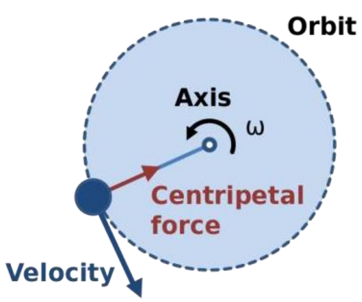
$$\omega = \frac{\theta}{t}$$

Anglular speed is the angle an object rotates through per second. It is measured in radians per second ($rads^{-1}$)

$$arc\ length = r\theta^*$$

*θ must be in radians!

$$Circumference\ of\ a\ circle = 2\pi r$$



$$\omega = \frac{v}{r}$$

v= Linear velocity: is always at a tangent to the circle

The further a point is from the centre of a uniformly rotating object, the faster its linear velocity.

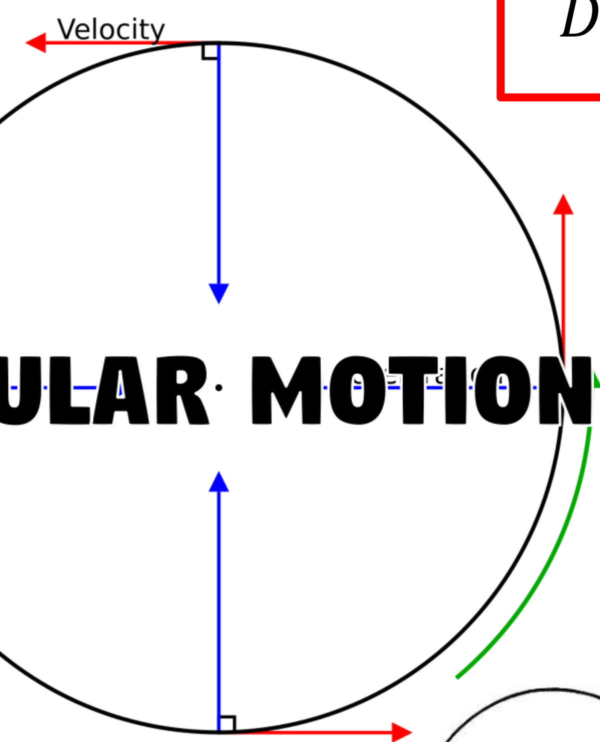
$$Rad\ to\ Degrees = Radian\frac{180}{\pi}$$

$$Degrees\ to\ Rad = Degree\left(\frac{\pi}{180}\right)$$

$$\omega = \frac{2\pi}{T} = \frac{v}{r} = 2\pi f$$

Angular velocity defined as the angular displacement per second.

CIRCULAR MOTION



The frequency of a rotating object is the number of complete revolutions per second ($revs^{-1}\ or\ Hz$)

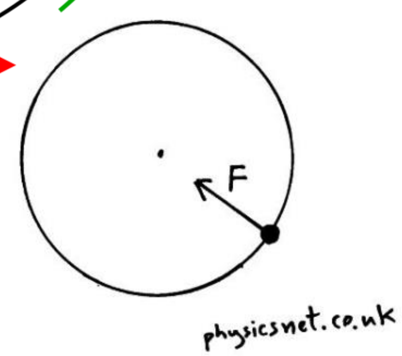
$$f = \frac{1}{T}$$

$$v = \frac{2\pi r}{T} = 2\pi r f$$

Centripetal Force and Acceleration

If an object's direction is constantly changing, its velocity is changing. If its velocity is changing over time, then it is accelerating. (ms^{-2})

$$a = \frac{v^2}{r} = \omega^2 r$$



For an object swinging on the end of a string, the tension acts as the centripetal force.

For a satellite orbiting around the Earth, the gravitational force acts as the centripetal force.

$$F = \frac{mv^2}{r} = m\omega^2 r$$

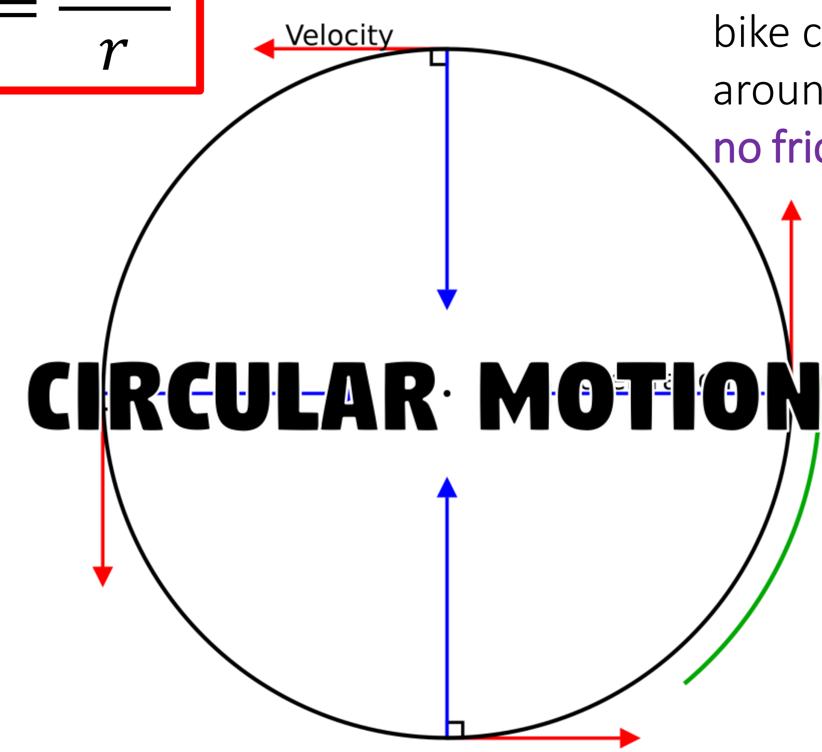
The *resultant force* which causes an object to undergo circular motion is called the centripetal force.

Key

Blue equation – *Given formulae*

Red equation – *Not given formulae*

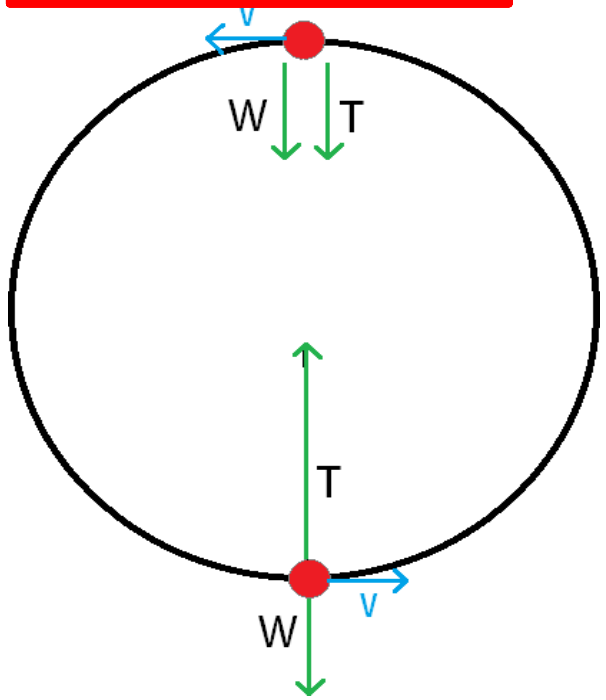
CIRCULAR MOTION



Vertical Circles

$$T = \frac{mv^2}{r} - mg$$

Tension at the top of a vertical circle:



At the middle T= F_c

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

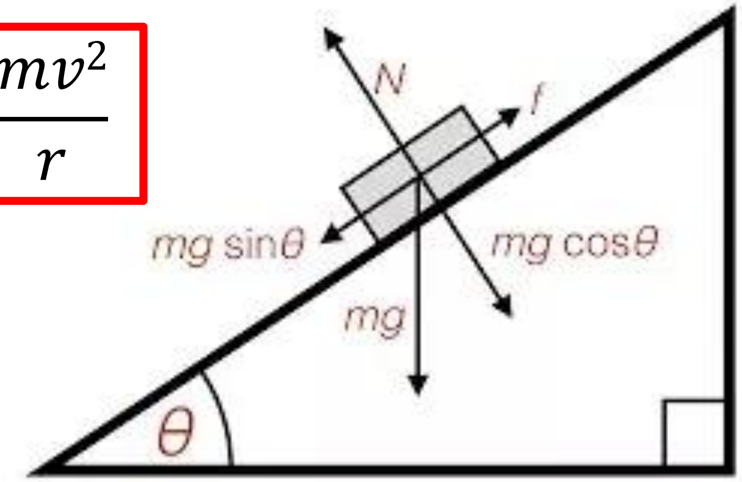
$$T = \frac{mv^2}{r} + mg$$

At the bottom T is greatest due to the added weight component

At some angle theta, Tension can be calculated by:

$$T = \frac{mv^2}{r} + mg\cos\theta$$

Banked Turns



Resolving horizontally, the centripetal force acting on the car.

$$N\sin\theta + F\cos\theta = \frac{mv^2}{r}$$

Resolving vertically

$$N\cos\theta = mg$$

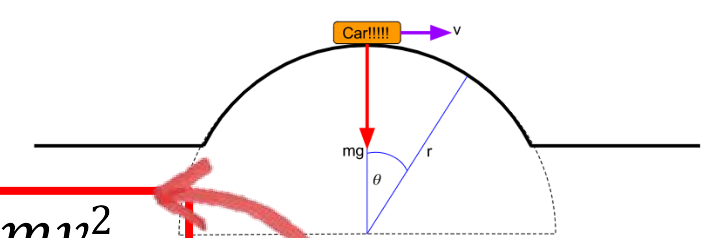
At a certain speed the bike could travel around the track with no friction

$$\tan\theta = \frac{v2}{r}$$

The speed the bike would need to be travelling at for there to be no sideways friction

$$v = \sqrt{gr\tan\theta}$$

Cars Going Over Hills



a bridge, with a radius of r the maximum speed the car would be able to go before it became airborne would be:

$$v_0 = \sqrt{gr}$$

$$S - mg = \frac{mv^2}{r}$$

$$S = m\left(\frac{v^2}{\mathrm{r}} - g\right)$$

Which tells us that the centripetal force which causes the car to travel in a circular path is the difference between the weight and the support force.

Key

Blue equation– *Given formulae*

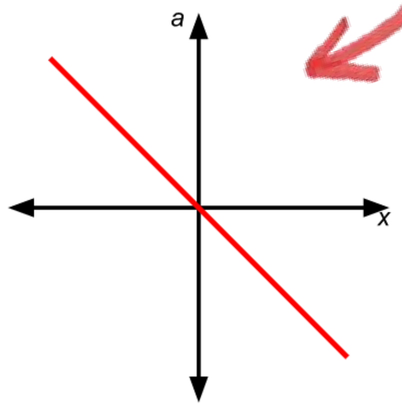
Red equation – *Not given formulae*

SIMPLE HARMONIC MOTION (SHM)

$$a = -\omega^2 x = -(2\pi f t)^2 x$$

For an object to undergo SHM, its acceleration must be directly proportional to its displacement from the equilibrium position in the opposite direction.

