PLTW Gateway

PLTW Gateway Formula Sheet 2016 (v5.0)

Statistics

Mean

$$\mu = \frac{\sum x_i}{N} \qquad \bar{x} = \frac{\sum x_i}{n}$$

μ = population mean
$\bar{x}$ = sample mean
$\sum x_i$ = sum of all data values (x_1, x_2, x_3, …)
N = size of population
n = size of sample

Median

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

N = size of population

Constants

g = 9.8 m/s^2 = 32.27 ft/s^2
G = 6.67 x 10^{-11} m^3/kg·s^2
π = 3.14159

Mode

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

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

Range (1.5)

Range = x_{max} - x_{min}

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

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

Heat Loss/Gain

Heat Loss/Gain

$Q' = AU\Delta T$

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

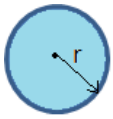
Q = thermal energy
A = area of thermal conductivity
U = coefficient of heat conductivity (U-factor)
ΔT = change in temperature
R = resistance to heat flow (R-value)

Glaister Equation

$$\frac{98.4 - \text{measured rectal temperature}}{1.5} = \text{approximate hours since death}$$

Plane Geometry

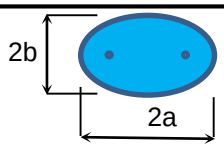
Circle



Circumference $= 2\pi r$

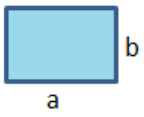
Area $= \pi r^2$

Ellipse



Area $= \pi a b$

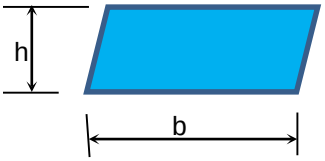
Rectangle



Perimeter $= 2a + 2b$

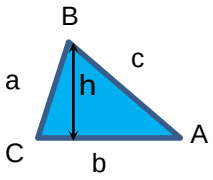
Area $= ab$

Parallelogram



Area $= bh$

Triangle (3.6)



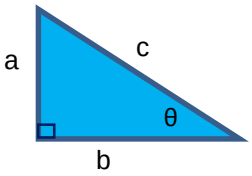
Area $= \frac{1}{2}\, bh$

$a^2 = b^2 + c^2 - 2bc \cdot \cos\angle A$

$b^2 = a^2 + c^2 - 2ac \cdot \cos\angle B$

$c^2 = a^2 + b^2 - 2ab \cdot \cos\angle C$

Right Triangle



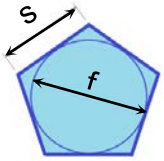
$c^2 = a^2 + b^2$

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

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

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

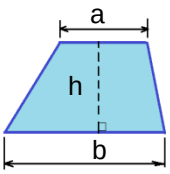
Regular Polygons



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

n = number of sides

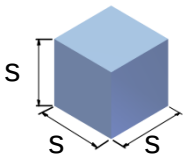
Trapezoid



Area $= \frac{1}{2}(a + b)h$

Solid Geometry

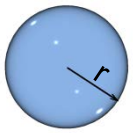
Cube



Volume $= s^3$

Surface Area $= 6s^2$

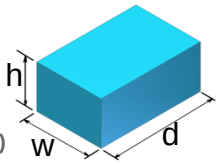
Sphere



Volume $= \frac{4}{3}\pi r^3$

Surface Area $= 4\pi r^2$

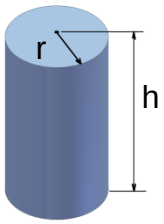
Rectangular Prism



Volume $= wdh$

Surface Area $= 2(wd + wh + dh)$ (4.4)

