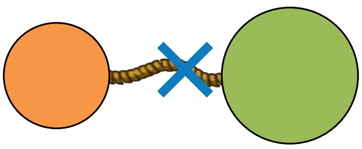
Physics Level 3

Mechanics

Translational Motion – Part 1

What you need to know:

- A system (and object) has a Centre of Mass
- You can calculate the position (distance) of the Centre of Mass
  Assuming rope is 'light weight'
- You can calculate the velocity of the Centre of Mass
  Assuming no external forces acting



Memorise:

$$d_{c.o.m} = \frac{d_1 m_1 + d_2 m_2 + \ldots}{m_1 + m_2 + \ldots}$$

$$v_{c.o.m} = \frac{v_1 m_1 + v_2 m_2 + \ldots}{m_1 + m_2 + \ldots}$$

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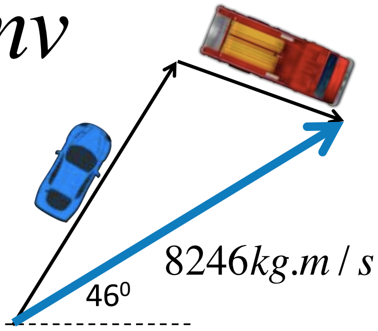
Translational Motion – Part 2

What you need to know:

$$\Delta p = F \Delta t$$

$$p = mv$$



Momentum is conserved in a collision (assuming no external forces are acting)

2-dimensions!

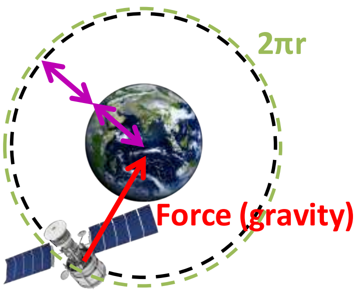
Add vectors head-to-tail

Use Pythagoras and SOH CAH TOA to solve

Momentum has size (number) and direction (angle)

Circular Motion – Part 1

1. Orbiting



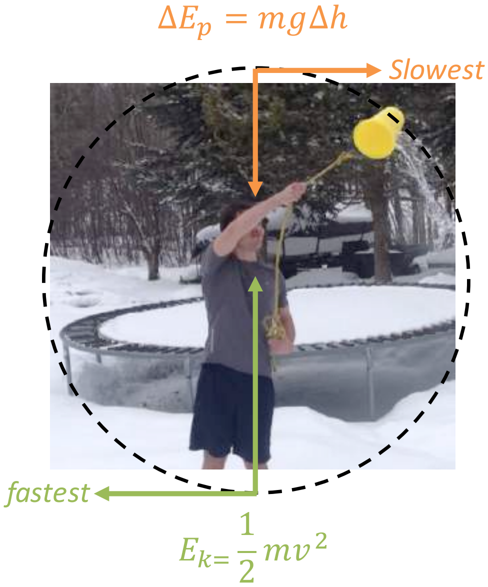
Gravity force

What you need to know

- Gravity is pulling the object towards the centre at all times
- The radius is the height of the object + the radius of the planet/mass
- The distance of one orbit = 2πr (circumference of the circle)
- In the formula:
  - *G* is the *gravitational constant* = *6.67* x 10^{-11} $N.m^2.kg^{-2}$
  - *M* is the mass of the planet
  - *m* is the mass of the circulating object
- Geostationary means an orbiting object stays above the same point on the earth at all times

Video Summaries

Circular Motion – Part 2



The force towards the center is:

- Gravity at the top (+ small tension)
- Big tension at the bottom (to overcome gravity)

