- Sig Figs

- Nonzero integers always count as significant figures
  - 3456 has 4 sig figs.
- Leading zeros are never significant
  - 0.000757 has 3 sig figs
- Captive zeros always count assignificant figures
  - 16.07 has 4 sig figs
- Trailing zeros are significant only if the number contains a decimal point.
  - 9.300 has 4 sig figs

MULTIPLICATION

123.1 × 23 = 2800

4 s.f. 2 s.f. 2 s.f.

DIVISION

123.1 / 23 = 5.4

4 s.f. 2 s.f. 2 s.f.

ADDITION

123.1 + 23 = 146

1 d.p. 0 d.p. 0 d.p.

SUBTRACTION

123.1 - 23 = 100.

1 d.p. 0 d.p. 0 d.p.

- Linear Motion

- Displacement = $\Delta X = X_f - X_i$
- $\vec{V}_{avg} = \Delta X / t$ m/s
- $V_{inst} = dx/dt$ m/s $|v|$
- $a_{avg} = \Delta V / \Delta t$ m/s²
- $a_{inst} = dv/dt$ m/s²
- gravitational acleration $g = \pm 9.81$ m/s²

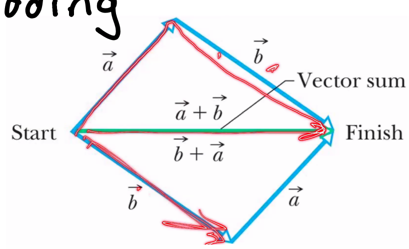
- Kinematic Equations

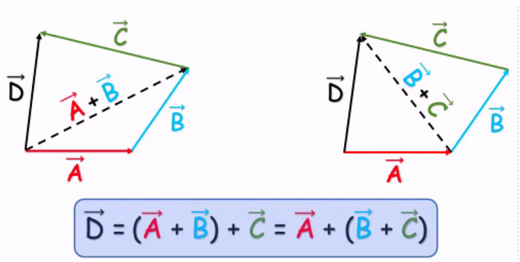
1. $v = v_0 + at$
2. $\Delta x = (\frac{v + v_0}{2})t$
3. $\Delta x = v_0 t + \frac{1}{2}at^2$
4. $v^2 = v_0^2 + 2a\Delta x$

- Vectors

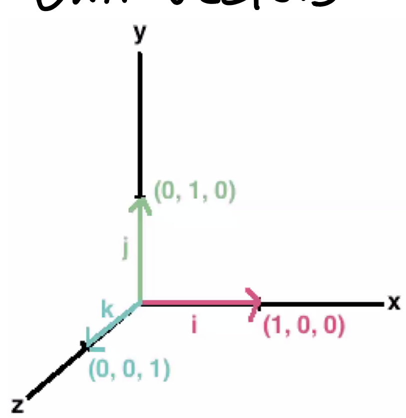
- vector has direction and magnitude

- Adding

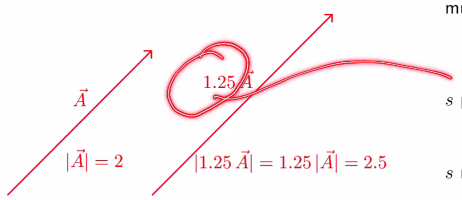




- Unit Vectors



- Multiplying



multiply magnitude by $|s|$

$$|s\,\vec{A}| = |s|\,|\vec{A}|$$

s positive
- $s\vec{A}$ has same direction

s negative
- $s\vec{A}$ has opposite direction

Notice that this is consistent with adding and subtracting vectors.

$$\vec{A}+\vec{A}+\vec{A} = 3\vec{A} \qquad \vec{A}+(-1)\vec{A} = \vec{A}-\vec{A} = 0$$

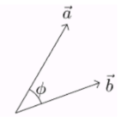
- Laws

$s(\vec{a}+\vec{b}) = s\vec{a}+s\vec{b}$	distributive law	$\left(\vec{a}+\vec{b}\right)+\vec{c} = \vec{a}+\left(\vec{b}+\vec{c}\right)$	associative law
$\vec{a}+\vec{b} = \vec{b}+\vec{a}$	commutative law	$\vec{d} = \vec{a}-\vec{b} = \vec{a}+\left(-\vec{b}\right)$	vector subtraction

- 2D+3D Motion

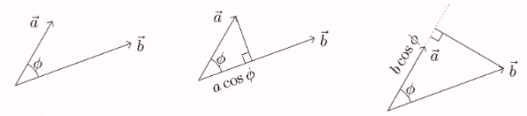
- Kinematic Equations
  - $\Delta x = vt$
  - $\Delta V = at$
  - $dV/dt = a$
  - $dx/dt = V$

$\vec{a} \cdot \vec{b} = |\vec{a}|\,|\vec{b}|\,\cos\phi$ $\quad$ ϕ = angle between $\vec{a}$ and $\vec{b}$



$\cos\phi = \cos(-\phi)$ $\quad$ $\cos 0° = 1$ $\quad$ $\cos 90° = 0$ $\quad$ $\cos 180° = -1$

$\vec{a} \cdot \vec{b} = \vec{b} \cdot \vec{a}$ $\quad$ $\vec{a} \cdot \vec{a} = |\vec{a}|^2$ $\quad$ $\vec{a} \perp \vec{b} \implies \vec{a} \cdot \vec{b} = 0$



$\vec{a} \cdot \vec{b} = ab\cos\phi$ $\quad$ $= b(a\cos\phi)$ $\quad$ $= a(b\cos\phi)$

$ab\cos\phi = b\times$ (component of $\vec{a}$ along $\vec{b}$) $= a\times$ (component of $\vec{b}$ along $\vec{a}$)

$\vec{a} \times \vec{b}$ is a vector $\begin{cases} \text{magnitude: } |\vec{a} \times \vec{b}| = |a||b|\sin\phi \\ \text{direction: } \perp \text{ to both } \vec{a} \text{ and } \vec{b} \end{cases}$

There are two $\perp$ directions. Use the "right-hand rule" to choose (next slide).

