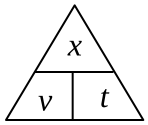
Physics Formulas

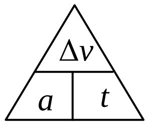
Chapter 2 - Linear Kinematics

Formulas:

$$v_{avg} = \frac{x}{t}$$



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



$$v_{avg} = \frac{(v_i + v_f)}{2}$$

$$v_f = v_i + at$$
$$x = \tfrac{1}{2}\left(v_i + v_f\right)\cdot t$$
$$x = v_i t + \tfrac{1}{2} a t^2$$
$$v_f^2 = v_i^2 + 2ax$$

Symbols and units:

v_{avg} - average velocity (m/s)
Δv - change in velocity (m/s)

x - displacement (m)
v_i - initial velocity (m/s)
v_f - final velocity (m/s)
a - acceleration (m/s/s)
t - elapsed time (s)

Distance and time:

1 hr = 60 min = 3600 sec
1 day = 86400 sec
1 km = 1000 m ≈ 0.6214 mile
1 mile = 5280 ft = 1760 yards ≈ 1609 m
1 foot = 12 inches ≈ 30.48 cm
1 cm = 2.54 cm (defined)
1 m ≈ 3.281 ft
1 yard = 3 feet

Shortcuts: (mph = miles/hour)

1 m/s = 3.6 km/hr ≈ 2.237 mph ≈ 3.281 ft/s
1 mph ≈ 1.467 f/s (1.46666666…) ≈ 1.609 km/hr ≈ 0.4470 m/s
1 f/s = 0.3048 m/s ≈ 0.6818 mph (.6818181818…) ≈ 1.0973 km/hr
1 km/hr ≈ 0.2778 m/s ≈ 0.6214 mph ≈ 0.9113 ft/s

Free Fall Problems:

Making the direction down negative (-)
- a = -9.8 m/s/s (always)
- v at top = 0 (because.....)

If starts and ends at same elevation:
- ½ total time to top
- Total time in air = 2x time to top
- $v_f = -v_i$

Chapter 3 - Two dimensional motion and vectors:

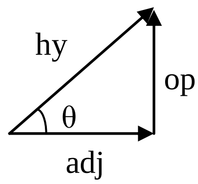
Vectors:

Finding Components:

1. Draw components from tail to tip
   Use arrows for components

2. Find the length of the sides:

opp = hyp Sin(θ)
adj = hyp Cos(θ)



3. Decide x or y, + or -

(-, +)	(+,
(-, -)	(+, -)

4. Write it as ______units $\hat{x}$ + _______units $\hat{y}$

Adding two component vectors:

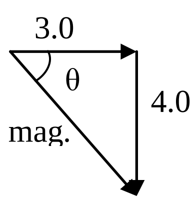
A = 1 m x + 2 m y
<u>B = 2 m x + 3 m y</u>
A+B = 3 m x + 5 m y

(Add x to x and y to y)

Converting Components to Angle Magnitude:

1. Draw the vector
Draw x, and from there draw y as arrows
The vector goes from the tail of the x to the tip of the y

e.g. 3.0 m x + -4.0 m y:



$$\theta = Tan^{-1}\left(\frac{opp}{adj}\right) = Tan^{-1}\left(\frac{4.0}{3.0}\right) = 53.1^o$$

$$mag. = \sqrt{x^2 + y^2} = \sqrt{3^2 + 4^2} = 5m$$

2. Find the angle using Tan^{-1}
3. Find the magnitude using the Pythagorean theorem

Projectile Motion:

H	V
X	X
V_i	V_i
V_f	V_f
a = 0	a = -9.80 m/s/s
t	t

Fill in given, solve. Time is shared by both sides

Cliff Problems:
Purely horizontal initial velocity, so V_i vertical = 0

Arc Problems:
1. Break launch velocity into components
2. Fill in H/V table
3. For level range remember vertical $V_f = -V_i$
4. To get greatest height remember vertical V_f at top = 0

Boat Crossing River:
1. Fill this in:

Across	Downstream
X	X
V	V
t	t

Solve. Time is shared by both sides.

Range Equation:

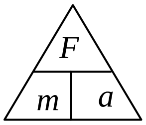
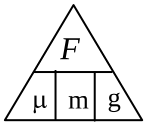
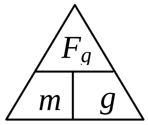
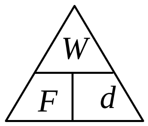
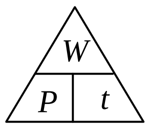
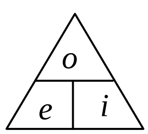
$$Range = \frac{v^2}{g}\sin(2\theta)$$

e.g. v²/9.8*sin(2*angle)

$$\theta = \frac{\sin^{-1}\left(\frac{g \bullet Range}{v^2}\right)}{2},\ 90 - \theta$$