The object moves fastest at the bottom of the swing (gravitation → kinetic energy)

$$F_c = \frac{mv^2}{r}$$

What you need to know

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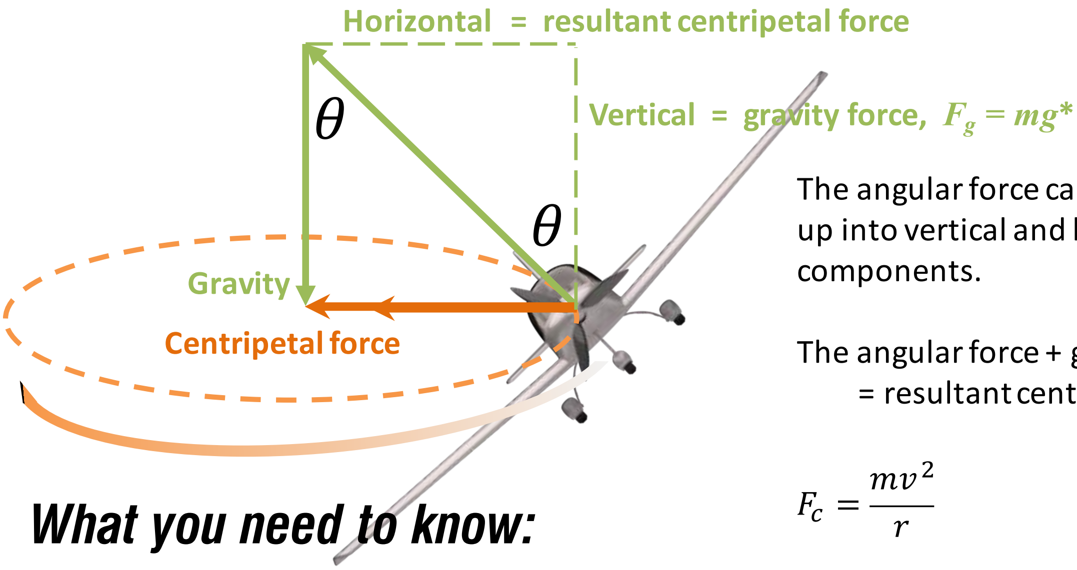
Circular Motion – Part 3



The angular force can be broken up into vertical and horizontal components.

The angular force + gravity force = resultant centripetal force

$$F_c = \frac{mv^2}{r}$$

What you need to know:

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Video Summaries

Rotational Motion – Part 1

$d = r\theta$

$v = r\omega$

$a = r\alpha$

$L = mvr$

$\omega = \dfrac{\Delta\theta}{\Delta t}$

$\alpha = \dfrac{\Delta\omega}{\Delta t}$

$\omega_f = \omega_i + \alpha t$

$\theta = \dfrac{(\omega_i + \omega_f)}{2}t$

$\omega_f{}^2 = \omega_i{}^2 + 2\alpha\theta$

$\theta = \omega_i t + \dfrac{1}{2}\alpha t^2$

$\tau = I\alpha$

$\tau = Fr$

$L = I\omega$

$E_{k(ROT)} = \dfrac{1}{2}I\omega^2$

$\omega = 2\pi f$

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

$I = mr^2$

There is an angular version of everything!

$d \rightarrow \theta$, Angle (*rads*) $v \rightarrow \omega$, Angular velocity (*rad.s*$^{-1}$) $a \rightarrow \alpha$, Angular acceleration (*rad.s*$^{-2}$)

$F \rightarrow \tau$, Torque (*Nm*) $p \rightarrow L$, Angular momentum (*kg m*^{2} *s*$^{-1}$)

$m \rightarrow I$, Inertia (*kg m*^{2}) $E_k \rightarrow E_{k(ROT)}$, Rotational kinetic energy (*J*)

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Simple Harmonic Motion – Part 1