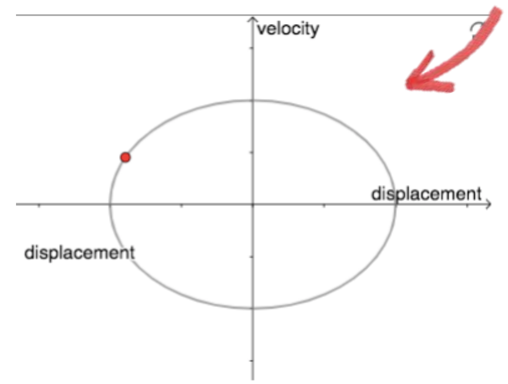
$$Phase\ Difference = \frac{2\pi\Delta t}{t} = \omega\Delta t$$

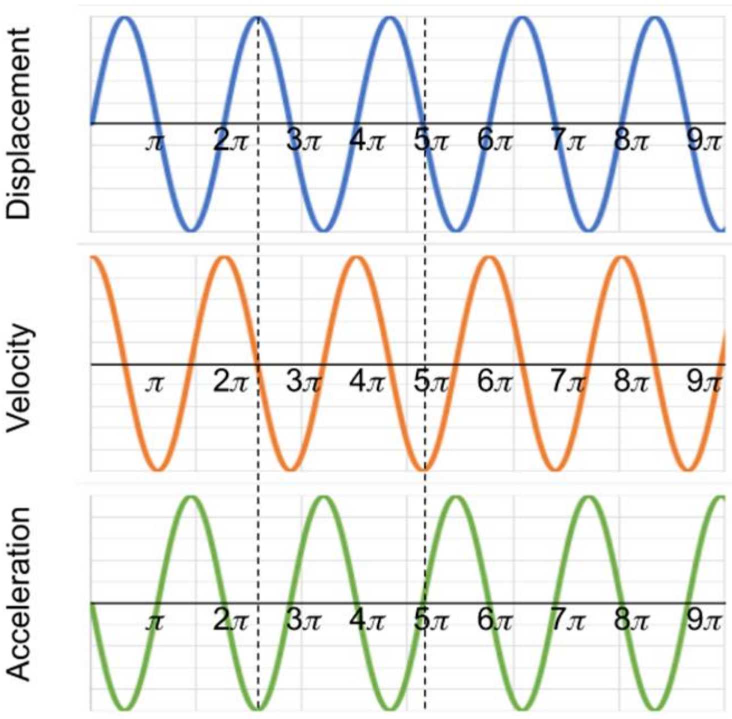


$$a_{max} = \omega^2 A$$

The acceleration of the object will be at a maximum when it is at its maximum amplitude

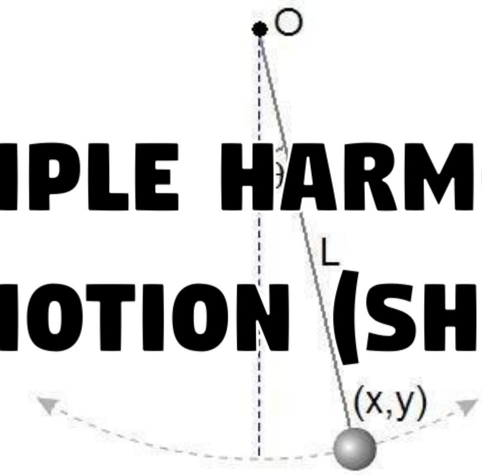
Velocity vs displacement graph





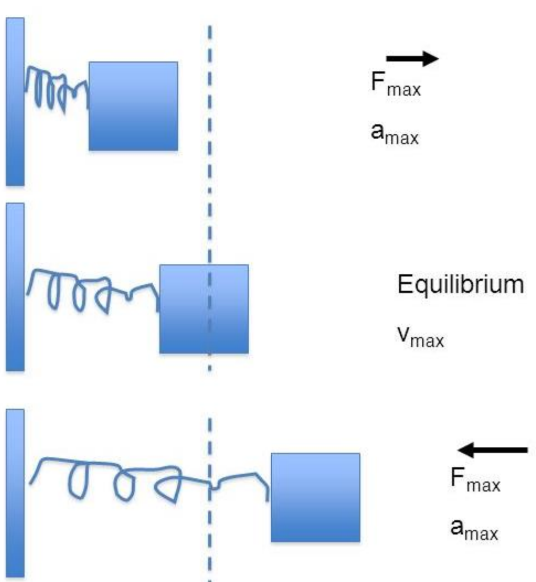
$$v = \omega \pm \sqrt{A^2 - x^2}$$

The velocity of the object will be at a maximum when it is passing through the equilibrium position



The gradient of the displacement graph will give you the velocity at any point.

$$v_{max} = \omega A$$



The variation of the displacement is sinusoidal and is given by the following expression.

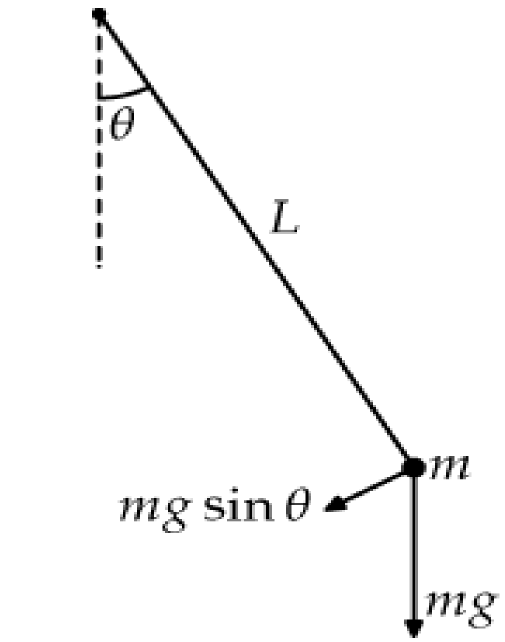
$$x = A\cos\omega t$$

$$x = A\cos 2\pi f t$$

At t = 0, the object is at maximum displacement. This is equal to the amplitude, A

Key
Blue equation – *Given formulae*
Red equation – *Not given formulae*

SIMPLE HARMONIC MOTION (SHM)



For a simple pendulum, the time period is only affected by the length of the pendulum and the gravitational field strength

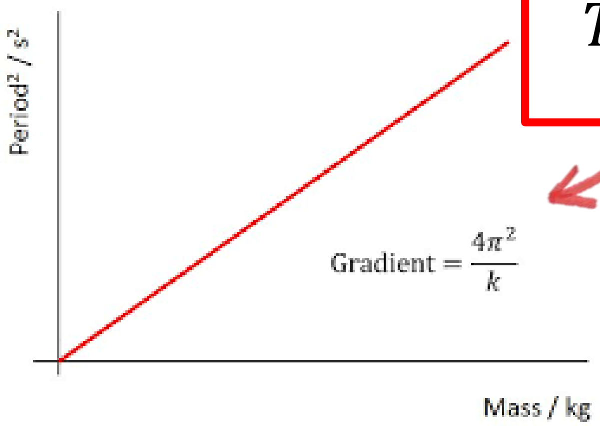
$$T = 2\pi\sqrt{\frac{l}{g}}$$

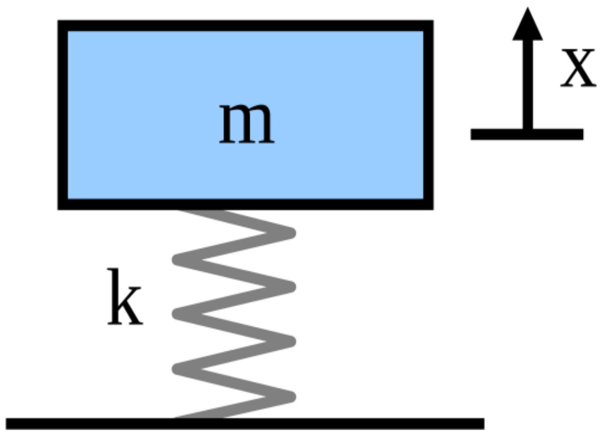
$$f = \frac{1}{2\pi}\sqrt{\frac{g}{l}}$$

Rearranged for length

$$l = \frac{T^2 g}{4\pi^2}$$

$$T^2 = 4\pi^2\frac{l}{g}$$

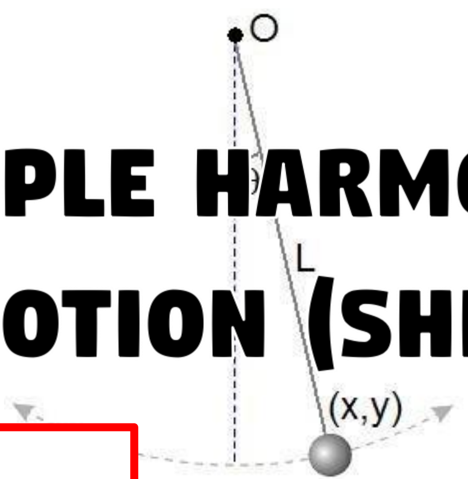




For a mass-spring system, the time period is only affected by the object's mass and the spring constant of the spring

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

$$T = 2\pi\sqrt{\frac{m}{k}}$$



The force on a pendulum is the component of gravity acting in the direction that the pendulum is moving in.

$$F = \mathrm{mg}\sin\theta$$

Using Newton's second law, we can express the acceleration of a pendulum

$$a = -\mathrm{g}\sin\theta$$

This equation only works values under 10 degrees. Sinθ can be written as follows:

$$\sin\theta = \frac{s}{L}$$

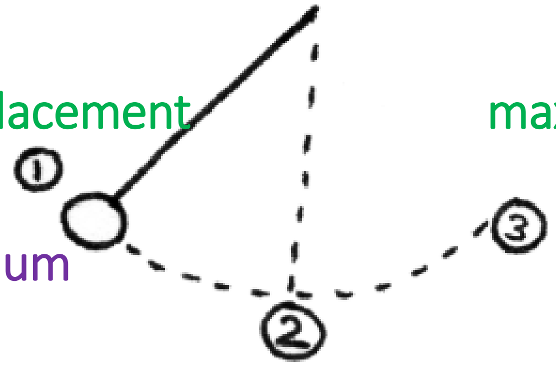
These equations shows you that the higher value for k the quicker it will oscillate. The more massive the spring the slower it will oscillate.

Key

Blue equation– *Given formulae*

Red equation – *Not given formulae*

Energy in an Oscillator



maximum displacement

E_p is at a maximum

E_k is at a zero

maximum displacement

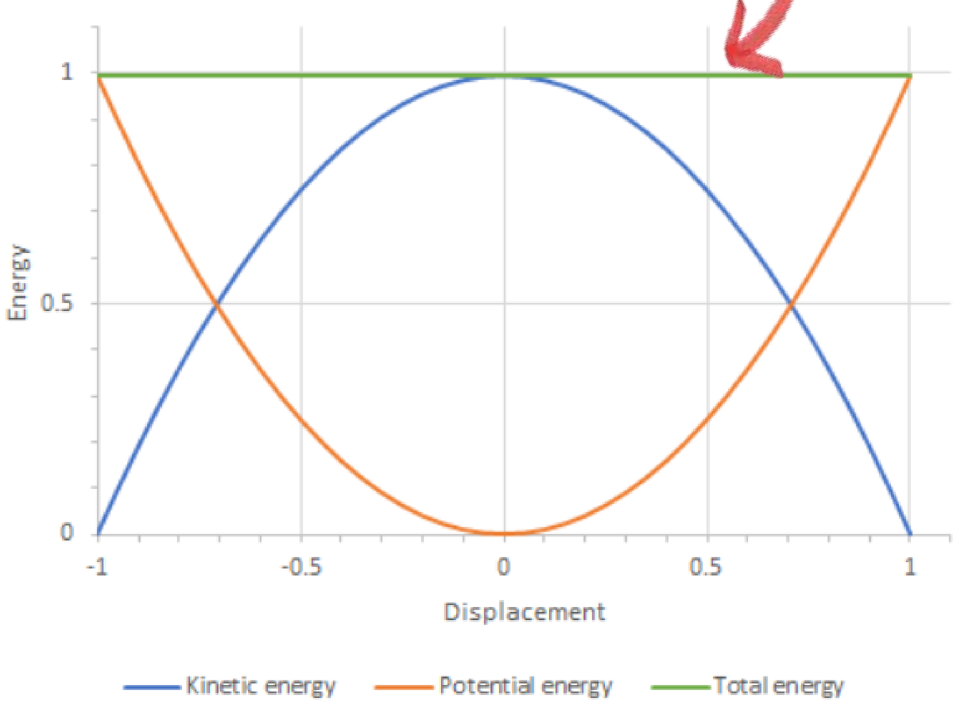
E_p is at a maximum

E_k is at a zero

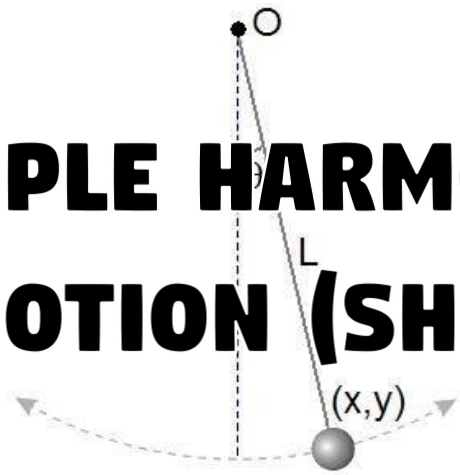
E_p is at a zero

E_k is at a maximum

$$Total\ Energy = Ek + Ep$$



SIMPLE HARMONIC MOTION (SHM)

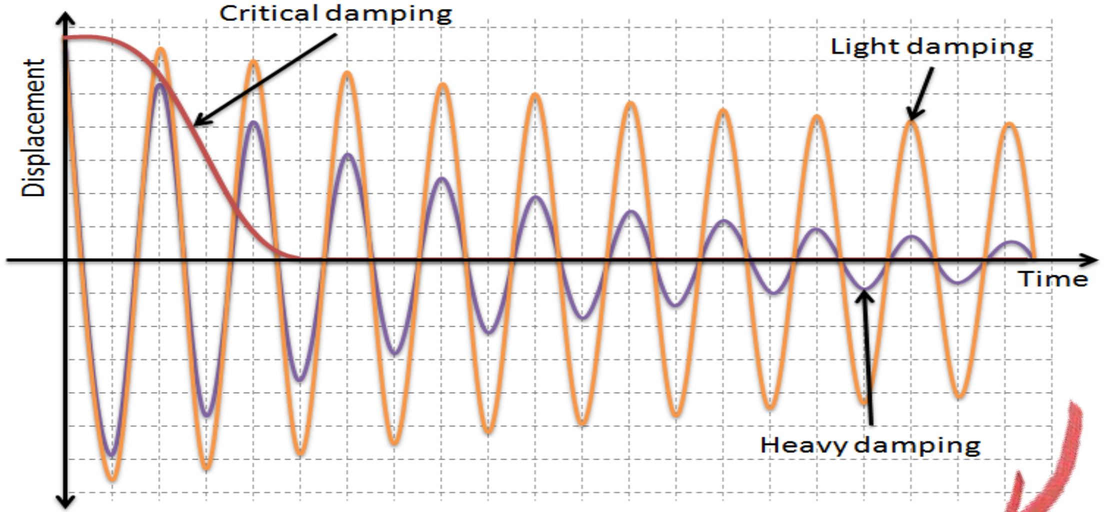


Kinetic energy is given by

$$E_k = \frac{1}{2}k(A - x)2$$

$$E_p = \frac{1}{2}kx^2$$

The potential energy in a spring is



Light damping: oscillations of constant time period continue with the amplitudes gradually decreasing over time.