e.g. sin⁻¹(9.8*range/v²)/2

Chapters 4, 5 and 6 Force, Work and Power, and Momentum

Force: **F = ma** **F_g = mg (g = 9.8 N/kg on earth)** **$F_f = \mu F_N$ (= μmg)** 	Symbols and units: *F* - force (N) *m* - mass (kg) (g/1000 = kg) *a* - acceleration (m/s/s) *μ* - coefficient of friction
Work and Power: **W = Fd = Fd(cosθ)**  **F = mg (lifting)** **or** **F = μmg (dragging)** $P = \frac{W}{t}$  **P = Fv**	Symbols and units: P - Power (W) W - Work (J) F - Force (N) d - distance (m) t - time (s) m - mass (kg) μ - coefficient of friction 1 HP = 745.7 W
Kinetic Energy: **KE = ½mv^2** Potential Energy: **PE = mgh** Elastic (Spring) Potential Energy: **$PE_{elastic}$ = ½kx^2** $e = \frac{W_o}{W_i} = \frac{P_o}{P_i} = \frac{output}{input}$  **Fd + mgh + ½mv^2 = Fd + mgh + ½mv^2**	KE - Kinetic Energy (J) m - Mass (kg) v - Velocity (m/s) PE - Potential Energy (J) m - Mass (kg) g - 9.8 N/kg h - Elevation (m) PE - Potential Energy (J) (Stored in a spring) k - Spring Constant (N/m) x - Stretch/Compression Distance (m)
Momentum: **p = mv** **FΔt = impulse** **FΔt = mΔv** $rate = \frac{m}{\Delta t}$ $F = (rate)\Delta v$	Symbols and units: *p* - momentum (kg m/s) m - mass (kg) *v* - velocity (m/s) *Δv* - change in velocity (m/s) *Δt* - elapsed time (s)

Chapter 7 - Circular Motion and Gravity

Circular Motion: $a = \frac{v^2}{r}$ $a = \frac{4\pi^2 r}{T^2}$ $F = ma$ $F = \mu mg$ $v = \frac{2\pi r}{T}$ $T = \frac{60s}{RPM}$ $F = \frac{mv^2}{r}$ $F = \frac{m4\pi^2 r}{T^2}$	Symbols and units: F - force (N) m - mass (kg) (g/1000 = kg) a - acceleration (m/s/s) μ - coefficient of friction v - tangential velocity (m/s) T - period (s)
Vertical Circle: Top: 1g – ride Bottom: 1g + ride (m/s/s) ÷ 9.8 = ("g"s) ("g"s) x 9.8 = (m/s/s)	Inverted "g"s are negative 1 "g" = 9.8 m/s/s a ≥ 9.8 for water to stay in the bucket etc.
Gravity: $F = \frac{Gm_1m_2}{r^2}$ G - Universal Gravitation Constant ($6.67\text{x}10^{-11}\ Nm^2/kg^2$)	Symbols and units: F - force (N) m_1 - the first mass (kg) m_2 - the second mass (kg) r - distance separating the centers (m) G - Universal Gravitation Constant ($6.67\text{x}10^{-11}\ Nm^2/kg^2$)
Orbit: (r, m, v): **Orbit: (r, m, T):** $\frac{m_s v^2}{r} = \frac{Gm_c m_s}{r^2}$ $\frac{m_s 4\pi^2 r}{T^2} = \frac{Gm_c m_s}{r^2}$ Note: - the satellite mass cancels if $m_s << m_c$. $v = \sqrt{\frac{Gm_c}{r}}$ $T = 2\pi\sqrt{\frac{r^3}{Gm_c}}$ $m_c = \frac{v^2 r}{G}$ $m_c = \frac{4\pi^2 r^3}{GT^2}$ $r = \frac{Gm_c}{v^2}$ $r = \sqrt[3]{\frac{Gm_c T^2}{4\pi^2}}$	Symbols and units: m_c - central body mass (kg) m_s - satellite mass (kg) v - orbital velocity (m/s) r - orbital radius (m) T - period (s) G - Universal Gravitation Constant ($6.67\text{x}10^{-11}\ Nm^2/kg^2$)

Chapter 12 - Waves

Basic Waves: $v = f\lambda$ $f = \frac{1}{T}$ $v = \frac{\lambda}{T}$	Symbols and units: λ - Wavelength (m) f - Frequency (Hz) v - Wave speed (m/s) T - Period (s)
Standing Waves $L = \frac{n\lambda}{4}$  = 1 λ  or  $= \frac{1}{4}\lambda$	Symbols and units: *L* - Length of standing wave (m) λ - Wavelength (m) n - Number of quarter wavelengths
Doppler: Moving Source: $f^{'} = f\left(\frac{v}{v \pm u_s}\right)$ Moving Observer: $f^{'} = f\left(\frac{v \pm u_o}{v}\right)$	Symbols and units: f' - Shifted Frequency (Hz) f - Original Frequency (Hz) v - Speed of sound (m/s) u_s - Speed of source (m/s) u_o - Speed of observer (m/s)