Engineering Formula Sheet

Statistics

Mean

$$\mu = \frac{\sum x_i}{n}$$

μ = mean value
Σx_i = sum of all data values (x_1, x_2, x_3, …)
n = number of data values

Standard Deviation

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

σ = standard deviation
x_i = individual data value (x_1, x_2, x_3, …)
μ = mean value
n = number of data values

Mode

Place data in ascending order.
Mode = most frequently occurring value

If two values occur at the maximum frequency the data set is *bimodal.*
If three or more values occur at the maximum frequency the data set is *multi-modal.*

Median

Place data in ascending order.
If n is odd, median = central value
If n is even, median = mean of two central values

n = number of data values

Range

Range = x_{max} - x_{min}

x_{max} = maximum data value
x_{min} = minimum data value

Probability

Frequency

$$f_x = \frac{n_x}{n}$$

$$P_x = \frac{f_x}{f_a}$$

f_x = relative frequency of outcome x
n_x = number of events with outcome x
n = total number of events
P_x = probability of outcome x
f_a = frequency of all events

Binomial Probability (order doesn't matter)

$$P_k = \frac{n!(p^k)(q^{n-k})}{k!(n-k)!}$$

P_k = binomial probability of k successes in n trials
p = probability of a success
q = 1 – p = probability of failure
k = number of successes
n = number of trials

Independent Events

P (A and B and C) = $P_A P_B P_C$

P (A and B and C) = probability of independent events A and B and C occurring in sequence
P_A = probability of event A

Mutually Exclusive Events

P (A or B) = $P_A + P_B$

P (A or B) = probability of either mutually exclusive event A or B occurring in a trial
P_A = probability of event A
Σx_i = sum of all data values (x_1, x_2, x_3, …)
n = number of data values

Conditional Probability

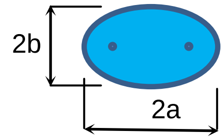
$$P(A|D) = \frac{P(A) \cdot P(D|A)}{P(A) \cdot P(D|A) + P(\sim A) \cdot P(D|\sim A)}$$

P (A|D) = probability of event A given event D
P(A) = probability of event A occurring
P(~A) = probability of event A not occurring
P(D|~A) = probability of event D given event A did not occur

Plane Geometry

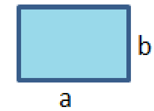
Ellipse

Area = π a b



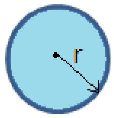
Rectangle

Perimeter = 2a + 2b
Area = ab



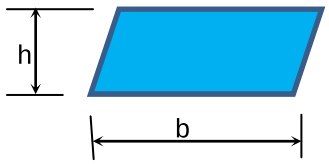
Circle

Circumference =2 π r
Area = π r^2



Parallelogram

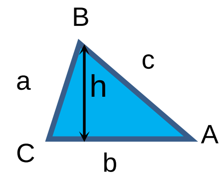
Area = bh



Triangle

Area = ½ bh

$a^2 = b^2 + c^2 - 2bc \cdot \cos\angle A$
$b^2 = a^2 + c^2 - 2ac \cdot \cos\angle B$
$c^2 = a^2 + b^2 - 2ab \cdot \cos\angle C$



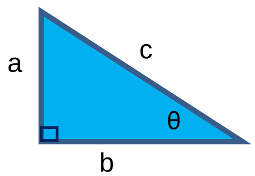
Right Triangle

$c^2 = a^2 + b^2$

$\sin\theta = \frac{a}{c}$

$\cos\theta = \frac{b}{c}$

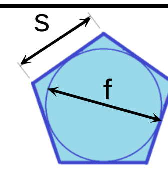
$\tan\theta = \frac{a}{b}$



Regular Polygons

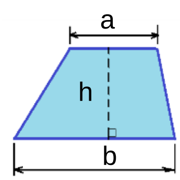
Area = $n\,\dfrac{s(\frac{1}{2}f)}{2}$

n = number of sides



Trapezoid

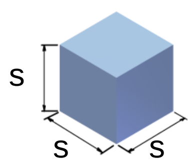
Area = ½(a + b)h



Solid Geometry

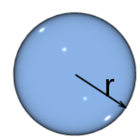
Cube

Volume = s^3
Surface Area = $6s^2$



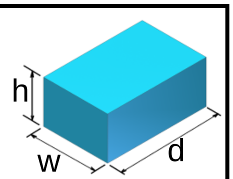
Sphere

Volume $\frac{4}{3}\pi r^3$
Surface Area = 4 π r^2



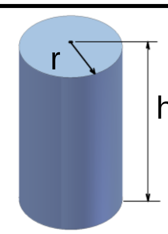
Rectangular Prism

Volume = wdh
Surface Area = 2(wd + wh + dh)