Critical damping: the object returns to equilibrium in the shortest possible time without passing through to negative displacement.

Heavy damping: This results in the displaced object returning to equilibrium more slowly than if the system was critically damped.

$$E_{Total} = \frac{1}{2}kA^2$$

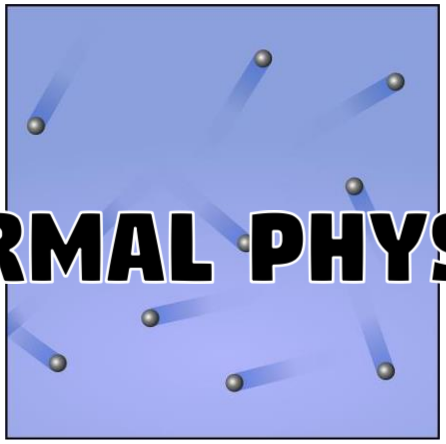
At the maximum displacement, the total energy of the system is

Key

Blue equation – *Given formulae*

Red equation – *Not given formulae*

THERMAL PHYSICS



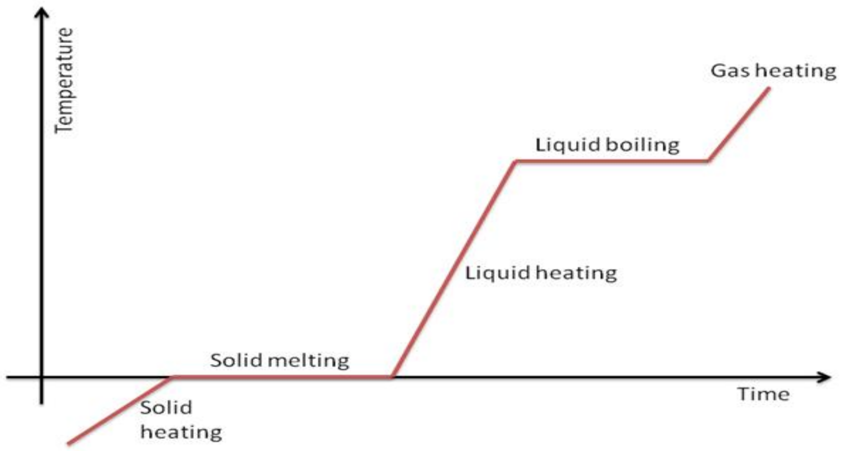
$$K = C + 273$$

Absolute zero is the point at which all molecules have zero kinetic energy

A change of $1K$ equals a change of $1°C$

Specific latent heat is the energy needed per kg to be gained or lost in order to change state. It is measured in Jkg^{-1}.

$$Q = \mathrm{mL}$$



l_f means the latent heat of fusion (solid to liquid)

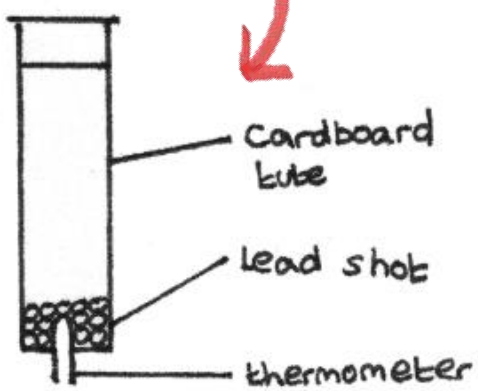
l_v means the latent heat of vaporisation (liquid to gas)

$$\Delta U = \Delta Q - \Delta W$$

First law = The change in internal energy, ΔU, of a system is equal to the heat, ΔQ, added to the system minus the work done, ΔW, by the system.

A method used to determine the **specific heat capacity of a substance** is the inversion tube experiment.

$$c = \frac{gLn}{\Delta T}$$



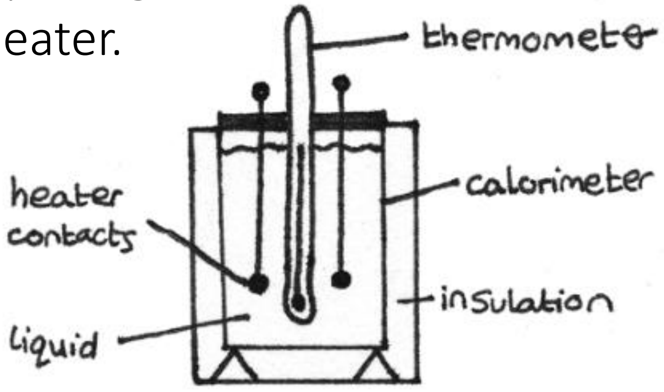
Internal Energy

$$U = E_k - E_{pot}$$

Specific heat capacity is the energy needed to raise the temperature of 1kg of a substance by $1K$ (or $1°C$).

$$Q = mc\Delta\theta$$

A method of determining the specific heat capacity of a liquid is by using a calorimeter and a heater.



some energy is used to heat the liquid and some to heat the calorimeter

$$IV\Delta t = m_1 c_1 \Delta T + mcalccal\Delta T$$

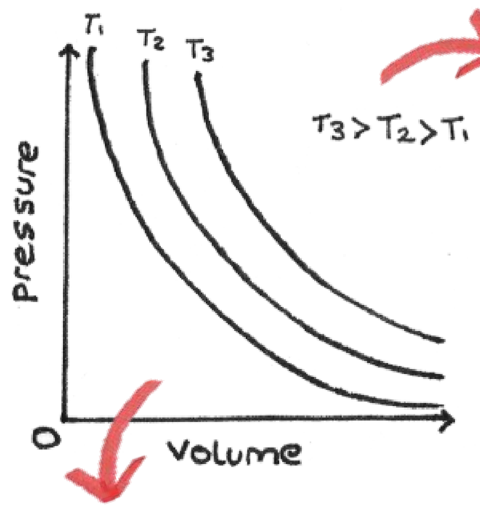
Key

Blue equation – *Given formulae*

Red equation – *Not given formulae*

Boyle's Law states that for a gas of fixed mass at a constant temperature, the pressure (p) and volume (V) are inversely proportional:

$$P_iV_i = PfVf$$



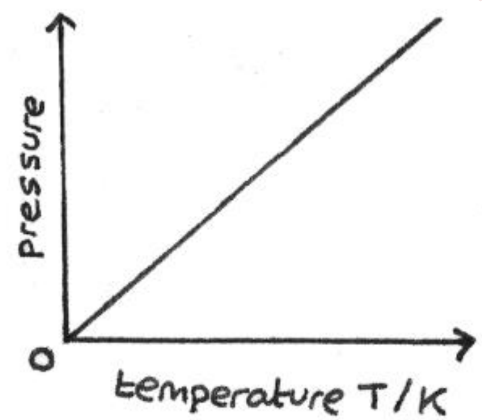
$$P \propto \frac{1}{V}$$

Area under the graph is equal to the work done.

$$\Delta W = p\Delta V$$

Charles's Law states that for a gas of fixed mass at constant pressure, the volume, V is directly proportional to its absolute temperature, T.

$$\frac{V_i}{T_i} = \frac{V_f}{T_f}$$

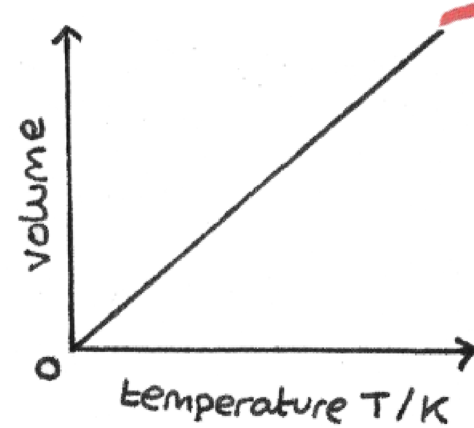


$$V \propto T$$

The pressure law states that for a gas of fixed mass at constant volume, the pressure, p is directly proportional to its absolute temperature, T.

$$\frac{P_i}{T_i} = \frac{P_f}{T_f}$$

T is always in **Kelvin**



$$P \propto T$$

$$N = nNA$$

N_A is Avogadro's number, the number of molecules present in 1 mole. **N is the number of molecules** and n is the number of moles

$$n = \frac{m}{M_r}$$

(Relative) **Molecular mass, M_r** is the sum of the atomic masses which make up a molecule (measured in grams)

The molar mass, M_u, is the mass of one mol of a *substance* *(usually measured in* $\mathbf{kgmol^{-1}}$*, but check units inquestions!)*

$$\frac{PV}{T} = constant$$

Ideal gas

$$pV = nRT$$

$$pV = NkT$$

$$k = \frac{R}{N_A}$$

K is the Boltzmann constant

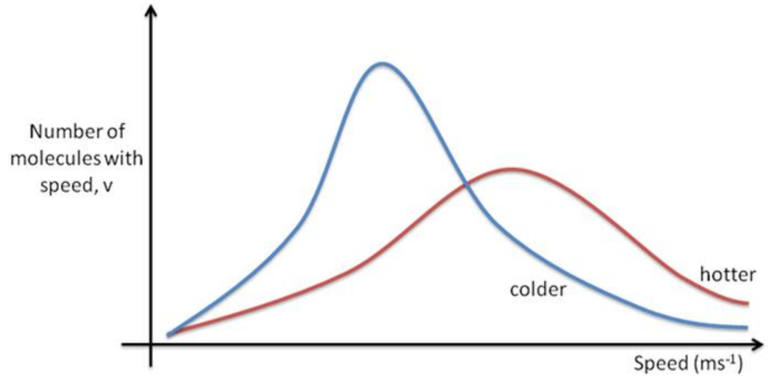
Key

Blue equation– *Given formulae*

Red equation – *Not given formulae*

Kinetic Theory and Molecular Speeds

Distribution of speed remains the same provided the temperature is constant.

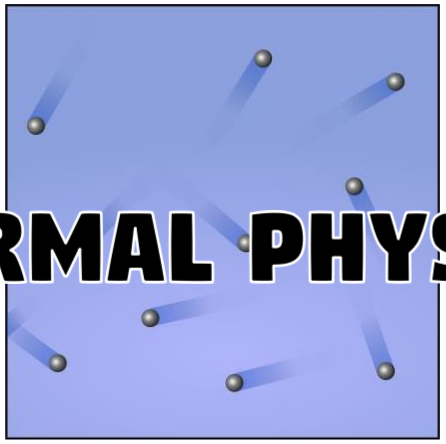


$$c_{rms} = \left[\frac{(C_1^2 + c_2^2 + c_3^2 \ldots)}{N}\right]^{1/2}$$

T always in Kelvin

The rms speed of molecules in an ideal gas, this gives a mean of the magnitude of the speeds:

THERMAL PHYSICS



$$pV = \frac{1}{3} N m (C_{rms})^2$$

Mass of ONE MOLECULE

The kinetic theory equation demonstrates that that for N molecules of gas at a given volume, the mass and the r.m.s. speed affect the pressure

Ideal Gas Assumptions

R – The motion of all molecules is random.

A – No attraction between molecules

V - Molecules take up negligible volume.

E - All collisions between molecules and the walls of the container are completely elastic.

