-53	-61	-69	-77	-85
45	-55	-63	-71	-79	-86

Wind Speed Miles/hour	Measured Outside Temperature °F -25	-30	-35	-40	-45
4	-25	-30	-35	-40	-45
6	-36	-42	-47	-53	-58
8	-45	-51	-57	-62	-68
10	-52	-58	-64	-70	-77
12	-58	-64	-71	-77	-83
14	-63	-70	-76	-83	-89
16	-67	-74	-81	-88	-95
18	-71	-78	-85	-92	-99
20	-75	-82	-89	-96	-103
22	-78	-85	-92	-99	-107
24	-80	-88	-95	-102	-110
26	-83	-90	-97	-105	-112
28	-85	-92	-100	-107	-115
30	-86	-94	-102	-109	-117
35	-90	-98	-106	-114	-121
40	-93	-101	-109	-116	-124
45	-94	-102	-110	-118	-126

NOTE: Wind speeds greater than 45 miles/hour have little additional effect on the Wind Chill Factor. The following formula can be used to determine Wind Chill Factors not listed in the above table:

$$\text{Wind Chill Factor} = (\{(10.45 + (6.686112 \times \sqrt{\text{Wind speed}}) - (0.447041 \times \text{Wind speed}))/22.034\} \times (\text{Temperature}-91.4)) + 91.4$$

HEAT - HUMIDITY FACTOR

In order to determine a "Heat Factor", locate the measured outside temperature row and then the humidity column and then read the corresponding apparent temperature at the intersection of the row and column. This "Heat Factor" is the combined effect of actual temperature and humidity that makes the measured outside temperature "feel" hotter. Heat exhaustion danger occurs when the "Heat Factor" is greater than 105°F.

Measured Temp °F	Percent Relative Humidity 0	10	20	30
70	64	65	66	67
75	69	70	72	73
80	73	75	77	78
85	78	80	82	84
90	83	85	87	90
95	87	90	93	96
100	91	95	99	104
105	95	100	105	113
110	99	105	112	123
115	103	111	120	135
120	107	116	130	148

Measured Temp °F	Percent Relative Humidity 40	50	60	70
70	68	69	70	70
75	74	75	76	77
80	79	81	82	85
85	86	88	90	93
90	93	96	100	106
95	101	107	114	124
100	110	120	132	144
105	123	135	149	
110	137	150		
115	151			

Measured Temp °F	Percent Relative Humidity 80	90	100
70	71	71	72
75	78	79	80
80	86	88	91
85	97	102	108
90	113	122	
95	136		

FIREWOOD / FUEL COMPARISONS

Fuel Type	Million BTU /Unit (1)	Available Units /million BTU (2)	Comment
#2 Fuel Oil	0.135/gallon	11.5	65% efficient
Charcoal	0.013/pound	128	60% efficient
Coal:			60% efficient
Anthracite	15.2/ton	0.07	
Bituminous	22.0/ton	0.08	Low Volatile
Bituminous	28.6/ton	0.06	High Volatile
Lignite	13.8/ton	0.12	
Electricity	0.003/KWH	293	100% efficient
Kerosene	0.135/gallon	11.5	65% efficient
Natural Gas	700/MCF	1.43	70% efficient
Propane	0.09/gallon	15.7	70% efficient
Wood:			50% to 60% efficient
Apple	30/cord	0.047	L–smoke, L–spark
Aspen	18/cord	0.077	M–smoke, H–spark
Cottonwood	17/cord	0.082	M–smoke, L–spark
Elm, Red	29/cord	0.048	M–smoke, M–spark
Fir, Douglas	24/cord	0.058	H–smoke, M–spark
Hickory	27/cord	0.052	L–smoke, L–spark
Juniper	15/cord	0.093	M–smoke, M–spark
Maple, Silver	20/cord	0.070	L–smoke, L–spark
Oak, Red	30/cord	0.047	L–smoke, L–spark
Oak, White	32/cord	0.044	L–smoke, L–spark
Pine, Lodgepole	21/cord	0.066	M–smoke, M–spark
Pine, Pinon	27/cord	0.052	M–smoke, M–spark
Pine, Ponderosa	20/cord	0.070	M–smoke, M–spark
Spruce, Englem.	18/cord	0.077	M–smoke, H–spark

"L–" is Low, "M–" is Medium, and "H–" is High
In order to calculate the actual cost of heat for each type, simply multiply the "Available Units/million BTU" by the current cost per unit. For example, if natural gas is currently $4 per MCF, the cost of 1 million BTU is $4 x 1.43 = $5.72. In the case of White Oak, the cost of 1 million BTU is $150/cord x 0.072 = $10.80. Note that the wood efficiency can vary greatly, depending on moisture and efficiency of the furnace you are using.

(1) Million BTU/Unit defines the average amount of heat per unit that is available for that fuel type, assuming 100% burning efficiency. For example, Aspen wood contains 18,000,000 BTU per dry cord.

(2) Available Units/million BTU defines the actual number of units required to produce 1,000,000 BTU. The efficiency of burning (shown in the Comment column) is considered, as well as the moisture content of woods (average 20% moisture for dry wood).

FREQUENCY SPECTRUM

Frequency (Wavelength)	Name
0 Hertz	Steady direct current
16–16,000 Hz	Audio frequencies
10–30 kHz (30,000–10,000m)	v.l.f. – very low frequency
10–16 kHz	ultrasonic
30 kHz to 30,000 megahertz	Radio Frequencies
30–300 kHz(10,000–1000m)	l.f. – low frequencies
30–535 kHz	Marine com & navigation, aero nav.
300–3000 kHz(1000–100m)	m.f. – medium frequencies
535–1605 kHz	AM broadcast bands
1800–2000 kHz	160 meter band
3–30 MHz(100–10m)	h.f. – high frequencies
3.5–4 MHz	80 meter band
7–7.3 MHz	40 meter band
14–14.35 MHz	20 meter band
21–21.45 MHz	15 meter band
26.95–27.54 MHz	Industrial, scientific, & medical
28–29.7 MHz	10 meter band
26.965–27.455 MHz	Citizens Band Class D
30–300 MHz(10–1m)	v.h.f. – very high frequencies
30–50 MHz	Police, fire, forest, highway, railroad
50–54 MHz	6 meter band
54–72 MHz	TV channels 2 to 4
72–76 MHz	Government, Aero. Marker 75MHz
76–88 MHz	TV channels 5 and 6
88–108 MHz	FM broadcast band
108–118 MHz	Aeronautical navigation
118–136 MHz	Civil Communication Band
148–174 MHz	Government
144–148 MHz	2 meter band
174–216 MHz	TV channels 7 to 13
216–470 MHz	Amateur, government, CB Band, non–government, fixed or mobile aeronautical navigation
220–225 MHz	Amateur band, 1-1/4 meter
225–400 MHz	Military
420–450 MHz	Amateur band, 0.7 meter
462.5–465 MHz	Citizens Band

FREQUENCY SPECTRUM

Frequency (Wavelength)	Name
300–3000 MHz(100–10cm)	u.h.f. – ultra high frequencies
470–890 MHz	TV channels 14 to 83
890–3000 MHz	Aero navigation, amateur bands, government & non–government, fixed and mobile
1300–1600	Radar band
3000–30,000 MHz(10–1cm)	s.h.f. – super high frequencies Government and non–government, amateur bands, radio navigation
30,000 MHz to 300 GHz (1–0.1cm)	Extra–high frequencies (weather radar, experimental, government)
30–0.76 μm	Infrared light and heat
0.76–0.39 μm	Visible light
6470–7000 angstroms	Red light
5850–6740 angstroms	Orange light
5750–5850 angstroms	Yellow light
5560–5750 angstroms	Maximum visibility
4912–5560 angstroms	Green light
4240–4912 angstroms	Blue light
4000–4240 angstroms	Violet light
0.39–0.032 μm	Ultraviolet light
0.032–0.00001 μm	X–rays
0.00001–0.0000006 μm	Gamma rays
0.0005 angstroms	Cosmic rays

μm = micrometer(10^{-6}m): m = meter: cm = centimeter
Hz = hertz: MHz = megahertz (10^{6} Hz): kHz = kilohertz(10^{3} Hz)
GHz = gigahertz(10^{9} Hz): 1 angstrom = 10^{-10} meters

PLANETARY DATA

SUN:

Mass	4.381×10^{30} pounds
Density	88.0 lbs/cubic foot
Mean Radius	432,500 miles
Gravity relative to earth	27.9
Rotation period	24 days, 16 hours, 48 minutes
Number of moons	0

MERCURY:

Mass	6.982×10^{23} pounds
Density	340.9 lbs/cubic foot
Mean Radius	150.3 miles
Max distance from the sun	43,770,000 miles
Min distance from the sun	28,580,000 miles
Gravity relative to earth	0.37
Rotation period	58 days, 21 hours, 58 minutes
Revolution time around sun	88 days
Orbital velocity	29.75 miles/second
Number of moons	0

VENUS:

Mass	1.074×10^{25} pounds
Density	309.6 lbs/cubic foot
Mean Radius	3890 miles
Max distance from the sun	67,730,000 miles
Min distance from the sun	66,490,000 miles
Gravity relative to earth	0.88
Rotation period	243 days
Revolution time around sun	224.7 days
Orbital velocity	21.76 miles/second
Number of moons	0

EARTH:

Mass	1.317×10^{25} pounds
Density	347.7 lbs/cubic foot
Mean Radius	3958 miles
Max distance from the sun	94,510,000 miles
Min distance from the sun	91,400,000 miles
Gravity relative to earth	1.00
Rotation period	23 hours, 56 minutes
Revolution time around sun	365.26 days
Orbital velocity	18.51 miles/second
Number of moons	1

EARTH'S MOON:

Mass	1.619×10^{23} pounds
Density	207.9 lbs/cubic foot
Mean Radius	1080 miles
Max distance from earth	252,900 miles
Min distance from earth	221,800 miles
Gravity relative to earth	0.17
Rotation period	27 days, 7 hours, 43 minutes
Orbital velocity	0.101 miles/second

MARS:

Mass	1.409×10^{24} pounds
Density	246.6 lbs/cubic foot
Mean Radius	2106 miles
Max distance from the sun	154,700,000 miles
Min distance from the sun	127,400,000 miles
Gravity relative to earth	0.38
Rotation period	24 hours, 37 minutes
Revolution time around sun	687 days
Orbital velocity	14.99 miles/second
Number of moons	2, Deimos, Phobos

JUPITER:

Mass	4.189×10^{27} pounds
Density	83.0 lbs/cubic foot
Mean Radius	43,430 miles
Max distance from the sun	507,000,000 miles
Min distance from the sun	459,800,000 miles
Gravity relative to earth	2.64
Rotation period	9 hours, 3 minutes
Revolution time around sun	12 years (4332.6 days)
Orbital velocity	8.12 miles/second
Number of moons	17 + ,Amalthea, Io, Europa,
	Ganymede, Callisto

SATURN:

Mass	1.254×10^{27} pounds
Density	43.7 lbs/cubic foot
Mean Radius	35,730 miles
Max distance from the sun	938,300,000 miles
Min distance from the sun	838,900,000 miles
Gravity relative to earth	1.15
Rotation period	10 hours, 30 minutes
Revolution time around sun	29 years (10759.2 days)
Orbital velocity	5.99 miles/second
Number of moons	22 +

URANUS:

Mass	1.916×10^{26} pounds
Density	97.4 lbs/cubic foot
Mean Radius	14,730 miles
Max distance from the sun	1,870,000,000 miles
Min distance from the sun	1,696,000,000 miles
Gravity relative to earth	1.15
Rotation period	15 hours, 36 minutes
Revolution time around sun	84 years (30685.9 days)
Orbital velocity	4.23 miles/second
Number of moons	15, Miranda, Ariel, Umbriel,
	Titania, Oberon are largest.

NEPTUNE:

Mass	2.271×10^{26} pounds
Density	142.3 lbs/cubic foot
Mean Radius	13,360 miles
Max distance from sun	2,881,000,000 miles
Min distance from sun	2,771,000,000 miles
Gravity relative to earth	1.12
Rotation period	18 hours, 26 minutes
Revolution time around sun	164 years (60187.6 days)
Orbital velocity	3.38 miles/second
Number of moons	3, Triton, Nereid, ?

PLUTO:

Mass	1.184×10^{25} pounds
Density	280.9 lbs/cubic foot
Mean Radius	1802 miles
Max distance from sun	4,580,000,000 miles
Min distance from sun	2,765,000,000 miles
Gravity relative to earth	0.04
Rotation period	6 days, 9 hours, 17 minutes
Revolution time around sun	247.7 years (90885 days)
Orbital velocity	2.95 miles/second
Number of moons	1, Charon

POCKET REF

Geology

Dana's Manual of Mineralogy, Field Geologists' Manual and A Field Guide to Rocks and Minerals were used as source material for much of the Geology chapter, see page 2 for the reference.

(See also GENERAL SCIENCE on page 177)
(See alsoWEIGHTS OF MATERIALS on page 389)

MINERAL TABLE ABBREVIATIONS

Abbreviations used in the "Name" column are:

(A)	=	Amphibole group
(B)	=	Bauxite component
(C)	=	Clay group or clay like
(D)	=	Diopside series
(E)	=	Enstatite group
(F)	=	Feldspar group
(Fp)	=	Feldspathoid group
(G)	=	Garnet group
(H)	=	Hornblende
(J)	=	Jamesonite group
(M)	=	Mica group
(O)	=	Orthoclase
(Ov)	=	Olivine group
(P)	=	Pyroxene group
(R)	=	Rare Earth Oxide group
(S)	=	Spinel group
(Sc)	=	Scapolite series
(W)	=	Wolframite series
(Z)	=	Zeolite group

The "Hard" column lists hardness as defined by Mhos scale of hardness (see Mhos table, page 231, also in this geology section).

"Sys" column lists the crystal system of each mineral:

Is	=	Isometric
Hx	=	Hexagonal–Hexagonal
Rh	=	Hexagonal–rhombohedral
Te	=	Tetragonal
Or	=	Orthorhombic
Mo	=	Monoclinic
Tr	=	Triclinic

Name	Composition	Density	Hard	Sys
	– A –			
Acanthite	Ag_2S	7.2-7.3	2-2.5	Mo
Achroite	Colorless tourmaline			
Acmite (P)	$NaFe(SiO_3)_2$	3.4-3.6	6-6.5	Mo
Actinolite (A)	$Ca_2(Mg,Fe)_5(Si_8O_{22})(OH)_2$	3.0-3.2	5-6	Mo
Adularia (O)	Clear orthoclase			
Aegirte	Acmite, Aegirine			
Agate	Banded chalcedony			
Alabandite	MnS	4.0	3.4-4	Is
Alabaster	Fine grained gypsum			
Albite (P)	$Na(AlSi_3O_8)$	2.62	6	Tr
Alexandrite	Chrysoberyl - gemstone			
Allanite	$(Ce,Ca,Y)(Al,Fe)_3(SiO_4)_3(OH)$	3.5-4.2	5.5-6	Mo
Allemontite	AsSb	5.8-6.2	3-4	Hx
Allophane (C)	$Al_2O_3 \bullet SiO_2 \bullet nH_2O$	1.8-1.9	3	Am
Almandite (G)	$Fe_3Al_2(SiO_4)_3$ - red	4.25	7	Is
Altaite	PbTe	8.16	3	Is
Alunite	$KAl_3(SO_4)_2(OH)_6$	2.6-2.8	4	Rh
Amazonstone (F)	Green microcline			
Amblygonite	$(Li,Na)AlPO_4(F,OH)$	3.0-3.1	6	Tr
Amethyst	Purple quartz			
Amphibole	A group of minerals			
Analcime (Fp)	$Na(AlSi_2O_6) \bullet H_2O$	2.27	5-5.5	Is
Anatase	TiO_2	3.9	5.5-6	Te
Anauxite	Silicon rich Kaolinite			
Andalusite	Al_2SiO_5	3.1-3.2	7.5	Or
Andesine (P)	$Ab_{70}An_{30}$-$Ab_{50}An_{50}$	2.69	6	Tr
Andradite (G)	$Ca_3Fe_2(SiO_4)_3$	3.75	7	Is
Anglesite	$PbSO_4$	6.2-6.4	3	Or
Anhydrite	$CaSO_4$	2.8-3.0	3-3.5	Or
Ankerite	$Ca(Fe,Mg,Mn)(CO_3)_2$	2.9-3	3.5	Rh
Annabergite	$(Ni,Co)_3(AsO_4)_2 \bullet 8H_2O$	3.0	3.5-3	Mo
Anorthite (P)	$CaAl_2Si_2O_8$	2.76	6	Tr
Anorthoclase (O)	$(Na,K)AlSi_3O_8$	2.58	6	Tr
Anthophyllite(A)	$(Mg,Fe)_7(Si_8O_{22})(OH)_2$	2.8-3.2	5.5-6	Or
Antigorite	Serpentine			
Antimony	Sb	6.7	3	Rh
Antlerite	$Cu_3SO_4(OH)_4$	3.9	3.5-4	Or
Apatite	$Ca_5(PO_4,CO_3)_3(F,OH,Cl)$	3.1-3.2	5	He
Apophyllite	$KCa_4Si_8O_{20}(F,OH) \bullet H_2O)$	2.3-2.4	4.5-5	Te
Aquamarine	Green-blue beryl - gemstone			
Aragonite	$CaCO_3$	2.95	3.5-4	Or
Arfvedsonite(A)	$Na_{2-3}(Fe,Mg,Al)_5Si_8O_{22}(OH)_2$	3.45	6	Mo
Argentite	Ag_2S	7.3	2-2.5	Is
Arsenic	As	5.7	3.5	Rh
Arsenopyrite	FeAsS	5.9-6.2	5.5-6	Mo
Asbestos	A group of minerals			

Name	Composition	Density	Hard	Sys
Atacamite	$Cu_2Cl(OH)_3$	3.7-3.8	3-3.5	Or
Augite (P)	$(Ca,Na)(Mg,Fe,Al)(Si,Al)_2(O)_6$	3.2-3.4	5-6	Mo
Aurichalcite	$(Zn,Cu)_5(CO_3)_2(OH)_6$	3.2-3.7	2	Mo
Autunite	$Ca(UO_2)_2((PO_4)_2 \bullet 10H_2O$	3.1-3.2	2-2.5	Te
Awaruite	$FeNi_2$	7.7-8.1	5	Is
Axinite	$(Ca,Mn,Fe)_3Al_2BSi_4O_{15}(OH)$	3.2-3.4	6.5-7	Tr
Azurite	$Cu_3(CO_3)_2(OH)_2$	3.77	3.5-4	Mo
– B –				
Balas ruby	Red spinel - gemstone			
Barite	$BaSO_4$	4.5	3-3.5	Or
Barytes	Barite			
Bastnaesite(R)	$(Ce,La)(CO_3)(F,OH)$	4.9-5.2	4-4.5	He
Bauxite	Aluminum hydroxide mixture...			
Beidellite (C)	$Al_8(Si_4O_{10})_3(OH)_{12} \bullet 12H_2O$	2.6	1.5	Or
Bentonite (C)	Montmorillonite clay			
Beryl	$Be_3Al_2(Si_6O_{18})$	2.7-2.8	7.5-8	He
Biotite (M)	$K(Mg,Fe^{2+})_3(Al,Fe^{3+})$.... $Si_3O_{10}(OH)_2$	2.8-3.2	2.5-3	Mo
Bismite	Bi_2O_3	8	4.5	Mo
Bismuth	Bi	9.8	2-2.5	Rh
Black Jack	Sphalerite			
Blende	Sphalerite			
Bloodstone	Heliotrope			
Blue vitriol	Chalcanthite			
Boehmite (B)	$AlO(OH)$	3.0-3.1		Or
Boracite	$Mg_3B_7O_{13}Cl$	2.9-3	7	Or
Borax	$Na_2B_4O_7 \bullet 10H_2O$	1.7	2-2.5	Mo
Bornite	Cu_5FeS_4	5.0-5.1	3	Is
Boulangerite	$Pb_5Sb_4S_{11}$	6-6.3	2.5-3	Or
Bournonite	$PbCuSbS_3$	5.8-5.9	2.5-3	Or
Brannerite	$(U,Ca,Ce)(Ti,Fe)_2O_6$	4.5-5.4	4.5	?
Braunite	$3Mn_2O_3 \bullet MnSiO_3$	4.8	6-6.5	Te
Bravoite	$(Ni,Fe)S_2$	4.66	5.5-6	Is
Brochantite	$Cu_4(OH)_6SO_4$	3.9	3.5-4	Mo
Bromyrite	$Ag(Br,Cl)$ - BrCl	6-6.5	2.5	Is
Bronzite (E)	$(Mg,Fe)SiO_3$	3.1-3.3	5.5	Or
Brookite	TiO_2	3.9-4.1	5.5-6	Or
Brucite	$Mg(OH)_2$	2.39	2.5	Rh
Bytownite (P)	$Ab_{30}An_{70}$-$Ab_{10}An_{90}$	2.74	6	Tr
– C –				
Cairngorm	Quartz - black to smoky			
Calamine	Hemimorphite			
Calaverite	$AuTe_2$	9.35	2.5	Mo
Calcite	$CaCO_3$	2.72	3	Rh
Californite	Idocrase - gemstone			
Calomel	Hg_2Cl_2	7.2	1.5	Te

Name	Composition	Density	Hard	Sys
Cancrinite(Fp)	$(Na_2,Ca)_4(AlSiO_4)_6 CO_3 \bullet nH_2O$	2.45	5-6	He
Carnallite	$KMgCl_3 \bullet 6H_2O$	1.6	1	Or
Carnelian	Chalcedony - red			
Carnotite	$K(UO_2)_2(VO_4)_2 \bullet 3H_2O$	4.1	soft	Or
Cassiterite	SnO_2	6.8-7.1	6-7	Te
Cat's Eye	Chrysoberyl or quartz - gemstone			
Celestite	$SrSo_4$	3.9-4.0	3-3.5	Or
Celsian (F)	$BaAl_2Si_2O_8$	3.37	6	Mo
Cerargyrite	Ag(Cl,Br) - ClBr	5.5-6	2.5	Is
Cerussite	$PbCO_3$	6.55	3-3.5	Or
Cervanite	Sb_2O_4	4.0-5.0	4-5	Or
Chabazite (Z)	$Ca(Al_2Si_4O_{12}) \bullet 6H_2O$	2.0-2.2	4-5	Rh
Chalcanthite	$CuSO_4 \bullet 5H_2O$	2.1-2.3	2.5	Tr
Chalcedony	Cryptocrystalline quartz	2.6-2.7		
Chalcocite	Cu_2S	5.5-5.8	2.5-3	Or
Chalcopyrite	$CuFeS_2$	4.1-4.3	3.5-4	Te
Chalcotrichite	Cuprite - fibrous			
Chalk	Calcite - fine grained			
Chalybite	Siderite			
Chert	SiO_2 - cryptocrystalline quartz.	2.65	7	
Chessylite	Azurite			
Chiastolite	Andalusite			
Chloanthite	Skutterudite - nickel variety			
Chlorite	$(Mg,Fe^{2+},Fe^{3+})_6 AlSi_3O_{10}(OH)_8$	2.6-2.9	2-2.5	Mo
Chloritoid (M)	$Fe_2Al_4Si_2O_{10}(OH)_4$	3.5	6-7	Mo
Chondrodite	$(Mg,Fe)_3SiO_4(OH,F)_2$	3.1-3.2	6-6.5	Mo
Chromite	$(Fe,Mg)O \bullet (Fe,Al,Cr)_2O_3$	4.3-4.6	5.5	Is
Chrysoberyl	$BeAl_2O_4$	3.6-3.8	8.5	Or
Chrysocolla	$Cu_2H_2(Si_2O_5)(OH)_4$	2.0-2.4	2-4	?
Chrysolite	Olivine			
Chrysoprase	Chalcedony - green			
Chrysotile	Serpentine asbestos			
Cinnabar	HgS	8.10	2.5	Rh
Cinnamon stone	Grossularite garnet			
Citrine	Quartz - pale yellow			
Clay	A group of minerals			
Cleavelandite	Albite - white			
Cliachite	Al hydroxide in bauxite			
Clinochlore	Chlorite			
Clinoclase	$Cu_3(AsO_4)(OH)_3$	4.38	2.5-3	Mo
Clinoenstatite(E)	$(Mg,Fe)SiO_3$	3.19	6	Mo
Clinoferrosilite(P)	$(Fe,Mg)SiO_3$	3.6	6	Mo
Clinohumite	$Mg_9Si_4O_{16}(F,OH)_2$	3.1-3.2	6	Mo
Clinozoisite	$Ca_2Al_3Si_3O_{12}(OH)$	3.2-3.4	6-6.5	Mo
Cobaltite	CoAsS	6.33	5.5	Is
Colemanite	$Ca_2B_6O_{11} \bullet 5H_2O$	2.42	4-4.5	Mo
Collophane	Apatite			

Name	Composition	Density	Hard	Sys
Columbite	$(Fe,Mn)(Nb,Ta)_2O_6$ - NbTa	5.2-6.7	6	Or
Copper	Cu	8.9	2.5-3	Is
Copper glance	Chalcocite			
Copper pyrites	Chalcopyrite			
Cordierite	$(Mg,Fe)_2Al_4Si_5O_{18}$	2.6-2.7	7-7.5	Or
Corundum	Al_2O_3	4.02	9	Rh
Covellite	CuS	4.6-4.7	1.5-2	He
Cristobalite	SiO_2 - high temp quartz	2.3	7	
Crocidolite	$Na_3Fe^{2+}{}_3Fe^{3+}{}_2(SiO_{23})(OH)$	3.2-3.3	4	Mo
Crocoite	$PbCrO_4$	5.9-6.1	2.5-3	Mo
Cryolite	Na_3AlF_6	2.9-3	2.5	Mo
Cubanite	$CuFe_2S_3$	4.0-4.2	3.5	Or
Cummingtonite (A)	$(Fe,Mg)_7(Si_8O_{22})(OH)_2$	3.1-3.6	6	Mo
Cuprite	Cu_2O	6	3.5-4	Is
Cyanite	Kyanite			
Cymophane	Chrysoberyl			

– D –

Name	Composition	Density	Hard	Sys
Danaite	$(Fe,Co)AsS$	5.9-6.2	5.5-6	Mo
Danburite	$CaB_2(SiO_4)_2$	2.9-3.0	7	Or
Datolite	$CaB(SiO_4)(OH)$	2.8-3	5-5.5	Mo
Davidite	Brannerite - Th variety			
Demantoid (G)	Andradite garnet - green gemstone			
Diallage	Diopside			
Diamond	C	3.5	10	Is
Diaspore	$AlO(OH)$	3.3-3.4	6.5-7	Or
Diatomite	Diatoms - siliceous	0.4-0.6	2	
Dichroite	Cordierite			
Dickite (C)	$Al_2Si_2O_5(OH)_4$ - Kaoline	2.6	2-2.5	Mo
Digenite	Cu_9S_5	5.6	2.5-3	Is
Diopside (P)	$CaMg(SiO_3)_2$	3.2-3.3	5-6	Mo
Dioptase	$CuSiO_2(OH)_2$	3.3	5	Rh
Disthene	Kyanite			
Dolomite	$CaMg(CO_3)_2$	2.85	3.5-4	Rh
Dry bone ore	Smithsonite			
Dumortierite	$(Al,Fe)_7O_3(BO_3)(SiO_4)_3$	3.2-3.4	7	Or

– E –

Name	Composition	Density	Hard	Sys
Edenite (H)	$Ca_2NaMg_5(AlSi_7O_{22})(OH)_2$	3	6	Mo
Electrum	Au,Ag - natural alloy	13.5-17	3	Is
Eleolite	Nepheline			
Embolite	$Ag(Cl,Br)$ - Cl = Br	5.6	1-1.5	Is
Emerald	Beryl - green gemstone			
Emery	Corundum with magnetite			
Enargite	Cu_3AsS_4	4.4-4.5	3	Or
Endlichite	Vanadinite - arsenic variety			
Enstatite (P)	$MgSiO_3$	3.2-3.5	5.5	Or
Epidote	$Ca_2(Al,Fe)_3Si_3O_{12}(OH)$	3.3-3.5	6-7	Mo

Name	Composition	Density	Hard	Sys
Epsomite	$MgSO_4 \bullet 7H_2O$ - Epsom salt	1.75	2-2.5	Or
Erythrite	$Co_3(AsO_4)_2 \bullet 8H_2O$	2.95	1.5-2.5	Mo
Essonite (G)	Grossularite			
Euclase	$BeAlSiO_4(OH)$	3.1	7.5	Mo
Eucryptite	$LiAlSiO_4$ - after spodumene	2.67		He
Euxenite	$(Y,Ce,Ca,U,Th)_2$ . . . . $(Ti,Nb,Ta,Fe)_2O_6$	5-5.9	5.5-6.5	Or

– F –

Name	Composition	Density	Hard	Sys
Fahlore	Tetrahedrite			
Fayalite (Ov)	Fe_2SiO_4	4.14	6.5	Or
Feather ore	Jamesonite			
Feldspar (F)	A group of minerals			
Feldspathoid	A group of minerals			
Ferberite (W)	$FeWO_4$	7.5	5	Mo
Fergusonite (R)	$(RE,Fe)(Nb,Ta,Ti)O_4$	4.2-5.8	5.5-6.5	Te
Ferrimolybdite	$Fe_2(MoO_4)_3 \bullet 8H_2O$	3	1.5	Or
Ferrosilite (P)	$FeSiO_3$	3.6	6	Or
Fibrolite	Sillimanite			
Flint	SiO_2 - cryptocrystalline quartz.	2.65	7	
Flos ferri	Aragonite - arborescent			
Fluorite	CaF_2	3.18	4	Is
Fool's gold	Pyrite			
Formanite (R)	Fergusonite with TaNb			
Forsterite (Ov)	Mg_2SiO_4	3.2	6.5	Or
Fowlerite	Rhodonite - zinc bearing			
Franklinite	(Fe^{2+},Zn,Mn^{2+}) . . . . $(Fe^{3+},Mn^{3+})_2O_4$	5.15	6	Is
Freibergite	Tetrahedrite - silver bearing			

– G –

Name	Composition	Density	Hard	Sys
Gadolinite (R)	$Be_2FeY_2Si_2O_{10}$	4-4.5	6.5-7	Mo
Gahnite (S)	$ZnAl_2O_4$	4.55	7.5-8	Is
Galaxite (S)	$MnAl_2O_4$	4.03	7.5-8	Is
Galena	PbS	7.4-7.6	2.5	Is
Garnet (G)	A group of minerals	3.5-4.3	6.5-7.5	Is
Garnierite	$(Ni,Mg)_3Si_2O_5(OH)_4$	2.2-2.8	2-3	Am
Gaylussite	$Na_2Ca(CO_3)_2 \bullet 5H_2O$	1.99	2-3	Mo
Gedrite (A)	Anthophyllite - Al variety			
Geocronite	$Pb_5(Sb,As)_2S_8$	6.3-6.5	2.5	Or
Gersdorffite	NiAsS	5.9	5.5	Is
Geyserite	Opal			
Gibbsite	$Al(OH)_3$	2.3-2.4	2.5-3.5	Mo
Glauberite	$Na_2Ca(SO_4)_2$	2.7-2.8	2.5-3	Mo
Glaucodot	Danaite			
Glauconite (M)	$(K,Na)(Al,Fe^{3+},Mg)_2$ . . . . $(Al,Si)_4O_{10}(OH)_2$	2.3	2	Mo

Name	Composition	Density	Hard	Sys
Glaucophane (A)	$Na_2(Mg,Fe^{2+})_3 \ldots Al_2Si_8O_{22}(OH)_2$	3.0-3.2	6-6.5	Mo
Gmelinite (Z)	$(Na_2,Ca)Al_2Si_4O_{12} \bullet 6H_2O$	2.0-2.2	4.5	Rh
Goethite	$FeO(OH)$	4.37	5-5.5	Or
Gold	Au	15-19.3	2.5-3	Is
Goslarite	$ZnSO_4 \bullet 7H_2O$	1.98	2-2.5	Or
Graphite	C	2.3	1-2	He
Greenockite	CdS	4.9	3-3.5	He
Grossularite (G)	$Ca_3Al_2(SiO_4)_3$	3.53	6.5	Is
Gummite	$UO_3 \bullet nH_2O$	3.9-6.4	2.5-5	
Gypsum	$CaSO_4 \bullet 2H_2O$	2.32	2	Mo

– H –

Name	Composition	Density	Hard	Sys
Halite	NaCl - common salt	2.16	2.5	Is
Halloysite (C)	$Al_2Si_2O_5(OH) \bullet nH_2O$	2.0-2.2	1-2	Am
Harmotome (Z)	$(Ba,K)(Al,Si)_2Si_6O_{16} \bullet 6H_2O$	2.45	4.5	Mo
Hastingsite (H)	$NaCa_2(Fe,Mg)_5Al_2 \ldots Si_6O_{22}(OH)_2$	3.2	6.0	Mo
Hausmannite	$MnMn_2O_4$	4.84	5.5	Te
Hauynite (Fp)	$(Na,Ca)_{4\text{-}8}Al_6Si_6 \ldots O_{24} \bullet (SO_4,S)_{1\text{-}2}$	2.4-2.5	5.5-6	Is
Hectorite (C)	$(Mg,Li)_6Si_8O_{20}(OH)_4$	2.5	1-1.5	Mo
Hedenbergite (P)	$CaFe(Si_2O_6)$	3.55	5-6	Mo
Heliotrope	Chalcedony - green and red			
Helvite	$(Mn,Fe,Zn)_4Be_3(SiO_4)_3S$	3.2-3.4	6-6.5	Is
Hematite	Fe_2O_3	5.26	5.5-6.5	Rh
Hemimorphite	$Zn_4(Si_2O_7)(OH)_2 \bullet H_2O$	3.4-3.5	4.5-5	Or
Hercynite (S)	$FeAl_2O_4$	4.39	7.5-8	Is
Hessite	Ag_2Te	8.4	2.5-3	Is
Heulandite	$(Na,Ca)_{4\text{-}6}Al_6 \ldots (Al,Si)_4Si_{26}O_{72} \bullet 24H_2O$	2.2	3.5-4	Mo
Hiddenite	Spodumene - green			
Holmquisite (A)	Glaucophane - Li variety			
Hornblende	$Ca_2Na(Mg,Fe^{2+})_4(Al, \ldots Fe^{3+},Ti)AlSi_8O_{22}(O,OH)_2$	3.2	5-6	Mo
Horn silver	Cerargyrite			
Huebnerite (W)	$MnWO_4$	7.0	5	Mo
Humite	$Mg_7(SiO_4)_3(F,OH)_2$	3.1-3.2	6	Or
Hyacinth	Zircon - brown to orange			
Hyalite	Opal - globular and colorless			
Hyalophane (O)	$(K,Ba)Al(Al,Si)_3O_8$	2.8	6	Mo
Hydromica (M)	Illite			
Hydrozincite	$Zn_5(CO_3)_2(OH)_6$	3.6-3.8	2-2.5	Mo
Hypersthene (P)	$(Mg,Fe)SiO_3$	3.4-3.5	5-6	Or

– I –

Name	Composition	Density	Hard	Sys
Ice	H_2O	0.917	1.5	He
Iceland spar	Calcite - clear			

Name	Composition	Density	Hard	Sys
Iddingsite	$H_8Mg_9Fe_2Si_3O_{14}$	3.5-3.8	3	Or
Idocrase	$Ca_{10}(Mg,Fe)_2Al_4(SiO_4)_5 \ldots (Si_2O_7)_2(OH)_4$	3.3-3.4	6.5	Te
Illite (C)	Al,K,Ca,Mg			
Ilmenite	$FeTiO_3$	4.7	5.5-6	Rh
Ilvaite	$CaFe^{2+}2Fe^{3+}(SiO_4)_2(OH)$	4.0	5.5-6	Or
Indicolite	Tourmaline - dark blue			
Iodobromite	Ag(Cl,Br,I)	5.7	1-1.5	Is
Iodyrite	AgI	5.7	1-1.5	He
Iolite	Cordierite - gemstone			
Iridium	Ir - platinoid	22.7	6-7	Is
Iridosmine	Ir,Os - platinoid	19.3-21	6-7	Rh
Iron pyrite	Pyrite			

–J–

Name	Composition	Density	Hard	Sys
Jacinth	Hyacinth, zircon			
Jacobsite (S)	$(Mn^{2+},Fe^{2+},Mg) \ldots (Fe^{3+},Mn^{3+})_2O_4$	5.1	5.5-6.5	Is
Jade	Jadeite or nephrite			
Jadeite (P)	$Na(Al,Fe)Si_2O_6$	3.3-3.5	6.5-7	Mo
Jamesonite	$Pb_4FeSb_6S_{14}$	5.5-6	2-3	Mo
Jargon	Zircon - clear, yellow, or smoky			
Jarosite	$KFe_3(SO_4)_2(OH)_6$	2.9-3.3	3	Rh
Jasper	Quartz - red cryptocrystalline			

–K–

Name	Composition	Density	Hard	Sys
Kainite	$MgSO_4 \bullet KCl \bullet 3H_2O$	2.1	3	Mo
Kalinite	Alum - potash variety			
Kaliophilite	$K(AlSiO_4)$	2.61	6	He
Kalsilite	Nepheline series			
Kaolin group	Clay mineral family			
Kaolinite	$Al_2(Si_2O_5)(OH)_4$	2.6-2.7	2-2.5	Mo
Kernite	$Na_2B_4O_7 \bullet 4H_2O$	1.95	3	Mo
Krennerite	$AuTe_2$	8.62	2-3	Or
Kunzite	Spodumene - pink			
Kyanite	Al_2SiO_5	3.6-3.7	5-7	Tr

–L–

Name	Composition	Density	Hard	Sys
Labradorite (P)	$Ab_{50}An_{50}$-$Ab_{30}An_{70}$	2.71	6	Tr
Langbeinite	$K_2Mg_2(SO_4)_3$	2.83	2.5-3.5	Is
Lapis lazuli	Lazurite - impure			
Larsenite (Ov)	$PbZnSiO_4$	5.9	3	Or
Laumontite (Z)	$(Ca,Na)Al_2Si_4O_{12} \bullet 4H_2O$ -	2.28	4	Mo
Lawsonite	$CaAl_2(Si_2O_7)(OH)_2 \bullet H_2O$	3.09	8	Or
Lazulite	$(Mg,Fe^{3+})Al_2(PO_4)_2(OH)_2$	3.0-3.1	5-5.5	Mo
Lazurite	$(Na,Ca)_4(AlSiO_4)_3(SO_4,S,Cl)$	2.4-2.5	5-5.5	Is
Lechatelierite	SiO_2 - fused silica	2.2	6-7	Am
Lepidocrocite	$FeO(OH)$	4.09	5	Or

Name	Composition	Density	Hard	Sys
Lepidolite (M)	$K(Li,Al)_3(Si,Al)_4O_{10}(F,OH)_2$	2.8-3	2.5-4	Mo
Leucite (Fp)	$K(AlSi_2O_6)$	2.4-2.5	5.5-6	Is
Libethenite	$Cu_2(PO_4)(OH)$	4	4	Or
Limonite	$FeO(OH) \bullet nH_2O$	3.6-4	5-5.5	Am
Linarite	$PbCu(SO_4)(OH)_2$	5.3	2.5	Mo
Linnaeite	Co_3S_4	4.8	4.5-5.5	Is
Lithium mica	Lepidolite			
Lithiophilite	$Li(Mn^{2+},Fe^{2+})PO_4$	3.5	5	Or
Loellingite	$FeAs_2$	7.4-7.5	5-5.5	Or
– M –				
Magnesite	$MgCO_3$	3.0-3.2	3.5-5	Rh
Magnetite (S)	$(Fe,Mg)Fe_2O_4$	5.18	6	Is
Malachite	$Cu_2CO_3(OH)_2$	3.9-4.0	3.5-4	Mo
Manganite	$MnO(OH)$	4.3	4	Or
Manganosite	MnO	5.0-5.4	5.5	Is
Marcasite	FeS_2 - white iron pyrite	4.89	6-6.5	Or
Margarite (M)	$CaAl_2(Al_2Si_2O_{10})(OH)_2$	3.0-3.1	3.5-5	Mo
Marialite (Sc)	$3NaAlSi_3O_8 \bullet NaCl$	2.7	5.5-6	Te
Marmatite	Sphalerite - iron bearing	3.9-4		
Martite	Hematite after magnetite			
Meerschaum	Sepiolite			
Meionite (Sc)	$3CaAl_2Si_2O_8 \bullet CaCO_3$	2.7	5.5-6	Te
Melaconite	Tenorite			
Melanite (G)	Andradite garnet - black			
Melanterite	$FeSO_4 \bullet 7H_2O$	1.90	2	Mo
Melilite	$(Na,Ca)_2(Mg,Al)(Si,Al)_2O_7$	2.9-3.1	5	Te
Menaccanite	Ilmenite			
Menaghinite (J)	$CuPb_{13}Sb_7S_{24}$	6.36	2.5	Or
Mercury	Hg - fluid, quicksilver	13.6		
Miargyrite	$AgSbS_2$	5.2-5.3	2.5	Mo
Mica (M)	A group of minerals			
Microcline (F)	$K(AlSi_3O_8)$ - k feldspar	2.5-2.6	6	Tr
Microlite	$(Na,Ca)_2(Ta,Nb)_2O_6$	6.33	5.5	Is
Microperthite (F)	Microcline and albite			
Millerite	NiS	5.3-5.7	3-3.5	Rh
Mimetite	$Pb_5Cl(AsO_4)_3$	7.0-7.2	3.5	He
Minium	Pb_3O_4	8.9-9.2	2.5	
Mispickel	Arsenopyrite			
Molybdenite	MoS_2	4.6-4.7	1-1.5	He
Monazite	$(Ce,La,Y,Th)(PO_4,SiO_4)$	5.0-5.3	5-5.5	Mo
Monticellite	$CaMgSiO_4$ - rare olivine	3.2	5	Or
Montmorillonite (C)	$(Al,Mg)_8(Si_4O_{10})_3 \ldots (OH)_{10} \bullet 10H_2O$	2.5	1-1.5	Mo
Moonstone (O)	Opalescent albite or orthoclase			
Morganite	Beryl - rose color			
Mullite	$Al_6Si_2O_{13}$	3.23	6-7	Or
Muscovite (M)	$KAl_2(AlSi_3O_{10})(OH)_2$	2.7-3.1	2-2.5	Mo

Name	Composition	Density	Hard	Sys
– N –				
Nacrite (C)	$Al_2(Si_2O_5)(OH)_2$ -kaolin group	2.6	2-2.5	Mo
Nagyagite	$Pb_5Au(Te,Sb)_4S_{5-8}$	7.4	1-1.5	Mo
Natroalunite	Alunite with NaK			
Natrolite (Z)	$Na_2(Al_2Si_3O_{10}) \bullet 2H_2O$	2.25	5-5.5	Mo
Nepheline (Fp)	$(Na,K)AlSiO_4$	2.5-2.7	5.5-6	He
Nephrite	Tremolite, similar to jade			
Niccolite	NiAs	7.78	5-5.5	Ne
Nickel bloom	Annabergite			
Nickel iron	Ni,Fe - Meteorite alloy	7.8-8.2	5	Is
Ni skutterudite	$(Ni,CO,Fe)As_3$	6.1-6.9	5.5-6	Is
Nitre	KNO_3 - saltpeter	2-2.1	2	Or
Nontronite (C)	$Fe(AlSi)_8O_{20}(OH)_4$	2.5	1-1.5	Mo
Norbergite	$Mg_3(SiO_4)(F,OH)_2$	3.1-3.2	6	Or
Noselite (Fp)	$Na_8Al_6Si_6O_{24}(SO_4)$ -	2.2-2.4	6	Is
– O –				
Octahedrite	Anatase			
Oligoclase (P)	$Ab_{90}An_{10}$-$Ab_{70}An_{30}$	2.65	6	Tr
Olivine (Ov)	$(Mg,Fe)_2SiO_4$	3.3-4.4	6.5-7	Or
Onyx	Chalcedony - layered structure			
Opal	$SiO_2 \bullet nH_2O$	1.9-2.2	5-6	Am
Orpiment	As_2S_3	3.49	1.5-2	Mo
Orthite	Allanite			
Orthoclase (F)	$K(AlSi_3O_8)$ - K feldspar	2.57	6	Mo
Osmiridium	Iridosmine			
Ottrelite (M)	$(Fe^{2+},Mn)(Al,Fe^{3+})$ .... $Si_3O_{10} \bullet H_2O$	3.5	6-7	Mo
– P –				
Palladium	Pd	11.9	4.5-5	Is
Paragonite (M)	$NaAl_2(AlSi_3O_{10})(OH)_2$	2.85	2	Mo
Pargasite (H)	$NaCa_2Mg_4Al_3Si_6O_{22}(OH)_2$	3-3.5	5.5	Mo
Peacock ore	Bornite			
Pearceite	$(Ag,Cu)_{16}As_2S_{11}$	6.15	3	Mo
Pectolite	$NaCa_2Si_3O_8(OH)$	2.7-2.8	5	Tr
Penninite	Chlorite			
Pentlandite	$(Fe,Ni)_9S_8$	4.6-5	3.5-4	Is
Peridot (Ov)	Olivine - gemstone			
Perovskite	$CaTiO_3$	4.03	5.5	Is
Perthite (F)	Microcline and albite mix			
Petalite (Fp)	$Li(AlSi_4O_{10})$	2.4	6-6.5	Mo
Petzite	Ag_3AuTe_2	8.7-9	2.5-3	Is
Phenacite	Be_2SiO_4	2.9-3.0	7.5-8	Rh
Phillipsite (Z)	$(K_2,Na_2,Ca)Al_2$ .... $Si_4O_{12} \bullet 4.5H_2O$	2.2	4.5-5	Mo
Phlogopite (M)	$K(Mg,Fe)_3AlSi_3O_{10}(OH,F)_2$	2.86	2.5-3	Mo

Name	Composition	Density	Hard	Sys
Phosgenite	$Pb_2Cl_2CO_3$	6.0-6.3	3	Te
Phosphuranylite	$Ca(UO_2)_4(PO_4)_2$ . . . . $(OH)_4 \bullet 7H_2O$	?	2.5	Te
Picotite (S)	Spinel - chromium			
Piedmontite	Epidote - Mn^{2+}	3.4	6.5	Mo
Pigeonite (P)	$(Ca,Mg,Fe)SiO_3$	3.2-3.4	5-6	Mo
Pinite (M)	Muscovite mica			
Pitchblende	Uraninite			
Plagioclase (P)	A group of Al silicate minerals			
Plagionite (J)	$Pb_5Sb_8S_{17}$ -	5.56	2.5	Mo
Platinum	Platinum metal alloy	14-19	4-4.5	Is
Pleonaste (S)	Spinel - iron			
Plumbago	Graphite			
Polianite	MnO_2 - pyrolusite	5.0	6-6.5	Te
Pollucite	$(Cs,Na)_2Al_2Si_4O_{12} \bullet H_2O$	2.9	6.5	Is
Polybasite	$(Ag,Cu)_{16}Sb_2S_{11}$	6.0-6.2	2-3	Mo
Polycrase (R)	Y,Ce,Ca,U,Th,Ti, ... Nb,Ta,Fe oxide	4.7-5.9	5.5-6.5	Or
Polyhalite	$K_2Ca_2Mg(SO_4)_4 \bullet 2H_2O$	2.78	2.5-3	Tr
Potash Alum	$KAl(SO_5)_2 \bullet 11H_2O$	1.75	2-2.5	Is
Potassium Feld	$KAlSi_3O_8$ - see orthoclase			
Potash mica (M)	Muscovite			
Powellite	$CaMoO_4$	4.23	3.5-4	Te
Prase	Jasper - green			
Prehnite	$Ca_2Al_2(Si_3O_{10})(OH)_2$	2.8-2.9	6-6.5	Or
Prochlorite	Chlorite group			
Proustite	Ag_3AsS_3	5.55	2-2.5	Rh
Psilomelane	Manganese mineral group - massive			
Pyrargyrite	Ag_3SbS_3	5.85	2.5	Rh
Pyrite	FeS_2	5.02	6-6.5	Is
Pyrochlore	$(Na,Ca)_2(Nb,Ta)_2O_6(OH,F)$	4.2-4.5	5	Is
Pyrolusite	MnO_2	4.75	1-2	Te
Pyromorphite	$Pb_5(PO_4)_3Cl$	6.5-7.1	3.5-4	He
Pyrope (G)	$(Mg,Fe)_3Al_2(SiO_4)_3$	3.51	7	Is
Pyrophyllite	$AlSi_2)_5(OH)$	2.8-2.9	1-2	Mo
Pyroxene (P)	A group of minerals			
Pyrrhotite	$Fe_{1-x}S$ where x = 0 to 0.2	4.6	4	He

-Q-

Quartz	SiO_2	2.65	7	Rh

-R-

Rammelsbergite	$NiAs_2$	7.1	5.5-6	Or
Rasorite	Kernite			
Realgar	AsS	3.48	1.5-2	Mo
Red ochre	Hematite			
Rhodochrosite	$MnCO_3$	3.5-3.6	3.5-4.5	Rh
Rhodolite (G)	$3(Mg,Fe)O,Al_2O_3 \bullet 3SiO_2$	3.84	7	Is

Name	Composition	Density	Hard	Sys
Rhodonite	$MnSiO_3$	3.6-3.7	5.5-6	Tr
Riebeckite (A)	$Na_2(Fe,Mg)_5Si_8O_{22}(OH)_2$	3.44	4	Mo
Rock salt	Halite			
Roscoelite (M)	$K(U,Al,Mg)_3Si_3O_{10}(OH)_2$	2.97	2.5	Mo
Rubellite	Tourmaline - red or pink			
Ruby	Corundum - red, gemstone			
Ruby copper	Cuprite			
Ruby silver	Pyrargyrite or proustite			
Rutile	TiO_2	4.2-4.3	6-6.5	Te

– S –

Name	Composition	Density	Hard	Sys
Samarskite	$(RE,U,Ca,Fe,Pb,Th,$ . . . . $Nb,Ta,Ti,Sn)O_6$	4.1-6.2	5-6	Or
Sanadine (O)	Orthoclase - high temperature			
Saponite (C)	$(Mg,Al)_6(Si,Al)_8O_{20}(OH)_4$	2.5	1-1.5	Mo
Sapphire	Corundum - blue, gemstone			
Satin spar	Gypsum - fibrous			
Scapolite	$(Na$ or $Ca)_4Al_3(Al,Si)_3$ . . . . $Si_6O_{24}(Cl,CO_3,SO_4)$	2.6-2.7	5-6	Te
Scheelite	$CaWO_4$	5.9-6.1	4.5-5	Te
Schorlite	Tourmaline - black			
Scolecite (Z)	$Ca(Al_2Si_3O_{10}) \bullet 3H_2O$	2.2-2.4	5-5.5	Mo
Scorodite	$FeAsO_4 \bullet 2H_2O$	3.1-3.3	3.5-4	Or
Scorzalite	$(Fe,Mg)Al_2(PO_4)_2(OH)_2$	3.35	5.5-6	Mo
Selenite	Gypsum - clear, crystalline			
Semseyite	$Pb_9Sb_8S_{21}$	5.8	2.5	Mo
Sepiolite	$Mg_4(Si_2O_5)_3(OH)_2$ . . . . $\bullet 6H_2O$ - Meerschaum	2.0	2-2.5	Mo
Sericite (M)	Muscovite mica - fine grained			
Serpentine	$(Mg,Fe)_3Si_2O_5(OH)_4$	2.2	2-5	Mo
Siderite	$FeCO_3$	3.8-3.9	3.5-4	Rh
Siegenite	$(CO,Ni)_3S_4$ - Linnaeite series	4.8	4.5-5.5	Is
Sillimanite	Al_2SiO_5	3.2	6-7	Or
Silver	Ag	10.5	2.5-3	Is
Silver glance	Argentite			
Sklodowskite	$Mg(UO_2)_2Si_2O_7 \bullet 6H_2O$	3.54		Or
Skutterudite	$(Co,Ni,Fe)As_3$	6.1-6.9	5	Is
Smaltite	Skutterudite variety			
Smithsonite	$ZnCO_3$	4.3-4.4	5	Rh
Soapstone	Talc			
Sodalite (Fp)	$Na_4Al_3Si_3O_{12}Cl$	2.2-2.3	5.5-6	Is
Soda nitre	$NaNO_3$	2.29	1-2	Rh
Specular iron	Hematite - foliated			
Sperrylite	$PtAs_2$	10.5	6-7	Is
Spessartite (G)	$Mn_3Al_2(SiO_4)_3$ - red,brown	4.18	7	Is
Sphalerite	$(Zn,Fe)S$	3.9-4.1	3.5-4	Is
Sphene	$CaTiO(SiO_4)$	3.4-3.5	5-5.5	Mo
Spinel group	$(Mg,Fe,Zn,Mn)Al_2O_4$	3.6-4	8	Is

Name	Composition	Density	Hard	Sys
Spodumene (P)	$LiAl(Si_2O_6)$	3.1-3.2	6.5-7	Mo
Stannite	Cu_2FeSnS_4	4.4	4	Te
Staurolite	$(Fe,Mg)_2Al_2Si_4O_{23}(OH)$	3.6-3.8	7-7.5	Or
Steatite	Talc			
Stephanite	Ag_5SbS_4	6.2-6.3	2-2.5	Or
Sternbergite	$AgFe_2S_3$	4.1-4.2	1-1.5	Or
Stibnite	Sb_2S_3	4.5-4.6	2	Or
Stilbite (Z)	$NaCa_2Al_5Si_3O_{36} \bullet 14H_2O$	2.1-2.2	3.5-4	Mo
Stillwellite	$(Ce,La,Ca)BSiO_5$	4.57		Rh
Stolzite	$PbWO_4$	8.3-8.4	2.5-3	Te
Stromeyerite	$(Cu,Ag)S$	6.2-6.3	2.5-3	Or
Strontianite	$SrCO_3$	3.7	3.5-4	Or
Sulphur	S	2-2.1	1.5-2.5	Or
Sunstone (F)	Oligoclase, translucent			
Sylvanite	$(Au,Ag)Te_2$	8-8.2	1.5-2	Mo
Sylvite	KCl	1.99	2	Is

– *T* –

Name	Composition	Density	Hard	Sys
Talc	$Mg_3(Si_4O_{10})(OH)_2$	2.7-2.8	1	Mo
Tantalite	$(Fe,Mn)(Ta,Nb)_2O_6$, TaNb	6.2-8	6-6.5	Or
Tennantite	$(Cu,Fe,Zn,Ag)_{12}As_4S_{13}$	4.6-5.1	3-4.5	Is
Tenorite	CuO	5.8-6.4	3-4	Tr
Tephroite (Ov)	$Mn_2(SiO_4)$	4.1	6	Or
Tetrahedrite	$(Cu,Fe,Zn,Ag)_{12}Sb_4S_{13}$	4.6-5.1	3-4.5	Is
Thenardite	Na_2SO_4	2.68	2.5	Or
Thomsonite (Z)	$NaCa_2Al_5Si_5O_{20} \bullet 6H_2O$	2.3	5	Or
Thorianite	ThO_2	9.7	6.5	Is
Thorite	$Th(SiO_4)$	5.3	5	Te
Thulite	Zoisite, pink to red			
Tiger's eye	Quartz after crocidolite, yellow			
Tin	Sn	7.3	2	Te
Tinstone	Cassiterite			
Titanite	Sphene			
Topaz	$Al_2(SiO_4)(F,OH)_2$	3.4-3.6	8	Or
Torbernite	$Cu(UO_2)_2(PO_4)_2 \bullet 8H_2O$	3.22	2-2.5	Te
Tourmaline	$(Na,Ca)(Al,Fe,Li,Mg)_3Al_6$ . . . $(BO_3)_3(Si_6O_{18})(OH)_4$	3-3.2	7-7.5	Rh
Tremolite (A)	$Ca_2Mg_5(Si_8O_{22})(OH)_2$	3-3.3	5-6	Mo
Tridymite	SiO_2	2.26	7	Or
Triphylite	$Li(Fe,Mn)PO_4$	3.4-3.6	4.5-5	Or
Troilite	Pyrrhotite			
Trona	$Na_2CO_3 \bullet NaHCO_3 \bullet 2H_2O$	2.13	3	Mo
Troostite	Willemite, manganiferous			
Tungstite	$WO_3 \bullet nH_2O$		2.5	Or
Turgite	$2Fe_2O_3 \bullet nH_2O$	4.2-4.6	6.5	?
Turquoise	$CuAl_6(PO_4)_4(OH)_8 \bullet 5H_2O$	2.6-2.8	6	Tr
Tyuyamunite	$Ca(UO_2)_2(VO_4)_2 \bullet 5H_2O$	3.7-4.3	2	Or

Name	Composition	Density	Hard	Sys
– U –				
Ulexite	$NaCaB_5O_9 \bullet 8H_2O$	1.96	1	Tr
Uralite (H)	Hornblende after pyroxene			
Uraninite	UO_2 to UO_3	9-9.7	5.5	Is
Uranophane	$Ca(UO_2)_2Si_2O_7 \bullet 6H_2O$	3.8-3.9	2-3	Or
Uvarovite (G)	$Ca_3Cr_2(SiO_4)_3$ green	3.45	7.5	Is
– V –				
Vanadinite	$Pb_5(VO_4)_3Cl$	6.7-7.1	3	He
Variscite	$Al(PO_4) \bullet 2H_2O$	2.4-2.6	3.5-4.5	Or
Vermiculite (M)	Biotite, altered	2.4	1.5	Mo
Vesuvianite	Idocrase			
Violarite	Ni_2FeS_4	4.8	4.5-5.5	Is
Vivianite	$Fe_3(PO_4)_2 \bullet 8H_2O$	2.6-2.7	1.5-2	Mo
– W –				
Wad	Manganese oxides			
Wavellite	$Al_3(OH)_3(PO_4)_2 \bullet 5H_2O$	2.33	3.5-4	Or
Wernerite (Sc)	Scapolite			
White pyrite	Marcasite			
White mica (M)	Muscovite			
Willemite	Zn_2SiO_4	3.9-4.2	5.5	Rh
Witherite	$BaCO_3$	4.3	3.5	Or
Wolframite	$(Fe,Mn)WO_4$	7-7.5	5-5.5	Mo
Wollastonite	$Ca(SiO_3)$	2.8-2.9	5-5.5	Tr
Wood tin	Cassiterite			
Wulfenite	$PbMoO_4$	6.5-7.5	3	Te
Wurtzite	$(Zn,Fe)S$	4	4	He
– X –				
Xenotime	YPO_4	4.4-5.1	4-5	Te
– Z –				
Zeolite	A group of minerals			
Zincite	ZnO	5.68	4-4.5	He
Zinc spinel	Gahnite			
Zinkenite (J)	$Pb_6Sb_{14}S_{27}$	5.3	3-3.5	He
Zinnwaldite	Fe,Li mica	3	2.5-3	Mo
Zircon	$ZrSiO_4$	4.68	7.5	Te
Zoisite	$Ca_2Al_3Si_3O_{12}(OH)$	3.3	6	Or

ELEMENT–OXIDE CONVERSION

Element	Multiply by	To get this Oxide
Al	1.889	Al_2O_3
As	1.320	As_2O_3
As	1.534	As_2O_5
B	3.220	B_2O_3
Ba	1.117	BaO
Be	2.775	BeO
Bi	1.115	Bi_2O_3
Ca	1.399	CaO
Ce	1.171	Ce_2O_3
Co	1.271	CoO
Cr	1.462	Cr_2O_3
Cs	1.060	Cs_2O
Cu	1.252	CuO
F	2.055	CaF_2
Fe	1.430	Fe_2O_3
Fe	1.382	Fe_3O_4
Fe	1.286	FeO
K	1.205	K_2O
La	1.173	La_2O_3
Mg	1.658	MgO
Mn	1.291	MnO
Mn	1.582	MnO_2
Mo	1.500	MoO_3
Na	1.348	Na_2O
Nb	1.431	Nb_2O_5
Ni	1.273	NiO
P	2.291	P_2O_5
Pb	1.077	PbO
Rb	1.094	Rb_2O
Sb	1.197	Sb_2O_3
Si	2.139	SiO_2
Sn	1.270	SnO_2
Sr	1.183	SrO
Ta	1.221	Ta_2O_5
Th	1.138	ThO_2
Ti	1.668	TiO_2
U	1.179	U_3O_8
U	1.202	UO_3
U	1.134	UO_2
V	1.785	V_2O_5
W	1.261	WO_3
Y	1.270	Y_2O_3
Zn	1.245	ZnO
Zr	1.351	ZrO_2

MINERALS SORTED BY DENSITY

Name	Density
Diatomite	0.4-0.6
Ice	0.917
Carnallite	1.6
Borax	1.7
Epsomite	1.75
Potash Alum	1.75
Allophane (C)	1.8-1.9
Melanterite	1.90
Opal	1.9-2.2
Kernite	1.95
Ulexite	1.96
Goslarite	1.98
Gaylussite	1.99
Sylvite	1.99
Chabazite (Z)	2.0-2.2
Chrysocolla	2.0-2.4
Gmelinite (Z)	2.0-2.2
Halloysite (C)	2.0-2.2
Nitre	2-2.1
Sepiolite	2.0
Sulphur	2-2.1
Chalcanthite	2.1-2.3
Kainite	2.1
Stilbite (Z)	2.1-2.2
Trona	2.13
Halite	2.16
Garnierite	2.2-2.8
Heulandite	2.2
Lechatelierite	2.2
Noselite (Fp)	2.2-2.4
Phillipsite (Z)	2.2
Scolecite (Z)	2.2-2.4
Serpentine	2.2
Sodalite (Fp)	2.2-2.3
Natrolite (Z)	2.25
Tridymite	2.26
Analcime (Fp)	2.27
Laumontite (Z)	2.28
Soda nitre	2.29
Apophyllite	2.3-2.4
Cristobalite	2.3
Gibbsite	2.3-2.4
Glauconite (M)	2.3
Graphite	2.3
Thomsonite (Z)	2.3
Gypsum	2.32
Wavellite	2.33
Brucite	2.39
Hauynite (Fp)	2.4-2.5
Lazurite	2.4-2.5
Leucite (Fp)	2.4-2.5
Petalite (Fp)	2.4
Variscite	2.4-2.6
Vermiculite (M)	2.4
Colemanite	2.42
Cancrinite(Fp)	2.45
Harmotome (Z)	2.45
Hectorite (C)	2.5
Microcline (F)	2.5-2.6
Montmorillonite	2.5
Nepheline (Fp)	2.5-2.7
Nontronite (C)	2.5
Saponite (C)	2.5
Orthoclase (F)	2.57
Anorthoclase (O)	2.58
Alunite	2.6-2.8
Beidellite (C)	2.6
Chalcedony	2.6-2.7
Chlorite	2.6-2.9
Cordierite	2.6-2.7
Dickite (C)	2.6
Kaolinite	2.6-2.7
Nacrite (C)	2.6
Scapolite	2.6-2.7
Turquoise	2.6-2.8
Vivianite	2.6-2.7
Kaliophilite	2.61
Albite (P)	2.62
Chert	2.65
Flint	2.65
Oligoclase (P)	2.65
Quartz	2.65
Eucryptite	2.67
Thenardite	2.68
Andesine (P)	2.69
Beryl	2.7-2.8
Glauberite	2.7-2.8
Marialite (Sc)	2.7
Meionite (Sc)	2.7
Muscovite (M)	2.7-3.1
Pectolite	2.7-2.8
Talc	2.7-2.8
Labradorite (P)	2.71
Calcite	2.72
Bytownite (P)	2.74
Anorthite (P)	2.76

MINERALS SORTED BY DENSITY

Name	Density
Polyhalite	2.78
Anhydrite	2.8-3.0
Anthophyllite(A)	2.8-3.2
Biotite (M)	2.8-3.2
Datolite	2.8-3
Hyalophane (O)	2.8
Lepidolite (M)	2.8-3
Prehnite	2.8-2.9
Pyrophyllite	2.8-2.9
Wollastonite	2.8-2.9
Langbeinite	2.83
Dolomite	2.85
Paragonite (M)	2.85
Phlogopite (M)	2.86
Ankerite	2.9-3
Boracite	2.9-3
Cryolite	2.9-3
Danburite	2.9-3.0
Jarosite	2.9-3.3
Melilite	2.9-3.1
Phenacite	2.9-3.0
Pollucite	2.9
Aragonite	2.95
Erythrite	2.95
Roscoelite (M)	2.97
Actinolite (A)	3.0-3.2
Amblygonite	3.0-3.1
Annabergite	3.0
Boehmite (B)	3.0-3.1
Edenite (H)	3
Ferrimolybdite	3
Glaucophane (A)	3.0-3.2
Lazulite	3.0-3.1
Magnesite	3.0-3.2
Margarite (M)	3.0-3.1
Pargasite (H)	3-3.5
Tourmaline	3-3.2
Tremolite (A)	3-3.3
Zinnwaldite	3
Lawsonite	3.09
Andalusite	3.1-3.2
Apatite	3.1-3.2
Autunite	3.1-3.2
Bronzite (E)	3.1-3.3
Chondrodite	3.1-3.2
Clinohumite	3.1-3.2
Cummingtonite	3.1-3.6
Euclase	3.1
Humite	3.1-3.2
Norbergite	3.1-3.2
Scorodite	3.1-3.3
Spodumene (P)	3.1-3.2
Fluorite	3.18
Clinoenstatite(E)	3.19
Augite (P)	3.2-3.4
Aurichalcite	3.2-3.7
Axinite	3.2-3.4
Clinozoisite	3.2-3.4
Crocidolite	3.2-3.3
Diopside (P)	3.2-3.3
Dumortierite	3.2-3.4
Enstatite (P)	3.2-3.5
Forsterite (Ov)	3.2
Hastingsite (H)	3.2
Helvite	3.2-3.4
Hornblende	3.2
Monticellite	3.2
Pigeonite (P)	3.2-3.4
Sillimanite	3.2
Torbernite	3.22
Mullite	3.23
Diaspore	3.3-3.4
Dioptase	3.3
Epidote	3.3-3.5
Idocrase	3.3-3.4
Jadeite (P)	3.3-3.5
Olivine (Ov)	3.3-4.4
Zoisite	3.3
Scorzalite	3.35
Celsian (F)	3.37
Acmite (P)	3.4-3.6
Hemimorphite	3.4-3.5
Hypersthene (P)	3.4-3.5
Piedmontite	3.4
Sphene	3.4-3.5
Topaz	3.4-3.6
Triphylite	3.4-3.6
Riebeckite (A)	3.44
Arfvedsonite(A)	3.45
Uvarovite (G)	3.45
Realgar	3.48
Orpiment	3.49
Allanite	3.5-4.2
Chloritoid (M)	3.5
Diamond	3.5
Garnet (G)	3.5-4.3

MINERALS SORTED BY DENSITY

Name	Density	Name	Density
Iddingsite	3.5-3.8	Sternbergite	4.1-4.2
Lithiophilite	3.5	Tephroite (Ov)	4.1
Ottrelite (M)	3.5	Fayalite (Ov)	4.14
Rhodochrosite	3.5-3.6	Spessartite (G)	4.18
Pyrope (G)	3.51	Fergusonite (R)	4.2-5.8
Grossularite (G)	3.53	Pyrochlore	4.2-4.5
Sklodowskite	3.54	Rutile	4.2-4.3
Hedenbergite (P)	3.55	Turgite	4.2-4.6
Chrysoberyl	3.6-3.8	Powellite	4.23
Clinoferrosilite	3.6	Almandite (G)	4.25
Ferrosilite (P)	3.6	Chromite	4.3-4.6
Hydrozincite	3.6-3.8	Manganite	4.3
Kyanite	3.6-3.7	Smithsonite	4.3-4.4
Limonite	3.6-4	Witherite	4.3
Rhodonite	3.6-3.7	Goethite	4.37
Spinel group	3.6-4	Clinoclase	4.38
Staurolite	3.6-3.8	Hercynite (S)	4.39
Atacamite	3.7-3.8	Enargite	4.4-4.5
Strontianite	3.7	Stannite	4.4
Tyuyamunite	3.7-4.3	Xenotime	4.4-5.1
Andradite (G)	3.75	Barite	4.5
Azurite	3.77	Brannerite	4.5-5.4
Siderite	3.8-3.9	Stibnite	4.5-4.6
Uranophane	3.8-3.9	Gahnite (S)	4.55
Rhodolite (G)	3.84	Stillwellite	4.57
Anatase	3.9	Covellite	4.6-4.7
Antlerite	3.9	Molybdenite	4.6-4.7
Brochantite	3.9	Pentlandite	4.6-5
Brookite	3.9-4.1	Pyrrhotite	4.6
Celestite	3.9-4.0	Tennantite	4.6-5.1
Gummite	3.9-6.4	Tetrahedrite	4.6-5.1
Malachite	3.9-4.0	Bravoite	4.66
Sphalerite	3.9-4.1	Zircon	4.68
Willemite	3.9-4.2	Ilmenite	4.7
Alabandite	4.0	Polycrase (R)	4.7-5.9
Cervanite	4.0-5.0	Pyrolusite	4.75
Cubanite	4.0-4.2	Braunite	4.8
Gadolinite (R)	4-4.5	Linnaeite	4.8
Ilvaite	4.0	Siegenite	4.8
Libethenite	4	Violarite	4.8
Wurtzite	4	Hausmannite	4.84
Corundum	4.02	Marcasite	4.89
Galaxite (S)	4.03	Bastnaesite(R)	4.9-5.2
Perovskite	4.03	Greenockite	4.9
Lepidocrocite	4.09	Bornite	5.0-5.1
Carnotite	4.1	Euxenite	5-5.9
Chalcopyrite	4.1-4.3	Manganosite	5.0-5.4
Samarskite	4.1-6.2	Monazite	5.0-5.3