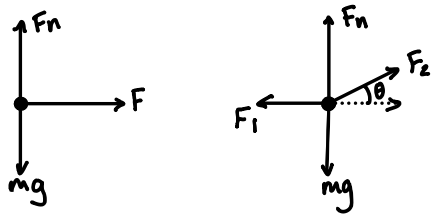
$\sin 0° = \sin 180° = 0$ so $\vec{a} \parallel \vec{b}$ (parallel) $\implies \vec{a} \times \vec{b} = 0$

- Newtons Laws

First Law - Object in rest stays in rest, an object in motion stays in motion, unless acted on by an outside force.

Second Law - $F = ma$, Force is a vector

- $\Sigma F_x = 0 = F\cos\theta - F_1$
- $\Sigma F_y = 0 = F_n \overset{2}{-} mg + F_2 \sin\theta$



Third Law - When an object exerts a force on another object, the first body experiences a force that is equal and opposite to the force it exerts.

Internal Forces	External Force
- A force acting from one part of a system to another	- Acting on a system from outside the system

- Circular Motion

$s = r\theta$ $\quad$ $V = r\Delta\theta$ $\quad$ $V_T = \omega r$ $\quad$ $a_1 = \alpha r$ $\quad$ $\alpha = V_T^2/r$

$f = 1/T$ $\quad$ $T = 2\pi/\omega$ $\quad$ $\omega = \theta/t$ $\quad$ $\omega = V_T/r$ $\quad$ $\omega = d\theta/dt$

$\alpha = d\omega/dt$ $\quad$ $\omega_f = \omega_0 t + \alpha t$ $\quad$ $\omega_f^2 = \omega_0^2 + 2\alpha\theta$

$\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

- Circular Motion

Work = Fd (Joules) $\quad$ $KE = \frac{1}{2}mv^2$ $\quad$ $GPE = mgh$ $\quad$ $W_i = W_f$

Spring PE = $\frac{1}{2}kx^2$ $\quad$ Elastic Force = $F = -kx$ $\quad$ Power = J/s (watts)

$W_{net} = \Delta h = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_0^2$ $\quad$ $W = \int \vec{F}\,dr$ $\quad$ $W = F \cdot d$] → dot product

$W_F = F_F d$ $\quad \mathcal{E}_i - W_{friction} = \mathcal{E}_f$ Depends on situation

- Conservative Forces = Any path that begins & ends @ the same place will require zero total work

- Potential Energy

- Gravational $PE = mgh$
- Elastic Force = $F = -kx$
- Elastic/Spring $PE = \frac{1}{2}kx^2$

· Any force that begins & ends @ the same place will require zero total work

- Momentum & Impulse

Momentum

$\vec{p} = m\vec{v}$

$\Sigma P_i = \Sigma P_f$ (Conservation of Momentum)

Types

- Elastic: No energy loss
- Totally inelastic: Energy loss (stick together)
- Explosion

Equations

Elastic: $m_1 v_{10} + m_2 V_{20} = m_1 v_{1f} + m_2 v_{2f}$

Inelastic: $m_1 v_{10} + m_2 v_{20} = (m_1 + m_2) v_f$

Explosion = $0 = (m_1 v_{1f} + m_2 v_{2f})$

Impulse

$I = mV_f - mV_0$ (kg m/s)

$I = Ft$ (Ns)

$I = \int F(t)\, dt$

Average Center of Mass

$\Sigma md / \# m$

Collisions & Conservation Laws =

- Basically like last weeks 1D momentum problems, but this time you have to split it into the x and y direction to solve your problems
  - It is the same thought process as when we did projectile motion in terms of splitting the problem into the x and y components
    - Technically you don't have to split the problem up like that, but it definitely makes your life 10x easier and it is easier to understand
- You will see the splitting in the HW

Gravity

$T^2 \sim r^3$

$F_g = Gm_1 m_2 / r^2$

$m = \rho \frac{4}{3}\pi r^3$

$PE = -Gm_1 m_2 / r$

$g_{\text{on planets}} = Gm/r^2$

G constant = 6.67430E-11

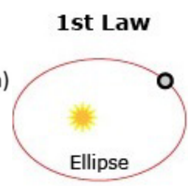
Re = 6.371E6 m

Me = 5.972E24 kg

Keplers Laws

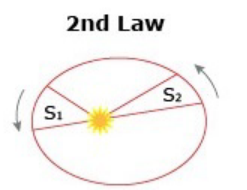
First Law

Each planet moves in an elliptical orbit with it's star (Sun) at one focus



Second Law

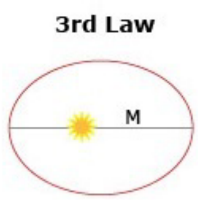
(law of equal areas): an orbiting object will take the same amount of time to travel between points A & B as it takes to travel between points C & D



Equal area in the same time area S1 = area S2

Third Law

(law of harmonics): The square of a planet's orbital time is proportional to its average distance from the star (Sun) cubed.



P: period (the time for one cycle)

M: length of the major axis

P^2/M^3 is the same for all planets