D – The duration of the collision is negligible in comparison to the duration between collisions

$$E_{Kin} = \frac{3}{2} KT$$

microscopic

Mean kinetic energy of one molecule

macroscopic

The total energy for n moles of an ideal gas

$$E_K = \frac{1}{2} m (c_{rms})^2$$

$$E_{K\,Total} = \frac{3}{2} NKT$$

$$E_K = \frac{3}{2} nRT$$

Key

Blue equation – *Given formulae*

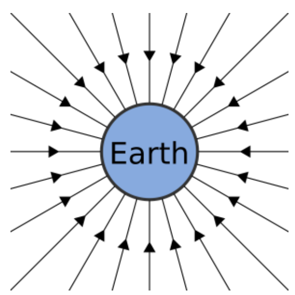
Red equation – *Not given formulae*

$$F_g = \frac{Gm_1m_2}{r^2}$$

Coulombs Law: Force between two masses is directly proportional to the product of their masses and inversely proportional to the distance between them squared.
Vector quantity

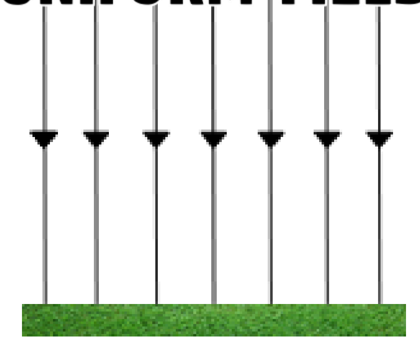
$$\Delta E_{pot} = mg\Delta h$$

RADIAL FIELD



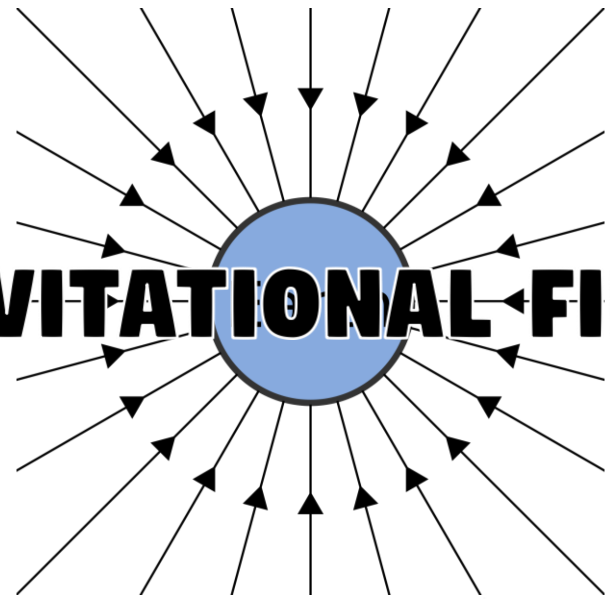
$$g = \frac{GM}{r^2}$$

UNIFORM FIELD



Gravitational field strength is the force per unit mass (Nkg^{-1}) *Vector quantity*

GRAVITATIONAL FIELDS



$$g = \frac{F}{m}$$

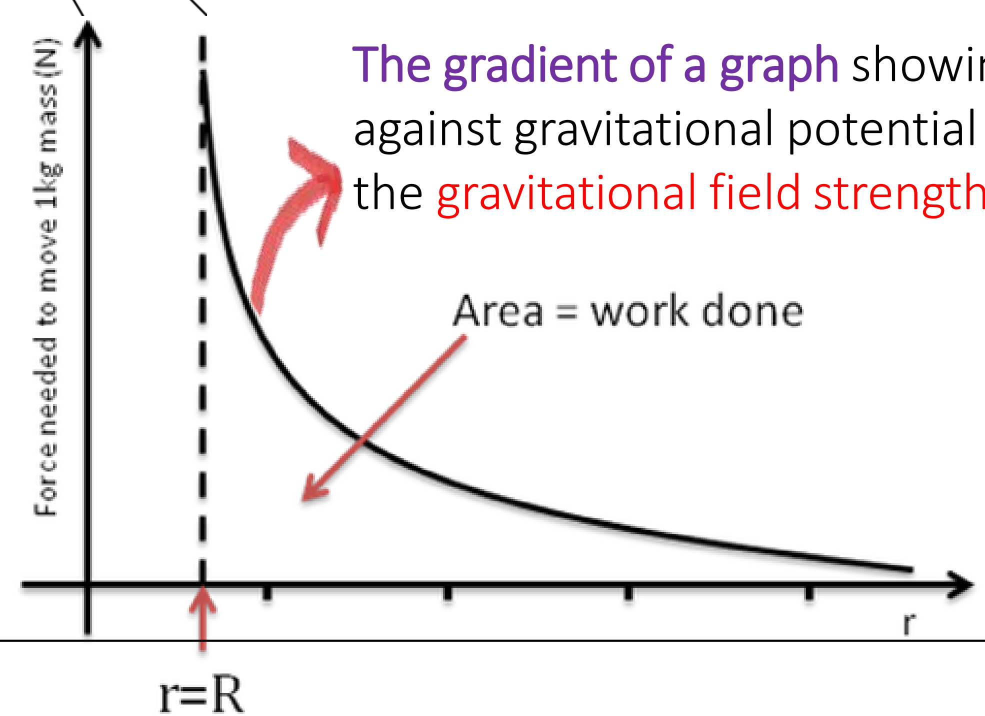
$$M = \frac{4}{3}\pi r^3\rho$$

Calculating the mass of a planet with its density

Subbing this into $g = \frac{GMM}{r^2}$ you get :

$$g = \frac{4}{3}G\pi r\rho$$

The gradient of a graph showing distance against gravitational potential gives you the gravitational field strength.



Key
Blue equation – *Given formulae*
Red equation – *Not given formulae*

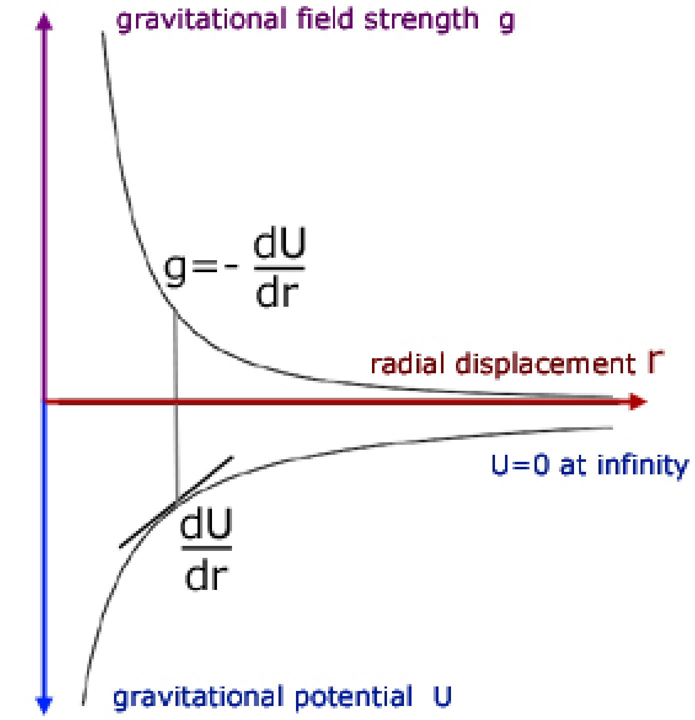
GRAVITATIONAL FIELDS

Gravitational Potential is:
the work done per unit mass in bringing a point mass from infinity to a point in a gravitational field (Jkg^{-1})
Scalar quantity

$$V = \frac{W}{m}$$

$$\Delta E_{pot} = \Delta W = m\Delta V$$

Gravitational Potential is always negative as by convention, zero potential is at a point which is an infinite distance away from a gravitational field

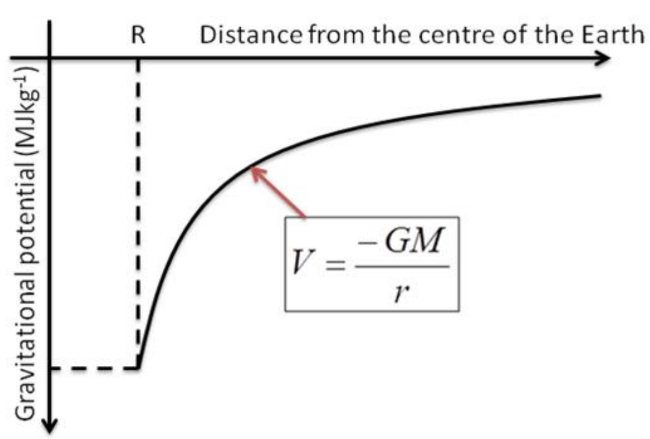


Gravitational potential gradient: the change of potential per metre at that point ($\frac{\Delta V}{\Delta R}$).

$$V = -\frac{GM}{r}$$

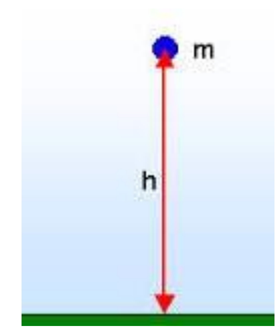
$$\Delta V = \left(-GM\left(\frac{1}{r_1} - \frac{1}{r_2}\right)\right)$$

$$g = \frac{\Delta V}{\Delta R}$$



$$E_{pot} = \frac{Gm_1m_2}{r}$$

Gravitational Potential Energy in a radial field

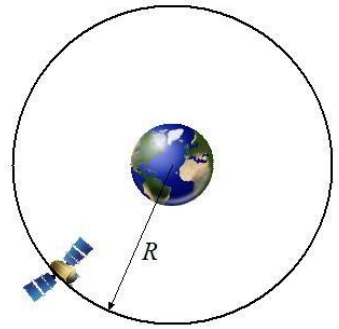


Key
Blue equation– *Given formulae*
Red equation – *Not given formulae*

GRAVITATIONAL FIELDS

$$E = \frac{Gm_1m_2}{2r}$$

Total energy INPUT required to put a satellite into an orbit of radius r around a planet of mass M and radius R is therefore the sum of the gravitational potential energy and the kinetic energy of the satellite



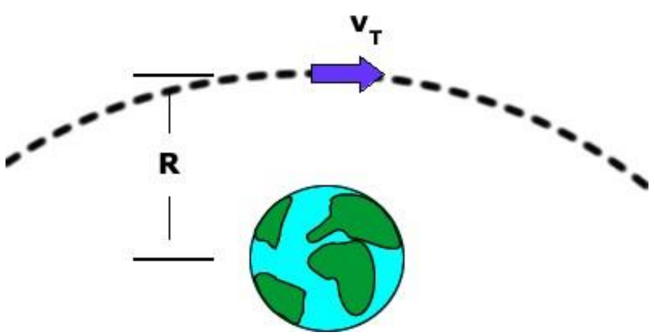
Centripetal Force = Gravitational Force

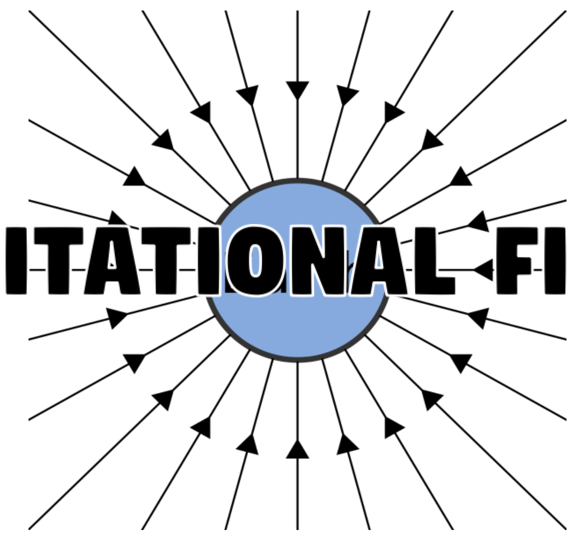
$$\frac{\mathrm{mv}^2}{\mathrm{r}} = \frac{Gm_1m_2}{r^2}$$

$$v = \sqrt{\frac{GM}{r}}$$

The orbital speed of a satellite is inversely proportional to the square root of the radius of its orbit

$$mr\left(\frac{2\pi}{\mathrm{T}}\right)^2 = \frac{Gm_1m_2}{r^2}$$



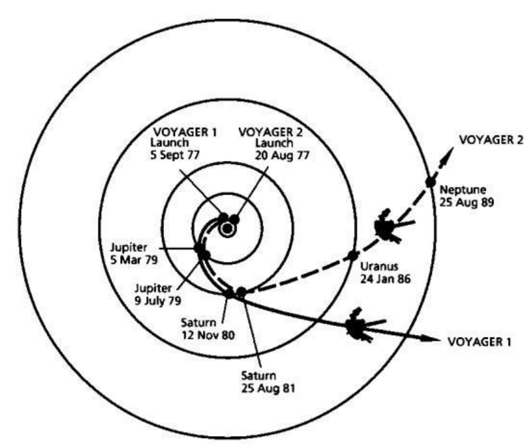


The time period of a satellite's orbit around a planet squared is directly to proportional to the radius of its orbit cubed (Circular motion applies)

$$\mathrm{T}^2 = \left(\frac{4\pi^2}{G\mathrm{M}}\right)r^3$$

$$v = \sqrt{\frac{2GM}{r}}$$

The escape velocity of an object is the velocity needed for an object to be completely free of a gravitational field from a planet