Cylinder

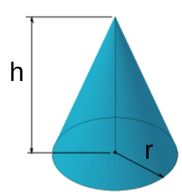
Volume = $\pi r^2 h$
Surface Area = $2\pi r h + 2\pi r^2$



Right Circular Cone

Volume = $\dfrac{\pi r^2 h}{3}$

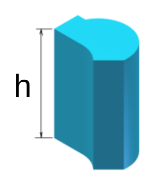
Surface Area = $\pi r \sqrt{r^2+h^2}$



Irregular Prism

Volume = Ah

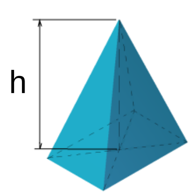
A = area of base



Pyramid

Volume = $\dfrac{Ah}{3}$

A = area of base



Constants

g = 9.8 m/s² = 32.27 ft/s² ($g = 9.8\ m/s^2 = 32.27\ ft/s^2$)

$G = 6.67 \times 10^{-11}\ m^3/kg \cdot s^2$

π = 3.14159

Conversions

Mass

1 kg	= 2.205 lb_m
1 slug	= 32.2 lb_m
1 ton	= 2000 lb_m

Area

1 acre	= 4047 m^2
	= 43,560 ft^2
	= 0.00156 mi^2

Force

1 N	= 0.225 lb_f
1 kip	= 1,000 lb_f

Energy

1 J	= 0.239 cal
	= 9.48 x 10^{-4} Btu
	= 0.7376 ft·lb_f
1kW h	= 3,6000,000 J

Length

1 m	= 3.28 ft
1 km	= 0.621 mi
1 in.	= 2.54 cm
1 mi	= 5280 ft
1 yd	= 3 ft

Volume

1L	= 0.264 gal
	= 0.0353 ft^3
	= 33.8 fl oz
1mL	= 1 cm^3 = 1 cc

Pressure

1 atm	= 1.01325 bar
	= 33.9 ft H_2O
	= 29.92 in. Hg
	= 760 mm Hg
	= 101,325 Pa
	= 14.7 psi
1psi	= 2.31 ft of H_2O

Temperature Change

1 K	= 1 ºC
	= 1.8 ºF
	= 1.8 ºR

Time

1 d	= 24 h
1 h	= 60 min
1 min	= 60 s
1 yr	= 365 d

Power

1 W	= 3.412 Btu/h
	= 0.00134 hp
	= 14.34 cal/min
	= 0.7376 ft·lb_f/s

Defined Units

1 J	= 1 N·m
1 N	= 1 kg·m / s^2
1 Pa	= 1 N / m^2
1 V	= 1 W / A
1 W	= 1 J / s
1 Ω	= 1 V / A
1 Hz	= 1 s^{-1}
1 F	= 1 A·s / V
1 H	= 1 V·s / V

SI Prefixes

Numbers Less Than One

Power of 10	Prefix	Abbreviation
10^{-1}	deci-	d
10^{-2}	centi-	c
10^{-3}	milli-	m
10^{-6}	micro-	µ
10^{-9}	nano-	n
10^{-12}	pico-	p
10^{-15}	femto-	f
10^{-18}	atto-	a
10^{-21}	zepto-	z
10^{-24}	yocto-	y

Numbers Greater Than One

Power of 10	Prefix	Abbreviation
10^{1}	deca-	da
10^{2}	hecto-	h
10^{3}	kilo-	k
10^{6}	Mega-	M
10^{9}	Giga-	G
10^{12}	Tera-	T
10^{15}	Peta-	P
10^{18}	Exa-	E
10^{21}	Zetta-	Z
10^{24}	Yotta-	Y