MINERALS SORTED BY DENSITY

Name	Density
Polianite	5.0
Pyrite	5.02
Jacobsite (S)	5.1
Franklinite	5.15
Magnetite (S)	5.18
Columbite	5.2-6.7
Miargyrite	5.2-5.3
Hematite	5.26
Linarite	5.3
Millerite	5.3-5.7
Thorite	5.3
Zinkenite (J)	5.3
Cerargyrite	5.5-6
Chalcocite	5.5-5.8
Jamesonite	5.5-6
Proustite	5.55
Plagionite (J)	5.56
Digenite	5.6
Embolite	5.6
Zincite	5.68
Arsenic	5.7
Iodobromite	5.7
Iodyrite	5.7
Allemontite	5.8-6.2
Bournonite	5.8-5.9
Semseyite	5.8
Tenorite	5.8-6.4
Pyrargyrite	5.85
Arsenopyrite	5.9-6.2
Crocoite	5.9-6.1
Danaite	5.9-6.2
Gersdorffite	5.9
Larsenite (Ov)	5.9
Scheelite	5.9-6.1
Boulangerite	6-6.3
Bromyrite	6-6.5
Cuprite	6
Phosgenite	6.0-6.3
Polybasite	6.0-6.2
Ni skutterudite	6.1-6.9
Skutterudite	6.1-6.9
Pearceite	6.15
Anglesite	6.2-6.4
Stephanite	6.2-6.3
Stromeyerite	6.2-6.3
Tantalite	6.2-8
Geocronite	6.3-6.5
Cobaltite	6.33
Microlite	6.33
Menaghinite (J)	6.36
Pyromorphite	6.5-7.1
Wulfenite	6.5-7.5
Cerussite	6.55
Vanadinite	6.7-7.1
Cassiterite	6.8-7.1
Huebnerite (W)	7.0
Mimetite	7.0-7.2
Wolframite	7-7.5
Rammelsbergite	7.1
Acanthite	7.2-7.3
Calomel	7.2
Argentite	7.3
Tin	7.3
Galena	7.4-7.6
Loellingite	7.4-7.5
Nagyagite	7.4
Ferberite (W)	7.5
Awaruite	7.7-8.1
Niccolite	7.78
Nickel iron	7.8-8.2
Bismite	8
Sylvanite	8-8.2
Cinnabar	8.10
Altaite	8.16
Stolzite	8.3-8.4
Hessite	8.4
Krennerite	8.62
Petzite	8.7-9
Minium	8.9-9.2
Uraninite	9-9.7
Calaverite	9.35
Thorianite	9.7
Bismuth	9.8
Silver	10.5
Sperrylite	10.5
Palladium	11.9
Electrum	13.5-17
Mercury	13.6
Platinum	14-19
Gold	15-19.3
Iridosmine	19.3-21
Iridium	22.7

MINERALS SORTED BY HARDNESS

Name	Hardness	Name	Hardness
Boehmite (B)	0 soft	Gypsum	2
Carnotite	0 soft	Hydrozincite	2-2.5
Mercury	0	Jamesonite	2-3
Carnallite	1	Kaolinite	2-2.5
Embolite	1-1.5	Krennerite	2-3
Graphite	1-2	Melanterite	2
Halloysite (C)	1-2	Muscovite (M)	2-2.5
Hectorite (C)	1-1.5	Nacrite (C)	2-2.5
Iodobromite	1-1.5	Nitre	2
Iodyrite	1-1.5	Paragonite (M)	2
Molybdenite	1-1.5	Polybasite	2-3
Montmorillonite	1-1.5	Potash Alum	2-2.5
Nagyagite	1-1.5	Proustite	2-2.5
Nontronite (C)	1-1.5	Sepiolite	2-2.5
Pyrolusite	1-2	Serpentine	2-5
Pyrophyllite	1-2	Stephanite	2-2.5
Saponite (C)	1-1.5	Stibnite	2
Soda nitre	1-2	Sylvite	2
Sternbergite	1-1.5	Tin	2
Talc	1	Torbernite	2-2.5
Ulexite	1	Tyuyamunite	2
Beidellite (C)	1.5	Uranophane	2-3
Calomel	1.5	Biotite (M)	2.5-3
Covellite	1.5-2	Boulangerite	2.5-3
Erythrite	1.5-2.5	Bournonite	2.5-3
Ferrimolybdite	1.5	Bromyrite	2.5
Ice	1.5	Brucite	2.5
Orpiment	1.5-2	Calaverite	2.5
Realgar	1.5-2	Cerargyrite	2.5
Sulphur	1.5-2.5	Chalcanthite	2.5
Sylvanite	1.5-2	Chalcocite	2.5-3
Vermiculite (M)	1.5	Cinnabar	2.5
Vivianite	1.5-2	Clinoclase	2.5-3
Acanthite	2-2.5	Crocoite	2.5-3
Argentite	2-2.5	Cryolite	2.5
Aurichalcite	2	Digenite	2.5-3
Autunite	2-2.5	Galena	2.5
Bismuth	2-2.5	Geocronite	2.5
Borax	2-2.5	Gibbsite	2.5-3.5
Chlorite	2-2.5	Glauberite	2.5-3
Chrysocolla	2-4	Gold	2.5-3
Diatomite	2	Gummite	2.5-5
Dickite (C)	2-2.5	Halite	2.5
Epsomite	2-2.5	Hessite	2.5-3
Garnierite	2-3	Langbeinite	2.5-3.5
Gaylussite	2-3	Lepidolite (M)	2.5-4
Glauconite (M)	2	Linarite	2.5
Goslarite	2-2.5	Menaghinite (J)	2.5

MINERALS SORTED BY HARDNESS

Name	Hardness
Miargyrite	2.5
Minium	2.5
Petzite	2.5-3
Phlogopite (M)	2.5-3
Phosphuranylite	2.5
Plagionite (J)	2.5
Polyhalite	2.5-3
Pyrargyrite	2.5
Roscoelite (M)	2.5
Semseyite	2.5
Silver	2.5-3
Stolzite	2.5-3
Stromeyerite	2.5-3
Thenardite	2.5
Tungstite	2.5
Zinnwaldite	2.5-3
Allemontite	3-4
Allophane (C)	3
Altaite	3
Anglesite	3
Anhydrite	3-3.5
Atacamite	3-3.5
Barite	3-3.5
Bornite	3
Calcite	3
Celestite	3-3.5
Cerussite	3-3.5
Electrum	3
Enargite	3
Eucryptite	?
Greenockite	3-3.5
Iddingsite	3
Jarosite	3
Kainite	3
Kernite	3
Larsenite (Ov)	3
Millerite	3-3.5
Pearceite	3
Phosgenite	3
Tennantite	3-4.5
Tenorite	3-4
Tetrahedrite	3-4.5
Trona	3
Vanadinite	3
Wulfenite	3
Zinkenite (J)	3-3.5
Alabandite	3.4-4
Ankerite	3.5
Annabergite	3.5-3
Antlerite	3.5-4
Aragonite	3.5-4
Arsenic	3.5
Azurite	3.5-4
Brochantite	3.5-4
Chalcopyrite	3.5-4
Cubanite	3.5
Cuprite	3.5-4
Dolomite	3.5-4
Heulandite	3.5-4
Magnesite	3.5-5
Malachite	3.5-4
Margarite (M)	3.5-5
Mimetite	3.5
Pentlandite	3.5-4
Powellite	3.5-4
Pyromorphite	3.5-4
Rhodochrosite	3.5-4.5
Scorodite	3.5-4
Siderite	3.5-4
Sphalerite	3.5-4
Stilbite (Z)	3.5-4
Strontianite	3.5-4
Variscite	3.5-4.5
Wavellite	3.5-4
Witherite	3.5
Alunite	4
Bastnaesite(R)	4-4.5
Cervanite	4-5
Chabazite (Z)	4-5
Colemanite	4-4.5
Crocidolite	4
Fluorite	4
Laumontite (Z)	4
Libethenite	4
Manganite	4
Platinum	4-4.5
Pyrrhotite	4
Riebeckite (A)	4
Stannite	4
Wurtzite	4
Xenotime	4-5
Zincite	4-4.5
Apophyllite	4.5-5
Bismite	4.5
Brannerite	4.5
Gmelinite (Z)	4.5

MINERALS SORTED BY HARDNESS

Name	Hardness
Harmotome (Z)	4.5
Hemimorphite	4.5-5
Linnaeite	4.5-5.5
Palladium	4.5-5
Phillipsite (Z)	4.5-5
Scheelite	4.5-5
Siegenite	4.5-5.5
Triphylite	4.5-5
Violarite	4.5-5.5
Actinolite (A)	5-6
Analcime (Fp)	5-5.5
Apatite	5
Augite (P)	5-6
Awaruite	5
Cancrinite(Fp)	5-6
Datolite	5-5.5
Diopside (P)	5-6
Dioptase	5
Ferberite (W)	5
Goethite	5-5.5
Hedenbergite (P)	5-6
Hornblende	5-6
Huebnerite (W)	5
Hypersthene (P)	5-6
Kyanite	5-7
Lazulite	5-5.5
Lazurite	5-5.5
Lepidocrocite	5
Limonite	5-5.5
Lithiophilite	5
Loellingite	5-5.5
Melilite	5
Monazite	5-5.5
Monticellite	5
Natrolite (Z)	5-5.5
Niccolite	5-5.5
Nickel iron	5
Opal	5-6
Pectolite	5
Pigeonite (P)	5-6
Pyrochlore	5
Samarskite	5-6
Scapolite	5-6
Scolecite (Z)	5-5.5
Skutterudite	5
Smithsonite	5
Sphene	5-5.5
Thomsonite (Z)	5
Thorite	5
Tremolite (A)	5-6
Wolframite	5-5.5
Wollastonite	5-5.5
Allanite	5.5-6
Anatase	5.5-6
Anthophyllite(A)	5.5-6
Arsenopyrite	5.5-6
Bravoite	5.5-6
Bronzite (E)	5.5
Brookite	5.5-6
Chromite	5.5
Cobaltite	5.5
Danaite	5.5-6
Enstatite (P)	5.5
Euxenite	5.5-6.5
Fergusonite (R)	5.5-6.5
Gersdorffite	5.5
Hausmannite	5.5
Hauynite (Fp)	5.5-6
Hematite	5.5-6.5
Ilmenite	5.5-6
Ilvaite	5.5-6
Jacobsite (S)	5.5-6.5
Leucite (Fp)	5.5-6
Manganosite	5.5
Marialite (Sc)	5.5-6
Meionite (Sc)	5.5-6
Microlite	5.5
Nepheline (Fp)	5.5-6
Ni skutterudite	5.5-6
Pargasite (H)	5.5
Perovskite	5.5
Polycrase (R)	5.5-6.5
Rammelsbergite	5.5-6
Rhodonite	5.5-6
Scorzalite	5.5-6
Sodalite (Fp)	5.5-6
Uraninite	5.5
Willemite	5.5
Acmite (P)	6-6.5
Albite (P)	6
Amblygonite	6
Andesine (P)	6
Anorthite (P)	6
Anorthoclase (O)	6
Arfvedsonite(A)	6
Braunite	6-6.5

MINERALS SORTED BY HARDNESS

Name	Hardness
Bytownite (P)	6
Cassiterite	6-7
Celsian (F)	6
Chloritoid (M)	6-7
Chondrodite	6-6.5
Clinoenstatite(E)	6
Clinoferrosilite	6
Clinohumite	6
Clinozoisite	6-6.5
Columbite	6
Cummingtonite	6
Edenite (H)	6
Epidote	6-7
Ferrosilite (P)	6
Franklinite	6
Glaucophane (A)	6-6.5
Hastingsite (H)	6.0
Helvite	6-6.5
Humite	6
Hyalophane (O)	6
Iridium	6-7
Iridosmine	6-7
Kaliophilite	6
Labradorite (P)	6
Lechatelierite	6-7
Magnetite (S)	6
Marcasite	6-6.5
Microcline (F)	6
Mullite	6-7
Norbergite	6
Noselite (Fp)	6
Oligoclase (P)	6
Orthoclase (F)	6
Ottrelite (M)	6-7
Petalite (Fp)	6-6.5
Polianite	6-6.5
Prehnite	6-6.5
Pyrite	6-6.5
Rutile	6-6.5
Sillimanite	6-7
Sperrylite	6-7
Tantalite	6-6.5
Tephroite (Ov)	6
Turquoise	6
Zoisite	6
Axinite	6.5-7
Diaspore	6.5-7
Fayalite (Ov)	6.5
Forsterite (Ov)	6.5
Gadolinite (R)	6.5-7
Garnet (G)	6.5-7.5
Grossularite (G)	6.5
Idocrase	6.5
Jadeite (P)	6.5-7
Olivine (Ov)	6.5-7
Piedmontite	6.5
Pollucite	6.5
Spodumene (P)	6.5-7
Thorianite	6.5
Turgite	6.5
Almandite (G)	7
Andradite (G)	7
Boracite	7
Chalcedony	7
Chert	7
Cordierite	7-7.5
Cristobalite	7
Danburite	7
Dumortierite	7
Flint	7
Pyrope (G)	7
Quartz	7
Rhodolite (G)	7
Spessartite (G)	7
Staurolite	7-7.5
Tourmaline	7-7.5
Tridymite	7
Andalusite	7.5
Beryl	7.5-8
Euclase	7.5
Gahnite (S)	7.5-8
Galaxite (S)	7.5-8
Hercynite (S)	7.5-8
Phenacite	7.5-8
Uvarovite (G)	7.5
Zircon	7.5
Lawsonite	8
Spinel group	8
Topaz	8
Chrysoberyl	8.5
Corundum	9
Diamond	10

METAL CONTENT OF MINERALS

Name	% Metal
Aluminum:	
Bauxite	74
Corundum	53
Antimony:	
Jamesonite	29
Stibnite	71
Arsenic:	
Arsenopyrite	31
Orpiment	61
Realgar	70
Barium: Barite	59
Beryllium: Beryl	5
Bismuth:	
Bismuthinite	81
Chromium: Chromite	46
Cobalt:	
Cobaltite	36
Linnaeite	48
Smaltite	28
Copper:	
Azurite	55
Bornite	63
Chalcocite	80
Chalcopyrite	35
Chrysocolla	36
Covellite	66
Cuprite	89
Malachite	57
Tetrahedrite	52
Iron:	
Hematite	70
Limonite	60
Magnetite	72
Marcasite	46
Pyrite	46
Pyrrhotite	61
Siderite	48
Lead:	
Anglesite	68
Cerussite	77
Galena	87
Magnesium:	
Magnesite	29
Periclase	60
Manganese:	
Pyrolusite	63
Rhodochrosite	62
Rhodonite	48
Mercury:	
Calomel	85
Cinnabar	86
Metacinnabarite	86
Molybdenum:	
Molybdenite	60
Wulfenite	26
Nickel:	
Chloanthite	28
Millerite	65
Niccolite	44
Pentlandite	22
Niobium Pentoxide:	
Columbite-Tantal.	83
Silver:	
Argentite	87
Cerargyrite	75
Polybasite	76
Proustite	65
Pyrargyrite	60
Stephanite	68
Tantalum Pentoxide:	
Columbite-Tantal.	86
Tin:	
Cassiterite	79
Stannite	28
Titanium:	
Illmenite	32
Rutile	60
Tungsten:	
Ferberite	64
Huebnerite	61
Scheelite	64
Wolframite	51
Uranium: % in U_3O_8	85
Vanadium:	
Vanadinite-V_2O_5%	19
% in V_2O_5	56
Zinc:	
Calamine	54
Franklinite	16
Smithsonite	52
Sphalerite	67
Willemite	59
Zincite	80
Zirconium:	
Zircon	50

DISTINCT COLOR MINERALS

Color	Mineral	Composition
Blue–Gray	Chalcocite	Cu_2S
Brass–Yellow	Chalcopyrite	$CuFeS_2$
Brass–Yellow(pale)	Electrum	Au,Ag
	Marcasite	FeS_2
	Millerite	NiS
	Pentlandite	(Fe,Ni)S
	Pyrite	FeS_2
Copper–Pink	Copper	Cu
	Niccolite	NiAs
	Breithauptite	NiSb
Copper–Pink (pale)	Maucherite	Ni_3As_2
	Melonite	$NiTe_2$
Cream	Emplecite	$Cu_2S \bullet Bi_2S_3$
	Calaverite / Krennerite	$(Au,Ag)Te_2$
Gold–Yellow	Gold	Au
Indigo–Blue	Covellite	CuS
Orange–Red	Crocoite	$PbCrO_4$
	Wulfenite	$PbMoO_4$
Pink	Erythrite	$Co_3(AsO_4)_2 \bullet 8H_2O$
	Kunzite	$LiAl(Si_2O_6)$
	Rhodochrosite	$MnCO_3$
	Rhodonite	$Mn(SiO_3)$
Pink to lilac	Lepidolite	$K_2Li_3Al_3(AlSi_3O_{10})_2$
Pink–Buffish	Bornite	Cu_5FeS_4
Pink–Cream	Cobaltite	CoAsS
	Bismuth	Bi
	Pyrrhotite	FeS
	Cubanite	$Cu_2S.Fe_4S_5$
Pink–Gray	Enargite	$Cu_2S \bullet CuS \bullet As_2S_3$
	Famatinite	$Cu_2S \bullet CuS \bullet Sb_2S_3$
	Coloradote	HgTe
Purple	Bornite	Cu_5FeS_4
	Rickardite	Cu_3Te_2
	Umangite	Cu_3Se_3
	Germanite	$Cu_3(Fe,Ge)S_4$
Red	Cinnabar	HgS
	Lepidocrocite	FeO(OH)
	Realgar	AsS
	Zoisite (Thulite)	$Ca_2Al_3(SiO_4)_3(OH)$
Violet	Violarite	$(Ni,Fe)_3S_4$
	Bravoite	$(Ni, Fe)S_2$
Yellow	Carnotite	$K_2(UO_2)_2(VO_4)_2 \bullet nH_2O$
	Orpiment	As_2S_3
	Perovskite	$CaTiO_3$
	Serpentine	$Mg_6(Si_4O_{10})(OH)_8$
	Tyuyamunite	$Ca(UO_2)_2(VO_4)_2$
Yellow–Brown	Jarosite	$KFe_3(OH)_6(SO_4)_2$
Yellow–Green	Autunite	$Ca(UO_2)_2(PO_4)_2 \bullet$ 10 to 12 H_2O
Yellow–Orange	Greenockite	CdS
Yellow–Red	Chondrodite	$Mg_5(SiO_4)_2(F,OH)_2$

MINERAL CRYSTAL SYSTEM

Xtal System	Xtal Class	Xtal Symmetry
Isometric	Hexoctahedral *	C,3A4,4A3,6A2,9P
	Gyroidal	3A4,4A3,6A2
	Hextetrahedral *	3A2,4A3,6P
	Diploidal *	C,3A2,4A3,3P
	Tetartoidal	3A2,4A3
Hexagonal:		
Hexagonal	Dihexagonal-dipyramidal *	C,1A6,6A2,7P
	Hexagonal-trapezohedral	1A6,6A2
	Dihexagonal-pyramidal *	1A6,6P
	Ditrigonal-dipyramidal	1A3,3A2,4P
	Hexagonal-dipyramidal *	C,1A6,1P
	Hexagonal-pyramidal	1A6
	Trigonal-dipyramidal	1A3,1P
Rhombohedral	Hexagonal-scalenohedral *	C,1A3,3A2,2P
	Trigonal-trapezohedral *	1A3,3P
	Ditrigonal-pyramidal *	1A3,3P
	Rhombohedral	C,1A3
	Trigonal-pyramidal	1A3
Tetragonal	Ditetragonal-dipyramidal *	C,1A4,4A2,5P
	Tetragonal-trapezohedral	1A4,4A2
	Ditetragonal-pyramidal	1A4,4P
	Tetragonal-scalenohedral *	3A2,2P
	Tetragonal-dipyramidal	C,1A4,1P
	Tetragonal-pyramidal	1A4
	Tetragonal-disphenoidal	1A2
Orthorhombic	Rhombic-dipyramidal *	C,3A2,3P
	Rhombic-disphenoidal	3A2
	Rhombic-pyramidal *	1A2,2P
Monoclinic	Prismatic *	C,1A2,1P
	Sphenoidal	1A2
	Domatic	1P
Triclinic	Pinacoidal *	C
	Pedial	None

Symmetry values are coded as in the following example:
"C,1A4,4A2,3P" is **C**enter of symmetry, **1 A**xis of **4** fold symmetry, **4 A**xes of **2** fold symmetry, and **3 P**lanes of symmetry.

There are a total of 32 crystal classes, however most minerals crystallize in only 15 of those classes. The 15 common classes are marked with an " * " after their name.
The above data was obtained from *Danas Manual of Mineralogy. by James D. Dana, 1959.*

MINOR ELEMENTS IN SED ROCK

	Average Concentration in parts per million (ppm)				
		Sedimentary Rocks Types			
Element	Earth Crust	Soil	Calcar-eous	Arenac-eous	Argillac-eous
Antimony	0.2	2	...	1	3
Arsenic	1.8	7.5	0.5	0.5	20
Barium	425	300	60	250	450
Beryllium	2.8	0.5-4	...	...	3
Bismuth	0.17	0.8	...	0.3	1
Boron	10	29	18	90	220
Cadmium	0.2	0.3	0.05	...	0.2
Chlorine	130	...	200	...	...
Chromium	100	43	4	70	450
Cobalt	25	10	1	1	18
Copper	55	15	5	10	140
Fluorine	625	300	250	...	550
Gold	0.004	0.002	0.003	0.004	0.004
Iodine	0.5	...	4	0.4	1.7
Iron		21000	3800	9700	46000
Lead	0.004	17	7	10	22
Lithium	20	22	10	15	51
Manganese	950	320	400	152	750
Mercury	0.08	0.056	0.03	0.4	0.8
Molybdenum	1.5	2.5	0.4	0.6	3
Nickel	75	17	3	5	44
Niobium	20	...	0.3	...	20
Phosphorus		300	200	300	740
Platinum Gp	0.006	...	...	...	...
Potassium		11000	2700	10600	12000
Rare Earths			22	17	100
Rhenium	0.0004	0.005	...	0.0003	0.0005
Rubidium	90	35	56	40	143
Selenium	0.05	0.31	0.07	1	0.7
Silver	0.07	0.09	0.20	0.4	250
Strontium	375	67	600	20	260
Sulphur		100-2000	2000	2400	1850
Tantalum	2	...	...	...	0.8
Tellerium	0.001	...	...	...	...
Thallium	0.45	0.1	...	2	2
Thorium	10	13	2	2	12
Tin	2	10	...	...	40
Titanium	5700	5000	400	1200	4500
Tungsten	1.5	1	0.6	...	3
Uranium	2.7	1	2	0.4	4
Vanadium	135	57	10	20	130
Zinc	70	36	12	15	200
Zirconium	165	270	25	260	160

MINOR ELEMENTS IN IGN ROCK

	Average Concentration in parts per million (ppm) Igneous Rocks Types				
Element	Granite/ Rhyolite	Syenite/ Trachyte	Diorite/ Andesite	Gabbro/ Basalt	Ultra Mafic
Antimony	0.2	0.5	0.2	0.15	0.1
Arsenic	1.8	3	2.5	1.7	1.1
Barium	600	1100	230	220	1.0
Beryllium	3.5	3.5	2.0	1	0.1
Bismuth	0.02	...	0.008	0.4	1.0
Boron	13	...	16	8	10
Cadmium	0.1	...	0.01	0.15	0.1
Chlorine	300	400	550	230	...
Chromium	10	1.3	55	225	2700
Cobalt	2.5	1	7	46	140
Copper	13	6	40	90	40
Fluorine	805	...	...	375	60
Gold	0.002	0.003	0.004	0.003	0.006
Iodine	0.17	0.15	0.2	0.11	0.12
Iron	14200	27000	32000	86500	94300
Lead	19	13	15	6	1.2
Lithium	40	30	25	16	0.2
Manganese	425	750	900	1550	1200
Mercury	0.06	...	0.06	0.05	0.008
Molybdenum	1.3	0.6	1.0	1.6	0.3
Nickel	5.0	4	35	135	2000
Niobium	20	35	15	19	11
Phosphorus	630	1300	1300	2000	1000
Platinum Gp	0.009	...	...	0.15	0.4
Potassium	42000	51000	21000	8300	34
Rare Earths	200	...	40	50	20
Rhenium	0.0006	...	0.0005	0.0006	...
Rubidium	276	...	10	32	0.14
Selenium	0.1	0.07	0.07	0.1	0.1
Silver	0.4	...	0.07	0.1	0.06
Strontium	125	...	350	460	15
Sulphur	350	...	...	1000	2000
Tantalum	4.0	2	1.7	0.7	0.2
Tellerium	0.007	...	...	...	...
Thallium	2.3	1.5	0.4	0.3	0.02
Thorium	18	13	8.5	3	0.004
Tin	3.1	...	1.4	1.5	0.5
Titanium	1100	...	7400	12300	2700
Tungsten	1.7	1.2	1.5	0.9	0.3
Uranium	3.7	4.0	2.8	0.6	0.02
Vanadium	40	30	106	240	30
Zinc	50	80	55	100	56
Zirconium	180	500	180	130	43

IGNEOUS ROCK CLASSIFICATION[1]

Potash (K) Feldspar > 2/3 of Total Feldspar

Accessory Minerals: biotite, hornblende, pyroxene, muscovite

Coarse Grain	Fine Grain	Components
Granite	Rhyolite	Quartz > 10%
Syenite	Trachyte	Quartz & Feldspathoid < 10%
XXX Syenite	Phonolite	XXX Feldspathoid > 10%

Potash (K) Feldspar 1/3 to 2/3 of Total Feldspar

Accessory Minerals: biotite, hornblende, pyroxene

Coarse Grain	Fine Grain	Components
Quartz monzonite	Quartz Latite	Quartz > 10%
Monzonite	Latite	Quartz & Feldspathoid > 10%
XXX Monzonite	XXX Latite	XXX Feldspathoid > 10%

Plagioclase Feldspar > 2/3 of Total Feldspar
Potash (K) Feldspar > 10% of Total Feldspar

Accessory Minerals: hornblende, biotite, pyroxene

Coarse Grain	Fine Grain	Components
Granodiorite	Dacite	Quartz > 10%

Soda Plagioclase, Potash Feldspar < 10% of Total Feldspar

Accessory Minerals: hornblende, biotite, pyroxene

Coarse Grain	Fine Grain	Components
Quartz Diorite	Dacite	Quartz > 10%
Diorite	Andesite	Quartz & Feldspathoid < 10%

Calcic Plagioclase, Potash Feldspar < 10% of Total Feldspar

Accessory Minerals: pyroxene, olivine, uralite

Coarse Grain	Fine Grain	Components
Gabbro,anorthosite	Basalt	Quartz & Feldspathoid < 10%
Diabase		Quartz & Feldspathoid < 10%
Theralite	Tephrite	Feldspathoid & Pyroxene > 10%

Minor or No Feldspar – Mainly Pyroxene and/or Olivine

Accessory Minerals: Serpentine, iron ore

Coarse Grain	Fine Grain	Components
Peridotite,dunite	Limburgite	Pyroxene & olivine

Minor or No Feldspar – Mainly FerroMags & Feldspathoids

Accessory Minerals: hornblende, biotite, iron ore

Coarse Grain	Fine Grain	Components
Fergusite,Missourite	Leucite	FerroMags & Feldspathoids

Trap = Dark aphanitic rock, Felsite = Light aphanitic rock
Porphyry is > 50% phenocrysts, porphyritic is < 50% phenocrysts.
XXX is a descriptor, such as "biotite latite" for "XXX latite"

(1) *Classification of Rocks, 1955, Russell Travis, Colorado School Mines, Golden, Colorado.* See this book for more detail.

IGNEOUS ROCK CLASS BY COLOR

There is no standard for the classification of igneous rocks by the percentage of dark minerals, however, the following three classes are most common:

S.J. Shand, 1947, Eruptive Rocks, John Wiley, New York

% Dark Minerals	Class Name
0 to 30	Leucocratic
30 to 60	Mesocratic
60 to 90	Melanocratic
> 90	Hypermelanic

S.J. Ellis, 1948, Minerology Magazine, Vol 28, p447-469

% Dark Minerals	Class Name
0 to 10	Holofelsic
10 to 40	Felsic
40 to 70	Mafelsic
> 70	Mafic

I.U.G.S, Anon, 1973, Geotimes, October 1973, p26-30

% Dark Minerals	Class Name
0 to 35	Leucocratic
35 to 65	Mesocratic
65 to 90	Melanocratic
> 90	Ultramafic

SEDIMENTARY ROCK CLASSES[1]

Grain Size < 1/256 mm - Clastic and Crystalline

Mudstone: Includes claystone and siltstone
Shale: Clay based unit, finely fissile
Argillite: Indurated shale, recrystallized
Bentonite: Clay that swells when wet
Chert: Cryptocrystalline varieties of silica, flint is a variety
Diatomite: Rock made of silica frustules of diatom plants
Limestone: > 80% Calcium carbonate, crystalline
Dolomite: >80% Magnesium carbonate, crystalline
Chalk: Soft lime unit made of microorganism tests, calcite matrix
Caliche: Lime unit formed near surface, calcium carbonate cap
Marlstone: 25 to 75% clay and calcium carbonate
Siderite: Iron carbonate
Coal: Indurated, dense, carbon rock, made from lignite. Types range from bituminous to anthracite to graphite, 8400 btu to 16000+ btu
Phosphorite: Phosphate (Collophane) Rock, massive
Halite (rock salt), Gypsum, & Anhydrite: Massive evaporites

Grain Size 1/256 – 2 mm - Clastic and Crystalline

Oolite: Spherical with concentric or radial structure parts
Limestone: > 80% Calcium carbonate, crystalline
Dolomite: >80% Magnesium carbonate, crystalline
Sandstone: Compacted clastic sediment, usually quartz grains
Arkose: Sandstone with > 25% feldspar grains
Graywacke: Sandstone w/ large quartz and feldspar fragments in a clay matrix, angular frags, well indurated
Subgraywacke: Graywacke w/ less feldspar and more quartz
Peat: Residual of partially decomposed vegetation in a bog
Lignite: Consolidated peat, between peat & coal, <8400 btu

Grain Size > 2 mm - Clastic

Conglomerate: Consolidated & rounded parts
Breccia: Consolidated & angular fragments
Gravel: Unconsolidated & rounded fragments
Rubble: Unconsolidated & angular fragments
Till: Unsorted glacial debris, mix of clay, sand, gravel, boulders

Grain Size 1/256 to >2 mm - Clastic Volcanics

Agglomerate: Consolidated & rounded fragments > 32 mm
Volcanic Breccia: Consolidated & angular fragments > 4mm
Tuff: Consolidated volcanic ash
Ash: Unconsolidated particles < 4 mm

(1) Based in part on classes set up by *Classification of Rocks, 1955, Russell Travis, Colorado School Mines, Golden, CO.*

METAMORPHIC ROCK CLASSES[1]

Primary Minerals

Quartz, feldspar, calcite, dolomite, talc, muscovite, sericite, chlorite, hornblende, serpentine, biotite, pyroxene, actinolite, epidote, olivine, magnetite

Accessory Minerals

Muscovite, sericite, sillimanite, kyanite, cordierite, tremolite, wollastonite, albite, andalusite, garnet, phlogopite, diopside, enstatite, staurolite, glaucophane, anthophyllite, pyrophyllite, chloritoid, actinolite, tourmaline, epidote, chiastolite, olivine, serpentine, chlorite, biotite, graphite, chondrodite, scapolite

Massive / Granular Structure (Contact Metamorphism) Nondirectional – Fine, to Medium, to Coarse Grained:

Hornfels (catch–all term for nondirectional metamorphic unit)
Metaquartzite – primarily quartz, with silica cement
Marble – metamorphosed calcite or dolomite
Serpentine – metamorphosed olivine & pyroxene forming antigorite or chrysotile (asbestos)
Soapstone – massive talc

Lineate / Foliate Structure (Mechanical Metamorphism) Cataclastic:

Mylonite - foliated, fine ground
Augen Gneiss – Augen (eye) structures in a gneissic rock of alternating bands of coarse granular minerals & schist minerals
Flaser Unite – Small lenses of granular material separated by wavy ribbons & streaks of fine crystalline, foliated material

Lineate / Foliate Structure (Regional Metamorphism) Slaty, Phyllitic, Schistose, and Gneissose Structure:

Slate – metamorphosed shale, fissile, slatey cleavage
Phyllite – Argillic unit between slate and schist, silky sheen
Schist – med to coarse grained, mica minerals parallel orientation
Amphibolite – amphibole (hornblende) & plagioclase schist
Gneiss – coarse grained unit of alternating bands of coarse granular minerals & schistose minerals
Granulite – alternating coarse & fine bands of hornblende and mica, very planar schistosity, high temperature unit

Lineate / Foliate Structure (Plutonic Metamorphism) Migmatitic Structure:

Migmatites – mixed unit of metamorphic material, this alternating layers or lenses of granitic and schistose materlal

(1) See previous page footnote for reference.

GEOCHEM DETECTION LIMITS [1]

Element	Lower Detection Limit	Standard Analysis Method
Aluminum	0.1%	Total acid digestion
Antimony	1 ppm	GC, Fusion, organic extraction
Arsenic	1 ppm	GC, Perchloric/nitric, hydride
Barium	0.005%	Lithium meta-borate fusion
Beryllium	0.2 / 0.02 ppm	Perchloric-nitric / 4 acid digestion
Bismuth	0.2 ppm	GC, HCl (soils), Cl2 (rock)
Cadmium	0.2 / 0.02 ppm	Perchloric-nitric / 4 acid digestion
Calcium	0.005%	Lithium meta-borate fusion
Cobalt	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Copper	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Fluorine	0.01%	Fusion, specific ion electrode
Gold	0.002 ppm	GC,Roast, aqua regia, organic extr
Gold	0.005 oz/ton	Fire assay
Gold	0.001 ppm	Fire assay – atomic absorption
Iron	0.005%	Lithium meta-borate fusion
Lead	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Lithium	0.005%	Total acid digestion
Lithium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Magnesium	0.005%	Lithium meta-borate fusion
Manganese	0.005%	Total acid digestion
Manganese	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Mercury	0.01 ppm	GC, Perchloric/nitric, cold vapor
Molybdenum	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Potassium	0.005%	Lithium meta-borate fusion
Rubidium	0.005%	Lithium meta-borate fusion
Rubidium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Silicon	0.1%	Lithium meta-borate fusion, color
Silver	0.05 oz/ton	Fire assay
Silver	0.2 / 0.02 ppm	Perchloric-nitric / 4 acid digestion
Sodium	0.005%	Lithium meta-borate fusion
Strontium	0.005%	Lithium meta-borate fusion
Strontium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Tellurium	0.2 ppm	GC, HBr/Br, organic extraction
Thallium	0.02 ppm	GC, Total digestion, organic extract
Tin	1 ppm	GC, Fusion, organic extraction
Tungsten	1 ppm	GC, Fusion, colorimetric
Uranium	0.2 ppm	GC, Total, extraction, fluorimetric
Uranium	0.2 ppm	GC, 1N nitric, extraction, fluorimetric
Vanadium	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion
Zinc	1 / 0.1 ppm	Perchloric-nitric / 4 acid digestion

GC stands for Standard Geochemical Analysis. There are many more analysis methods available, however, these are common.

(1) Data courtesy of *Cone Geochemical Inc. Denver, Colorado.*

MHOS SCALE OF HARDNESS

Mhos Index	Rock
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Orthoclase
7	Quartz
8	Topaz
9	Corundum
10	Diamond

PARTICLE SIZE DESCRIPTIONS

Size Term	Particle Diameter
Sedimentary Units:	
Boulder	>256 mm
Cobble	64 to 256 mm
Pebble	4 to 64 mm
Granule	2 to 4 mm
Very Coarse Sand	1 to 2 mm
Coarse Sand	1/2 to 1 mm
Medium Sand	1/4 to 1/2 mm
Fine Sand	1/8 to 1/4 mm
Very Fine Sand	1/16 to 1/8 mm
Silt	1/256 to 1/16 mm
Clay	< 1/256 mm
Pyroclastic Units:	
Bomb or block	>32 mm
Lapilli	4 to 32 mm
Coarse Ash	1/4 to 4 mm
Fine Ash	< 1/4 mm
Igneous Rocks:	
Pegmatitic	> 30 mm
Coarse Grained	5 to 30 mm
Medium Grained	1 to 5 mm
Fine Grained	< 1 mm

RICHTER EARTHQUAKE SCALE

Richter Magnitude	Mercalli Intensity	Description
2	I	Usually not felt, detected by instruments.
2	II	Felt by few, especially on upper floors of buildings, detected by instruments.
3	III	Felt noticeably indoors, vibration like a passing vehicle, cars may rock.
	IV	Felt indoors by many, outdoors by few, dishes & doors disturbed, like heavy truck nearby, walls–cracking sound.
4	V	Felt by most people, slight damage; some dishes & windows broken, some cracked plaster, trees disturbed.
5	VI	Felt by all, many frightened and run outdoors, damage minor to moderate.
5 to 6	VII	Everyone runs outdoors, much damage to poor design buildings, minor damage to good design buildings, some chimneys broken, noticed by people driving cars.
6	VIII	Everyone runs outdoors, damage is moderate to major. Damage minor in well designed structures, major in poor designs; chimneys, columns, & walls fall, heavy furniture turned, well water changes; sand & mud ejected.
7	IX	Major damage in all structures, ground cracked, pipes broken, shift foundation.
7 & 8	X	Major damage, most masonry & frame structures destroyed, ground badly cracked, landslides, water sloshed over river banks, rails bent.
8	XI	Almost all masonry structures destroyed bridges fall, big fissures in ground, land slumps, rails bent greatly.
8	XII	Total destruction. ground surface waves seen, objects thrown up into the air. All construction destroyed.

Richter Magnitudes increase energy logarithmically, 10 times for each number jump, so 8 is not twice as large as 4, it is 10,000 times as large! Richter Magnitudes are measured on instruments.

Mercalli Intensity is based on actual observations of the resulting damage, and therefore can not be measured on instruments.

CORE DRILL SPECS

Core Size	Core Diameter Inch	Core Diameter mm	Core Volume cu inch/foot	Hole Diameter Inch	Hole Diameter mm
CONVENTIONAL:					
EX or EWM	0.845	21.5	6.7	1.485	37.7
EXT	0.905	23.0	7.7	1.485	37.7
E17	0.968	24.6	8.8	1.485	37.7
AX or AWM	1.185	30.1	13.2	1.890	48.0
AXT	1.280	32.5	15.4	1.890	48.0
A17	1.310	33.3	16.2	1.890	48.0
BX,BXM,BWM	1.655	42.0	25.8	2.360	59.9
NX, NXM, NXMS, NWM	2.155	54.7	43.8	2.980	75.7
BM	1.281	32.5	15.5	2.360	59.9
BMLC	1.386	35.2	18.1	2.360	59.9
NMLC	2.045	51.9	39.4	2.980	75.7
A19DT	1.156	29.4	12.6	1.890	48.0
A19TT	1.062	27.0	10.6	1.890	48.0
B19DT	1.565	39.8	23.1	2.360	59.9
B19TT	1.500	38.1	21.2	2.360	59.9
N19DT	2.095	53.2	41.4	2.980	75.7
N19TT	2.045	51.9	39.4	2.980	75.7
H19DT	2.500	63.5	58.9	3.783	96.1
H19TT	2.406	61.1	54.6	3.783	96.1
WIRELINE:					
AQ	1.062	27.0	10.6	1.890	48.0
BQ	1.433	36.4	19.3	2.360	59.9
NQ	1.875	47.6	33.1	2.980	75.7
HQ	2.500	63.5	58.9	3.783	96.1
BQ3	1.320	33.5	16.4	2.360	59.9
NQ3	1.775	45.1	29.7	2.980	75.7
HQ3	2.406	61.1	54.6	3.783	96.1
PQ3	3.270	83.1	100.8	4.828	122.6
B18DT	1.565	39.8	23.1	2.360	59.9
B18TT	1.500	38.1	21.2	2.360	59.9
N18DT	2.095	53.2	41.4	2.980	75.7
N18TT	2.045	51.9	39.4	2.980	75.7
H18DT	2.500	63.5	58.9	3.783	96.1
H18TT	2.406	61.1	54.6	3.783	96.1

GEOLOGIC TIME SCALE

Era	Period or System	Epoch, Age or Series	Approximate Million Years Before Present (1)
Phanerozoic Eon:			0 to 600
Cainozoic or Cenozoic:			0 to 65
	Quaternary		0 to 2
	Holocene		0 to 0.011
		Bronze Age	
		Iron Age	
		Neolithic	
		Mesolithic	
	Pleistocene		0.011 to 2
		Paleolithic:	0.01 to start
		Young Pal.	0.01 to 0.033
		Perigordian	0.023 to 0.033
		Middle Pal.	0.033 to 0.07
		Old Pal.	0.07 to start
	Tertiary		2 to 65
	Neogene		2 to 22.5
		Pliocene	2 to 6
		Miocene	6 to 22.5
	Paleogene		22.5 to 65
		Oligocene	22.5 to 36
		Eocene	36 to 58
		Paleocene	58 to 65
Mesozoic			65 to 230
	Cretaceous		65 to 141
	Jurassic		141 to 195
	Triassic		195 to 230
Paleozoic			230 to 600
	Permian		230 to 280
	Carboniferous		280 to 345
	Pennsylvanian		280 to 310
	Mississippian		310 to 345
	Devonian		345 to 395
	Silurian		395 to 435
	Ordovician		435 to 500
	Cambrian		500 to 600
Proterozoic & Archaen:			600 to start
Precambrian Z			600 to 800
Precambrian Y			800 to 1600
Precambrian X			1600 to 2500
Precambrian W or Archaean			2500 to start

(1) Accepted dates vary greatly, these represent an average set.

POCKET REF

Glues, Solvents, Paints & Finishes

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Acrylic Resin	Bonds to anything porous & nonporous, waterproof, very strong, fast setting (3 to 30 min), oil and gas resistant, good gap & hole filling. 2 part – liquid and powder, expensive, tan. Brands: "3 Ton Adhesive" & "P.A.C.", both by Tridox Labs, Philadelphia, PA, F88 Adhesive.
Acrylonitrile	Bonds to anything porous & nonporous, not recommended for wood, flexible, waterproof, similar to rubber cement. 1 part liquid, flammable, brown. Brands: "Pliobond" (Goodyear) by W.J.Ruscoe Co, Akron, Ohio.
Aliphatic Resin (yellow glue)	Use mainly for wood, moisture resistant (not waterproof), very strong, dries translucent, instant sticky but dries 45 min to 24 hrs, high resistance to solvents and heat, sandable, will set at temps from 45°F to 110°F, dries hard, glue can be colored with water soluble dyes. 1 part liquid, non-toxic,non-flammable,no stain. Brands: "Titebond Glue" by Franklin Glue Co, Columbus, Ohio (many others, common glue).
Casein (protein glue)	Use mainly for wood, high water resistance (not waterproof), resistant to oil, grease, gas, good gap filling, set at temps above 32°F, clamps recommended, dries in 8 hours. 1 part powder, mix with water, inexpensive. Brands: "No 30 Casein Glue" by National Casein Co, Chicago, IL.
Cellulose Nitrate	Bonds to many porous & nonporous, good water resistance (not waterproof), fast setting (2 hrs to 24 hrs), moderately high strength (up to 3500 psi), shrinks some on drying. 1 part liquid, flammable, clear to amber. Brands: "Ever Fast Liquid Cement" by Ambroid Co, Taunton, MA and "Duco Cement" by E.I. du Pont de Nemours & Co, Wilmington, DE.
Contact Cement	Bonds to many porous & nonporous but mainly for laminates to wood, water resistant (not waterproof), requires application to both pieces, let dry 40 minutes then put pieces together for an instant bond, moderate to high strength. 1 part liquid, flammable (solvent). Brand: "Weldwood Contact Cement" by Roberts Consolidated Industries, City of Industry, CA and "Veneer Glue" by Albert Constantine & Son Bronx, NY.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Cyanoacrylate Ester	Bonds many materials including metals, rubber, & most plastics, non-porous, oil, water, and chemical resistant, very fast setting (< 5 secs), not a gap filler, poor shock and peel resistance, no clamping needed. Show extreme care when using this glue, IT BONDS SKIN ! 1 part liquid, non-flammable. Brand: "Zip Grip" by Devcon Corp, Danvers, MA and "Permabond" by Edmund Scientific, Barrington, New Jersey.
Epoxy	Bonds to many materials, porous & non-porous, waterproof, resistant to most solvents and acid, setting ranges from very fast (5 min) to very long (weeks), very high strength, usually dries transparent to honey colored, can be thinned & cleaned with acetone, non-shrinking if no thinner, hardens without evaporation (uses chemical reaction & heat). 2 part liquid, non-flammable, not flexible, clear. Brand: Extremely common; for unusual purpose epoxies contact "Miller-Stephenson Chemical Co, Danbury, CT.
Hide Glue – flake	Bonds wood primarily (this is the main glue type used in cabinet work in the past; known as "Hot Glue"), non-staining, fast setting, high strength (2000 psi), not waterproof. Flakes, water mixed, non-flammable, apply hot and be careful of "cold joints" on the work. Brand: "Constantine's Cabinet Flake Glue" by Albert Constantine & Son, Bronx, New York.
Hide Glue – liquid	Bonds to wood primarily, similar to flake Hide Glue but requires no mixing or heating, long setting time, heat resistant, resists most sealers, lacquers, water, mold & varnish, high strength, water resistant, not flexible but not brittle. 1 part liquid, non-flammable, honey color. Brand: "Franklin Liquid Hide Glue" by Franklin Glue Co, Columbus, Ohio.
Hot Melt Glue	Bonds most materials but is primarily suited for plastics, very fast setting time, moderate to no flexibility, not cured by evaporation, medium strength, waterproof. 1 part solid cartridges, non-flammable. Brand: "Hot-Grip" by Adhesive Products Corp, New York, New York.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Latex Combo	Sticks a variety of materials, porous and non-porous, especially good for fabric and paper items, water resistant (some are waterproof), moderate to weak strength, very flexible (becomes a synthetic rubber on set) 1 part liquid or paste, non-flammable. Brand: "Flexible Patch–Stix" by Adhesive Products Corp, New York, New York.
Neoprene Base	Bonds a variety of materials, porous and non-porous but primarily used to bond paneling to walls, water resistant, moderate to high strength, setting time is two part – apply and separate for 10 minutes to increase tack, then join parts, final set 24 hours. 1 part viscous liquid, flammable. Brand: "Weldwood Panel Adhesive" by Roberts Consolidated Industries, City of Industry, CA.
Polyester Resin	Bonds a variety of materials but used mainly with fiberglass cloth to bond to wood for boat hulls and car bodies, waterproof, not flexible, high strength, use at temps from 70° to 80°F, setting time < 30 minutes, color is usually clear to amber but can be tinted, can be sanded and painted. 2 part liquid, flammable, catalyst amount is critical so measure precisely. Brand: Numerous, Fiber-Glass-Evercoat Co Cincinnati, Ohio; Pettit Polyester Resin.
Polyethylene Hot Melt	Sticks to most materials, porous and non-porous, waterproof, moderately strong, very fast setting (< 1 minute), moderately flexible, usually cream colored, some are clear, applied with a special hot melt "gun". 1 part solid cartridges, non-flammable. Brand: Several, USM Corp, Middleton, MA and Swingline Inc, Long Island, New York.
Polysulfide	Bonds to a variety of materials but is primarily for sealing seams, basically a caulking type adhesive that when it dries it is completely waterproof, setting time varies from several days to several weeks depending on humidity, medium strength, when cured it becomes a synthetic rubber, flexible. 1 or 2 part. Brand: "Exide Polysulfide Caulk" by Atlas Minerals, Mertztown, Pennsylvania.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Polyvinyl Acetate Resin (PVA) (Elmers Glue) (White glue)	Bonds primarily wood and paper products, not waterproof, very strong if no moisture, setting times vary from several hours to several days, dries transparent, poor gap filling and do not use where glue must support load, corrodes metal, very common glue. 1 part liquid, non-flammable, white-dries clear. Brand: "Weldwood Presto–Set" by Roberts Consolidated Industries, City of Industry, CA.
Polyvinyl Chloride (PVC)	Bonds glass, china, porcelain, metal, marble, hard plastics, and other materials including some porous (treat both sides for porous), not generally for wood, waterproof, resistant to gas, oil, and alcohol, fast setting (minutes), clean up with lacquer thinner. 1 part liquid, flammable, clear. Brand: "Sheer Magic" by Miracle Adhesives Corp, Long Island, New York.
Resorcinol Resin	Bonds to a variety of materials but is used mainly as a boat building glue (the main one), completely waterproof, thinning and cleanup before setting with alcohol and water, when cured it is resistant to gas, oil, acids, alkalis, and many solvents, setting time varies on temperature – 10 hrs @ 70°F to 3 hours @ 100°F, do not use at temperatures below 70°F, very strong, cures to a very dark color, can be sanded and painted, good gap filler. 2 part – liquid & powder, caustic powder, red. Brand: "Weldwood Resoricinol Waterproof Glue", by Roberts Consolidated Industries, City of Industry, California.
Rubber Base	Bonds to almost anything, porous or non-porous, waterproof, moderately flexible, good gap filling, setting time 24 hours, 1 part viscous liquid. Brand: "Black Magic Tough Glue" by Miracle Adhesives Corp, Long Island, New York.
Silicon Base	Although this group is primarily a sealer or caulking compound, it does have adhesive characteristics, porous or non-porous, mod. to weak strength, waterproof, setting time from 2 hours to 2 days, can withstand temps of 400 to 600°F, flexible, resists oil & some solvents. 1 part viscous liquid, non-flammable. Brand: "Hi Temp Silicone" by General Electric.

GLUE TYPES & APPLICATIONS

Glue Type	Characteristics (1)
Urea–Resin Glue (Plastic-Resin)	Bonds wood primarily, resistant to water, oil, gas, and many solvents when cured, setting time ranges from 3 to 7 hours (less at high temperatures), very high strength (stronger than wood usually), not a gap filler, non-staining, light tan to black color. Powder, mix with water to form cream. Brand: "Weldwood Plastic Resin Glue" by Roberts Consolidated Industries, City of Industry, California.
Water–Phase Epoxy	Bonds to many materials but is used primarily with fiberglass as a repair tool, water soluble when liquid and completely waterproof when hard, med to high strength, fast setting < 30 minutes, can be sanded and painted 2 part liquid. Brand: "Dur–A–Poxy" by Dur–A–Flex, Hartford Connecticut.

Other Glues

Albumin Glue	Made from blood and casein, used in plywood not as strong as animal glues, doesn't resist mold and fungi.
Bone Glue	Made from bones, used mostly in making of cartons and paper boxes, there are 15 grades of Bone Glue based on quality of raw material, the method of extraction and the blend. Green Bone Glue is used for gummed paper and tapes for cartons.
Cellulose Acetate	Typically used as the bonding cement for the soles of shoes. 10 psi strength.
Ceramic Adhesive	Made with porcelain enamel grit, iron oxide, & stainless steel powder. Heat resistant to 1500°F, shear strength of 1500 psi, must be heated to 1750°F in order to cure.
Fish Glue	Made from the jelly separated from fish oil or the solutions of the skins. It is used mainly for photo mounting, gummed paper, household use and in paints. The best Fish Glue is made from Russian isinglass.
Furan Cement	Made with furfural alcohol resins and is very strong and highly resistant to chemicals. Commonly used for bonding acid resistant brick and tile.
Latex Pastes	Rub-off latex, used mainly in photographic mounting, does not shrink.

Pyroxylin Cement	Solution of nitrocellulose in a solvent which is sometimes mixed with resin, gum or synthetic, poor tack but excellent adhesion to almost everything. Typically called household cement.
Soybean Glue	Made from soybean cake, used in plywoods, better water resistance than most vegetable pastes and better adhesive power.
Tapioca Paste	Typically known as vegetable glue, it is used in cheap plywoods, postage stamps, envelopes, and labels. Quick tack and cheap, but deteriorates.
Ultraviolet Glue	Glues that are liquid on application and do not cure until exposed to ultraviolet light, typically used for glass bonding.

(1) In all of the above glue descriptions, the term "wood" also refers to "wood products" such as plywood, particle board, and aspen board.

Hints and general rules:

1. Apply glues and adhesives to clean, dry surfaces.
2. Drying times can usually be reduced by increasing the temperature. 70°F or higher is generally preferred.
3. Be careful of the solvents and catalysts used in many adhesives, most are toxic and can also hurt your eyes.
4. Hardwoods require less clamping time than softwoods.
5. The end grain of any wood is highly absorbent and will create a weak joint. To prevent this, apply a thin coat of glue to the end grain before the rest of the work and then give it a second coat when doing the normal gluing.
6. Precision alignment of parts glued with contact cement can be obtained by placing a thin sheet of paper between the pieces after the cement has been applied and is no longer tacky, align the pieces, press together and then pull out the piece of paper for final bonding.
7. Don't glue green or damp wood.
8. Clamp glue joints whenever possible to be safe.
9. Don't apply too much glue, this can actually weaken a joint in some cases. FOLLOW DIRECTIONS.

An excellent book of common glues and adhesives is *Home and Workshop Guide to Glues and Adhesives, 1979, by George Daniels, Popular Science, Harper & Row, New York.* It contains an abundance of info on glue types, glue techniques, and hints and is and absolute must for the good reference library!

SOLVENTS

A solvent is a material, usually a liquid, that has the power to dissolve another material and form a homogeneous mixture known as a solution. There are literally thousands of solvents available commercially but most are not readily available to the average person. The following list of solvents are readily available in hardware stores and provide an excellent range of capabilities. Note that most of these are toxic and flammable, so exercise caution when using them and keep out of the reach of children. NOTE: These have been arranged in an approximate order of "strength", ie, top of the list dissolves a lot of plastics in particular.

Solvent	Characteristics
Lacquer Thinner	A mixture of toluene, isopropanol, methyl isobutyl keytone, acetone, propylene glycol, monomethyl ether acetate and ethyl acetate. Photochemically reactive. Used to thin lacquers and epoxies but can be used as a general cleaner and degreaser also. Highly flammable. Dissolves or softens many plastics.
Acetone	2–Propanone or Dimethyl ketone is the actual chemical, CH_3COCH_3 , soluble in water and alcohol, non–photochemically reactive; used to clean and remove epoxy resins, polyester, ink, adhesives, contact cement, and fiberglass cleanup. Dissolves or softens many plastics.
Finger Nail Polish Remover	Mixture of acetone, cocamidopropyl dimethylamine propionate, and amp isostearic hydrolyzed animal protein. Good for various apps., dissolves plastics.
Weldwood Cleaner & Solvent	Mixture of 1,1,1 Trichloroethane (methyl – chloroform CH_3CCl_3) and Dichloromethane (CH_2Cl_2) A very powerful solvent that is typically used with adhesives, non–photochemically reactive, this solvent will clean up brushes and tools that have dried adhesives on them if you let them soak for an hour. Good for cleaning rubber platins, rollers and other parts in printers and type–writers. Dissolves or softens some plastics Avoid breathing fumes for long periods.
Plastic Cement	Methyl ethyl keytone or 2–Butanone, $CH_3CH_2COCH_3$, soluble in water and alcohols, actually a solvent that dissolves plastic and is typically used in making model airplanes.

SOLVENTS

Methylene Chloride	Dichloromethane, CH_2Cl_2, not a very common solvent but when mixed with xylene (dimethylbenzene) makes a strong solvent for things like crayon marks, lipstick, ink, magic marker, gum, latex, oil, and wax. Dissolves or softens some plastics. Marketed as "Klean–Clean" by Klean–Strip, W.W. Barr Inc, Memphis, TN.
Naptha	Naphthalene, slight smell but good for some applications, non–photochemically reactive. Very fast evaporation.
Turpentine (Paint thinner)	"Steam Distilled" or "Gum Spirits", made from pine trees; used as a thinner and cleaner for oil based paint, varnish, enamel, and stain. Photochemically reactive.
Solvent Alcohol	Methanol or Methyl Alcohol or wood alcohol, CH_3OH, non–photochemically reactive, poisonous, used primarily as a thinner for shellac and shellac base primers. Do not use with oil or latex paints, stains, or varnishes. Also used in marine alcohol stoves, soluble in water and other alcohols. Can be mixed with gasoline in the gas tank to eliminate moisture problems (1/2 pint per 15 gallons). Good cleaner for computer plastic parts.
Freon	Trichlortrifluoroethane, Freon TF, available in spray cans, non–flammable, non–conductive, low toxicity, odorless and does not attack plastic, rubber, paints or metal; low surface tension, evaporates fast. Although not commonly seen, freon is an excellent solvent and is typically used to clean electrical connectors and computer components.
Denatured Alcohol	Ethyl or grain alcohol made unfit for drinking by the addition of compounds. Soluble in water and other alcohols. Non–photochemically reactive, typically used to thin shellac, clean glass and metal, to clean ink from rubber rollers, and as a fuel in marine stoves. To clean glass, porcelain and piano keys, mix 1:1 with water.
Rubbing Alcohol (Isopropyl)	2–Propanol is the actual chemical, $CH_3CHOHCH_3$, soluble in water and other alcohols, general cleaner and disinfectant, specifically used to clean tape recorder heads and computer disk drive heads.

PAINTS AND FINISHES

Type	Characteristics
House Paints	There are basically 5 groups of house paints. Oil Base, Alkyd, Emulsion, Water Thinned, and Catalytic. Each of these classes is subdivided into Exterior and Interior.
Oil Base	Interior and Exterior, oil vehicle, thinned by solvents such as turpentine and mineral spirits, very slow drying, strong smell. Mainly used as Exterior paint. Use in well ventilated area. Good adhesion to chalky surfaces.
Alkyd	Synthetic oil vehicle of a resin known as Alkyd. Interior and Exterior enamels, easy to apply, fast drying, odorless, and produce a tough coating. Easy cleanup and thinning with mineral spirits. Excellent interior paint, not resistant to chemicals, solvents, or corrosives.
Emulsion	Water based paint mixture. Latex paints fall into this category and the most common are acrylic and vinyl (PVA). Available as interior and exterior, and as flat, gloss, and semigloss enamels. Very quick drying (sometimes less than 1 hour) but do not wash for 2 to 4 weeks, paints over damp surfaces, odorless, alkalis resistant, doesn't usually blister and peel. Excellent cover and blending characteristics, but poor adhesion to chalky surfaces, easy cleanup. Use special latex primers for painting bare wood. Paint at temperatures above 45°F. By far the most popular paint today.
Water–Thinned	Generally used to describe non–emulsion paint such as calcimine and casein and white wash. These paints are used primarily on masonry surfaces. The most common water thinned paint being Portland Cement Paints.
Catalytic	This class of paints cures by a chemical heat process, not by evaporation of a solvent or water as in the other paints. Catalytic paints are usually two part paints which means that you have to mix two

Type	Characteristics
	parts to start the curing process. Included in this class are the epoxy and polyurethane resins. They are extremely tough and durable and are highly resistant to water, wear, acids, solvents, abrasion, salt water, and chemicals. Drying times are very fast (several hours). Good ventilation is necessary when working with these paints. Catalytic paints can not be applied over other paint types. Follow the manufacturers instructions very closely, these are not easy paints to use.

House paints are further subgroupped into Exterior and Interior types as described below:

Type	Characteristics
Exterior Paint	These paints are designed to have long life spans, good adhesion and resistance to moisture, ultraviolet light, mildew, and sulfide and acid fumes. This class also includes the varnish and stain groups described later. Never use interior paints in place of exterior paints, they will not hold up under the weather.
Interior Paint	Interior paints are designed to maximize the hiding ability of the paint with only 1 or 2 coats. Flat paints contain more pigment than high sheen paints but are less durable. Good interior paints can be touched up easily without major changes in the sheen or color.
Varnish	Varnish is a solution of a hard resin, a drying oil, metallics for driers, and solvent. There are two types, natural and synthetic. Natural types are slow drying (24 to 48 hrs) and are subclassed as "long oil" (meaning high oil content) and "short oil" (meaning less oil content). Naturals are tough and used mainly for exterior and marine applications. Synthetics contain resins such as alkyd (the most common), polyurethane, vinyl, and phenolic and are more durable and faster drying than naturals. Apply with natural bristle brushes; apply 3 to 4 coats

Type	Characteristics
	total, let dry between coats and sand with 240 grit sandpaper. Varnishes are usually transparent and are excellent sealers.
Shellac	Shellac is one of the oldest wood finishes. It is made from a mixture of the dry resinous secretions of the lac bug (SE Asia) and alcohol. Once mixed, shellac has a very short shelf life, so store it in flake form. Shellac is mixed in what is called a "cut". A "3 pound cut" is 3 pounds of shellac in 1 gallon of alcohol. Initial coats are typically 1 or 2 pound cuts. Shellac is applied with a brush and the better finishes use 6 to 8 coats. Each coat should be sanded with 220 to 240 grit sand paper after it has dried (1 to 2 hours). The final coat is typically rubbed out with a fine 3/0 steel wool.
<u>Automotive Paints:</u>	
Urethane Enamel	The best of the car finishes, lasts over 10 years, has the best look, and is the most expensive. Paint jobs can run over $1000 and paint cost alone ranges from $50 to $100 per gallon.
"Clear Coat"	This is the top coat of a two part paint. The Clear Coat is applied over a base coat of acrylic enamel or acrylic lacquer and produces a beautiful "wet look" finish just like a factory paint job. This type of finish is very difficult to apply and should be done by an expert. Has a life of 8 to 10 years and costs between $400 & $600.
Acrylic Lacquer .	Mid range auto paint, very fast drying, much higher gloss and better durability than the alkyd enamels. Must be machine polished after drying so it is more expensive than the Acrylic Enamel paints. Acrylic lacquer must not be painted over acrylic enamel.Expect to pay $300 to $500 for this paint job. Life span is 5 to 7 years.

PAINTS AND FINISHES

Type	Characteristics
Acrylic Enamel	Mid range auto paint, very slow drying, much higher gloss and better durability than the alkyd enamels and acrylic lacquer. Acrylic enamel should not be painted over acrylic lacquer. Usually requires a heat booth to aid drying. Expect to pay \$200 to \$300 for a paint job.
Alkyd Enamel	Cheap paint with low durability (will sometimes loose its gloss in less than 2 months). Paint life will only be 1 to 3 years. The paint job will probably only cost \$100 to \$200 and is commonly referred to as the "baked enamel" job since the vehicle is baked at 150°F in a heat booth to set the paint.
Lacquer	Lacquer is a fast–drying, high gloss varnish used by most furniture manufacturers as the top–coat finish. It is very hard, dries crystal clear and is highly resistant to alcohols, water, heat, and mild acids. Although the original lacquers came from insects and the sumac tree, almost all produced today are synthetic and are mixed with some combination of resins (better adhesion), nitrocellulose, linseed or castor oil (improves flexibility), vinyls, acrylics or synthetic polymers. The main problem with lacquers is that they dry so fast that it is sometimes difficult to get a good finish. Use a spray gun if possible. Multiple coats are usually necessary
Primers	Primers are paints intended to produce a good foundation for the overlying coats of paint. Exterior wood primers penetrate deeply into the surface, adhere tightly to the surface, and seal off the wood. Primers typically have an abundance of pigment to allow sanding if necessary. Metal primers are specifically designed to adhere to the metal and stop any oxidation (rusting). Automotive primers usually have a lot of resin included also.

PAINTS AND FINISHES

Type	Characteristics
Oils	Penetrating oils such as linseed oil, tung oil, and Danish rubbing oil make up a class of finishes that protect wood while leaving the grain and natural texture visible. Oils won't crack, chip, or scale off and provide a beautiful surface. The addition of resins such as polyurethane greatly increase the toughness of the surface and still maintain the clear finish. The oils are applied with a soft rag, allowed to sit for 30 minutes to allow the oil to soak in, then buffed with a soft clean rag. Buffing with fine 4/0 steel wood will improve the sheen.

Miscellaneous:

Fire–Retardants	Paints that decompose by melting into a thick mass of cellular charred material that insulates the material it is painted on. The decomposition begins at a temperature below the combustion point of the substrate; ratings are based on the ability to suppress combustion.
Floor Paint	Specialized coatings that hard substances such as epoxy and phenolic modified alkyds, chlorinated rubber, & varnish. The coatings must also be water resistant.
Texture Paint	Interior coatings for ceilings and walls that produce a matte finish. They can contain sand, styrene fragments, nut shells, perlite, volcanic ash, or any other coarse material.
Two Part Paints	This class of paint is generally expensive & includes the epoxies, polyesters, urethanes, and styrene–solubilized polyesters. They are all thermosetting, i.e. they cure by heat once a reactant has been added. These paints are extremely tough and durable and chemically resistant.

POCKET REF

Hardware

(See also TOOLS, page 361, for drill, tap, & die info)

BOLT TORQUE SPECIFICATIONS

				
Bolt Size Inches	Coarse Thread / inch	SAE 0–1–2 74,000 psi Low Carbon Steel	SAE Grade 3 100,000 psi Med. Carbon Steel	SAE Grade 5 120,000 psi Med.Carbon Heat T. Steel
		Standard Dry Torque in Foot–Pounds		
1/4	20	6	9	10
5/16	18	12	17	19
3/8	16	20	30	33
7/16	14	32	47	54
1/2	13	47	69	78
9/16	12	69	103	114
5/8	11	96	145	154
3/4	10	155	234	257
7/8	9	206	372	382
1	8	310	551	587
1–1/8	7	480	872	794
1–1/4	7	675	1211	1105
1–3/8	6	900	1624	1500
1–1/2	6	1100	1943	1775
1–5/8	5.5	1470	2660	2425
1–3/4	5	1900	3463	3150
1–7/8	5	2360	4695	4200
2	4.5	2750	5427	4550

In order to determine the torque for a fine thread bolt, increase the above coarse thread ratings by 9%.

Effect of Lubrication on Torque

	Torque Rating in Foot–Pounds	
Lubricant	5/16–18 thread/inch	1/2–13 thread/inch
NO LUBE, steel	29	121
Plated & cleaned	19 (66%)	90 (26%)
SAE 20 oil	18 (38%)	87 (28%)
SAE 40 oil	17 (41%)	83 (31%)
Plated & SAE 30	16 (45%)	79 (35%)
White grease	16 (45%)	79 (35%)
Dry Moly film	14 (52%)	66 (45%)
Graphite & oil	13 (55%)	62 (49%)

Use the above lubrication percentages to calculate the approximate decrease in torque rating for other bolt sizes.

BOLT TORQUE SPECIFICATIONS

Bolt Size Inches	Coarse Thread / inch	 SAE Grade 6 133,000 psi Med Carbon Temp. Steel	 SAE Grade 7 133,000 psi Med. Carbon Alloy Steel	 SAE Grade 8 150,000 psi Med.Carbon Alloy Steel
		Standard Dry Torque in Foot-Pounds		
1/4	20	12.5	13	14
5/16	18	24	25	29
3/8	16	43	44	47
7/16	14	69	71	78
1/2	13	106	110	119
9/16	12	150	154	169
5/8	11	209	215	230
3/4	10	350	360	380
7/8	9	550	570	600
1	8	825	840	700
1-1/8	7	1304	1325	1430
1-1/4	7	1815	1825	1975
1-3/8	6	2434	2500	2650
1-1/2	6	2913	3000	3200
1-5/8	5.5	3985	4000	4400
1-3/4	5	5189	5300	5650
1-7/8	5	6980	7000	7600
2	4.5	7491	7500	8200

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%.

Grades over Grade 8 are not common commercially, except in aircraft use. The following are a few of those types:

- Supertanium, 160,000 psi, 8 points on head, quenched and tempered special alloy steel.
- A354BD;A490, 150,000 psi, no markings, med. carbon quenched and tempered steel.
- N.A.S. 144, MS2000, Military and Aircraft Std, 160,000 psi, high carbon alloy, quenched and tempered.
- N.A.S. 623, National Aircraft Standard, 180,000 psi, high carbon alloy, quenched and tempered.
- Aircraft Assigned Steel, no number, 220,000 psi, high carbon alloy, quenched and tempered.

Torque ratings for the above special alloy bolts should be obtained from the manufacturer.

BOLT TORQUE SPECIFICATIONS

Bolt Size Inches or Number	Coarse Thread / inch	Allen Head 160,000 psi High Carbon CaseH Steel	Machine Scr. 60,000 psi Yellow Brass	Machine Scr. 70,000 psi Silicone Bronze
		Standard Dry Torque in Foot–Pounds		
#2	56	...	2 in#	2.3 in#
#3	48	...	3.3 in#	3.7 in#
#4	40	...	4.4 in#	4.9 in#
#5	40	...	6.4 in#	7.2 in#
#6	32	21	8 in#	10 in#
#8	32	46	16 in#	19 in#
#10	24	60	20 in#	22 in#
1/4	20	16	65 in#	70 in#
5/16	18	33	110 in#	125 in#
3/8	16	54	17	20
7/16	14	84	27	30
1/2	13	125	37	41
9/16	12	180	49	53
5/8	11	250	78	88
3/4	10	400	104	117
7/8	9	640	160	180
1	8	970	215	250
1–1/8	7	1520	325	365
1–1/4	7	2130	400	450
1–3/8	6	2850	...	...
1–1/2	6	3450	595	655
1–5/8		4700	...	...
1–3/4	5	6100	...	...
1–7/8		8200	...	...
2	4-1/2	8800	...	...

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%.

Socket Set Screws (looks like an allen head without the head) are usually rated at 212,000 psi, and are high carbon, case hardened steel. Torque ratings are as follows: #6 = 9 in-lbs, #8 = 16 in-lbs, #10 = 30 in-lbs, 1/4 in = 70 in-lbs, 5/16 in = 140 in-lbs, 3/8 in = 18 ft-lbs, 7/16 in = 29 ft-lbs, 1/2 in = 43 ft-lbs, 9/16 in = 63 ft-lbs, 5/8 in = 100 ft-lbs, and 3/4 in = 146 ft-lbs.