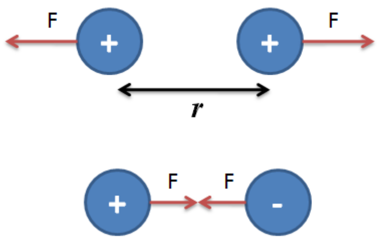
$$\mathrm{r}^3 = \left(\frac{G\mathrm{M}}{4\pi^2}\right)T^2$$

$$\mathrm{r}^3 \propto T^2$$

Key
Blue equation– *Given formulae*
Red equation – *Not given formulae*

$$F = \pm\frac{kQ_1Q_2}{r^2}$$

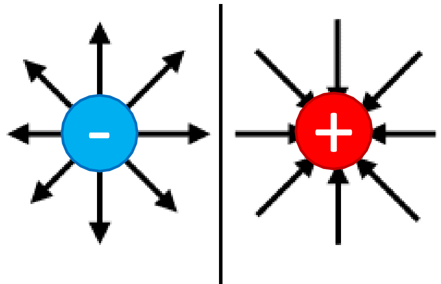
Coulombs Law: Force between two charges is directly proportional to the product of their charges and inversely proportional to the distance between them squared. *Vector quantity,*



$$* k = \frac{1}{4\pi\varepsilon_0}$$

RADIAL FIELD

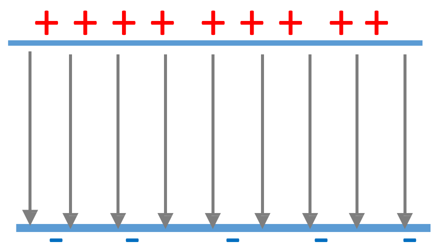
$$E = \frac{kQ}{r^2}$$



Electric field strength in a radial field is inversely proportional to the distance from the charge squared

$$E = \frac{F}{Q}$$

UNIFORM FIELD

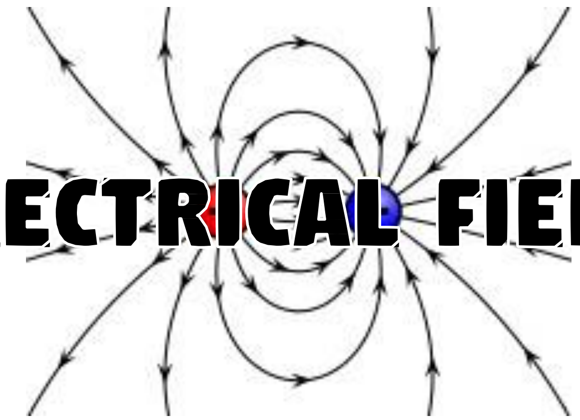


Electric field strength is the force per unit charge (NC^{-1}) *Vector quantity*

$$\Delta W = Q\Delta V$$

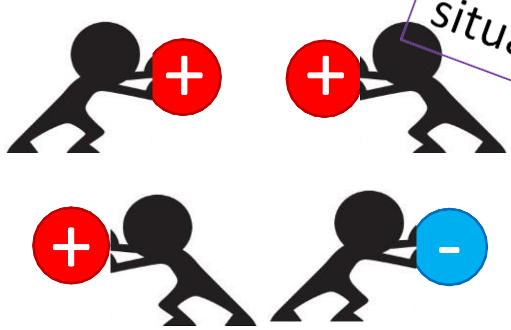
Electric Potential is the work done per unit charge in bringing a positive charge to infinity from a point in an electric field $(JC^{-1}\ or\ V)$ *Scalar quantity*

ELECTRICAL FIELDS



The electric field strength, E, is equal to the negative of the potential gradient

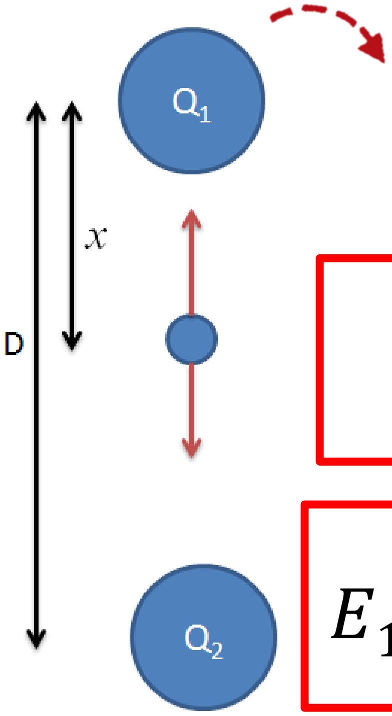
$$E = \frac{\Delta V}{\Delta r}$$



High potential situation

$$V = \pm\frac{kQ}{r}$$

Depending on the charge, electric potential may be positive or negative as it is the work done in *bringing a positive point charge* to a point in a field



Electric fields when there is more than one charge

$$E_1 - E_2 = k\left(\frac{Q_1}{r_1{}^2} - \frac{Q_2}{r_2{}^2}\right)$$

$$E_1 - E_2 = k\left(\frac{Q_1}{x^2} - \frac{Q_2}{(D-x)2}\right)$$

Key

Blue equation – *Given formulae*

Red equation – *Not given formulae*

$$C = \frac{Q}{V}$$

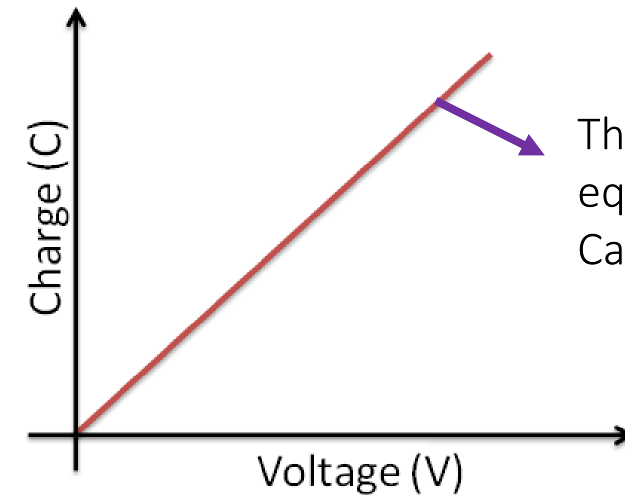
Capacitance is the charge stored per unit potential difference by a capacitor $(Farads,\ F\ or\ CV^{-1})$

Relative permittivity is the ratio between the permittivity of a material and the permittivity of free space (Fm^{-1})

$$\varepsilon_r = \frac{\varepsilon_1}{\varepsilon_o}$$

$$\varepsilon_r = \frac{Q}{Q_o}$$

$$\varepsilon_r = \frac{C}{C_o}$$

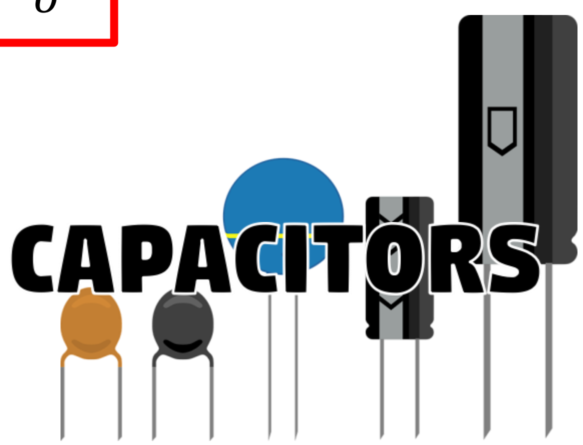


The Gradient is equal to the Capacitance

The **energy stored** is equal to the work done to force extra charge

$$C = \frac{A\varepsilon_0\varepsilon_r}{d}$$

Capacitance is directly proportional to the area of the plates, and inversely proportional to the distance between them

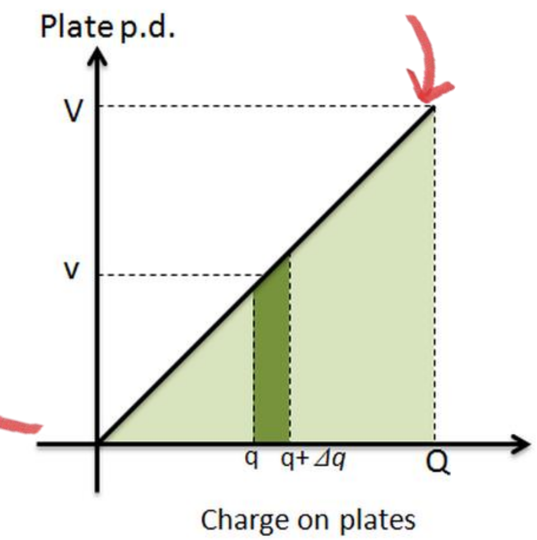


$$E = \frac{1}{2}QV$$

$$E = \frac{1}{2}CV^2$$

$$E = \frac{1}{2}\frac{Q^2}{C}$$

Area under the graph is equal to the energy stored



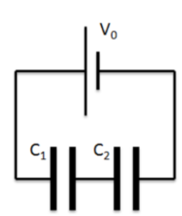
$$Time\ to \approx 100\%\ charge = 5(RC)$$

The **greater** the relative permittivity of a material, the **higher the capacitance**

$$time\ constant = RC = 0.37Q_0$$

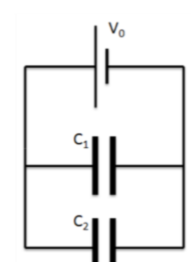
The **time constant** is the time taken for the voltage/current/charge of a capacitor to ≈ 37%

Series



$$C_{Total} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$$

Parallel

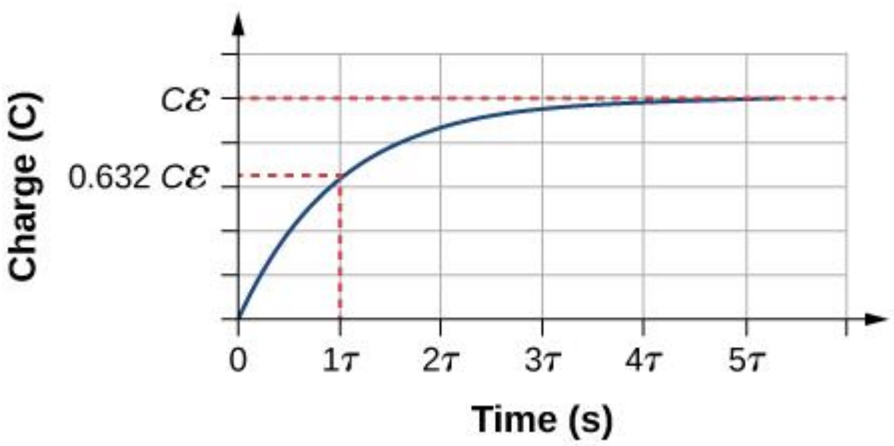


$$C_{Total} = C_1 + C_2 + \cdots$$

Key
Blue equation – *Given formulae*
Red equation – *Not given formulae*

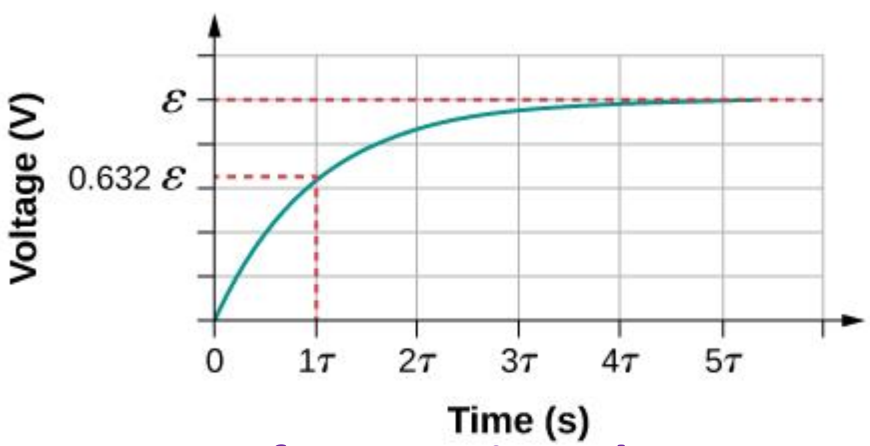
CHARGING CAPACITORS

Charge vs. Time Capacitor



(a)