Equations

Mass and Weight

$M = VD_m$

$W = mg$

$W = VD_w$

V = volume
D_m = mass density
m = mass
D_w = weight density
g = acceleration due to gravity

Temperature

$T_K = T_C + 273$

$T_R = T_F + 460$

$$\frac{T_F - 32}{180} = \frac{T_C}{100}$$

T_K = temperature in Kelvin
T_C = temperature in Celsius
T_R = temperature in Rankin
T_F = temperature in Fahrenheit

Force

$F = ma$

F = force
m = mass
a = acceleration

Equations of Static Equilibrium

$\Sigma F_x = 0 \quad \Sigma F_y = 0 \quad \Sigma M_P = 0$

F_x = force in the x-direction
F_y = force in the y-direction
M_P = moment about point P

Equations (Continued)

Energy: Work

$W = F \cdot d$

W = work
F = force
d = distance

Power

$P = \frac{E}{t} = \frac{W}{t}$

$P = \frac{\tau \cdot rpm}{5252}$

P = power
E = energy
W = work
t = time
τ = torque
rpm = revolutions per minute

Efficiency

$\text{Efficiency (\%)} = \frac{P_{out}}{P_{in}} \cdot 100\%$

P_{out} = useful power output
P_{in} = total power input

Energy: Potential

$U = mgh$

U = potential energy
m =mass
g = acceleration due to gravity
h = height

Energy: Kinetic

$K = \frac{1}{2} mv^2$

K = kinetic energy
m = mass
v = velocity

Energy: Thermal

$Q = mc\Delta T$

Q = thermal energy
m = mass
c = specific heat
ΔT = change in temperature

Fluid Mechanics

$P = \frac{F}{A}$

$\frac{V_1}{T_1} = \frac{V_2}{T_2}$ (Charles' Law)

$\frac{P_1}{T_1} = \frac{P_2}{T_2}$ (Guy-Lussanc's Law)

$P_1V_1 = P_2V_2$ (Boyle's Law)

$Q = Av$

$A_1v_1 = A_2v_2$

$\text{Horsepower} = \frac{QP}{1714}$

absolute pressure = gauge pressure + atmospheric pressure

P = absolute pressure
F = Force
A = Area
V = volume
T = absolute temperature
Q = flow rate
v = flow velocity

Mechanics

$s = \frac{d}{t}$ *(where acceleration = 0)*

$\mathbf{v} = \frac{\mathbf{d}}{t}$ *(where acceleration = 0)*

$a = \frac{v_f - v_i}{t}$

$X = \frac{v_i \sin(2\theta)}{-g}$

$v = v_0 + at$

$d = d_0 + v_0t + \frac{1}{2}at^2$

$v^2 = v_0^2 + 2a(d - d_0)$

$\tau = dF\sin\theta$

s = speed
v = velocity
a = acceleration
X = range
t = time
d = distance
g = acceleration due to gravity
d = distance
θ = angle
τ = torque
F = force

Electricity

Ohm's Law
$V = IR$

$P = IV$

$R_T \text{ (series)} = R_1 + R_2 + \cdots + R_n$

$R_T \text{ (parallel)} = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}}$

Kirchhoff's Current Law
$I_T = I_1 + I_2 + \cdots + I_n$

or $I_T = \sum_{k=1}^{n} I_k$

Kirchhoff's Voltage Law
$V_T = V_1 + V_2 + \cdots + V_n$

or $V_T = \sum_{k=1}^{n} V_k$

V = voltage
V_T = total voltage
I = current
I_T = total current
R = resistance
R_T = total resistance
P = power

Thermodynamics

$P = Q' = AU\Delta T$

$P = \frac{Q}{\Delta t}$

$U = \frac{1}{R} = \frac{k}{L}$

$P = \frac{kA\Delta T}{L}$

$A_1v_1 = A_2v_2$

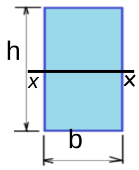
$P_{net} = \sigma Ae(T_2^4 - T_1^4)$

P = rate of heat transfer
Q = thermal energy
A = Area of thermal conductivity
U = coefficient of heat conductivity (U-factor)
ΔT = change in temperature
Δt = change in time
R = resistance to heat flow (R-value)
k = thermal conductivity
v = velocity
P_{net} = net power radiated
$\sigma = 5.6696 \times 10^{-8} \frac{W}{m^2 \cdot K^4}$
e = emissivity constant