BOLT TORQUE SPECIFICATIONS

METRIC

Bolt Size Milli-meters	Coarse Thread Pitch	5D Standard 5D 71,160 psi Med Carbon Steel	8G Standard 8G 113,800 psi Med Carbon Steel	10K Standard 10K 142,000 psi Med Carbon Steel
		Standard Dry Torque in Foot-Pounds		
6 mm	1.00	5	6	8
8 mm	1.00	10	16	22
10 mm	1.25	19	31	40
12 mm	1.25	34	54	70
14 mm	1.25	55	89	117
16 mm	2.00	83	132	175
18 mm	2.00	111	182	236
22 mm	2.50	182	284	394
24 mm	3.00	261	419	570

METRIC

Bolt Size Milli-meters	Coarse Thread Pitch	12K Standard 12K 170,674 psi Med Carbon Steel
		Standard Dry Torque in Foot-Pounds
6 mm	1.00	10
8 mm	1.00	27
10 mm	1.25	49
12 mm	1.25	86
14 mm	1.25	137
16 mm	2.00	208
18 mm	2.00	283
22 mm	2.50	464
24 mm	3.00	689

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%. See first page of Bolt Torque Specifications for information on the Effects of Lubrication on Bolt Torque.

BOLT TORQUE SPECIFICATIONS

Whitworth

Bolt Size Inches	Coarse Thread / inch	Grades A & B 62,720 psi Med Carbon Steel	Grade S 112,000 psi Med Carbon Steel	Grade T 123,200 psi Med Carbon Steel
		Standard Dry Torque in Foot–Pounds		
1/4	20	5	7	9
5/16	18	9	15	18
3/8	16	15	27	31
7/16	14	24	43	51
1/2	12	36	64	79
9/16	12	52	94	111
5/8	11	73	128	155
3/4	11	118	213	259
7/8	9	186	322	407
1	8	276	497	611

Whitworth

Bolt Size Inches	Coarse Thread / inch	Grade V 145,600 psi Med Carbon Steel		
		Standard Dry Torque in Foot–Pounds		
1/4	20	10		
5/16	18	21		
3/8	16	36		
7/16	14	58		
1/2	12	89		
9/16	12	128		
5/8	11	175		
3/4	11	287		
7/8	9	459		
1	8	693		

In order to determine the torque for a fine thread bolt increase the above coarse thread ratings by 9%. See first page of Bolt Torque Specifications for information on the Effects of Lubrication on Bolt Torque.

WOOD SCREW SPECIFICATIONS

Screw Number	Pilot Hole Sizes Hard Wood Drill Number	Pilot Hole Sizes Soft Wood Drill Number	Shank Diameter Inches	Shank Hole Clearance Drill Number
0	66	75	0.060	52
1	57	71	0.073	47
2	54	65	0.086	42
3	53	58	0.099	37
4	51	55	0.112	32
5	47	53	0.125	30
6	44	52	0.138	27
7	39	51	0.151	22
8	35	48	0.164	18
9	33	45	0.177	14
10	31	43	0.190	10
11	29	40	0.203	4
12	25	38	0.216	2
14	14	32	0.242	D
16	10	29	0.268	I
18	6	26	0.294	N
20	3	19	0.320	P
24	D	15	0.372	V

See the chapter on Tools for additional drill information and Drill Number to Inch conversions.

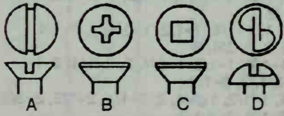
Wood Screw Number vs Std Lengths

Screw Number	Standard Lengths in Inches
0	1/4
1	1/4, 3/8
2	1/4, 3/8, 1/2
3	1/4, 3/8, 1/2, 5/8
4	3/8, 1/2, 5/8, 3/4
5	3/8, 1/2, 5/8, 3/4
6	3/8, 1/2, 5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2
7	3/8, 1/2, 5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2
8	1/2, 5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2
9	5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4
10	5/8, 3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4 2-1/2
11	3/4, 7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3
12	7/8, 1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3, 3–1/2
14	1, 1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4 3, 3–1/2, 4, 4-1/2
16	1–1/4, 1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3 3–1/2, 4, 4–1/2, 5, 5–1/2
18	1–1/2, 1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3, 3-1/2,4 4–1/2, 5, 5–1/2, 6
20	1–3/4, 2, 2–1/4, 2–1/2, 2–3/4, 3, 3–1/2, 4, 4-1/2 5, 5–1/2, 6
24	3–1/2, 4, 4–1/2, 5, 5–1/2, 6

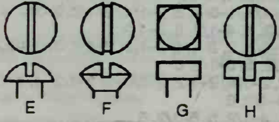
SHEET METAL SCREW SPECS

Screw Diameter # (inch)	Thickness of Metal Gauge #	Diameter of Pierced Hole (inch)	Drilled Hole Size Drill Number
	28	0.086	44
	26	0.086	44
#4 (0.112)	24	0.093	42
	22	0.098	42
	20	0.100	40
	28	0.111	39
	26	0.111	39
#6 (0.138)	24	0.111	39
	22	0.111	38
	20	0.111	36
	28	0.121	37
	26	0.121	37
#7 (0.155)	24	0.121	35
	22	0.121	33
	20	0.121	32
	18	....	31
	26	0.137	33
	24	0.137	33
#8 (0.165)	22	0.137	32
	20	0.137	31
	18	....	30
	26	0.158	30
	24	0.158	30
#10 (0.191)	22	0.158	30
	20	0.158	29
	18	0.158	25
	24	....	26
	22	0.185	25
#12 (0.218)	20	0.185	24
	18	0.185	22
	24	....	15
	22	0.212	12
#14 (0.251)	20	0.212	11
	18	0.212	9

Note: The above values are recommended average values only. Variations in materials and local conditions may require significant deviations from the recommended values.



A. Flat head
B. Phillips head
C. Square head
D. Security head



E. Round head
F. Oval head
G. Square head
H. Pan head

CABLE CLAMPS FOR WIRE ROPE

Rope Diameter Inches	Number of Clamps Required	Clip Spacing Inches	Rope Turn-back Inches
1/8	2	3	3–1/4
3/16	2	3	3–3/4
1/4	2	3–1/4	4–3/4
5/16	2	3–1/4	5–1/4
3/8	2	4	6–1/2
7/16	2	4–1/2	7
1/2	3	5	11–1/2
9/16	3	5–1/2	12
5/8	3	5–3/4	12
3/4	4	6–3/4	18
7/8	4	8	19
1	5	8–3/4	26
1–1/8	6	9–3/4	34
1–1/4	6	10–3/4	37
1–7/16	7	11–1/2	44
1–1/2	7	12–1/2	48
1–5/8	7	13–1/4	51
1–3/4	7	14–1/2	53
2	8	16–1/2	71
2–1/4	8	16–1/2	73
2–1/2	9	17–3/4	84
2–3/4	10	18	100
3	10	18	106

The above Number of Clamps and Spacing is based on data for Crosby–Laughlin clamps, Fort Wayne, Indiana, A Division of American Hoist. If more specific or detailed information is needed, contact Crosby–Laughlin. The data assumes approximately 80% efficiency and is based on the estimated breaking strength of a right regular or Lang lay wire rope in the 6 x 19 or 6 x 37 class.

When placing cable clamps on the wire, it is imperative that the U–bolt side of the clip is placed on the short, turn–back side and the saddle goes on the long side (the "live" end). Torque the nuts down to the specified torque for the particular U–bolt diameter, place a load on the wire, and then re–torque the clamps. If torque specs are not available from the manufacturer, refer to page number 249 in the HARDWARE chapter for approximate torque ratings.

NAILS

The "d" listed after each Size Number stands for "penny", which was originally used in old England as a way of describing the number of pennies needed to buy 100 nails. Today, "penny" is used only to define the length of the nail.

COMMON NAILS
For General Construction

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, inches	Number per Pound
2d	1	15 (0.072)	11/64	840
3d	1-1/4	14 (0.080)	13/64	530
4d	1-1/2	12-1/2 (0.095)	1/4	300
5d	1-3/4	12-1/2 (0.095)	1/4	260
6d	2	11-1/2 (0.113)	17/64	170
7d	2-1/4	11-1/2 (0.113)	17/64	150
8d	2-1/2	10-1/4 (0.131)	9/32	105
9d	2-3/4	10-1/4 (0.131)	9/32	95
10d	3	9 (0.148)	5/16	65
12d	3-1/4	9 (0.148)	5/16	60
16d	3-1/2	8 (0.162)	11/32	44
20d	4	6 (0.192)	13/32	30
30d	4-1/2	5 (0.207)	7/16	22
40d	5	4 (0.225)	15/32	18
50d	5-1/2	3 (0.244)	1/2	14
60d	6	2 (0.263)	17/32	10

BOX NAILS
For Light Construction

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, inches	Number per Pound
2d	1	15-1/2 (0.067)	11/64	1010
3d	1-1/4	14-1/2 (0.073)	13/64	620
4d	1-1/2	14 (0.080)	1/4	450
5d	1-3/4	14 (0.080)	1/4	375
6d	2	12-1/2 (0.095)	17/64	230
7d	2-1/4	12-1/2 (0.095)	17/64	200
8d	2-1/2	11-1/2 (0.109)	9/32	130
10d	3	10-1/2 (0.128)	5/16	88
12d	3-1/4	10-1/2 (0.128)	5/16	80
16d	3-1/2	10 (0.135)	11/32	70
20d	4	9 (0.148)	13/32	52
30d	4-1/2	9 (0.148)	7/16	45
40d	5	8 (0.162)	15/32	35

COMMON WIRE SPIKES

For Heavy Construction

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, Gauge	Number per Pound
10d	3	6 (0.192)	3	43
12d	3–1/4	6 (0.192)	3	39
16d	3–1/2	5 (0.207)	2	31
20d	4	4 (0.225)	1	23
30d	4–1/2	3 (0.244)	0	18
40d	5	2 (0.263)	2/0	14
50d	5–1/2	1 (0.283)	3/0	11
60d	6	1 (0.283)	3/0	9
5/6 in	7	(0.312)	0.370 in	7
3/8 in	8–1/2	(0.375)	0.433 in	4

CASING NAILS

For Interior Trim

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, Gauge	Number per Pound
3d	1–1/4	14–1/2 (0.073)	11–1/2	625
4d	1–1/2	14 (0.080)	11	490
6d	2	12–1/2 (0.095)	9–1/2	250
8d	2–1/2	11–1/2 (0.113)	8–1/2	145
10d	3	10–1/2 (0.128)	7–1/2	95
16d	3–1/2	10 (0.135)	7	70
20d	4	9 (0.148)	6	52

FINISHING NAILS

For Cabinet Work and Interior Trim

Size Number	Length Inches	Shaft Diameter Gauge (inches)	Diameter of Head, Gauge	Number per Pound
2d	1	16–1/2 (0.058)	13–1/2	1350
3d	1–1/4	15–1/2 (0.067)	12–1/2	850
4d	1–1/2	15 (0.072)	12	550
5d	1–3/4	15 (0.072)	12	500
6d	2	13 (0.091)	10	300
8d	2–1/2	12–1/2 (0.095)	9–1/2	190
10d	3	11–1/2 (0.113)	8–1/2	125
16d	3–1/2	11 (0.120)	8	90
20d	4	10 (0.135)	7	60

CONCRETE NAILS
Round, Square, or Fluted
For Fastening to Concrete

Length Inches	Number per Pound
5 Gauge (0.207 inch) Nail with 1/2 inch head:	
1/2	190
5/8	150
3/4	130
7/8	115
1	99
1-1/8	89
1-1/4	80
1-1/2	65
1-3/4	60
2	51
2-1/4	45
2-1/2	40
2-3/4	37
3	34
7 Gauge (0.177 inch) Nail with 3/8 inch head:	
1/2	330
5/8	260
3/4	210
7/8	175
1	155
1-1/8	135
1-1/4	120
1-1/2	100
1-3/4	85
2	75
2-1/4	65
2-1/2	60
2-3/4	55
3	50
9 Gauge (0.148 inch) Nail with 21/64 inch head:	
1/2	440
5/8	350
3/4	285
7/8	240
1	210
1-1/8	185
1-1/4	165
1-1/2	140
1-3/4	120
2	105
2-1/4	90
2-1/2	85
2-3/4	75
3	69
3-3/4	64

NAILS

ROOFING NAILS

Size Number	Length Inches	Number per Pound
	7/8	250
2d	1	225
3d	1-1/4	190
4d	1-1/2	165
5d	1-3/4	145

SPIRAL FLOORING NAILS

Size Number	Length Inches	Number per Pound
6d	2	177
7d	2-1/4	158
8d	2-1/2	142

FENCE STAPLES

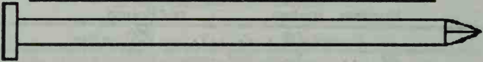
Length Inches	Number per Pound
7/8	125
1	105
1-1/4	88
1-1/2	72
1-3/4	60

WIRE TACKS

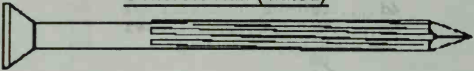
Size Oz	Length Inches	Shaft Diameter Gauge
1	3/16	18
1-1/2	7/32	18
2	1/4	17
2-1/2	5/16	17
3	3/8	16
4	7/16	16
6	1/2	15
8	9/16	15
10	5/8	14-1/2
12	11/16	14-1/2
14	3/4	14
16	13/16	14
18	7/8	13-1/2
20	15/16	13-1/2
22	1	13-1/2
24	1-1/8	13

NAILS

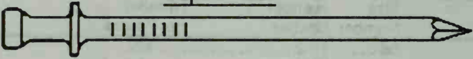
Common or Box (Box has smaller diameter)



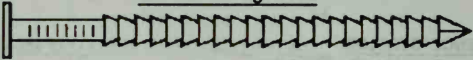
Concrete Nail (fluted)



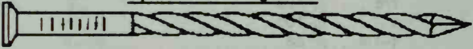
Duplex Nail



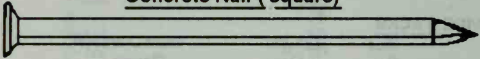
Annular Ring Nail



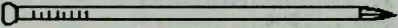
Spiral Flooring Nail



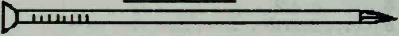
Concrete Nail (square)



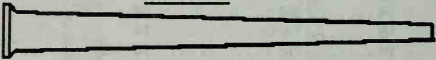
Finishing Nail



Casing Nail



Cut Nail



POCKET REF

Math

(See also CONSTANTS, page 104)

(See also SURVEYING, page 349)

(See also COMPUTER, page 61)

NUMERIC PREFIXES

Prefix	Abbreviation	Pronounce	Multiplier
atto	a	at–to	10^{-18}
femto	f	fem–to	10^{-15}
pico	p	pe–ko	10^{-12}
nano	n	nan–o	10^{-9}
micro	μ	mi–kro	10^{-6}
milli	m	mil – l	10^{-3}
centi	c	sent–ti	10^{-2}
deci	d	des – l	10^{-1}
deka	da	dek–a	10^{1}
hecto	h	hek–to	10^{2}
kilo	k	kil–o	10^{3}
mega	M	meg–a	10^{6}
giga	G	ji–ga	10^{9}
tera	T	ter–a	10^{12}
peta	P	pe–ta	10^{15}
exa	E	ex–a	10^{18}
		sextillion	10^{21}
		septillion	10^{24}
		octillion	10^{27}
		nonillion	10^{30}

ROMAN NUMERALS

Roman	Arabic	Roman	Arabic
I	1	LXX	70
II	2	LXXX	80
III	3	XC	90
IV	4	C	100
V	5	CC	200
VI	6	CCC	300
VII	7	CD	400
VIII	8	D	500
IX	9	DC	600
X	10	CM	900
XI	11	M	1000
XII	12	MD	1500
XX	20	$M\overline{V}$	4000
XXX	30	$\overline{V}$	5000
XL	40	$\overline{X}$	10000
L	50	$\overline{XX}$	20000
LX	60	$\overline{C}$	100000

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.001		0.00008	0.0254	
0.002		0.00017	0.0508	
0.003		0.00025	0.0762	
0.004		0.00033	0.1016	
0.005		0.00042	0.1270	
0.006		0.00050	0.1524	
0.007		0.00058	0.1778	
0.0078	1/128	0.00065	0.1981	
0.008		0.00067	0.2032	
0.009		0.00075	0.2286	
0.010		0.00083	0.2540	
0.011		0.00092	0.2794	
0.012		0.00100	0.3048	
0.013		0.00108	0.3302	
0.0135		0.00112	0.3429	80
0.014		0.00117	0.3556	
0.0145		0.00121	0.3683	79
0.015		0.00125	0.3810	
0.0156	1/64	0.00130	0.3962	
0.016		0.00133	0.4064	78
0.017		0.00142	0.4318	
0.018		0.00150	0.4572	77
0.019		0.00158	0.4826	
0.020		0.00167	0.5080	76
0.021		0.00175	0.5334	75
0.022		0.00183	0.5588	
0.0225		0.00187	0.5715	74
0.023		0.00192	0.5842	
0.0234	3/128	0.00195	0.5944	
0.024		0.00200	0.6096	73
0.025		0.00208	0.6350	72
0.026		0.00217	0.6604	71
0.027		0.00225	0.6858	
0.028		0.00233	0.7112	70
0.029		0.00242	0.7366	
0.0292		0.00243	0.7417	69
0.030		0.00250	0.7620	
0.031		0.00258	0.7874	68
0.0312	1/32	0.00260	0.7925	
0.032		0.00267	0.8128	67
0.033		0.00275	0.8382	66
0.034		0.00283	0.8636	
0.035		0.00292	0.8890	65
0.036		0.00300	0.9144	64
0.037		0.00308	0.9398	63
0.038		0.00317	0.9652	62
0.039	5/128	0.00325	0.9906	61
0.040		0.00333	1.0160	60
0.041		0.00342	1.0414	59
0.042		0.00350	1.0668	58
0.043		0.00358	1.0922	57
0.044		0.00367	1.1176	
0.045		0.00375	1.1430	

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.046		0.00383	1.1684	
0.0465		0.00387	1.1582	56
0.0469	3/64	0.00390	1.1913	
0.047		0.00392	1.1938	
0.048		0.00400	1.2192	
0.049		0.00408	1.2446	
0.050		0.00417	1.2700	
0.051		0.00425	1.2954	
0.052		0.00433	1.3208	55
0.053		0.00442	1.3462	
0.054		0.00450	1.3716	
0.0547	7/128	0.00456	1.3894	
0.055		0.00458	1.3970	54
0.056		0.00467	1.4224	
0.057		0.00475	1.4478	
0.058		0.00483	1.4732	
0.059		0.00492	1.4986	
0.0595		0.00496	1.5113	53
0.060		0.00500	1.5240	
0.061		0.00508	1.5494	
0.062		0.00517	1.5748	
0.0625	1/16	0.00521	1.5875	
0.063		0.00525	1.6002	
0.0635		0.00529	1.6129	52
0.064		0.00533	1.6256	
0.065		0.00542	1.6510	
0.066		0.00550	1.6764	
0.067		0.00558	1.7018	51
0.068		0.00567	1.7272	
0.069		0.00575	1.7526	
0.070	9/128	0.00583	1.7780	50
0.071		0.00592	1.8034	
0.072		0.00600	1.8288	
0.073		0.00608	1.8542	49
0.074		0.00617	1.8796	
0.075		0.00625	1.9050	
0.076		0.00633	1.9304	48
0.077		0.00642	1.9558	
0.078		0.00650	1.9812	
0.0781	5/64	0.00651	1.9837	
0.0785		0.00654	1.9939	47
0.079		0.00658	2.0066	
0.080		0.00667	2.0320	
0.081		0.00675	2.0574	46
0.082		0.00683	2.0828	45
0.083		0.00692	2.1082	
0.084		0.00700	2.1336	
0.085		0.00708	2.1590	
0.086	11/128	0.00717	2.1844	44
0.087		0.00725	2.2098	
0.088		0.00733	2.2352	
0.089		0.00742	2.2606	43

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.090		0.00750	2.2860	
0.091		0.00758	2.3114	
0.092		0.00767	2.3368	
0.093		0.00775	2.3622	
0.0935		0.00779	2.3749	42
0.0937	3/32	0.00781	2.3800	
0.094		0.00783	2.3876	
0.095		0.00792	2.4130	
0.096		0.00800	2.4384	41
0.097		0.00808	2.4638	
0.098		0.00817	2.4892	40
0.099		0.00825	2.5146	
0.0995		0.00829	2.5273	39
0.100		0.00833	2.5400	
0.101		0.00842	2.5654	
0.1015		0.00846	2.5781	38
0.1016	13/128	0.00847	2.5806	
0.102		0.00850	2.5908	
0.103		0.00858	2.6162	
0.104		0.00867	2.6416	37
0.105		0.00875	2.6670	
0.106		0.00883	2.6924	
0.1065		0.00887	2.7051	36
0.107		0.00892	2.7178	
0.108		0.00900	2.7432	
0.109		0.00908	2.7686	
0.1094	7/64	0.00912	2.7788	
0.110		0.00917	2.7940	35
0.111		0.00925	2.8194	34
0.112		0.00933	2.8448	
0.113		0.00942	2.8702	33
0.114		0.00950	2.8956	
0.115		0.00958	2.9210	
0.116		0.00967	2.9464	32
0.117		0.00975	2.9718	
0.1172	15/128	0.00977	2.9769	
0.118		0.00983	2.9972	
0.119		0.00992	3.0226	
0.120		0.01000	3.0480	31
0.121		0.01008	3.0734	
0.122		0.01017	3.0988	
0.123		0.01025	3.1242	
0.124		0.01033	3.1496	
0.125	1/8	0.01042	3.1750	
0.126		0.01050	3.2004	
0.127		0.01058	3.2258	
0.128		0.01067	3.2512	
0.1285		0.01071	3.2639	30
0.129		0.01075	3.2766	
0.130		0.01083	3.3020	
0.131		0.01092	3.3274	
0.132		0.01100	3.3528	
0.1328	17/128	0.01107	3.3731	

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.133		0.01108	3.3782	
0.134		0.01117	3.4036	
0.135		0.01125	3.4290	
0.136		0.01133	3.4544	29
0.137		0.01142	3.4798	
0.138		0.01150	3.5052	
0.139		0.01158	3.5306	
0.140		0.01167	3.5560	
0.1405		0.01171	3.5687	28
0.1406	9/64	0.01172	3.5712	
0.141		0.01175	3.5814	
0.142		0.01183	3.6068	
0.143		0.01192	3.6322	
0.144		0.01200	3.6576	27
0.145		0.01208	3.6830	
0.146		0.01217	3.7084	
0.147		0.01225	3.7338	26
0.148		0.01233	3.7592	
0.1484	19/128	0.01237	3.7694	
0.149		0.01242	3.7846	
0.1495		0.01246	3.7973	25
0.150		0.01250	3.8100	
0.151		0.01258	3.8354	
0.152		0.01267	3.8608	24
0.153		0.01275	3.8862	
0.154		0.01283	3.9116	23
0.155		0.01292	3.9370	
0.156		0.01300	3.9624	
0.1562	5/32	0.01302	3.9675	
0.157		0.01308	3.9878	22
0.158		0.01317	4.0132	
0.159		0.01325	4.0386	21
0.160		0.01333	4.0640	
0.161		0.01342	4.0894	20
0.162		0.01350	4.1148	
0.163		0.01358	4.1402	
0.164		0.01367	4.1656	
0.1641	21/128	0.01368	4.1681	
0.165		0.01375	4.1910	
0.166		0.01383	4.2164	19
0.167		0.01392	4.2418	
0.168		0.01400	4.2672	
0.169		0.01408	4.2926	
0.1695		0.01413	4.3053	18
0.170		0.01417	4.3180	
0.171		0.01425	4.3434	
0.1719	11/64	0.01433	4.3663	
0.172		0.01433	4.3688	
0.173		0.01442	4.3942	17
0.174		0.01450	4.4196	
0.175		0.01458	4.4450	
0.176		0.01467	4.4704	
0.177		0.01475	4.4958	16

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.178		0.01483	4.5212	
0.179		0.01492	4.5466	
0.1797	23/128	0.01498	4.5644	
0.180		0.01500	4.5720	15
0.181		0.01508	4.5974	
0.182		0.01517	4.6228	14
0.183		0.01525	4.6482	
0.184		0.01533	4.6736	
0.185		0.01542	4.6990	13
0.186		0.01550	4.7244	
0.187		0.01558	4.7498	
0.1875	3/16	0.01563	4.7625	
0.188		0.01567	4.7752	
0.189		0.01575	4.8006	12
0.190		0.01583	4.8260	
0.191		0.01592	4.8514	11
0.192		0.01600	4.8768	
0.193		0.01608	4.9022	
0.1935		0.01613	4.9149	10
0.194		0.01617	4.9276	
0.195		0.01625	4.9530	
0.1953	25/128	0.01628	4.9606	
0.196		0.01633	4.9784	9
0.197		0.01642	5.0038	
0.198		0.01650	5.0292	
0.199		0.01658	5.0546	8
0.200		0.01667	5.0800	
0.201		0.01675	5.1054	7
0.202		0.01683	5.1308	
0.203		0.01692	5.1562	
0.2031	13/64	0.01693	5.1587	
0.204		0.01700	5.1816	6
0.205		0.01708	5.2070	
0.2055		0.01713	5.2197	5
0.206		0.01717	5.2324	
0.207		0.01725	5.2578	
0.208		0.01733	5.2832	
0.209		0.01742	5.3086	4
0.210		0.01750	5.3340	
0.2109	27/128	0.01756	5.3569	
0.211		0.01758	5.3594	
0.212		0.01767	5.3848	
0.213		0.01775	5.4102	3
0.214		0.01783	5.4356	
0.215		0.01792	5.4610	
0.216		0.01800	5.4864	
0.217		0.01808	5.5118	
0.218		0.01817	5.5372	
0.2187	7/32	0.01823	5.5550	
0.219		0.01825	5.5626	
0.220		0.01833	5.5880	
0.221		0.01842	5.6134	2

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.222		0.01850	5.6388	
0.223		0.01858	5.6642	
0.224		0.01867	5.6896	
0.225		0.01875	5.7150	
0.226		0.01883	5.7404	
0.2266	29/128	0.01888	5.7556	
0.227		0.01892	5.7658	
0.228		0.01900	5.7912	1
0.229		0.01908	5.8166	
0.230		0.01917	5.8420	
0.231		0.01925	5.8674	
0.232		0.01933	5.8928	
0.233		0.01942	5.9182	
0.234		0.01950	5.9436	A
0.2344	15/64	0.01953	5.9538	
0.235		0.01958	5.9690	
0.236		0.01967	5.9944	
0.237		0.01975	6.0198	
0.238		0.01983	6.0452	B
0.239		0.01992	6.0706	
0.240		0.02000	6.0960	
0.241		0.02008	6.1214	
0.242		0.02017	6.1468	C
0.2422	31/128	0.02018	6.1519	
0.243		0.02025	6.1722	
0.244		0.02033	6.1976	
0.245		0.02042	6.2230	
0.246		0.02050	6.2484	D
0.247		0.02058	6.2738	
0.248		0.02067	6.2992	
0.249		0.02075	6.3246	
0.250	1/4	0.02083	6.3500	E
0.251		0.02092	6.3754	
0.252		0.02100	6.4008	
0.253		0.02108	6.4262	
0.254		0.02117	6.4516	
0.255		0.02125	6.4770	
0.256		0.02133	6.5024	
0.257		0.02142	6.5278	F
0.2578	33/128	0.02148	6.5481	
0.258		0.02150	6.5532	
0.259		0.02158	6.5786	
0.260		0.02167	6.6040	
0.261		0.02175	6.6294	G
0.262		0.02183	6.6548	
0.263		0.02192	6.6802	
0.264		0.02200	6.7056	
0.265		0.02208	6.7310	
0.2656	17/64	0.02213	6.7462	
0.266		0.02217	6.7564	H
0.267		0.02225	6.7818	
0.268		0.02233	6.8072	

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.269		0.02242	6.8326	
0.270		0.02250	6.8580	
0.271		0.02258	6.8834	
0.272		0.02267	6.9088	I
0.273		0.02275	6.9342	
0.2734	35/128	0.02278	6.9444	
0.274		0.02283	6.9596	
0.275		0.02292	6.9850	
0.276		0.02300	7.0104	
0.277		0.02308	7.0358	J
0.278		0.02317	7.0612	
0.279		0.02325	7.0866	
0.280		0.02333	7.1120	
0.281		0.02342	7.1374	K
0.2812	9/32	0.02343	7.1425	
0.282		0.02350	7.1628	
0.283		0.02358	7.1882	
0.284		0.02367	7.2136	
0.285		0.02375	7.2390	
0.286		0.02383	7.2644	
0.287		0.02392	7.2898	
0.288		0.02400	7.3152	
0.289		0.02408	7.3406	
0.2891	37/128	0.02409	7.34314	
0.290		0.02417	7.3660	L
0.291		0.02425	7.3914	
0.292		0.02433	7.4168	
0.293		0.02442	7.4422	
0.294		0.02450	7.4676	
0.295		0.02458	7.4930	M
0.296		0.02467	7.5184	
0.29687	19/64	0.02474	7.5405	
0.297		0.02475	7.5438	
0.298		0.02483	7.5692	
0.299		0.02492	7.5946	
0.300		0.02500	7.6200	
0.301		0.02508	7.6454	
0.302		0.02517	7.6708	N
0.303		0.02525	7.6962	
0.304		0.02533	7.7216	
0.30469	39/128	0.02539	7.7391	
0.305		0.02542	7.7470	
0.306		0.02550	7.7724	
0.307		0.02558	7.7978	
0.308		0.02567	7.8232	
0.309		0.02575	7.8486	
0.310		0.02583	7.8740	
0.311		0.02592	7.8994	
0.312		0.02600	7.9248	
0.3125	5/16	0.02604	7.9375	
0.313		0.02608	7.9502	
0.314		0.02617	7.9756	
0.315		0.02625	8.0010	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.316		0.02633	8.0264	O
0.317		0.02642	8.0518	
0.318		0.02650	8.0772	
0.319		0.02658	8.1026	
0.320		0.02667	8.1280	
0.32031	41/128	0.02669	8.1359	
0.321		0.02675	8.1534	
0.322		0.02683	8.1788	
0.323		0.02692	8.2042	P
0.324		0.02700	8.2296	
0.325		0.02708	8.2550	
0.326		0.02717	8.2804	
0.327		0.02725	8.3058	
0.328		0.02733	8.3312	
0.32812	21/64	0.27344	8.3342	
0.329		0.02742	8.3566	
0.330		0.02750	8.3820	
0.331		0.02758	8.4074	
0.332		0.02767	8.4328	Q
0.333		0.02775	8.4582	
0.334		0.02783	8.4836	
0.335		0.02792	8.5090	
0.33594	43/128	0.02799	8.5329	
0.336		0.02800	8.5344	
0.337		0.02808	8.5598	
0.338		0.02817	8.5852	
0.339		0.02825	8.6106	R
0.340		0.02833	8.6360	
0.341		0.02842	8.6614	
0.342		0.02850	8.6868	
0.343		0.02858	8.7122	
0.34375	11/32	0.02865	8.7312	
0.344		0.02867	8.7376	
0.345		0.02875	8.7630	
0.346		0.02883	8.7884	
0.347		0.02892	8.8138	
0.348		0.02900	8.8392	S
0.349		0.02908	8.8646	
0.350		0.02917	8.8900	
0.351		0.02925	8.9154	
0.35156	45/128	0.02930	8.9296	
0.352		0.02933	8.9408	
0.353		0.02942	8.9662	
0.354		0.02950	8.9916	
0.355		0.02958	9.0170	
0.356		0.02967	9.0424	
0.357		0.02975	9.0678	
0.358		0.02983	9.0932	T
0.359		0.02992	9.1186	
0.35937	23/64	0.02995	9.1280	
0.360		0.03000	9.1440	
0.361		0.03008	9.1694	
0.362		0.03017	9.1948	

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.363		0.03025	9.2202	
0.364		0.03033	9.2456	
0.365		0.03042	9.2710	
0.366		0.03050	9.2964	
0.367		0.03058	9.3218	
0.36719	47/128	0.03060	9.3266	
0.368		0.03067	9.3472	U
0.369		0.03075	9.3726	
0.370		0.03083	9.3980	
0.371		0.03092	9.4234	
0.372		0.03100	9.4488	
0.373		0.03108	9.4742	
0.374		0.03117	9.4996	
0.375	3/8	0.03125	9.5250	
0.376		0.03133	9.5504	
0.377		0.03142	9.5758	V
0.378		0.03150	9.6012	
0.379		0.03158	9.6266	
0.380		0.03167	9.6520	
0.381		0.03175	9.6774	
0.382		0.03183	9.7028	
0.38281	49/128	0.03190	9.7234	
0.383		0.03192	9.7282	
0.384		0.03200	9.7536	
0.385		0.03208	9.7790	
0.386		0.03217	9.8044	W
0.387		0.03225	9.8298	
0.388		0.03233	9.8552	
0.389		0.03242	9.8806	
0.390		0.03250	9.9060	
0.39062	25/64	0.03255	9.9217	
0.391		0.03258	9.9314	
0.392		0.03267	9.9568	
0.393		0.03275	9.9822	
0.394		0.03283	10.0076	
0.395		0.03292	10.0330	
0.396		0.03300	10.0584	
0.397		0.03308	10.0838	X
0.398		0.03317	10.1092	
0.39844	51/128	0.03320	10.1204	
0.399		0.03325	10.1346	
0.400		0.03333	10.1600	
0.401		0.03342	10.1854	
0.402		0.03350	10.2108	
0.403		0.03358	10.2362	
0.404		0.03367	10.2616	Y
0.405		0.03375	10.2870	
0.406		0.03383	10.3124	
0.40625	13/32	0.03385	10.3187	
0.407		0.03392	10.3378	
0.408		0.03400	10.3632	
0.409		0.03408	10.3886	

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.410		0.03417	10.4140	
0.411		0.03425	10.4394	
0.412		0.03433	10.4648	
0.413		0.03442	10.4902	Z
0.414		0.03450	10.5156	
0.41406	53/128	0.03451	10.5171	
0.415		0.03458	10.5410	
0.416		0.03467	10.5664	
0.417		0.03475	10.5918	
0.418		0.03483	10.6172	
0.419		0.03492	10.6426	
0.420		0.03500	10.6680	
0.421		0.03508	10.6934	
0.42187	27/64	0.03516	10.7155	
0.422		0.03517	10.7188	
0.423		0.03525	10.7442	
0.424		0.03533	10.7696	
0.425		0.03542	10.7950	
0.426		0.03550	10.8204	
0.427		0.03558	10.8458	
0.428		0.03567	10.8712	
0.429		0.03575	10.8966	
0.42968	55/128	0.03581	10.9139	
0.430		0.03583	10.9220	
0.431		0.03592	10.9474	
0.432		0.03600	10.9728	
0.433		0.03608	10.9982	
0.434		0.03617	11.0236	
0.435		0.03625	11.0490	
0.436		0.03633	11.0744	
0.437		0.03642	11.0998	
0.4375	7/16	0.03646	11.1125	
0.438		0.03650	11.1252	
0.439		0.03658	11.1506	
0.440		0.03667	11.1760	
0.441		0.03675	11.2014	
0.442		0.03683	11.2268	
0.443		0.03692	11.2522	
0.444		0.03700	11.2776	
0.445		0.03708	11.3030	
0.44531	57/128	0.03711	11.3109	
0.446		0.03717	11.3284	
0.447		0.03725	11.3538	
0.448		0.03733	11.3792	
0.449		0.03742	11.4046	
0.450		0.03750	11.4300	
0.451		0.03758	11.4554	
0.452		0.03767	11.4808	
0.453		0.03775	11.5062	
0.45312	29/64	0.03776	11.5092	
0.454		0.03783	11.5316	
0.455		0.03792	11.5570	

CONVERT INCH–FOOT–MM–DRILL

Decimals of Inch	Fractions of Inch	Decimals of Foot	Millimeters	Drill Number
0.456		0.03800	11.5824	
0.457		0.03808	11.6078	
0.458		0.03817	11.6332	
0.459		0.03825	11.6586	
0.460		0.03833	11.6840	
0.46094	59/128	0.03841	11.7079	
0.461		0.03842	11.7094	
0.462		0.03850	11.7348	
0.463		0.03858	11.7602	
0.464		0.03867	11.7856	
0.465		0.03875	11.8110	
0.466		0.03883	11.8364	
0.467		0.03892	11.8618	
0.468		0.03900	11.8872	
0.46875	15/32	0.03906	11.9062	
0.469		0.03908	11.9126	
0.470		0.03917	11.9380	
0.471		0.03925	11.9634	
0.472		0.03933	11.9888	
0.473		0.03942	12.0142	
0.474		0.03950	12.0396	
0.475		0.03958	12.0650	
0.476		0.03967	12.0904	
0.47656	61/128	0.03971	12.1046	
0.477		0.03975	12.1158	
0.478		0.03983	12.1412	
0.479		0.03992	12.1666	
0.480		0.04000	12.1920	
0.481		0.04008	12.2174	
0.482		0.04017	12.2428	
0.483		0.04025	12.2682	
0.484		0.04033	12.2936	
0.48437	31/64	0.04036	12.3030	
0.485		0.04042	12.3190	
0.486		0.04050	12.3444	
0.487		0.04058	12.3698	
0.488		0.04067	12.3952	
0.489		0.04075	12.4206	
0.490		0.04083	12.4460	
0.491		0.04092	12.4714	
0.492		0.04100	12.4968	
0.49219	63/128	0.04102	12.5016	
0.493		0.04108	12.5222	
0.494		0.04117	12.5476	
0.495		0.04125	12.5730	
0.496		0.04133	12.5984	
0.497		0.04142	12.6238	
0.498		0.04150	12.6492	
0.499		0.04158	12.6746	
0.500	1/2	0.04167	12.7000	

SQUARES, CUBES, AND ROOTS

n	Square	Cube	Square Root	Cube Root
1	1	1	1.00000	1.00000
2	4	8	1.41421	1.25992
3	9	27	1.73205	1.44225
4	16	64	2.00000	1.58740
5	25	125	2.23607	1.70998
6	36	216	2.44949	1.81712
7	49	343	2.64575	1.91293
8	64	512	2.82843	2.00000
9	81	729	3.00000	2.08008
10	100	1000	3.16228	2.15443
11	121	1331	3.31662	2.22398
12	144	1728	3.46410	2.28943
13	169	2197	3.60555	2.35133
14	196	2744	3.74166	2.41014
15	225	3375	3.87298	2.46621
16	256	4096	4.00000	2.51984
17	289	4913	4.12311	2.57128
18	324	5832	4.24264	2.62074
19	361	6859	4.35890	2.66840
20	400	8000	4.47214	2.71442
21	441	9261	4.58258	2.75892
22	484	10648	4.69042	2.80204
23	529	12167	4.79583	2.84387
24	576	13824	4.89898	2.88450
25	625	15625	5.00000	2.92402
26	676	17576	5.09902	2.96250
27	729	19683	5.19615	3.00000
28	784	21952	5.29150	3.03659
29	841	24389	5.38516	3.07232
30	900	27000	5.47723	3.10723
31	961	29791	5.56776	3.14138
32	1024	32768	5.65685	3.17480
33	1089	35937	5.74456	3.20753
34	1156	39304	5.83095	3.23961
35	1225	42875	5.91608	3.27107
36	1296	46656	6.00000	3.30193
37	1369	50653	6.08276	3.33222
38	1444	54872	6.16441	3.36198
39	1521	59319	6.24500	3.39121
40	1600	64000	6.32456	3.41995
41	1681	68921	6.40312	3.44822
42	1764	74088	6.48074	3.47603
43	1849	79507	6.55744	3.50340
44	1936	85184	6.63325	3.53035
45	2025	91125	6.70820	3.55689
46	2116	97336	6.78233	3.58305
47	2209	103823	6.85565	3.60883
48	2304	110592	6.92820	3.63424
49	2401	117649	7.00000	3.65931
50	2500	125000	7.07107	3.68403
51	2601	132651	7.14143	3.70843
52	2704	140608	7.21110	3.73251
53	2809	148877	7.28011	3.75629
54	2916	157464	7.34847	3.77976

SQUARES, CUBES, AND ROOTS

n	Square	Cube	Square Root	Cube Root
55	3025	166375	7.41620	3.80295
56	3136	175616	7.48331	3.82586
57	3249	185193	7.54983	3.84850
58	3364	195112	7.61577	3.87088
59	3481	205379	7.68115	3.89300
60	3600	216000	7.74597	3.91487
61	3721	226981	7.81025	3.93650
62	3844	238328	7.87401	3.95789
63	3969	250047	7.93725	3.97906
64	4096	262144	8.00000	4.00000
65	4225	274625	8.06226	4.02073
66	4356	287496	8.12404	4.04124
67	4489	300763	8.18535	4.06155
68	4624	314432	8.24621	4.08166
69	4761	328509	8.30662	4.10157
70	4900	343000	8.36660	4.12129
71	5041	357911	8.42615	4.14082
72	5184	373248	8.48528	4.16017
73	5329	389017	8.54400	4.17934
74	5476	405224	8.60233	4.19834
75	5625	421875	8.66025	4.21716
76	5776	438976	8.71780	4.23582
77	5929	456533	8.77496	4.25432
78	6084	474552	8.83176	4.27266
79	6241	493039	8.88819	4.29084
80	6400	512000	8.94427	4.30887
81	6561	531441	9.00000	4.32675
82	6724	551368	9.05539	4.34448
83	6889	571787	9.11043	4.36207
84	7056	592704	9.16515	4.37952
85	7225	614125	9.21954	4.39683
86	7396	636056	9.27362	4.41400
87	7569	658503	9.32738	4.43105
88	7744	681472	9.38083	4.44796
89	7921	704969	9.43398	4.46475
90	8100	729000	9.48683	4.48140
91	8281	753571	9.53939	4.49794
92	8464	778688	9.59166	4.51436
93	8649	804357	9.64365	4.53065
94	8836	830584	9.69536	4.54684
95	9025	857375	9.74679	4.56290
96	9216	884736	9.79796	4.57886
97	9409	912673	9.84886	4.59470
98	9604	941192	9.89949	4.61044
99	9801	970299	9.94987	4.62607
100	10000	1000000	10.00000	4.64159
110	12100	1331000	10.48809	4.79142
120	14400	1728000	10.95445	4.93242
130	16900	2197000	11.40175	5.06580
140	19600	2744000	11.83216	5.19249
150	22500	3375000	12.24745	5.31329
160	25600	4096000	12.64911	5.42884
170	28900	4913000	13.03840	5.53966
180	32400	5832000	13.41641	5.64622

n	Square	Cube	Square Root	Cube Root
190	36100	6859000	13.78405	5.74890
200	40000	8000000	14.14214	5.84804
210	44100	9261000	14.49138	5.94392
220	48400	10648000	14.83240	6.03681
230	52900	12167000	15.16575	6.12693
240	57600	13824000	15.49193	6.21447
250	62500	15625000	15.81139	6.29961
260	67600	17576000	16.12452	6.38250
270	72900	19683000	16.43168	6.46330
280	78400	21952000	16.73320	6.54213
290	84100	24389000	17.02939	6.61911
300	90000	27000000	17.32051	6.69433
310	96100	29791000	17.60682	6.76790
320	102400	32768000	17.88854	6.83990
330	108900	35937000	18.16590	6.91042
340	115600	39304000	18.43909	6.97953
350	122500	42875000	18.70829	7.04730
360	129600	46656000	18.97367	7.11379
370	136900	50653000	19.23538	7.17905
380	144400	54872000	19.49359	7.24316
390	152100	59319000	19.74842	7.30614
400	160000	64000000	20.00000	7.36806
410	168100	68921000	20.24846	7.42896
420	176400	74088000	20.49390	7.48887
430	184900	79507000	20.73644	7.54784
440	193600	85184000	20.97618	7.60590
450	202500	91125000	21.21320	7.66309
460	211600	97336000	21.44761	7.71944
470	220900	103823000	21.67948	7.77498
480	230400	110592000	21.90890	7.82974
490	240100	117649000	22.13594	7.88374
500	250000	125000000	22.36068	7.93701
510	260100	132651000	22.58318	7.98957
520	270400	140608000	22.80351	8.04145
530	280900	148877000	23.02173	8.09267
540	291600	157464000	23.23790	8.14325
550	302500	166375000	23.45208	8.19321
560	313600	175616000	23.66432	8.24257
570	324900	185193000	23.87467	8.29134
580	336400	195112000	24.08319	8.33955
590	348100	205379000	24.28992	8.38721
600	360000	216000000	24.49490	8.43433
610	372100	226981000	24.69818	8.48093
620	384400	238328000	24.89980	8.52702
630	396900	250047000	25.09980	8.57262
640	409600	262144000	25.29822	8.61774
650	422500	274625000	25.49510	8.66239
660	435600	287496000	25.69047	8.70659
670	448900	300763000	25.88436	8.75034
680	462400	314432000	26.07681	8.79366
690	476100	328509000	26.26785	8.83656
700	490000	343000000	26.45751	8.87904
710	504100	357911000	26.64583	8.92112
720	518400	373248000	26.83282	8.96281

SQUARES, CUBES, AND ROOTS

n	Square	Cube	Square Root	Cube Root
730	532900	389017000	27.01851	9.00411
740	547600	405224000	27.20294	9.04504
750	562500	421875000	27.38613	9.08560
760	577600	438976000	27.56810	9.12581
770	592900	456533000	27.74887	9.16566
780	608400	474552000	27.92848	9.20516
790	624100	493039000	28.10694	9.24434
800	640000	512000000	28.28427	9.28318
810	656100	531441000	28.46050	9.32170
820	672400	551368000	28.63564	9.35990
830	688900	571787000	28.80972	9.39780
840	705600	592704000	28.98275	9.43539
850	722500	614125000	29.15476	9.47268
860	739600	636056000	29.32576	9.50969
870	756900	658503000	29.49576	9.54640
880	774400	681472000	29.66479	9.58284
890	792100	704969000	29.83287	9.61900
900	810000	729000000	30.00000	9.65489
910	828100	753571000	30.16621	9.69052
920	846400	778688000	30.33150	9.72589
930	864900	804357000	30.49590	9.76100
940	883600	830584000	30.65942	9.79586
950	902500	857375000	30.82207	9.83048
960	921600	884736000	30.98387	9.86485
970	940900	912673000	31.14482	9.89898
980	960400	941192000	31.30495	9.93288
990	980100	970299000	31.46427	9.96655
1000	1000000	1000000000	31.62278	10.00000

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
1	0.01745	0.01745	0.99985	0.01746
2	0.03491	0.03490	0.99939	0.03492
3	0.05236	0.05234	0.99863	0.05241
4	0.06981	0.06976	0.99756	0.06993
5	0.08727	0.08716	0.99619	0.08749
6	0.10472	0.10453	0.99452	0.10510
7	0.12217	0.12187	0.99255	0.12278
8	0.13963	0.13917	0.99027	0.14054
9	0.15708	0.15643	0.98769	0.15838
10	0.17453	0.17365	0.98481	0.17633
11	0.19199	0.19081	0.98163	0.19438
12	0.20944	0.20791	0.97815	0.21256
13	0.22689	0.22495	0.97437	0.23087
14	0.24435	0.24192	0.97030	0.24933
15	0.26180	0.25882	0.96593	0.26795
16	0.27925	0.27564	0.96126	0.28675
17	0.29671	0.29237	0.95630	0.30573
18	0.31416	0.30902	0.95106	0.32492
19	0.33161	0.32557	0.94552	0.34433

n	n Radians	Sine	Cosine	Tangent
20	0.34907	0.34202	0.93969	0.36397
21	0.36652	0.35837	0.93358	0.38386
22	0.38397	0.37461	0.92718	0.40403
23	0.40143	0.39073	0.92050	0.42447
24	0.41888	0.40674	0.91355	0.44523
25	0.43633	0.42262	0.90631	0.46631
26	0.45379	0.43837	0.89879	0.48773
27	0.47124	0.45399	0.89101	0.50953
28	0.48869	0.46947	0.88295	0.53171
29	0.50615	0.48481	0.87462	0.55431
30	0.52360	0.50000	0.86603	0.57735
31	0.54105	0.51504	0.85717	0.60086
32	0.55851	0.52992	0.84805	0.62487
33	0.57596	0.54464	0.83867	0.64941
34	0.59341	0.55919	0.82904	0.67451
35	0.61087	0.57358	0.81915	0.70021
36	0.62832	0.58779	0.80902	0.72654
37	0.64577	0.60182	0.79864	0.75355
38	0.66323	0.61566	0.78801	0.78129
39	0.68068	0.62932	0.77715	0.80978
40	0.69813	0.64279	0.76604	0.83910
41	0.71558	0.65606	0.75471	0.86929
42	0.73304	0.66913	0.74314	0.90040
43	0.75049	0.68200	0.73135	0.93252
44	0.76794	0.69466	0.71934	0.96569
45	0.78540	0.70711	0.70711	1.00000
46	0.80285	0.71934	0.69466	1.03553
47	0.82030	0.73135	0.68200	1.07237
48	0.83776	0.74314	0.66913	1.11061
49	0.85521	0.75471	0.65606	1.15037
50	0.87266	0.76604	0.64279	1.19175
51	0.89012	0.77715	0.62932	1.23490
52	0.90757	0.78801	0.61566	1.27994
53	0.92502	0.79864	0.60182	1.32704
54	0.94248	0.80902	0.58779	1.37638
55	0.95993	0.81915	0.57358	1.42815
56	0.97738	0.82904	0.55919	1.48256
57	0.99484	0.83867	0.54464	1.53986
58	1.01229	0.84805	0.52992	1.60033
59	1.02974	0.85717	0.51504	1.66428
60	1.04720	0.86603	0.50000	1.73205
61	1.06465	0.87462	0.48481	1.80405
62	1.08210	0.88295	0.46947	1.88073
63	1.09956	0.89101	0.45399	1.96261
64	1.11701	0.89879	0.43837	2.05030
65	1.13446	0.90631	0.42262	2.14451
66	1.15192	0.91355	0.40674	2.24604
67	1.16937	0.92050	0.39073	2.35585
68	1.18682	0.92718	0.37461	2.47509
69	1.20428	0.93358	0.35837	2.60509
70	1.22173	0.93969	0.34202	2.74748
71	1.23918	0.94552	0.32557	2.90421
72	1.25664	0.95106	0.30902	3.07768
73	1.27409	0.95630	0.29237	3.27085

n	n Radians	Sine	Cosine	Tangent
74	1.29154	0.96126	0.27564	3.48741
75	1.30900	0.96593	0.25882	3.73205
76	1.32645	0.97030	0.24192	4.01078
77	1.34390	0.97437	0.22495	4.33148
78	1.36136	0.97815	0.20791	4.70463
79	1.37881	0.98163	0.19081	5.14455
80	1.39626	0.98481	0.17365	5.67128
81	1.41372	0.98769	0.15643	6.31375
82	1.43117	0.99027	0.13917	7.11537
83	1.44862	0.99255	0.12187	8.14435
84	1.46608	0.99452	0.10453	9.51436
85	1.48353	0.99619	0.08716	11.43005
86	1.50098	0.99756	0.06976	14.30067
87	1.51844	0.99863	0.05234	19.08114
88	1.53589	0.99939	0.03490	28.63625
89	1.55334	0.99985	0.01745	57.28996
90	1.57080	1.00000	0.00000	infinity
91	1.58825	0.99985	–0.01745	–57.28996
92	1.60570	0.99939	–0.03490	–28.63625
93	1.62316	0.99863	–0.05234	–19.08114
94	1.64061	0.99756	–0.06976	–14.30067
95	1.65806	0.99619	–0.08716	–11.43005
96	1.67552	0.99452	–0.10453	–9.51436
97	1.69297	0.99255	–0.12187	–8.14435
98	1.71042	0.99027	–0.13917	–7.11537
99	1.72788	0.98769	–0.15643	–6.31375
100	1.74533	0.98481	–0.17365	–5.67128
101	1.76278	0.98163	–0.19081	–5.14455
102	1.78024	0.97815	–0.20791	–4.70463
103	1.79769	0.97437	–0.22495	–4.33148
104	1.81514	0.97030	–0.24192	–4.01078
105	1.83260	0.96593	–0.25882	–3.73205
106	1.85005	0.96126	–0.27564	–3.48741
107	1.86750	0.95630	–0.29237	–3.27085
108	1.88496	0.95106	–0.30902	–3.07768
109	1.90241	0.94552	–0.32557	–2.90421
110	1.91986	0.93969	–0.34202	–2.74748
111	1.93732	0.93358	–0.35837	–2.60509
112	1.95477	0.92718	–0.37461	–2.47509
113	1.97222	0.92050	–0.39073	–2.35585
114	1.98968	0.91355	–0.40674	–2.24604
115	2.00713	0.90631	–0.42262	–2.14451
116	2.02458	0.89879	–0.43837	–2.05030
117	2.04204	0.89101	–0.45399	–1.96261
118	2.05949	0.88295	–0.46947	–1.88073
119	2.07694	0.87462	–0.48481	–1.80405
120	2.09440	0.86603	–0.50000	–1.73205
121	2.11185	0.85717	–0.51504	–1.66428
122	2.12930	0.84805	–0.52992	–1.60033
123	2.14675	0.83867	–0.54464	–1.53986
124	2.16421	0.82904	–0.55919	–1.48256
125	2.18166	0.81915	–0.57358	–1.42815
126	2.19911	0.80902	–0.58779	–1.37638
127	2.21657	0.79864	–0.60182	–1.32704

n	n Radians	Sine	Cosine	Tangent
128	2.23402	0.78801	−0.61566	−1.27994
129	2.25147	0.77715	−0.62932	−1.23490
130	2.26893	0.76604	−0.64279	−1.19175
131	2.28638	0.75471	−0.65606	−1.15037
132	2.30383	0.74314	−0.66913	−1.11061
133	2.32129	0.73135	−0.68200	−1.07237
134	2.33874	0.71934	−0.69466	−1.03553
135	2.35619	0.70711	−0.70711	−1.00000
136	2.37365	0.69466	−0.71934	−0.96569
137	2.39110	0.68200	−0.73135	−0.93252
138	2.40855	0.66913	−0.74314	−0.90040
139	2.42601	0.65606	−0.75471	−0.86929
140	2.44346	0.64279	−0.76604	−0.83910
141	2.46091	0.62932	−0.77715	−0.80978
142	2.47837	0.61566	−0.78801	−0.78129
143	2.49582	0.60182	−0.79864	−0.75355
144	2.51327	0.58779	−0.80902	−0.72654
145	2.53073	0.57358	−0.81915	−0.70021
146	2.54818	0.55919	−0.82904	−0.67451
147	2.56563	0.54464	−0.83867	−0.64941
148	2.58309	0.52992	−0.84805	−0.62487
149	2.60054	0.51504	−0.85717	−0.60086
150	2.61799	0.50000	−0.86603	−0.57735
151	2.63545	0.48481	−0.87462	−0.55431
152	2.65290	0.46947	−0.88295	−0.53171
153	2.67035	0.45399	−0.89101	−0.50953
154	2.68781	0.43837	−0.89879	−0.48773
155	2.70526	0.42262	−0.90631	−0.46631
156	2.72271	0.40674	−0.91355	−0.44523
157	2.74017	0.39073	−0.92050	−0.42447
158	2.75762	0.37461	−0.92718	−0.40403
159	2.77507	0.35837	−0.93358	−0.38386
160	2.79253	0.34202	−0.93969	−0.36397
161	2.80998	0.32557	−0.94552	−0.34433
162	2.82743	0.30902	−0.95106	−0.32492
163	2.84489	0.29237	−0.95630	−0.30573
164	2.86234	0.27564	−0.96126	−0.28675
165	2.87979	0.25882	−0.96593	−0.26795
166	2.89725	0.24192	−0.97030	−0.24933
167	2.91470	0.22495	−0.97437	−0.23087
168	2.93215	0.20791	−0.97815	−0.21256
169	2.94961	0.19081	−0.98163	−0.19438
170	2.96706	0.17365	−0.98481	−0.17633
171	2.98451	0.15643	−0.98769	−0.15838
172	3.00197	0.13917	−0.99027	−0.14054
173	3.01942	0.12187	−0.99255	−0.12278
174	3.03687	0.10453	−0.99452	−0.10510
175	3.05433	0.08716	−0.99619	−0.08749
176	3.07178	0.06976	−0.99756	−0.06993
177	3.08923	0.05234	−0.99863	−0.05241
178	3.10669	0.03490	−0.99939	−0.03492
179	3.12414	0.01745	−0.99985	−0.01746
180	3.14159	0.00000	−1.00000	0.00000
181	3.15905	−0.01745	−0.99985	0.01746

n	n Radians	Sine	Cosine	Tangent
182	3.17650	–0.03490	–0.99939	0.03492
183	3.19395	–0.05234	–0.99863	0.05241
184	3.21141	–0.06976	–0.99756	0.06993
185	3.22886	–0.08716	–0.99619	0.08749
186	3.24631	–0.10453	–0.99452	0.10510
187	3.26377	–0.12187	–0.99255	0.12278
188	3.28122	–0.13917	–0.99027	0.14054
189	3.29867	–0.15643	–0.98769	0.15838
190	3.31613	–0.17365	–0.98481	0.17633
191	3.33358	–0.19081	–0.98163	0.19438
192	3.35103	–0.20791	–0.97815	0.21256
193	3.36849	–0.22495	–0.97437	0.23087
194	3.38594	–0.24192	–0.97030	0.24933
195	3.40339	–0.25882	–0.96593	0.26795
196	3.42085	–0.27564	–0.96126	0.28675
197	3.43830	–0.29237	–0.95630	0.30573
198	3.45575	–0.30902	–0.95106	0.32492
199	3.47321	–0.32557	–0.94552	0.34433
200	3.49066	–0.34202	–0.93969	0.36397
201	3.50811	–0.35837	–0.93358	0.38386
202	3.52557	–0.37461	–0.92718	0.40403
203	3.54302	–0.39073	–0.92050	0.42447
204	3.56047	–0.40674	–0.91355	0.44523
205	3.57792	–0.42262	–0.90631	0.46631
206	3.59538	–0.43837	–0.89879	0.48773
207	3.61283	–0.45399	–0.89101	0.50953
208	3.63028	–0.46947	–0.88295	0.53171
209	3.64774	–0.48481	–0.87462	0.55431
210	3.66519	–0.50000	–0.86603	0.57735
211	3.68264	–0.51504	–0.85717	0.60086
212	3.70010	–0.52992	–0.84805	0.62487
213	3.71755	–0.54464	–0.83867	0.64941
214	3.73500	–0.55919	–0.82904	0.67451
215	3.75246	–0.57358	–0.81915	0.70021
216	3.76991	–0.58779	–0.80902	0.72654
217	3.78736	–0.60182	–0.79864	0.75355
218	3.80482	–0.61566	–0.78801	0.78129
219	3.82227	–0.62932	–0.77715	0.80978
220	3.83972	–0.64279	–0.76604	0.83910
221	3.85718	–0.65606	–0.75471	0.86929
222	3.87463	–0.66913	–0.74314	0.90040
223	3.89208	–0.68200	–0.73135	0.93252
224	3.90954	–0.69466	–0.71934	0.96569
225	3.92699	–0.70711	–0.70711	1.00000
226	3.94444	–0.71934	–0.69466	1.03553
227	3.96190	–0.73135	–0.68200	1.07237
228	3.97935	–0.74314	–0.66913	1.11061
229	3.99680	–0.75471	–0.65606	1.15037
230	4.01426	–0.76604	–0.64279	1.19175
231	4.03171	–0.77715	–0.62932	1.23490
232	4.04916	–0.78801	–0.61566	1.27994
233	4.06662	–0.79864	–0.60182	1.32704
234	4.08407	–0.80902	–0.58779	1.37638
235	4.10152	–0.81915	–0.57358	1.42815

n	n Radians	Sine	Cosine	Tangent
236	4.11898	–0.82904	–0.55919	1.48256
237	4.13643	–0.83867	–0.54464	1.53986
238	4.15388	–0.84805	–0.52992	1.60033
239	4.17134	–0.85717	–0.51504	1.66428
240	4.18879	–0.86603	–0.50000	1.73205
241	4.20624	–0.87462	–0.48481	1.80405
242	4.22370	–0.88295	–0.46947	1.88073
243	4.24115	–0.89101	–0.45399	1.96261
244	4.25860	–0.89879	–0.43837	2.05030
245	4.27606	–0.90631	–0.42262	2.14451
246	4.29351	–0.91355	–0.40674	2.24604
247	4.31096	–0.92050	–0.39073	2.35585
248	4.32842	–0.92718	–0.37461	2.47509
249	4.34587	–0.93358	–0.35837	2.60509
250	4.36332	–0.93969	–0.34202	2.74748
251	4.38078	–0.94552	–0.32557	2.90421
252	4.39823	–0.95106	–0.30902	3.07768
253	4.41568	–0.95630	–0.29237	3.27085
254	4.43314	–0.96126	–0.27564	3.48741
255	4.45059	–0.96593	–0.25882	3.73205
256	4.46804	–0.97030	–0.24192	4.01078
257	4.48550	–0.97437	–0.22495	4.33148
258	4.50295	–0.97815	–0.20791	4.70463
259	4.52040	–0.98163	–0.19081	5.14455
260	4.53786	–0.98481	–0.17365	5.67128
261	4.55531	–0.98769	–0.15643	6.31375
262	4.57276	–0.99027	–0.13917	7.11537
263	4.59022	–0.99255	–0.12187	8.14435
264	4.60767	–0.99452	–0.10453	9.51436
265	4.62512	–0.99619	–0.08716	11.43005
266	4.64258	–0.99756	–0.06976	14.30067
267	4.66003	–0.99863	–0.05234	19.08114
268	4.67748	–0.99939	–0.03490	28.63625
269	4.69494	–0.99985	–0.01745	57.28996
270	4.71239	–1.00000	0.00000	infinity
271	4.72984	–0.99985	0.01745	–57.28996
272	4.74730	–0.99939	0.03490	–28.63625
273	4.76475	–0.99863	0.05234	–19.08114
274	4.78220	–0.99756	0.06976	–14.30067
275	4.79966	–0.99619	0.08716	–11.43005
276	4.81711	–0.99452	0.10453	–9.51436
277	4.83456	–0.99255	0.12187	–8.14435
278	4.85202	–0.99027	0.13917	–7.11537
279	4.86947	–0.98769	0.15643	–6.31375
280	4.88692	–0.98481	0.17365	–5.67128
281	4.90438	–0.98163	0.19081	–5.14455
282	4.92183	–0.97815	0.20791	–4.70463
283	4.93928	–0.97437	0.22495	–4.33148
284	4.95674	–0.97030	0.24192	–4.01078
285	4.97419	–0.96593	0.25882	–3.73205
286	4.99164	–0.96126	0.27564	–3.48741
287	5.00909	–0.95630	0.29237	–3.27085
288	5.02655	–0.95106	0.30902	–3.07768
289	5.04400	–0.94552	0.32557	–2.90421

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
290	5.06145	–0.93969	0.34202	–2.74748
291	5.07891	–0.93358	0.35837	–2.60509
292	5.09636	–0.92718	0.37461	–2.47509
293	5.11381	–0.92050	0.39073	–2.35585
294	5.13127	–0.91355	0.40674	–2.24604
295	5.14872	–0.90631	0.42262	–2.14451
296	5.16617	–0.89879	0.43837	–2.05030
297	5.18363	–0.89101	0.45399	–1.96261
298	5.20108	–0.88295	0.46947	–1.88073
299	5.21853	–0.87462	0.48481	–1.80405
300	5.23599	–0.86603	0.50000	–1.73205
301	5.25344	–0.85717	0.51504	–1.66428
302	5.27089	–0.84805	0.52992	–1.60033
303	5.28835	–0.83867	0.54464	–1.53986
304	5.30580	–0.82904	0.55919	–1.48256
305	5.32325	–0.81915	0.57358	–1.42815
306	5.34071	–0.80902	0.58779	–1.37638
307	5.35816	–0.79864	0.60182	–1.32704
308	5.37561	–0.78801	0.61566	–1.27994
309	5.39307	–0.77715	0.62932	–1.23490
310	5.41052	–0.76604	0.64279	–1.19175
311	5.42797	–0.75471	0.65606	–1.15037
312	5.44543	–0.74314	0.66913	–1.11061
313	5.46288	–0.73135	0.68200	–1.07237
314	5.48033	–0.71934	0.69466	–1.03553
315	5.49779	–0.70711	0.70711	–1.00000
316	5.51524	–0.69466	0.71934	–0.96569
317	5.53269	–0.68200	0.73135	–0.93252
318	5.55015	–0.66913	0.74314	–0.90040
319	5.56760	–0.65606	0.75471	–0.86929
320	5.58505	–0.64279	0.76604	–0.83910
321	5.60251	–0.62932	0.77715	–0.80978
322	5.61996	–0.61566	0.78801	–0.78129
323	5.63741	–0.60182	0.79864	–0.75355
324	5.65487	–0.58779	0.80902	–0.72654
325	5.67232	–0.57358	0.81915	–0.70021
326	5.68977	–0.55919	0.82904	–0.67451
327	5.70723	–0.54464	0.83867	–0.64941
328	5.72468	–0.52992	0.84805	–0.62487
329	5.74213	–0.51504	0.85717	–0.60086
330	5.75959	–0.50000	0.86603	–0.57735
331	5.77704	–0.48481	0.87462	–0.55431
332	5.79449	–0.46947	0.88295	–0.53171
333	5.81195	–0.45399	0.89101	–0.50953
334	5.82940	–0.43837	0.89879	–0.48773
335	5.84685	–0.42262	0.90631	–0.46631
336	5.86431	–0.40674	0.91355	–0.44523
337	5.88176	–0.39073	0.92050	–0.42447
338	5.89921	–0.37461	0.92718	–0.40403
339	5.91667	–0.35837	0.93358	–0.38386
340	5.93412	–0.34202	0.93969	–0.36397
341	5.95157	–0.32557	0.94552	–0.34433
342	5.96903	–0.30902	0.95106	–0.32492
343	5.98648	–0.29237	0.95630	–0.30573

DEGREES & TRIG FUNCTIONS

n	n Radians	Sine	Cosine	Tangent
344	6.00393	−0.27564	0.96126	−0.28675
345	6.02139	−0.25882	0.96593	−0.26795
346	6.03884	−0.24192	0.97030	−0.24933
347	6.05629	−0.22495	0.97437	−0.23087
348	6.07375	−0.20791	0.97815	−0.21256
349	6.09120	−0.19081	0.98163	−0.19438
350	6.10865	−0.17365	0.98481	−0.17633
351	6.12611	−0.15643	0.98769	−0.15838
352	6.14356	−0.13917	0.99027	−0.14054
353	6.16101	−0.12187	0.99255	−0.12278
354	6.17847	−0.10453	0.99452	−0.10510
355	6.19592	−0.08716	0.99619	−0.08749
356	6.21337	−0.06976	0.99756	−0.06993
357	6.23083	−0.05234	0.99863	−0.05241
358	6.24828	−0.03490	0.99939	−0.03492
359	6.26573	−0.01745	0.99985	−0.01746
360	6.28319	0.00000	1.00000	0.00000

LOG, LOG e, CIRCUMFRENCE & AREA

n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Radius n
1	0.00000	0.00000	3.1416	0.7854
2	0.30103	0.69315	6.2832	3.1416
3	0.47712	1.09861	9.4248	7.0686
4	0.60206	1.38629	12.5664	12.5664
5	0.69897	1.60944	15.7080	19.6350
6	0.77815	1.79176	18.8496	28.2743
7	0.84510	1.94591	21.9911	38.4845
8	0.90309	2.07944	25.1327	50.2655
9	0.95424	2.19722	28.2743	63.6173
10	1.00000	2.30259	31.4159	78.5398
11	1.04139	2.39790	34.5575	95.0332
12	1.07918	2.48491	37.6991	113.0973
13	1.11394	2.56495	40.8407	132.7323
14	1.14613	2.63906	43.9823	153.9380
15	1.17609	2.70805	47.1239	176.7146
16	1.20412	2.77259	50.2655	201.0619
17	1.23045	2.83321	53.4071	226.9801
18	1.25527	2.89037	56.5487	254.4690
19	1.27875	2.94444	59.6903	283.5287
20	1.30103	2.99573	62.8319	314.1593
21	1.32222	3.04452	65.9734	346.3606
22	1.34242	3.09104	69.1150	380.1327
23	1.36173	3.13549	72.2566	415.4756
24	1.38021	3.17805	75.3982	452.3893
25	1.39794	3.21888	78.5398	490.8739
26	1.41497	3.25810	81.6814	530.9292
27	1.43136	3.29584	84.8230	572.5553
28	1.44716	3.33220	87.9646	615.7522
29	1.46240	3.36730	91.1062	660.5199
30	1.47712	3.40120	94.2478	706.8583