Voltage vs. Time Capacitor



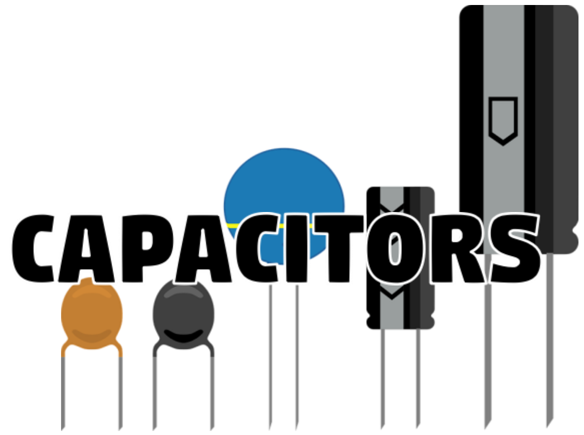
The equation **for capacitor charge** is:

$$V = Vo\left(1 - e^{-\frac{t}{RC}}\right)$$

$$Q = Qo\left(1 - e^{-\frac{t}{RC}}\right)$$

$$t_{1/2} = ln2RC$$

The **half life of a capacitor** is the time taken for the **voltage/current/charge** of a capacitor reaches half of its original value

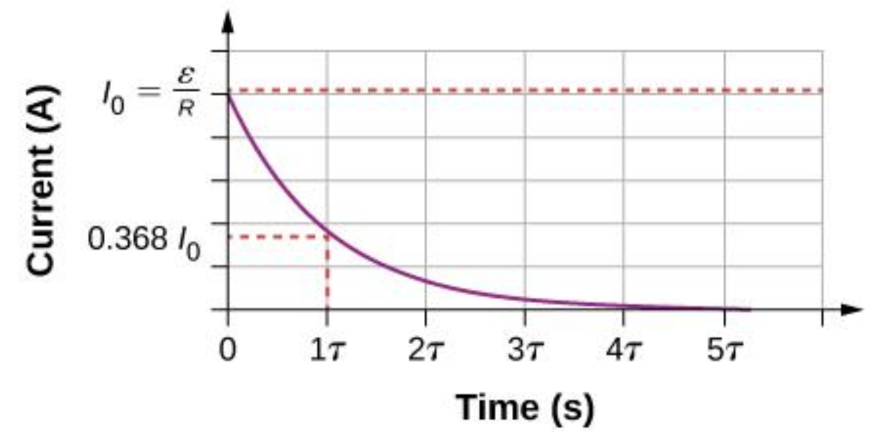


$$V = Voe^{-\frac{t}{RC}}$$

$$I = Ioe^{-\frac{t}{RC}}$$

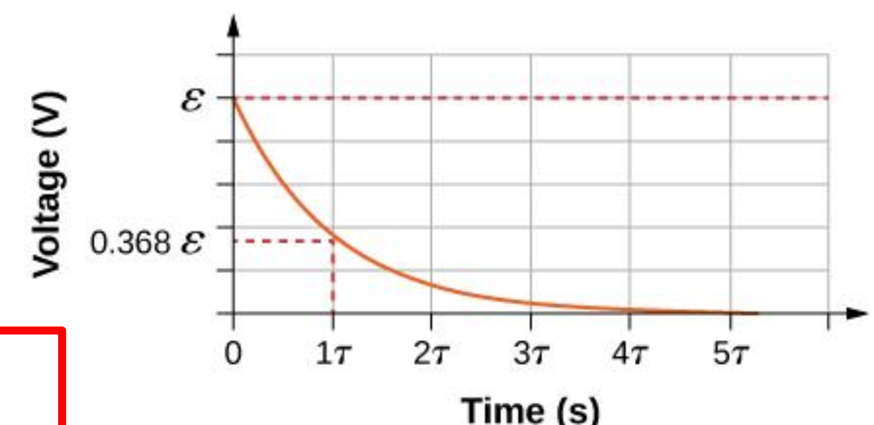
DISCHARGING CAPACITORS

Current vs. Time Resistor



(b)

Voltage vs. Time Resistor



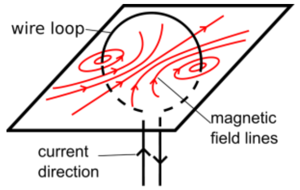
$$Q = Qoe^{-\frac{t}{RC}}$$

For a **discharging capacitor**, the rate at which charge and voltage change over time obey an exponential decay relationship

Key
Blue equation – *Given formulae*
Red equation – *Not given formulae*

MAGNETIC FIELDS

$$F = BIl$$



$$F = (BIl)n$$

The force on a current carrying wire is directly proportional to the magnetic flux density (field strength), the current in the wire and the length of the wire.

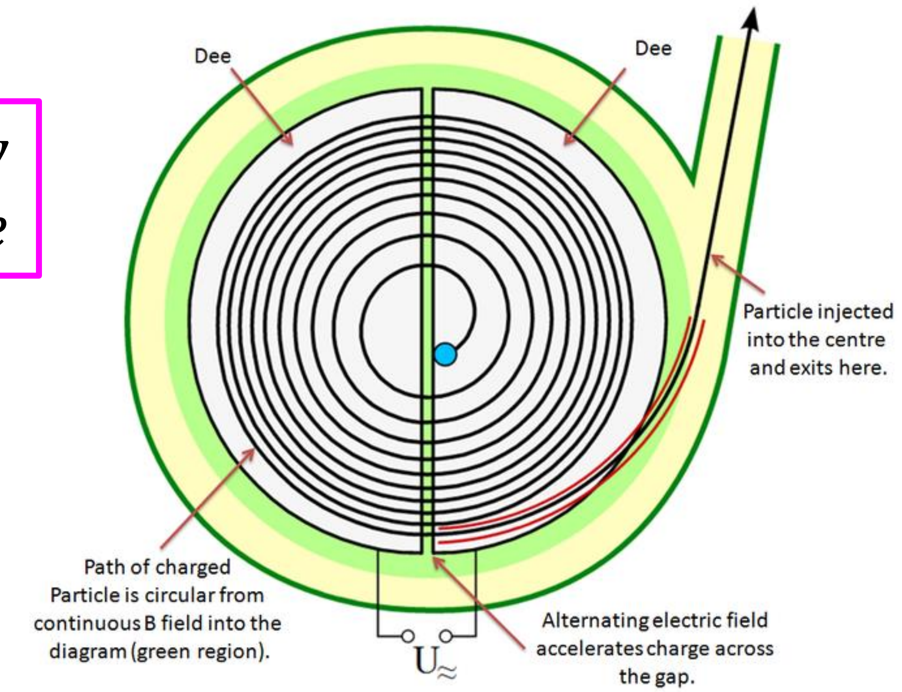
$$F = Bev$$

The force on a charge in a magnetic field is affected by the magnetic flux density, the size of the charge and the velocity of its motion perpendicular to the field.

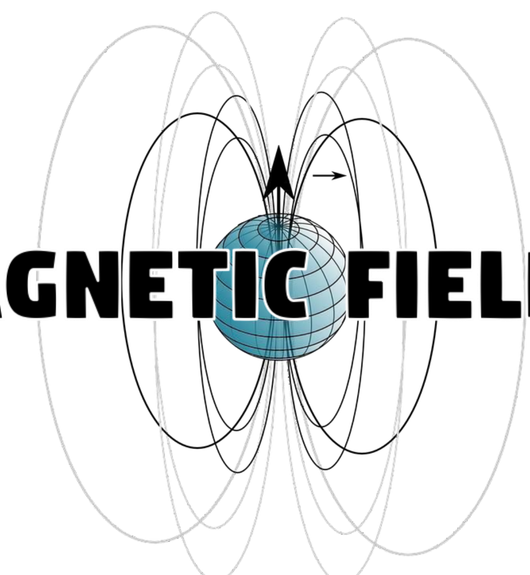
$$\Phi = BA$$

Magnetic Flux Density is measured in $Teslas, T \; or \; NA^{-1}m^{-1}$ *Vector quantity*

$$v = velocity$$
$$V = Voltage$$



Magnetic Flux is the total magnetic flux passing through a given area. It is measured in $Webers$, $Wb \; or \; Tm^{-2}$ *Scalar quantity*

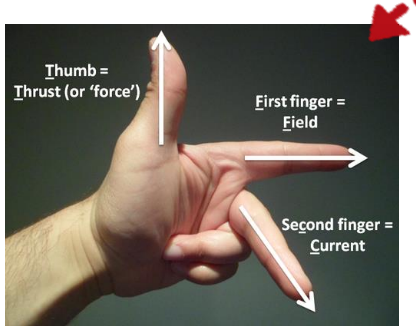


$$N\Phi = BAN \cos\theta$$

$$\frac{1}{f} = T = \frac{2\pi m}{BQ}$$

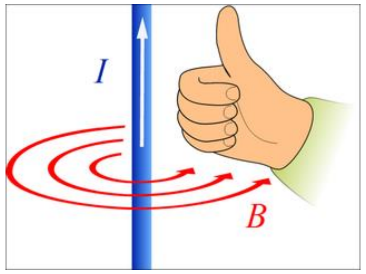
$$\varepsilon = BAN\omega \sin\theta\omega t$$

The emf of a coil rotating uniformly in a magnetic field is dependant on the flux linkage and the angular speed.



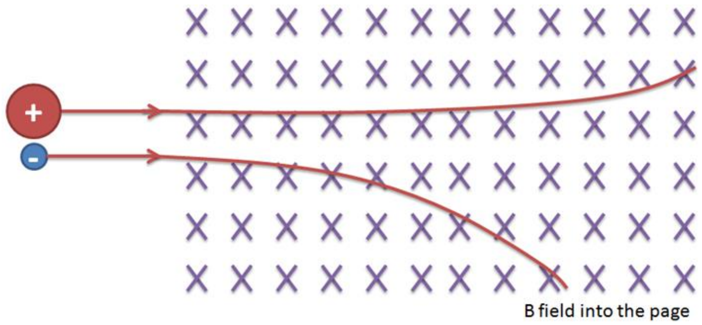
Fleming's left hand rule

Applied for charges moving through conventional current +ve → -ve



The time period of a charged particle moving through a magnetic field is independent of its velocity.

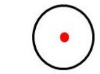
Key
Blue equation – *Given formulae*
Red equation – *Not given formulae*



$$r = \frac{mv}{BQ}$$

$$v = velocity$$
$$V = Voltage$$

Current going into Page



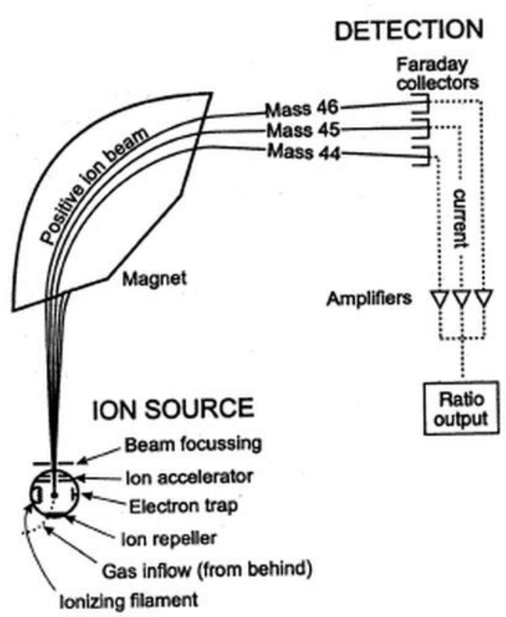
Current coming out of Page

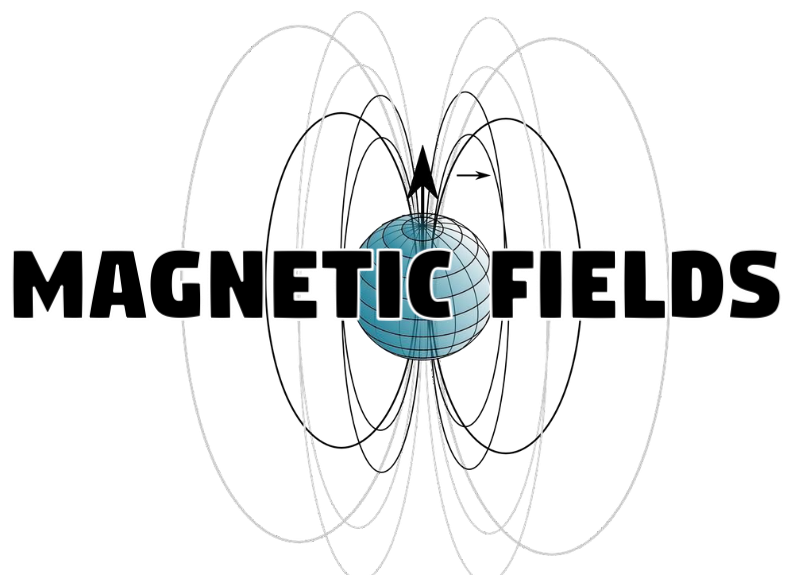
The radius of a charged particle moving through a magnetic field is directly proportional to its momentum and inversely proportional to the magnetic flux density and its charge.