Section Properties

Moment of Inertia

$$I_{xx} = \frac{bh^3}{12}$$



I_{xx} = moment of inertia of a rectangular section about x-x axis

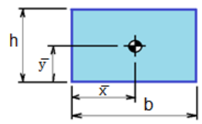
Complex Shapes Centroid

$$\bar{x} = \frac{\Sigma x_i A_i}{\Sigma A_i} \quad \text{and} \quad \bar{y} = \frac{\Sigma y_i A_i}{\Sigma A_i}$$

$\bar{x}$ = x-distance to the centroid
$\bar{y}$ = y-distance to the centroid
x_i = x distance to centroid of shape i
y_i = y distance to centroid of shape i
A_i = Area of shape i

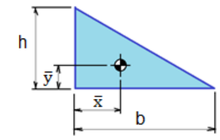
Rectangle Centroid

$$\bar{x} = \frac{b}{2} \quad \text{and} \quad \bar{y} = \frac{h}{2}$$



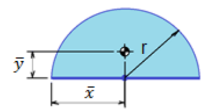
Right Triangle Centroid

$$\bar{x} = \frac{b}{3} \quad \text{and} \quad \bar{y} = \frac{h}{3}$$



Semi-circle Centroid

$$\bar{x} = r \quad \text{and} \quad \bar{y} = \frac{4r}{3\pi}$$



$\bar{x}$ = x-distance to the centroid
$\bar{y}$ = y-distance to the centroid

Material Properties

Stress (axial)

$$\sigma = \frac{F}{A}$$

σ = stress
F = axial force
A = cross-sectional area

Strain (axial)

$$\epsilon = \frac{\delta}{L_0}$$

ϵ = strain
L_0 = original length
δ = change in length

Modulus of Elasticity

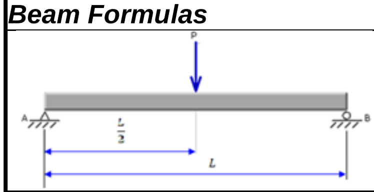
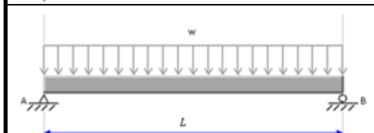
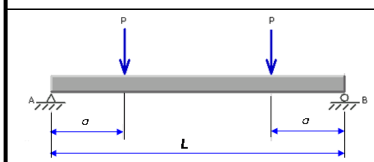
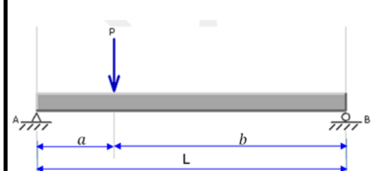
$$E = \frac{\sigma}{\varepsilon}$$

$$E = \frac{\sigma(F_2 - F_1)L_0}{(\delta_2 - \delta_1)A}$$

E = modulus of elasticity
σ = stress
ε = strain
A = cross-sectional area
F = axial force
δ = deformation

Structural Analysis

Beam Formulas

	**Reaction** $R_A = R_B = \frac{P}{2}$ **Moment** $M_{max} = \frac{PL}{4}$ (at point of load) **Deflection** $\Delta_{max} = \frac{PL^3}{48EI}$ (at point of load)
	**Reaction** $R_A = R_B = \frac{\omega L}{2}$ **Moment** $M_{max} = \frac{\omega L^2}{8}$ (at center) **Deflection** $\Delta_{max} = \frac{5\omega L^4}{384EI}$ (at center)
	**Reaction** $R_A = R_B = P$ **Moment** $M_{max} = Pa$ (between loads) **Deflection** $\Delta_{max} = \frac{Pa}{24EI}(3L^2 - 4a^2)$ (at center)
	**Reaction** $R_A = \frac{Pb}{L}$ and $R_B = \frac{Pa}{L}$ **Moment** $M_{max} = \frac{Pab}{L}$ (at Point of Load) **Deflection** $\Delta_{max} = \frac{Pab(a+2b)\sqrt{3a(a+2b)}}{27EI}$ (at $x = \sqrt{\frac{a(a+2b)}{3}}$, when $a > b$)