LOG–LOG e–CIRCUMFERENCE–AREA

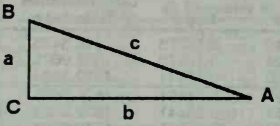
n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Radius n
31	1.49136	3.43399	97.3894	754.7676
32	1.50515	3.46574	100.5310	804.2477
33	1.51851	3.49651	103.6726	855.2986
34	1.53148	3.52636	106.8142	907.9203
35	1.54407	3.55535	109.9557	962.1128
36	1.55630	3.58352	113.0973	1017.8760
37	1.56820	3.61092	116.2389	1075.2101
38	1.57978	3.63759	119.3805	1134.1149
39	1.59106	3.66356	122.5221	1194.5906
40	1.60206	3.68888	125.6637	1256.6371
41	1.61278	3.71357	128.8053	1320.2543
42	1.62325	3.73767	131.9469	1385.4424
43	1.63347	3.76120	135.0885	1452.2012
44	1.64345	3.78419	138.2301	1520.5308
45	1.65321	3.80666	141.3717	1590.4313
46	1.66276	3.82864	144.5133	1661.9025
47	1.67210	3.85015	147.6549	1734.9445
48	1.68124	3.87120	150.7964	1809.5574
49	1.69020	3.89182	153.9380	1885.7410
50	1.69897	3.91202	157.0796	1963.4954
51	1.70757	3.93183	160.2212	2042.8206
52	1.71600	3.95124	163.3628	2123.7166
53	1.72428	3.97029	166.5044	2206.1834
54	1.73239	3.98898	169.6460	2290.2210
55	1.74036	4.00733	172.7876	2375.8294
56	1.74819	4.02535	175.9292	2463.0086
57	1.75587	4.04305	179.0708	2551.7586
58	1.76343	4.06044	182.2124	2642.0794
59	1.77085	4.07754	185.3540	2733.9710
60	1.77815	4.09434	188.4956	2827.4334
61	1.78533	4.11087	191.6372	2922.4666
62	1.79239	4.12713	194.7787	3019.0705
63	1.79934	4.14313	197.9203	3117.2453
64	1.80618	4.15888	201.0619	3216.9909
65	1.81291	4.17439	204.2035	3318.3072
66	1.81954	4.18965	207.3451	3421.1944
67	1.82607	4.20469	210.4867	3525.6524
68	1.83251	4.21951	213.6283	3631.6811
69	1.83885	4.23411	216.7699	3739.2807
70	1.84510	4.24850	219.9115	3848.4510
71	1.85126	4.26268	223.0531	3959.1921
72	1.85733	4.27667	226.1947	4071.5041
73	1.86332	4.29046	229.3363	4185.3868
74	1.86923	4.30407	232.4779	4300.8403
75	1.87506	4.31749	235.6194	4417.8647
76	1.88081	4.33073	238.7610	4536.4598
77	1.88649	4.34381	241.9026	4656.6257
78	1.89209	4.35671	245.0442	4778.3624
79	1.89763	4.36945	248.1858	4901.6699
80	1.90309	4.38203	251.3274	5026.5482
81	1.90849	4.39445	254.4690	5152.9973
82	1.91381	4.40672	257.6106	5281.0173
83	1.91908	4.41884	260.7522	5410.6079

LOG–LOG e–CIRCUMFERENCE–AREA

n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Radius n
84	1.92428	4.43082	263.8938	5541.7694
85	1.92942	4.44265	267.0354	5674.5017
86	1.93450	4.45435	270.1770	5808.8048
87	1.93952	4.46591	273.3186	5944.6787
88	1.94448	4.47734	276.4602	6082.1234
89	1.94939	4.48864	279.6017	6221.1389
90	1.95424	4.49981	282.7433	6361.7251
91	1.95904	4.51086	285.8849	6503.8822
92	1.96379	4.52179	289.0265	6647.6101
93	1.96848	4.53260	292.1681	6792.9087
94	1.97313	4.54329	295.3097	6939.7782
95	1.97772	4.55388	298.4513	7088.2184
96	1.98227	4.56435	301.5929	7238.2295
97	1.98677	4.57471	304.7345	7389.8113
98	1.99123	4.58497	307.8761	7542.9640
99	1.99564	4.59512	311.0177	7697.6874
100	2.00000	4.60517	314.1593	7853.9816
110	2.04139	4.70048	345.5752	9503.3178
120	2.07918	4.78749	376.9911	11309.7336
130	2.11394	4.86753	408.4070	13273.2290
140	2.14613	4.94164	439.8230	15393.8040
150	2.17609	5.01064	471.2389	17671.4587
160	2.20412	5.07517	502.6548	20106.1930
170	2.23045	5.13580	534.0708	22698.0069
180	2.25527	5.19296	565.4867	25446.9005
190	2.27875	5.24702	596.9026	28352.8737
200	2.30103	5.29832	628.3185	31415.9265
210	2.32222	5.34711	659.7345	34636.0590
220	2.34242	5.39363	691.1504	38013.2711
230	2.36173	5.43808	722.5663	41547.5628
240	2.38021	5.48064	753.9822	45238.9342
250	2.39794	5.52146	785.3982	49087.3852
260	2.41497	5.56068	816.8141	53092.9158
270	2.43136	5.59842	848.2300	57255.5261
280	2.44716	5.63479	879.6459	61575.2160
290	2.46240	5.66988	911.0619	66051.9855
300	2.47712	5.70378	942.4778	70685.8347
310	2.49136	5.73657	973.8937	75476.7635
320	2.50515	5.76832	1005.3096	80424.7719
330	2.51851	5.79909	1036.7256	85529.8600
340	2.53148	5.82895	1068.1415	90792.0277
350	2.54407	5.85793	1099.5574	96211.2750
360	2.55630	5.88610	1130.9734	101787.6020
370	2.56820	5.91350	1162.3893	107521.0086
380	2.57978	5.94017	1193.8052	113411.4948
390	2.59106	5.96615	1225.2211	119459.0606
400	2.60206	5.99146	1256.6371	125663.7061
410	2.61278	6.01616	1288.0530	132025.4313
420	2.62325	6.04025	1319.4689	138544.2360
430	2.63347	6.06379	1350.8848	145220.1204
440	2.64345	6.08677	1382.3008	152053.0844
450	2.65321	6.10925	1413.7167	159043.1281
460	2.66276	6.13123	1445.1326	166190.2514

n	Log 10	Log e	Circumference @ Diameter n	Circle Area @ Radius n
470	2.67210	6.15273	1476.5485	173494.4543
480	2.68124	6.17379	1507.9645	180955.7368
490	2.69020	6.19441	1539.3804	188574.0990
500	2.69897	6.21461	1570.7963	196349.5408
510	2.70757	6.23441	1602.2123	204282.0623
520	2.71600	6.25383	1633.6282	212371.6634
530	2.72428	6.27288	1665.0441	220618.3441
540	2.73239	6.29157	1696.4600	229022.1044
550	2.74036	6.30992	1727.8760	237582.9444
560	2.74819	6.32794	1759.2919	246300.8640
570	2.75587	6.34564	1790.7078	255175.8633
580	2.76343	6.36303	1822.1237	264207.9422
590	2.77085	6.38012	1853.5397	273397.1007
600	2.77815	6.39693	1884.9556	282743.3388
610	2.78533	6.41346	1916.3715	292246.6566
620	2.79239	6.42972	1947.7874	301907.0540
630	2.79934	6.44572	1979.2034	311724.5310
640	2.80618	6.46147	2010.6193	321699.0877
650	2.81291	6.47697	2042.0352	331830.7240
660	2.81954	6.49224	2073.4512	342119.4400
670	2.82607	6.50728	2104.8671	352565.2355
680	2.83251	6.52209	2136.2830	363168.1107
690	2.83885	6.53669	2167.6989	373928.0656
700	2.84510	6.55108	2199.1149	384845.1001
710	2.85126	6.56526	2230.5308	395919.2142
720	2.85733	6.57925	2261.9467	407150.4079
730	2.86332	6.59304	2293.3626	418538.6813
740	2.86923	6.60665	2324.7786	430084.0343
750	2.87506	6.62007	2356.1945	441786.4669
760	2.88081	6.63332	2387.6104	453645.9792
770	2.88649	6.64639	2419.0263	465662.5711
780	2.89209	6.65929	2450.4423	477836.2426
790	2.89763	6.67203	2481.8582	490166.9938
800	2.90309	6.68461	2513.2741	502654.8246
810	2.90849	6.69703	2544.6900	515299.7350
820	2.91381	6.70930	2576.1060	528101.7251
830	2.91908	6.72143	2607.5219	541060.7947
840	2.92428	6.73340	2638.9378	554176.9441
850	2.92942	6.74524	2670.3538	567450.1730
860	2.93450	6.75693	2701.7697	580880.4816
880	2.94448	6.77992	2764.6015	608212.3377
890	2.94939	6.79122	2796.0175	622113.8852
900	2.95424	6.80239	2827.4334	636172.5123
910	2.95904	6.81344	2858.8493	650388.2191
920	2.96379	6.82437	2890.2652	664761.0055
930	2.96848	6.83518	2921.6812	679290.8715
940	2.97313	6.84588	2953.0971	693977.8172
950	2.97772	6.85646	2984.5130	708821.8424
960	2.98227	6.86693	3015.9289	723822.9474
970	2.98677	6.87730	3047.3449	738981.1319
980	2.99123	6.88755	3078.7608	754296.3961
990	2.99564	6.89770	3110.1767	769768.7399
1000	3.00000	6.90776	3141.5927	785398.1634

RIGHT TRIANGLE TRIG FORMULAS



A, B, C = Angles a, b, c = Distances

$$\sin A = \frac{a}{c} \ , \ \cos A = \frac{b}{c} \ , \ \tan A = \frac{a}{b}$$

$$\cot A = \frac{b}{a} \ , \ sec\, A = \frac{c}{b} \ , \ cosec\, A = \frac{c}{a}$$

Given a and b, Find A, B, and c

$$\tan A = \frac{a}{b} = \cot B \ , \ c = \sqrt{a^2+b^2} = a\sqrt{1+\frac{b^2}{a^2}}$$

Given a and c, Find A, B, b

$$\sin A = \frac{a}{c} = \cos B \ , \ b = \sqrt{(c+a)(c-a)} = c\sqrt{1-\frac{a^2}{c^2}}$$

Given A and a, Find B, b, c

$$B = 90^o - A \ , \ b = a \cot A \ , \ c = \frac{a}{\sin A}$$

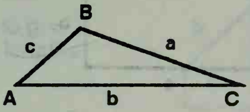
Given A and b, Find B, a, c

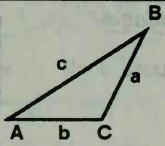
$$B = 90^o - A \ , \ a = b \tan A \ , \ c = \frac{b}{\cos A}$$

Given A and c, Find B, a, b

$$B = 90^o - A \ , \ a = c \sin A \ , \ b = c \cos A$$

OBLIQUE TRIANGLE FORMULAS





Given A, B and a, Find b, C, and c

$$b = \frac{a \sin B}{\sin A}, \quad C = 180^o - (A+B), \quad c = \frac{a \sin C}{\sin A}$$

Given A, a and b, Find B, C, and c

$$\sin B = \frac{b \sin A}{a}, \quad C = 180^o - (A+B), \quad c = \frac{a \sin C}{\sin A}$$

Given a, b and C, Find A, B, and c

$$A+B = 180^o - C, \quad c = \frac{a \sin C}{\sin A}$$

$$\tan \tfrac{1}{2}(A-B) = \frac{(a-b) \tan \tfrac{1}{2}(A+B)}{a+b}$$

Given a, b and c, Find A, B, and C

$$s = \frac{a+b+c}{2}, \quad \sin \tfrac{1}{2} A = \sqrt{\frac{(s-b)(s-c)}{bc}}$$

$$\sin \tfrac{1}{2} B = \sqrt{\frac{(s-a)(s-c)}{ac}}, \quad C = 180^o - (A+B)$$

Given a, b and c, Find Area

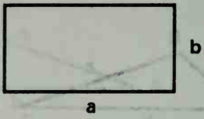
$$s = \frac{a+b+c}{2}, \quad Area = \sqrt{s(s-a)(s-b)(s-c)}$$

$$Area = bc \sin \frac{A}{2}, \quad Area = \frac{a^2 \sin B \sin C}{2 \sin A}$$

PLANE FIGURE FORMULAS

Rectangle

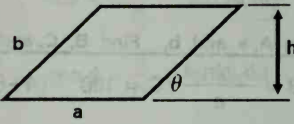
If square, a = b



Area = ab
Perimeter = $2(a + b)$, *Diagonal* = $\sqrt{a^2 + b^2}$

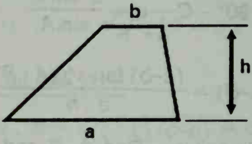
Parallelogram

All sides are parallel
θ = degrees



Area = $ah = ab \sin\theta$, *Perimeter* = $2(a + b)$

Trapezoid

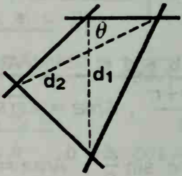


$$Area = \frac{(a + b)}{2} h$$

Perimeter = Sum of lengths of sides

Quadrilateral

θ = degrees

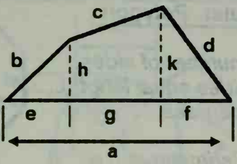


$$Area = \frac{d_1 \times d_2 \times \sin\theta}{2}$$

PLANE FIGURE FORMULAS

Trapezium

a to g = lengths

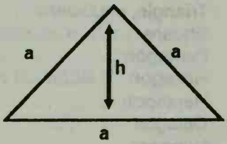


Perimeter $= a + b + c + d$

$$Area = \frac{(h+k)\,g + e\,h + f\,k}{2}$$

Equilateral Triangle

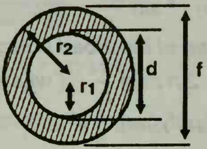
a = all sides equal



Perimeter $= 3\,a$, $h = \frac{a}{2}\sqrt{3} = 0.866\,a$

$$Area = a^2\,\frac{\sqrt{3}}{4} = 0.433\,a^2$$

Annulus

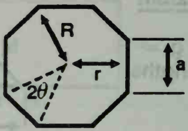


$$Area = 0.7854\,(d^2 - f^2)$$

$$Area = \pi\,(r_1 + r_2)\,(r_2 - r_1)$$

PLANE FIGURE FORMULAS

Regular Polygons



n = number of sides
(all sides equal length)
θ = degrees

Perimeter $= n\,a$

$$Area = \frac{n\,a\,r}{2} = n\,r^2 \tan\theta = \frac{n\,R^2}{2}\sin 2\,\theta$$

Polygon	Number of Sides	Area
Triangle, equilateral	3	$0.4330\ a^2$
Square	4	$1.0000\ a^2$
Pentagon	5	$1.7205\ a^2$
Hexagon	6	$2.5981\ a^2$
Heptagon	7	$3.6339\ a^2$
Octagon	8	$4.8284\ a^2$
Nonagon	9	$6.1818\ a^2$
Decagon	10	$7.6942\ a^2$
Undecagon	11	$9.3656\ a^2$
Dodecagon	12	$11.1961\ a^2$

Area of inscribed polygon in a circle of radius r =

$$\tfrac{1}{2}\,n\,r^2 \sin\frac{2\pi}{n}$$

Perimeter of inscribed polygon in circle of radius

$$r = 2\,n\,r \sin\frac{\pi}{n} \quad (\textit{where } \pi \textit{ radians} = 180^{o})$$

Area of polygon in circumscribed circle , radius

$$R = n\,r^2 \tan\frac{\pi}{n}$$

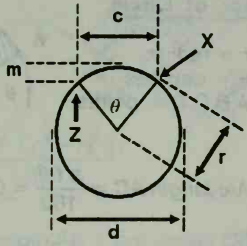
Perimeter of circumscribed polygon in circle ,

with radius $r = \ 2\,n\,r \tan\frac{\pi}{n}$

PLANE FIGURE FORMULAS

Circle

Z = point
X = point
θ = degrees
c,d,r,m = lengths
π = 3.14159
c = cord
r = radius



$$Circumference = 2\pi r = \pi d = 3.14159\, d$$

$$Circumference\ or\ Perimeter = 2\pi r = \pi d$$

$$Area = \pi r^2 = \pi \frac{d^2}{4} = 0.78539\, d^2$$

$$Area = \frac{Perimeter^2}{4}\pi = 0.07958\ Perimeter^2$$

$$Length\ of\ \text{arc}\ XZ = \theta \frac{\pi}{180} r = 0.017453\, \theta\, r$$

$$r = \frac{m^2 + 1/4\, c^2}{2m} = \frac{1/2\, c}{\sin 1/2\, \theta}$$

$$c = 2\sqrt{2mr - m^2} = 2r \sin 1/2\, \theta$$

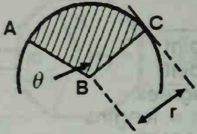
$$m = r \pm \sqrt{r^2 - \frac{c^2}{4}} \quad (\text{use + if arc} \geq 180^o, \ - \text{if arc} < 180^o)$$

$$m = 1/2\, c \tan 1/4\, \theta = 2r \sin^2 1/4\, \theta$$

PLANE FIGURE FORMULAS

Sector of Circle

r = radius
θ = degrees
A,B,C,D = points



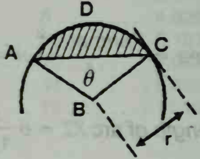
$$\text{Arc length } AC = \frac{\pi r \theta}{180} = 0.1745\, r\, \theta$$

$$\text{Area } ABCA = \frac{\pi \theta r^2}{360} = 0.008727\, \theta\, r^2$$

$$\text{Area } ABCA = \frac{\text{Arc length } AC \times r}{2}$$

Segment of Circle

r = radius
θ = degrees
A,B,C,D = points



For $\theta < 90°$

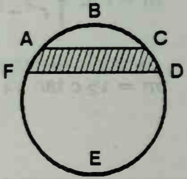
$$\text{Area } ACDA = \frac{r^2}{2}\left(\frac{\pi \theta}{180} - \sin\theta\right)$$

For $\theta > 90°$

$$\text{Area } ACDA = \frac{r^2}{2}\left(\frac{\pi \theta}{180} - \sin(180 - \theta)\right)$$

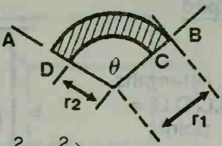
Circular Zone

Area ACDFA =
Circle Area –
Segment Area ABCA –
Segment Area FDEF



Hollow Circle Sector

θ = degrees
A,B,C,D = points
r = radius

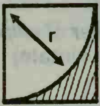


$$Area\ ABCDA = \frac{\pi\,\theta\,(r_2^2 - r_1^2)}{360}$$

$$Area\ ABCDA = \frac{r_1 - r_2}{2}\,(\,Arc\ length\ AB + Arc\ length\ CD\,)$$

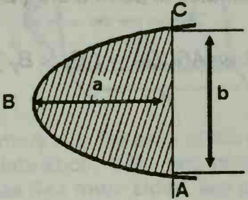
Fillet

r = radius
Area of fillet = $0.215\,r^2$



Parabola

A,B,C = points
a,b = lengths

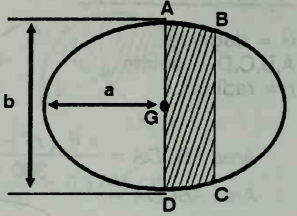


$$Area\ ABCA = \frac{2}{3}\,a\,b$$

$$Arc\ Length\ ABC = b\left\{\frac{1}{2}\left(1 + 16\left(\frac{a}{b}\right)^2\right)^{\frac{1}{2}} + \frac{1}{8\left(\frac{a}{b}\right)}\log_e \times \left[4\,n + \left(1 + 16\left(\frac{a}{b}\right)^2\right)^{\frac{1}{2}}\right]\right\}$$

Ellipse

a,b = lengths
A,B,C,D,G = points



Area of ellipse $= \pi\, a\, b$

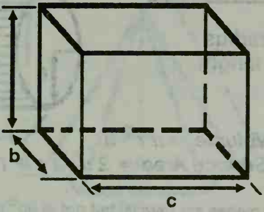
Perimeter of ellipse $= \pi \left[\, 1.5\,(a + b) - \sqrt{ab}\,\right]$
(approximate)

Assuming point G is the center of the ellipse, which has (x, y) coordinates of (0, 0), and the coordinates of point B are (B_x, B_y) :

$$\text{Area } ABCDA = (B_x \times B_y) + ab \sin^{-1}\left(\frac{B_x}{a}\right)$$

Parallelopiped and Cube

a,b,c = lengths



If a Cube:

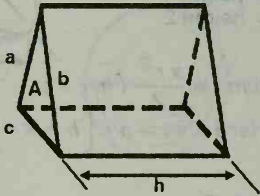
Volume $= a^3$ *Surface area* $= 6\,a^2$

If a Parallelopiped (a, b, and c can be different):

Volume $= a\,b\,c$ *Area* $= 2\,(\,ab + bc + ac\,)$

Prism – Right, or oblique, regular or irregular

A = area
h = length
a,b,c = length



Volume $= A\,h$ where A is the area of the end plate abca. If the end plate has 3 or more sides, see page 294 for rules of calculating areas of polygons.

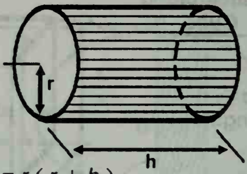
Convex Surface area $= h\,(\,a+b+c+\ldots.n \text{ sides}\,)$

If end planes are parallel but not at 90° to h, the same formulas apply but a slice at 90° through the prism must be used to determine a, b, and c.

SOLID FIGURE FORMULAS

Right Cylinder

r = radius
h = length

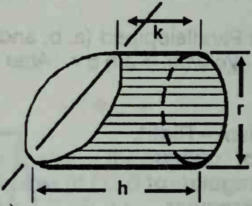


Volume = $\pi r^2 h$
Surface Area = $2 \pi r (r + h)$

If end planes are parallel but not at 90° to h, the same formulas apply but a slice at 90° through the prism must be used to determine r.

Frustrum of a Right Cylinder

r = radius
h = height 1
k = height 2

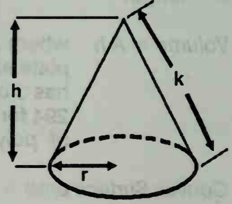


$$Volume = \frac{\pi r^2}{2} (h + k)$$

$$Surface\ Area = \pi r \left[h + k + r + \sqrt{r^2 + \left(\frac{h - k}{2}\right)^2} \right]$$

Right Cone

r = radius
h = height
k = side length



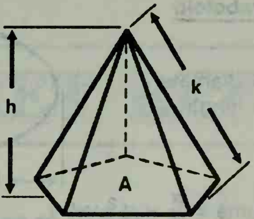
$$Volume = \frac{\pi r^2 h}{3}$$

Surface Area = $\pi r (r + k)$

SOLID FIGURE FORMULAS

Right Pyramid

A = base plane
h = height
k = side length



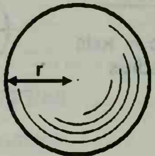
$$Volume = \frac{(\text{Perimeter of base } A)\, h}{3}$$

$$\text{Surface Area (no base)} = \text{Perimeter of base } A \times \frac{k}{2}$$

Use polygon areas on page 294 , if you want to include the base area

Sphere

r = radius

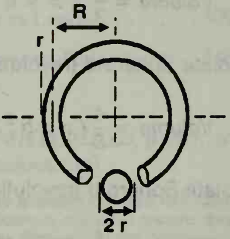


$$Volume = \frac{4 \pi r^3}{3}$$

$$\text{Surface Area} = 4 \pi r^2$$

Circular Ring

r = cross section radius
R = ring radius

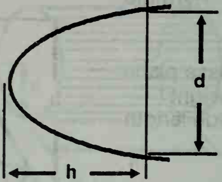


$$Volume = 2 \pi^2 R r$$

$$\text{Surface Area} = 2 \pi^2 R r^2$$

Paraboloid

d = diameter
h = length



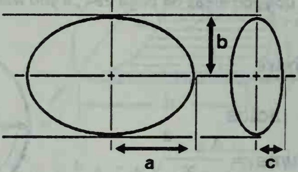
$$Volume = \frac{\pi}{8} \times d^2 \times h$$

Surface Area (no base) =

$$\frac{2}{3} \times \pi \times \frac{d}{h^2}\left[\left(\frac{d^2}{16} + h^2\right)^{\frac{3}{2}} - \left(\frac{d}{4}\right)^3\right]$$

Ellipsoid and Spheroid

a, b, c = axis radius



$$Volume = \frac{4}{3} \times \pi \times a \times b \times c$$

Prolate Spheroid (revolution about major axis b)

$$Volume = \frac{4}{3}(\pi\, a\, b^2)$$

Oblate Spheroid (revolution about minor axis a)

$$Volume = \frac{4}{3}(\pi\, b\, a^2)$$

POCKET REF

Mine and Mill [1]

(See also WEIGHTS OF MATERIALS, p. 389, for Angle of Repose, Rock Densities, etc)

[1] Two pocket sized handbooks are available that deal with roadway and milling equipment specifications and other general data: (a) *Pioneer Facts and Figures, Portec Pioneer Division, Minneapolis, MN* and (b) *Cedarapids Reference Book, Iowa Mfg Co. Cedar Rapids, Iowa*.

STANDARD SIEVE SERIES

Tyler Inch/Mesh #	US Standard Inch/Sieve #	Sieve Opening Inches	Sieve Opening Millimeters
	4.24 inch	4.24	107.6
	4 inch	4.00	101.6
	2.12 inch	2.12	53.8
	2 inch	2.00	50.8
	1-1/2 inch	1.50	38.1
	1-1/4 inch	1.25	31.5
1.05 inch	1.06 inch	1.06	26.5
	1.00 inch	1.00	25.0
0.883 inch	7/8 inch	0.875	22.4
0.742 inch	3/4 inch	0.750	19.0
0.624 inch	5/8 inch	0.625	16.0
0.525 inch	0.530 inch	0.530	13.2
	1/2 inch	0.500	12.5
0.441 inch	7/16 inch	0.4375	11.2
0.371 inch	3/8 inch	0.375	9.5
2 1/2	5/16 inch	0.3125	8.0
3	0.265 inch	0.265	6.7
	1/4 inch	0.250	6.3
3 1/2	3-1/2	0.223	5.66
4	4	0.187	4.76
5	5	0.157	4.00
6	6	0.132	3.66
7	7	0.111	2.83
8	8	0.0937	2.38
9	10	0.0787	2.00
10	12	0.0661	1.68
12	14	0.0555	1.41
14	16	0.0469	1.19
16	18	0.0394	1.00
20	20	0.0331	0.84
24	25	0.0280	0.71
28	30	0.0232	0.59
32	35	0.0197	0.50
35	40	0.0165	0.42
42	45	0.0138	0.35
48	50	0.0117	0.297
60	60	0.0098	0.250
65	70	0.0083	0.210
80	80	0.0070	0.177
100	100	0.0059	0.149
115	120	0.0049	0.125
150	140	0.0041	0.105
170	170	0.0035	0.088
200	200	0.0029	0.074
250	230	0.0024	0.062
270	270	0.0021	0.053
325	325	0.0017	0.044
400	400	0.0015	0.037

Note: 1 millimeter = 1000 microns

MINERAL DRESSING SIZING SCALE

Size	Mineral Dressing Method
+ 4 inch to 400 mesh	Screening
+ 4 inch to 65 mesh	Magnetic Separator (dry)
+ 4 inch to 325 mesh	Magnetic Separator (wet)
+ 4 inch to 4 mesh	Sink – Float
+ 4 inch to 65 mesh	Hammer Mill – Jaw Crusher
+ 4 inch to 65 mesh	Gyratory Crusher
+ 4 inch to 28 mesh	Rolls
4 inch to 20 mesh	Jigging
2 inch to 3 mesh	Rod Mill
1 inch to 325 mesh	Ball Mill
0.5 inch to 26 micron	Pulverizer
3 mesh to 48 mesh	Weinig Jig
4 mesh to 100 mesh	Humphreys Spiral
8 mesh to 200 mesh	Shaking Table
10 mesh to 18.5 micron	Isodynamic Separator
35 mesh to 4.6 micron	Classification
35 mesh to 6.5 micron	Flotation
48 mesh to 3.25 micron	Turbidimetry
65 mesh to 9.25 micron	Superpanner
100 mesh to 6.5 micron	Infrasizer
0.81 micron to 0.25 micron	Centrifuge
400 mesh to 0.2 micron	Normal Microscope Range
± 0.5 micron	Brownian Movement and the wavelength of visible light
0.41 micron to 0.001 micron	Normal Electron Microscope
± 0.025 micron	Thinnest files visible by light interference
0.004 micron	Large Molecules
0.0007 micron	Average Crystal Unit

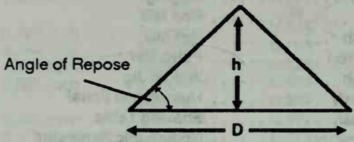
NOTE: The above size ranges are approximations only and the actual size range can vary considerably depending on the material and current technology.

STOCKPILE VOLUME & WEIGHT

The following formula is used to calculate the volume of a stockpile if the diameter and height are known:

$$\textbf{Volume in cubic feet} = 0.2618 \times D^2 \times h$$

D = Diameter of the base of the cone in feet
h = Height of the cone in feet



In order to calculate the actual weight of material in the stockpile, determine the density or weight/cubic foot (or look up an approximation of the density in the WEIGHTS OF MATERIALS chapter.)

$$\textbf{Weight in tons} = \textbf{Volume in cubic feet} \times \frac{\textbf{Density in lbs/cu. feet}}{2000}$$

CONICAL STOCKPILE VOLUMES (37° Angle of Repose)

Diameter in feet	Height in feet	Volume in Cu Yds	Weight at 100 lbs/cu foot
26.50	10	68	92
39.83	15	230	310
53.00	20	545	735
66.30	25	1065	1440
79.50	30	1845	2490
92.83	35	2930	3955
106.00	40	4370	5900
132.66	50	8540	11525
159.16	60	14755	19915
186.00	70	23375	31555
212.16	80	34970	47210
238.83	90	49795	67225
265.30	100	68300	92210

MATERIAL DUMPING ANGLES

Material	Dumping Angle in Degrees
Ashes, dry	33
Ashes, moist	36
Ashes, wet	30
Asphalt	45
Cinders, dry	33
Cinders, moist	34
Cinders, wet	31
Cinders and Clay	30
Clay	45
Coal, hard	24
Coal, soft	30
Coke	23
Concrete	30
Earth, loose	28
Earth, compact	50
Garbage	30
Gravel	40
Ore, dry	30
Ore, damp	37
Rubble	45
Sand, dry	35
Sand, damp	40
Sand, with crushed stone	27
Stone	30
Stone, broken	27
Stone, crushed	30

ROCK BULKING FACTORS

Material	Density In Place	Density After Mined	Percent Expansion
Basalt	3.00	1.72	75 to 80%
Clay	1.86	1.49	20 to 30%
Dolomite	2.56	1.73	50 to 60%
Gneiss	2.69	1.54	75 to 80%
Granite	2.72	1.55	75 to 80%
Gravel, dry	1.80	1.40	20 to 30%
Gravel, wet	2.00	1.60	20 to 30%
Gravel, wet w/clay	1.92	1.28	50 to 60%
Limestone	2.69	1.54	75 to 80%
Quartz	2.64	1.51	75 to 80%
Sand, dry	1.60	1.28	20 to 30%
Sand, wet	1.95	1.56	20 to 30%
Sandstone	2.42	1.38	75 to 80%
Slate	2.80	1.52	85 to 90%
Soil, w/clay	1.76	1.41	20 to 30%

LENGTH OF BELT IN A ROLL

In order to calculate the number of feet of conveyor belt in a tightly coiled roll, use the following equations:

$$A = \text{Diameter of coil in inches} + \text{Diameter of coil hole in inches}$$

$$\text{Belt length in feet} = A \times \text{Number of coils} \times 0.131$$

CONVEYOR SLOPE MAXIMUMS

Material	Maximum Slope Degrees
Cement, loose	22
Coke, screened	18
Coke, breeze	20
Concrete, 6 inch slump	12
Concrete, 4 inch slump	20
Concrete, 2 inch slump	24 to 26
Coal, +4 inch lump, soft	15
Coal, – 4 inch lump, soft	16
Coal, anthracite	16
Coal, unsized	18
Coal, soft, fine	20 to 22
Earth, loose	20
Earth, sluggish	22
Glass batch	21
Gravel, sized, washed	12
Gravel, sized, unwashed	15
Gravel, unsized	18 to 20
Grain, whole	15
Gypsum, powdered	23
Lime, powdered	23
Logs, no bark	10
Ore, +4 inch	18
Ore, – 4 inch	20
Ore, sized	16
Packages, paper wrapped, smooth belt	16
Packages, paper wrapped, ribflex belt	25 to 45
Salt	20
Sand, dry	16
Sand, moist, bank run	20
Sand, foundry	24
Sulphur, powdered	21
Stone, sized, +4 inch	15
Stone, sized, – 4 inch	16
Stone, unsized, +4 inch	16
Stone, unsized, – 4 inch	18
Stone, – 3/8 inch	20
Wood chips	25

CONVEYOR CAPACITIES

Belt Width Inches	Material Size Inches	Belt Speed Feet/min	Tons/hour capacity @ lbs/cu ft material weight with 22° idlers.
12	2 to 3	200	14 @ 30, 44 @ 100, 70 @ 150
16	3 to 5	300	36 @ 30, 123 @ 100, 183 @ 150
18	4 to 6	300	39 @ 30, 156 @ 100, 231 @ 150
24	6 to 8	300	84 @ 30, 276 @ 100, 414 @ 150
30	7 to 12	350	150 @ 30, 504 @ 100, 756 @ 150
36	8 to 16	350	228 @ 30, 728 @ 100, 1088 @ 150
42	10 to 20	400	340 @ 30, 1128 @ 100, 1692 @ 150
48	12 to 24	400	452 @ 30, 1512 @ 100, 2248 @ 150

Note: For capacities with 35° idlers, multiply 22° capacity by 1.15

CONVEYOR HORSEPOWER vs LOAD

Conv Length Feet	Horsepower Required for Transporting Material on Level Ground at the given Tons/Hour Capacity					
	100	200	400	600	800	1000
25	2.0	2.5	3.5	4.5	5.5	6.5
50	2.4	3.0	4.2	5.4	6.6	7.8
100	3.0	3.8	5.3	6.8	8.3	9.8
200	4.3	5.3	7.5	9.7	11.9	14.1
300	5.6	7.0	9.8	12.6	15.4	18.2
400	6.8	8.5	11.9	15.3	18.7	22.1
500	8.0	10.1	14.3	18.5	22.7	26.9

Conv Lift Feet	Extra Horsepower Required in addition to above HP For Lifting at the given Tons/Hour Capacity					
	100	200	400	600	800	1000
10	1	2	4	6	8	10
20	2	4	8	12	16	20
30	3	6	12	18	24	30
40	4	8	16	24	32	40
50	5	10	20	30	40	50
60	6	12	24	36	48	60
80	8	16	32	48	64	80
100	10	20	40	60	80	100

The above data is for equipment manufactured by *Portec Pioneer Division, Minneapolis, MN 55414.*

JAW CRUSHER HP vs TONS/HOUR

The following data is for *Pioneer. Portec Division Jaw Crushers. Contact Pioneer in Minneapolis. MN* for current, exact specs.

Model Size(1)	Horsepower Elec/Diesel	Tons/Hr Capacity @ given Feed Size(in) 3/4	1	1-1/4	1-1/2	2	2-1/2	3
1016	15/25	7	10	12	14	19	24	28
1020	20/30	8	12	15	18	24	30	36
1024	25/40	10	15	18	22	29	36	44
1036	40/60	...	22	27	33	44	55	67
1524	40/60	...	...	...	...	36	45	54
1536	75/110	...	...	...	...	54	68	81
1830	60/90	...	...	...	...	...	61	74
2036	100/140	...	...	...	...	...	...	93
2148	125/170	...	...	...	...	...	...	124
2854	150/190	3-1/2 inch feed = 178 TPH						

Model Size(1)	Horsepower Elec/Diesel	Tons/Hr Capacity @ given Feed Size(in) 4	5	6	7	8	9	10
1524	40/60	72	...	...	...	...	...	...
1536	75/110	109	136	...	...	...	...	...
1830	60/90	98	123	...	...	...	...	...
2036	100/140	124	156	187	...	...	...	...
2436	100/150	136	171	205	239	273	...	...
2148	125/170	165	207	248	...	...	...	...
2854	150/190	204	256	308	360	410	...	...
3042	150/190	178	223	268	313	357	...	...
3546	200/250	210	275	318	370	423	475	...
4248	250/310	...	315	365	425	485	546	607
4248	250/310	11 inch feed = 668 TPH						
4248	250/310	12 inch feed = 730 TPH						

(1) Model Size values in column 1 describe the dimensions at the top of the jaw opening. The first two digits, e.g. "15" in Model 1524, are the number of inches between the jaw plates. The second two digits, e.g. "24" in Model 1524, are the number of inches between the side plates.

Capacities in the above tables are based on material that weighs 2700 lbs/cu. yard (100 lbs/cu. foot) and the Jaw Crusher has closed side plates.

POCKET REF

Money

CURRENCY EXCHANGE RATES

"Value" below is what 1 unit of Currency is worth in US Dollars

Country	Currency	Value	Country	Currency	Value
Afghanistan	Afghani	0.020	Iraq	Dinar	3.226
Algeria	Dinar	0.190	Ireland (Eire)	Punt	1.581
Argentina	Austral	0.220	Israel	Shekel	0.633
Australia	Dollar	0.857	Italy	Lire	0.00078
Austria	Schilling	0.083	Jamaica	Dollar	0.182
Bahamas	Dollar	1.000	Japan	Yen	0.0079
Bahrain	Dinar	2.640	Kenya	Shilling	0.063
Barbados	Dollar	0.497	Korea	Won	0.0013
Belgium	Franc	0.028	Laos	Kip	0.0028
Belize	Dollar	0.497	Lebanon	Pound	0.0027
Bermuda	Dollar	1.000	Libya	Dinar	3.571
Brazil	Crusado	0.010	Malta	Lira	0.328
Bulgaria	Leva	1.205	Mexico	Peso	0.00046
Burma	Kyat	0.160	Morocco	Dirham	0.124
Cameroun	CFA	0.0035	Nepal	Rupee	0.048
Canada	Dollar	0.866	Netherlands	Guilder	0.514
Caribbean,E	Dollar	0.370	New Zealand	Dollar	0.731
Cayman Is.	Dollar	1.205	Norway	Krone	0.162
Chad	CFA	0.0035	Oman	Rial	2.632
Chile	Peso	0.0041	Pakistan	Rupee	0.057
China	Renminbi	0.306	Papua NG	Kina	1.111
Columbia	Peso	0.0037	Paraguay	Guarani	0.0011
Costa Rica	Colon	0.014	Peru	Inti	0.030
Cuba	Peso	1.316	Philippines	Peso	0.048
Cyprus	Pound	0.461	Poland	Zloty	0.0026
Czechoslovakia	Kroner	0.192	Portugal	Escudo	0.0073
Denmark	Krone	0.154	Romania	Leu	0.117
Dominican R.	Peso	0.202	Saudi Arabia	Riyal	0.267
Ecuador	Sucre	0.0028	Scotland	Pound	0.564
Egypt	Pound	0.446	Singapore	Dollar	0.531
El Salvador	Colon	0.200	South Africa	Rand	0.481
Ethiopia	Birr	0.483	Spain	Peseta	0.0088
Fiji	Dollar	0.785	Sweden	Krona	0.169
Finland	Mark	0.247	Switzerland	Franc	0.699
France	Franc	0.172	Syria	Pound	0.033
Gambia	Dalasi	0.137	Tahiti	CFP Franc	0.0096
Germany,E	Ostmark	0.578	Taiwan	Dollar	0.035
Germany,W	Mark	0.578	Thailand	Baht	0.039
Ghana	Cedi	0.0055	Tunisia	Dinar	1.219
Great Britain	Pound	1.797	Turkey	Lira	0.00085
Greece	Drachma	0.0075	Uganda	Shilling	0.017
Guatemala	Quetzal	0.394	Uruguay	Peso	0.0033
Haiti	Gourde	0.200	USSR	Rouble	1.666
Holland	Guilder	0.526	Venezuela	Bolivar	0.034
Hong Kong	Dollar	0.134	Vietnam	Dong	0.0027
Hungary	Forint	0.021	Yemen,N	Rial	0.101
Iceland	Kroner	0.027	Yugoslavia	Dinar	0.00074
India	Rupee	0.077	Zaire	Zaire	0.007
Indonesia	Rupiah	0.0006	Zambia	Kwacha	0.125
Iran	Rial	0.015	Zimbabwe	Dollar	0.575

Use these exchange rates only as a general guide. If you need current rates, call a foreign exchange company such as *Deak International, 1580 Court Place, Denver, CO 80202, (303) 571-0808.*

	Rate of Interest per Year in Percent						
Year	5	6	7	8	9	10	11
1	0.952	0.943	0.935	0.926	0.917	0.909	0.901
2	0.907	0.890	0.873	0.857	0.842	0.826	0.812
3	0.864	0.840	0.816	0.794	0.772	0.751	0.731
4	0.823	0.792	0.763	0.735	0.708	0.683	0.659
5	0.784	0.747	0.713	0.681	0.650	0.621	0.593
6	0.746	0.705	0.666	0.630	0.596	0.564	0.535
7	0.711	0.665	0.623	0.583	0.547	0.513	0.482
8	0.677	0.627	0.582	0.540	0.502	0.467	0.434
9	0.645	0.592	0.544	0.500	0.460	0.424	0.391
10	0.614	0.558	0.508	0.463	0.422	0.386	0.352
11	0.585	0.527	0.475	0.429	0.388	0.350	0.317
12	0.557	0.497	0.444	0.397	0.356	0.319	0.286
13	0.530	0.469	0.415	0.368	0.326	0.290	0.258
14	0.505	0.442	0.388	0.340	0.299	0.263	0.232
15	0.481	0.417	0.362	0.315	0.275	0.239	0.209
20	0.377	0.312	0.258	0.215	0.178	0.149	0.124

	Rate of Interest per Year in Percent						
Year	12	13	14	15	16	17	18
1	0.893	0.885	0.877	0.870	0.862	0.855	0.847
2	0.797	0.783	0.769	0.756	0.743	0.731	0.718
3	0.712	0.693	0.675	0.658	0.641	0.624	0.609
4	0.636	0.613	0.592	0.572	0.552	0.534	0.516
5	0.567	0.543	0.519	0.497	0.476	0.456	0.437
6	0.507	0.480	0.456	0.432	0.410	0.390	0.370
7	0.452	0.425	0.400	0.376	0.354	0.333	0.314
8	0.404	0.376	0.351	0.327	0.305	0.285	0.266
9	0.361	0.333	0.308	0.284	0.263	0.243	0.225
10	0.322	0.295	0.270	0.247	0.227	0.208	0.191
11	0.287	0.261	0.237	0.215	0.195	0.178	0.162
12	0.257	0.231	0.208	0.187	0.168	0.152	0.137
13	0.229	0.204	0.182	0.163	0.145	0.130	0.116
14	0.205	0.181	0.160	0.141	0.125	0.111	0.099
15	0.183	0.160	0.140	0.123	0.108	0.095	0.084
20	0.104	0.087	0.073	0.061	0.051	0.043	0.037

EXAMPLE:

What is the present value of $100 in 12 years at a 14% discount?

Net Present Value = $100 x 0.208 = $20.80

SIMPLE INTEREST ON $100

Days	Rate of Interest in Percent 5	6	7	8	9	10	11
1	0.014	0.016	0.019	0.022	0.025	0.027	0.030
2	0.027	0.033	0.038	0.044	0.049	0.055	0.060
3	0.041	0.049	0.058	0.066	0.074	0.082	0.090
4	0.055	0.066	0.077	0.088	0.099	0.110	0.121
5	0.069	0.082	0.096	0.110	0.123	0.137	0.151
6	0.082	0.099	0.115	0.132	0.148	0.164	0.181
7	0.096	0.115	0.134	0.153	0.173	0.192	0.211
8	0.110	0.132	0.153	0.175	0.197	0.219	0.241
9	0.123	0.148	0.173	0.197	0.222	0.247	0.271
10	0.137	0.164	0.192	0.219	0.247	0.274	0.301
20	0.274	0.329	0.384	0.438	0.493	0.548	0.603
30	0.411	0.493	0.575	0.658	0.740	0.822	0.904
40	0.548	0.658	0.767	0.877	0.986	1.10	1.21
50	0.685	0.822	0.959	1.10	1.23	1.37	1.51
60	0.822	0.986	1.15	1.32	1.48	1.64	1.81
70	0.959	1.15	1.34	1.53	1.73	1.92	2.11
80	1.10	1.32	1.53	1.75	1.97	2.19	2.41
90	1.23	1.48	1.73	1.97	2.22	2.47	2.71
100	1.37	1.64	1.92	2.19	2.47	2.74	3.01
200	2.74	3.29	3.84	4.38	4.93	5.48	6.03

Days	Rate of Interest in Percent 12	13	14	15	16	17	18
1	0.033	0.036	0.038	0.041	0.044	0.047	0.049
2	0.066	0.071	0.077	0.082	0.088	0.093	0.099
3	0.099	0.107	0.115	0.123	0.132	0.140	0.148
4	0.132	0.142	0.153	0.164	0.175	0.186	0.197
5	0.164	0.178	0.192	0.205	0.219	0.233	0.247
6	0.197	0.214	0.230	0.247	0.263	0.279	0.296
7	0.230	0.249	0.268	0.288	0.307	0.326	0.345
8	0.263	0.285	0.307	0.329	0.351	0.373	0.395
9	0.296	0.321	0.345	0.370	0.395	0.419	0.444
10	0.329	0.356	0.384	0.411	0.438	0.466	0.493
20	0.658	0.712	0.767	0.822	0.877	0.932	0.986
30	0.986	1.07	1.15	1.23	1.32	1.40	1.48
40	1.32	1.42	1.53	1.64	1.75	1.86	1.97
50	1.64	1.78	1.92	2.05	2.19	2.33	2.47
60	1.97	2.14	2.30	2.47	2.63	2.79	2.96
70	2.30	2.49	2.68	2.88	3.07	3.26	3.45
80	2.63	2.85	3.07	3.29	3.51	3.73	3.95
90	2.96	3.21	3.45	3.70	3.95	4.19	4.44
100	3.29	3.56	3.84	4.11	4.38	4.66	4.93
200	6.58	7.12	7.67	8.22	8.77	9.32	9.86

EXAMPLE: If you put $100 in savings for 30 days at 12% simple interest, how much interest do you earn during that period?

$0.986 (98.6¢)   130 days = 3.29 + 0.986 = $4.27

COMPOUND INTEREST

Year	Rate of Interest per Year in Percent						
	5	6	7	8	9	10	11
1	1.05	1.06	1.07	1.08	1.09	1.10	1.11
2	1.10	1.12	1.14	1.17	1.19	1.21	1.23
3	1.16	1.19	1.22	1.26	1.30	1.33	1.37
4	1.22	1.26	1.31	1.36	1.41	1.46	1.52
5	1.28	1.34	1.40	1.47	1.54	1.61	1.68
6	1.34	1.42	1.50	1.59	1.68	1.77	1.86
7	1.41	1.50	1.60	1.71	1.83	1.95	2.07
8	1.48	1.59	1.72	1.86	1.99	2.14	2.30
9	1.55	1.69	1.84	2.00	2.17	2.36	2.55
10	1.63	1.79	1.97	2.16	2.37	2.59	2.83
11	1.71	1.90	2.10	2.33	2.58	2.85	3.14
12	1.80	2.01	2.25	2.52	2.81	3.14	3.49
13	1.89	2.13	2.41	2.72	3.07	3.45	3.87
14	1.98	2.26	2.58	2.94	3.34	3.79	4.29
15	2.08	2.40	2.76	3.17	3.64	4.17	4.77
20	2.65	3.21	3.86	4.66	5.60	6.72	8.03

Year	Rate of Interest per Year in Percent						
	12	13	14	15	16	17	18
1	1.12	1.13	1.14	1.15	1.16	1.17	1.18
2	1.25	1.28	1.30	1.32	1.34	1.37	1.39
3	1.40	1.44	1.48	1.52	1.56	1.60	1.64
4	1.57	1.63	1.69	1.75	1.81	1.87	1.94
5	1.76	1.84	1.93	2.01	2.10	2.19	2.29
6	1.97	2.08	2.20	2.31	2.44	2.56	2.70
7	2.21	2.35	2.51	2.66	2.83	3.00	3.19
8	2.47	2.65	2.86	3.05	3.28	3.51	3.76
9	2.77	3.00	3.26	3.51	3.80	4.10	4.44
10	3.10	3.39	3.71	4.04	4.41	4.80	5.24
11	3.47	3.83	4.24	4.65	5.12	5.62	6.18
12	3.89	4.33	4.83	5.35	5.94	6.57	7.29
13	4.35	4.89	5.50	6.15	6.89	7.69	8.60
14	4.87	5.53	6.27	7.07	7.99	9.00	10.15
15	5.46	6.25	7.15	8.13	9.26	10.52	11.98
20	9.63	11.51	13.77	16.35	19.45	23.07	27.39

EXAMPLE (compounded annually):

If you put $100 in savings for 8 years at 12% compound interest, how much interest do you earn during that period?

[$100 x 2.47] – $100 = $147 interest

NUMBERED DAYS OF THE YEAR

Jan 1	1	Mar 15	74	May 27	147	Aug 8	220	Oct 20	293
Jan 2	2	Mar 16	75	May 28	148	Aug 9	221	Oct 21	294
Jan 3	3	Mar 17	76	May 29	149	Aug 10	222	Oct 22	295
Jan 4	4	Mar 18	77	May 30	150	Aug 11	223	Oct 23	296
Jan 5	5	Mar 19	78	May 31	151	Aug 12	224	Oct 24	297
Jan 6	6	Mar 20	79	Jun 1	152	Aug 13	225	Oct 25	298
Jan 7	7	Mar 21	80	Jun 2	153	Aug 14	226	Oct 26	299
Jan 8	8	Mar 22	81	Jun 3	154	Aug 15	227	Oct 27	300
Jan 9	9	Mar 23	82	Jun 4	155	Aug 16	228	Oct 28	301
Jan 10	10	Mar 24	83	Jun 5	156	Aug 17	229	Oct 29	302
Jan 11	11	Mar 25	84	Jun 6	157	Aug 18	230	Oct 30	303
Jan 12	12	Mar 26	85	Jun 7	158	Aug 19	231	Oct 31	304
Jan 13	13	Mar 27	86	Jun 8	159	Aug 20	232	Nov 1	305
Jan 14	14	Mar 28	87	Jun 9	160	Aug 21	233	Nov 2	306
Jan 15	15	Mar 29	88	Jun 10	161	Aug 22	234	Nov 3	307
Jan 16	16	Mar 30	89	Jun 11	162	Aug 23	235	Nov 4	308
Jan 17	17	Mar 31	90	Jun 12	163	Aug 24	236	Nov 5	309
Jan 18	18	Apr 1	91	Jun 13	164	Aug 25	237	Nov 6	310
Jan 19	19	Apr 2	92	Jun 14	165	Aug 26	238	Nov 7	311
Jan 20	20	Apr 3	93	Jun 15	166	Aug 27	239	Nov 8	312
Jan 21	21	Apr 4	94	Jun 16	167	Aug 28	240	Nov 9	313
Jan 22	22	Apr 5	95	Jun 17	168	Aug 29	241	Nov 10	314
Jan 23	23	Apr 6	96	Jun 18	169	Aug 30	242	Nov 11	315
Jan 24	24	Apr 7	97	Jun 19	170	Aug 31	243	Nov 12	316
Jan 25	25	Apr 8	98	Jun 20	171	Sep 1	244	Nov 13	317
Jan 26	26	Apr 9	99	Jun 21	172	Sep 2	245	Nov 14	318
Jan 27	27	Apr 10	100	Jun 22	173	Sep 3	246	Nov 15	319
Jan 28	28	Apr 11	101	Jun 23	174	Sep 4	247	Nov 16	320
Jan 29	29	Apr 12	102	Jun 24	175	Sep 5	248	Nov 17	321
Jan 30	30	Apr 13	103	Jun 25	176	Sep 6	249	Nov 18	322
Jan 31	31	Apr 14	104	Jun 26	177	Sep 7	250	Nov 19	323
Feb 1	32	Apr 15	105	Jun 27	178	Sep 8	251	Nov 20	324
Feb 2	33	Apr 16	106	Jun 28	179	Sep 9	252	Nov 21	325
Feb 3	34	Apr 17	107	Jun 29	180	Sep 10	253	Nov 22	326
Feb 4	35	Apr 18	108	Jun 30	181	Sep 11	254	Nov 23	327
Feb 5	36	Apr 19	109	Jul 1	182	Sep 12	255	Nov 24	328
Feb 6	37	Apr 20	110	Jul 2	183	Sep 13	256	Nov 25	329
Feb 7	38	Apr 21	111	Jul 3	184	Sep 14	257	Nov 26	330
Feb 8	39	Apr 22	112	Jul 4	185	Sep 15	258	Nov 27	331
Feb 9	40	Apr 23	113	Jul 5	186	Sep 16	259	Nov 28	332
Feb 10	41	Apr 24	114	Jul 6	187	Sep 17	260	Nov 29	333
Feb 11	42	Apr 25	115	Jul 7	188	Sep 18	261	Nov 30	334
Feb 12	43	Apr 26	116	Jul 8	189	Sep 19	262	Dec 1	335
Feb 13	44	Apr 27	117	Jul 9	190	Sep 20	263	Dec 2	336
Feb 14	45	Apr 28	118	Jul 10	191	Sep 21	264	Dec 3	337
Feb 15	46	Apr 29	119	Jul 11	192	Sep 22	265	Dec 4	338
Feb 16	47	Apr 30	120	Jul 12	193	Sep 23	266	Dec 5	339
Feb 17	48	May 1	121	Jul 13	194	Sep 24	267	Dec 6	340
Feb 18	49	May 2	122	Jul 14	195	Sep 25	268	Dec 7	341
Feb 19	50	May 3	123	Jul 15	196	Sep 26	269	Dec 8	342
Feb 20	51	May 4	124	Jul 16	197	Sep 27	270	Dec 9	343
Feb 21	52	May 5	125	Jul 17	198	Sep 28	271	Dec 10	344
Feb 22	53	May 6	126	Jul 18	199	Sep 29	272	Dec 11	345
Feb 23	54	May 7	127	Jul 19	200	Sep 30	273	Dec 12	346
Feb 24	55	May 8	128	Jul 20	201	Oct 1	274	Dec 13	347
Feb 25	56	May 9	129	Jul 21	202	Oct 2	275	Dec 14	348
Feb 26	57	May 10	130	Jul 22	203	Oct 3	276	Dec 15	349
Feb 27	58	May 11	131	Jul 23	204	Oct 4	277	Dec 16	350
Feb 28	59	May 12	132	Jul 24	205	Oct 5	278	Dec 17	351
Mar 1	60	May 13	133	Jul 25	206	Oct 6	279	Dec 18	352
Mar 2	61	May 14	134	Jul 26	207	Oct 7	280	Dec 19	353
Mar 3	62	May 15	135	Jul 27	208	Oct 8	281	Dec 20	354
Mar 4	63	May 16	136	Jul 28	209	Oct 9	282	Dec 21	355
Mar 5	64	May 17	137	Jul 29	210	Oct 10	283	Dec 22	356
Mar 6	65	May 18	138	Jul 30	211	Oct 11	284	Dec 23	357
Mar 7	66	May 19	139	Jul 31	212	Oct 12	285	Dec 24	358
Mar 8	67	May 20	140	Aug 1	213	Oct 13	286	Dec 25	359
Mar 9	68	May 21	141	Aug 2	214	Oct 14	287	Dec 26	360
Mar 10	69	May 22	142	Aug 3	215	Oct 15	288	Dec 27	361
Mar 11	70	May 23	143	Aug 4	216	Oct 16	289	Dec 28	362
Mar 12	71	May 24	144	Aug 5	217	Oct 17	290	Dec 29	363
Mar 13	72	May 25	145	Aug 6	218	Oct 18	291	Dec 30	364
Mar 14	73	May 26	146	Aug 7	219	Oct 19	292	Dec 31	365

POCKET REF

Plumbing & Pipe

(See also TOOLS, p. 361 for pipe thread data)

(See also WATER, p. 377 for Friction Loss Values)

COPPER PIPE & TUBING

When measuring copper pipe, sweat fittings are measured by their inside diameter (ID) and compression fittings are measured by their outside diameter (OD). Hard temper comes in 20 foot straight lengths and soft temper comes in 20 foot straight lengths or 60 foot coils. Copper tubing is normally designed to conform with ASTM Designation B88. See the code for specific information on each type.

Use 50/50 solid core solder (NOT RESIN CORE) and a high quality flux when soldering sweat fittings.

TYPES OF COPPER PIPE

Type	Characteristics
DWV	DWV stands for "Drain, Waste and Vent" and is recommended for above ground use only and no pressure applications. Sweat fittings only. Available only in hard type and in sizes from 1-1/4 inch to 6 inch.
K	A thick walled, flexible copper tubing. Much thicker wall than Type L and M and is required for all underground installations. Typical uses include water services, plumbing, heating, steam, gas, oil, oxygen, and other applications where thick walled tubing is required. Can be used with sweat, flared, and compression fittings. Available in hard and soft types.
L	Standard tubing used for interior, above ground plumbing. Uses include heating, air-conditioning, steam, gas and oil and for underground drainage lines. This is a flexible tubing but be very careful not to crimp the line when bending it. Special tools (inexpensive) are readily available to make bending much easier and safer. Although sweat, compression and flare fittings are available, only compression fittings are legal for gas lines. Available in hard and soft types.
M	Typically used with interior heating and pressure line applications. Wall thickness is slightly less than types K and L. Normally used with sweat fittings. Available in hard and soft types.

COPPER PIPE & TUBING

Nominal Size Inches	Actual OD Inches	Type K Wall Th. Inch	Type K Weight Lbs/foot	Type L Wall Th. Inch	Type L Weight Lbs/foot
1/4	0.375	0.035	0.145	0.030	0.126
3/8	0.500	0.049	0.269	0.035	0.198
1/2	0.625	0.049	0.344	0.040	0.285
5/8	0.750	0.049	0.418	0.042	0.362
3/4	0.875	0.065	0.641	0.045	0.455
1	1.125	0.065	0.839	0.050	0.655
1–1/4	1.375	0.065	1.040	0.055	0.884
1–1/2	1.625	0.072	1.360	0.060	1.140
2	2.125	0.083	2.060	0.070	1.750
2–1/2	2.625	0.095	2.930	0.080	2.480
3	3.125	0.109	4.000	0.090	3.330
3–1/2	3.625	0.120	5.120	0.100	4.290
4	4.125	0.134	6.510	0.110	5.380
5	5.125	0.160	9.670	0.125	7.610
6	6.125	0.192	13.90	0.140	10.20
8	8.125	0.271	25.90	0.200	19.30
10	10.125	0.338	40.30	0.250	30.10
12	12.125	0.405	57.80	0.280	40.40

Nominal Size Inches	Actual OD Inches	Type M Wall Th. Inch	Type M Weight Lbs/foot	Type DWV Wall Th. Inch	Type DWV Weight Lbs/foot
1–1/4	1.375	0.042	0.682	0.040	0.65
1–1/2	1.625	0.049	0.940	0.042	0.81
2	2.125	0.058	1.460	0.042	1.07
2–1/2	2.625	0.065	2.030	...	...
3	3.125	0.072	2.680	0.045	1.69
3–1/2	3.625	0.083	3.580	...	...
4	4.125	0.095	4.660	0.058	2.87
5	5.125	0.109	6.660	0.072	4.43
6	6.125	0.122	8.920	0.083	6.10
8	8.125	0.170	16.50	...	...
10	10.125	0.212	25.60	...	...
12	12.125	0.254	36.70	...	...

"Wall Th." stands for Wall Thickness
"OD" stands for Outside Diameter

Data included in this table is courtesy of *ITT–Grinnell Corporation, Providence, Rhode Island.*

PLASTIC PIPE

Although there are many plastic pipe types listed below, PVC and ABS are by far the most common types. It is imperative that the correct primers and solvents be used on each type of pipe or the joints will not seal properly and the overall strength will be weakened.

TYPES OF PLASTIC PIPE

Type	Characteristics
PVC	Polyvinyl Chloride, Type 1, Grade 1. This pipe is strong, rigid and resistant to a variety of acids and bases. Some solvents and chlorinated hydro–carbons may damage the pipe. PVC is very common, easy to work with and readily available at most hardware stores. Maximum useable temperature is 140°F (60°C) and pressure ratings start at a minimum of 125 to 200 psi (check for specific ratings on the pipe or ask the seller). PVC can be used with water, gas, and drainage systems but NOT with hot water systems.
ABS	Acrylonitrile Butadiene Styrene, Type 1. This pipe is strong and rigid and resistant to a variety of acids and bases. Some solvents and chlorinated hydro–carbons may damage the pipe. ABS is very common, easy to work with and readily available at most hardware stores. Maximum useable temperature is 160°F (71°C) at low pressures. It is most common as a DWV pipe.
CPVC	Chlorinated polyvinyl chloride. Similar to PVC but designed specifically for piping water at up to 180°F (82°C) (can actually withstand 200°F for a limited time). Pressure rating is 100 psi.
PE	Polyethylene. A flexible pipe for pressurized water systems such as sprinklers. Not for hot water.
PB	Polybutylene. A flexible pipe for pressurized water systems both hot and cold. ONLY compression type joints can be used.
Polypropylene	Low pressure, lightweight material that is good up to 180°F (82°C). Highly resistant to acids, bases, and many solvents. Good for laboratory plumbing.
PVDF	Polyvinylidene fluoride. Strong, very tough, and resistant to abrasion, acids, bases, solvents, and much more. Good to 280°F (138°C). Good in lab.
FRP Epoxy	A thermosetting plastic over fiberglass. Very high strength and excellent chemical resistance. Good to 220°F (105°C). Excellent for labs.