What you need to know

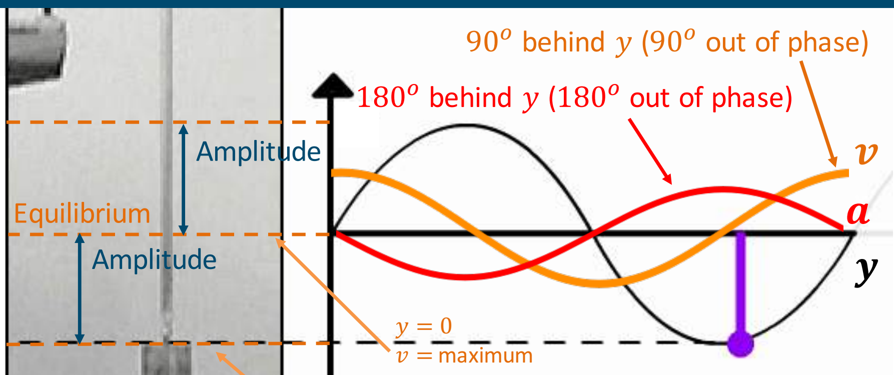
Simple Harmonic Motion (SHM) is oscillating, with a force toward the centre (equilibrium position) shown by:

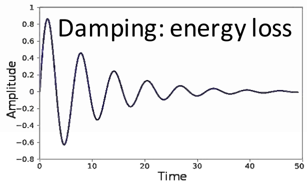
$$\boldsymbol{a = -\omega^2 y}$$

(This formula the defines SHM)

SHM has a resonant frequency, $\boldsymbol{f_0}$, and natural time period, $\boldsymbol{T}$:

$T = 2\pi\sqrt{\dfrac{l}{g}}$ and $T = 2\pi\sqrt{\dfrac{m}{k}}$





SHM has a low amplitude for frequencies that are NOT resonant frequencies

$\boldsymbol{\omega}$ is angular frequency

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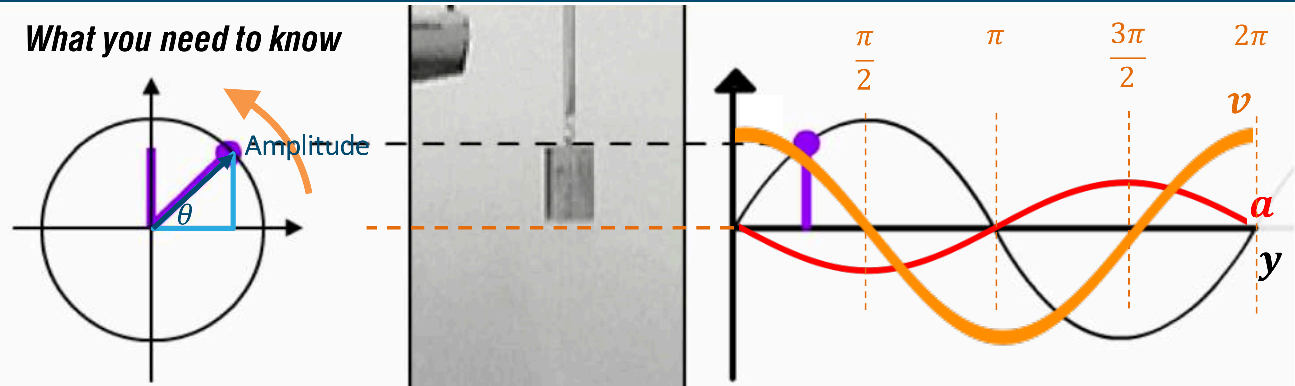
Simple Harmonic Motion – Part 2

What you need to know



$y = A\sin\omega t$ ($\sin\omega t$ = 1)

$v = A\omega\cos\omega t$ ($\cos\omega t$ = maximum)

$a = -A\omega^2\sin\omega t$ ($\sin\omega t$ = maximum) ← Middle

$y = A\cos\omega t$ ($\cos\omega t$ = 1)

$v = A\omega\sin\omega t$ ($\sin\omega t$ = maximum)

$a = -A\,\omega^2\cos\omega t$ ($\cos\omega t$ = maximum) ← Top/bottom