Deformation: Axial

$$\delta = \frac{FL_0}{AE}$$

δ = deformation
F = axial force
L_0 = original length
A = cross-sectional area
E = modulus of elasticity

Truss Analysis

2J = M + R

J = number of joints
M =number of members
R = number of reaction forces

Simple Machines

Mechanical Advantage (MA)

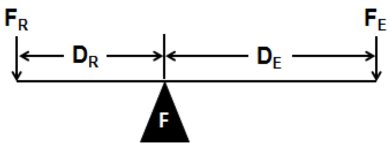
$$IMA = \frac{D_E}{D_R} \qquad AMA = \frac{F_R}{F_E}$$

$$\%\ Efficiency = \left(\frac{AMA}{IMA}\right) 100$$

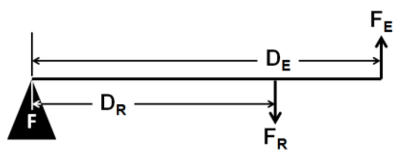
IMA = Ideal Mechanical Advantage
AMA = Actual Mechanical Advantage
D_E = Effort Distance D_R = Resistance Distance
F_E = Effort Force F_R = Resistance Force

Lever

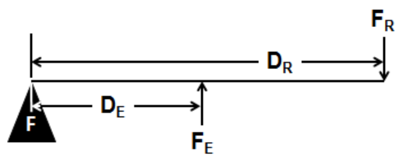
1st Class



2nd Class

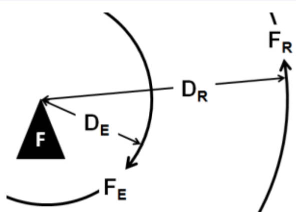


3rd Class

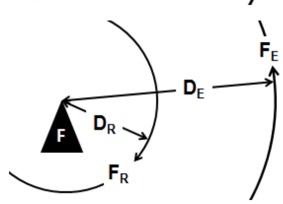


Wheel and Axle

Effort at Axle



Effort at Wheel



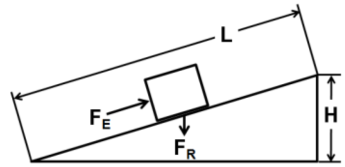
Pulley Systems

IMA = Total number of strands of a single string supporting the resistance

$$IMA = \frac{D_E\ \text{(string pulled)}}{D_R\ \text{(resistance lifted)}}$$

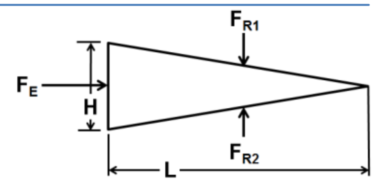
Inclined Plane

$$IMA = \frac{L\ \text{(slope)}}{H}$$



Wedge

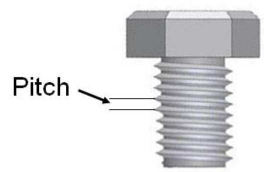
$$IMA = \frac{L\ (\perp \text{ to height})}{H}$$

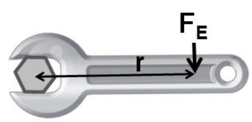


Screw

$$IMA = \frac{C}{Pitch}$$

$$Pitch = \frac{1}{TPI}$$





C = Circumference
r = radius
Pitch = distance between threads
TPI = Threads Per Inch

Compound Machines

$MA_{TOTAL} = (MA_1)\ (MA_2)\ (MA_3)\ .\ .\ .$

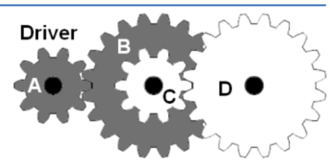
Gears; Sprockets with Chains; and Pulleys with Belts Ratios

$$GR = \frac{N_{out}}{N_{in}} = \frac{d_{out}}{d_{in}} = \frac{\omega_{in}}{\omega_{out}} = \frac{\tau_{out}}{\tau_{in}}$$

$$\frac{d_{out}}{d_{in}} = \frac{\omega_{in}}{\omega_{out}} = \frac{\tau_{out}}{\tau_{in}} \text{ (pulleys)}$$