PLASTIC PIPE

Nominal Size Inches	Actual OD Inches	PVC Sched. 40 Wall Th. Inch	PVC Sched. 40 Weight Lbs/foot	PVC Sched. 80 Wall Th. Inch	PVC Sched. 80 Weight Lbs/foot
1/4	0.540	...	...	0.119	0.10
1/2	0.840	0.109	0.16	0.147	0.21
3/4	1.050	0.113	0.22	0.154	0.28
1	1.315	0.133	0.32	0.179	0.40
1-1/4	1.660	0.140	0.43	0.191	0.57
1-1/2	1.990	0.145	0.52	0.200	0.69
2	2.375	0.154	0.70	0.218	0.95
2-1/2	2.875	0.203	1.10	0.276	1.45
3	3.500	0.216	1.44	0.300	1.94
4	4.500	0.237	2.05	0.337	2.83
6	6.625	0.280	3.61	0.432	5.41
8	8.625	0.322	5.45	0.500	8.22
10	10.750	0.365	7.91	0.593	12.28
12	12.750	0.406	10.35	0.687	17.10

Nominal Size Inches	Actual OD Inches	CPVC Sched. 40 Wall Th. Inch	CPVC Sched. 40 Weight Lbs/foot	CPVC Sched. 80 Wall Th. Inch	CPVC Sched. 80 Weight Lbs/foot
1/4	0.540	...	...	0.119	0.12
1/2	0.840	0.147	0.19	0.147	0.24
3/4	1.050	0.154	0.25	0.154	0.33
1	1.315	0.179	0.38	0.179	0.49
1-1/4	1.660	0.191	0.51	0.191	0.67
1-1/2	1.990	0.200	0.61	0.200	0.81
2	2.375	0.218	0.82	0.218	1.09
2-1/2	2.875	0.276	1.29	0.276	1.65
3	3.500	0.300	1.69	0.300	2.21
4	4.500	0.337	2.33	0.337	3.23
6	6.625	0.432	4.10	0.432	6.17
8	8.625	...	...	0.500	9.06

Nominal Size Inches	Actual OD Inches	PVDF Sched. 80 Wall Th. Inch	PVDF Sched. 80 Weight Lbs/foot	Polypropylene 80 Wall Th. Inch	Polypropylene 80 Weight Lbs/foot
1/2	0.840	0.147	0.24	0.147	0.14
3/4	1.050	0.154	0.33	0.154	0.19
1	1.315	0.179	0.49	0.179	0.27
1-1/4	1.660	0.191	...	0.191	0.38
1-1/2	1.990	0.200	0.81	0.200	0.45
2	2.375	0.218	1.13	0.218	0.62

$$\text{Pipe Schedule Number} = 1000 \times \frac{\text{psi internal pressure}}{\text{psi allowable fiber stress}}$$

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	...–...–10S	0.049	0.307	0.18
1/8	40–Std–40S	0.068	0.269	0.24
0.405	80–XS–80S	0.095	0.215	0.31
	...–...–10S	0.065	0.410	0.33
1/4	40–Std–40S	0.088	0.364	0.42
0.540	80–XS–80S	0.119	0.302	0.53
	...–...–5S	0.065	0.710	0.53
3/8	...–...–10S	0.065	0.545	0.42
0.675	40–Std–40S	0.091	0.493	0.56
	80–XS–80S	0.126	0.423	0.73
	...–...–5S	0.065	0.710	0.53
	...–...–10S	0.083	0.674	0.67
1/2	40–Std–40S	0.109	0.622	0.85
0.840	80–XS–80S	0.147	0.546	1.08
	160–...–...	0.187	0.466	1.30
	...–XXS–...	0.294	0.252	1.71
	...–...–5S	0.065	0.920	0.68
	...–...–10S	0.083	0.884	0.85
3/4	40–Std–40S	0.113	0.824	1.13
1.050	80–XS–80S	0.154	0.742	1.47
	160–...–...	0.218	0.614	1.93
	...–XXS–...	0.308	0.434	2.44
	...–...–5S	0.065	1.185	0.86
	...–...–10S	0.109	1.097	1.40
1	40–Std–40S	0.133	1.049	1.67
1.315	80–XS–80S	0.179	0.957	2.17
	160–...–...	0.250	0.815	2.84
	...–XXS–...	0.358	0.599	3.65
	...–...–5S	0.065	1.530	1.10
	...–...–10S	0.109	1.442	1.80
1–1/4	40–Std–40S	0.140	1.380	2.27
1.660	80–XS–80S	0.191	1.278	2.99
	160–...–...	0.250	1.160	3.76
	...–XXS–...	0.382	0.896	5.21
	...–...–5S	0.065	1.770	1.27
	...–...–10S	0.109	1.682	2.08
	40–Std–40S	0.145	1.610	2.71
1–1/2	80–XS–80S	0.200	1.500	3.63
1.900	160–...–...	0.281	1.338	4.85
	...–XXS–...	0.400	1.100	6.40
	...–...–...	0.525	0.850	7.71
	...–...–...	0.650	0.600	8.67
	...–...–5S	0.065	2.245	1.60
	...–...–10S	0.109	2.157	2.63
	40–Std–40S	0.154	2.067	3.65
2	80–XS–80S	0.218	1.939	5.02
2.375	160–...–...	0.343	1.689	7.44
	...–XXS–...	0.436	1.503	9.02
	...–...–...	0.562	1.251	11
	...–...–...	0.687	1.001	12

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	...–...–5S	0.083	2.709	2.0
	...–...–10S	0.120	2.635	3.5
	40–Std–40S	0.203	2.469	5.8
2–1/2	80–XS–80S	0.276	2.323	7.7
2.875	160–...–...	0.375	2.125	10
	...–XXS–...	0.552	1.771	14
	...–...–...	0.675	1.525	16
	...–...–...	0.800	1.275	18
	...–...–5S	0.083	3.334	3.0
	...–...–10S	0.120	3.260	4.3
	40–Std–40S	0.216	3.068	7.6
3	80–XS–80S	0.300	2.900	10.2
3.500	160–...–...	0.437	2.626	14.3
	...–XXS–...	0.600	2.300	19
	...–...–...	0.725	2.050	21
	...–...–...	0.850	1.800	24
	...–...–5S	0.083	3.834	3.5
3–1/2	...–...–10S	0.120	3.760	5.0
4.000	40–Std–40S	0.226	3.548	9.1
	80–XS–80S	0.318	3.364	12
	...–XXS–...	0.636	2.728	23
	...–...–5S	0.083	4.334	3.9
	...–...–10S	0.120	4.260	5.6
	...–...–...	0.188	4.124	8.6
	40–Std–40S	0.237	4.026	11
4	80–XS–80S	0.337	3.826	15
4.500	120–...–...	0.437	3.626	19
	...–...–...	0.500	3.500	21
	160–...–...	0.531	3.438	23
	...–XXS–...	0.674	3.152	28
	...–...–...	0.800	2.900	32
	...–...–...	0.925	2.650	35
	...–...–5S	0.109	5.345	6.3
	...–...–10S	0.134	5.295	7.8
	40–Std–40S	0.258	5.047	15
5	80–XS–80S	0.375	4.813	21
5.563	120–...–...	0.500	4.563	27
	160–...–...	0.625	4.313	33
	...–XXS–...	0.750	4.063	38
	...–...–...	0.875	3.813	44
	...–...–...	1.000	3.563	48
	...–...–5S	0.109	6.407	5.4
	...–...–10S	0.134	6.357	9.3
	...–...–...	0.219	6.187	15
	40–Std–40S	0.280	6.065	19
6	80–XS–80S	0.432	5.761	28
6.625	120–...–...	0.562	5.501	36
	160–...–...	0.718	5.189	45
	...–XXS–...	0.864	4.897	53
	...–...–...	1.000	4.625	60

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	...–...–...	1.125	4.375	66
	...–...–5S	0.109	8.407	9.9
	...–...–10S	0.148	8.329	13
	...–...–...	0.219	8.187	20
	20–...–...	0.250	8.125	22
	30–...–...	0.277	8.071	25
	40–Std–40S	0.322	7.981	29
8	60–...–...	0.406	7.813	36
8.625	80–XS–80S	0.500	7.625	43
	100–...–...	0.593	7.439	51
	120–...–...	0.718	7.189	61
	140–...–...	0.812	7.001	68
	160–...–...	0.906	6.813	75
	...–...–...	1.000	6.625	81
	...–...–...	1.125	6.375	90
	...–...–5S	0.134	10.482	15
	...–...–10S	0.165	10.420	19
	...–...–...	0.219	10.312	25
	20–...–...	0.250	10.250	28
	30–...–...	0.307	10.136	34
	40–Std–40S	0.365	10.020	40
	60–XS–80S	0.500	9.750	55
10	80–...–...	0.593	9.564	64
10.750	100–...–...	0.718	9.314	77
	120–...–...	0.843	9.064	89
	...–...–...	0.875	9.000	92
	140–...–...	1.000	8.750	104
	160–...–...	1.125	8.500	116
	...–...–...	1.250	8.250	127
	...–...–...	1.500	7.750	148
	...–...–5S	0.156	12.438	21
	...–...–10S	0.180	12.390	24
	20–...–...	0.250	12.250	33
	30–...–...	0.330	12.090	44
	...–Std–40S	0.375	12.000	50
	40–...–...	0.406	11.938	54
	...–XS...80S	0.500	11.750	65
12	60–...–...	0.562	11.626	73
12.750	80–...–...	0.687	11.376	89
	...–...–...	0.750	11.250	96
	100–...–...	0.843	11.064	107
	...–...–...	0.875	11.000	111
	120–...–...	1.000	10.750	125
	140–...–...	1.125	10.500	140
	...–...–...	1.250	10.250	154
	160–...–...	1.312	10.126	160
	...–...–5S	0.156	13.688	23
	...–...–10S	0.188	13.624	28
	...–...–...	0.210	13.580	31
	...–...–...	0.219	13.562	32

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	10–...–...	0.250	13.500	37
	...–...–...	0.281	13.438	41
	20–...–...	0.312	13.376	46
	...–...–...	0.344	13.312	50
	30–Std–...	0.375	13.250	55
	40–...–...	0.437	13.126	63
14	...–...–...	0.469	13.062	68
14.000	...–XS–...	0.500	13.000	72
	60–...–...	0.593	12.814	85
	...–...–...	0.625	12.750	89
	80–...–...	0.750	12.500	106
	100–...–...	0.937	12.126	131
	120–...–...	1.093	11.814	151
	140–...–...	1.250	11.500	170
	160–...–...	1.406	11.188	189
	...–...–5S	0.165	15.670	28
	...–...–10S	0.188	15.624	32
	10–...–...	0.250	15.500	42
	20–...–...	0.312	15.376	52
	30–Std–...	0.375	15.250	63
16	40–XS–...	0.500	15.000	83
16.000	60–...–...	0.656	14.688	107
	80–...–...	0.843	14.314	136
	100–...–...	1.031	13.938	165
	120–...–...	1.218	13.564	192
	140–...–...	1.437	13.126	224
	160–...–...	1.593	12.814	245
	...–...–5S	0.165	17.670	31
	...–...–10S	0.188	17.624	36
	10–...–...	0.250	17.500	47
	20–...–...	0.312	17.376	59
	...–Std–...	0.375	17.250	71
	30–...–...	0.437	17.126	82
18	...–XS–...	0.500	17.000	93
18.000	40–...–...	0.562	16.876	105
	60–...–...	0.750	16.500	138
	80–...–...	0.937	16.126	171
	100–...–...	1.156	15.688	208
	120–...–...	1.375	15.250	244
	140–...–...	1.562	14.876	274
	160–...–...	1.781	14.438	308
	...–...–5S	0.188	19.634	40
	...–...–10S	0.218	19.564	46
	10–...–...	0.250	19.500	53
20	20–Std–...	0.375	19.250	79
20.000	30–XS–...	0.500	19.000	104
	40–...–...	0.593	18.814	123
	60–...–...	0.812	18.376	166
	...–...–...	0.875	18.250	179
	80–...–...	1.031	17.938	209

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	100–...–...	1.281	17.438	256
	120–...–...	1.500	17.000	296
	140–...–...	1.750	16.500	341
	160–...–...	1.968	16.064	379
22 22.000	...–...–5S	0.188	21.624	44
	...–...–10S	0.218	21.564	51
	10–...–...	0.250	21.500	58
	20–Std–...	0.375	21.250	87
	30–XS–...	0.500	21.000	115
	...–...–...	0.625	20.750	143
	...–...–...	0.750	20.500	170
	60–...–...	0.875	20.250	197
	80–...–...	1.125	19.750	251
	100–...–...	1.375	19.250	303
	120–...–...	1.625	18.750	354
	140–...–...	1.875	18.250	403
	160–...–...	2.125	17.750	451
24 24.000	...–...–5s	0.218	23.564	55
	10–...–...	0.250	23.500	63
	20–Std–...	0.375	23.250	95
	...–XS–...	0.500	22.000	125
	30–...–...	0.562	22.876	141
	...–...–...	0.625	22.750	156
	40–...–...	0.687	22.626	171
	...–...–...	0.750	22.500	186
	...–...–...	0.875	22.250	216
	60–...–...	0.968	22.064	238
	80–...–...	1.218	21.564	296
	100–...–...	1.531	20.938	367
	120–...–...	1.812	20.376	429
	140–...–...	2.062	19.876	483
	160–...–...	2.343	19.314	542
26 26.000	...–...–...	0.250	25.500	67
	10–...–...	0.312	25.376	86
	...–Std–...	0.375	25.250	103
	20–XS–...	0.500	25.000	136
	...–...–...	0.625	24.750	169
	...–...–...	0.750	24.500	202
	...–...–...	0.875	24.250	235
	...–...–...	1.000	24.000	267
	...–...–...	1.125	23.750	299
28 28.000	...–...–...	0.250	27.500	74
	10–...–...	0.312	27.376	92
	...–Std–...	0.375	27.250	111
	20–XS–...	0.500	27.000	147
	30–...–...	0.625	26.750	183
	...–...–...	0.750	26.500	218
	...–...–...	0.875	26.250	253
	...–...–...	1.000	26.000	288
	...–...–...	1.125	25.750	323

STEEL PIPE

Nominal Size & OD Inches	Schedule Numbers (1) a – b – c	Wall Thick Inches	Inside Diameter Inches	Pipe Weight Lbs/foot
	...–...–5S	0.250	29.500	79
	10–...–10S	0.312	29.376	99
	...–Std–...	0.375	29.250	119
30	20–XS–...	0.500	29.000	158
30.000	30–...–...	0.625	28.750	196
	40–...–...	0.750	28.500	234
	...–...–...	0.875	28.250	272
	...–...–...	1.000	28.000	310
	...–...–...	1.125	27.750	347
	...–...–...	0.250	31.500	85
	10–...–...	0.312	31.376	106
	...–Std–...	0.375	31.250	127
	20–XS–...	0.500	31.000	168
32	30–...–...	0.625	30.750	209
32.000	40–...–...	0.688	30.624	230
	...–...–...	0.750	30.500	250
	...–...–...	0.875	30.250	291
	...–...–...	1.000	30.000	331
	...–...–...	1.125	29.750	371
	...–...–...	0.250	33.500	90
	10–...–...	0.312	33.376	112
	...–Std–...	0.375	33.250	135
	20–XS–...	0.500	33.000	179
34	30–...–...	0.625	32.750	223
34.000	40–...–...	0.688	32.624	245
	...–...–...	0.750	32.500	266
	...–...–...	0.875	32.250	310
	...–...–...	1.000	32.000	353
	...–...–...	1.125	31.750	395
	...–...–...	0.250	35.500	96
	10–...–...	0.312	35.376	119
	...–Std–...	0.375	35.250	143
36	20–XS–...	0.500	35.000	190
36.000	30–...–...	0.625	34.750	236
	40–...–...	0.750	34.500	282
	...–...–...	0.875	34.250	328
	...–...–...	1.000	34.000	374
	...–...–...	1.125	33.750	419
	...–...–...	0.250	41.500	112
	...–Std–...	0.375	41.250	167
	20–XS–...	0.500	41.000	222
42	30–...–...	0.625	40.750	276
42.000	40–...–...	0.750	40.500	330
	...–...–...	1.000	40.000	438
	...–...–...	1.250	39.500	544
	...–...–...	1.500	39.000	649

STEEL PIPE

(1) In the preceding tables, column 2 contains information on the schedules of various types of pipe. Specifically, these types of pipe for the a–b–c spec are as follows:

a – ANSI B36.10, Steel Pipe Schedule numbers
b – ANSI B36.10, Steel Pipe nominal wall thickness
c – ANSI B36.19, Stainless Steel Schedule numbers

Additional values pertaining to each steel pipe size can be calculated with the following formulas:

A = Square inches of metal
d = Inside diameter of pipe in inches
D = Outside diameter of pipe in inches
T = Thickness of pipe wall in inches
R = Radius of gyration of the pipe in inches
x = multiply

Weight of pipe in pounds per foot = $10.6802 \times T \times (D - T)$

Outside surface area in sq feet per foot = $0.2618 \times D$

Inside surface area in sq feet per foot = $0.2618 \times d$

Inside area of pipe in square inches = $0.785 \times d^2$

Total area of metal in square inches = $0.785 \times (D^2 - d^2)$

Moment of Inertia in inches^4 = $0.0491 \times (D^2 - d^2)$

Radius of Gyration in inches = $0.25 \times \sqrt{D^2 + d^2}$

Section Modulus in inches^3 = $(0.0982 \times (D^4 - d^4)) / D$

Weight of water in a pipe in pounds = $0.3405 \times d^2$

Pressure Ratings of Standard Schedule 40 Steel Pipe

1/8 to 1 inch continuous weld or seamless = 700 psi
1–1/4 to 3 inch continuous weld = 800 psi
3–1/2 to 4 inch continuous weld = 1200 psi
2 to 12 inch electric weld = 1000 to 1300 psi
1–1/4 to 3 inch seamless = 1000 psi
3 to 12 inch seamless = 1000 to 1300 psi

The basic steel data and formulas listed above are courtesy of *ITT–Grinnell Corporation, Providence, Rhode Island.*

POCKET REF

Rope–Cable–Chain

(See also HARDWARE, page 257, for Cable Clamps)

ROPE

Diameter Inches	Polypropylene Break Lbs	Polypropylene Lbs/100 feet	Nylon Break Lbs	Nylon Lbs/100 feet	Manila Break Lbs	Manila Lbs/100 feet	Safe Load Ratio
3/16	800	0.7	1000	1.0	406	1.5	10:1
1/4	1250	1.2	1650	1.5	540	2.0	10:1
5/16	1900	1.8	2550	2.5	900	2.9	10:1
3/8	2700	2.8	3700	3.5	1220	4.1	10:1
7/16	3500	3.8	5000	5.0	1580	5.3	10:1
1/2	4200	4.7	6400	6.5	2380	7.5	9:1
9/16	5100	6.1	8000	8.3	3100	10.4	8:1
5/8	6200	7.5	10400	10.5	3960	13.3	8:1
3/4	8500	10.7	14200	14.5	4860	16.7	7:1
13/16	9900	12.7	17000	17.0	5850	19.5	7:1
7/8	11500	15.0	20000	20.0	6950	22.4	7:1
1	14000	18.0	25000	26.4	8100	27.0	7:1
1-1/16	16000	20.4	28800	29.0	9450	31.2	7:1
1-1/8	18300	23.8	33000	34.0	10800	36.0	7:1
1-1/4	21000	27.0	37500	40.0	12200	41.6	7:1
1-5/16	23500	30.4	43000	45.0	13500	47.8	7:1
1-1/2	29700	38.4	53000	55.0	16700	60.0	7:1
1-5/8	36000	47.6	65000	66.5	20200	74.5	7:1
1-3/4	43000	59.0	78000	83.0	23800	89.5	7:1
2	52000	69.0	92000	95.0	28000	108	7:1
2-1/8	61000	80.0	106000	109	...	...	7:1
2-1/4	69000	92.0	125000	129	...	...	6:1
2-1/2	80000	107	140000	149	...	...	6:1
2-5/8	90000	120	162000	168	...	...	6:1
2-7/8	101000	137	180000	189	...	...	6:1
3	114000	153	200000	210	...	...	6:1
3-1/4	137000	190	250000	264	...	...	6:1
3-1/2	162000	232	300000	312	...	...	6:1
4	190000	276	360000	380	...	...	6:1

"Break Lbs" is the breaking or tensile strength in pounds and "Safe Load" is the ratio of breaking strength to safe load. Example: 1 inch Poly rope break strength = 14000 lbs, safe load = 14000 lbs / 7 = 2000 lbs. Base your working loads on the "Safe Load" not the "Break Lbs". Note also that the strength ratings are based on tests at room temperature; rope strength decreases with an increase of temperature. At 212°F strength is 30% less and decreases as the temperature rises.

"Lbs/foot" is the weight of the rope in pounds per linear foot.

The above data is courtesy of *Continental Western Corp, Denver, Colorado and Wall Industries, Granite Quarry, North Carolina.*

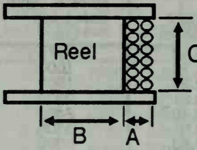
WIRE ROPE (6 strand x 19 wire)

Diameter Inches	Weight Lbs/foot	Normal Temp with Vertical Pull Safe Load Lbs	Breaking Point Lbs
1/4	0.10	675	4800
5/16	0.16	1000	7400
3/8	0.23	1500	10600
7/16	0.31	2000	14400
1/2	0.40	2400	18700
9/16	0.51	3300	23600
5/8	0.63	4000	29000
3/4	0.90	6000	41400
7/8	1.23	8000	56000
1	1.60	10000	72800
1-1/8	2.03	13000	91400
1-1/4	2.50	16000	112400
1-3/8	3.03	19000	135000
1-1/2	3.60	22000	160000
1-3/4	4.90	30500	216000
2	6.40	40000	278000
2-1/2	10.00	60000	424000

CHAIN

Rod Diameter Inches	Weight Lbs/foot	Normal Temp with Vertical Pull Safe Load Lbs	Breaking Point Lbs
1/4	0.75	1200	5000
5/16	1	1700	7000
3/8	1.5	2500	10000
7/16	2	3500	14000
1/2	2.5	4500	18000
9/16	3.25	5500	22000
5/8	4	6700	27000
11/16	5	8100	32500
3/4	6.25	10000	40000
13/16	7	10500	42000
7/8	8	12000	48000
15/16	9	13500	54000
1	10	15200	61000
1-1/16	12	17200	69000
1-1/8	13	19500	78000
1-3/16	14.5	22000	88000
1-1/4	16	23700	95000
1-5/16	17.5	26000	104000
1-3/8	19	28500	114000
1-7/16	21.5	30500	122000
1-1/2	23	33500	134000
1-9/16	25	35500	142000
1-5/8	28	38500	154000
1-11/16	30	39500	158000
1-3/4	31	41500	166000
1-13/16	33	44500	178000
1-7/8	35	47500	190000
1-15/16	38	50500	202000
2	40	54000	216000
2-1/4	53	68200	273000
2-1/2	65	84200	337000
2-3/4	73	96700	387000
3	86	109000	436000

FEET OF CABLE ON A REEL



The following formula can be used to accurately determine the number of feet of rope or cable that is smoothly wound on a drum or reel (A, B, and C are in inches):

$$\textit{Length in Feet} = A \times [\,A + B\,] \times C \times K$$

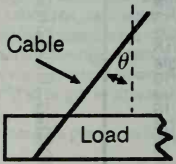
Values of K for above equation

Rope Diameter Inches	Value of K	Rope Diameter Inches	Value of K
1/4	3.29	1−1/8	0.191
5/16	2.21	1−1/4	0.152
3/8	1.58	1−3/8	0.127
7/16	1.19	1−1/2	0.107
1/2	0.925	1−5/8	0.0886
9/16	0.741	1−3/4	0.0770
5/8	0.607	1−7/8	0.0675
3/4	0.428	2	0.0597
7/8	0.308	2−1/8	0.0532
1	0.239	2−1/4	0.0476

PULL ANGLE vs STRENGTH LOSS

The load carrying capacity of a cable, rope, sling, etc decreases by the factor K as the angle θ increases.

θ	K
5	0.9962
10	0.9848
15	0.9659
20	0.9397
25	0.9063
30	0.8660
35	0.8792
40	0.7660
45	0.7071
50	0.6428
55	0.5736
60	0.5000
65	0.4226
70	0.3420
75	0.2588



POCKET REF

Steel

(See ALUMINUM, p. 60, for T Types)
(See also PLUMBING AND PIPE, p. 317)
(See also CHEMISTRY p.51 for melt and boil points and density of all metals)
(See also Rebar on page 44)

STEEL WIRE GAUGES

Gauge Number	American or Brown & Sharp	Birmingham or Stubs Iron	Washburn & Moen	W & M Music Wire	Imperial Wire
	Diameter in Decimals of an Inch				
7/0	...	...	...	0.0087	...
6/0	...	...	...	0.0095	0.464
5/0	...	...	...	0.010	0.432
4/0	0.460	0.454	0.3938	0.011	0.400
3/0	0.40964	0.425	0.3625	0.012	0.372
2/0	0.3648	0.380	0.3310	0.0133	0.348
0	0.32486	0.340	0.3065	0.0144	0.324
1	0.2893	0.300	0.2830	0.0156	0.300
2	0.25763	0.284	0.2625	0.0166	0.276
3	0.22942	0.259	0.2437	0.0178	0.252
4	0.20431	0.238	0.2253	0.0188	0.232
5	0.18194	0.220	0.2070	0.0202	0.212
6	0.16202	0.203	0.1920	0.0215	0.192
7	0.14428	0.180	0.1770	0.0230	0.176
8	0.12849	0.165	0.1620	0.0243	0.160
9	0.11443	0.148	0.1483	0.0256	0.144
10	0.10189	0.134	0.1350	0.0270	0.128
11	0.09074	0.120	0.1205	0.0284	0.116
12	0.08080	0.109	0.1055	0.0296	0.104
13	0.07196	0.095	0.0915	0.0314	0.092
14	0.06408	0.083	0.0800	0.0326	0.080
15	0.05706	0.072	0.0720	0.0345	0.072
16	0.05082	0.065	0.0625	0.0360	0.064
17	0.04525	0.058	0.0540	0.0377	0.056
18	0.04030	0.049	0.0475	0.0395	0.048
19	0.03589	0.042	0.0410	0.0414	0.040
20	0.03106	0.035	0.0348	0.0434	0.036
21	0.02846	0.032	0.0317	0.0460	0.032
22	0.02534	0.028	0.0286	0.0483	0.028
23	0.02257	0.025	0.0258	0.0510	0.024
24	0.0201	0.022	0.0230	0.0550	0.022
25	0.0179	0.020	0.0204	0.0586	0.020
26	0.01594	0.018	0.0181	0.0626	0.018
27	0.01419	0.016	0.0173	0.0658	0.0164
28	0.01264	0.014	0.0162	0.0720	0.0149
29	0.01125	0.013	0.0150	0.0760	0.0136
30	0.01002	0.012	0.0140	0.0800	0.0124
31	0.00892	0.010	0.0132	...	0.0116
32	0.00795	0.009	0.0128	...	0.0108
33	0.00708	0.008	0.0118	...	0.0100
34	0.00630	0.007	0.0104	...	0.0092
35	0.00561	0.005	0.0095	...	0.0084
36	0.005	0.004	0.0090	...	0.0076
37	0.00445	...	...	...	0.0068
38	0.00396	...	...	...	0.0060
39	0.00353	...	...	...	0.0052
40	0.00314	...	...	...	0.0048
41	0.00280	...	...	...	...
42	0.00249	...	...	...	...
43	0.00222	...	...	...	...
44	0.00198	...	...	...	...
45	0.00176	...	...	...	...
46	0.00157	...	...	...	...
47	0.00140	...	...	...	...
48	0.00124	...	...	...	...
49	0.00111	...	...	...	...
50	0.00099	...	...	...	...

STEEL SHEET GAUGES

Gauge Number	Steel Weight lbs per sq foot	Thickness Inches US Standard Gauge	Thickness Inches Manufacturers Standard	Weight lbs/sq ft Galvanized Sheet	Weight lbs/sq ft Stainless Steel
7/0	20.00	0.5000	...	...	...
6/0	18.75	0.4687	...	...	...
5/0	17.50	0.4375	...	...	...
4/0	16.25	0.4062	...	...	...
3/0	15.00	0.3750	...	...	...
2/0	13.75	0.3437	...	...	...
0	12.50	0.3125	...	...	...
1	11.25	0.2812	...	...	...
2	10.62	0.2656	...	...	...
3	10.00	0.2500	0.2391	...	...
4	9.37	0.2344	0.2242	...	...
5	8.75	0.2187	0.2092	...	...
6	8.12	0.2031	0.1943	...	...
7	7.50	0.1875	0.1793	...	...
8	6.87	0.1719	0.1644	...	...
9	6.25	0.1562	0.1495	...	...
10	5.62	0.1406	0.1345	5.7812	5.7937
11	5.00	0.1250	0.1196	5.1562	5.1500
12	4.37	0.1094	0.1046	4.5312	4.5063
13	3.75	0.0937	0.0897	3.9062	3.8625
14	3.12	0.0781	0.0747	3.2812	3.2187
15	2.81	0.0703	0.0673	2.9687	2.8968
16	2.50	0.0625	0.0598	2.6562	2.5750
17	2.25	0.0562	0.0538	2.4062	2.3175
18	2.00	0.0500	0.0478	2.1562	2.0600
19	1.75	0.0437	0.0418	1.9062	1.8025
20	1.50	0.0375	0.0359	1.6562	1.5450
21	1.37	0.0344	0.0329	1.5312	1.4160
22	1.25	0.0312	0.0299	1.4062	1.2875
23	1.12	0.0281	0.0269	1.2812	1.1587
24	1.00	0.0250	0.0239	1.1562	1.0300
25	0.875	0.0219	0.0209	1.0312	0.9013
26	0.750	0.0187	0.0179	0.9062	0.7725
27	0.687	0.0172	0.0164	0.8437	0.7081
28	0.625	0.0156	0.0149	0.7812	0.6438
29	0.562	0.0141	0.0135	0.7187	0.5794
30	0.500	0.0125	0.0120	0.6562	0.5150
31	0.437	0.0109	0.0105	...	...
32	0.406	0.0102	0.0097	...	...
33	0.375	0.0094	0.0090	...	...
34	0.344	0.0086	0.0082	...	...
35	0.312	0.0078	0.0075	...	...
36	0.281	0.0070	0.0067	...	...
37	0.266	0.0066	0.0064	...	...
38	0.250	0.0062	0.0060	...	...
39	0.234	0.0059	...	...	...
40	0.219	0.0055	...	...	...
41	0.211	0.0053	...	...	...
42	0.203	0.0051	...	...	...
43	0.195	0.0049	...	...	...
44	0.187	0.0047	...	...	...

STEEL PLATE SIZES

Thickness Inches	Weight Lbs/sq foot	Thickness Inches	Weight Lbs/sq foot
3/16	7.65	2-1/8	86.70
1/4	10.20	2-1/4	91.80
5/16	12.75	2-1/2	102.00
3/8	15.30	2-3/4	112.20
7/16	17.85	3	122.40
1/2	20.40	3-1/4	132.60
9/16	22.95	3-1/2	142.80
5/8	25.50	3-3/4	153.00
11/16	28.05	4	163.20
3/4	30.60	4-1/4	173.40
13/16	33.15	4-1/2	183.60
7/8	35.70	5	204.00
1	40.80	5-1/2	224.40
1-1/8	45.90	6	244.80
1-1/4	51.00	6-1/2	265.20
1-3/8	56.10	7	285.60
1-1/2	61.20	7-1/2	306.00
1-5/8	66.30	8	326.40
1-3/4	71.40	9	367.20
1-7/8	76.50	10	408.00
2	81.60		

WIRE AND SHEET SPECIFICATIONS

Weights values listed on the previous three pages is based on a theoretical specific gravity of 7.7 for Iron (480 lbs/cubic foot) and 7.854 for Steel (489.6 lbs/cubic foot). B.W. gauge weights are based on a steel weight of 40.8 lbs/ square foot.

US Standard Gauge was established by Congress in 1893 and establishes that the weight determines the gauge, not the thickness. Galvanized Sheet Gauge is customarily assumed to be based on the US Standard Gauge except 2.5 ounces per square foot is added to the gauge weight of the same US Standard Gauge number.

CHANNEL STEEL SPECS

Size (Bar) Inches	Weight Lb/ ft
3/4 x 5/16 x 1/8	0.50
3/4 x 3/8 x 1/8	0.56
7/8 x 3/8 x 1/8	0.61
7/8 x 7/16 x 1/8	0.69
1 x 3/8 x 1/8	0.68
1 x 1/2 x 1/8	0.84
1-1/8 x 9/16 x 3/16	1.16
1-1/4 x 1/2 x 1/8	1.01
1-1/2 x 1/2 x 1/8	1.12
1-1/2 x 9/16 x 3/16	1.44
1-1/2 x 3/4 x 1/8	1.17
1-1/2 x 1-1/2 x 3/16	2.65
1-3/4 x 1/2 x 3/16	1.55
2 x 1/2 x 1/8	1.33
2 x 9/16 x 3/16	1.86
2 x 5/8 x 1/4	2.28
2 x 1 x 1/8	1.78
2 x 1 x 3/16	2.57
2-1/2 x 5/8 x 3/16	2.27

STRUCTURAL CHANNEL

Size Inches	Weight Lb/ ft
3 x 1/2 x 0.170	4.1
x 0.258	5.0
x 0.356	6.0
3 x 1-7/8 x 0.313	7.1
x 0.500	9.0
4 x 1-5/8 x 0.180	5.4
x 0.320	7.25
4 x 2-1/2 x0.500	13.8
5 x 1-3/4 x 0.190	6.7
x 0.325	9.0
6 x 2 x 0.0.200	8.2
x 0.314	10.5
x 0.437	13.0
6 x 2-1/2 x 0.313	12.0
6 x 3 x 0.313	15.1
x 0.375	16.3
6 x 3-1/2 x 0.340	15.3
x 0.375	18.0
7 x 2 x 0.210	9.8

STRUCTURAL CHANNEL

Size Inches	Weight Lb/ ft
7 x 2 x 0.314	12.25
x 0.419	14.75
7 x 3 x 0.375	17.6
7 x 3-1/2 x 0.350	19.1
8 x 1-7/8 x 0.187	8.50
8 x 2-1/4 x 0.220	11.5
x 0.303	13.75
x 0.487	18.75
8 x 3 x 0.350	18.7
x 0.400	20.0
8 x 3-1/2 x 0.375	21.4
x 0.425	22.8
9 x 2-1/2 x 0.230	13.4
x 0.285	15.0
x 0.448	20.0
9 x 3-1/2 x 0.400	23.9
x 0.450	25.4
10 x 2-5/8 x 0.240	15.3
x 0.379	20.0
x 0.526	25.0
x 0.673	30.0
10 x 3-1/2 x 0.325	21.9
x 0.375	24.9
x 0.425	25.3
x 0.475	28.3
10 x 4 x 0.425	28.5
x 0.575	33.6
x 0.794	41.1
12 x 3 x 0.280	20.7
x 0.387	25.0
x 0.510	30.0
13 x 4 x 0.375	31.8
x 0.447	35.0
x 0.560	40.0
x 0.787	50.0
15 x 3-3/8 x 0.400	33.9
x 0.520	40.0
x 0.716	50.0
18 x 4 x 0.450	42.7
x 0.500	45.8
x 0.600	51.9
x 0.700	58.0

ANGLE STEEL SPECS

Size Inches	Weight Lbs/ foot
1/2 x 1/2 x 1/8	0.38
5/8 x 5/8 x 1/8	0.48
3/4 x 3/4 x 1/8	0.59
x 3/32	0.463
x 3/16	0.84
7/8 x 7/8 x 1/8	0.70
1 x 5/8 x 1/8	0.64
1 x 3/4 x 1/8	0.70
1 x 1 x 1/8	0.80
x 3/16	1.16
x 1/4	1.49
1-1/4 x 1-1/4 x 1/8	1.01
x 3/16	1.48
x 1/4	1.92
1-3/8 x 7/8 x 1/8	0.91
x 3/16	1.32
1-1/2 x 1-1/4 x 3/16	1.64
1-1/2 x 1-1/2 x 1/8	1.23
x 3/16	1.80
x 1/4	2.34
x 5/16	2.86
x 3/8	3.35
1-3/4 x 1-1/4 x 1/8	1.23
x 1/4	2.34
1-3/4 x 1-3/4 x 1/8	1.44
x 3/16	2.12
x 1/4	2.77
x 5/16	3.39
x 3/8	3.99
2 x 1-1/4 x 3/16	1.96
x 1/4	2.55
2 x 1-1/2 x 1/8	1.44
x 3/16	2.12
x 1/4	2.77
2 x 2 x 1/8	1.65
x 3/16	2.44
x 1/4	3.19
x 5/16	3.92
x 3/8	4.70
x 1/2	6.00
2-1/4 x 1-1/2 x 3/16	2.28
x 1/4	2.98
2-1/4 x 2-1/4 x 3/16	2.75
x 1/4	3.62
x 5/16	4.50

Size Inches	Weight Lbs/ foot
2-1/4 x 2-1/4 x 3/8	5.30
2-1/2 x 1-1/2 x 3/16	2.44
x 1/4	3.19
x 5/16	3.92
2-1/2 x 2 x 1/8	1.86
x 3/16	2.75
x 1/4	3.62
x 5/16	4.50
x 3/8	5.30
x 1/2	6.74
2-1/2 x 2-1/2 x 3/16	3.07
x 1/4	4.10
x 5/16	5.00
x 3/8	5.90
x 1/2	7.70
3 x 2 x 3/16	3.07
x 1/4	4.1
x 5/16	5.0
x 3/8	5.9
x 1/2	7.7
3 x 2-1/2 x 3/16	3.4
x 1/4	4.5
x 5/16	5.6
x 3/8	6.6
x 1/2	8.5
3 x 3 x 3/16	3.7
x 1/4	4.9
x 5/16	6.1
x 3/8	7.2
x 7/16	8.3
x 1/2	9.4
3-1/2 x 2-1/2 x 1/4	4.9
x 5/16	6.1
x 3/8	7.2
x 1/2	9.4
3-1/2 x 3 x 1/4	5.4
x 5/16	6.6
x 3/8	7.9
x 1/2	10.2
3-1/2 x 3-1/2 x 1/4	5.8
x 5/16	7.2
x 3/8	8.5
x 7/16	9.8
x 1/2	11.1
4 x 3 x 1/4	5.8

ANGLE STEEL SPECS

Size Inches	Weight Lbs/ foot
x 5/16	7.2
x 3/8	8.5
x 7/16	9.8
x 1/2	11.1
x 5/8	13.6
4 x 3–1/2 x 1/4	6.2
x 5/16	7.7
x 3/8	9.1
x 7/16	10.6
x 1/2	11.9
4 x 4 x 1/4	6.6
x 5/16	8.2
x 3/8	9.8
x 7/16	11.3
x 1/2	12.8
x 5/8	15.7
x 3/4	18.5
5 x 3 x 1/4	6.6
x 5/16	8.2
x 3/8	9.8
x 7/16	11.3
x 1/2	12.8
5 x 3–1/2 x 1/4	7.2
x 5/16	8.7
x 3/8	10.4
x 7/16	12.0
x 1/2	13.6
x 5/8	16.8
x 3/4	19.8
5 x 5 x 5/16	10.3
x 3/8	12.3
x 7/16	14.3
x 1/2	16.2
x 5/8	20.0
x 3/4	23.6
6 x 3–1/2 x 5/16	9.8
x 3/8	11.7
x 1/2	15.3
6 x 4 x 5/16	10.3
x 3/8	12.3
x 7/16	14.3
x 1/2	16.2
x 5/8	20.0
x 3/4	23.6
x 7/8	27.2

Size Inches	Weight Lbs/ foot
6 x 6 x 3/8	14.9
x 7/16	17.2
x 1/2	19.6
x 5/8	24.2
x 3/4	28.7
x 7/8	33.1
x 1	37.4
7 x 4 x 3/8	13.6
x 7/16	15.8
x 1/2	17.9
x 5/8	22.1
8 x 4 x 1/2	19.6
x 5/8	24.2
x 3/4	28.7
x 7/8	33.1
8 x 6 x 1/2	23.0
x 5/8	28.5
x 3/4	33.8
x 1	44.2
8 x 8 x 1/2	26.4
x 5/8	32.7
x 3/4	38.9
x 1	44.2
9 x 4 x 1/2	21.3

TEE STEEL (BAR)

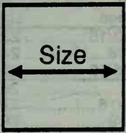
Size Inches Flange x Stem	Weight Lbs/ foot
3/4 x 3/4 x 1/8	0.61
1 x 1 x 1/8	0.85
x 3/16	1.20
1–1/4 x 1–1/4 x 1/8	1.09
x 3/16	1.55
x 1/4	1.93
1–1/2 x 1–1/2 x 3/16	1.90
x 1/4	2.43
1–3/4 x 1–3/4 x 3/16	2.26
x 1/4	2.90
2 x 1–1/2 x 1/4	3.12
2 x 2 x 1/4	3.62
x 5/16	4.30
2–1/4 x 2–1/4 x 1/4	4.10
2–1/2 x 2–1/2 x 1/4	4.60
x 3/8	6.40

ROUND STEEL BAR SPECS

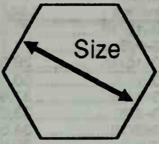
Size Inches	Weight Lbs/ foot
1/8	0.042
3/16	0.094
1/4	0.167
5/16	0.261
3/8	0.376
7/16	0.511
1/2	0.668
9/16	0.845
5/8	1.040
11/16	1.260
3/4	1.500
13/16	1.760
7/8	2.040
15/16	2.350
1	2.670
1-1/16	3.010
1-1/8	3.380
1-3/16	3.770
1-1/4	4.170
1-5/16	4.600
1-3/8	5.050
1-7/16	5.517
1-1/2	6.010
1-9/16	6.519
1-5/8	7.050
1-11/16	7.604
1-3/4	8.180
1-13/16	8.773
1-7/8	9.390
1-15/16	10.024
2	10.700
2-1/16	11.360
2-1/8	12.058
2-3/16	12.778
2-1/4	13.519
2-5/16	14.280
2-3/8	15.063
2-7/16	15.866
2-1/2	16.690
2-9/16	17.535
2-5/8	18.400
2-11/16	19.287
2-3/4	20.195
2-13/16	21.123
2-7/8	22.042
2-15/16	23.042
3	24.033
3-1/16	25.045
3-1/8	26.078
3-3/16	27.142
3-1/4	28.206
3-5/16	28.301
3-3/8	30.417

Size Inches	Weight Lbs/ foot
3-7/16	31.554
3-1/2	32.712
3-9/16	33.891
3-5/8	35.090
3-11/16	36.311
3-3/4	37.552
3-13/16	38.814
3-7/8	40.097
3-15/16	41.401
4	42.726
4-1/16	44.071
4-1/8	45.438
4-3/16	46.825
4-1/4	.48233
4-5/16	49.662
4-3/8	51.112
4-7/16	52.583
4-1/2	54.075
4-9/16	55.587
4-5/8	57.121
4-11/16	58.675
4-3/4	60.250
4-13/16	61.846
4-7/8	63.463
4-15/16	65.100
5	66.759
5-1/16	68.438
5-1/8	70.139
5-3/16	71.860
5-1/4	73.602
5-5/16	75.364
5-3/8	77.148
5-7/16	78.953
5-1/2	80.778
5-9/16	82.612
5-5/8	84.481
5-11/16	86.369
5-3/4	88.277
5-13/16	90.206
5-7/8	92.158
5-15/16	94.128
6	96.13
6-1/8	100.18
6-1/4	104.31
6-1/2	112.82
6-5/8	117.20
6-3/4	121.67
7	130.85
7-1/8	135.56
7-1/4	140.36
7-1/2	150.21
8	170.90

SQUARE STEEL BAR SPECS

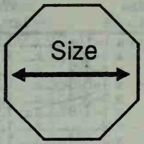


Size Inches	Weight Lbs/ foot
1/8	0.053
3/16	0.120
1/4	0.213
5/16	0.332
3/8	0.478
7/16	0.651
1/2	0.850
9/16	1.076
5/8	1.328
11/16	1.607
3/4	1.913
13/16	2.245
7/8	2.603
15/16	2.988
1	3.400
1-1/16	3.833
1-1/8	4.303
1-3/16	4.795
1-1/4	5.314
1-5/16	5.857
1-3/8	6.428
1-7/16	7.026
1-1/2	7.650
1-9/16	8.301
1-5/8	8.978
1-11/16	9.682
1-3/4	10.414
1-13/16	11.170
1-7/8	12.000
1-15/16	12.763
2	13.600
2-1/16	14.463
2-1/8	15.354
2-3/16	16.270
2-1/4	17.213
2-5/16	18.182
2-3/8	19.178
2-7/16	20.201
2-1/2	21.250
2-9/16	22.326
2-5/8	23.426
2-11/16	24.557
2-3/4	25.714
2-13/16	26.895
2-7/8	28.103
2-15/16	29.338
3	30.600
3-1/16	31.888
3-1/8	33.203
3-3/16	34.558
3-1/4	35.913
3-5/16	37.307
3-3/8	38.728
3-7/16	40.176
3-1/2	41.650
3-9/16	43.151
3-5/8	44.678
3-11/16	46.232
3-3/4	47.813
3-13/16	49.420
3-7/8	51.053
3-15/16	52.713
4	54.400
4-1/16	56.113
4-1/8	57.853
4-3/16	59.620
4-1/4	61.413
4-5/16	63.232
4-3/8	65.078
4-7/16	66.951
4-1/2	68.850
4-9/16	70.776
4-5/8	72.728
4-11/16	74.707
4-3/4	76.713
4-13/16	78.745
4-7/8	80.803
4-15/16	82.888
5	85.000
5-1/16	87.138
5-1/8	89.303
5-3/16	91.495
5-1/4	93.713
5-5/16	95.957
5-3/8	98.228
5-7/16	100.526
5-1/2	102.850
5-9/16	105.199
5-5/8	107.576
5-11/16	109.983
5-3/4	112.414
5-13/16	114.869
5-7/8	117.354
5-15/16	119.864
6	122.40



Size Inches	Weight Lbs/ foot
1/8	0.046
3/16	0.104
1/4	0.184
5/16	0.288
3/8	0.414
7/16	0.564
1/2	0.737
9/16	0.932
5/8	1.150
11/16	1.393
3/4	1.658
13/16	1.944
7/8	2.256
15/16	2.588
1	2.944
1-1/16	3.324
1-1/8	3.727
1-3/16	4.152
1-1/4	4.601
1-5/16	5.072
1-3/8	5.567
1-7/16	6.085
1-1/2	6.625
1-9/16	7.189
1-5/8	7.775
1-11/16	8.385
1-3/4	9.018
1-13/16	9.673
1-7/8	10.355
1-15/16	11.053
2	11.780
2-1/16	12.528
2-1/8	13.300
2-3/16	14.092
2-1/4	14.911
2-5/16	15.747
2-3/8	16.613
2-7/16	17.469
2-1/2	18.403
2-9/16	19.337
2-5/8	20.294
2-11/16	21.272
2-3/4	22.273
2-13/16	23.295
2-7/8	24.343
2-15/16	25.412
3	26.500
3-1/16	27.621
3-1/8	28.755
3-3/16	29.928
3-1/4	31.101
3-5/16	32.315
3-3/8	33.540
3-7/16	34.798
3-1/2	36.979
3-9/16	37.375
3-5/8	38.692
3-11/16	40.046
3-3/4	41.407
3-13/16	42.806
3-7/8	44.213
3-15/16	45.659
4	47.112
4-1/16	48.604
4-1/8	50.112
4-3/16	51.641
4-1/4	53.196
4-5/16	54.771
4-3/8	56.370
4-7/16	57.990
4-1/2	59.636
4-9/16	61.303
4-5/8	62.996
4-11/16	64.710
4-3/4	66.448
4-13/16	68.206
4-7/8	69.991
4-15/16	71.796
5	73.625
5-1/16	75.477
5-1/8	77.353
5-3/16	79.250
5-1/4	81.173
5-5/16	83.117
5-3/8	85.084
5-7/16	87.072
5-1/2	89.086
5-9/16	91.121
5-5/8	93.183
5-11/16	95.265
5-3/4	97.371
5-13/16	99.497
5-7/8	101.650
5-15/16	103.823
6	106.016

OCTAGONAL STEEL BAR SPECS



Size Inches	Weight Lbs/ foot
1/8	0.044
3/16	0.099
1/4	0.176
5/16	0.275
3/8	0.396
7/16	0.539
1/2	0.704
9/16	0.891
5/8	1.100
11/16	1.331
3/4	1.584
13/16	1.859
7/8	2.157
15/16	2.476
1	2.817
1-1/16	3.180
1-1/8	3.565
1-3/16	3.972
1-1/4	4.401
1-5/16	4.852
1-3/8	5.325
1-7/16	5.820
1-1/2	6.338
1-9/16	6.877
1-5/8	7.438
1-11/16	8.021
1-3/4	8.626
1-13/16	9.253
1-7/8	9.902
1-15/16	10.574
2	11.267
2-1/16	11.982
2-1/8	12.719
2-3/16	13.478
2-1/4	14.259
2-5/16	15.063
2-3/8	15.888
2-7/16	16.735
2-1/2	17.604
2-9/16	18.495
2-5/8	19.409
2-11/16	20.344
2-3/4	21.301

Size Inches	Weight Lbs/ foot
2-13/16	22.280
2-7/8	23.281
2-15/16	24.305
3	25.350
3-1/16	26.417
3-1/8	27.506
3-3/16	28.628
3-1/4	29.751
3-5/16	30.906
3-3/8	32.084
3-7/16	33.283
3-1/2	34.504
3-9/16	35.747
3-5/8	37.013
3-11/16	38.300
3-3/4	39.309
3-13/16	40.941
3-7/8	42.294
3-15/16	42.669
4	45.067
4-1/16	46.475
4-1/8	47.927
4-3/16	49.379
4-1/4	50.876
4-5/16	52.372
4-3/8	53.912
4-7/16	55.450
4-1/2	57.037
4-9/16	58.618
4-5/8	60.250
4-11/16	61.876
4-3/4	63.551
4-13/16	65.219
4-7/8	66.911
4-15/16	68.651
5	70.416
5-1/16	72.171
5-1/8	73.965
5-3/16	75.779
5-1/4	77.634
5-5/16	79.476
5-3/8	81.357
5-7/16	83.258
5-1/2	85.204
5-9/16	87.130
5-5/8	89.101
5-11/16	91.092
5-3/4	93.126
5-13/16	95.139
5-7/8	97.197
5-15/16	99.275
6	101.373

FLAT STEEL SPECS

Size Inches	Weight Lbs/ foot
1/8 x 5/16	0.133
x 3/8	0.159
x 7/16	0.186
x 1/2	0.213
x 9/16	0.239
x 5/8	0.266
x 11/16	0.293
x 3/4	0.319
x 7/8	0.372
x 1	0.425
x 1-1/8	0.478
x 1-1/4	0.531
x 1-3/8	0.584
x 1-1/2	0.638
x 1-3/4	0.744
x 1-7/8	0.797
x 2	0.850
x 2-1/4	0.956
x 2-1/2	1.062
x 2-3/4	1.169
x 3	1.275
x 3-1/2	1.488
x 4	1.700
x 4-1/2	1.913
x 5	2.125
x 6	2.550
3/16 x 5/16	0.199
x 3/8	0.239
x 7/16	0.279
x 1/2	0.319
x 9/16	0.359
x 5/8	0.398
x 11/16	0.438
x 3/4	0.478
x 7/8	0.558
x 1	0.638
x 1-1/8	0.717
x 1-1/4	0.797
x 1-3/8	0.877
x 1-1/2	0.956
x 1-3/4	1.116
x 1-7/8	1.195
x 2	1.275
x 2-1/4	1.434
x 2-1/2	1.594
x 2-3/4	1.753
x 3	1.912
x 3-1/2	2.232
x 4	2.550
x 4-1/2	2.868
x 5	3.188
x 6	3.825
1/4 x 5/16	0.266
x 3/8	0.319
x 7/16	0.372
x 1/2	0.425
x 9/16	0.478
x 5/8	0.531
x 11/16	0.584
x 3/4	0.638
x 7/8	0.744
x 1	0.850
x 1-1/8	0.956

Size Inches	Weight Lbs/ foot
1/4 x 1-1/4	1.063
x 1-3/8	1.169
x 1-1/2	1.275
x 1-5/8	1.531
x 1-3/4	1.488
x 1-7/8	1.594
x 2	1.700
x 2-1/4	1.913
x 2-1/2	2.125
x 2-3/4	2.338
x 3	2.550
x 3-1/2	2.975
x 4	3.400
x 4-1/2	3.825
x 5	4.250
x 6	5.100
5/16 x 3/8	0.398
x 7/16	0.465
x 1/2	0.531
x 9/16	0.598
x 5/8	0.664
x 3/4	0.797
x 7/8	0.930
x 1	1.063
x 1-1/8	1.195
x 1-1/4	1.328
x 1-3/8	1.461
x 1-1/2	1.594
x 1-3/4	1.859
x 2	2.125
x 2-1/4	2.391
x 2-1/2	2.656
x 2-3/4	2.922
x 3	3.188
x 3-1/2	3.719
x 4	4.250
x 4-1/2	4.781
x 5	5.313
x 6	6.375
3/8 x 7/16	0.558
x 1/2	0.638
x 9/16	0.717
x 5/8	0.797
x 11/16	0.877
x 3/4	0.956
x 7/8	1.116
x 1	1.275
x 1-1/8	1.434
x 1-1/4	1.594
x 1-3/8	1.753
x 1-1/2	1.913
x 1-3/4	2.231
x 1-7/8	2.391
x 2	2.550
x 2-1/4	2.869
x 2-1/2	3.188
x 2-3/4	3.506
x 3	3.825
x 3-1/2	4.463
x 4	5.100
x 4-1/2	5.738
x 5	6.375
x 6	7.650

FLAT STEEL SPECS

Size Inches	Weight Lbs/ foot
1/2 x 9/16	0.956
x 5/8	1.063
x 11/16	1.169
x 3/4	1.275
x 13/16	1.382
x 7/8	1.488
x 1	1.700
x 1-1/8	1.913
x 1-1/4	2.125
x 1-3/8	2.338
x 1-1/2	2.550
x 1-3/4	2.975
x 2	3.400
x 2-1/4	3.825
x 2-1/2	4.250
x 2-3/4	4.675
x 3	5.100
x 3-1/2	5.950
x 4	6.800
x 5	8.500
x 6	10.200
5/8 x 11/16	1.461
x 3/4	1.594
x 13/16	1.727
x 7/8	1.859
x 1	2.125
x 1-1/8	2.391
x 1-1/4	2.656
x 1-3/8	2.922
x 1-1/2	3.188
x 1-3/4	3.719
x 1-7/8	3.984
x 2	4.250
x 2-1/4	4.781
x 2-1/2	5.313
x 2-3/4	5.844
x 3	6.375
x 3-1/2	7.438
x 4	8.500
x 5	10.625
x 6	12.750
3/4 x 7/8	2.231
x 1	2.550
x 1-1/8	2.869
x 1-1/4	3.188
x 1-3/8	3.506
x 1-1/2	3.825
x 1-3/4	4.463
x 1-7/8	4.470
x 2	5.100
x 2-1/4	5.738
x 2-1/2	6.375
x 2-3/4	7.013
x 3	7.650
x 3-1/2	8.925
x 4	10.200
x 5	12.750
x 6	15.300
7/8 x 1	2.975
x 1-1/8	3.347
x 1-1/4	3.719
x 1-3/8	4.091
x 1-1/2	4.463

Size Inches	Weight Lbs/ foot
7/8 x 1-3/4	5.206
x 1-7/8	5.578
x 2	5.950
x 2-1/4	6.694
x 2-1/2	7.438
x 2-3/4	8.181
x 3	8.925
x 3-1/2	10.413
x 4	11.900
x 5	13.388
x 6	17.850
1 x 1-1/8	3.825
x 1-1/4	4.250
x 1-3/8	4.675
x 1-1/2	5.100
x 1-3/4	5.950
x 1-7/8	6.375
x 2	6.800
x 2-1/4	7.650
x 2-1/2	8.500
x 2-3/4	9.350
x 3	10.200
x 3-1/2	11.900
x 4	13.600
x 5	17.000
x 6	20.400
1-1/4 x 1-3/8	5.844
x 1-1/2	6.375
x 1-3/4	7.438
x 1-7/8	7.969
x 2	8.500
x 2-1/4	9.563
x 2-1/2	10.625
x 2-3/4	11.688
x 3	12.750
x 3-1/2	14.875
x 4	17.000
x 5	21.250
x 6	25.500
1-1/2 x 1-3/4	8.925
x 1-7/8	9.563
x 2	10.200
x 2-1/4	11.475
x 2-1/2	12.750
x 2-3/4	14.025
x 3	15.300
x 3-1/2	17.850
x 4	20.400
x 5	25.500
x 6	30.600
2 x 2-1/4	15.300
x 2-1/2	17.000
x 2-3/4	18.700
x 3	20.400
x 3-1/2	23.800
x 4	27.200
x 5	34.000
x 6	40.800
3 x 4	40.800
x 5	51.000
x 6	61.200

SQUARE STEEL TUBING

OD Size Inches (guage)	Weight Lbs/ foot
1/2 x 0.049 (18)	0.301
x 0.065 (16)	0.384
5/8 x 0.049 (18)	0.384
x 0.065 (16)	0.495
3/4 x 0.035 (20)	0.340
x 0.049 (18)	0.467
x 0.065 (16)	0.605
x 0.120 (11)	1.03
7/8 x 0.049 (18)	0.550
x 0.065 (16)	0.716
1 x 0.035 (20)	0.459
x 0.049 (18)	0.634
x 0.065 (16)	0.826
x 0.073	0.920
x 0.083 (14)	1.04
x 0.095 (13)	1.09
x 0.102	1.25
x 0.109 (12)	1.32
x 0.120 (11)	1.44
1-1/4 x 0.049 (18)	0.800
x 0.065 (16)	1.05
x 0.083 (14)	1.32
x 0.120 (11)	1.84
x 0.135 (10)	1.96
x 0.188 (3/16)	2.62
1-1/2 x 0.049 (18)	0.967
x 0.065 (16)	1.27
x 0.083 (14)	1.60
x 0.120 (11)	2.25
x 0.140	2.50
x 0.180 (7)	3.23
x 0.188 (3/16)	3.23
1-3/4 x 0.065 (16)	1.49
x 0.083 (14)	1.88
x 0.120 (11)	2.66
2 x 0.065 (16)	1.71
x 0.083 (14)	2.16
x 0.095 (13)	2.46
x 0.110 (7/64)	2.69
x 0.120 (11)	3.07
x 0.125 (1/8)	3.24
x 0.145	3.51
x 0.188 (3/16)	4.31
x 0.250 (1/4)	5.59
2-1/2 x 0.083 (14)	2.73
x 0.120 (11)	3.88
x 0.141	4.32
2-1/2 x 0.188 (3/16)	5.59
x 0.250 (1/4)	7.10
3 x 0.083 (14)	3.29
x 0.120 (11)	4.70
x 0.155 (5/32)	5.78
x 0.188 (3/16)	6.86
x 0.250 (1/4)	8.80
3-1/2 x 0.120 (11)	5.52
x 0.156 (5/32)	6.88
x 0.188 (3/16)	8.14
x 0.220 (5)	9.81
x 0.250 (1/4)	10.50
x 0.313 (5/16)	12.69
4 x 0.120 (11)	6.33
x 0.188 (3/16)	9.31
x 0.250 (1/4)	12.02
x 0.313 (5/16)	14.52
x 0.375 (3/8)	16.84
x 0.500 (1/2)	20.88
5 x 0.188 (3/16)	11.86
x 0.250 (1/4)	15.42
x 0.313 (5/16)	18.77
x 0.375 (3/8)	21.94
x 0.500 (1/2)	27.68
6 x 0.188 (3/16)	14.41
x 0.250 (1/4)	18.82
x 0.313 (5/16)	23.02
x 0.375 (3/8)	27.04
x 0.500 (1/2)	34.48
7x 0.188 (3/16)	16.85
x 0.250 (1/4)	22.04
x 0.313 (5/16)	26.99
x 0.375 (3/8)	31.73
x 0.500 (1/2)	40.55
8 x 0.188 (1/4)	25.44
x 0.250 (5/16)	31.24
x 0.313 (3/8)	36.83
x 0.375 (1/2)	47.35
x 0.500 (5/8)	56.89
10 x 0.188 (1/4)	32.23
x 0.250 (5/16)	39.74
x 0.313 (3/8)	47.03
x 0.375 (1/2)	60.95
x 0.500 (5/8)	73.98

RECTANGLE STEEL TUBING

OD Size Inches (guage)	Weight Lbs/ foot
1-1/2 x 1 x 0.083 (14)	1.32
x 0.120 (11)	1.84
2 x 1 x 0.083 (14)	1.60
2 x 1-1/4 x 0.083 (14)	1.74
2 x 1-1/2 x 0.120 (11)	2.66
2-1/2 x 1 x 0.083 (14)	1.88
2-1/2 x 1-1/4 x 0.083(14)	2.02
2-1/2 x 1-1/2 x 0.083(14)	2.16
x 0.145	3.51
x 0.180 (7)	4.46
x 0.220 (5)	5.33
x 0.250	5.59
3 x 1 x 0.083 (14)	2.16
3 x 1-1/2 x 0.083 (14)	2.45
x 0.120 (11)	3.48
x 0.180 (7)	5.07
3 x 2 x 0.083 (14)	2.73
x 0.120 (11)	3.88
x 0.141 (9/64)	4.32
x 0.188 (3/16)	5.59
x 0.250 (1/4)	7.10
4 x 2 x 0.083 (14)	3.29
x 0.120 (11)	4.70
x 0.155 (5/32)	5.78
x 0.188 (3/16)	6.86
x 0.250 (1/4)	8.80
4 x 2-1/2 x 0.120 (11)	5.11
4 x 3 x 0.120 (11)	5.52
x 0.156 (5/32)	6.88
x 0.188 (3/16)	8.14
x 0.250 (1/4)	10.50
x 0.313 (5/16)	12.69
5 x 2 x 0.188 (3/16)	8.43
x 0.250 (1/4)	10.50
5 x 2-1/2 x 0.120 (11)	5.92
x 0.180 (7)	8.74
5 x 3 x 0.188 (3/16)	9.31
x 0.250 (1/4)	12.02
x 0.313 (5/16)	14.52
x 0.375 (3/8)	16.84
x 0.500 (1/2)	20.88
6 x 2 x 0.188 (3/16)	9.31
x 0.250 (1/4)	12.02
6 x 3 x 0.188 (3/16)	10.97
x 0.250 (1/4)	14.45
x 0.313 (5/16)	16.65
x 0.375 (3/8)	19.39

OD Size Inches (guage)	Weight Lbs/ foot
6 x 3 x 0.500 (1/2)	24.28
6 x 4 x 0.188 (3/16)	11.86
x 0.250 (1/4)	15.42
x 0.313 (5/16)	18.77
x 0.375 (3/8)	21.94
x 0.500 (1/2)	27.68
7 x 5 x 0.188 (3/16)	14.41
x 0.250 (1/4)	18.82
x 0.313 (5/16)	23.02
x 0.375 (3/8)	27.04
x 0.500 (1/2)	34.48
8 x 2 x 0.188 (3/16)	11.86
8 x 3 x 0.188 (3/16)	13.68
x 0.250 (1/4)	18.02
8 x 4 x 0.188 (3/16)	14.41
x 0.250 (1/4)	18.82
x 0.313 (5/16)	23.02
x 0.375 (3/8)	27.04
x 0.500 (1/2)	34.48
8 x 6 x 0.188 (3/16)	16.85
x 0.250 (1/4)	22.04
x 0.313 (5/16)	26.99
x 0.375 (3/8)	31.73
x 0.500 (1/2)	40.55
10 x 2 x 0.188 (3/16)	14.42
10 x 4 x 0.188 (3/16)	16.85
x 0.250 (1/4)	22.04
10 x 5 x 0.250 (1/4)	24.70
10 x 6 x 0.250 (1/4)	25.44
x 0.313 (5/16)	31.24
x 0.375 (3/8)	36.83
x 0.500 (1/2)	47.35
10 x 8 x 0.250 (1/4)	28.83
x 0.375 (3/8)	41.93
x 0.500 (1/2)	54.15
12 x 2 x 0.188 (3/16)	16.98
12 x 4 x 0.250 (1/4)	26.03
x 0.375 (3/8)	38.55
12 x 6 x 0.250 (1/4)	28.83
x 0.375 (3/8)	41.93
x 0.500 (1/2)	54.15

ROUND STEEL TUBING

OD Size Inches (guage)	Weight Lbs/ foot
1/8 x 0.028	0.0290
x 0.035	0.0336
5/32 x 0.028	0.0384
x 0.035	0.0452
3/16 x 0.022	0.0390
x 0.028	0.0478
x 0.035	0.0572
x 0.049	0.0727
x 0.065	0.0854
1/4 x 0.194	0.0664
x 0.035	0.0804
x 0.049	0.1052
x 0.065	0.1284
5/16 x 0.028	0.0852
x 0.035	0.1039
x 0.049	0.1382
3/8 x 0.028	0.1038
x 0.035	0.1271
x 0.049	0.1706
x 0.065	0.2152
7/16 x 0.049	0.2036
x 0.065	0.2589
x 0.095	0.3480
1/2 x 0.035	0.1738
x 0.042	0.2054
x 0.049	0.2360
x 0.065	0.3020
x 0.083	0.3696
x 0.095	0.4109
9/16 x 0.049	0.2690
x 0.065	0.3457
x 0.120	0.5677
5/8 x 0.035	0.2205
x 0.049	0.3014
x 0.065	0.3888
x 0.095	0.5377
x 0.120	0.6472
11/16 x 0.049	0.3344
x 0.083	0.5363
x 0.109	0.6740
3/4 x 0.035	0.2673
x 0.049	0.3668
x 0.065	0.4755
x 0.083	0.5913
x 0.109	0.7462
x 0.120	0.8074
x 0.250	1.3350
13/16 x 0.035	0.2908
x 0.049	0.3998
x 0.120	0.8881
7/8 x 0.035	0.3140
x 0.049	0.4323
x 0.065	0.5623

OD Size Inches (guage)	Weight Lbs/ foot
7/8 x 0.083	0.7021
x 0.095	0.7914
x 0.109	0.8917
x 0.120	0.9676
15/16 x 0.049	0.4652
x 0.095	0.8553
1 x 0.035	0.3670
x 0.049	0.4977
x 0.065	0.6491
x 0.083	0.8129
x 0.095	0.9182
x 0.109	1.037
x 0.120	1.128
x 0.250	2.003
1-1/4 x 0.049	0.6285
x 0.065	0.8226
x 0.109	1.328
x 0.120	1.448
1-1/2 x 0.049	0.7593
x 0.065	0.9962
x 0.095	1.426
x 0.109	1.619
x 0.250	3.338
x 0.500	5.340
2 x 0.049	1.021
x 0.065	1.343
x 0.095	1.933
x 0.120	2.409
x 0.250	4.673
x 0.500	8.010
2-1/2 x 0.065	1.690
x 0.095	2.440
x 0.120	3.050
x 0.250	6.008
x 0.500	10.68
3 x 0.065	2.037
x 0.109	3.604
x 0.120	3.691
x 0.250	7.343
x 0.500	13.35
4 x 0.065	2.732
x 0.109	4.530
x 0.120	4.973
x 0.250	10.01
x 0.500	18.69
5 x 0.109	5.694
x 0.120	6.254
x 0.250	12.68
x 0.500	24.03
6 x 0.120	7.536
x 0.250	15.35
x 0.500	29.37
x 1.000	53.40

POCKET REF

Survey & Mapping

(See also MATH, page 263, for Trig Functions)

PERCENT GRADE TO DEGREES

slope degrees	gradient 1:X	% grade
0.1	573.1	0.2
0.2	286.5	0.3
0.3	191.0	0.5
0.4	143.3	0.7
0.5	114.6	0.9
0.6	95.5	1.0
0.7	81.9	1.2
0.8	71.6	1.4
0.9	63.7	1.6
1.0	57.3	1.7
2.0	28.6	3.5
3.0	19.1	5.2
4.0	14.3	7.0
5.0	11.4	8.7
6.0	9.5	10.5
7.0	8.1	12.3
8.0	7.1	14.1
9.0	6.3	15.8
10.0	5.7	17.6
11.0	5.1	19.4
12.0	4.7	21.3
13.0	4.3	23.1
14.0	4.0	24.9
15.0	3.7	26.8
16.0	3.5	28.7
17.0	3.3	30.6
18.0	3.1	32.5
19.0	2.9	34.4
20.0	2.7	36.4
21.0	2.6	38.4
22.0	2.5	40.4
23.0	2.4	42.4
24.0	2.2	44.5
25.0	2.1	46.6
26.0	2.1	48.8
27.0	2.0	50.9
28.0	1.9	53.2
29.0	1.8	55.4
30.0	1.7	57.7
31.0	1.7	60.1
32.0	1.6	62.5
33.0	1.5	64.9
34.0	1.5	67.4
35.0	1.4	70.0
36.0	1.4	72.6
37.0	1.3	75.3
38.0	1.3	78.1
39.0	1.2	81.0
40.0	1.2	83.9
41.0	1.2	86.9
42.0	1.1	90.0
43.0	1.1	93.2
44.0	1.0	96.5
45.0	1.0	100.0
46.0	1.0	103.5
47.0	0.9	107.2
48.0	0.9	111.0

PERCENT GRADE TO DEGREES

slope degrees	gradient 1:X	% grade
49.0	0.9	115.0
50.0	0.8	119.1
51.0	0.8	123.4
52.0	0.8	127.9
53.0	0.8	132.7
54.0	0.7	137.6
55.0	0.7	142.8
56.0	0.7	148.2
57.0	0.6	153.9
58.0	0.6	160.0
59.0	0.6	166.4
60.0	0.6	173.1
61.0	0.6	180.3
62.0	0.5	188.0
63.0	0.5	196.2
64.0	0.5	204.9
65.0	0.5	214.3
66.0	0.4	224.5
67.0	0.4	235.4
68.0	0.4	247.3
69.0	0.4	260.3
70.0	0.4	274.6
71.0	0.3	290.2
72.0	0.3	307.5
73.0	0.3	326.8
74.0	0.3	348.4
75.0	0.3	372.8
76.0	0.2	400.7
77.0	0.2	432.6
78.0	0.2	469.9
79.0	0.2	513.7
80.0	0.2	566.3
81.0	0.2	630.3
82.0	0.1	710.1
83.0	0.1	812.6
84.0	0.1	948.9
85.0	0.1	1139.3
86.0	0.1	1424.3
87.0	0.1	1897.7
88.0	0.0	2840.0
89.0	0.0	5634.4
90.0	0.0	337465.3

$$\textit{Tan [Slope Degrees]} = \frac{\textit{Vertical Rise Distance}}{\textit{Horizontal Distance}}$$

$$\textit{Gradient} = 1 : \frac{\textit{Horizontal Distance}}{\textit{Vertical Rise Distance}}$$

$$\textit{\% Grade is } 100 \textit{ Tan [Slope]} = \frac{100 \times \textit{Vertical Rise}}{\textit{Horizontal Distance}}$$

STADIA FORMULA

Most theodolites have an internal set of cross hairs that when used with a stadia rod, allows the calculation of slope distance. (magnification is normally 100 and slope distance = 100 x Stadia Rod Vertical Intercept). If angles are involved, the formula is:

$$D = HI + [\text{Slope Distance} \times \sin(2V)/2] - M$$

D = Elevation difference between survey points
HI = Instrument height above survey point
V = Vertical angle (degrees) at the theodolite
M = Mid point cross hair reading on stadia rod

STADIA TABLE

Assume stadia slope distance of 100

Slope Angle (°)	Vertical Distance	Horizontal Distance
0.0	0.00	100.00
0.5	0.87	99.99
1.0	1.74	99.97
1.5	2.62	99.93
2.0	3.49	99.88
2.5	4.36	99.81
3.0	5.23	99.73
3.5	6.09	99.63
4.0	6.96	99.51
4.5	7.82	99.38
5.0	8.68	99.24
5.5	9.54	99.08
6.0	10.40	98.91
6.5	11.25	98.72
7.0	12.10	98.51
7.5	12.94	98.30
8.0	13.78	98.06
8.5	14.62	97.82
9.0	15.45	97.55
9.5	16.28	97.28
10.0	17.10	96.98
10.5	17.92	96.68
11.0	18.73	96.36
11.5	19.54	96.03
12.0	20.34	95.68
12.5	21.13	95.32
13.0	21.92	94.94
13.5	22.70	94.55
14.0	23.47	94.15

STADIA TABLE

Assume stadia slope distance of 100

Slope Angle (°)	Vertical Distance	Horizontal Distance
14.5	24.24	93.73
15.0	25.00	93.30
15.5	25.75	92.86
16.0	26.50	92.40
16.5	27.23	91.93
17.0	27.96	91.45
17.5	28.68	90.96
18.0	29.39	90.45
18.5	30.09	89.93
19.0	30.78	89.40
19.5	31.47	88.86
20.0	32.14	88.30
20.5	32.80	87.74
21.0	33.46	87.16
21.5	34.10	86.57
22.0	34.73	85.97
22.5	35.36	85.36
23.0	35.97	84.73
23.5	36.57	84.10
24.0	37.16	83.46
24.5	37.74	82.80
25.0	38.30	82.14
25.5	38.86	81.47
26.0	39.40	80.78
26.5	39.93	80.09
27.0	40.45	79.39
27.5	40.96	78.68
28.0	41.45	77.96
28.5	41.93	77.23
29.0	42.40	76.50
29.5	42.86	75.75
30.0	43.30	75.00
30.5	43.73	74.24
31.0	44.15	73.47
31.5	44.55	72.70
32.0	44.94	71.92
32.5	45.32	71.13
33.0	45.68	70.34
33.5	46.03	69.54
34.0	46.36	68.73
34.5	46.68	67.92
35.0	46.98	67.10
35.5	47.28	66.28
36.0	47.55	65.45
36.5	47.82	64.62
37.0	48.06	63.78
37.5	48.30	62.94
38.0	48.51	62.10
38.5	48.72	61.25
39.0	48.91	60.40

STADIA TABLE

Assume stadia slope distance of 100

Slope Angle ($^{\circ}$)	Vertical Distance	Horizontal Distance
39.5	49.08	59.54
40.0	49.24	58.68
40.5	49.38	57.82
41.0	49.51	56.96
41.5	49.63	56.09
42.0	49.73	55.23
42.5	49.81	54.36
43.0	49.88	53.49
43.5	49.93	52.62
44.0	49.97	51.74
44.5	49.99	50.87
45.0	50.00	50.00
45.5	49.99	49.13
46.0	49.97	48.26
46.5	49.93	47.38
47.0	49.88	46.51
47.5	49.81	45.64
48.0	49.73	44.77
48.5	49.63	43.91
49.0	49.51	43.04
49.5	49.38	42.18
50.0	49.24	41.32
50.5	49.08	40.46
51.0	48.91	39.60
51.5	48.72	38.75
52.0	48.51	37.90
52.5	48.30	37.06
53.0	48.06	36.22
53.5	47.82	35.38
54.0	47.55	34.55
54.5	47.28	33.72
55.0	46.98	32.90
55.5	46.68	32.08
56.0	46.36	31.27
56.5	46.03	30.46
57.0	45.68	29.66
57.5	45.32	28.87
58.0	44.94	28.08
58.5	44.55	27.30
59.0	44.15	26.53
59.5	43.73	25.76
60.0	43.30	25.00

Horizontal Distance = Slope Distance x Cos^2(Slope Degrees)

Vertical Distance = (Slope Distance/2) x Sin(2 x Slope Degrees)

MAPPING SCALES & AREAS

scale 1:X	Feet/ Inch	Inch/ Mile	Acres/ Sq Inch	Sq Miles/ Sq Inch
100	8.3	633.60	0.0016	0.000002
120	10.0	528.00	0.0023	0.000004
200	16.7	316.80	0.0064	0.000010
240	20.0	264.00	0.0092	0.000014
250	20.8	253.44	0.0100	0.000016
300	25.0	211.20	0.0143	0.000022
400	33.3	158.40	0.0255	0.000040
480	40.0	132.00	0.0367	0.000057
500	41.7	126.72	0.0399	0.000062
600	50.0	105.60	0.0574	0.000090
1000	83.3	63.36	0.1594	0.000249
1200	100.0	52.80	0.2296	0.000359
1500	125.0	42.24	0.3587	0.000560
2000	166.7	31.68	0.6377	0.000996
2400	200.0	26.40	0.9183	0.001435
2500	208.3	25.34	0.9964	0.001557
3000	250.0	21.12	1.4348	0.002242
3600	300.0	17.60	2.0661	0.003228
4000	333.3	15.84	2.5508	0.003986
4800	400.0	13.20	3.6731	0.005739
5000	416.7	12.67	3.9856	0.006227
6000	500.0	10.56	5.7392	0.008968
7000	583.3	9.05	7.8117	0.012206
7200	600.0	8.80	8.2645	0.012913
7920	660.0	8.00	10.0000	0.015625
8000	666.7	7.92	10.2030	0.015942
8400	700.0	7.54	11.2489	0.017576
9000	750.0	7.04	12.9132	0.020177
9600	800.0	6.60	14.6924	0.022957
10000	833.3	6.34	15.9423	0.024910
10800	900.0	5.87	18.5950	0.029055
12000	1000.0	5.28	22.9568	0.035870
13200	1100.0	4.80	27.7778	0.043403
14400	1200.0	4.40	33.0579	0.051653
15000	1250.0	4.22	35.8701	0.056047
15600	1300.0	4.06	38.7971	0.060620
15840	1320.0	4.00	40.0000	0.062500
16000	1333.3	3.96	40.8122	0.063769
16800	1400.0	3.77	44.9954	0.070305
18000	1500.0	3.52	51.6529	0.080708
19200	1600.0	3.30	58.7695	0.091827
20000	1666.7	3.17	63.7690	0.099639
20400	1700.0	3.11	66.3453	0.103664

MAPPING SCALES & AREAS

scale 1:X	Feet/ Inch	Inch/ Mile	Acres/ Sq Inch	Sq Miles/ Sq Inch
21120	1760.0	3.00	71.1111	0.111111
21600	1800.0	2.93	74.3802	0.116219
22800	1900.0	2.78	82.8742	0.129491
24000	2000.0	2.64	91.8274	0.143480
25000	2083.3	2.53	99.6391	0.155686
30000	2500.0	2.11	143.4803	0.224188
31680	2640.0	2.00	160.0000	0.250000
40000	3333.3	1.58	255.0760	0.398556
45000	3750.0	1.41	322.8306	0.504423
48000	4000.0	1.32	367.3095	0.573921
50000	4166.7	1.27	398.5563	0.622744
60000	5000.0	1.06	573.9210	0.896752
62500	5208.3	1.01	622.7442	0.973038
63360	5280.0	1.00	640.0000	1.000000
80000	6666.7	0.79	1020.3041	1.594225
90000	7500.0	0.70	1291.3223	2.017691
96000	8000.0	0.66	1469.2378	2.295684
100000	8333.3	0.63	1594.2251	2.490977
125000	10416.7	0.51	2490.9767	3.892151
126720	10560.0	0.50	2560.0000	4.000000
200000	16666.7	0.32	6376.9003	9.963907
250000	20833.3	0.25	9963.9067	15.568604
253440	21120.0	0.25	10240.0000	16.000000
380160	31680.0	0.17	23040.0000	36.000000
500000	41666.7	0.13	39855.6270	62.274417
760320	63360.0	0.08	92160.0000	144.000000
1000000	83333.3	0.06	159422.5079	249.097669

Feet / Inch = Scale / 12

Meters / Inch = Scale / 39.37

Miles / Inch = Scale / 63,291.14

Chains / Inch = Scale / 792.08

Inch / Mile = Scale / 63360

Acres / Square Inch = Scale^2 / 6,272,640

Square Miles / Square Inch = Scale^2 / 4,014,489,600

APPARENT DIP TABLE

True Dip	Angle between Strike and direction of Cross Section 5°	10°	15°	20°	25°
5°	0.4	0.9	1.3	1.7	2.1
10°	0.9	1.8	2.6	3.5	4.3
15°	1.3	2.7	4.0	5.2	6.5
20°	1.8	3.6	5.4	7.1	8.7
25°	2.3	4.6	6.9	9.1	11.1
30°	2.9	5.7	8.5	11.2	13.7
35°	3.5	6.9	10.3	13.5	16.5
40°	4.2	8.3	12.3	16.0	19.5
45°	5.0	9.9	14.5	18.9	22.9
50°	5.9	11.7	17.1	22.2	26.7
55°	7.1	13.9	20.3	26.0	31.1
60°	8.6	16.7	24.1	30.6	36.2
65°	10.6	20.4	29.0	36.3	42.2
70°	13.5	25.5	35.4	43.2	49.3
75°	18.0	32.9	44.0	51.9	57.6
80°	26.3	44.6	55.7	62.7	67.4
85°	44.9	63.3	71.3	75.7	78.3

True Dip	Angle between Strike and direction of Cross Section 30°	35°	40°	45°	50°
5°	2.5	2.9	3.2	3.5	3.8
10°	5.0	5.8	6.5	7.1	7.7
15°	7.6	8.7	9.8	10.7	11.6
20°	10.3	11.8	13.2	14.4	15.6
25°	13.1	15.0	16.7	18.2	19.7
30°	16.1	18.3	20.4	22.2	23.9
35°	19.3	21.9	24.2	26.3	28.2
40°	22.8	25.7	28.3	30.7	32.7
45°	26.6	29.8	32.7	35.3	37.5
50°	30.8	34.4	37.5	40.1	42.4
55°	35.5	39.3	42.6	45.3	47.6
60°	40.9	44.8	48.1	50.8	53.0
65°	47.0	50.9	54.0	56.6	58.7
70°	53.9	57.6	60.5	62.8	64.6
75°	61.8	65.0	67.4	69.2	70.7
80°	70.6	72.9	74.7	76.0	77.0
85°	80.1	81.3	82.2	82.9	83.5

APPARENT DIP TABLE

True Dip	Angle between Strike and direction of Cross Section 55°	60°	65°	70°	75°
5°	4.1	4.3	4.5	4.7	4.8
10°	8.2	8.7	9.1	9.4	9.7
15°	12.4	13.1	13.6	14.1	14.5
20°	16.6	17.5	18.3	18.9	19.4
25°	20.9	22.0	22.9	23.7	24.2
30°	25.3	26.6	27.6	28.5	29.1
35°	29.8	31.2	32.4	33.3	34.1
40°	34.5	36.0	37.3	38.3	39.0
45°	39.3	40.9	42.2	43.2	44.0
50°	44.3	45.9	47.2	48.2	49.0
55°	49.5	51.0	52.3	53.3	54.1
60°	54.8	56.3	57.5	58.4	59.1
65°	60.3	61.7	62.8	63.6	64.2
70°	66.0	67.2	68.1	68.8	69.4
75°	71.9	72.8	73.5	74.1	74.5
80°	77.9	78.5	79.0	79.4	79.7
85°	83.9	84.2	84.5	84.7	84.8

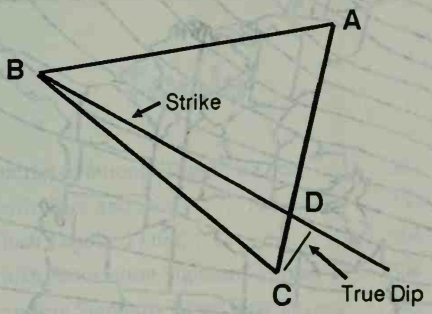
When a cross section cuts across the plane of a bedding surface, fault or topography (at any angle less than 90°), the observed dip (apparent dip) at the cross section intersection will always be less than the true dip. In order to use the above table, first, determine the "Angle Between Strike" value by subtracting the true strike (bearing) of the unit from the bearing of the cross section; second, measure the observed dip and locate that number in the body of the table; third, follow the row across to the left in order to determine the true dip. If you need a more precise value than listed in the table, use the following formula to calculate the answer:

Tan (Apparent Dip) = Tan (True Dip) x Sin (Angle Between)

Note that if the "Angle between Strike" value is 80° to 90°, the value of the true dip and apparent dip are nearly identical.