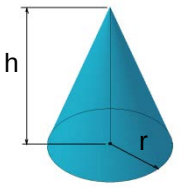
Cylinder



Volume $= \pi r^2 h$

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

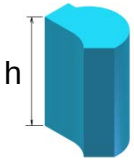
Right Circular Cone



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

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

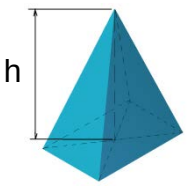
Irregular Prism



Volume $= Ah$

A = area of base

Pyramid



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

A = area of base

Conversions

Mass/Weight

1 kg	= 2.205 lb_m
1 slug	= 32.2 lb_m
1 ton	= 2000 lb
1 lb	= 16 oz

Length

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

Time

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

Area

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

Volume

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

Temperature Unit Equivalents

1 K	= 1 ºC
	= 1.8 ºF
	= 1.8 ºR

See below for temperature calculation

Force

1 N	= 0.225 lb
1 kip	= 1,000 lb

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

Power

1 W	= 3.412 Btu/h
	= 0.00134 hp
	= 14.34 cal/min
	= 0.7376 $ft \cdot lb_f/s$
1 hp	= 550 ft·lb/sec

Energy

1 J	= 0.239 cal
	= 9.48 x 10^{-4} Btu
	= 0.7376 $ft \cdot lb_f$
1kW h	= 3,600,000 J

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

Equations

Electricity

Ohm's Law

$V = IR$

$P = IV$

V = voltage
I = current
R = resistance
P = power

Mass and Weight

$m = VD_m$

$W = mg$

$W = VD_w$

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

Power

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

$P = \tau \omega$

P = power
E = energy
W = work
t = time
τ = torque
ω = angular velocity

Energy: Work

$W = F_{\parallel} \cdot \mathbf{d}$

W = work
$F_{\parallel}$ = force parallel to direction of displacement
d = displacement

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

$\Delta Q = mc\Delta T$

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

Simple Machines

Mechanical Advantage (MA)

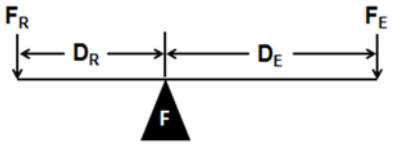
$$IMA = \frac{D_E}{D_R} \qquad AMA = \frac{F_R}{F_E}$$

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

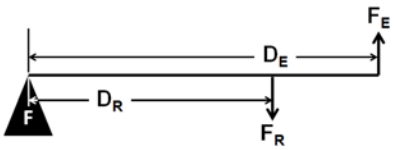
IMA = ideal mechanical advantage
AMA = actual mechanical advantage
D_E = effort distance D_R = resistance distance
F_E = effort force F_R = resistance force

Lever

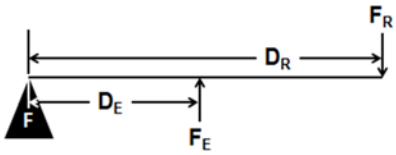
1st Class



2nd Class

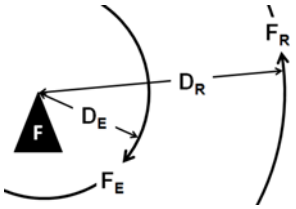


3rd Class

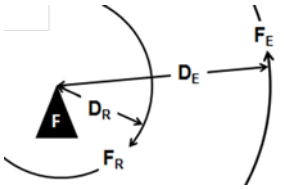


Wheel and Axle

Effort at Axle



Effort at Wheel



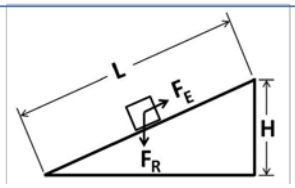
Pulley Systems

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

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

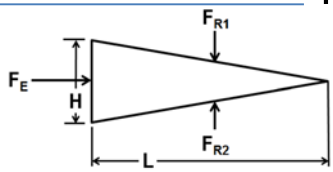
Inclined Plane

$$IMA = \frac{L}{H}$$



Wedge

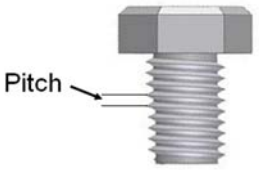
$$IMA = \frac{L}{H}$$



Screw

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

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



C = circumference
r = radius
Pitch = distance between threads
TPI = threads per inch

Compound Machines

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

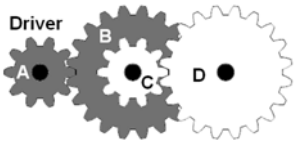
Gears; Sprockets with Chains; and Pulleys with Belts Ratios

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

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

Compound Gears

$$GR_{TOTAL} = \left(\frac{B}{A}\right)\left(\frac{D}{C}\right) \quad \textbf{(13.13)}$$



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

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

$$F_N = W(v_j - v_o)$$

$$I = F_{ave}\Delta t$$

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

$$a = \frac{v_f}{\Delta t}$$

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.

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

Energy

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

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

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

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

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

Electronics

Resistor Color Code

	1st Band	2nd Band	Multiplier	Tolerance
NONE				20%
Silver			0.01	10%
Gold			0.1	5%
Black	0	0	1	
Brown	1	1	10	
Red	2	2	100	
Orange	3	3	1K	
Yellow	4	4	10K	
Green	5	5	100K	
Blue	6	6	1M	
Violet	7	7	10M	
Gray	8	8	100M	
White	9	9	1000M	

Capacitor Code

Code	Tolerance
A	±0.05%
B	±0.1%
C	±0.25%
D	±0.5%
F	±1%
G	±2%
J	±5%
K	±10%
M or NONE	±20%
N	±30%
Q	−10%, +30%
S	−20%, +50%
T	−10%, +50%
Z	−20%, +80%