Compound Gears

$$GR_{TOTAL} = \left(\frac{B}{A}\right)\left(\frac{D}{C}\right)$$



GR = Gear Ratio
ω_{in} = Angular Velocity - driver
ω_{out} = Angular Velocity - driven
N_{in} = Number of Teeth - driver
N_{out} = Number of Teeth - driven
d_{in} = Diameter - driver
d_{out} = Diameter - driven
τ_{in} = Torque - driver
τ_{out} = Torque - driven

Structural Design

Steel Beam Design: Shear

$$V_a = \frac{V_n}{\Omega_v}$$

$$V_n = 0.6F_yA_w$$

V_a = allowable shear strength
V_n = nominal shear strength
Ω_v = 1.5 = factor of safety for shear
F_y = yield stress
A_w = area of web

Steel Beam Design: Moment

$$M_a = \frac{M_n}{\Omega_b}$$

$$M_n = F_yZ_x$$

M_a = allowable bending moment
M_n = nominal moment strength
Ω_b = 1.67 = factor of safety for bending moment
F_y = yield stress
Z_x = plastic section modulus about neutral axis

Spread Footing Design

$$q_{net} = q_{allowable} - p_{footing}$$

$$p_{footing} = t_{footing} \cdot 150\frac{lb}{ft^2}$$

$$q = \frac{P}{A}$$

q_{net} = net allowable soil bearing pressure
$q_{allowable}$ = total allowable soil bearing pressure
$p_{footing}$ = soil bearing pressure due to footing weight
$t_{footing}$ = thickness of footing
q = soil bearing pressure
P = column load applied
A = area of footing

Storm Water Runoff

Storm Water Drainage

$$Q = C_fCiA$$

$$C_c = \frac{C_1A_1 + C_2A_2 + \cdots}{A_1 + A_2 + \cdots}$$

Q = peak storm water runoff rate (ft^3/s)
C_f = runoff coefficient adjustment factor
C = runoff coefficient
i = rainfall intensity (in./h)
A = drainage area (acres)

Runoff Coefficient Adjustment Factor	
Return Period	***Cf***
1, 2, 5, 10	***1.0***
25	***1.1***
50	***1.2***
100	***1.25***

Rational Method Runoff Coefficients	
Categorized by Surface	
Forested	0.059—0.2
Asphalt	0.7—0.95
Brick	0.7—0.85
Concrete	0.8—0.95
Shingle roof	0.75—0.95
Lawns, well drained (sandy soil)	
Up to 2% slope	0.05—0.1
2% to 7% slope	0.10—0.15
Over 7% slope	0.15—0.2
Lawns, poor drainage (clay soil)	
Up to 2% slope	0.13—0.17
2% to 7% slope	0.18—0.22
Over 7% slope	0.25—0.35
Driveways,	0.75—0.85
Categorized by Use	
Farmland	0.05—0.3
Pasture	0.05—0.3
Unimproved	0.1—0.3
Parks	0.1—0.25
Cemeteries	0.1—0.25
Railroad yard	0.2—0.40
Playgrounds	0.2—0.35
Business Districts	
Neighborhood	0.5—0.7
City (downtown)	0.7—0.95
Residential	
Single-family	0.3—0.5
Multi-plexes,	0.4—0.6
Multi-plexes,	0.6—0.75
Suburban	0.25—0.4
Apartments,	0.5—0.7
Industrial	
Light	0.5—0.8
Heavy	0.6—0.9

Water Supply

Hazen-Williams Formula

$$h_f = \frac{10.44LQ^{1.85}}{C^{1.85}d^{4.8655}}$$

h_f = head loss due to friction (ft of H_2O)
L = length of pipe (ft)
Q = water flow rate (gpm)
C = Hazen-Williams constant
d = diameter of pipe (in.)