THREE POINT PROBLEM

A common problem in both surveying and geology is the determination of the strike (bearing) of a bedding surface, fault, topographic surface, etc. when the location and elevation of three points on the surface are known.



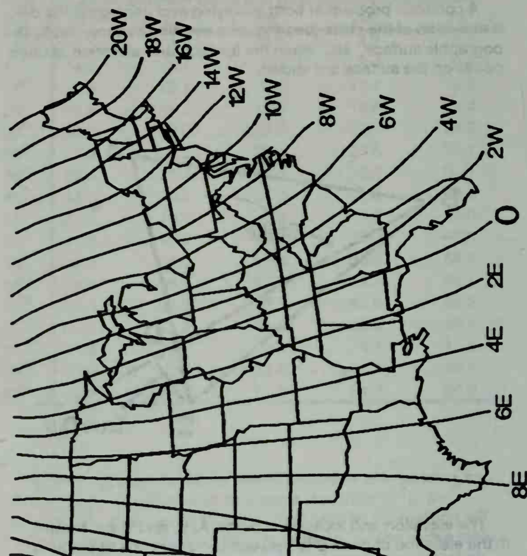
The elevation and location of points A, B, and C are known. If the elevation of point B is between the elevations of points A (the highest point) and C (the lowest point), then the strike (bearing) of the plane defined by ABC is determined by locating point D, on the line between A and C, and then drawing a strike line between B and D. Since strike is defined as the bearing of a horizontal line on the plane of ABC, the elevations of point B and D must be the same. The exact location of point D can be calculated from the following equation:

$$\text{Length AD} = \text{Length AC} \times \frac{\text{AB elevation difference}}{\text{AC elevation difference}}$$

Note that the true dip must always be at a right angle to the strike. The value of the true dip can be calculated with the following equation:

$$\text{Dip Angle } (^{\circ}) = \text{Arc Sin } ((\text{Elev D–C}) \,/\, \text{Length True Dip Line})$$

MAGNETIC DECLINATION MAP



POCKET REF

Tools

(See WELDING, p. 397 for more tools & soldering)

(See also MATH, p.265 for drill number table)

AMERICAN NATIONAL TAPS & DIES

	Fine Threads			Coarse Threads		
Thread	Threads / inch	Tap Drill	Tap Decimal inch	Threads / inch	Tap Drill	Tap Decimal inch
#0	80	3/64	0.0469	...	...	...
#1	72	#53	0.0595	64	#53	0.0595
#2	64	#50	0.0700	56	#50	0.0700
#3	56	#45	0.0820	48	#47	0.0785
#4	48	#42	0.0935	40	#43	0.0890
1/8	40	#38	0.1015	32	3/32	0.0937
#5	44	#37	0.1040	40	#38	0.1015
#6	40	#33	0.1130	32	#36	0.1065
#8	36	#29	0.1360	32	#29	0.1360
3/16	32	#22	0.1570	24	#26	0.1470
#10	32	#21	0.1590	24	#25	0.1495
#12	28	#14	0.1820	24	#16	0.1770
1/4	28	#3	0.2130	20	#7	0.2010
5/16	24	I	0.2720	18	F	0.2570
3/8	24	Q	0.3320	16	5/16	0.3125
7/16	20	25/64	0.3906	14	U	0.3680
1/2	20	29/64	0.4531	13	27/64	0.4219
9/16	18	33/64	0.5156	12	31/64	0.4844
5/8	28	37/64	0.5781	11	17/32	0.5312
3/4	26	11/16	0.6875	10	21/32	0.6562
7/8	24	13/16	0.8125	9	49/64	0.7656
1	14	15/16	0.9375	8	7/8	0.8750
1-1/8	12	1-3/64	1.0469	7	63/64	0.9844
1-1/4	12	1-11/64	1.1719	7	1-7/64	1.1094
1-3/8	12	1-19/64	1.2969	6	1-7/32	1.2187
1-1/2	12	1-27/64	1.4219	6	1-11/32	1.3281
1-3/4	...	...	...	5	1-9/16	1.5469
2	...	...	...	4-1/2	1-25/32	1.7812
2-1/4	...	...	...	4-1/2	2-1/32	2.0312
2-1/2	...	...	...	4	2-1/4	2.2500
2-3/4	...	...	...	4	2-1/2	2.5000
3	...	...	...	4	2-3/4	2.7500
3-1/4	...	...	...	4	3	3.0000
3-1/2	...	...	...	4	3-1/4	3.2500
3-3/4	...	...	...	4	3-1/2	3.5000
4	...	...	...	4	3-3/4	3.7500

Note that there are literally hundreds of other sizes and thread per inch taps and dies available, e.g. 1/4 inch can have 10,12,14, 16,18,22,23,24,25,26,27,30,32,34,36,38,40,42,44,48,50,52,56,60, 64,72, and 80 threads/inch depending on the standard. Threads shown in the table above are simply the most common.

METRIC TAPS AND DIES

Thread Size		Pitch in mm		Tap Drill Size	
mm	Inches	French	International	mm	Inches
1.5	0.0590	0.35	...	1.10	0.0433
2	0.0787	0.45	...	1.50	0.0590
2	0.0787	...	0.40	1.60	0.0630
2.3	0.0895	...	0.40	1.90	0.0748
2.5	0.0984	0.45	...	2.00	0.0787
2.6	0.1124	...	0.45	2.10	0.0827
3	0.1181	...	0.5	2.50	0.0984
3	0.1181	0.60	...	2.40	0.0945
3.5	0.1378	0.60	0.60	2.90	0.1142
4	0.1575	0.75	...	3.25	0.1279
4	0.1575	...	0.70	3.30	0.1299
4.5	0.1772	0.75	0.75	3.75	0.1476
5	0.1968	0.90	...	4.10	0.1614
5	0.1968	...	0.80	4.20	0.1653
5.5	0.2165	0.90	0.90	4.60	0.1811
6	0.2362	1.00	1.00	5.00	0.1968
7	0.2856	1.00	1.00	6.00	0.2362
8	0.3150	1.00	...	7.00	0.2756
8	0.3150	...	1.25	6.80	0.2677
9	0.3543	1.00	...	8.00	0.3150
9	0.3543	...	1.25	7.80	0.3071
10	0.3937	1.50	1.50	8.60	0.3386
11	0.3937	...	1.50	9.60	0.3780
12	0.4624	1.50	...	10.50	0.4134
12	0.4624	...	1.75	10.50	0.4134
14	0.5512	2.00	2.00	12.00	0.4724
16	0.6299	2.00	2.00	14.00	0.5118
18	0.7087	2.50	2.50	15.50	0.6102
20	0.7974	2.50	2.50	17.50	0.6890
22	0.8771	2.50	2.50	19.50	0.7677
24	0.9449	3.00	3.00	21.00	0.8268
26	1.0236	3.00	...	23.00	0.9055
27	1.0630	...	3.00	24.00	0.9449
28	1.1024	3.00	...	25.00	0.9842
30	1.1811	3.50	3.50	26.50	1.0433
32	1.2598	3.50	...	28.50	1.1220
33	1.2992	...	3.50	29.50	1.1614
34	1.3386	3.50	...	30.50	1.2008
36	1.4173	4.00	4.00	32.00	1.2598
38	1.4961	4.00	...	34.00	1.3386
39	1.5354	...	4.00	35.00	1.3779
40	1.5748	4.00	...	36.00	1.4173
42	1.6535	4.50	4.50	37.00	1.4567

BRITISH TAPS & DIES

	British Std Whitworth		British Standard Fine	
Thread	Threads / inch	Tap Drill	Threads / inch	Tap Drill
1/8	40	2.55mm	...	...
3/16	24	3.70mm	32	5/32
7/32	...	...	28	4.65mm
1/4	20	5.10mm	26	5.3mm
9/32	...	...	26	...
5/16	18	6.50mm	22	6.75mm
3/8	16	5/16	20	8.25mm
7/16	14	9.25mm	18	9.70mm
1/2	12	10.5mm	16	7/16
9/16	12	12.1mm	16	1/2
5/8	11	13.5mm	14	14mm
11/16	11	...	14	...
3/4	10	41/64	12	16.75mm
7/8	9	19.25mm	11	25/32
1	8	22.00mm	10	22.75
1-1/8	7	24.75mm	9	25.50mm
1-1/4	7	1-3/32	9	28.75mm
1-3/8	...	...	8	31.50mm
1-1/2	6	33.50mm	8	1-23/64
1-3/4	5	39.00mm	...	...
2	4.5	44.50mm	...	...

BRITISH ASSOC STD THREAD (B.A.)

Thread	Threads / inch	Pitch mm	Major Diameter mm
0	25.4	1.00	6.0
1	28.2	0.90	5.3
2	31.4	0.81	4.7
3	34.8	0.73	4.1
4	38.5	0.66	3.6
5	43.0	0.59	3.2
6	47.9	0.53	2.8
7	52.9	0.48	2.5
8	59.1	0.43	2.2
9	65.1	0.39	1.9
10	72.6	0.35	1.7
11	82.0	0.31	1.5
12	90.7	0.28	1.3
13	102.0	0.25	1.2
14	110.0	0.23	1.0
15	121.0	0.21	0.9
16	134.0	0.19	0.79

AMERICAN STD TAPER PIPE

Pipe Size inch	Threads per inch	Pipe Diameter inch	Tap Drill
1/8	27	0.405	R
1/4	18	0.540	7/16
3/8	18	0.675	37/64
1/2	14	0.840	23/32
3/4	14	1.050	59/64
1	11.5	1.315	1-5/32
1-1/4	11.5	1.660	1-1/2
1-1/2	11.5	1.900	1-47/64
2	11.5	2.375	1-7/32
2-1/2	8	2.875	2-5/8
3	8	3.500	3-1/4
3-1/2	8	4.000	3-3/4
4	8	4.500	4-1/4
4-1/2	8	5.000	4-3/4
5	8	5.563	5-9/32
6	8	6.625	6-11/32
7	8	7.625	...
8	8	8.625	...
9	8	9.625	...
10	8	10.750	...
12	8	12.750	...
> 14 OD	8	Same as Col 1	...

AMERICAN STD STRAIGHT PIPE

Pipe Size inch	Threads per inch	Pipe Diameter inch	Tap Drill
1/8	27	0.405	S
1/4	18	0.540	29/64
3/8	18	0.675	19/32
1/2	14	0.840	47/64
3/4	14	1.050	15/16
1	11.5	1.315	1-3/16
1-1/4	11.5	1.660	1-33/64
1-1/2	11.5	1.900	1-3/4
2	11.5	2.375	2-7/32
2-1/2	8	2.875	2-21/32
3	8	3.500	3-9/32
3-1/2	8	4.000	3-25/32
4	8	4.500	4-9/32
4-1/2	8	5.000	4-25/32
5	8	5.563	5-11/32
6	8	6.625	6-13/32

DRILL & CUTTING LUBRICANTS

Material to be Worked	Machine Process		
	Drilling	Threading	Lathe
Aluminum	Soluble oil Kerosene Lard oil	Soluble oil, Kerosene, & Lard oil	Soluble oil
Brass	Dry Soluble oil Kerosene Lard Oil	Soluble oil Lard oil	Soluble oil
Bronze	Dry Soluble oil Mineral oil Lard oil	Soluble oil Lard oil	Soluble oil
Cast Iron	Dry Air jet Soluble oil	Dry Sulphurized oil Mineral lard oil	Dry Soluble oil
Copper	Dry Soluble oil Mineral lard oil Kerosene	Soluble oil Lard oil	Soluble
Malleable Iron	Dry Soda water	Lard oil Soda water	Soluble oil Soda water
Monel metal	Soluble oil Lard oil	Lard oil	Soluble oil
Steel alloys	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil
Steel, machine	Soluble oil Sulphurized oil Lard oil Mineral lard oil	Soluble oil Mineral lard oil	Soluble oil
Steel, tool	Soluble oil Sulphurized oil Mineral lard oil	Sulphurized oil Lard oil	Soluble oil

The above table of cutting fluids is courtesy of Cincinnati Milacron.

DRILLING SPEEDS vs MATERIAL

Material	Speed rpm	Description
Cast Iron	6000 to 6500	1/16 inch drill
	3500 to 4500	1/8 inch drill
	2500 to 3000	3/16 inch drill
	2000 to 2500	1/4 inch drill
	1500 to 2000	5/16 inch drill
	1500 to 2000	3/8 inch drill
	1000 to 1500	> 7/16 inch drill
Glass	700	Special metal tube drilling
Plastics	6000 to 6500	1/16 inch drill
	5000 to 6000	1/8 inch drill
	3500 to 4000	3/16 inch drill
	3000 to 3500	1/4 inch drill
	2000 to 2500	5/16 inch drill
	1500 to 2000	3/8 inch drill
	500 to 1000	> 7/16 inch drill
Soft Metals	6000 to 6500	1/16 inch drill
(copper)	6000 to 6500	1/8 inch drill
	5000 to 6000	3/16 inch drill
	4500 to 5000	1/4 inch drill
	3500 to 4000	5/16 inch drill
	3000 to 3500	3/8 inch drill
	1500 to 2500	> 7/16 inch drill
Steel	5000 to 6500	1/16 inch drill
	3000 to 4000	1/8 inch drill
	2000 to 2500	3/16 inch drill
	1500 to 2000	1/4 inch drill
	1000 to 1500	5/16 inch drill
	1000 to 1500	3/8 inch drill
	500 to 1000	> 7/16 inch drill
Wood	4000 to 6000	Carving and routing
	3800 to 4000	All woods, 0 to 1/4 inch drills
	3100 to 3800	All woods, 1/4 to 1/2 inch drills
	2300 to 3100	All woods, 1/2 to 3/4 inch drills
	2000 to 2300	All woods, 3/4 to 1 inch drills
	700 to 2000	All woods, > 1 inch drills, fly cutters,
	< 700	and multi–spur bits

If in doubt about what speed to use, always select the slower speeds. Speeds for drill sizes not listed above can be estimated by looking at speeds for sizes one step over and one step under.

FIRE EXTINGUISHERS

Fire extinguishers are an absolute must in any shop, garage, home, automobile, or business. Fire extinguishers are classified by the types of fires they will put out and the size of the fire they will put out. The basic types are as follows:

TYPE A: For wood, cloth, paper, trash and other common materials. These fires are put out by "heat absorbing" water or water based materials or smothered by dry chemicals.

TYPE B: For oil, gasoline, grease, paints & other flammable liquids. These fires are put out by smothering, preventing the releas of combustible vapors, or stopping the combustion chain. Use Halon, dry chemicals, carbon dioxide, or foam.

TYPE C: For "live" electrical equipment. These fires are put out by the same process as TYPE B, but the extinguishing material must be electrically non-conductive. Use halon, dry chemicals, or carbon dioxide.

TYPE D: For combustible metals such as magnesium. These fires must be put out by heat absorption and smothering. Obtain specific information on these requirements from the fire department.

Combinations of the above letters indicate the extinguisher will put out more than one type of fire. For example, a Type ABC unit will put out all three types of fires. The "size" of the fire an extinguisher will put out is shown by a number in front of the Type, such as "10B". The base line numbers are as follows:

FIRE EXTINGUISHERS

Class "1A": Will put out a stack of 50 burning sticks that are 20 inches long each.

Class "1B": Will put out an area of burning naptha that is 2.5 square feet in size.

Any number other than the "1" simply indicates the extinguisher will put out a fire that many times larger, for example "10A" will put out a fire 10 times larger than "1A".

Some general recommendations when purchasing a fire extinguisher are as follows:

1: Buy TYPE ABC so that you never have to think about what type of fire you are using it on. Also, buy a halon or carbon dioxide extinguisher so you don't damage electronic equipment and there is much less mess. The relative prices of extinguishers are Foam (very expensive – used on big fires such as aircraft), Carbon Dioxide (also expensive but leaves no mess), Halon (medium range prices), and Dry Chemical (very inexpensive, but leaves a mess).

2. Buy units with metal components and a gauge and are approved by Underwriters Labs or other testing group. Plastic units are generally poorly constructed and break easily; buy good extinguishers, your life and property may depend on it !

3. Buy more than one extinguisher and mount them on the wall near escape routes so that children can reach them.

4. Study the instructions when you get the unit, there may not be time after a fire has started.

SANDPAPER & ABRASIVES

Grit Current System	Grit Old System	Word Description	Use
12	4-1/2	Very Coarse	Very rough work,
16	4	Very Coarse	usually requires
20	3-1/2	Very Coarse	high speed, heavy
24	3	Very Coarse	machines. For
30	2-1/2	Coarse	unplanned woods,
36	2	Coarse	wood floors, rough cut.
40	1-1/2	Coarse	Rough wood work,
50	1	Coarse	#1 is coarsest for
60	1/2	Medium	use with pad sander.
80	1/0	Medium	General wood work,
100	2/0	Medium	plaster patches, 1st
120	3/0	Fine	smooth of old paint.
150	4/0	Fine	Hardwood prep, final for
180	5/0	Fine	softwoods, old paint.
220	6/0	Very Fine	Final sanding or between
240	7/0	Very Fine	coats, won't show sand
280	8/0	Very Fine	marks, dry sanding.
320	9/0	Extra Fine	Polish final coats, between
360		Extra Fine	coats, wet sand paints
400	10/0	Extra Fine	& varnishes, top coats.
500		Super Fine	Sand metal, plastic, &
600		Super Fine	ceramics, wet sanding.

COATING TYPES:

Open coat: Grains cover 50% to 70% of the backing, which leaves a lot of space between each grain. The open space is necessary in applications where the material being sanded has a tendency to clog up or "load" the abrasive surface. The clogging drastically reduces the cutting ability of the abrasive and reduces the life of the abrasive. Less common than Closed coat.

Closed coat: Grains cover all of the backing. This type is much more efficient (removes material faster) than Open coat since there are more abrasion grains per square inch. Closed coat is the preferred coating type as long as grain clogging is not a problem.

GLUE TYPES

Glues are generally restricted to a combination of "Hide" glues and resin based glues, depending on the application. Glues are usually applied as a two part process, the base coat and the top grain holding coat.

BACKING TYPES:

Paper: Weights range from "A" through "F". "A" is the most flexible and is used mainly for finishing jobs and with small grain sizes abrasives. "A" is primarily used for hand sanding. "C" and "D" weights are stronger, less flexible, and used for both hand sanding and power sanders. "E" is much stronger, very tear resistant and much less flexible than "C" and "D" and is used mainly in belt and disc applications. "F" is the strongest paper and is used mainly for rolls and belts.

Cloth: Weights are "J" (jeans) and "X" (drills). "J" is used for finishing and polishing operations, particularly where contours are involved. "X" is less flexible than "J" but is stronger. "X" is used for heavy belt, disk and drum grinding and polishing.

Fiber: Composed of multiple layers of paper that has been chemically treated. These backings are very tough, heat resistant and used mostly for drum and disc applications, particularly high speed.

Combination: Composed of both paper and cloth or cloth and fiber, producing a very strong, flexible, non–stretching, and tear resistant backing. They are used mostly in high speed, drum sanding applications

ABRASIVE TYPES:

Silicon Carbide: The hardest and sharpest of all abrasives but is more brittle than aluminum oxide. Color is blue–black and it is a manufactured abrasive. Typically used in applications such as finishing of soft metals, glass, ceramics, hard wood floors and plastics. It is very fast cutting and is therefore good for both material removal as well as polishing. This abrasive is very popular for sanding lacquered and enameled surfaces such as car paints. Durite by Norton is a common brand name. Grain sizes normally range from 600 to 12.

Aluminum Oxide: Extremely tough, grit is very sharp and much harder than flint, garnet and emery. Color is red to brown and it is a manufactured abrasive. More expensive than most other types but its toughness results in a longer lasting abrasive so its cost is actually equivalent. Recommended for metals and hard woods and is the preferred choice for power sanding. Norton brand names – Adalox or Metalite. Grain sizes normally range from 500 to 16.

Garnet: Much softer than the synthetic abrasives listed above but harder and sharper than flint. Garnet is a crushed natural mineral, red to brown in color. Used mainly in furniture finishing and woodworking. Yields an excellent wood finish. Grain sizes normally range from 280 to 20.

Flint: Generally poor cutting strength and durability so it is not used in production environments. Used in the leather industry and as a good non–clogging abrasive in paint removal and some woodwork. Flint is gray to white colored natural quartz mineral. Flint is non–conductive and therefore is also useful as an abrasive in the electronics industry. Inexpensive. Grain sizes normally range from 4/0 to 3.

Emery: Good polishing features but poor for material removal. Grains are round and black in color. Poor penetration but good for polishing metals. Poor for wood use. Grain sizes normally range from 3/0 to 3.

Crocus: Soft and short lived. Made of ferrous oxide (red color). Good for polishing, particularly soft metals like gold.

Pumice: Powdered volcanic glass that is commonly used to tone down a glossy finish to a satin, smooth surface. Grades range from 4–F (the finest) through #7 (the coarsest). Frequent inspections of the work surface should be made in order to prevent breaking through the surface.

Cork: Cork is sometimes used as a wet polishing media.

Rottenstone: Also referred to as diatomaceous earth. It is much softer and finer grained than pumice and is used in combination with water, solvents, or oils to produce a satin finish on woods.

Rubbing Compounds: Sometimes also referred to as "rouge" is normally used as a polish for enamel and lacquer paints. It is not for use on bare woods.

Steel Wool: Although not technically an abrasive, it is commonly used to remove rust, old finishes, and to smooth rough surfaces. Sizes range from 3/0 (the finest) through #5 (the coarsest). With steel wool, it is important to rub the wood in the direction of the grain, not across it, so that the surface is not scratched.

Some of the above abrasive data is courtesy of *Norton. Coated Abrasives Division. Troy. New York.*

Chain Saw Classification

Chain saws can be broadly grouped into the following four categories, based on ruggedness and size:

1. Mini–saw: Light weight (6 to 9 pounds), small engine size (1.8 to 2.5 cubic inches or electric), and short bar lengths (8 to 12 inches, 1/4 inch pitch). Good for <3 cords per year.

2. Light–Duty: Light weight (9 to 13 pounds), small engine size (2.5 to 3.8 cubic inches or electric), and medium bar lengths (14 to 16 inches, 3/8 inch pitch). Good for 3 to 6 cords per year.

3. Medium–Duty: Medium weight (13 to 18 pounds), medium engine size (3.5 to 4.8 cubic inches), and medium–long bar lengths (16 to 24 inches, 3/8 to 0.404 inch pitch). Good for 6 to 10 cords per year. If money permits, this class of saw is probably the best choice for the average wood cutter, even if he does not cut the 6 to 10 cords per year. It is heavy duty enough to last a long time under light use.

4. Heavy–Duty: Heavy weight (over 18 pounds), large engine size (over 4.8 cubic inches), and long bar lengths (over 24 inches, 0.404 to 1/2 inch pitch). These heavy duty units are generally for the professional. They are heavy, expensive, and require more strength to use. They can be used continuously.

Depth Capacity of Std Circular Power Handsaws

Blade Diameter	Capacity @ 90°	Capacity @ 45°
4-1/2	1-5/16	1-1/16 to 1-1/14
6-1/2	2-1/16	1-5/8
6-3/4	2-7/32	1-3/4
7-1/4	2-3/8 to 2-7/16	1-7/8 to 1-29/32
7-1/2	2-17/22	2-1/16
8-1/4	2-15/16	2-1/4
10-1/4	3-5/8	2-3/4
12	4-3/8	3-5/16

Cut–off Wheel

Abrasive blade made of aluminum oxide (metal cutting) or silicon carbide (masonry cutting). Comes in standard sizes of 6, 7, and 8 inch diameter and with 1/2 or 5/8 diameter arbor. No teeth.

Hollow–Ground

Quiet, accurate and leaves a very smooth finish. Designed especially for crosscuts and miters across wood grain. Acceptable for ripping, but it's not as fast as ripping blades. Hollow–Ground blades minimize chipping.

Ripping Blade

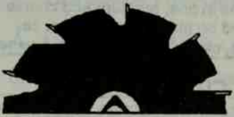
These blades have large, set teeth with deep gullets. Designed especially for cutting fast in the direction of the wood grain. Minimum binding of blade. Very rough finish.

Chisel–Tooth

General purpose, set–tooth blade. Good for both ripping and crosscuts and it cuts fast but leaves a rough cut. This is the most common blade used by contractors. Bevel–ground, carbide–tipped blades of the same basic design are among the most durable of the blades.

Crosscut, Fine–Tooth, & Paneling Blades

All of these blades have a large number of small teeth that are very sharp. Crosscut has the least teeth, Fine–Tooth has more and Paneling has the most. Crosscut, as the name implies, was designed for cutting across the wood grain and leaving a smooth edge. It is also good for plywood. Fine–Tooth blades are also good for plywood, but are also used on fiber boards (Celotex), veneers, and thin plastics. Paneling blades have many, extra fine teeth. It is particularly useful in cutting paneling and laminates since the cut edge usually does not have to be touched up.



Flattop–Ground Carbide Tipped

A fast cutting, long lasting blade used as a combo blade in construction. Good for ripping, crosscutting and mitering but does not leave a good smooth edge.

Steel Cutting Blade

A unusually designed blade that is used to cut ferrous (iron and steel) sheetmetal that is up to 3/32 inch thick. This blade actually "burns" its way through the metal, leaving a clean edge.

SABER SAW BLADES

Teeth per inch	Blade Usage
3	Lumber up to 6 inches thick, fast cutting, very rough cut, good ripping blade.
5 or 6	Lumber up to 2 inches thick, fast cutting, rough cut, good ripping blade.
7 or 8	Best general purpose blade, relatively smooth cut. Good for lumber and fiber insulation board.
10	Good general purpose blade, smoother cut than the 7 or 8 blade. Use 10 through 14 for cutting hardwoods under 1/2 inch thick and for plastics, composition board, drywall, and plywood when a smooth edge is needed. If hard, abrasive materials are to be cut, such as laminates, use the metal cutting H.S.S. types. Good for some scrollwork.
12 or 14	Very smooth cutting blade but is also very slow cutting. Good for hardwoods, plywood, fiberglass, plastics, rubber, linoleum, laminates, and plexiglass. As with the 10 tpi blades, if the material is particularly hard or abrasive, use the metal cutting H.S.S. types instead.
Knife	These blades have either a knife edge or a sharp edge with an abrasive grit bonded to the blade. No grit blades are useful for cutting rubber, cork, leather, cardboard, styrofoam, & silicones. Grit blades come in fine, medium and coarse and can be used on fiberglass, epoxies, ceramic tile, stone, clay pipe, brick, steel, & veneer
	H.S.S. METAL CUTTING BLADES
6 to 10	Rough cutting for aluminum, brass, copper, laminates, hardwoods and other soft materials. Good up to 1/2 inch thickness.
14	Cuts same materials as 6 to 10 tpi plus mild steels and hardboards. Leaves a much smoother edge. Thickness should be 1/4 to 1/2 inch maximum.
18	Same as 14 tpi but maximum thickness 1/8 inch.
24	Smooth edge cutting for steel and sheet metal. Also good for other hard materials such as plastics, tile, and Bakelite. Maximum thickness should be 1/8 inch.
32	Very fine cuts for steel and thin wall tubing up to 1/16 inch thick.

POCKET REF

Water

(See also AIR chapter, p. 14 for more pollution data)

FRICTION LOSS IN STEEL PIPE

Flow GPM	Feet of Head Loss per 100 Feet @ Diameter (inches) 1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
0.5	0.6	...	...	...	...	...	...
1	2.1	...	...	...	...	...	...
2	7.6	1.9	0.6	...	...	...	...
3	16.0	4.1	1.3	...	...	...	...
4	27.3	6.9	2.1	0.6	...	...	...
5	41.2	10.5	3.4	0.9	...	...	...
10	149	37.8	11.7	3.1	1.4	0.5	...
15	...	80.0	24.8	6.5	2.9	0.9	...
20	...	136	42.1	11.1	5.2	1.5	0.7
30	...	...	89.2	23.5	11.1	3.3	1.4
40	...	...	152	40.0	18.9	5.6	2.4
50	...	...	...	60.4	28.5	8.5	3.6
60	...	...	...	87.4	40.0	11.9	5.0
70	...	...	...	144	53.2	15.8	6.6
80	...	...	...	...	68.1	20.2	8.5
90	...	...	...	...	84.7	25.1	10.6
100	...	...	...	...	103	30.5	12.8
150	...	...	...	...	...	64.7	27.3
200	...	...	...	...	...	110	46.3
250	...	...	...	...	...	...	81.7
300	...	...	...	...	...	...	98.1

Flow GPM	Feet of Head Loss per 100 Feet @ Diameter (inches) 3	4	5	6	8	10	12
50	2.3	0.3	...	...	...	...	...
75	3.3	0.7	1.2	...	...	...	...
100	4.5	2.6	1.6	0.2	...	...	...
150	6.8	3.8	2.4	0.4	...	...	...
200	9.1	5.1	3.3	2.3	0.1	...	...
250	11.3	6.4	4.1	2.8	0.2	...	...
300	13.6	7.7	4.9	3.4	0.3	0.1	...
400	18.2	10.2	6.5	4.5	0.5	0.2	1.1
500	22.7	12.8	8.2	5.7	0.8	0.3	1.4
600	...	15.3	9.8	6.8	1.2	0.4	1.7
700	...	17.9	11.4	7.9	1.5	0.5	2.0
800	...	20.4	13.1	9.1	2.0	0.7	2.3
900	...	23.0	14.7	10.2	2.5	0.8	2.5
1000	...	...	16.3	11.4	3.0	1.0	2.8
1200	...	...	19.6	13.6	4.2	1.4	3.5
1500	...	...	...	17.0	6.3	2.1	4.3
2000	...	...	...	...	10.8	3.6	5.2
3000	...	...	...	...	...	7.7	8.5
4000	...	...	...	...	...	13.1	11.4
5000	...	...	...	...	...	...	14.2

FRICTION LOSS IN PLASTIC PIPE

Flow GPM	Feet of Head Loss per 100 Feet @ Diameter (inches) 1/2	3/4	1	1–1/4	1–1/2	2	2–1/2
0.5	0.3	...	...	...	...	...	...
1	1.1	...	...	...	...	...	...
2	4.1	1.0	0.3	...	...	...	...
3	8.6	2.2	0.7	...	...	...	...
4	14.8	3.7	1.1	0.3	...	...	...
5	22.2	5.7	1.7	0.5	...	...	...
10	80.5	20.4	6.3	1.7	0.8	0.2	...
15	...	43.3	13.4	3.5	1.6	0.5	...
20	...	73.5	22.8	6.0	2.8	0.8	0.3
30	...	...	48.1	12.7	6.0	1.8	0.7
40	...	...	82.0	21.6	10.2	3.0	1.3
50	...	...	...	32.6	15.4	4.6	1.9
60	...	...	...	45.6	21.6	6.4	2.7
70	...	...	...	...	28.7	8.5	3.6
80	...	...	...	...	36.8	10.9	4.6
90	...	...	...	...	45.7	13.6	5.7
100	...	...	...	...	56.6	16.5	6.9
150	...	...	...	...	...	35.0	14.7
200	...	...	...	...	...	59.4	25.0
250	...	...	...	...	...	...	44.1

FRICTION LOSS IN COPPER PIPE

Flow GPM	Feet of Head Loss per 100 Feet @ Diameter (inches) 1/2	3/4	1	1–1/4	1–1/2	2	2–1/2
0.5	0.3	...	...	...	...	...	...
1	1.3	...	...	...	...	...	...
2	4.6	1.2	0.3	...	...	...	...
3	9.7	2.6	0.7	...	...	...	...
4	16.4	4.4	1.2	0.4	...	...	...
5	24.8	6.6	1.9	0.6	...	...	...
10	89.4	23.7	6.8	2.0	0.9	0.3	...
15	...	49.1	14.4	4.2	1.9	0.6	...
20	...	83.5	24.4	7.1	3.3	1.0	0.4
30	...	...	51.6	15.0	7.0	2.0	0.8
40	...	...	88.0	25.6	12.0	3.5	1.3
50	...	...	...	38.7	14.9	5.2	2.0
60	...	...	...	54.1	25.3	7.3	2.9
70	...	...	...	73.2	33.8	9.8	3.8
80	...	...	...	92.4	43.1	12.5	4.9
90	...	...	...	...	53.6	15.6	6.1
100	...	...	...	...	65.1	18.9	7.4
150	...	...	...	...	...	40.1	15.6
200	...	...	...	...	...	68.0	47.3
250	...	...	...	...	...	...	56.8

FRICTION LOSS IN PIPE FITTINGS

Steel/Copper Fitting	Feet of Head Loss per Joint @ Diameter (inches) 1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
90° Std Elbow	1.6	2.1	2.6	3.5	4.0	5.5	6.2
90° Long Elbow	1	1.4	1.7	2.3	2.7	4.3	5.1
90° Street Elbow	3	3.4	4.4	5.8	6.7	8.6	10.3
45° Std Elbow	0.8	1.1	1.4	1.8	2.1	2.8	3.3
45° Street Elbow	1	1.8	2.3	3.0	3.5	4.5	5.4
Square Elbow	3	3.9	5.0	6.5	7.6	9.8	11.7
Std T Flow Run	1	1.4	1.7	2.3	2.7	4.3	5.1
Std T Flow Branch	4	5.1	6.0	6.9	8.1	12.0	14.3
Gate Valve–open	.7	0.9	1.1	1.5	1.7	2.2	2.7

FRICTION LOSS IN PIPE FITTINGS

Plastic Fitting	Feet of Head Loss per Joint @ Diameter (inches) 1/2	3/4	1	1-1/4	1-1/2	2	2-1/2
90° Std Elbow	4	5	6	7	8	9	10
Std T Flow Run	4	4	4	5	6	7	8
Std T Flow Branch	7	8	9	12	13	17	20

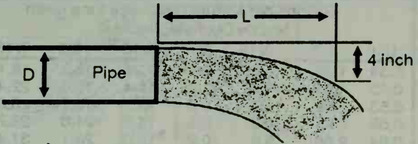
SUCTION, HEAD, VAPOR PRESSURE

Water Temp °F	Vapor Pressure	Suction Lift or Head @ Altitude in Feet 0	2000	4000	8000	12000
60	0.6 ft water	20	17.5	15.5	11.5	7.5
70	0.8 ft water	19.5	17	15	11	7
80	1.2 ft water	19.5	17	15	11	7
90	1.6 ft water	19	16.5	14.5	10.5	6.5
100	2.2 ft water	18.5	16	14	10	6
110	2.9 ft water	17.5	15	13	9	5
120	3.9 ft water	16.5	14	12	8	4
130	5.1 ft water	15.5	13	11	7	3
140	6.7 ft water	14	111.5	9.5	5.5	1.5
150	8.6 ft water	12	9.5	7.5	3.5	–0.5
160	10.9 ft water	9.5	7	5	1	...
170	13.8 ft water	6.5	4	2	–2	...
180	17.3 ft water	3	0.5	–1.5	...	...
190	21.6 ft water	–1	–3.5	–5.5	...	...
200	26.6 ft water	–6	–8.5	...	...	...
210	32.6 ft water	–12	...	...	...	...
212	34.0 ft water	–13.5	...	...	...	...

+ values indicate suction lift, – values indicate suction head

See also Air and Water table on page 9.

HORIZONTAL PIPE DISCHARGE



L Distance inches	Gallons per Minute Discharge for a given Nominal Pipe Diameter D (Inches) 1	1-1/4	1-1/2	2	2-1/2	3	4
4	6	10	13	22	31	48	83
5	7	12	17	27	39	61	104
6	8	15	20	33	47	73	125
7	10	17	23	38	55	85	146
8	11	20	26	44	62	97	166
9	13	22	30	49	70	110	187
10	14	24	33	55	78	122	208
11	16	27	36	60	86	134	229
12	17	29	40	66	94	146	250
13	18	31	43	71	102	158	270
14	20	34	46	77	109	170	292
15	21	36	50	82	117	183	312
16	23	39	53	88	125	196	334
17	...	41	56	93	133	207	355
18	...	...	60	99	144	220	375
19	...	...	...	110	148	232	395
20	...	...	...	...	156	244	415
21	...	...	...	...	...	256	435
22	...	...	...	...	...	...	460

L Distance inches	Gallons per Minute Discharge for a given Nominal Pipe Diameter D (Inches) 5	6	8	10	12
5	163	...	...	...	...
6	195	285	...	...	...
7	228	334	580	...	...
8	260	380	665	1060	...
9	293	430	750	1190	1660
10	326	476	830	1330	1850
11	360	525	915	1460	2020
12	390	570	1000	1600	2220
13	425	620	1080	1730	2400
14	456	670	1160	1860	2590
15	490	710	1250	2000	2780
16	520	760	1330	2120	2960
17	550	810	1410	2260	3140
18	590	860	1500	2390	3330
19	620	910	1580	2520	3500
20	650	950	1660	2660	3700
21	685	1000	1750	2800	3890
22	720	1050	1830	2920	4060
23	750	1100	1910	3060	4250
24	...	1140	2000	3200	4440

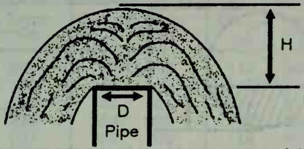
NOZZLE DISCHARGE

Nozzle Pressure lbs/sq in	Gallons per Minute Discharge for a given Nozzle Diameter (Inches)						
	1/16	1/8	3/16	1/4	5/16	3/8	7/16
10	0.38	1.48	3.3	5.9	9.24	13.3	18.1
15	0.45	1.81	4.1	7.2	11.4	16.3	22.4
20	0.53	2.09	4.7	8.3	13.1	18.7	25.6
25	0.59	2.34	5.3	9.3	14.6	21.0	28.7
30	0.64	2.56	5.8	10.2	16.0	23.1	31.4
35	0.69	2.78	6.2	11.1	17.1	25.0	33.8
40	0.74	2.96	6.7	11.7	18.4	26.6	36.2
45	0.79	3.14	7.1	12.6	19.5	28.2	38.3
50	0.83	3.30	7.4	13.2	20.6	29.9	40.5
60	0.90	3.62	8.2	14.5	22.6	32.6	44.3
70	0.98	3.91	8.8	15.7	24.4	35.3	47.9
80	1.05	4.19	9.4	16.8	26.1	37.6	51.2
90	1.11	4.43	10.0	17.7	27.8	40.1	54.5
100	1.17	4.67	10.4	18.7	29.2	42.2	57.3
120	1.23	5.17	11.5	20.4	31.8	46.0	62.4
140	1.28	5.70	12.4	22.1	34.4	49.8	67.6
160	1.32	6.30	13.3	23.6	36.9	53.3	72.3
180	1.36	6.92	14.1	25.0	39.0	56.4	76.5
200	1.38	7.52	14.9	26.4	41.1	59.5	81.6

Nozzle Pressure lbs/sq in	Gallons per Minute Discharge for a given Nozzle Diameter (Inches)						
	1/2	9/16	5/8	3/4	7/8	1	1-1/8
10	23.6	30.2	36.9	53.3	72.5	94.8	120
15	28.9	36.7	45.2	65.1	88.7	116	147
20	33.4	42.4	52.2	75.4	102	134	169
25	37.3	47.3	58.2	84.0	115	149	189
30	40.9	51.9	63.9	92.2	126	164	208
35	44.2	56.1	69.0	99.8	136	177	224
40	47.3	59.9	73.8	106	145	189	239
45	50.1	63.4	78.2	113	153	200	254
50	52.8	67.0	82.5	119	162	211	268
60	57.9	73.3	90.4	130	177	232	293
70	62.6	79.3	97.8	141	192	251	317
80	66.8	84.8	105	151	205	268	339
90	70.8	90.3	111	160	218	285	360
100	74.9	95.0	117	169	229	300	379
120	81.8	103	128	184	250	327	413
140	88.3	112	138	199	271	354	447
160	94.6	120	148	213	289	378	478
180	100	127	156	225	306	400	506
200	106	134	165	238	323	423	535

NOTE: The above discharge rates are theoretical. Actual values will only be 95% of the above values, depending on such factors as shape of the nozzle, bore smoothness, etc.

VERTICAL PIPE DISCHARGE



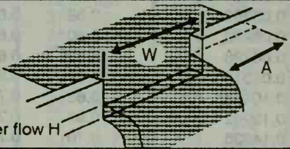
The following formula is an approximation of the output of a vertical pipe.

$$GPM = \sqrt{H} \times K \times D^2 \times 5.68$$

GPM = gallons per minute
H = height in inches
D = diameter of pipe in inches
K = constant from 0.87 to 0.97 for diameters of 2 to 6 inches and heights (H) up to 24 inches.

Example: 6 inch diameter with 10 inch height = ±626 gpm

WEIR DISCHARGE VOLUMES



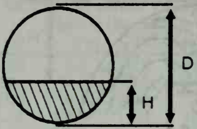
Head Inches	GPM for Width of Weir in Feet 1	3	5	gpm/foot over 5 feet wide
1	35	107	180	36
1.5	65	197	330	66
2	98	302	506	102
2.5	136	422	706	143
3	178	552	926	187
4	269	846	1424	288
5	370	1175	1985	405
6	477	1535	2600	528
7	...	1928	3260	668
8	...	2338	3956	814
9	...	2765	4699	970
10	...	3216	5490	1136
12	...	4185	7165	1495

Based on the Francis formula:

$$\text{Cu ft/sec water} = 3.33\,(W - 0.2\,H)\,H^{1.5}$$

(distance "A" should be at least 3 H)

HORIZONTAL CYLINDER FILLAGE



The following equation can be used to calculate the number of gallons remaining in a horizontal tank if the height of the liquid remaining in the tank and the diameter of the tank are known.

Gallons Remaining = Depth Factor × Total Tank Gallons

Use the formula $Ratio = \frac{H}{D}$ and then the following table in order to calculate the Depth Factor.

Ratio	Depth Factor	Ratio	Depth Factor
0.02	0.00480	0.52	0.52544
0.04	0.01348	0.54	0.55087
0.06	0.02451	0.56	0.57625
0.08	0.03750	0.58	0.60147
0.10	0.05202	0.60	0.62646
0.12	0.06798	0.62	0.65133
0.14	0.08511	0.64	0.67594
0.16	0.10323	0.66	0.70024
0.18	0.12242	0.68	0.72427
0.20	0.14235	0.70	0.74770
0.22	0.16308	0.72	0.77080
0.24	0.18447	740.	0.79350
0.26	0.20650	0.76	0.81533
0.28	0.22919	0.78	0.83692
0.30	0.25230	0.80	0.85765
0.32	0.27573	0.82	0.87758
0.34	0.29976	0.84	0.89677
0.36	0.32406	0.86	0.91489
0.38	0.34867	0.88	0.93202
0.40	0.37354	0.90	0.94797
0.42	0.39852	0.92	0.96250
0.44	0.42375	0.94	0.97550
0.46	0.44913	0.96	0.98652
0.48	0.46456	0.98	0.99520
0.50	0.50000		

STEAM TABLE

Gauge psi	Temp °F	Gauge psi	Temp °F	Gauge psi	Temp °F	Gauge psi	Temp °F
5	228	55	302	110	344	210	391
6	230	56	303	112	345	212	392
7	233	57	304	114	346	214	393
8	235	58	305	116	348	216	394
9	237	59	306	118	349	218	394
10	240	60	307	120	350	220	395
11	242	61	308	122	351	222	396
12	244	62	309	124	352	224	397
13	246	63	310	126	353	226	397
14	248	64	311	128	354	228	398
15	250	65	312	130	355	230	399
16	252	66	312	132	356	232	400
17	254	67	313	134	357	234	400
18	255	68	314	136	359	235	401
19	257	69	315	138	360	237	401
20	259	70	316	140	361	239	402
21	261	71	317	142	362	241	403
22	262	72	317	144	363	243	403
23	264	73	318	146	364	245	404
24	265	74	319	148	365	247	405
25	267	75	320	150	366	249	405
26	268	76	321	152	367	251	406
27	270	77	321	154	368	253	407
28	271	78	322	156	368	255	407
29	273	79	323	158	369	257	408
30	274	80	324	160	370	259	409
31	275	81	324	162	371	261	409
32	277	82	325	164	372	263	410
33	278	83	326	166	373	265	411
34	279	84	327	168	374	267	411
35	281	85	327	170	375	269	412
36	282	86	328	172	376	271	413
37	283	87	329	174	377	273	413
38	284	88	330	176	378	275	414
39	285	89	330	178	378	277	415
40	287	90	331	180	379	279	415
41	288	91	332	182	380	281	416
42	289	92	332	184	381	283	416
43	290	93	333	186	382	285	417
44	291	94	334	188	383	295	420
45	292	95	334	190	384	305	423
46	293	96	335	192	384	355	437
47	294	97	336	194	385	375	442
48	295	98	336	196	386	385	444
49	297	99	337	198	387	405	449
50	298	100	338	200	388	455	460
51	299	102	339	202	388	510	472
52	300	104	340	204	389	560	481
53	301	106	341	206	390	585	486
54	302	108	343	208	391		

WATER POLLUTION

Drinking water standards as adopted by the EPA, Safe Drinking Water Act, and US Public Health Service in 1946 and adopted by the American Water Works Association are summarized below:

Pollutant	Maximum Contaminant Level (MCL) mg/liter or ppm
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic	0.05
Barium	1.00
Cadmium	0.01
Chloride	250.0
Coliform bacteria	< 1/100 ml
Color (platinum–cobalt scale)	20 units
Copper	1.0
Carbon Chloroform Extract (CCE)	0.2
Chromium (hexavalent)	0.05
Cyanide	0.01
Endrin (organic)	0.0002
Fluoride	1.4 to 2.4
Iron (> 0.3 makes red water)	0.3
Lead	0.05
Lindane (organic)	0.004
Manganese (> 0.1 forms brown-black stain)	0.05
Mercury	0.002
Methoxychlor (organic)	0.1
Nitrate	45.0
Phenols	0.001
Selenium	0.01
Silver	0.05
Sulfate (SO_4)(> 500 has a laxative effect)	250.0
Total Dissolved Solids	500.0
Toxaphene (organic)	0.005
Trihalomethanes (organic)	0.1
Turbidity (silica scale)	10 ,1 to 5 TU
Zinc	5.0
2, 4 – D (organic)	0.1
2, 4, 5 – TP Silvex (organic)	0.01

RADIONUCLIDES:	
Gross Alpha particle activity	15 pCi/l
Beta particle and photon radioactivity	4 mrem
Radium–226 and Radium–228	5 pCi/l

Exposures over safe limits can result in a variety of serious health problems ranging from liver and kidney damage, high cancer risk, nervous system disorders, skin discoloration, hypertension, and a variety of others. For specific information, refer to the the 1974, 1977, and 1986 versions of the Safe Drinking Water Act.

See also the AIR Chapter for more on pollution, page 14.

WATER HARDNESS

Water hardness is a function of the amount of dissolved calcium salts, magnesium salts, iron and aluminum. The salts occur in a variety of forms but are typically calcium and magnesium bicarbonates (referred to as "temporary hardness") and sulphates and chlorides (referred to as "permanent hardness").

Although the most obvious effect of hard water is in preventing soap from lathering, most people cannot tolerate drinking water that exceeds 300 ppm carbonate, or 1500 ppm chloride, or 2000 ppm sulphate. As shown in the table to the left, >500 ppm sulphate can produce a laxative effect in the body. Livestock can usually tolerate much higher levels of hardness, but total dissolved solids >10,000 ppm will create problems.

The following formula is used to calculate total hardness:

Total Hardness in ppm Carbonate = (ppm Calcium x 2.497)
+ (ppm Magnesium x 4.115) + (ppm Iron x 1.792 +
+ (ppm Manganese x 1.822)

Hard water is treated by either a zeolite process (home water softeners) or a lime–soda ash process (large operations).

Hardness is also measured in "grains per gallon" and "degrees". Equivalents are as follows:

1 ppm = 0.058 grains/US gallon
1 ppm = 0.07 Clark degrees
1 ppm = 0.10 French degrees
1 ppm = 0.056 German degrees
1 French degree = 1 hydrotimetric degree
1 Clark degree = 1 grain / Imperial gallon as carbonate
1 French degree = 1 part / 100,000 calcium carbonate
1 German degree = 1 part / 100,000 calcium oxide
1 grain / US gallon = 17.1 ppm
1 grain / US gallon = 1.20 Clark degrees
1 grain / US gallon = 1.71 French degrees
1 grain / US gallon = 0.958 German degrees

WATER DATA & FORMULAS

1 gallon water = 231 cubic inches = 8.333 pounds
1 po
1 cubic foot water = 7.5 gallons = 62.5 pounds (salt water weighs approximately 64.3 pounds per cubic foot)
pounds per square inch at bottom of a column of water = height of column in feet x 0.434
1 miner's inch = 9 to 12 gallons per minute

Horsepower to Raise Water

$$\textit{Horsepower} = \frac{\textit{gallons per minute} \times \textit{Total Head in feet}}{3960}$$

(if pumping a liquid other than water, multiply the gallons per minute above by the liquids specific gravity)

Gallons Per Minute through a Pipe

$$\textit{GPM} = 0.0408 \times \textit{Pipe Diameter inches}^2 \times \textit{Feet / minute water velocity}$$

Weight of Water in a Pipe

$$\textit{Pounds Water} = \textit{Pipe Length feet} \times \textit{Pipe diameter inches}^2 \times 0.34$$

Gallons per Minute of a Slurry

$$\textit{GPM Slurry} = \textit{GPM Water} + \frac{4 \times \textit{Tons per hour of solids}}{\textit{Specific Gravity of Solids}}$$

Cost to Pump Water – Electric

$$\textit{\$ per hour} = \frac{\textit{gpm} \times \textit{Head in feet} \times 0.746 \times \textit{Rate per KWH}}{3960 \times \textit{Pump Efficiency} \times \textit{Electric Motor Efficiency}}$$

(70% Pump and 90% Motor Efficiency is a good average)

Cost to Pump Water – Gasoline and Diesel

$$\textit{\$ per hour} = \frac{\textit{GPM} \times \textit{Head in feet} \times K \times \textit{\$ per gallon fuel}}{3960 \times \textit{Pump Efficiency}}$$

K = 0.110 for gasoline or 0.065 for diesel
(K is actually gallons of fuel per horsepower)

(70% Pump Efficiency is a good average value)

POCKET REF

Weights of Materials

(See also GEOLOGY, page 197 for minerals)
(See also CARPENTRY, page 34 for woods)
(See also STEEL, page 333)

WEIGHTS OF MATERIALS

Material	Density	lbs per cu foot	Weights lbs per cu yard	kgs per cu meter	Angle of Repose
Acetic acid, 90%	1.06	66.3	1790	1062.0	
Alcohol, ethyl	0.01	0.789	21.3	12.6	
Alcohol, methyl	0.01	0.796	21.5	12.8	
Alfalfa, ground	0.26	16	432	256.3	+45
Alum, lumpy	0.88	55	1485	881.0	30-45
Alum, pulverized	0.75	47	1269	752.9	30-45
Alumina	0.96	60	1620	961.1	30-45
Aluminum, solid	2.64	165	4455	2643.1	
Aluminum oxide	1.52	95	2565	1521.8	30
Ammonia gas	0.00	0.048	1.29	0.8	
Ammonium sulfate	0.83	52	1404	833.0	
Andesite, solid	2.77	173	4671	2771.2	
Antimony, cast	6.70	418	11286	6695.7	
Apple wood, dry	0.71	44	1188	704.8	
Apples	0.64	40	1080	640.7	
Arsenic	5.67	354	9558	5670.5	
Asbestos, shredded	0.35	22	594	352.4	30
Asbestos, solid	2.45	153	4131	2450.8	
Ash wood, black, dry	0.54	34	918	544.6	
Ash wood, white, dry	0.67	42	1134	672.8	
Ashes	0.66	41	1107	656.8	
Aspen wood	0.42	26	702	416.5	
Asphalt, crushed	0.72	45	1215	720.8	30-45
Babbitt	7.28	454	12258	7272.4	
Bagasse	0.12	7.5	202	120.1	45
Bakelite, solid	1.36	85	2295	1361.6	
Baking powder	0.72	45	1215	720.8	30-45
Barium	3.78	236	6372	3780.4	
Bark, wood refuse	0.24	15	405	240.3	45
Barley	0.61	38	1026	608.7	
Barite, crushed	2.88	180	4860	2883.3	
Basalt, broken	1.96	122	3294	1954.3	
Basalt, solid	3.01	188	5076	3011.5	
Bauxite, crushed	1.28	80	2160	1281.5	30-45
Beans, castor	0.58	36	972	576.7	
Beans, cocoa	0.59	37	999	592.7	
Beans, navy	0.80	50	1350	800.9	
Beans,soy	0.72	45	1215	720.8	
Beeswax	0.96	60	1620	961.1	
Beets	0.72	45	1215	720.8	
Bentonite	0.59	37	999	592.7	45
Bicarbonate of Soda	0.69	43	1161	688.8	42
Birch wood, yellow	0.71	44	1188	704.8	
Bismuth	9.79	611	16497	9787.3	
Bones, pulverized	0.88	55	1485	881.0	
Borax, fine	0.85	53	1431	849.0	30-45
Bran	0.26	16	432	256.3	30-45
Brass, cast	8.56	534	14418	8553.9	
Brass, rolled	8.56	534	14418	8553.9	
Brewers grain	0.43	27	729	432.5	45
Brick, common red	1.92	120	3240	1922.2	
Brick, fire clay	2.40	150	4050	2402.8	
Brick, silica	2.05	128	3456	2050.4	
Brick, chrome	2.80	175	4725	2803.2	
Brick, magnesia	2.56	160	4320	2563.0	

WEIGHTS OF MATERIALS

Material	Density	lbs per cu foot	Weights lbs per cu yard	kgs per cu meter	Angle of Repose
Bronze	8.16	509	13743	8153.4	
Buckwheat	0.66	41	1107	656.8	
Butter	0.87	54	1458	865.0	
Cadmium	8.65	540	14580	8650.0	
Calcium carbide	1.20	75	2025	1201.4	30-45
Caliche	1.44	90	2430	1441.7	
Carbon, solid	2.15	134	3618	2146.5	
Carbon, powdered	0.08	5	135	80.1	
Carbon dioxide	0.00	0.1234	3.3318	2.0	
Carbon monoxide	0.00	0.0781	2.1087	1.3	
Cardboard	0.69	43	1161	688.8	
Cedar, red	0.38	24	648	384.4	
Cement, Portland	1.60	100	2700	1601.8	
Cement, Mortar	2.16	135	3645	2162.5	
Cement, slurry	1.44	90	2430	1441.7	
Chalk, solid	2.50	156	4212	2498.9	
Chalk, lumpy	1.44	90	2430	1441.7	45
Chalk, fine	1.12	70	1890	1121.3	45
Charcoal	0.21	13	351	208.2	
Cherry wood, dry	0.56	35	945	560.6	
Chestnut wood, dry	0.48	30	810	480.6	
Chloroform	1.52	95	2565	1521.8	
Chocolate, powder	0.64	40	1080	640.7	
Chromic acid, flake	1.20	75	2025	1201.4	25
Chromium	6.86	428	11556	6855.9	
Chromium ore	2.16	135	3645	2162.5	30-45
Cinders, Furnace	0.91	57	1539	913.1	
Cinders, Coal,ash	0.64	40	1080	640.7	25-40
Clay, Dry excavated	1.09	68	1836	1089.3	
Clay, Wet excavated	1.83	114	3078	1826.1	
Clay, Dry lump	1.07	67	1809	1073.2	25-45
Clay, fire	1.36	85	2295	1361.6	
Clay, Wet lump	1.60	100	2700	1601.8	
Clay, compacted	1.75	109	2943	1746.0	
Clover seed	0.77	48	1296	768.9	28
Coal, Anthracite,solid	1.51	94	2538	1505.7	
Coal, Anthracite,brkn	1.11	69	1863	1105.3	30-45
Coal, Bituminous,solid	1.35	84	2268	1345.6	
Coal, Bituminous,brkn	0.83	52	1404	833.0	30-45
Cobalt	8.75	546	14742	8746.1	
Coconut, meal	0.51	32	864	512.6	
Coconut, shredded	0.35	22	594	352.4	45
Coffee, fresh beans	0.56	35	945	560.6	35-45
Coffee, roast beans	0.43	27	729	432.5	
Coke	0.42	26	702	416.5	
Concrete, Asphaltic	2.24	140	3780	2242.6	
Concrete, Gravel	2.40	150	4050	2402.8	
Concrete, Limestone w/Portland	2.37	148	3996	2370.7	
Copper, cast	8.69	542	14634	8682.0	
Copper, rolled	8.91	556	15012	8906.3	
Copper sulphate, ground	0.00	0	0.0		
Copra, medium size	0.53	33	891	528.6	20
Copra, meal, ground	0.64	40	1080	640.7	39

WEIGHTS OF MATERIALS

Material	Density	lbs per cu foot	Weights lbs per cu yard	kgs per cu meter	Angle of Repose
Copra, expeller cake ground	0.51	32	864	512.6	30
Copra, expeller cake chopped	0.46	29	783	464.5	20
Cork, solid	0.24	15	405	240.3	
Cork, ground	0.16	10	270	160.2	45
Corn, on the cob	0.72	45	1215	720.8	
Corn, shelled	0.72	45	1215	720.8	
Corn, grits	0.67	42	1134	672.8	30-45
Cottonseed, dry, de-linted	0.56	35	945	560.6	30-45
Cottonseed, dry, not de-linted	0.32	20	540	320.4	45
Cottonseed, cake, lumpy	0.67	42	1134	672.8	30-45
Cottonseed, hulls	0.19	12	324	192.2	45
Cottonseed, meal	0.59	37	999	592.7	30-45
Cottonseed, meats	0.64	40	1080	640.7	30-45
Cottonwood	0.42	26	702	416.5	
Cryolite	1.60	100	2700	1601.8	30-45
Cullet	1.60	100	2700	1601.8	30-45
Culm	0.75	47	1269	752.9	
Cypress wood	0.51	32	864	512.6	
Dolomite, solid	2.90	181	4887	2899.3	
Dolomite, pulverized	0.74	46	1242	736.9	
Dolomite, lumpy	1.52	95	2565	1521.8	30-45
Earth, loam, dry, excavated	1.25	78	2106	1249.4	30-45
Earth, moist, excavated	1.44	90	2430	1441.7	30-45
Earth, wet, excavated	1.60	100	2700	1601.8	30-45
Earth, dense	2.00	125	3375	2002.3	30-45
Earth, soft loose mud	1.73	108	2916	1730.0	
Earth, packed	1.52	95	2565	1521.8	
Earth, Fullers, raw	0.67	42	1134	672.8	35
Ebony wood	0.96	60	1620	961.1	
Elm, dry	0.56	35	945	560.6	
Emery	4.01	250	6750	4004.6	
Ether	0.74	46	1242	736.9	
Feldspar, solid	2.56	160	4320	2563.0	
Feldspar, pulverized	1.23	77	2079	1233.4	45
Fertilizer, acid phosphate	0.96	60	1620	961.1	
Fir, Douglas	0.53	33	891	528.6	
Fish, scrap	0.72	45	1215	720.8	
Fish, meal	0.59	37	999	592.7	45
Flaxseed, whole	0.72	45	1215	720.8	
Flour, wheat	0.59	37	999	592.7	45
Fluorspar, solid	3.21	200	5400	3203.7	
Fluorspar, lumps	1.60	100	2700	1601.8	45
Fluorspar, pulverized	1.44	90	2430	1441.7	45
Garbage	0.48	30	810	480.6	
Glass, window	2.58	161	4347	2579.0	
Glue, animal, flaked	0.56	35	945	560.6	
Glue, vegetable,					

WEIGHTS OF MATERIALS

Material	Density	lbs per cu foot	Weights lbs per cu yard	kgs per cu meter	Angle of Repose
glue powdered	0.64	40	1080	640.7	
Gluten, meal	0.63	39	1053	624.7	30-45
Gneiss, bed in place	2.87	179	4833	2867.3	
Gneiss, broken	1.86	116	3132	1858.1	
Gold, pure 24 Kt	19.29	1204	32508	19286.3	
Granite, solid	2.69	168	4536	2691.1	
Granite, broken	1.65	103	2781	1649.9	
Graphite, flake	0.64	40	1080	640.7	30-45
Gravel, loose, dry	1.52	95	2565	1521.8	30-45
Gravel, w/ sand, natural	1.92	120	3240	1922.2	
Gravel, dry, 1/4 to 2 inch	1.68	105	2835	1681.9	
Gravel, wet, 1/4 to 2 inch	2.00	125	3375	2002.3	
Gypsum, solid	2.79	174	4698	2787.2	
Gypsum, broken	1.81	113	3051	1810.1	
Gypsum, crushed	1.60	100	2700	1601.8	
Gypsum, pulverized	1.12	70	1890	1121.3	45
Halite (salt), solid	2.32	145	3915	2322.7	
Halite (salt), broken	1.51	94	2538	1505.7	
Hay, pressed	0.38	24	648	384.4	
Hay, loose	0.08	5	135	80.1	
Hematite, solid	4.90	306	8262	4901.7	
Hematite, broken	3.22	201	5427	3219.7	
Hemlock, dry	0.40	25	675	400.5	
Hickory, dry	0.85	53	1431	849.0	
Hops, moist	0.56	35	945	560.6	45
Hydrochloric acid 40%	1.20	75	2025	1201.4	
Ice, solid	0.92	57.4	1549.8	919.5	
Ice, crushed	0.59	37	999	592.7	
Ilmenite	2.31	144	3888	2306.7	30-45
Iridium	22.16	1383	37341	22153.6	
Iron, cast	7.21	450	12150	7208.3	
Iron, wrought	7.77	485	13095	7769.0	
Iron oxide pigment	0.40	25	675	400.5	40
Ivory	1.84	115	3105	1842.1	
Kaolin, green crushed	1.03	64	1728	1025.2	35
Kaolin, pulverized	0.35	22	594	352.4	45
Lead, cast	11.35	708	19116	11341.1	
Lead, rolled	11.39	711	19197	11389.1	
Lead, red	3.69	230	6210	3684.3	
Lead, white pigment	4.09	255	6885	4084.7	
Leather	0.95	59	1593	945.1	
Lignite, dry	0.80	50	1350	800.9	30-45
Lignum Vitae, dry	1.28	80	2160	1281.5	
Lime, quick, lump	0.85	53	1431	849.0	
Lime, quick, fine	1.20	75	2025	1201.4	
Lime, stone, large	2.69	168	4536	2691.1	
Lime, stone, lump	1.54	96	2592	1537.8	
Lime, hydrated	0.48	30	810	480.6	30-45
Limonite, solid	3.80	237	6399	3796.4	
Limonite, broken	2.47	154	4158	2466.8	
Limestone, solid	2.61	163	4401	2611.0	
Limestone, broken	1.55	97	2619	1553.8	

Material	Density	lbs per cu foot	Weights lbs per cu yard	kgs per cu meter	Angle of Repose
Limestone, pulverized	1.39	87	2349	1393.6	45
Linseed, whole	0.75	47	1269	752.9	
Linseed, meal	0.51	32	864	512.6	30-45
Locust, dry	0.71	44	1188	704.8	
Magnesite, solid	3.01	188	5076	3011.5	
Magnesium, solid	1.75	109	2943	1746.0	
Magnesium sulfate, crystal	1.12	70	1890	1121.3	
Magnetite, solid	5.05	315	8505	5045.8	
Magnetite, broken	3.29	205	5535	3283.8	
Mahogany, Spanish, dry	0.85	53	1431	849.0	
Mahogany, Honduras, dry	0.54	34	918	544.6	
Malt	0.34	21	567	336.4	30-45
Manganese, solid	7.61	475	12825	7608.8	
Manganese oxide	1.92	120	3240	1922.2	
Manure	0.40	25	675	400.5	
Maple, dry	0.71	44	1188	704.8	
Marble, solid	2.56	160	4320	2563.0	
Marble, broken	1.57	98	2646	1569.8	30-45
Marl, wet, excavated	2.24	140	3780	2242.6	
Mercury @ 32oF	13.61	849	22923	13599.7	
Mica, solid	2.88	180	4860	2883.3	
Mica, broken	1.60	100	2700	1601.8	30-45
Milk, powdered	0.45	28	756	448.5	45
Molybdenum	10.19	636	17172	10187.8	
Mortar, wet	2.40	150	4050	2402.8	
Mud, packed	1.91	119	3213	1906.2	
Mud, fluid	1.73	108	2916	1730.0	
Nickel, rolled	8.67	541	14607	8666.0	
Nickel silver	8.45	527	14229	8441.7	
Nitric acid, 91%	1.51	94	2538	1505.7	
Nitrogen	0.00	0.0784	2.1168	1.3	
Oak, live, dry	0.95	59	1593	945.1	
Oak, red	0.71	44	1188	704.8	
Oats	0.43	27	729	432.5	32
Oats, rolled	0.30	19	513	304.4	30-45
Oil Cake	0.79	49	1323	784.9	
Oil, linseed	0.94	58.8	1587.6	941.9	
Oil, petroleum	0.88	55	1485	881.0	
Oxygen	0.00	0.0892	2.4084	1.4	
Oyster shells, ground	0.85	53	1431	849.0	30-45
Paper, standard	1.20	75	2025	1201.4	
Paraffin	0.72	45	1215	720.8	
Peanuts, shelled	0.64	40	1080	640.7	30-45
Peanuts, not shelled	0.27	17	459	272.3	30-45
Peat, dry	0.40	25	675	400.5	
Peat, moist	0.80	50	1350	800.9	
Peat, wet	1.12	70	1890	1121.3	
Pecan wood	0.75	47	1269	752.9	
Phosphate Rock, broken	1.76	110	2970	1762.0	
Phosphorus	2.34	146	3942	2338.7	
Pine, White, dry	0.42	26	702	416.5	

WEIGHTS OF MATERIALS

Material	Density	lbs per cu foot	Weights lbs per cu yard	kgs per cu meter	Angle of Repose
Pine, Yellow Northern, dry	0.54	34	918	544.6	
Pine, Yellow Southern, dry	0.72	45	1215	720.8	
Pitch	1.15	72	1935.9	1148.5	
Plaster	0.85	53	1431	849.0	
Platinum	21.51	1342	36234	21496.8	
Porcelain	2.40	150	4050	2402.8	
Porphyry, solid	2.55	159	4293	2546.9	
Porphyry, broken	1.65	103	2781	1649.9	
Potash	1.28	80	2160	1281.5	
Potassium chloride	2.00	125	3375	2002.3	30-45
Potatoes, white	0.77	48	1296	768.9	
Pumice stone	0.64	40	1080	640.7	
Quartz, solid	2.64	165	4455	2643.1	
Quartz, lump	1.55	97	2619	1553.8	
Quartz sand	1.20	75	2025	1201.4	
Redwood, Calif, dry	0.45	28	756	448.5	
Resin,synthetic,crshd	0.56	35	945	560.6	
Rice, hulled	0.75	47	1269	752.9	
Rice, rough	0.58	36	972	576.7	30-45
Rice grits	0.69	43	1161	688.8	30-45
Rip-rap	1.60	100	2700	1601.8	
Rosin	1.07	67	1809	1073.2	
Rubber, caoutchouc	0.95	59	1593	945.1	
Rubber, mfged	1.52	95	2565	1521.8	
Rubber, ground scrap	0.48	30	810	480.6	45
Rye	0.71	44	1188	704.8	
Salt cake	1.44	90	2430	1441.7	30-45
Salt, coarse	0.80	50	1350	800.9	30-45
Salt, fine	1.20	75	2025	1201.4	30-45
Saltpeter	1.20	75	2025	1201.4	30-45
Sand, wet	1.92	120	3240	1922.2	45
Sand, dry	1.60	100	2700	1601.8	34
Sand, loose	1.44	90	2430	1441.7	30-45
Sand, rammed	1.68	105	2835	1681.9	
Sand, water filled	1.92	120	3240	1922.2	15-30
Sandstone, solid	2.32	145	3915	2322.7	
Sandstone, broken	1.51	94	2538	1505.7	
Sand, dry, loose	1.60	100	2700	1601.8	
Sand, damp	1.92	120	3240	1922.2	
Sand, wet	2.08	130	3510	2082.4	
Sand, wet packed	2.08	130	3510	2082.4	
Sand and Gravel, dry	1.73	108	2916	1730.0	
Sand and Gravel, wet	2.00	125	3375	2002.3	
Sawdust	0.27	17	459	272.3	
Sewage, sludge	0.72	45	1215	720.8	
Shale, solid	2.68	167	4509	2675.1	
Shale, broken	1.59	99	2673	1585.8	30-45
Silver	10.46	653	17631	10460.1	
Slag, solid	2.12	132	3564	2114.4	
Slag, broken	1.76	110	2970	1762.0	
Slag, crushed /4 inch	1.19	74	1998	1185.4	
Slag, furn. granulated	0.96	60	1620	961.1	
Slate, solid	2.69	168	4536	2691.1	

WEIGHTS OF MATERIALS

Material	Density	Weights lbs per cu foot	Weights lbs per cu yard	kgs per cu meter	Angle of Repose
Slate, broken	1.67	104	2808	1665.9	
Slate, pulverized	1.36	85	2295	1361.6	30-45
Snow, freshly fallen	0.16	10	270	160.2	
Snow, compacted	0.48	30	810	480.6	
Soap, solid	0.80	50	1350	800.9	
Soap, chips	0.16	10	270	160.2	30-45
Soap, flakes	0.16	10	270	160.2	30-45
Soap, powder	0.37	23	621	368.4	30-45
Soda Ash, heavy	0.96	60	1620	961.1	30-45
Soda Ash, light	0.43	27	729	432.5	30-45
Sodium	0.98	61	1647	977.1	
Sodium Aluminate ground	1.15	72	1944	1153.3	
Sodium Nitrate,grnd	1.20	75	2025	1201.4	
Soybeans, whole	0.75	47	1269	752.9	
Spruce, Calif, dry	0.45	28	756	448.5	
Starch, powdered	0.56	35	945	560.6	
Steel, cast	7.85	490	13230	7849.1	
Steel, rolled	7.93	495	13365	7929.2	
Stone, crushed	1.60	100	2700	1601.8	
Sugar, brown	0.72	45	1215	720.8	
Sugar, powdered	0.80	50	1350	800.9	
Sugar, granulated	0.85	53	1431	849.0	30-45
Sugar, raw cane	0.96	60	1620	961.1	45
Sugarbeet pulp, dry	0.21	13	351	208.2	
Sugarbeet pulp, wet	0.56	35	945	560.6	
Sugarcane	0.27	17	459	272.3	45
Sulfur, solid	2.00	125	3375	2002.3	
Sulfur, lump	1.31	82	2214	1313.5	30-45
Sulfur, pulverized	0.96	60	1620	961.1	30-45
Sulfuric acid, 87%	1.79	112	3024	1794.1	
Sycamore, dry	0.59	37	999	592.7	
Taconite	2.80	175	4725	2803.2	
Talc, solid	2.69	168	4536	2691.1	
Talc, broken	1.75	109	2943	1746.0	
Tanbark, ground	0.88	55	1485	881.0	
Tankage	0.96	60	1620	961.1	
Tar	1.15	72	1935.9	1148.5	
Tin, cast	7.36	459	12393	7352.5	
Tobacco	0.32	20	540	320.4	45
Trap rock, solid	2.88	180	4860	2883.3	
Trap rock, broken	1.75	109	2943	1746.0	
Tungsten	19.62	1224	33048	19606.6	
Turf	0.40	25	675	400.5	
Turpentine	0.87	54	1458	865.0	
Vanadium	5.50	343	9261	5494.3	
Walnut, black, dry	0.61	38	1026	608.7	
Water, pure	1.00	62.4	1684.8	999.6	
Water, sea	1.03	64.08	1730.16	1026.5	
Wheat	0.77	48	1296	768.9	28
Wheat, cracked	0.67	42	1134	672.8	30-45
Willow wood	0.42	26	702	416.5	
Wool	1.31	82	2214	1313.5	
Zinc, cast	7.05	440	11880	7048.1	
Zinc oxide	0.40	25	675	400.5	45

POCKET REF

Welding

ARC ELECTRODES - MILD STEEL

Electrode #	Description
⇓	This digit indicates the following:
Exx1z	All positions of welding
Exx2z	Flat and horizontal positions
Exx3z	Flat welding positions only
⇓⇓	These digits indicate the following:
Exx10	DC, reverse polarity
Exx11	AC or DC, reverse polarity
Exx12	DC, straight polarity or AC
Exx13	AC or DC, straight polarity
Exx14	DC, either polarity or AC, iron powder
Exx15	DC, reverse polarity, low hydrogen
Exx16	AC or DC, reverse polarity, low hydrogen
Exx18	AC or DC, reverse, iron powder, low hydrogen
Exx20	DC, straight polarity, or AC for horizontal fillet welds; and DC either polarity, or AC, for flat position welding
Exx24	DC, either polarity, or AC, iron powder
Exx27	DC, straight polarity, or AC for horizontal fillet welding; and DC, either polarity, or AC, for flat position welding, iron powder
Exx28	AC or DC, reverse polarity, iron powder, low hydrogen

The "xx" shown above is a two digit number indicating the weld metal tensile strength in 1000psi increments. For example, E7018 is 70,000 psi weld metal.