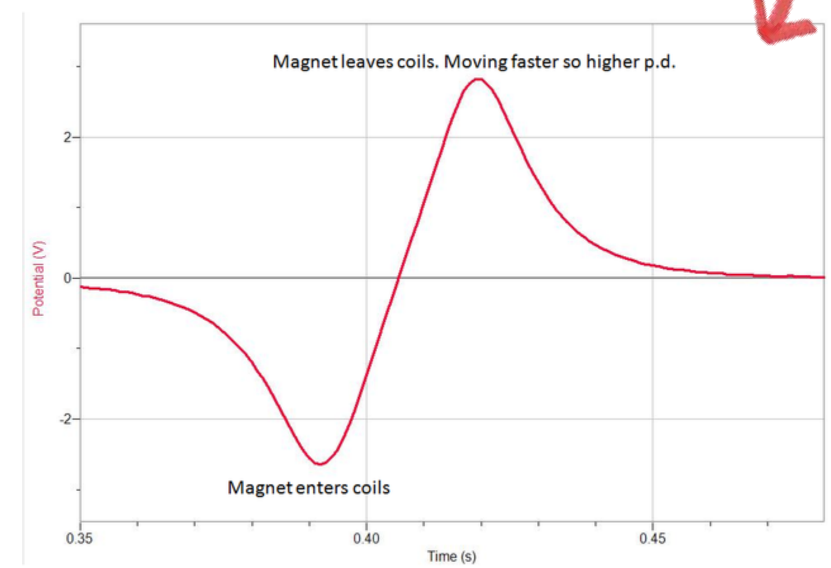
$$\varepsilon = -\frac{N\Delta\Phi}{\Delta t}$$

Lenz's Law

The induced emf across a conductor is directly proportional to the rate of change of flux linkage in a magnetic field

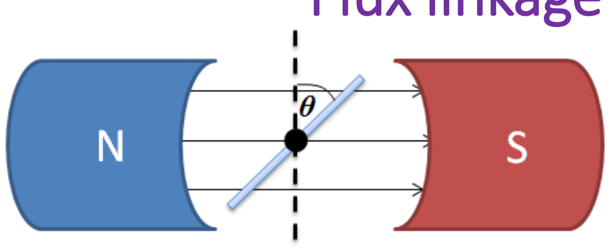




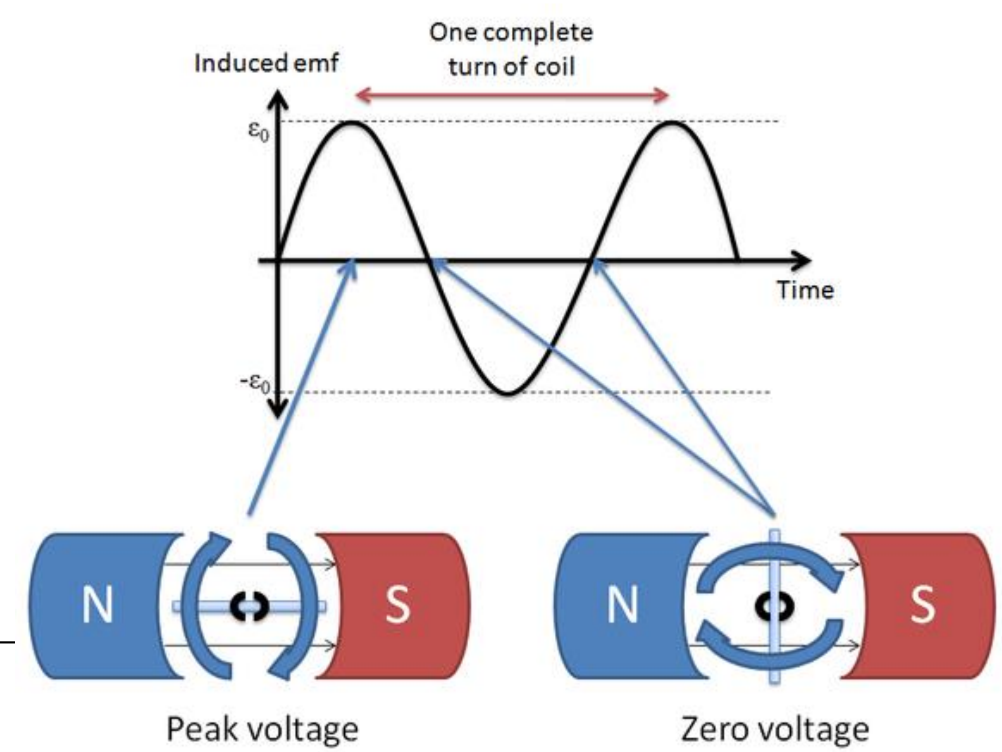


AC Generator

Flux linkage through the coil is

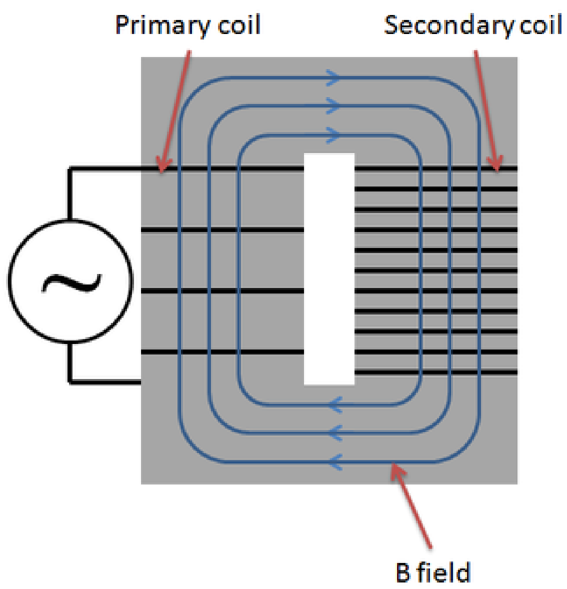


$$N\Phi = BAN \sin\theta$$



Key
Blue equation – *Given formulae*
Red equation – *Not given formulae*

MAGNETIC FIELDS



From Faraday's law the induced emf in the primary and secondary coils are:

$$V_p = Np\frac{\Delta\Phi}{\Delta t}$$

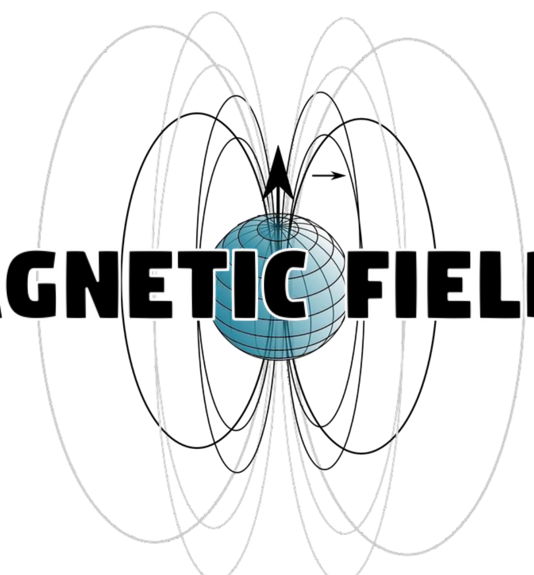
$$V_s = Ns\frac{\Delta\Phi}{\Delta t}$$

Assuming that a transformer is 100% efficient, the ratio of the number of turns on the primary and secondary coil is equal to the ratio of their voltages

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

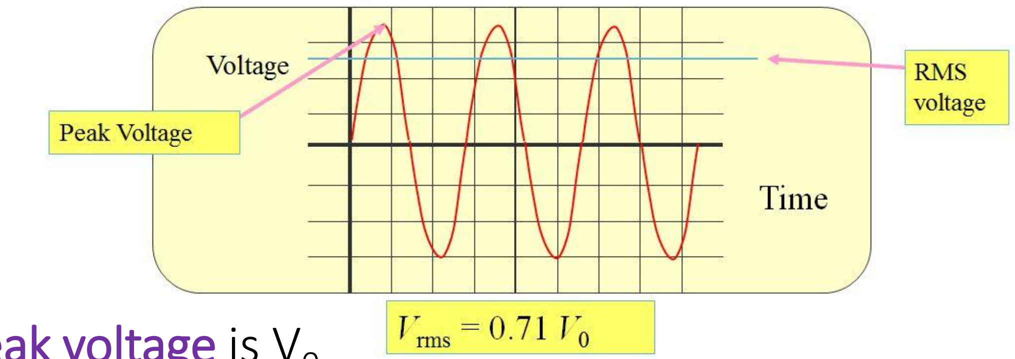
$$Efficiency = \frac{I_sV_s}{I_pV_p}x100$$



$$P = IrmsVrms$$

$$I_pV_p = I_sV_s$$

Effective voltage, V_{rms}.



Peak voltage is V_0

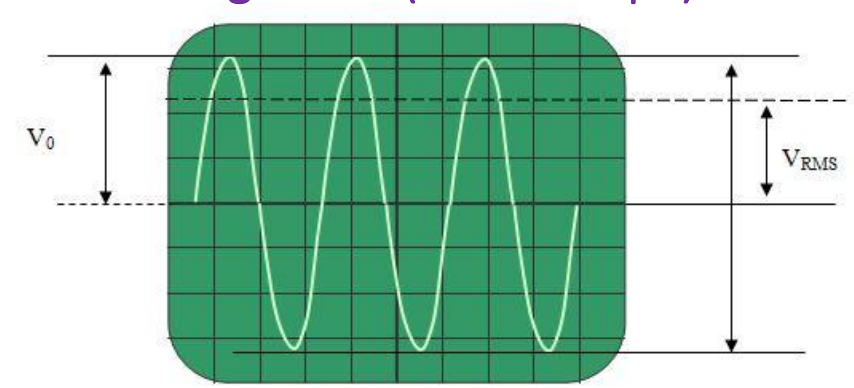
The r.m.s. current/voltage of an A.C supply can be directly compared to its DC equivalent

$$I_{rms} = \frac{I_0}{\sqrt{2}}$$

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

We use the rms value because its use allows us to do electrical calculations as if they were direct currents.

Using a CRO (Oscilloscope)

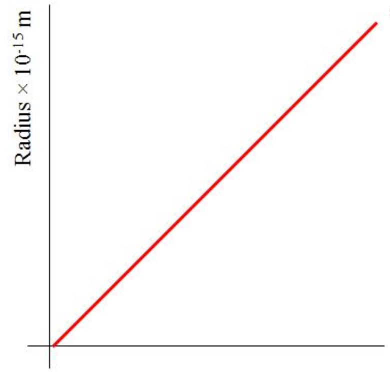


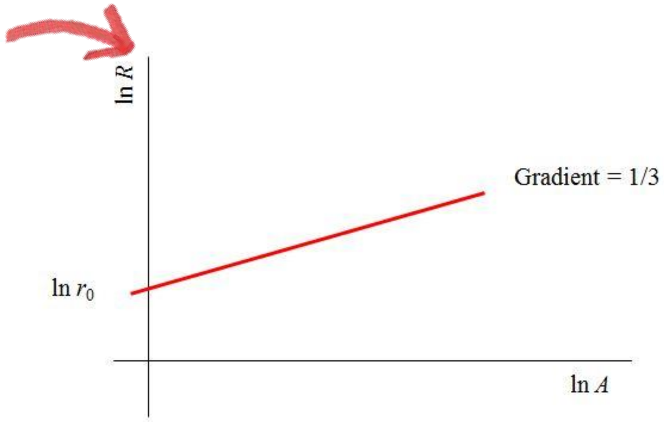
Key
Blue equation– *Given formulae*
Red equation – *Not given formulae*

NUCLEAR PHYSICS

$$R = r_o A^{\frac{1}{3}}$$

$$r_o = 1.5\text{fm}$$

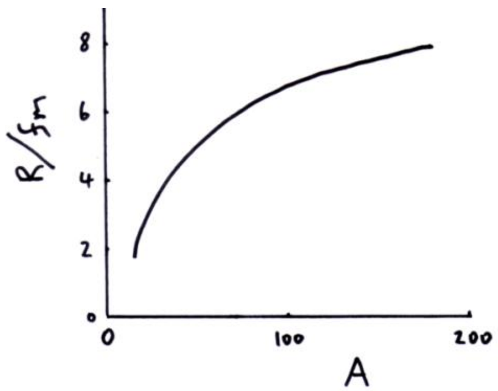




$$\rho = \frac{3m}{4\pi r_o}$$

The nuclear density of a nucleus is approx 1.8 x 10^{17} kgm^{-3}

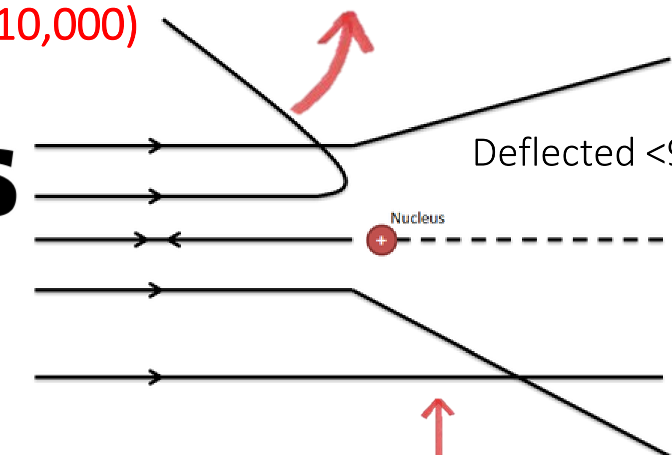
$$V = \frac{4}{3}\pi r_o A$$



The radius of a nucleus is directly proportional to the cube root of an atoms nucleon number