Dynamic Head

dynamic head = static head – head loss

Hazen-Williams Constants

Pipe Material	Typical Range	Clean, New Pipe	Typical Design Value
Cast Iron and Wrought Iron	80 - 150	130	100
Copper, Glass or Brass	120 - 150	140	130
Cement lined Steel or Iron		150	140
Plastic PVC or ABS	120 - 150	140	130
Steel, welded and seamless or interior riveted	80-150	140	100

Equivalent Length of (Generic) Fittings

Screwed Fittings		Pipe Size										
		1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4
Elbows	Regular 90 degree	2.3	3.1	3.6	4.4	5.2	6.6	7.4	8.5	9.3	11.0	13.0
	Long radius 90 degree	1.5	2.0	2.2	2.3	2.7	3.2	3.4	3.6	3.6	4.0	4.6
	Regular 45 degree	0.3	0.5	0.7	0.9	1.3	1.7	2.1	2.7	3.2	4.0	5.5
Tees	Line Flow	0.8	1.2	1.7	2.4	3.2	4.6	5.6	7.7	9.3	12.0	17.0
	Branch Flow	2.4	3.5	4.2	5.3	6.6	8.7	9.9	12.0	13.0	17.0	21.0
Return Bends	Regular 180 degree	2.3	3.1	3.6	4.4	5.2	6.6	7.4	8.5	9.3	11.0	13.0
Valves	Globe	21.0	22.0	22.0	24.0	29.0	37.0	42.0	54.0	62.0	79.0	110.0
	Gate	0.3	0.5	0.6	0.7	0.8	1.1	1.2	1.5	1.7	1.9	2.5
	Angle	12.8	15.0	15.0	15.0	17.0	18.0	18.0	18.0	18.0	18.0	18.0
	Swing Check	7.2	7.3	8.0	8.8	11.0	13.0	15.0	19.0	22.0	27.0	38.0
Strainer			4.6	5.0	6.6	7.7	18.0	20.0	27.0	29.0	34.0	42.0

Flanged Fittings		Pipe Size																
		1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	4	5	6	8	10	12	14	16	18
Elbows	Regular 90 degree	0.9	1.2	1.6	2.1	2.4	3.1	3.6	4.4	5.9	7.3	8.9	12.0	14.0	17.0	18.0	21.0	23.0
	Long radius 90 degree	1.1	1.3	1.6	2.0	2.3	2.7	2.7	3.4	4.2	5.0	5.7	7.0	8.0	9.0	9.4	10.0	11.0
	Regular 45 degree	0.5	0.6	0.8	1.1	1.3	1.7	2.0	2.6	3.5	4.5	5.6	7.7	9.0	11.0	13.0	15.0	16.0
Tees	Line Flow	0.7	0.8	1.0	1.3	1.5	1.8	1.9	2.2	2.8	3.3	3.8	4.7	5.2	6.0	6.4	7.2	7.6
	Branch Flow	2.0	2.6	3.3	4.4	5.2	6.6	7.5	9.4	12.0	15.0	18.0	24.0	30.0	34.0	37.0	43.0	47.0
Return Bends	Regular 180 degree	0.9	1.2	1.6	2.1	2.4	3.1	3.6	4.4	5.9	7.3	8.9	12.0	14.0	17.0	18.0	21.0	23.0
	Long radius 180 degree	1.1	1.3	1.6	2.0	2.3	2.7	2.9	3.4	4.2	5.0	5.7	7.0	8.0	9.0	9.4	10.0	11.0
Valves	Globe	38.0	40.0	45.0	54.0	59.0	70.0	77.0	94.0	120.0	150.0	190.0	260.0	310.0	390.0			
	Gate						2.6	2.7	2.8	2.9	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	Angle	15.0	15.0	17.0	18.0	18.0	21.0	22.0	28.0	38.0	50.0	63.0	90.0	120.0	140.0	160.0	190.0	210.0
	Swing Check	3.8	5.3	7.2	10.0	12.0	17.0	21.0	27.0	38.0	50.0	63.0	90.0	120.0	140.0			