ELECTRODE AMPERAGES

Type	1/16	5/64	3/32	1/8	5/32
	Amperage Per Rod Diameter (inches)				
E6010			60-90	80-120	110-160
E6011			50-90	80-130	120-180
E6012			40-90	80-120	120-190
E6013	20-40	25-60	30-80	80-120	120-190
E7010-A1			30-80	70-120	100-160
E7014			80-110	110-150	140-190
E7016			75-105	100-150	140-190
E7018 (& -A1)			70-120	100-150	120-200
E7020-A1					
E7024			90-120	120-150	180-230
E7028					175-250
E8016-B2			60-100	80-120	140-190
E8018-C3			70-120	100-150	120-200
Stainless:					
3xx AC-DC	20-40	30-60	60-90	90-120	120-160
4xx AC-DC	20-40	30-60	60-90	90-120	120-160
5xx AC-DC	20-40	30-60	60-90	90-120	120-160

Type	3/16	7/32	1/4	5/16	3/8
	Amperage Per Rod Diameter (inches)				
E6010	150-200	175-250	225-300		
E6011	140-220	170-250	225-325		
E6012	140-240	180-315	225-350		
E6013	140-240	225-300	250-350		
E6020	175-250	225-325	250-350	325-450	450-600
E6027	225-300	275-375	350-450		
E7010-A1	130-200				
E7014	180-260	250-325	300-400	400-500	
E7016	190-250	250-300	300-375		
E7018	200-275	275-350			
E7020-A1	250-350				
E7024	250-300	300-350	350-400	400-500	
E7028	175-250	250-325	300-400		
E8016-B2	180-250	300-425			
E8018-C3	200-275				
Stainless:					
3xx AC-DC	150-190	225-300			
4xx AC-DC	150-190				
5xx AC-DC	150-190		225-300		

Note: All of the above ratings are estimates and you should always verify amperages with the manufacturer before you start a job.

ELECTRODES - LOW ALLOY STEEL

Low Alloy Steel Specifications (American Welding Society Specification A 5.5-69) are coded the same as the Mild Steel Specification of two pages ago, except that the specification number is followed by a dash and then a letter-number code indicating the chemical composition of the weld metal.

For example, **E8016–C1**

The composition codes are as follows:

–A ....Carbon-molybdenum steel
–B ....Chromium-molybdenum steel
–C ....Nickel steel
–D ....Manganese-molybdenum steel
–G ....All other Low Alloy Steel Electrodes, with
.... minimums of 0.2% molybdenum, 0.3%
.... chromium, 1% manganese, 0.8% silicon,
.... 0.5% nickel, and 0.1% vanadium.
–M ....Military specification

The final digit of the composition code specifies the exact composition of the weld metal.

ELECTRODES - STAINLESS STEEL

Stainless electrode specifications (AWS A5.4-62T) are coded with the American Iron and Steel Institute alloy type number followed by a dash and two digit number (either 15 or 16) indicating usability or a set of letters (AC, DC, AC–DC or ELC AC–DC) indicating the type of current to be used.

For example, **E308–15**

or **308 ELC AC–DC**

ELECTRODE BRAND CONVERSION

Make	E6010	E6011	E6012
Airco	6010	6011,C,LOC	6012,C
Air Products	6010IP	6011,C	6012GP,SF,IP
Arc Products	SW610,AP100	SW14,IMP	SW612,PFA
Gen. Dynamics	610,IP	611,A	612,A
Hobart Bros.	10,IP	335A	12,212A,12A
Lincoln (Fleetweld)	5,5P	35,180,35LS	7
McKay Co	6010,IP	6011,IP	6012
Murex Weld Prod	Speedex 610	Type A,611C	Type N13
Reid Avery (Raco)	6010	6011,IP	6012,IP
Westinghouse	XL610,A	ACP611	FP612,2-612

Make	E6013	E6020	E6027
Airco	6013,C	6020	Easyarc 6027
Air Products	6013GP,SF	6020	6027IP
Arc Products	SW16		DH27
Gen. Dynamics	613,A	620	IP627
Hobart Bros.	13A,447A,413		27
Lincoln (Fleetweld)	37,57		Jetweld 2
McKay Co	6013	6020	
Murex Weld Prod	Type U,U13	Type D,FHP	Speedex 27
Reid Avery Co	6013		
Westinghouse	SW613,2M-613	DH620	ZIP 27

Make	E7014	E7016	E7018
Airco	Easyarc 7014	7016,M	7018MR,C
Air Products	7014IP	7016,A	7018,IP
Arc Products	SW15IP	70LA-2	170LA,SW47
Gen. Dynamics	IP714	716,A	IP718,A
Hobart Bros.	14A	16	LH718
Lincoln (Fleetweld)	47		Jetweld-LH70
McKay Co	7014	Puralloy 70AC	7018
Murex Weld Prod	Speedex U	Type HTS,18,180	HTS,M,718
Reid Avery Co	7014	7016	7018
Westinghouse	ZIP 14	LOH-2-716	WIZ-18

Make	E7024	E7028
Airco	Easyarc 7024	Easyarc 7028
Air Products	7024IP	7028
Arc Products	SW44	DH170
Gen. Dynamics	IP724	IP728
Hobart Bros.	24	
Lincoln	Jetweld 3,1	Jetweld HL3800
McKay Co	7024	
Murex Weld Prod	Speedex 24	Speedex 28
Reid Avery Co		
Westinghouse	ZIP 24	WIZ 28

GAS WELDING RODS

Rod Diameter	Rods per Pound (36 inch long) Steel	Brass	Aluminum	Cast Iron
1/16	31	29	91	NA
3/32	14	13	41	NA
1/8	8	7	23	NA
5/32	5	NA	NA	NA
3/16	3-1/2	3	9	5-1/2
1/4	2	2	6	2-1/4
5/16	1-1/3	NA	NA	1/2
3/8	1	1	NA	1/4

WELDING GASES

Gas	Tank Sizes Cubic Ft	Comments
Acetylene	300 100 75 40 10	Formula – C_2H_2, explosive Colorless, flammable gas, garlic-like odor, explosion danger if used in welding with gage pressures over 15 psig (30 psig absolute).
Oxygen	244, 122, 80, 40, 20 4500 liquid	Formula – O_2, non-explosive Colorless, odorless, tasteless. Supports combustion in welding.
Nitrogen	225, 113 80, 40, 20	Formula – N_2, non-explosive Colorless, odorless, tasteless, inert.
Argon	330, 131 4754 liquid	Formula – Ar, non-explosive Colorless, odorless, tasteless, inert.
Carbon Dioxide	50 lbs 20 lbs	Formula – CO_2, non-explosive Toxic in large quantities Colorless, odorless, tasteless, inert.
Hydrogen	191	Formula – H_2, explosive Colorless, odorless, tasteless Lightest gas known.
Helium	221	Formula – He, non-explosive Colorless, odorless, tasteless, inert.

HARD & SOFT SOLDER ALLOYS

Metal to be Soldered	Alloy Component Percentage: Tin	Lead	Zinc	Copper	Other
SOFT SOLDER:					
Aluminum	70		25		Al = 3, Pho = 2
Bismuth	33	33			Bi = 34
Block tin	99	1			
Brass	66	34			
Copper	60	40			
Gold	67	33			
Gun metal	63	37			
Iron & Steel	50	50			
Lead	33	67			
Pewter	25	25			Bi = 50
Silver	67	33			
Steel, galvanized	58	42			
Steel, tinned	64	36			
Zinc	55	45			
HARD SOLDER:					
Brass, soft			78	22	
Brass, hard			55	45	
Copper			50	50	
Iron, cast			45	55	
Iron & Steel			36	64	
Gold				22	Ag = 11, Au = 67
Silver			10	20	Ag = 70

FLUX:	**Metal to be used on:**
Ammonia Chloride	Galvanized iron, iron, nickel, tin, zinc, brass, copper, gun metal
Borax	For hard solders, brass, copper, gold, iron & steel, silver
Cuprous oxide	Cast iron
Hydrochloric Acid	Galvanized iron and steel, tin, zinc
Organic	Lead, pewter
Resin	Brass, bronze, cadmium, copper, lead, silver, gun metal, tinned steel
Stainless Steel Flux	Special for stainless steel only
Sterling	Silver
Tallow	Lead, pewter
Zinc Chloride	Bismuth, tin, brass, copper, gold, silver, gun metal, tinned steel

TEMPERING COLOR FOR STEEL

Heated Color of Carbon Steel	Temperature °F	Temper Item or Comment
Faint yellow	420	Knives, hammers
Very pale yellow	430	Reamers
Light yellow	440	Lathe tools, scrapers, milling cutters, reamers
Pale straw–yellow	450	Twist drills for hard use
Straw–yellow	460	Dies, punches, bits, reamers
Deep straw–yellow	470	
Dark yellow	480	Twist drills, large taps
	485	Knurls
Yellow–brown	490	
Brown–yellow	500	Axes, wood chisels, drifts, taps 1/2 inch or over, nut taps, thread dies
Spotted red–brown	510	
Brown–purple	520	Taps 1/4 inch and under
Light purple	530	
Full purple	540	Cold chisels, center punches
Dark purple	550	
Full blue	560	Screwdrivers, springs, gears
Dark blue	570	
Medium blue	600	Scrapers, spokeshaves
Light blue	640	
Red-visible at night	750	
Red-visible at twilight	885	
Red-visible in daylight	975	
Red-visible in sunlight	1075	
Dark red	1290	
Dull cherry red	1475	
Cherry red	1650	
Bright cherry red	1830	
Orange–red	2010	
Orange–yellow	2190	
Yellow–white	2370	
White	2550	
Brilliant white	2730	
Blue–white	2900	
Acetylene flame	4080	
Induction furnace	5450	
Electric arc light	7200	

Tempering is commonly a two step process. Step 1: To harden the tool, heat the tool end to a bright red, quench tool end in cold water until it is cool to the touch, then sharpen or polish tool end. At this point the tool has been hardened but it is now brittle. Step 2: To temper the tool, heat the tool to the temperature indicated by its color in the above table, then quench the tool in water. The amount of temper is a function of what type of work the tool will be doing, so if your tool is not listed above, simply select one of the above tools that does similar work.

Conversion Tables

NOTE: Conversions listed in these tables are not exact. Refer to sources such as *Handbook of Chemistry and Physics* and *C.R.C Standard Math Tables* by The Chemical Rubber Publishing Co, *Scientific Tables* by Ciba-Geigy Ltd, *Websters Desk Encyclopedia* by Grisewood & Dempsey, *Field Geologists Manual* by The Australian Institute of Mining & Metallurgy, *Conversion Factors* by Forney's Inc, *Conversions* by Cahn Instruments, and *Technical Reference Handbook* by E.P Rasis for more detailed conversions and specifications.

TIPS ON CONVERSION FACTORS

The tables that follow contain some of the most commonly used conversion factors. If you can not locate the conversion you need (such as "Feet" to "Inches"), try looking up the reverse conversion ("Inches" to "Feet") and if it exists, divide that number into 1 to get your conversion. In order to save space, only one direction of conversion is listed in some cases.

ABBREVIATIONS USED IN CONVERSION TABLES

abs .... absolute
apoth .. apothecary
atm .... atmosphere
avdp ... avoirdupois
Brit .... British
Btu .... British thermal unit
Cal .... calorie
cgs .... centimeter-gram-second
chem .. chemical
cm .... centimeter
cu ..... cubic
db ..... decibel
^{o}C ..... Degrees centigrade
^{o}F ..... Degrees Fahrenheit
^{o}K ..... Degrees Kelvin
^{o}R ..... Degrees Reaumur
EM .... electromagnetic
Engl ... English
ES ..... electrostatic
flu ..... fluid
ft ...... feet
Germ .. German
gm .... gram
hr ..... hour
Int ..... International
IST .... Intl. Steam Table
kg ..... kilogram
lbs .... pounds
liq ..... liquid
ln ..... logarithm (natural)
log .... logarithm (common)
mech .. mechanical
min .... minute
mm .... millimeter
Naut ... nautical
oz ..... ounces
petro ... petroleum
sec .... second
sq ..... square
US .... United States

Convert From	Into	Multiply By
Abamperes	Amperes	10
	Faradays/sec (chem)	1.03638×10^{-4}
	Statamperes	2.99793×10^{10}
Abcoulombs	Ampere–hours	0.00278
	Coulombs	10
	Electronic charges	6.24196×10^{19}
	Faradays (chem)	1.03638×10^{-4}
	Statcoulombs	2.99793×10^{10}
Abfarads	Farads	1×10^{9}
	Microfarads	1×10^{15}
	Statfarads	8.98758×10^{20}
Abhenries	Henries	1×10^{-9}
Abmhos	Megamhos	1000
	Mhos	1×10^{9}
	Statmhos	8.98758×10^{20}
Abohms	Megohms	1×10^{-15}
	Microhms	0.001
	Ohms	1×10^{-9}
Abohm–cm	Ohm–cm	1×10^{-9}
Abvolts	Microvolts	0.01
	Millivolts	1×10^{-5}
	Volts	1×10^{-8}
Abvolts/cm	Volts/cm	1×10^{-8}
	Volts/inch	2.54×10^{-8}
Acres	Hectare or sq hectometer	0.4047
	Sq chains (Gunters)	10
	Sq cm	4.04686×10^{7}
	Sq feet	43560
	Sq feet (US Survey)	43559.83
	Sq inches	6.27264×10^{6}
	Sq kilometers	4.04686×10^{-3}
	Sq Gunter links	1×10^{5}
	Sq meters	4046.86
	Sq miles (statute)	1.5625×10^{-3}
	Sq perches	160
	Sq rods	160
	Sq yards	4840
Acre–feet	Cu feet	43560
	Cu meters	1233.482
	Cu yards	1613.33
	Gallons (US)	3.259×10^{5}
Acre–inches	Cu feet	3630
	Cu meters	102.79033
	Cu yards	134.44975
	Gallons (US)	27154.286
Almude, Portugal	Liters	16.7
Almude, Spain	Liters	4.625
Amma (Ancient Greece)	Orguias	10
	Stadion	0.01
Amma (Ancient Rome)	Digiti	4
Amperes	Abamperes	0.1
	Amperes (Int)	1.00016
	Coulombs/sec	1
	Faradays/sec (Chem)	1.03638×10^{-5}
	Statamperes	2.99793×10^{9}

Convert From	Into	Multiply By
Amperes (Int)	Amperes	0.99984
Ampere–hours	Abcoulombs	360
	Coulombs	3600
	Faradays (Chem)	0.3731
Amperes/sq cm	Amps/sq inch	6.452
	Amps/sq meter	10^4
Amperes/sq inch	Amps/sq cm	0.1550
	Amps/sq meter	1550.0
Amperes/sq meter	Amps/sq cm	10^{-4}
	Amps/sq inch	6.452×10^{-4}
Ampere–turns	Gilberts	1.25664
Angstrom units	Centimeters	1×10^{-8}
	Inches	3.9370×10^{-9}
	Meters	1×10^{-10}
	Microns	0.0001
	Millimicrons	0.1
Anker, Latvia	Liters	38.256
Anoman, Cylon	Bushels, US	5.83
Archin, Turkey	Meters	1
Ares	Acres	0.024711
	Sq dekameters	1
	Sq feet	1076.39
	Sq meters	100
	Sq miles	3.86102×10^{-5}
	Sq yards	119.60
Arpent (French)	Acre (see next line too) ...	$\approx$0.85
Arpent (French)	Meters (see above line) ...	$\approx$58.6
Arroba, Spain	Liters of wine	16.14
Artaba, Iran	Liters	66
Astronomical Unit	Kilometers	1.459×10^8
Atmospheres	Bars	1.01325
	Cm of Hg @ 0^0C	76
	Cm of H^2O @ 4^0C	1033.26
	Dynes/sq cm	1.01325×10^6
	Ft of H^2O @ 39.2^0F	33.8995
	Grams/sq cm	1033.23
	In of Hg @ 32^0F	29.9213
	Kg/sq cm	1.0332
	Kg/sq meter	10332
	Mm of Hg @ 0^0C	760
	Pounds/sq inch	14.6960
	Tons (short)/sq inch	0.00735
	Tons (short)/sq foot	1.05811
	Torrs	760
Aune, France	Meters	1.188
Baht, Thailand	Grams	15
Barile, Rome	Liters	58.34
Barns	Sq cm	1×10^{-24}
Barrels (Brit)	Bags (Brit)	1.5
	Barrels (US dry)	1.41540
	Barrels (US liq)	1.37251
	Bushels (Brit)	4.5
	Bushels (US)	4.64425
	Cu feet	5.77957
	Cu meters	0.16366

Convert From	Into	Multiply By
Barrels (Brit)	Gallons (Brit)	36
	Liters	163.6546
Barrels (US oil)	Cu feet	5.61458
	Gallons (US)	42
	Liters	158.9828
Barrels (US dry)	Barrels (US liq)	0.969696
	Bushels (US)	3.28122
	Cu feet	4.08333
	Cu inches	7056
	Cu meters	0.11563
	Quarts (US dry)	105
Barrels (US liq)	Barrels (US dry)	1.0312
	Barrels (wine)	1
	Cu feet	4.2104
	Cu inches	7276.5
	Cu meters	0.11924
	Gallons (Brit)	26.22925
	Gallons (US liq)	31.5
	Liters	119.2371
Bars	Atmospheres	0.98692
	Baryes	1×10^6
	Cm of Hg @ 0^0C	75.0062
	Dynes/sq cm	1×10^6
	Ft of H2O @ 60^0F	33.4883
	Grams/sq cm	1019.72
	In of Hg @ 32^0F	29.530
	Kg/sq cm	1.01972
	Millibars	1000
	Pounds/sq foot	2089.0
	Pounds/sq inch	14.5038
Baryl	Atmospheres	9.8692×10^{-7}
	Bars	1×10^{-6}
	Dynes/sq cm	1
	Grams/sq cm	0.00102
	Millibars	0.001
Baryl	Dyne/sq cm	1.000
Bath (Old Testament)	Liters	22
Bekah (Old Testament)	Grams	appx 5
	Shekel	0.5
Bels	Decibels	10
Biot	Amperes	0.10
Bit	Byte (computers)	1/8
Board feet	Cu cm	2359.74
	Cu feet	0.8333
	Cu inches	144
Bolts of cloth	Ells	32
	Linear feet	120
	Meters	36.576
Bougie decimales	Candles (Int)	1.0
Btu	Btu (Int Steam Tab)	0.99935
	Btu (mean)	0.99856
	Btu @ 60^0F	0.99969
	Cal, gm	251.996
	Cal, gm (Int Steam Tab)	251.831
	Cal, gm (mean)	251.634

Convert From	Into	Multiply By
Btu	Cal, gm @ 20^0C	252.122
	Ergs	1.0543×10^{10}
	Foot-poundals	25020.1
	Foot-pounds	777.649
	Gram-cm	1.0751×10^7
	Hp-hours	0.00039
	Joules	1054.35
	Joules (Int)	1054.18
	Kg-calories	0.2520
	Kg-meters	107.514
	Kw-hours	0.00029287
	Kw-hours (Int)	0.00029283
	Liter-atm	10.4053
	Therm	0.00001
	Watt-seconds	1054.35
	Watt-seconds (Int)	1054.18
Btu (IST)	Btu	1.00065
Btu (Mean)	Btu	1.00144
Btu @ 60^0F	Btu	1.00031
Btu/hr	Calorie-kg/hr	0.252
	Ergs/sec	2.92875×10^5
	Foot-pounds/hr	777.649
	Gram-cal/sec	0.0700
	Horsepower-hours	0.00039
	Kilowatts	0.00029
	Watts	0.29287
Btu/min	Foot-pounds/sec	12.96
	Horsepower	0.02356
	Kilowatts	0.01757
	Watts	17.5725
Btu/lb	Cal, gm/gram	0.55555
	Foot-pounds/lb	777.649
	Joules/gram	2.3244
Btu/sq ft/min	Watts/sq inch	0.1221
Buckets (Brit)	Cu cm	18184.35
	Gallons (Brit)	4
Bushels (Brit)	Bags (Brit)	0.3333
	Bushels (US)	1.03206
	Cu cm	36368.7
	Cu feet	1.28435
	Cu inches	2219.35
	Gallons (Brit)	8
	Liters	36.3677
Bushels (US)	Barrels (US dry)	0.30476
	Bushels (Brit)	0.96894
	Cu cm	35239.07
	Cu feet	1.24446
	Cu inches	2150.42
	Cu meters	0.03524
	Cu yards	0.04609
	Gallons (US dry)	8
	Gallons (US liq)	9.30918
	Liters	35.23808
	Ounces (US fluid)	1191.57
	Pecks (US)	4

Convert From	Into	Multiply By
Bushels (US)	Pints (US dry)	64
	Quarts (US dry)	32
	Quarts (US liq)	37.23671
Butts (Brit)	Bushels (US)	13.53503
	Cu feet	16.84375
	Cu meters	0.47696
	Gallons (US)	126
Byte	Bit (computers)	8
Cable (English)	Degrees latitude	1/600th
	Meter	185.37
Cable lengths	Fathoms	120
	Feet	720
	Meters	219.456
Calories, gm	Btu	0.003968
	Btu (IST)	0.003966
	Btu (mean)	0.00396
	Btu @ 60^{0}F	0.00397
	Cal, gm (IST)	0.99935
	Cal, gm (mean)	0.99856
	Cal, gm @ 20^{0}C	1.00050
	Cu cm–atm	41.2929
	Cu ft–atm	0.00146
	Ergs	4.184×10^7
	Foot–poundals	99.2878
	Foot–pounds	3.08596
	Gram–cm	42664.9
	Hp–hours	1.558×10^{-6}
	Joules	4.184
	Joules (Int)	4.1833
	Kg–meters	0.42665
	Kw–hours	1.162×10^{-6}
	Liter–atm	0.04129
	Watt–hours	0.00116
	Watt–hours (Int)	0.001162
	Watt–seconds	4.184
Cal, gm (mean)	Btu	0.00397
	Cal, gm	1.00144
Cal, gm @ 20^{0}C	Btu	0.00397
	Cal, gm	0.99949
Calories, kg	Btu	3.96832
	Btu (IST)	3.96573
	Btu (mean)	3.96262
	Btu @ 60^{0}F	3.96709
	Cal, gm	1000
	Cal, kg (mean)	0.99856
	Cal, kg @ 20^{0}C	1.0005
	Cu cm–atm	41292.9
	Ergs	4.184×10^{10}
	Foot–poundals	99287
	Foot–pounds	3085.96
	Gram–cm	4.266×10^7
	Hp–hours	0.00156
	Joules	4184
	Kw–hours	0.00116
	Liter–atm	41.292

Convert From	Into	Multiply By
Calories, kg	Watt–hours	1.1622
Cal, kg (mean)	Btu	3.974
	Cal, gm	1001.4
Cal, gm/gm	Btu/lb	1.8
	Foot–pounds/lb	1399.8
	Joules/gram	4.184
Cal, gm/hr	Btu/hr	0.00397
	Ergs/sec	11622
	Watts	0.00116
Cal, kg/hr	Watts	1.1622
Cal, gm/min	Btu/min	0.00397
	Ergs/sec	697333
	Watts	0.0697
Cal, kg/min	Watts	69.733
Cal, gm/sec	Btu/sec	0.00397
	Foot–pounds/sec	3.086
	Horsepower	0.0056
	Watts	4.184
Cal, gm–sec	Planck's constant	6.315×10^{33}
Candles (Engl)	Candles (Int)	1.04
Candles (Germ)	Candles (Int)	1.05
Candles (Int)	Candles (Engl)	0.96
	Candles (Germ)	0.95
	Candles (pentane)	1.00
	Carcel units	0.104
	Hefner units	1.11
	Lumens/steradian	1
Candles/sq cm	Candles/sq in	6.452
	Candles/sq meter	10000
	Foot–lamberts	2918
	Lamberts	3.1416
Candles/sq in	Candles/sq cm	0.155
	Candles/sq ft	144
	Foot–lamberts	452.39
	Lamberts	0.4869
Candle power	Lumens	12.566
Cape foot (S. Africa)	Meter	0.315
Cape rood (S. Africa)	Meter	3.788
Carats (gold)	Milligrams/gram	41.666
Carats	Grains	3.0865
	Grams	0.2
	Milligrams	200
Carcel units	Candles (Int)	9.61
Centals	Kilograms	45.359
	Pounds	100
Centares	Ares	0.01
	Sq feet	10.764
	Sq inches	1550
	Sq meters	1
	Sq yards	1.19599
Centigrams	Grains	0.15432
	Grams	0.01
Centiliters	Cu cm	10.00028
	Cu inches	0.61025
	Drams	2.705

Convert From	Into	Multiply By
Centiliters	Liters	0.01
	Ounces (US fluid)	0.33815
Centimeters	Angstrom units	1×10^{8}
	Feet	0.03281
	Hands	0.0984
	Inches	0.3937
	Kilometers	10^{-5}
	Links (Gunter's)	0.0497
	Links (Ramden's)	0.0328
	Meters	0.01
	Microns	10000
	Miles (Naut)	5.3996×10^{-6}
	Miles (statute)	6.2137×10^{-6}
	Millimeters	10
	Millimicrons	1×10^{7}
	Mils	393.7
	Picas (printers)	2.371
	Points (printers)	28.4528
	Rods	0.00199
	Yards	0.01094
Cm–dynes	Cm–grams	1.02×10^{-3}
	Meter–kgs	1.02×10^{-8}
	Pound–feet	7.376×10^{-8}
Cm–grams	Cm–dynes	980.7
	meter–kgs	10^{-5}
	Pound–feet	7.23×10^{-5}
Cm of Hg 0^{0}C	Atmospheres	0.01316
	Bars	0.01333
	Dynes/sq cm	13332
	Ft of H_2O @ 4^{0}C	0.446
	In Hg @ 0^{0}C	0.3937
	Kg/sq meter	135.95
	Lbs/sq ft	27.845
	Lbs/sq in	0.1934
	Torrs	10
Cm of H_2O 4^{0}C	Atmospheres	0.00097
	Lbs/sq in	0.1422
Cm/sec	Feet/min	1.9685
	Feet/sec	0.0328
	Km/hr	0.036
	Km/min	0.0006
	Knots	0.0194
	Meters/min	0.6
	Miles/hr	0.02237
	Miles/min	0.000373
Cm/sec/sec	Ft/sec/sec	0.0328
	Km/hr/sec	0.036
	Meters/sec/sec	0.01
	Miles/hr/sec	0.0224
Cm/year	Inches/year	0.3937
Centipoises	Gms/cm/sec	0.01
	Poises	0.01
	Lbs/ft/hr	2.4191
	Lbs/ft/sec	0.00067
Chains (Gunter)	Centimeters	2011.7

Convert From	Into	Multiply By
Chains (Gunter)	Chains (Ramden)	0.66
	Feet	66
	Feet (US Survey)	65.99
	Furlongs	0.1
	Inches	792
	Links (Gunter)	100
	Links (Ramden)	66
	Meters	20.117
	Miles	0.0125
	Rods	4
	Yards	22
Chains (Ramden)	Chains (Gunter)	1.5151
	Feet	100
Chaldron, dry (English)	Bushels	36
Cheval vapeur	Horsepower	1.0139
Circles	Degrees	360
	Grades	400
	Minutes	21600
	Radians	6.2832
	Signs	12
Circular inches	Circular mm	645.16
	Sq cm	5.067
	Sq inches	0.7854
Circular mm	Sq cm	0.00785
	Sq inches	0.00122
	Sq mm	0.7854
Circular mils	Circular inches	1×10^{-6}
	Sq cm	5.06707
	Sq inches	7.85398×10^{-7}
	Sq mm	0.000507
	Sq mills	0.7854
Circumference	Degrees	360
	Radians	6.28318
Cords	Cord feet	8
	Cu feet	128
	Cu meters	3.6246
Cord–feet	Cords	0.125
	Cu feet	16
Coulombs	Abcoulombs	0.1
	Ampere–hours	0.000278
	Ampere–seconds	1
	Coulombs (Int)	1.00016
	Faradays (Chem)	1.0364×10^{-5}
	Faradays (Phys)	1.0361×10^{-5}
	Mks elec chg unit	1
	Statcoulombs	2.9979×10^{9}
Coulombs/sq cm	Coulombs/sq in	64.52
	Coulombs/sq meter	10000
Coulombs/sq in	Coulombs/sq cm	0.1550
	Coulombs/sq meter	1550
Coulombs/sq meter	Coulombs/sq cm	10^{-4}
	Coulombs/sq inch	6.452×10^{-4}
Cu centimeters	Board feet	0.00042
	Bushels (Brit)	2.7496×10^{-5}
	Bushels (US)	2.8378×10^{-5}

Convert From	Into	Multiply By
Cu centimeters	Cu feet	3.5315×10^{-5}
	Cu inches	0.06102
	Cu meters	1×10^{-6}
	Cu yards	1.308×10^{-6}
	Drachms	0.28156
	Drams (US fluid)	0.27051
	Gallons (Brit)	0.00022
	Gallons (US dry)	0.00023
	Gallons (US liq)	0.00026
	Gills (Brit)	0.00704
	Gills (US)	0.00845
	Liters	0.00099
	Ounces (Brit liq)	0.03519
	Ounces (US liq)	0.03381
	Pints (US dry)	0.00182
	Pints (US liq)	0.00211
	Quarts (Brit)	0.00088
	Quarts (US dry)	0.00091
	Quarts (US liq)	0.00106
Cu cm/gram	Cu ft/lb	0.01602
Cu cm/sec	Cu ft/min	0.00212
	Gallons (US)/min	0.01585
	Gallons (US)/sec	0.00026
Cu cm–atm	Btu	9.61×10^{-5}
	Cal, gm	0.02422
	Joules	0.10132
	Watt–hours	2.81×10^{-5}
Cu decimeters	Cu cm	1000
	Cu feet	0.03532
	Cu inches	61.0237
	Cu meters	0.001
	Cu yards	0.00131
	Liters	0.99997
Cu dekameters	Cu decimeters	1×10^{6}
	Cu feet	35314.7
	Cu inches	6.102×10^{7}
	Cu meters	1000
	Liters	999972
Cu feet	Acre–feet	2.296×10^{-5}
	Board–feet	12
	Bushels (Brit)	0.7786
	Bushels (US)	0.8036
	Cords of wood	0.00781
	Cord–feet	0.0625
	Cu centimeters	28316.8
	Cu inches	1728.0
	Cu meters	0.02832
	Cu yards	0.03704
	Gallons (US dry)	6.42851
	Gallons (US liq)	7.48052
	Liters	28.316
	Ounces (Brit fluid)	996.614
	Ounces (US fluid)	957.506
	Pints (US dry)	51.4281
	Pints (US liq)	59.8442

Convert From	Into	Multiply By
Cu feet	Quarts (US dry)	25.714
	Quarts (US liq)	29.922
Cu ft H_2O 60^0F	Lbs of H_2O	63.367
Cu ft/hr	Acre–feet/hr	2.2957×10^{-5}
	Cu cm/sec	7.8658
	Cu ft/hr	60
	Gallons (US)/hr	7.4805
	Liters/hr	28.316
Cu ft/min	Acre–feet/hr	0.00138
	Acre–feet/min	2.2956×10^{-5}
	Cu cm/sec	471.95
	Cu ft/hr	60
	Gallons (US)/min	7.48052
	Gallons (US)/sec	0.1247
	Liters/sec	0.47193
	Pounds of H_2O/min	62.43
Cu ft/pound	Cu cm/gram	62.428
	Mm/gram	62.4262
Cu ft/sec	Acre–inches/hr	0.99173
	Cu cm/sec	28316.8
	Cu yards/min	2.2222
	Gallons (US)/min	448.83
	Liters/min	1698.96
	Liters/sec	28.316
	Million gallons/day	0.64632
Cu ft H_2O/sec	Lbs H_2O/min	3741.98
Cu ft–atm	Btu	2.7213
	Cal, gm	685.76
	Foot–pounds	2116.2
	Hp–hours	0.00107
	Kg–meters	292.58
	Kw–hours	0.000797
Cubic inches	Barrels (Brit)	0.0001
	Barrels (US dry)	0.0001417
	Board feet	0.00694
	Bushels (Brit)	0.00045
	Bushels (US)	0.00046
	Cu cm	16.3871
	Cu feet	0.000579
	Cu meters	1.639×10^{-5}
	Cu yards	2.143×10^{-5}
	Drams (US fluid)	4.43290
	Gallons (Brit)	0.00360
	Gallons (US dry)	0.00372
	Gallons (US liq)	0.00433
	Liters	0.01639
	Milliliters	16.3866
	Ounces (Brit fluid)	0.57674
	Ounces (US fluid)	0.55411
	Pecks	0.00186
	Pints (US dry)	0.02976
	Pints (US liq)	0.03463
	Quarts (US dry)	0.01488
	Quarts (US liq)	0.01732
Cu in H_2O 60^0F	Lbs of H_2O	0.03609

Convert From	Into	Multiply By
Cu meters	Acre–feet	0.00081
	Barrels (Brit)	6.11026
	Barrels (US dry)	8.64849
	Barrels (US liq)	8.38641
	Bushels (Brit)	27.4962
	Bushels (US)	28.3776
	Cu cm	1×10^6
	Cu feet	35.3147
	Cu inches	61023.7
	Cu yards	1.30795
	Gallons (Brit)	219.969
	Gallons (US liq)	264.172
	Hogshead	4.1932
	Liters	999.97
	Pints (US liq)	2113.38
	Quarts (US liq)	1056.69
	Steres	1
Cu meters/min	Gallons (Brit)/min	219.969
	Gallons (US)/min	264.172
	Liters/min	999.97
Cu mm	Cu cm	0.001
	Cu inches	6.102×10^{-5}
	Cu meters	1×10^{-9}
	Minims (Brit)	0.01689
	Minims (US)	0.01623
Cu yards	Bushels (Brit)	21.0223
	Bushels (US)	21.6962
	Cu cm	764554.9
	Cu feet	27
	Cu inches	46.656
	Cu meters	0.76455
	Gallons (Brit)	168.179
	Gallons (US dry)	173.569
	Gallons (US liq)	201.974
	Liters	764.533
	Prospecting dishes	112
	Quarts (Brit)	672.715
	Quarts (US dry)	694.279
	Quarts (US liq)	807.896
Cu yards/min	Cu ft/sec	0.45
	Gallons (US)/sec	3.3662
	Liters/sec	12.742
Cubits	Centimeters	45.72 to 55.9
	Feet	1.5
	Inches	18 to 22

Cubit is the distance from the elbow to the finger tip:

Cubit (Bible)	Inches	21.8
Cubit (Egypt 2650BC)	Inches	20.6
Cubit (Babylon 1500BC)	Inches	20.9
Cubit (Assyrian 700 BC)	Inches	21.6
Cubit (Jerusalem (1 AD)	Inches	20.6
Cubit (Druid Eng 1AD)	Inches	20.4
Cubit (Black, Arabia, 800 AD)	Inches	21.3
Cubit (Mexico–Aztec)	Inches	20.7
Cubit (Ancient China)	Inches	20.9

Convert From	Into	Multiply By
Cubit (Ancient Greece)	Inches	18.2
Cubit (England)	Inches	18.0
Cubit (Northern 3000BC to 1800AD)	Inches	26.6
Cup	Gallons	0.0625
	Gills	2
	Pint	0.5
	Milliliters	284.13
	Ounces, fluid	8
	Quarts	0.25
	Tablespoons	16
	Teaspoons	48
Cup, metric	Milliliters	250.0
Cup, tea	Pint	0.25
	Milliliters	142.06
Daltons (Chem)	Grams	1.66×10^{-24}
Daltons (Phys)	Grams	1.659×10^{-24}
Day– mean solar	Day (sidereal)	1.0027379
	Hours (mean solar)	24
	Hours (sidereal)	24.06571
	Years (calendar)	0.0027397
	Years (sidereal)	0.002738
	Years (tropical)	0.002738
Days (sidereal)	Days (mean solar)	0.9972696
	Hours (mean solar)	23.93447
	Hours (sidereal)	24
	Min (mean solar)	1436.068
	Min (sidereal)	1440
	Second (sidereal)	86400
	Years (calendar)	0.002732
	Years (sidereal)	0.00273
	Years (tropical)	0.00273
Decibels	Bels	0.1
Decigrams	Grams	0.1
Deciliters	Liters	0.1
Decimeters	Centimeters	10
	Feet	0.32808
	Inches	3.937
	Meters	0.1
Decisteres	Cu meters	0.1
Degrees	Circles	0.00278
	Minutes	60
	Quadrants	0.01111
	Radians	0.01745
	Seconds	3600
Degrees/cm	Radians/cm	0.01745
Degrees/foot	Radians/cm	0.00056
Degrees/inch	Radians/cm	0.00687
Degrees/min	Degrees/sec	0.01667
	Radians/sec	0.00029
	Revolutions/sec	4.6296×10^{-5}
Degrees/sec	Radians/sec	0.01745
	Revolutions/min	0.16666
	Revolutions/sec	0.00278
Dekagrams	Grams	10.0
Dekaliters	Liters	10.0

Convert From	Into	Multiply By
Dekaliters	Pecks	1.1351
	Pints (US dry)	18.162
Dekameters	Centimeters	1000
	Feet	32.8084
	Inches	393.7008
	Kilometers	0.01
	Meters	10
	Yards	10.9361
Demals	Gm–equiv/cu decim.	1
Digit (Ancient Greece)	Centimeters	1.84
	Inches	0.72
	Orguia	0.01
Digitus (Ancient Rome)	Centimeters	1.84
	Inches	0.73
	Palmus	0.25
Drachms	Cu centimeter	3.55163
	Cu inches	0.21673
	Drams	0.96076
	Grams	4.2923
	Milliliters	3.55153
	Scruples	3
Drachm, fluid	Cubic inches	0.21673
	Minims	60
	Milliliters	3.55163
Drams (troy)	Drams (avdp)	2.19429
	Grains	60
	Grams	3887.93
	Ounces (troy)	0.125
Drams (avdp)	Drams (troy)	0.455729
	Grains	27.3437
	Grams	1.771845
	Ounces (troy)	0.056966
	Ounces (avdp)	0.0625
	Pennyweights	1.13932
	Pounds (troy)	0.004747
	Pounds (avdp)	0.00391
	Scruples (apoth)	1.36719
Drams (US fluid)	Cu cm	3.6967
	Cu inches	0.225586
	Drachms	1.04084
	Gills (US)	0.03125
	Millimeters	3.69659
	Minims	60
	Ounces (US fluid)	0.125
	Pints (US liq)	0.00781
Dynes	Grains	0.015737
	Grams	0.0010197
	Joules/cm	10^{-7}
	Joules/meter (newtons)	10^{-5}
	Kilograms	1.02×10^{-6}
	Newtons	0.00001
	Poundals	7.233×10^{-5}
	Pounds	2.248×10^{-6}
Dynes/cm	Ergs/sq cm	1
	Ergs/sq mm	0.01

Convert From	Into	Multiply By
Dynes/cm	Grams/cm	0.0010197
	Poundals/inch	0.0001837
Dynes/cu cm	Grams/cu cm	0.0010197
	Poundals/cu inch	0.001185
Dynes/sq cm	Atmospheres	9.869×10^{-7}
	Bars	1×10^{-6}
	Baryes	1
	Cm of Hg @ 0°C	
	Cm of H20 @ 4°C	0.00101975
	Grams/sq cm	0.00101972
	In of Hg @ 32°F	2.953×10^{-5}
	In of H2O @ 4°C	0.000401
	Kg/sq meter	0.010197
	Poundals/sq in	0.0004666
	Pounds/sq in	1.450×10^{-5}
Dyne–Cm	Ergs	1
	Foot–poundals	2.373×10^{-6}
	Foot–pounds	7.376×10^{-5}
	Gram–cm	0.00102
	inch–pounds	8.8507×10^{-7}
	Kg–meters	1.0197×10^{-8}
	Newton–neters	1×10^{-7}
Electron Volts	Ergs	1.6021×10^{-12}
	kcal/mole	1.602×10^{-12}
Electronic charges	Abcoulombs	1.6021×10^{-20}
	Coulombs	1.6021×10^{-19}
	Statcoulombs	4.803×10^{-10}
Ells (cloth)	Cm	114.3
	Inches	45
Em, Pica	Inch	0.167
	Cm	0.4233
Ephah	Liters	22
	Omers	10
Ergs	Btu	9.4845×10^{-11}
	Gram calorie	2.3901×10^{-8}
	Kg calorie	2.3901×10^{-11}
	Cu cm–atmospheres	9.8692×10^{-7}
	Cu ft–atmospheres	3.4853×10^{-11}
	Cu ft–lbs/sq in	5.122×10^{-10}
	Dyne–cm	1
	Electron Volts	6.242×10^{11}
	Foot–poundals	2.374×10^{-6}
	Foot–pounds	7.376×10^{-8}
	Gram–calories	0.239×10^{-7}
	Gram–cm	0.0010197
	Horsepower–hours	3.725×10^{-14}
	Joules	1×10^{-7}
	Joules (Int)	0.998×10^{-7}
	Kw–hours	2.778×10^{-14}
	Kg–calories	2.389×10^{-11}
	Kg–meters	1.0197×10^{-8}
	Liter–atmospheres	9.869×10^{-10}
	Watt–hours	0.278×10^{-10}
	Watt–sec	1×10^{-7}
Ergs/sec	Btu/min	5.691×10^{-9}

Convert From	Into	Multiply By
Ergs/sec	Gram calorie/min	1.434×10^{-6}
	Dyne–cm/sec	1
	Foot–pounds/min	4.425×10^{-6}
	Foot–pounds/sec	7.376×10^{-8}
	Gram–cm/sec	0.0010197
	Horsepower	1.341×10^{-10}
	Joules/sec	1×10^{-7}
	Kg–calories/minute	1.43×10^{-9}
	Kilowatts	1×10^{-10}
	Watts	1×10^{-7}
Ergs/sq cm	Dynes/cm	1
	Ergs/sq mm	0.01
Ergs/sq mm	Dynes/cm	100
	Ergs/sq cm	100
Erg–sec	Planck's constant	1.5093×10^{26}
Faraday	Ampere–hours	26.8
	Coloumbs	9.649×10^{4}
Faraday/sec	Ampere (absolute)	9.65×10^{4}
Farads	Abfarads	1×10^{-9}
	Farads (Int)	1.00049
	Microfarads	1×10^{6}
	Statfarads	8.98758×10^{11}
Farads (Int)	Farads	0.9995
Fathoms	Centimeters	182.88
	Feet	6
	Furlongs	0.1
	Inches	72
	Meters	1.8288
	Miles (naut,Int)	0.00098747
	Miles (statute)	0.0011363
	Yards	2
Feet	Centimeters	30.48
	Chains (Gunter's)	0.015151
	Fathoms	0.16666
	Feet (US Survey)	0.999998
	Furlongs	0.001515
	Inches	12
	Kilometers	3.048×10^{-4}
	Meters	0.2048
	Microns	304800
	Miles (naut,Int)	0.000165
	Miles (statute)	0.000189
	Millimeters	304.8
	Mils	1.2×10^{4}
	Rods	0.060606
	Ropes (Brit)	0.05
	Yards	0.333333
Feet (US Survey)	Centimeters	30.48006
	Chains (Gunter's)	0.015152
	Chains (Ramden's)	0.01000002
	Feet	1.000002
	Inches	12.000024
	Links (Gunter's)	1.515155
	Links (Ramden's)	1.000002
	Meters	0.304801

Convert From	Into	Multiply By
Feet (US Survey)	Miles (statute)	0.00018939
	Rods	0.06060618
	Yards	0.333334
Feet (Athens History)	Inches	12.44
Feet (Aegina History)	Inches	12.36
Feet (Miletus History)	Inches	12.52
Feet (Olympia History)	Inches	12.64
Feet (Etruria History)	Inches	12.44
Feet (Rome History)	Inches	11.66
Feet (North History)	Inches	13.19
Feet (England History)	Inches	13.19
Feet (France History)	Inches	12.79
Feet (Moscos History)	Inches	13.17
Feet of Air @ 60°F	Atmospheres	3.608×10^{-5}
	Ft of Hg @ 32°F	0.0009
	Ft of H2O @ 60°F	0.00122
	In of Hg @ 32°F	0.00108
	Pounds/sq in	0.00053
Feet of Hg @ 32°F	Cm of Hg @ 0°C	30.48
	Ft of H2O @ 60°F	13.608
	In of H2O @ 60°F	163.30
	Ounces/sq in	94.302
	Pounds/sq in	5.8938
Feet of H2O @ 4°C	Atmospheres	0.0295
	Cm of Hg @ 0°C	2.2419
	Dynes/sq cm	29889.8
	Grams/sq cm	30.479
	In of Hg @ 32°F	0.8826
	Kg/sq meter	304.79
	Pounds/sq foot	62.43
	Pounds/sq inch	0.43351
Feet/hour	Cm/hr	30.48
	Cm/minute	0.508
	Cm/second	0.00846
	Feet/minute	0.01666
	Inches/hour	12
	Kilometers/hr	0.0003
	Kilometers/min	5.08×10^{-6}
	Knots (Int)	0.00016458
	Miles/hr	0.0001894
	Miles/min	3.15656×10^{-6}
	Miles/sec	5.2609×10^{-8}
Feet/minute	Cm/sec	0.508
	Feet/sec	0.01666
	Kilometers/hr	0.018288
	Meters/min	0.3048
	Meters/sec	0.00508
	Miles/hr	0.011363
Feet/second	Cm/sec	30.48
	Kilometers/hr	1.09728
	Kilometers/min	0.01829
	Knots	0.5921
	Meters/min	18.288
	Miles/hr	0.681818
	Miles/min	0.011364

Convert From	Into	Multiply By
Feet/(sec x sec)	Cm/(sec x sec)	30.48
	Km/(hr x sec)	1.0973
	Meters/(sec x sec)	0.3048
	Miles/(hr x sec)	0.681818
Feet/100 feet	Percent grade	1
Fifth	Jiggers	38.4
	Ounces, fluid	25.6
	Pints	1.6
	Pony	76.9
	Quart	0.80
	Shots	25.6
Firkins (Brit)	Bushels (Brit)	1.125
	Cu cm	40914.8
	Cu feet	1.44489
	Firkins (US)	1.2009
	Gallons (Brit)	9
	Liters	40.91364
	Pints (Brit)	72
Firkins (US)	Barrels (US dry)	0.294643
	Barrels (US liq)	0.285715
	Bushels (US)	0.966788
	Cu feet	1.203125
	Firkins (Brit)	0.832675
	Gallons (US liq)	9
	Liters	34.0677
	Pints (US liq)	72
Flask of mercury	Kilograms	34.5
Foot–candles	Lumens/sq ft	1
	Lumens/sq meter	10.7639
	Lux	10.7639
	Milliphots	1.07639
Foot–lamberts	Candles/sq cm	0.00034
	Candles/sq ft	0.31831
	Millilamberts	1.07639
	Lamberts	0.0010764
	Lumens/sq ft	1
Foot–poundals	Btu	3.9968×10^{-5}
	Btu (IST)	3.9942×10^{-5}
	Btu (mean)	3.991×10^{-5}
	Cal, gram	0.010072
	Cal, gram (IST)	0.010065
	Cal, gram (mean)	0.010057
	Cu cm–atmospheres	0.41589
	Cu ft–atmospheres	1.4687×10^{-5}
	Dyne–cm	4.21401×10^{5}
	Ergs	4.21401×10^{5}
	Foot–pounds	0.03108
	Hp–hours	1.5697×10^{-8}
	Joules	0.0421401
	Joules (Int)	0.042133
	Kg–meters	0.004297
	Kw–hours	1.1706×10^{-8}
	Liter–atmospheres	0.0004159
Foot–pounds	Btu	0.001286
	Btu (IST)	0.001285

Convert From	Into	Multiply By
Foot-pounds	Btu (mean)	0.00128
	Cal, gram	0.32405
	Cal, gram (IST)	0.32384
	Cal, gram (mean)	0.32358
	Cal, gram @ 20°C	0.32421
	Cal, kg	0.00032
	Cu ft-atmospheres	0.00047
	Dyne-cm	1.3558×10^7
	Ergs	1.3558×10^7
	Foot-poundals	32.174
	Gram-calories	0.3238
	Gram-cm	13825.5
	Hp-hours	5.05×10^{-7}
	Joules	1.3558
	Kg-calories	3.24×10^{-4}
	Kg-meters	0.13825
	Kw-hours	3.766×10^{-7}
	Kw-hours (Int)	3.766×10^{-7}
	Liter-atmospheres	0.01338
	Newton-meters	1.35582
	Watt-hours	0.000377
Foot-pounds/hr	Btu/min	2.1432×10^{-5}
	Btu (mean)/min	2.1401×10^{-5}
	Cal, gram/min	0.0054
	Cal, gram (mean)/min	0.00539
	Ergs/min	2.2597×10^5
	Foot-pounds/min	0.01666
	Horsepower	5.0505×10^{-7}
	Horsepower (metric)	5.1205×10^{-7}
	Kilowatts	3.7662×10^{-7}
	Watts	0.0003766
	Watts (Int)	0.0003765
Foot-pounds/min	Btu/minute	1.286×10^{-3}
	Btu/sec	2.1432×10^{-5}
	Btu (mean)/sec	2.1401×10^{-5}
	Cal, gm/sec	0.00540
	Cal, gm(mean)/sec	0.00539
	Ergs/sec	2.2597×10^5
	Foot-pounds/sec	0.0166
	Horsepower	3.0303×10^{-5}
	Horsepower (metric)	3.0723×10^{-5}
	Joules/sec	0.0226
	Joules (Int)/sec	0.02259
	Kilogram-calories/min	3.24×10^{-4}
	Kilowatts	2.2597×10^{-5}
	Watts	0.022597
Foot-pounds/lb	Btu/lb	0.001286
	Btu (IST)/lb	0.001286
	Btu (mean)/lb	0.001284
	Cal, gm/gm	0.000714
	Cal, gm (IST)/gm	0.0007139
	Cal, gm (mean)/gm	0.0007134
	Hp-hr/lb	5.0505×10^{-7}
	Joules/gram	0.002989
	Kg-meters/gram	0.0003

Convert From	Into	Multiply By
Foot-pounds/lb	Kw-hr/gram	8.303×10^{-10}
Foot-pounds/sec	Btu/hour	4.6263
	Btu/min	0.077156
	Btu (mean)/min	0.07704
	Btu/sec	0.00129
	Btu (mean)/sec	0.00128
	Cal, gm/sec	0.32405
	Cal, gm (mean)/sec	0.32358
	Ergs/sec	1.3558×10^{7}
	Gram-cm/sec	13825.5
	Horsepower	0.001818
	Joules/sec	1.3558
	Kg-calories/min	0.01945
	Kilowatts	0.001356
	Watts	1.3558
	Watts (Int)	1.3556
Furlongs	Centimeters	20116
	Chains (Gunter's)	10
	Chains (Ramden's)	6.6
	Feet	660
	Inches	7920
	Meters	201.17
	Miles (naut,Int)	0.1086
	Miles (statute)	0.125
	Rods	40
	Yards	220
Gallons (Brit)	Barrels (Brit)	0.0277
	Bushels (Brit)	0.125
	Cu centimeters	4546.09
	Cu feet	0.1605
	Cu inches	277.419
	Drachms (Brit flu)	1280
	Firkins (Brit)	0.1111
	Gallons (US liq)	1.2009
	Gills (Brit)	32
	Liters	4.546
	Minims (Brit)	76800
	Ounces (Brit flu)	160
	Ounces (US flu)	153.721
	Pecks (Brit)	0.5
	Lbs of H_2O @ 62^oF	10
Gallons (US dry)	Barrels (US dry)	0.038096
	Barrels (US liq)	0.03694
	Bushels (US)	0.125
	Cu centimeters	4404.88
	Cu feet	0.15556
	Cu inches	268.8
	Gallons (US liq)	1.163647
	Liters	4.4048
Gallons (US liq)	Acre-feet	3.0688×10^{-6}
	Barrels (US liq)	0.031746
	Barrels (US petro)	0.023809
	Bushels (US)	0.10742
	Cu centimeters	3785.41
	Cu feet	0.13368

Convert From	Into	Multiply By
Gallons (US liq)	Cu inches	231
	Cu meters	0.00378
	Cu yards	0.00495
	Gallons (Brit)	0.83267
	Gallons (US dry)	0.85937
	Gallons (wine)	1
	Gills (US)	32
	Liters	3.7853
	Minims (US)	61440
	Ounces (US flu)	128
	Pints (US liq)	8
	Quarts (US liq)	4
Gallons(US)H_2O @4°C	Lb of H_2O	8.34517
Gallons(US)H_2O@60°F	Lb of H_2O	8.33717
Gallons (US)/day	Cu feet/hr	0.00557
Gallons (Brit)/hour	Cu meters/min	7.5768×10^{-5}
Gallons (US)/hour	Acre–feet/hr	3.0689×10^{-6}
	Cu feet/hr	0.13368
	Cu meters/min	6.309×10^{-5}
	Cu yards/min	8.2519×10^{-5}
	Liters/hr	3.7853
Gallons (US)/min	Liters/sec	0.06308
	Cu feet/sec	2.228×10^{-3}
	Cu feet/hour	8.0208
Gallons (Brit)/sec	Cu cm/sec	4546.09
Gallons (US)/sec	Cu cm/sec	3785.4
	Cu feet/min	8.0208
	Cu yards/min	0.29707
	Liters/min	227.118
Gammas	Grams	1×10^{-6}
	Micrograms	1
Gausses	Gausses (Int)	0.9997
	Maxwells/sq cm	1
	Lines/sq cm	1
	Lines/sq inch	6.4516
	Webers/sq cm	10^{-8}
	Webers/sq inch	6.452×10^{-8}
	Webers/sq meter	10^{-4}
Gausses (Int)	Gausses	1.00033
Geepounds	Slugs	1
	Kilograms	14.594
Gerah (Old Testament)	Bekahs	0.1
	Grams	appx 0.5
	Shekels	0.05
Gigameters	Meters	1×10^{9}
Gilberts	Abampere–turns	0.07958
	Ampere–turns	0.79577
	Gilberts (Int)	1.00016
Gilberts (Int)	Gilberts	0.99983
Gilberts/cm	Ampere–turns/cm	0.79577
	Ampere–turns/in	2.02127
	Ampere–turns/meter	79.58
	Oersteds	1
Gilberts/maxwell	Ampere–turns/weber	7.958×10^{7}
Gills (Brit)	Cu centimeters	142.06

Convert From	Into	Multiply By
Gills (Brit)	Gallons (Brit)	0.0312
	Gills (US)	1.2009
	Liters	0.142
	Ounces (Brit flu)	5
	Ounces (US flu)	4.8038
	Pints (Brit)	0.25
Gills (US)	Cu centimeters	118.29
	Cu inches	7.2187
	Drams (US flu)	32
	Gallons (US liq)	0.0312
	Gills (Brit)	0.8327
	Liters	0.1183
	Minims (US)	1920
	Ounces (US flu)	4
	Pints (US liq)	0.25
	Quarts (US liq)	0.125
Grades	Circles	0.0025
	Circumferences	0.0025
	Degrees	0.9
	Minutes	54
	Radians	0.01571
	Revolutions	0.0025
	Seconds	3240
Grains	Carats (metric)	0.32399
	Drams (troy)	0.01667
	Drams (avdp)	0.03657
	Dynes	63.546
	Grams	0.0648
	Milligrams	64.7989
	Ounces (troy)	0.00208
	Ounces (avdp)	0.00229
	Pennyweights	0.04167
	Pounds (troy)	0.00017
	Pounds (avdp)	0.00014
	Scruples (apoth)	0.05
	Tons (metric)	6.4799×10^{-8}
Grains/cu ft	Grams/cu meter	2.2883
Grains/gal (US)	Parts/million (1gm/ml)	17.118
	Pounds/million gal	142.86
Grains/gal (Brit)	Parts/million	14.286
Grams	Carats (metric)	5
	Decigrams	10
	Dekagrams	0.1
	Drams (troy)	0.2572
	Drams (avdp)	0.5644
	Dynes	980.66
	Grains	15.432
	Joules/cm	9.807×10^{-5}
	Joules/meter (newtons)	9.807×10^{-3}
	Kilograms	0.001
	Micrograms	1×10^{6}
	Milligrams	1000
	Myriagrams	0.0001
	Ounces (troy)	0.03215
	Ounces (avdp)	0.03527

Convert From	Into	Multiply By
Grams	Pennyweights	0.64301
	Poundals	0.07093
	Pounds (troy)	0.00268
	Pounds (avdp)	0.0022
	Scruples (apoth)	0.77162
	Tons (metric)	1×10^{-6}
Grams/cm	Dynes/cm	980.66
	Grams/inch	2.54
	Kg/km	100
	Kg/meter	0.1
	Poundals/inch	0.18017
	Pounds/ft	0.067197
	Pounds/inch	0.0056
	Tons (metric)/km	0.1
Grams/(cm x sec)	Poises	1
	Lb/(ft x sec)	0.0672
Grams/cu cm	Dynes/cu cm	980.66
	Grains/milliliter	15.4328
	Grams/milliliter	1.000028
	Poundals/cu inch	1.16236
	Pounds/cu foot	62.428
	Pounds/cu inch	0.0361
	Pounds/gal (Brit)	10.022
	Pounds/gal (US dry)	9.7111
	Pounds/gal (US liq)	8.3454
Grams/cu meter	Grains/cu ft	0.437
Grams/liter	Grains/gallon	58.417
	Parts/million (1gm/ml)	1000
	Lbs/cu foot	0.0624
	Lbs/gal (US)	8.3452
Grams/milliliter	Grams/cu cm	0.99997
	Pounds/cu foot	62.426
	Pounds/gallon (US)	8.34517
Grams/sq cm	Atmospheres	0.00097
	Bars	0.00098
	Cm of Hg @ 0°C	0.07356
	Dynes/sq cm	980.66
	In of Hg @ 32oF	0.02896
	Kg/sq meter	10
	Mm of Hg @ 0oC	0.73556
	Poundals/sq inch	0.45762
	Pounds/sq inch	0.01422
	Pounds/sq foot	2.0481
Grams/ton (long)	Milligrams/kg	0.9842
Grams/ton (short)	Milligrams/kg	1.1023
Gram–calories	Btu	3.968×10^{-3}
	Ergs	4.1868×10^{7}
	Foot/pounds	3.088
	Horsepower–hours	1.5596×10^{-6}
	Kilowatt–hours	1.163×10^{-6}
	Watt–hours	1.163×10^{-3}
Gram–calories/sec	Btu/hr	14.286
Grams–cm	Btu	9.3×10^{-8}
	Btu (IST)	9.29×10^{-8}
	Btu (mean)	9.288×10^{-8}

Convert From	Into	Multiply By
Grams–cm	Cal, gram	2.344×10^{-5}
	Cal, gram (IST)	2.342×10^{-5}
	Cal, gram (mean)	2.34×10^{-5}
	Cal, gram (15°C)	2.343×10^{-5}
	Cal, gram (20°C)	2.345×10^{-5}
	Cal, kg	2.344×10^{-8}
	Cal, kg (IST)	2.342×10^{-8}
	Cal, kg (mean)	2.34×10^{-8}
	Dyne–cm	980.7
	Ergs	980.7
	Foot–poundals	0.00233
	Foot–pounds	7.233×10^{-5}
	Hp–hours	3.653×10^{-11}
	Joules	9.807×10^{-5}
	Kw–hours	2.724×10^{-11}
	Kw–hours (Int)	2.724×10^{-11}
	Newton–meters	9.807×10^{-5}
	Watt–hours	2.724×10^{-8}
Gram–cm/sec	Btu/sec	9.301×10^{-8}
	Cal, gram/sec	2.344×10^{-5}
	Ergs–sec	980.7
	Foot–pounds/sec	7.23×10^{-5}
	Horsepower	1.315×10^{-7}
	Joules/sec	9.807×10^{-5}
	Kilowatts	9.807×10^{-8}
	Kilowatts (Int)	9.805×10^{-8}
	Watts	9.807×10^{-5}
Grams/sq cm	Pounds/sq inch	0.00034
Gram wt–sec/sq cm	Poises	980.7
Gravity constant	Cm/(sec x sec)	980.6
	Ft/(sec x sec)	32.17
Hands	Centimeters	10.16
	Feet	.3333
	Inches	4
Hectares	Acres	2.471
	Ares	100
	Sq cm	1×10^{8}
	Sq feet	107629
	Sq meters	10000
	Sq miles	0.00386
	Sq rods	395.369
Hectograms	Grams	100
	Poundals	7.0932
	Pounds (apoth or troy)	0.2679
	Pounds (avdp)	0.2205
Hectoliters	Bushels (Brit)	2.7497
	Bushels (US)	2.8378
	Cu cm	1.00028×10^{5}
	Cu feet	3.5316
	Gallons (US liq)	26.418
	Liters	100
	Ounces (US flu)	3381.5
	Pecks (US)	11.351
Hectometers	Centimeters	10000
	Decimeters	1000

Convert From	Into	Multiply By
Hectometers	Dekameters	10
	Feet	328.08
	Meters	100
	Rods	19.88
	Yards	109.36
Hectowatts	Watts	100
Hefner units	Candles (English)	0.86
	Candles (German)	0.85
	Candles (Int)	0.9
	10cp pentane candles	0.09
Henries	Abhenries	1×10^9
	Henries (Int)	0.9995
	Millihenries	1000
	Mks (r or nr) units	1
	Stathenries	1.113×10^{-12}
Henries (Int)	Henries	1.0005
Henries/meter	Gausses/oersted	79577
	Mks (nr) units	0.0796
	Mks (r) units	1
Hin (Old Testament)	Liters	3.66
Hogsheads	Butts (Brit)	0.5
	Cu feet	8.4219
	Cu inches	14553
	Cu meters	0.238
	Gallons (Brit)	52.458
	Gallons (US)	63
	Gallons (wine)	63
	Liters	238.47
Hogshead (Brit)	Cu feet	10.11
Homer (Old Testament)	Liters	220
Horsepower (mech)	Btu (mean)/hr	2542.48
	Btu/min	42.436
	Btu (mean)/sec	0.706
	Cal, gram/hr	6.416×10^5
	Cal, gram (IST)/hr	6.412×10^5
	Cal, gram (mean)/hr	6.4069×10^5
	Cal, gram/min	10693
	Cal, gram (IST)/min	10686
	Cal, gram (mean)/min	10678
	Ergs/sec	7.457×10^9
	Foot-pounds/hr	1980000
	Foot-pounds/min	33000
	Foot-pounds/sec	550
	Horsepower (boiler)	0.076
	Horsepower (electric)	0.9996
	Horsepower (metric)	1.0139
	Joules/sec	745.7
	Kg-calories/min	10.68
	Kilowatts	0.7457
	Kilowatts (Int)	0.7456
	Tons of refrigerant	0.212
	Watts	745.7
Horsepower (boiler)	Btu (mean)/hr	33445
	Cal, gram/min	140671
	Cal, gram (mean)/min	140469

