- 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/s^2
- $a_{inst} = dV/dt$ m/s^2
- gravitational acleration
  $g = \pm 9.81$ m/s^2

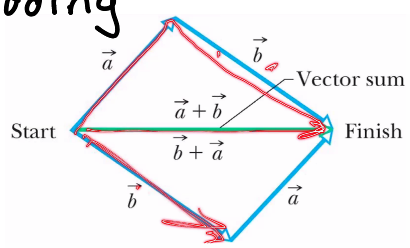
- Kinematic Equations

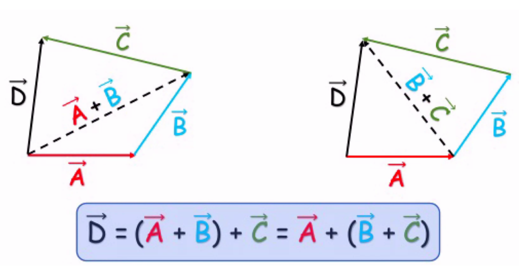
1. $v = v_0 + at$
2. $\Delta x = (\frac{v + v_0}{2})t$
3. $\Delta x = v_0 t + \frac{1}{2}at^2$
4. $v^2 = v_0^2 + 2a\Delta x$

- Vectors

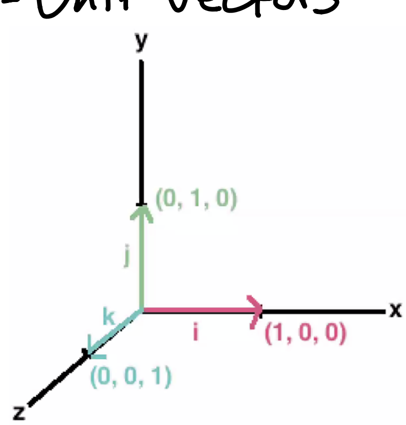
- vector has direction and magnitude

- Adding

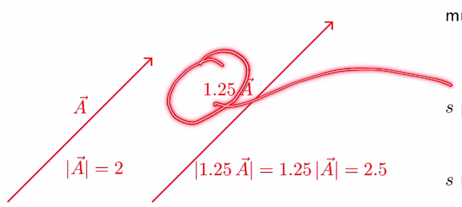




- Unit Vectors



- 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.

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

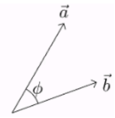
- Laws

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

- 2D + 3D Motion

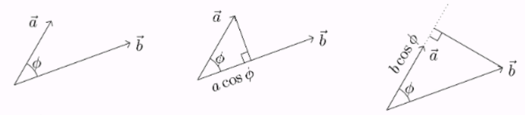
- Kinematic Equations
  - $\Delta x = vt$
  - $\Delta v = at$
  - $dv/dt = a$
  - $dx/dt = v$

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



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

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



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

$ab\cos\phi = b\times$ (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).

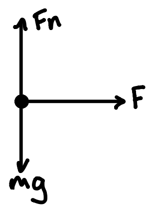
$\sin 0^\circ = \sin 180^\circ = 0$ so $\vec{a} \parallel \vec{b}$ (parallel) $\implies \vec{a} \times \vec{b} = 0$

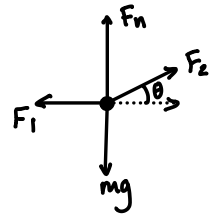
- Newtons Laws

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

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





Third Law - When an object exerts a force on another object, the first body expriences 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

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

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

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

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

- 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: $m_1 v_{1o} + m_2 V_{2o} = m_1 v_{1f} + m_2 v_{2f}$

Inelastic: $m_1 v_{1o} + m_2 v_{2o} = (m_1 + m_2) v_f$

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

$T^2 \sim r^3$ $\quad F_g = Gm_1m_2/r^2$

$m = \rho \frac{4}{3}\pi r^3$ $\quad PE = -Gm_1m_2/r$

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

G constant $= 6.67430E-11$

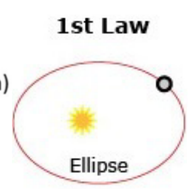
$R_e = 6.371E6$ m

$M_e = 5.972E24$ kg

Keplers Laws

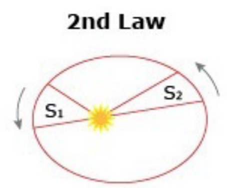
First Law

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



Second Law

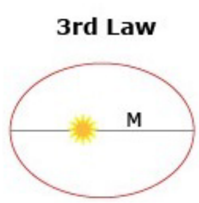
(law of equal areas): an orbiting object will take the same amount of time to travel between points A & B as it takes to travel between points C & D



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