555 Timer Design Equations

$T = 0.693\,(R_A + 2R_B)C$

$f = \dfrac{1}{T}$

$\text{duty-cycle} = \dfrac{(R_A + R_B)}{(R_A + 2R_B)} \cdot 100\%$

T = period
f = frequency
R_A = resistance A
R_B = resistance B
C = capacitance

Boolean Algebra

Boolean Theorems

$X \bullet 0 = 0$

$X \bullet 1 = X$

$X \bullet X = X$

$X \bullet \overline{X} = 0$

$X + 0 = X$

$X + 1 = 1$

$X + X = X$

$X + \overline{X} = 1$

$\overline{\overline{X}} = X$

Commutative Law

$X \bullet Y = Y \bullet X$

$X + Y = Y + X$

Associative Law

$X(YZ) = (XY)Z$

$X + (Y + Z) = (X + Y) + Z$

Distributive Law

$X(Y+Z) = XY + XZ$

$(X+Y)(W+Z) = XW+XZ+YW+YZ$

Consensus Theorems

$X + \overline{X}Y = X + Y$

$X + \overline{X}\overline{Y} = X + \overline{Y}$

$\overline{X} + XY = \overline{X} + Y$

$\overline{X} + X\overline{Y} = \overline{X} + \overline{Y}$

DeMorgan's Theorems

$\overline{XY} = \overline{X} + \overline{Y}$

$\overline{X+Y} = \overline{X} \bullet \overline{Y}$

Speeds and Feeds

$N = \dfrac{CS\left(12\frac{\text{in.}}{\text{ft}}\right)}{\pi d}$

$f_m = f_t \cdot n_t \cdot N$

Plunge Rate = $\frac{1}{2} \cdot f_m$

N = spindle speed (rpm)
CS = cutting speed (in./min)
d = diameter (in.)
f_m = feed rate (in./min)
f_t = feed (in./tooth)
n_t = number of teeth

Aerospace Equations

Forces of Flight

$C_D = \frac{2D}{A\rho v^2}$

$R_e = \frac{\rho v l}{\mu}$

$C_L = \frac{2L}{A\rho v^2}$

$M = Fd$

C_L = coefficient of lift
C_D = coefficient of drag
L = lift
D = drag
A = wing area
ρ = density
R_e = Reynolds number
v = velocity
l = length of fluid travel
μ = fluid viscosity
F = force
m = mass
g = acceleration due to gravity
M = moment
d = moment arm (distance from datum perpendicular to F)

Propulsion

$F_N = W(v_j - v_o)$

$I = F_{ave}\Delta t$

$F_{net} = F_{avg} - F_g$

$a = v_f \Delta t$

F_N = net thrust
W = air mass flow
v_o = flight velocity
v_j = jet velocity
I = total impulse
F_{ave} = average thrust force
Δt = change in time (thrust duration)
F_{net} = net force
F_{avg} = average force
F_g = force of gravity
v_f = final velocity
a = acceleration
Δt = change in time (thrust duration)

NOTE: F_{ave} and F_{avg} are easily confused.

Energy

$K = \frac{1}{2}mv^2$

$U = \frac{-GMm}{R}$

$E = U + K = -\frac{GMm}{2R}$

K = kinetic energy
m =mass
v = velocity
U = gravitational potential energy
G = universal gravitation constant
M =mass of central body
m = mass of orbiting object
R = Distance center main body to center of orbiting object
E = Total Energy of an orbit

Orbital Mechanics

$e = \sqrt{1 - \frac{b^2}{a^2}}$

$T = 2\pi \frac{a^{\frac{3}{2}}}{\sqrt{\mu}} = 2\pi \frac{a^{\frac{3}{2}}}{\sqrt{GM}}$

$F = \frac{GMm}{r^2}$

e = eccentricity
b = semi-minor axis
a =semi-major axis
T = orbital period
a = semi-major axis
μ = gravitational parameter
F = force of gravity between two bodies
G = universal gravitation constant
M =mass of central body
m = mass of orbiting object
r = distance between center of two objects

Bernoulli's Law

$\left(P_s + \frac{\rho v^2}{2}\right)_1 = \left(P_s + \frac{\rho v^2}{2}\right)_2$

P_S = static pressure
v = velocity
ρ = density

Atmosphere Parameters

$T = 15.04 - 0.00649h$

$p = 101.29\left[\frac{(T + 273.1)}{288.08}\right]^{5.256}$

$\rho = \frac{p}{0.2869(T + 273.1)}$

T = temperature
h = height
p = pressure
ρ = density