Convert From	Into	Multiply By
Horsepower (boiler)	Cal, gram (20°C)/min	140742
	Ergs/sec	9.809×10^{10}
	Foot-pounds/min	434107
	Horsepower (mech)	13.155
	Horsepower (electric)	13.149
	Horsepower (metric)	13.337
	Horsepower (water)	13.149
	Joules/sec	9809.5
	Kilowatts	9.809
Horsepower (electric)	Btu/hr	2547.16
	Btu (IST)/hr	2545.5
	Btu (mean)/hr	2543.5
	Cal, gram/sec	178.298
	Cal, kg/hr	641.87
	Ergs/sec	7.46×10^{9}
	Foot-pounds/min	33013
	Foot-pounds/sec	550.2
	Horsepower (mech)	1.0004
	Horsepower (boiler)	0.07605
	Horsepower (metric)	1.01428
	Horsepower (water)	0.99994
	Joules/sec	746
	Kilowatts	0.746
	Watts	746
Horsepower (metric)	Btu/hr	2511.3
	Btu (IST)/hr	2509.7
	Btu (mean)/hr	2507.7
	Cal, gram/hr	6.328×10^{5}
	Cal, gram (IST)/hr	6.324×10^{5}
	Cal, gram (mean)/hr	6.319×10^{5}
	Ergs/sec	7.355×10^{9}
	Foot-pounds/min	32548.6
	Foot-pounds/sec	542.476
	Horsepower (mech)	0.9863
	Horsepower (boiler)	0.07498
	Horsepower (electric)	0.9859
	Horsepower (water)	0.98587
	Kg-meters/sec	75
	Kilowatts	0.7355
	Watts	735.499
Horsepower (water)	Foot-pounds/min	33015
	Horsepower (mech)	1.00046
	Horsepower (boiler)	0.076
	Horsepower (electric)	1.00006
	Horsepower (metric)	1.0143
	Kilowatts	0.746
Horsepower-hours	Btu	2546.1
	Btu (IST)	2544.5
	Btu (mean)	2542.5
	Cal, gram	641616
	Cal, gram (IST)	641196
	Cal, gram (mean)	640693
	Ergs	2.684×10^{13}
	Foot-pounds	1.98×10^{6}
	Gram-calories	641190

Convert From	Into	Multiply By
Horsepower–hours	Joules	2.684×10^6
	Kg–calories	641.1
	Kg–meters	273745
	Kw–hours	0.7457
	Watt–hours	745700
Horsepower–hr/lb	Btu/lb	2546
	Cal, gram/gram	1414.5
	Cu ft–(lb/sq in)/lb	13750
	Foot–pounds/lb	1980000
	Joules/gram	5918.35
Hours (mean solar)	Days (mean solar)	0.0417
	Days (sidereal)	0.04178
	Hours (sidereal)	1.002738
	Minutes (mean solar)	60
	Minutes (sidereal)	60.164
	Seconds (mean solar)	3600
	Seconds (sidereal)	3609.86
	Weeks (mean calendar)	0.00595
Hours (sidereal)	Days (mean solar)	0.41553
	Days (sidereal)	0.04167
	Hours (mean solar)	0.99727
	Minutes (mean solar)	59.836
	Minutes (sidereal)	60
Hundredweights (long)	Kilograms	50.802
	Pounds	112
	Quarters (Brit long)	4
	Quarters (US long)	0.2
	Tons (long)	0.05
Hundredweights (short)	Kilograms	45.359
	Ounces (advp)	1600
	Pounds (advp)	100
	Quarters (Brit short)	4
	Quarters (US short)	0.2
	Tons (long)	0.04464
	Tons (metric)	0.04536
	Tons (short)	0.05
Inches	Ångström units	2.54×10^8
	Centimeters	2.54
	Chains (Gunter's)	0.001263
	Cubits	0.0555
	Fathoms	0.01388
	Feet	0.08333
	Feet (US Survey)	0.08333
	Links (Gunter's)	0.12626
	Links (Ramden's)	0.08333
	Meters	0.0254
	Miles	1.578×10^{-5}
	Millimeters	25.40
	Mils	1000
	Picas (printer)	6.0225
	Points (printer)	72.27
	Yards	0.0278
Inches of Hg @ 32°F	Atmospheres	0.03342
	Bars	0.03386
	Dynes/sq cm	33864

Convert From	Into	Multiply By
Inches of Hg @ 32°F	Ft of air @ 1atm,60°F	926.2
	Ft of H_2O @ 39.2°F	1.1329
	Grams/sq cm	34.532
	Kg/sq meter	345.32
	Mm of Hg @ 60°C	25.4
	Ounces/sq inch	7.858
Inches of Hg @ 32°F	Pounds/sq ft	70.726
Inches of Hg @ 60°F	Atmospheres	0.033327
	Dynes/sq cm	39768
	Grams/sq cm	34.434
	Mm of Hg @ 60°F	25.4
	Ounces/sq inch	7.8363
	Pounds/sq ft	70.5269
Inches of H_2O @ 4°C	Atmospheres	0.002458
	Dynes/sq cm	2490.8
	Inch of Hg @ 32°F	0.07355
	Kg/sq meter	25.399
	Ounces/sq foot	83.235
	Ounces/sq inch	0.57802
	Pounds/sq foot	5.20218
	Pounds/sq inch	0.03613
Inch-Pounds	Foot-Pounds	0.083 or 1/12
Inches/hour	Cm/hour	2.54
	Feet/hour	0.0833
	Miles/hour	1.5783×10^{-5}
Inches/minute	Cm/hour	152.4
	Feet/hour	5
	Miles/hour	0.000947
Jiggers	Fifths	0.026
	Ounces, fluid	1.5
	Pints	0.04166
	Pony	2
	Shots	1.5
Joules (abs)	Btu	0.0009484
	Btu (IST)	0.0009478
	Btu (mean)	0.0009471
	Cal, gram	0.23901
	Cal, gram (IST)	0.23885
	Cal, gram (mean)	0.23866
	Cal, gram @ 20°C	0.23913
	Cal, kg (mean)	0.000239
	Cu ft-atmosphere	0.000348
	Ergs	1×10^{7}
	Foot-poundals	23.73
	Foot-pounds	0.7376
	Gram-cm	10197.2
	Horsepower-hours	3.7251×10^{-7}
	Joules (Int)	0.9998
	Kg-calories	2.389×10^{-4}
	Kg-meters	0.10197
	Kw-hours	2.78×10^{-7}
	Liter-atmospheres	0.009869
	Volt-coulombs (Int)	0.999835
	Watt-hours (abs)	0.0002778
	Watt-hours (Int)	0.0002777

Convert From	Into	Multiply By
Joules (abs)	Watt-seconds	1
	Watt-seconds (Int)	0.9998
Joules (Int)	Btu	0.000949
	Btu (IST)	0.000948
	Btu (mean)	0.000947
	Cal, gram	0.23904
	Cal, gram (IST)	0.23888
	Cal, gram (mean)	0.2387
	Cu cm-atmosphere	9.87086
	Cu ft-atmosphere	0.000349
	Dyne-cm	1.00016×10^7
	Ergs	1.00016×10^7
	Foot-poundals	23.734
	Foot-pounds	0.7377
	Gram-cm	10199
	Joules (abs)	1.00016
	Kw-hours	2.778×10^{-7}
	Liter-atmosphere	0.00987
	Volt-coulombs	1.00016
	Volt-coulombs (Int)	1
	Watt-second	1.00016
	Watt-second (Int)	1
Joules/ampere-hour	Joules/abcoulomb	0.00278
	Joules/statcoulomb	9.266×10^{-14}
Joules/coulomb	Joules/abcoulomb	10
	Volts	1
Joules/cm	Dynes	10^7
	Grams	1.020×10^4
	Joules/meter (newtons)	100
	Poundals	723.3
	Pounds	22.48
Joules/second (abs)	Btu/min	0.0569
	Cal, gram/min	14.34
	Cal, kg/min	0.01434
	Cal, kg (mean)/min	0.01432
	Dyne-cm/sec	1×10^7
	Ergs/sec	1×10^7
	Foot-pounds/sec	0.73756
	Gram-cm/sec	10197
	Horsepower	0.00134
	Watts	1
	Watts (Int)	0.9998
Joules (Int)/sec	Btu/min	0.05692
	Btu (mean)/min	0.05683
	Cal, gram/min	14.343
	Cal, kg/min	0.01434
	Dyne-cm/sec	1.00016×10^7
	Ergs/sec	1.00016×10^7
	Foot-pounds/min	44.26
	Foot-pounds/sec	0.73768
	Gram-cm/sec	10198
	Horsepower	0.00134
	Watts	1.00016
	Watts (Int)	1
Kab (Old Testament)	Liters	1.2

Convert From	Into	Multiply By
Kantar (Egypt)	Pounds (avdp)	99.094
Kati (Malaysia)	Kilograms	0.60
	Pounds	1.333
Kilderkins (Brit)	Cu cm	81829
	Cu feet	2.8898
	Cu inches	4993.5
	Cu meters	0.0818
	Gallons (Brit)	16 to 18
	Liters	72.7 to 81.8
Kilograms	Drams (apoth or troy)	257.21
	Drams (avdp)	564.38
	Dynes	980665
	Grains	15432.36
	Grams	1000
	Hundredweights (long)	0.019684
	Hundredweights (short)	0.022046
	Joules/cm	0.09807
	Joules/meter (newtons)	9.807
	Ounces (apoth or troy)	32.1507
	Ounces (avdp)	35.27396
	Pennyweights	643.0149
	Poundals	70.9316
	Pounds (apoth or troy)	2.67923
	Pounds (avdp)	2.20462
	Quarters (Brit long)	0.078736
	Quarters (US long)	0.003937
	Scruples (apoth)	771.6179
	Slugs	0.06852
	Tons (long)	0.00098
	Tons (metric)	0.001
	Tons (short)	0.001102
Kilograms/cu meter	Grams/cu cm	0.001
	Lb/cu ft	0.0624
	Lb/cu inch	3.6127×10^{-5}
	Lb/mil-foot	3.405×10^{-10}
Kilograms/meter	Pounds/ft	0.672
Kilograms/sq cm	Atmospheres	0.9678
	Bars	0.98066
	Cm of Hg @ 0°C	73.556
	Dynes/sq cm	98066
	Ft of H_2O @ 39.2°F	32.809
	In of Hg @ 32°F	28.959
	Pounds/sq inch	14.22
Kilograms/sq meter	Atmospheres	9.678×10^{-5}
	Bars	9.8966×10^{-5}
	Dynes/sq cm	98.066
	Ft of H_2O @ 39.2°F	0.00328
	Grams/sq cm	0.1
	In of Hg @ 32°F	0.0029
	Mm of Hg @ 0°C	0.07356
	Pounds/sq foot	0.20482
	Pounds/sq inch	0.00142
Kilograms/sq mm	Pounds/sq ft	204816
	Pounds/sq in	1422.3
	Tons (short)/sq in	0.71117

Convert From	Into	Multiply By
Kilogram sq cm	Pounds sq ft	0.00237
	Pounds sq in	0.34172
Kilogram-meters	Btu (mean)	0.00929
	Cal, gram (mean)	2.3405
	Cal, kg (mean)	0.00234
	Cu ft-atmospheres	0.003418
	Dyne-cm	9.807×10^7
	Ergs	9.807×10^7
	Foot-poundals	232.71
	Foot-pounds	7.233
	Gram-cm	100000
	Horsepower-hours	3.653×10^{-6}
	Joules	9.8066
	Joules (Int)	0.8050
	Kw-hours	2.724×10^{-6}
	Liter-atmospheres	0.0968
	Newton-meters	9.8066
	Watt-hours	0.002724
	Watt-hours (Int)	0.0027236
Kilogram-meters/sec	Watts	9.8066
Kilolines	Maxwells	1000
	Webers	1×10^{-5}
Kiloliters	Cu centimeters	1.000028×10^6
	Cu feet	35.3157
	Cu inches	61025.4
	Cu meters	1.000028
	Cu yards	1.30799
	Gallons (Brit)	219.975
	Gallons (US dry)	227.027
	Gallons (US liq)	264.179
	Liters	1000
Kilometers	Astronomical units	6.689×10^{-9}
	Centimeters	100000
	Feet	3280.84
	Feet (US Survey)	3280.83
	Inches	3.937×10^4
	Light years	1.057×10^{-13}
	Meters	1000
	Miles (naut, Int)	0.53996
	Miles (statute)	0.62137
	Millimeters	10^6
	Myriameters	0.1
	Rods	198.839
	Yards	1093.61
Kilometers/hr	Cm/sec	27.778
	Feet/hr	3280.84
	Feet/min	54.6807
	Knots (Int)	0.53996
	Meters/sec	0.2778
	Miles (statute)/hr	0.62137
Kilometers/hr/sec	Cm/sec/sec	27.78
	Ft/sec/sec	0.9113
	Meters/sec/sec	0.2778
	Miles/hr/sec	0.6214
Kilometers/min	Cm/sec	1666.67

Convert From	Into	Multiply By
Kilometers/min	Feet/min	3280.8
	Kilometers/hr	60
	Knots (Int)	32.397
	Miles/hr	37.2823
	Miles/min	0.62137
Kilovolts/cm	Abvolts/cm	1×10^{11}
	Microvolts/meter	1×10^{11}
	Millivolts/meter	1×10^{11}
	Statvolts/cm	3.336
	Volts/inch	2540
Kilowatts	Btu/hr	3414.4
	Btu (IST)/hr	3412.2
	Btu (mean)/hr	3409.5
	Btu (mean)/min	56.82
	Btu (mean)/sec	0.9471
	Cal, gram(mean)/hr	859184
	Cal, gram(mean)/min	14319
	Cal, gram(mean)/sec	238.66
	Cal, kg (mean)/hr	859.18
	Cal, kg (mean)/min	14.32
	Cal, kg (mean)/sec	0.23866
	Cu ft-atm/hr	1254.7
	Ergs/sec	1×10^{10}
	Foot-poundals/min	1.424×10^{6}
	Foot-pounds/hr	2.655×10^{6}
	Foot-pounds/min	44253
	Foot-pounds/sec	737.56
	Gram-cm/sec	1.0197×10^{7}
	Horsepower	1.341
	Horsepower (boiler)	0.1019
	Horsepower (electric)	1.34
	Horsepower (metric)	1.3596
	Joules/hr	3.6×10^{6}
	Joules (IST)/hr	3.599×10^{6}
	Joules/sec	1000
	Kg-meters/hr	3.671×10^{5}
	Kilowatts (Int)	0.99983
	Watts (Int)	999.83
Kilowatts (Int)	Btu/hr	3414.99
	Btu (IST)/hr	3412.76
	Btu (mean)/hr	3410.08
	Btu (mean)/min	56.835
	Btu (mean)/sec	0.9472
	Cal, gram (mean)/hr	859326
	Cal, gram (mean)/min	14322
	Cal, kg/hr	860.56
	Cal, kg (IST)/hr	860
	Cal, kg (mean)/hr	859.3
	Cu cm-atm/hr	3.55×10^{7}
	Cu ft-atm/hr	1254.9
	Ergs/sec	1.00016×10^{10}
	Foot-poundals/min	1.424×10^{6}
	Foot-pounds/min	44261
	Foot-pounds/sec	737.68
	Gram-cm/sec	1.0199×10^{7}

Convert From	Into	Multiply By
Kilowatts (Int)	Horsepower	1.341
	Horsepower (boiler)	0.102
	Horsepower (electric)	1.341
	Horsepower (metric)	1.3598
	Joules/hr	3.6006×10^6
	Joules (Int)/hr	3.6×10^6
	Kg-meters/hr	367158
	Kilowatts	1.00016
Kilowatt-hours	Btu (mean)	3409.5
	Cal, gram (mean)	859184
	Ergs	3.6×10^{13}
	Foot-pounds	2.655×10^6
	Gram-calories	859850
	Hp-hours	1.341
	Joules	3.6×10^6
	Kg-calories	860.5
	Kg-meters	367098
	Lb H_2O evaporated from and at 212°F	3.53
	Lb H_2O raised from 62° to 212°F	22.75
	Watt-hours	1000
	Watt-hours (Int)	999.8
Kilowatt-hours (Int)	Btu (mean)	3410.1
	Cal, gram (IST)	860000
	Cal, gram (mean)	859326
	Cu cm-atm	3.553×10^7
	Cu ft-atm	1254.9
	Foot-pounds	2.656×10^6
	Hp-hours	1.3412
	Joules	3.6006×10^6
	Joules (Int)	3.6×10^6
	Kg-meters	367158
Kw-hr/gram	Btu/lb	1.549×10^6
	Btu (IST)/lb	1.548×10^6
	Btu (mean)/lb	1.546×10^6
	Cal, gram/gram	860421
	Cal, gram (mean)/gram	859184
	Cu cm-atm/gram	3.553×10^7
	Cu ft-atm/gram	569124
	Hp-hr/lb	608.28
	Joules/gram	3.6×10^6
Kin (Japan)	Kilograms	0.600
Knots (Int)	Cm/sec	51.44
	Feet/hr	6076.1
	Feet/min	101.269
	Feet/sec	1.688
	Kilometers/hr	1.852
	Meters/min	30.87
	Meters/sec	0.5144
	Miles (naut,Int)/hr	1
	Miles (statute)/hr	1.1508
	Yards/hour	2027
Koku (Japan)	Liters	180.39
Kotyle (Greece)	Decileters	1

Convert From	Into	Multiply By
Kwan (Japan)	Kilograms	3.75
	Pounds (avdp)	8.267
Lamberts	Candles/sq cm	0.31831
	Candles/sq ft	295.72
	Candles/sq inch	2.0536
	Foot-lamberts	929.03
	Lumens/sq cm	1
Lasts (Brit)	Liters	2909.4
Leagues (naut, Brit)	Feet	1824
	Kilometers	5.559
	Leagues (naut, Int)	1.0006
	Leagues (statute)	1.151
	Miles (statute)	3.4545
Leagues (naut, Int)	Fathoms	3038.06
	Feet	18228
	Kilometers	5.556
	Leagues (statute)	1.1508
	Miles (statute)	3.4523
Leagues (statute)	Fathoms	2640
	Feet	15840
	Kilometers	4.828
	Leagues (naut, Int)	0.86898
	Miles (naut, Int)	2.607
	Miles (statute)	3
Li (China)	Miles	0.333
Libbra (Italy)	Kilograms	1
Light years	Astronomical units	63279
	Kilometers	9.46×10^{12}
	Miles (statute)	5.878×10^{12}
Lines	Maxwells	1
Lines (Brit)	Centimeters	0.2117
	Inches	0.0833
Lines/sq cm	Gausses	1
Lines/sq inch	Gausses	0.155
	Webers/sq cm	1.55×10^{-9}
	Webers/sq inch	1×10^{-8}
	Webers/sq meter	1.55×10^{-5}
Liniya (Russia)	Inches	0.1
Links (Gunters)	Chains (Gunters)	0.01
	Feet	0.66
	Feet (US Survey)	0.659998
	Inches	7.92
	Meters	0.2012
	Miles (statute)	0.000125
	Rods	0.04
Links (Ramdens)	Centimeters	30.48
	Chains (Ramdens)	0.01
	Feet	1
	Inches	12
Liters	Bath (Old Testament)	0.0454
	Bushels (Brit)	0.0275
	Bushels (US)	0.02838
	Cu cm	1000.03
	Cu feet	0.03532
	Cu inches	61.002

Convert From	Into	Multiply By
Liters	Cu meters	0.00100003
	Cu yards	0.00131
	Drams (US flu)	270.52
	Ephah (Old Testament)	22
	Gallons (Brit)	0.21998
	Gallons (US dry)	0.22703
	Gallons (US liq)	0.26418
	Gills (Brit)	7.03922
	Gills (US)	8.4537
	Hin (Old Testament)	0.2732
	Hogsheads	0.00419
	Homer (Old Testament)	0.00454
	Kab (Old Testament)	0.833
	Log (Old Testament)	0.3
	Minims (US)	16231.2
	Omer (Old Testament)	2.2
	Ounces (Brit flu)	35.196
	Ounces (US flu)	33.81497
	Pecks (Brit)	0.10999
	Pecks (US)	0.1135
	Pints (Brit)	1.7598
	Pints (US dry)	1.8162
	Pints (US liq)	2.1134
	Quarts (Brit)	0.8799
	Quarts (US dry)	0.9081
	Quarts (US liq)	1.0567
Liters/min	Cu ft/min	0.0353
	Cu ft/sec	0.000588
	Gal (US liq)/min	0.26418
	Gal (US liq)/sec	4.403×10^{-3}
Liters/sec	Cu ft/min	2.1189
	Cu ft/sec	0.0353
	Cu yards/min	0.07848
	Gal (US liq)/min	15.8508
	Gal (US liq)/sec	0.26418
Liter–atmospheres	Btu	0.0961
	Btu (IST)	0.09604
	Btu (mean)	0.09597
	Cal, gram	24.2179
	Cal, gram (IST)	24.202
	Cal, gram (mean)	24.183
	Cu ft–atm	0.0353
	Foot–poundals	2404.5
	Foot–pounds	74.736
	Hp–hours	3.774×10^{-5}
	Joules	101.33
	Joules (Int)	101.31
	Kg–meters	10.33
	Kw–hours	2.815×10^{-5}
Load (English)	Cu yards of alluvium	1
Log (Old Testament)	Liters	0.3
Lumens	Candle power	0.07958
	Watt	0.0015
Lumens/sq cm	Lamberts	1
	Phots	1

Convert From	Into	Multiply By
Lumens/sq ft	Foot–candles	1
	Foot–lamberts	1
	Lumens/sq meter	10.7639
Lumens/sq meter	Foot–candles	0.0929
	Lumens/sq ft	0.0929
	Phots	0.0001
Lux	Foot–candles	0.0929
	Lumens/sq meter	1
	Phots	0.0001
Maass (Germany)	Liters	1.837
Mace (China)	Grains	58.33
Magnum	Bottles of wine	2.49797
	Quarts	2
Marc (France)	Kilograms	0.2448
Maxwells	Gauss–sq cm	1
	Lines	1
	Maxwells (Int)	0.99967
	Volt–seconds	1×10^{-8}
	Webers	1×10^{-8}
Maxwells (Int)	Maxwells	1.00033
Maxwells/sq cm	Maxwells/sq in	6.4516
Maxwells/sq in	Maxwells/sq cm	0.155
Megabyte	Bytes (computers)	1048576
Megmhos/cm	Abmhos/cm	0.001
	Megmhos/inch	2.54
	$(\text{Microhm–cm})^{-1}$	1
Megmhos/inch	megmhos/cm	0.3937
Megohms	Microhms	1×10^{12}
	Ohms	1×10^{6}
	Statohms	1.1126×10^{-6}
Meters	Angstrom units	1×10^{10}
	Centimeters	100
	Chains (Gunter's)	0.04971
	Chains (Ramden's)	0.03281
	Fathoms	0.54681
	Feet	3.28084
	Feet (US Survey)	3.28083
	Furlongs	0.00497
	Inches	39.3701
	Kilometers	0.001
	Links (Gunter's)	4.97097
	Links (Ramden's)	3.2808
	Megameters	1×10^{-6}
	Miles (Brit, naut)	0.0005396
	Miles (Int, naut)	0.0005399
	Miles (statute)	0.000621
	Millimeters	1000
	Millimicrons	1×10^{9}
	Mils	39370.08
	Rods	0.1988
	Yards	1.0936
Meters/hr	Feet/hr	3.2808
	Feet/min	0.05468
	Knots (Int)	0.00054
	Miles (statute)/hr	0.000621

Convert From	Into	Multiply By
Meters/min	Cm/sec	1.66667
	Feet/min	3.2808
	Feet/sec	0.05468
	Kilometers/hr	0.06
	Knots (Int)	0.032397
	Miles (statute)/hr	0.03728
Meters/sec	Feet/min	196.85
	Feet/sec	3.2808
	Kilometers/hr	3.6
	Kilometers/min	0.06
	Miles (statute)/hr	2.2369
	Miles (statute)/sec	0.03728
Meters/(sec x sec)	Cm/(sec x sec)	100
	Feet/(sec x sec)	3.281
	Kilometers/(hr x sec)	3.6
	Miles/(hr x sec)	2.2369
Meter–candles	Lumens/sq meter	1
Meter–kilograms	Cm–dynes	9.807×10^{7}
	Cm–grams	10^{5}
	Lb–feet	7.233
Mhos	Abmhos	1×10^{-9}
	Mhos (Int)	1.00049
	Mks units	1
	Siemen's units	1
	Statmhos	8.9876×10^{11}
Mhos (Int)	Abmhos	9.995×10^{-10}
	Mhos	0.9995
Mhos/meter	Abmhos/cm	1×10^{-11}
	Mhos (Int)/meter	1.00049
Microfarads	Abfarads	1×10^{-15}
	Farads	1×10^{-6}
	Statfarads	8.988×10^{5}
	Picofarads	1×10^{6}
Micrograms	Grams	1×10^{-6}
	Milligrams	0.001
Microhenries	Henries	1×10^{-6}
	Stathenries	1.113×10^{-18}
Microhms	Abohms	1000
	Megohms	1×10^{-12}
	Ohms	1×10^{-6}
	Statohms	1.113×10^{-18}
Microhm–cm	Abohm–cm	1000
	Circ mil–ohms/ft	6.015
	Microhm–inches	0.3937
	Ohm–cm	1×10^{-6}
Microhm–inches	Circ mil–ohms/ft	15.279
	Microhm–cm	2.54
Micromicrofarads	Farads	1×10^{-12}
Micromicrons	Angstrom units	0.01
	Centimeters	1×10^{-10}
	Inches	3.937×10^{-11}
	Meters	1×10^{-12}
	Microns	1×10^{-6}
Microns	Angstrom units	10000
	Centimeters	0.0001

Convert From	Into	Multiply By
Microns	Feet	3.2808×10^{-6}
	Inches	3.937×10^{-5}
	Meters	1×10^{-6}
	Millimeters	0.001
	Millimicrons	1000
Miglio (Rome)	Miles	0.925
Miles (Naut,Brit)	Cable lengths (Brit)	8.444
	Fathoms	1013.33
	Feet	6080
	Meters	1853.18
	Miles (Naut,Int)	1.00064
	Miles (statute)	1.1515
Miles (Naut,Int)	Cable lengths	8.439
	Fathoms	1012.69
	Feet	6067.11
	Feet (US survey)	6067.1
	Kilometers	1.852
	Leagues (Naut,Int)	0.3333
	Meters	1852
	Miles (Naut,Brit)	0.99936
	Miles (Statute)	1.15078
Miles (Statute)	Centimeters	160934
	Chains (Gunter's)	80
	Chains (Ramden's)	52.8
	Feet	5280
	Feet (US Survey)	5279.99
	Furlongs	8
	Inches	63360
	Kilometers	1.6094
	Light years	1.701×10^{-12}
	Links (Gunter's)	8000
	Meters	1609.34
	Miles (Naut,Brit)	0.8684
	Miles (Naut,Int)	0.86898
	Myriameters	0.16094
	Rods	320
	Yards	1760
Miles/hr	Cm/second	44.704
	Feet/hour	5280
	Feet/minute	88
	Feet/second	1.4667
	Kilometers/hour	1.6094
	Kilometers/min	0.0268
	Knots (Int)	0.86897
	Meters/min	26.822
	Miles/min	0.01667
Miles/(hr x min)	Cm/(sec x sec)	0.74507
Miles/(hr x sec)	Cm/(sec x sec)	44.704
	Ft/(sec x sec)	1.4667
	Kilometers/(hr x sec)	1.6093
	Meters/(sec x sec)	0.4470
Miles/min	Cm/second	2682.2
	Feet/hr	316800
	Feet/sec	88
	Kilometers/min	1.6093

Convert From	Into	Multiply By
Miles/min	Knots (Int)	52.1386
	Meters/min	1609.34
	Miles/hr	60
Milion (New Testament)	Meters	1478
	Yards	1618
Milliar (Ancient Rome)	Miles	0.92
	Stadia	8
Millibars	Atmospheres	0.000987
	Bars	0.001
	Baryes	1000
	Dynes/sq cm	1000
	Grams/sq cm	1.0197
	In of Hg @ 32°F	0.0295
	Pounds/sq ft	2.0885
	Pounds/sq inch	0.0145
Milligrams	Carats (1877 defn)	0.00487
	Carats (metric)	0.005
	Drams (troy)	0.000257
	Drams (avdp)	0.00056
	Grains	0.01543
	Grams	0.001
	Ounces (troy)	3.215×10^{-5}
	Ounces (avdp)	3.527×10^{-5}
	Pennyweights	0.000643
	Pounds (troy)	2.679×10^{-6}
	Pounds (avdp)	2.205×10^{-6}
	Scruples (apoth)	0.000772
Milligrams/assay ton	Milligrams/kg	34.2857
	Ounces (troy)/ton (avdp)	1
Milligrams/gm	Carats	0.024
	Grams/ton (short)	907.185
	Milligrams/assay ton	29.16667
	Ounces (avdp)/ton (long)	35.84
	Ounces (avdp)/ton (short)	32
	Ounces (troy)/ton (long)	32.6666
	Ounces (troy)/ton (short)	29.1666
Milligrams/inch	Dynes/cm	0.38609
	Dynes/inch	0.98066
	Grams/cm	0.000394
	Grams/inch	0.0001
Milligrams/kg	Pounds (avdp)/ton (short)	0.002
Milligrams/liter	Grains/gallon	0.05842
	Grams/liter	0.001
	Parts/million	1
	Lb/cu ft	6.2426×10^{-5}
Milligrams/met. ton	Parts/billion	1.1
Milligrams/mm	Dynes/cm	9.8066
Millihenries	Abhenries	1×10^{6}
	Henries	0.001
	Stathenries	1.1126×10^{-15}
Millilamberts	Candles/sq cm	0.000318
	Candles/sq inch	0.002054
	Foot-lamberts	0.929
	Lamberts	0.001
	Lumens/sq cm	0.001

Convert From	Into	Multiply By
Millilamberts	Lumens/sq ft	0.929
Milliliters	Cu cm	1.000028
	Cu inches	0.06102
	Drams (US fluid)	0.27052
	Gills (US)	0.00845
	Liters	0.001
	Minims (US)	16.231
	Ounces (Brit,flu)	0.035196
	Ounces (US,flu)	0.0338
	Pints (Brit)	0.00176
	Pints (US liq)	0.00211
Millimeters	Angstrom units	1×10^{7}
	Centimeters	0.1
	Decimeters	0.01
	Dekameters	0.0001
	Feet	0.00328
	Inches	0.03937
	Kilometers	10^{-6}
	Meters	0.001
	Microns	1000
	Mils	39.37
	Yards	1.094×10^{-3}
Millimeters Hg @ 0°C	Atmospheres	0.001316
	Bars	0.00133
	Dynes/sq cm	1333.2
	Grams/sq cm	1.3595
	Kg/sq meters	13.595
	Pounds/sq ft	2.7845
	Pounds/sq in	0.0193
	Torrs	1
Millimicrons	Angstrom units	10
	Centimeters	1×10^{-7}
	Inches	3.937×10^{-8}
	Meters	1×10^{-9}
	Microns	0.001
	Millimeters	1×10^{-6}
Million gal/day	cu ft/sec	1.547
Milliphots	Foot-candles	0.929
	Lumens/sq ft	0.929
	Lumens/sq meter	10
	Lux	10
	Phots	0.001
Millivolts	Statvolts	3.336×10^{-6}
	Volts	0.001
Mils	Centimeters	2.540×10^{-3}
	Feet	8.333×10^{-5}
	Inches	0.001
	Kilometers	2.540×10^{-8}
	Yards	2.778×10^{-5}
Mina	Pounds	0.944
Miners Inch	Cu feet/min	1.2 to 1.56
	Cu feet/sec	0.02 to 0.026
	Liters/sec	0.57 to 0.74
Minims (Brit)	Cu cm	0.0592
	Cu inches	0.0036

Convert From	Into	Multiply By
Minims (Brit)	Milliliters	0.05919
	Ounces (Brit,flu)	0.00208
	Scruples (Brit,flu)	0.05
Minims (US)	Cu cm	0.06161
	Cu inches	0.00376
	Drams (US,flu)	0.01667
	Gallons (US,liq)	1.628×10^{-5}
	Gills (US)	0.00052
	Liters	6.16098×10^{-5}
	Milliliters	0.06161
	Ounces (US,flu)	0.00208
	Pints (US,liq)	0.00013
Minutes (angle)	Degrees	0.016667
	Quadrants	0.000185
	Radians	0.0002909
	Seconds (angle)	60
Minutes (solar time)	Days (mean solar)	0.000694
	Days (sideral)	0.000696
	Hours (mean solar)	0.016667
	Hours (sideral)	0.016712
	Minutes (sideral)	1.002738
Minutes (sideral)	Days (mean solar)	0.000693
	Minutes (mean solar)	0.99727
	Months (mean calendar)	2.2769×10^{-5}
	Seconds (sideral)	60
Minutes(angle)/cm	Radians/cm	0.0002909
Mna (Greece)	Kilograms	1.5
Momme (Japan)	Grams	3.75
	Kwan	0.001
Months (lunar)	Days (mean solar)	29.5306
	Hours (mean solar)	708.734
	Minutes (mean solar)	42524.05
	Second (mean solar)	2.551×10^{6}
	Weeks (mean calendar)	4.2186
Months (mean calend.)	Days (mean solar)	30.4167
	Hours (mean solar)	730
	Months (lunar)	1.030005
	Weeks (mean calendar)	4.34524
	Years (calendar)	0.08333
	Years (sideral)	0.08327
	Years (tropical)	0.08328
Morgan (S. Africa)	Acres	2.1165
Mou (China)	Square yards	806.65
Myriagrams	Grams	10000
	Kilograms	10
	Pounds (avdp)	22.046
Myriawatts	Kilowatts	10
Nail (Old English)	Inches	2.25
Nepers	Decibels	8.686
Newtons	Dynes	100000
	Pounds	22.046
Newton-meters	Dyne-cm	1×10^{7}
	Gram-cm	10197
	Pound-inch	8.8507
	Kg-meters	0.10197

Convert From	Into	Multiply By
Newton-meters	Pound-feet	0.73756
Noggins (Brit)	Cm cm	142.06
	Gallons (Brit)	0.0312
	Gills (Brit)	1
Obolos (Greece)	Grams	0.1
Oersteds	Ampere-turns/inch	2.0213
	Ampere-turns/meter	79.577
	Gilberts/cm	1
	Oersteds (Int)	1.00016
Oersteds (Int)	Oersteds	0.9998
Ohms	Abohms	1×10^{9}
	Megohms	1×10^{-6}
	Microhms	1×10^{6}
	Ohms (Int)	0.9995
	Statohms	1.1126×10^{-12}
Ohms (Int)	Ohms	1.00049
Ohm-cm	Circ mil-ohms/ft	6.015×10^{6}
	Microhm-cm	1×10^{6}
	Ohm-inches	0.3937
Ohm-inches	Ohm-cm	2.54
Ohm-meters	Abohm-cm	$1.x\ 10^{11}$
	Statohm-cm	1.113×10^{-10}
Omer	Ephah	0.1
	Liters (Old Testament)	2.2
	Liters	3.964
Orguia (Ancient Greece)	Amma	0.01
	Digits	100
	Feet	6
Ounces (apoth or troy)	Dekagrams	1.7554
	Drams (apoth or troy)	8
	Drams (advp)	17.554
	Grains	480
	Grams	31.103
	Milligrams	31103
	Ounces (advp)	1.0971
	Pennyweights	20
	Pounds (apoth or troy)	0.0833
	Pounds (advp)	0.06857
	Scruples (apoth)	24
	Tons (short)	3.429×10^{-5}
Ounces (advp)	Drams (apoth or troy)	7.2917
	Drams (advp)	16
	Grains	437.5
	Grams	28.349
	Hundredweights (long)	0.000558
	Hundredweights (shrt)	0.00062
	Ounces (apoth or troy)	0.91146
	Pennyweights	18.229
	Pounds (apoth or troy)	0.0759
	Pounds (advp)	0.0625
	Scruples (apoth)	21.875
	Tons (long)	2.79×10^{-5}
	Tons (metric)	2.835×10^{-5}
	Tons (short)	3.125×10^{-5}
Ounces (Brit,flu)	Cu cm	28.413

Convert From	Into	Multiply By
Ounces (Brit,flu)	Cu inches	1.7339
	Drachms (Brit,flu)	8
	Drams (US,flu)	7.6861
	Gallons (Brit)	0.00625
	Milliliters	28.412
	Minims (Brit)	480
	Ounces (US,flu)	0.96076
Ounces (US,flu)	Cu cm	29.5737
	Cu inches	1.80469
	Cups	0.1698
	Cu meters	2.9574×10^{-5}
	Drops	360.14
	Drams (US,flu)	8
	Fifths	0.039
	Gallons (US,dry)	0.006714
	Gallons (US,liq)	0.00781
	Gills (US)	0.25
	Jiggers	0.6666
	Liters	0.02957
	Minims (US)	480
	Ounces (Brit,flu)	1.0408
	Pints (US,liq)	0.0625
	Ponys	1.333
	Quarts (US,liq)	0.0312
	Teaspoons	2
	Tablespoons	6
Ounces/sq inch	Dynes/sq cm	4309.2
	Grams/sq cm	4.39419
	In of H2O @ 39.2°F	1.73004
	In of H2O @ 60°F	1.73166
	Pounds/sq foot	9
	Pounds/sq inch	0.0625
Ounces (advp)/ton (L)	Milligrams/kg	27.9018
Ounces (advp)/ton (S)	Milligrams/kg	31.25
Ounces (troy)/ton (L)	Ounces (troy)/ton (Met)	0.984
	Ounces (troy)/ton (S)	0.8929
	Parts per million	30.612
Ounces (troy)/ton (S)	Ounces (troy)/ton (L)	1.120
	Ounces (troy)/ton (Met)	1.1023
	Parts per million	34.286
Ounces (troy)/ton (met)	Ounces (troy)/ton (L)	1.106
	Ounces (troy)/ton (S)	0.9072
	Parts per million	31.104
Paces	Centimeters	76.2
	Chains (Gunter's)	0.03788
	Chains (Ramden's)	0.025
	Feet	2.5
	Hands	7.5
	Inches	30
	Ropes (Brit)	0.125
Palmi (Ancient Rome)	Inches	2.9
	Digiti	4
	Pes	0.25
Palms	Centimeters	7.62
	Chains (Ramden's)	0.0025

Convert From	Into	Multiply By
Palms	Cubits	0.16667
	Feet	0.25
	Hands	0.75
	Inches	3
Parsecs	Kilometers	3.084×10^{13}
	Miles (statute)	1.916×10^{13}
Parts/billion	Milligrams/metric ton	0.90909
Parts/million	Grains/gal (Brit)	0.070155
	Grains/gal (US)	0.05842
	Grams/liter	0.001
	Grams/ton (Met)	1
	Milligrams/liter	1
	Ounces (troy)/ton (S)	0.0292
	Percent	0.0001
	Pounds/million gal	8.345
Passus (Ancient Rome)	Feet	4.86
	Pes	5
	Stadium	0.008
Pecks (Brit)	Bushels (Brit)	0.25
	Coombs (Brit)	0.0625
	Cu cm	9092.17
	Cu inches	554.84
	Gallons (Brit)	2
	Gills (Brit)	64
	Hogsheads	0.03812
	Kilderkins (Brit)	0.1111
	Liters	0.90192
	Pints (Brit)	16
	Quarterns (Brit,dry)	4
	Quarters (Brit,dry)	0.03125
	Quarts (Brit)	8
	Quarts (US,dry)	8.2564
Pecks (US)	Barrels (US,dry)	0.07619
	Bushels (US)	0.25
	Cu cm	8809.77
	Cu feet	0.31111
	Cu inches	537.6
	Gallons,(US,dry)	2
	Gallons (US,liq)	2.3273
	Liters	8.8095
	Pints (US,dry)	16
	Quarts (US,dry)	8
Pennyweights	Drams (apoth or troy)	0.4
	Drams (avdp)	0.87771
	Grains	24
	Grams	1.55517
	Ounces (apoth or troy)	0.05
	Ounces (avdp)	0.05486
	Pounds (apoth or troy)	0.00417
	Pounds (advp)	0.003429
Perch (Masonry)	Stone 12 in x 12 in x 16.5 feet long	
Perches	Cu feet	24.75
Pes (Ancient Rome)	Inches	11.7
	Palmi	4
	Passus	0.2

Convert From	Into	Multiply By
Petrograd standard	Cu feet	165
Phots	Foot-candles	929.03
	Lumens/sq cm	1
	Lumens/sq meter	10000
	Lux	10000
Picas (printing)	Centimeters	0.42175
	Inches	0.16604 or 1/6
	Points	12
Picofarads	Farads	1×10^{-12}
	Microfarads	1×10^{-6}
Picul (Malaysia)	Katis	100
	Kilogram	60.48
	Pound	133.33
Pie (Rome)	Inches	11.73
Pinch	Teaspoon	1/3 to 1/4
Pints (Brit)	Cu cm	568.261
	Gallons (Brit)	0.125
	Gills (Brit)	4
	Gills (US)	4.8038
	Liters	0.5682
	Minims (Brit)	9600
	Ounces (Brit,flu)	20
	Pints (US,dry)	1.03206
	Pints (US,liq)	1.2009
	Quarts (Brit)	0.5
	Scruples (Brit,flu)	480
Pints (US,dry)	Bushels (US)	0.0156
	Cu cm	550.61
	Cu inches	33.6003
	Gallons, (US,dry)	0.125
	Gallons (US,liq)	0.14546
	Liters	0.5506
	Pecks (US)	0.625
	Pints (US,liq)	1.1636
	Quarts (US,dry)	0.5
Pints (US,liq)	Cu cm	473.176
	Cu feet	0.01671
	Cu inches	28.875
	Cu yards	0.000619
	Cups	2
	Drams (US,flu)	128
	Fifths	0.625
	Gallons (US,liq)	0.125
	Gills (US)	4
	Jiggers	24
	Liters	0.47316
	Milliliters	473.163
	Minims (US)	7680
	Ounces (US,flu)	16
	Pints (Brit)	0.8327
	Pints (US,dry)	0.85937
	Ponys	48
	Quarts (US,liq)	0.5
	Shots	16
	Teaspoons	96

Convert From	Into	Multiply By
Pints (US,liq)	Tablespoons	32
Pipe (English, wine)	Gallons	105
	Liters	477.34
Planck's constant	Erg–seconds	6.625×10^{-27}
	Joule–seconds	6.625×10^{-34}
	Joule–sec/Avagad.#	3.99×10^{-10}
Points (printing)	Centimeters	0.0351
	Inches	0.01384 or 1/72
	Picas	0.0833
Poises	Grams/(cm x sec)	1
Poise–cu cm/gram	Sq cm/sec	1
Poise–cu ft/lb	Sq cm/sec	62.428
Poise–cu in/gram	Sq cm/sec	16.3871
Ponys	Fifths	0.013
	Jiggers	0.5
	Ounces, (US,fluid)	0.75
	Pints	0.0208
	Shots	0.75
Pottles (Brit)	Gallons (Brit)	0.5
	Liters	2.273
Poud (Russia)	Pounds	36.113
Pounce (France)	Millimeters	27.07
Poundals	Dynes	13825
	Grams	14.098
	Joules/cm	1.383×10^{-3}
	Joules/meter (newtons)	0.1383
	Kilograms	0.0141
	Pounds (avdp)	0.03108
Pounds (apoth or troy)	Drams (apoth or troy)	96
	Drams (avdp)	210.65
	Grains	5760
	Grams	373.24
	Kilograms	0.37324
	Ounces (apoth or troy)	12
	Ounces (avdp)	13.166
	Pennyweights	240
	Pounds (avdp)	0.82286
	Scruples (apoth)	288
	Tons (long)	0.000367
	Tons (metric)	0.000373
	Tons (short)	0.0004114
Pounds (avdp)	Drams (apoth or troy)	116.667
	Drams (avdp)	256
	Dynes	44.48×10^4
	Grains	7000
	Grams	453.59
	Hundredweights (long)	0.008929
	Hundredweights (shrt)	0.01
	Joules/cm	0.04448
	Joules/meter	4.448
	Kilograms	0.4536
	Ounces (apoth or troy)	14.583
	Ounces (avdp)	16
	Pennyweights	291.667
	Poundals	32.174

Convert From	Into	Multiply By
Pounds (avdp)	Pounds (apoth or troy)	1.21528
	Scruples (apoth)	350
	Slugs	0.03108
	Tons (long)	0.0004464
	Tons (metric)	0.0004536
	Tons (short)	0.0005
Pounds/cu foot	Grams/cu cm	0.016018
	Kg/cu meter	16.018
	Lbs/cu inch	5.787×10^{-4}
	Lbs/cu yard	27
	Lbs/mil–foot	5.456×10^{-9}
Pounds/cu inch	Grams/cu cm	27.6799
	Grams/liter	27.6807
	Kg/cu meter	27679.9
	Lbs/cu foot	1728
	Lbs/mil–foot	9.425×10^{-6}
Pounds/cu yard	Lbs/cu foot	0.037
Pounds/foot	Kilograms/meter	1.488
Pounds/gal (Brit)	Pounds/cu ft	6.2288
Pounds/gal (US,liq)	Grams/cu cm	0.11983
	Pounds/cu ft	7.48052
Pounds/inch	Grams/cm	178.5797
	Grams/ft	5443.11
	Grams/inch	453.592
	Ounces/cm	6.2992
	Ounces/inch	16
	Pounds/meter	39.37008
Pounds/mil–foot	Gms/cu cm	2.306×10^{6}
Pounds/minute	Kilograms/hr	27.2155
	Kilograms/min	0.45359
Pounds/sq ft	Atmospheres	0.00047
	Bars	0.000479
	Cm of Hg @ 0°C	0.03591
	Dynes/sq cm	478.803
	Feet of water	0.01602
	Grams/sq cm	0.48824
	In of Hg @ 32°F	0.014139
	In of H_2O @ 39.2°F	0.19223
	Kg/sq meter	4.88243
	Lbs/sq inch	0.00694
	Mm of Hg @ 0°C	0.35913
Pounds/sq in	Atmospheres	0.06805
	Bars	0.06895
	Cm of Hg @ 0°C	5.17149
	Cm of H_2O @ 4°C	70.3089
	Dynes/sq cm	68947
	Feet of water	2.307
	Grams/sq cm	70.307
	In of Hg @ 32°F	2.036
	In of H_2O @ 39.2°F	27.681
	Kg/sq cm	0.07031
	Lbs/sq foot	144
	Mm of Hg @ 0°C	51.715
Pounds of water	Cu feet	0.01602
	Cu inches	27.68

Convert From	Into	Multiply By
Pounds of water	Gallons	0.1198
Pounds of water/min	cu ft/sec	2.67×10^{-4}
Pound-feet	Cm-dynes	1.356×10^{7}
	Cm-grams	13825
	Meter-kilograms	0.1383
PPM	See parts/million	
Prospecting dish	Gallons	2
	Cu Yards	008929
Pu (China)	Inches	70.5
Puncheons (Brit)	Cu meters	0.31797
	Gallons (Brit)	69.9447
	Gallons (US)	84
Quadrants	Degrees	90
	Minutes	5400
	Radians	1.5708
	Seconds	3.24×10^{5}
Quarterns (Brit,dry)	Buckets (Brit)	0.125
	Bushels (Brit)	0.0625
	Cu cm	2273.04
	Gallons (Brit)	0.5
	Liters	2.27298
	Pecks (Brit)	0.25
Quarterns (Brit,liq)	Cu cm	142.065
	Gallons (Brit)	0.03125
	Liters	0.14206
Quarters (US,long)	Kilograms	254.0117
	Pounds (avdp)	560
Quarters (US,shrt)	Kilograms	226.796
	Pounds (avdp)	500
Quarts (Brit)	Cu cm	1136.52
	Cu inches	69.355
	Gallons (Brit)	0.25
	Gallons (US,liq)	0.30024
	Liters	1.1365
	Quarts (US,dry)	1.0321
	Quarts (US,liq)	1.2009
Quarts (US,dry)	Bushels (US)	0.03125
	Cu cm	1101.2
	Cu feet	0.03889
	Cu inches	67.2006
	Gallons (US,dry)	0.25
	Gallons (US,liq)	0.29091
	Liters	1.10119
	Pecks (US)	0.125
	Pints (US,dry)	2
Quarts (US,liq)	Cu cm	946.353
	Cu feet	0.0334
	Cu inches	57.75
	Cu meters	9.464×10^{-4}
	Cu yards	1.238×10^{-3}
	Drams (US,flu)	256
	Fifth	1.25
	Gallons (US,dry)	0.2148
	Gallons (US,liq)	0.25
	Gills (US)	8

Convert From	Into	Multiply By
Quarts (US,liq)	Liters	0.9463
	Magnums	0.5
	Ounces (US,flu)	32
	Pints (US,liq)	2
	Quarts (Brit)	0.83267
	Quarts (US,dry)	0.859367
	Shots	32
Quintals (metric)	Grams	100000
	Hundredweights (long)	1.9684
	Kilograms	100
	Pounds (avdp)	220.462
Quintal (USA, old)	Kilograms	45.36
	Pounds	100
Quires	Ream	0.05
	Sheets	24
Radians	Circumferences	0.15915
	Degrees	57.29578
	Minutes	3437.747
	Quadrants	0.63662
	Revolutions	0.15915
	Seconds	206264
Radians/cm	Degrees/cm	57.2958
	Degrees/ft	1746.37
	Degrees/in	145.531
	Minutes/cm	3437.75
Radians/sec	Degrees/sec	57.2958
	Revolutions/min	9.5493
	Revolutions/sec	0.15915
Radians/(sec x sec)	Revolutions/(min x min)	572.96
	Revolutions/(min x sec)	9.549297
	Revolutions/(sec x sec)	0.15915
Rattel (Arabia)	Pounds (avdp)	1.02
Ream	Quires	20
	Sheets	480
Register tons	Cu feet	100
	Cu meters	2.8317
Revolutions	Degrees	360
	Grades	400
	Quadrants	4
	Radians	6.2832
Revolutions/min	Degrees/sec	6
	Radians/sec	0.1047
	Revolutions/sec	0.01667
Revolutions/(min x min)	Radians/(sec x sec)	1.745×10^{-3}
	Revolutions/(min x sec)	0.01667
	Revolutions/(sec x sec)	2.778×10^{-4}
Revolutions/sec	Degrees/sec	360
	Radians/sec	6.283
	Revolutions/min	60
Revolutions/(sec x sec)	Radians/(sec x sec)	6.283
	Revolutions/(min x min)	3600
	Revolutions/(min x sec)	60
Reyns	Centipoises	6.8948×10^{6}
Rhes	Poises^{-1}	1
Ri (Japan)	Miles	2.440

Convert From	Into	Multiply By
Rods	Centimeters	502.92
	Chains (Gunter's)	0.25
	Chains (Ramden's)	0.165
	Feet	16.5
	Feet (US Survey)	16.49997
	Furlongs	0.025
	Inches	198
	Links (Gunter's)	25
	Links (Ramden's)	16.5
	Meters	5.0292
	Miles (statute)	0.00312
	Perches	1
	Yards	5.5
Ropes (Brit)	Feet	20
	Meters	6.096
	Yards	6.66667
Sabbath's Day Journey	Cubits	2000
	Yards	1000
Schoppen (Germany)	Liters	0.5
Score		20
Scruples (apoth)	Drams (apoth or troy)	0.3333
	Drams (avdp)	0.73143
	Grains	20
	Grams	1.29598
	Ounces (apoth or troy)	0.04167
	Ounces (avdp)	0.45714
	Pennyweights	0.8333
	Pounds (apoth or troy)	0.00347
	Pounds (avdp)	0.002857
Scruples (Brit,flu)	Grains	20
	Minims (Brit)	20
Se (Japan)	Square Yards	118.615
Sea Mile	Degree of latitude	1/60th
Seah (Old Testament)	Liters	7.3
Seams (Brit)	Bushels (Brit)	8
	Cu feet	10.2
	Liters	290.94
Seconds (angle)	Degrees	0.000278
	Minutes	0.016667
	Quadrants	3.087×10^{-6}
	Radians	4.8481×10^{-6}
Seconds (mean solar)	Days (mean solar)	1.1574×10^{-5}
	Days (sideral)	1.1606×10^{-5}
	Hours (mean solar)	0.000278
	Hours (sideral)	0.000278
	Minutes (mean solar)	0.0166667
	Minutes (sideral)	0.016712
	Seconds (sideral)	1.002738
Seconds (sideral)	Days (mean solar)	1.1542×10^{-5}
	Days (sideral)	1.1574×10^{-5}
	Hours (mean solar)	0.000277
	Hours (sideral)	0.0002778
	Minutes (mean solar)	0.016621
	Minutes (sideral)	0.0166667
	Seconds (mean solar)	0.9972696

Convert From	Into	Multiply By
Seer (India)	Pounds (avdp)	2.057
Shaku (Japan)	Meters	10/33
Shekel (Old Palestine)	Grains	252
	Grams	16.33
	Pounds (avdp)	0.035999
	Talents	0.00033
Shekel (Old Testament)	Bekah	2
	Grams	11
	Mina	0.02
	Talent	0.00033
Sheng (China)	Liters	1.035
Shih (China)	Pounds	157.89
Sho (Japan)	Liters	1.804
Shots	Fifths	0.039
	Jiggers	0.666
	Ounces, (US, fluid)	1
	Pints	0.0625
	Ponys	1.333
	Quarts	0.03125
Skeins	Feet	360
	Meters	109.728
Slugs	Geepounds	1
	Kilograms	154.594
	Pounds (avdp)	32.174
Slugs/cu ft	Grams/cu cm	0.51538
Spans	Centimeters	22.86
	Fathoms	0.125
	Feet	0.75
	Inches	9
	Quarters (Brit)	1
Span (Old English)	Inches	6
Sphere	Steradians	12.57
Sq centimeters	Ares	1×10^{-6}
	Circ mm	127.324
	Circ mils	197352
	Sq chains (Gunter's)	2.471×10^{-7}
	Sq chains (Ramden's)	1.0764×10^{-7}
	Sq decimeters	0.01
	Sq feet	0.001076
	Sq feet (US Survey)	0.001076
	Sq inches	0.155
	Sq meters	0.0001
	Sq mm	100
	Sq miles	3.861×10^{-11}
	Sq mils	155000
	Sq rods	3.9537×10^{-6}
	Sq yards	0.0001196
Sq chains (Gunter's)	Acres	0.1
	Sq feet	4356
	Sq feet (US Survey)	4355.98
	Sq inches	627264
	Sq links (Gunter's)	10000
	Sq meters	404.69
	Sq miles	0.000156
	Sq rods	16

Convert From	Into	Multiply By
Sq chains (Gunter's)	Sq yards	484
Sq chains (Ramden's)	Acres	0.22957
	Sq feet	10000
	Sq feet (US Survey)	9999.96
	Sq inches	1.44×10^6
	Sq links (Ramden's)	10000
	Sq meters	929.03
	Sq miles	0.000305
	Sq rods	36.7309
	Sq yards	1111.11
Sq decimeters	Sq cm	100
	Sq inches	15.50003
Sq degrees	Steradians	0.0003
Sq dekameters	Acres	0.02471
	Ares	1
	Sq meters	100
	Sq yards	119.599
Sq feet	Acres	2.2957×10^{-5}
	Ares	0.000929
	Circular mils	1.833×10^8
	Sq cm	929.03
	Sq chains (Gunter's)	0.0002296
	Sq feet (US Survey)	0.999996
	Sq inches	144
	Sq links (Gunter's)	2.2957
	Sq meters	0.0929
	Sq miles	3.58701×10^{-8}
	Sq millimeters	9.290×10^4
	Sq rods	0.003673
	Sq yards	0.1111
Sq feet (US Survey)	Acres	2.2957×10^{-5}
	Sq centimeters	929.034
	Sq chains (Ramden's)	0.0001
	Sq feet	1.0000040
Sq hectometers	Sq meters	10000
Sq inches	Circular mils	1273239
	Sq cm	6.4516
	Sq chains (Gunter's)	1.5942×10^{-6}
	Sq decimeters	0.064516
	Sq feet	0.00694
	Sq ft (US Survey)	0.00694
	Sq links (Gunter's)	0.01594
	Sq meters	0.000645
	Sq miles	2.491×10^{-10}
	Sq mm	645.16
	Sq mils	1×10^6
Sq inches/sec	Sq cm/hour	23226
	Sq cm/sec	6.4516
	Sq ft/min	0.41667
Sq kilometers	Acres	247.105
	Sq centimeters	10^{10}
	Sq feet	1.07639×10^7
	Sq feet (US Survey)	1.07639×10^7
	Sq inches	1.550003×10^9
	Sq meters	1×10^6

Convert From	Into	Multiply By
Sq kilometers	Sq miles	0.3861
	Sq yards	1.196×10^6
Sq links (Gunter's)	Acres	1×10^{-5}
	Sq cm	404.686
	Sq chains (Gunter's)	0.0001
	Sq feet	0.4356
	Sq feet (US Survey)	0.4356
	Sq inches	62.726
Sq links (Ramden's)	Acres	2.2957×10^{-5}
	Sq feet	1
Sq meters	Acres	0.000247
	Ares	0.01
	Hectares	0.0001
	Sq cm	10000
	Sq feet	10.7639
	Sq inches	1550.003
	Sq kilometers	1×10^{-6}
	Sq links (Gunter's)	24.71054
	Sq links (Ramden's)	10.764
	Sq miles	3.861×10^{-7}
	Sq mm	1×10^6
	Sq rods	0.03954
	Sq yards	1.10599
Sq miles	Acres	640
	Hectares	258.999
	Sq chains (Gunter's)	6400
	Sq feet	2.78783×10^7
	Sq feet (US Survey)	2.7829×10^7
	Sq kilometers	2.58999
	Sq meters	258999
	Sq rods	102400
	Sq yards	3.098×10^6
Sq millimeters	Circular mm	1.2732
	Circular mils	1973.5
	Sq cm	0.01
	Sq feet	1.076×10^{-5}
	Sq inches	0.00155
	Sq meters	1×10^{-6}
Sq mils	Circular mils	1.273
	Sq cm	6.452×10^{-6}
	Sq inches	1×10^{-6}
	Sq mm	0.000645
Sq rods	Acres	0.00625
	Ares	0.25293
	Hectares	0.00253
	Sq cm	252928
	Sq feet	272.25
	Sq feet (US Survey)	272.249
	Sq inches	39204
	Sq links (Gunter's)	625
	Sq links (Ramden's)	272.25
	Sq meters	25.293
	Sq miles	9.7656×10^{-6}
	Sq yards	30.25
Sq yards	Acres	0.000207

Convert From	Into	Multiply By
Sq yards	Ares	0.00836
	Hectares	8.3613×10^{-5}
	Sq cm	8361.27
	Sq chains (Gunter's)	0.002066
	Sq chains (Ramden's)	0.0009
	Sq feet	9
	Sq feet (US Survey)	8.99996
	Sq inches	1296
	Sq links (Gunter's)	20.661
	Sq links (Ramden's)	9
	Sq meters	0.8361
	Sq miles	3.228×10^{-7}
	Sq millimeters	8.361×10^{5}
	Sq rods	0.03306
Stadia (Ancient Rome)	Miles	0.92
	Milliar	0.125
Stadion (Ancient Greece)	Ammas	10
	Yards	200
Stadium (Ancient Rome)	Passus	125
	Yards	202.3
Statamperes	Abamperes	3.3356×10^{-11}
	Amperes	3.3356×10^{-10}
Statcoulombs	Ampere–hours	9.2656×10^{-14}
	Coulombs	3.3356×10^{-10}
	Elecltronic charges	2.082×10^{9}
Statfarads	Farads	1.1126×10^{-12}
	Microfarads	1.1126×10^{-6}
Stathenries	Abhenries	8.9876×10^{29}
	Henries	8.9876×10^{11}
	Millihenries	8.9876×10^{14}
Statohms	Abohms	8.9876×10^{20}
	Ohms	8.9876×10^{11}
Statvolts	Abvolts	2.9979×10^{10}
	Volts	299.79
Statvolts/cm	Volts/cm	299.79
	Volts/inch	761.47
Statvolts/inch	Volts/cm	118.029
Steradians	Hemispheres	0.15915
	Solid angles	0.079577
	Spheres	0.079577
	Spher. right angles	0.63662
	Square degrees	3282.81
Steres	Cubic meters	1
	Decisters	10
	Dekasteres	0.1
	Liters	999.97
Stilbs	Candles/sq cm	1
	Candles/sq inch	6.4516
	Lamberts	3.14159
Stokes	Sq cm/sec	1
	Sq inches/sec	0.1550003
	Poise cu cm/gram	1
Stones (Brit,legal)	Centals (Brit)	0.14
	Pounds	14
Talent (Old Palestine)	Kilograms	20 to 40

Convert From	Into	Multiply By
Talent (Old Palestine)	Pounds	107.9999
	Mina	60
	Shekel	3000
Tablespoons	Cups	0.0625
	Drops	180
	Gills	0.125
	Ounces (US, fluid)	0.5
	Quarts	0.01562
	Teaspoons	3
Teaspoons	Cups	0.02083
	Drops	60
	Gills	0.0416
	Ounces (US, fluid)	0.1666
	Pinch	3 to 4
	Pints	0.01042
	Quarts	0.00521
	Tablespoons	0.3333
Therm	Btu	100000
Tierce	Gallons	42
To (Japan)	Liters	18.039
Toise (France)	Meters	1.949
Tonos (Greece)	Pounds (avdp)	3307
Tons (long)	Dynes	9.964×10^8
	Hundredweights (long)	20
	Hundredweights (shrt)	22.4
	Kilograms	1016.05
	Ounces (avdp)	35840
	Pounds (apoth or troy)	2722.2
	Pounds (avdp)	2240
	Tons (metric)	1.10605
	Tons (short)	1.12
Tons (metric)	Dynes	9.807×10^8
	Grams	$1.\times 10^6$
	Hundredweights (shrt)	22.0462
	Kilograms	1000
	Ounces (avdp)	35273.96
	Pounds (apoth or troy)	2679.23
	Pounds (avdp)	2204.62
	Tons (long)	0.98421
	Tons (short)	1.1023
Tons (short)	Dynes	8.8964×10^8
	Hundredweights (shrt)	20
	Kilograms	907.18
	Ounces (avdp)	32000
	Pounds (apoth or troy)	2430.55
	Pounds (avdp)	2000
	Tons (long)	0.89286
	Tons (metric)	0.90718
Tons (long)/sq ft	Atmospheres	1.0585
	Dynes/sq cm	1.0725×10^6
	Grams/sq cm	1093.66
	Pounds/sq ft	2240
Tons (short)/sq ft	Atmospheres	0.9451
	Dynes/sq cm	957.6
	Grams/sq cm	976.49

Convert From	Into	Multiply By
Tons (short)/sq ft	Pounds/sq inch	13.889
Tons (long)/sq in	Atmospheres	152.423
	Dynes/sq cm	1.544×10^8
	Grams/sq cm	15749
Tons (short)/sq in	Dynes/sq cm	1.3789×10^8
	Kg/sq mm	1406.14
	Pounds/sq inch	2000
Tons of water/24 hrs	Pounds of water/hr	83.333
	Gallons/min	0.16643
	Cu ft/hr	1.3349
Torrs	Mm of Hg @ 0°C	1
Townships	Acres	23040
	Sections	36
	Sq miles	36
Tu (China)	Miles	100.142
Tuns	Gallons (US)	252
	Hogsheads	4
	Pipes	2
	Puncheons	3
Vara (Old Spanish)	Feet	2.6816
	Meters	0.8359
Vara (S. America)	Meters	0.8 to 1.1
Vedro (Russia)	Liters	12.3
Verst (Russia)	Feet	3500
	Meters	1067.07
Volts	Abvolts	1×10^8
	Statvolts	0.00333
	Volts (Int)	0.99967
Volts (Int)	Volts	1.0003
Volt–coulombs	Joules (Int)	0.9998
Volt–seconds	Maxwells	1×10^8
Watts	Btu/hr	3.4144
	Btu (mean)/hr	3.4095
	Btu (mean)/min	0.056825
	Btu/sec	0.000948
	Btu (mean)/sec	0.000947
	Cal,gm/hr	860.42
	Cal,gm (mean)/hr	859.18
	Cal,gm (@20°C)/hr	860.85
	Cal,gm/min	14.34
	Cal,gm (IST)/min	14.331
	Cal,gm (mean)/min	14.3197
	Cal,kg/min	0.01434
	Cal,kg (IST)/min	0.01433
	Cal,kg (mean)/min	0.01432
	Ergs/sec	1×10^7
	Foot–pounds/min	44.2537
	Foot–pounds/sec	0.7378
	Horsepower	0.00134
	Horsepower (boiler)	0.0001
	Horsepower (electric)	0.00134
	Horsepower (metric)	0.0013596
	Joules/sec	1
	Kilogram–calories/min	0.01433
	Kilowatts	0.001

Convert From	Into	Multiply By
Watts	Liter-atmosphere/hr	35.528
	Watts (Int)	0.9998
Watts (Int)	Btu/hr	3.41499
	Btu (mean)/hr	3.41008
	Btu/min	0.56916
	Btu (mean)/min	0.0568
	Cal,gm/hr	860.56
	Cal,gm (mean)/hr	859.326
	Cal,kg/min	0.0143
	Cal,kg (IST)/min	0.01433
	Cal,kg (mean)/min	0.01432
	Ergs/sec	1.00016×10^7
	Joules (Int)/sec	1
	Watts	1.00016
Watts/sq cm	Btu/(hr x sq ft)	3172.1
	Cal,gm/(hr x sq cm)	860.421
	Ft-lb/(min x sq ft)	41113
Watts/sq in	Btu/(hr x sq ft)	491.68
	Cal,gm/(hr x sq cm)	133.36
	Ft-lb/(min x sq ft)	6372.5
Watt-hours	Btu	3.4144
	Btu (mean)	3.4095
	Cal,gm	860.42
	Cal,kg (mean)	0.85918
	Cal, gm (mean)	859.18
	Ergs	3.60×10^{10}
	Foot-pounds	2655.22
	Hp-hours	0.00134
	Joules	3600
	Joules (Int)	3599.41
	Kg-calories	0.8605
	Kg-meters	367.098
	Kw-hours	0.001
	Watt-hours (Int)	0.9998
Watt-sec	Foot-pounds	0.73756
	Gram-cm	10197.2
	Joules	1
	Liter-atmospheres	0.00987
	Volt-coulombs	1
Webers	Kilolines	1×10^5
	Lines	1×10^8
	Maxwells	1×10^8
	Volt-seconds	1
Webers/sq cm	Gausses	1×10^8
	Lines	1×10^8
	Lines/sq in	6.4515×10^8
Webers/sq in	Gausses	1.550003×10^7
	Lines/sq inch	10^8
	Webers/sq cm	0.1550
	Webers/sq meter	1550
Webers/sq meter	Gausses	10^4
	Lines/sq inch	6.452×10^4
	Webers/sq cm	10^{-4}
	Webers/sq inch	6.452×10^{-4}
Weeks (mean calendar)	Days (mean solar)	7

Convert From	Into	Multiply By
Weeks (mean calendar)	Days (sideral)	7.01916
	Hours (mean solar)	168
	Hours (sideral)	168.46
	Minutes (mean solar)	10080
	Minutes (sideral)	10107.6
	Months (lunar)	0.237042
	Months (mean calendar)	0.230137
	Years (calendar)	0.019178
	Years (sideral)	0.0191646
	Years (tropical)	0.019165
Weys (Brit)	Pounds (avdp)	252
Yards	Centimeters	91.44
	Chains (Gunter's)	0.454545
	Chains (Ramden's)	0.03
	Cubits	2
	Fathoms	0.5
	Feet	3
	Feet (US Survey)	2.999994
	Furlongs	0.004545
	Inches	36
	Kilometers	9.144×10^{-4}
	Meters	0.9144
	Miles (naut)	4.934×10^{-4}
	Miles (statute)	5.682×10^{-4}
	Millimeters	914.4
	Poles (Brit)	0.181818
	Quarters (Brit)	4
	Rods	0.181818
	Spans	4
Years (calendar)	Days (mean solar)	365
	Hours (mean solar)	8760
	Minutes (mean solar)	525600
	Months (lunar)	12.36006
	Months (mean calendar)	12
	Seconds (mean solar)	3.1536×10^{7}
	Weeks (mean calendar)	52.14286
	Years (sideral)	0.999298
	Years (tropical)	0.999337
Years (leap)	days (mean solar)	366
Years (sideral)	Days (mean solar)	365.2564
	Days (sideral)	366.2564
	Years (calendar)	1.000702
	Years (tropical)	1.000039
Years (tropical)	Days (mean solar)	365.242
	Days (sideral)	366.242
	Hours (mean solar)	8765.81
	Hours (sideral)	8789.81
	Months (mean calendar)	12.00796
	Seconds (mean solar)	3.15569×10^{7}
	Seconds (sideral)	3.16433×10^{7}
	Weeks (mean calendar)	52.17746
	Years (calendar)	1.000663
	Years (sideral)	0.99996
Zoll (Switzerland)	Centimeters	3
Zolotnik (Russia)	Grains	65.8306

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