RUTHERFORD'S SCATTERING EXPERIMENT

Deflected >90°= concentrated mass & +ve (1 in 10,000)



Deflected <90° = +ve nucleus

Pass through = empty space (1 in 2000)

CLOSEST APPROACH OF α PARTICLES

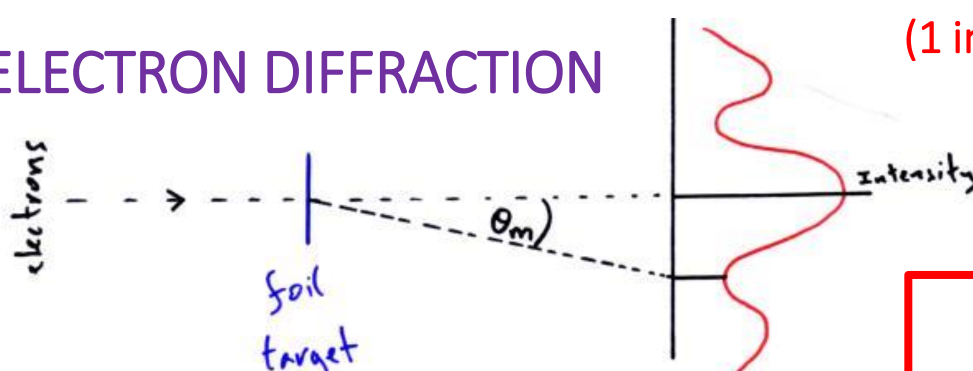
$$\text{Initial } Ek = \frac{kQ_1Q_2}{r}$$

$$* \, k = \frac{1}{4\pi\varepsilon_0}$$

Due to the conservation of energy, assuming no energy loss, the electrostatic potential energy will be equal to its initial kinetic energy.

$$r = \frac{kQ_1Q_2}{E_k}$$

ELECTRON DIFFRACTION



When determining the radius of a nucleus through electron diffraction, the minimum angle of diffraction is given as follows

$$r = \frac{0.61 \sin\theta_{min}}{\lambda}$$

Key
Blue equation– *Given formulae*
Red equation – *Not given formulae*

Alpha Decay, α
Nucleon number decreases by 4
Proton number decreases by 2

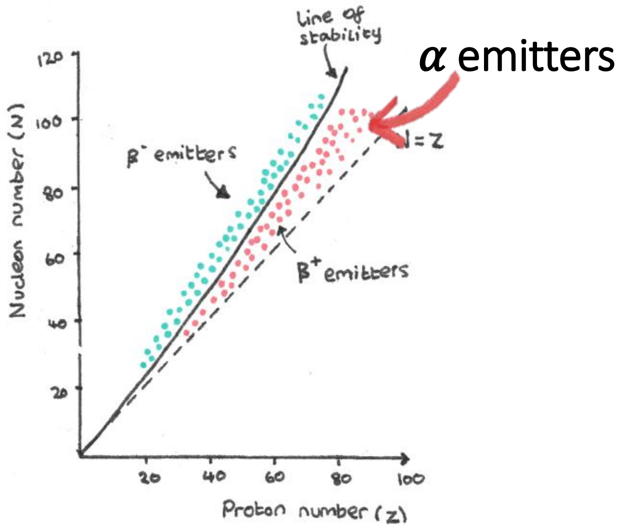
Beta minus decay, β^{-}
Nucleon number stays the same
Proton number increases by 1

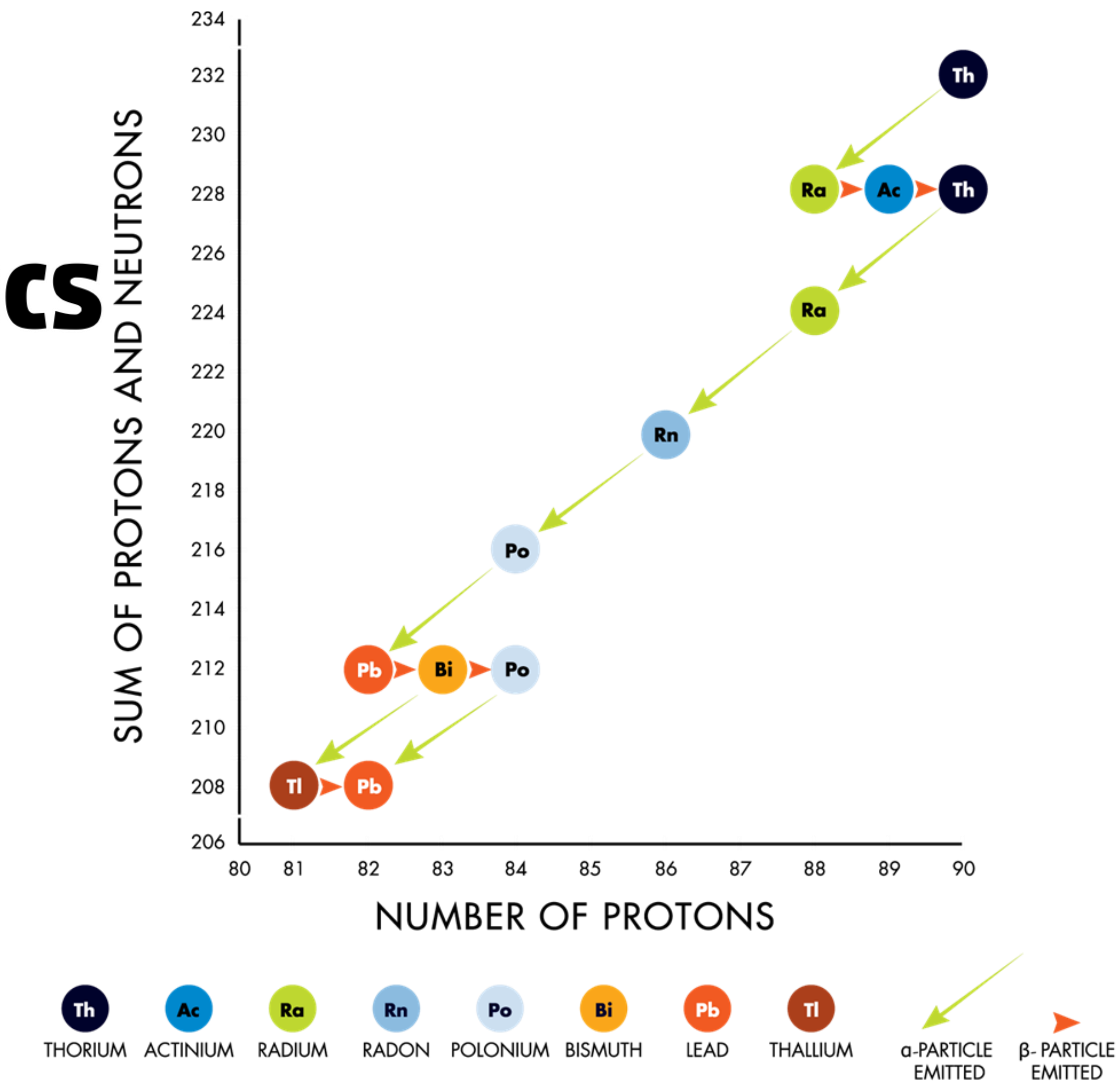
Beta plus decay, β^{+}
Nucleon number stays the same
Proton number decreases by 1

$$X_Z^A \rightarrow X'^{A-4}_{Z-2} + \alpha^4_2$$

$$X_Z^A \rightarrow X'^{A}_{Z+1} + \beta^{-}{}^{0}_{-1} + \bar{V}_e$$

$$X_Z^A \rightarrow X'^{A}_{Z-1} + \beta^{+}{}^{0}_{-1} + ve$$





	α	β	γ
Description	2 protons and 2 neutrons	β^{-} is an electron. β^{+} is an positron.	High frequency photons
Range in air	<10cm	<1m	Follows inverse square law
Deflection in magnetic field	Easily deflected	Opposite direction to α and less easily	Not deflected
Absorption	Stopped by paper	Stopped by thin sheet of aluminium	Reduced by several centimetres of lead
Ionisation	Intense, produces 10^4 ions per mm	Less intense, produces about 100 ions per mm	Weak ionising effect

Key
Blue equation– *Given formulae*
Red equation – *Not given formulae*

$$I = \frac{k}{x^2}$$

The intensity of radiation is inversely proportional to the distance from the source squared

Nuclear decay is random and spontaneous. The decay constant, λ is the probability of a nucleus decaying in a given time.

$$1u = 931.5MeV = 1.661 \times 10^{-27}\,kg$$

1 atomic mass unit has a binding energy of $931.5MeV$

$$E_{bind} = mc^2$$

$$A = N\lambda$$

The activity, A of a radioactive sample is directly proportional to the number of nuclei present. It is measured in becquerels, Bq

$$\frac{\Delta N}{\Delta t} = -\lambda N$$

The binding energy of a nucleus is the work that must be done to separate a nucleus into its constituent neutrons and protons.

$$\Delta m = Zm_p + (A - Z)m_N - mnucl_{eus}$$

The number of nuclei and activity of radioactive substance follow an exponential decay relationship over time

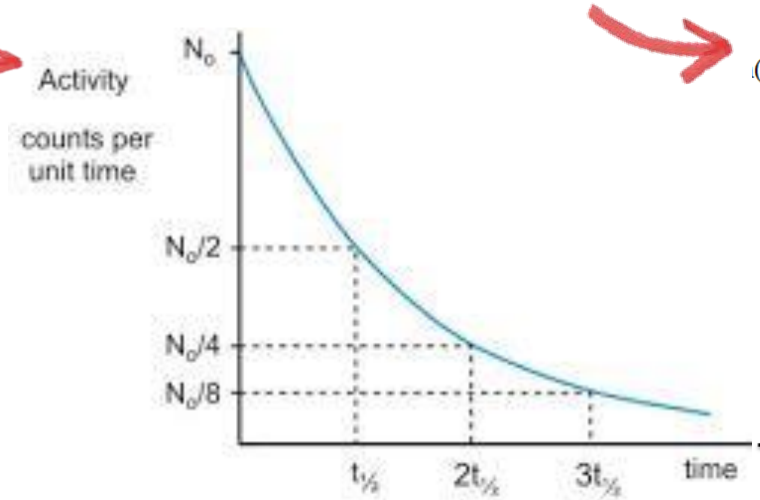
NUCLEAR PHYSICS

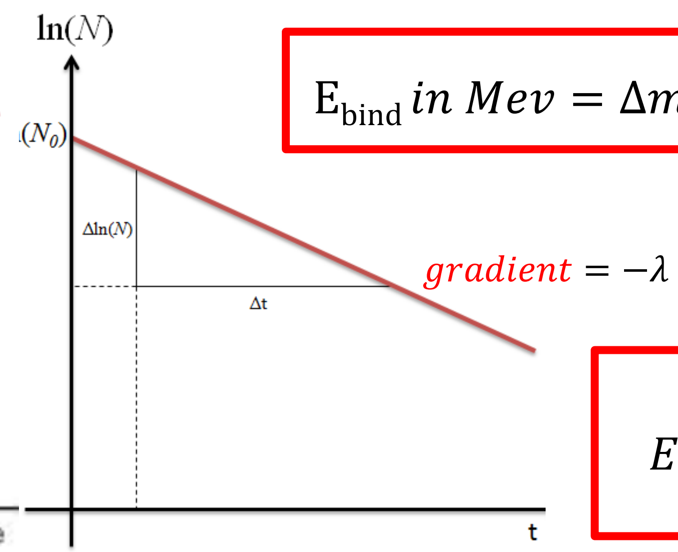
$$\ln(N) = \ln(N_0) - \lambda t$$

Mass defect of nucleus, the difference between the mass of separated nucleons and the mass of the nucleus

$$E_{bind}\ in\ Mev = \Delta m\ in\ u\ x\ 931.5Mev$$

$$N = N_0 e^{-\lambda t}$$





$$m = m_0 e^{-\lambda t}$$

$$E\ in\ \text{Joules} = \frac{E_{bind}Mev}{1.6x10^{-13}}$$

$$A = A_0 e^{-\lambda t}$$

$$t_{1/2} = \frac{ln2}{\lambda}$$

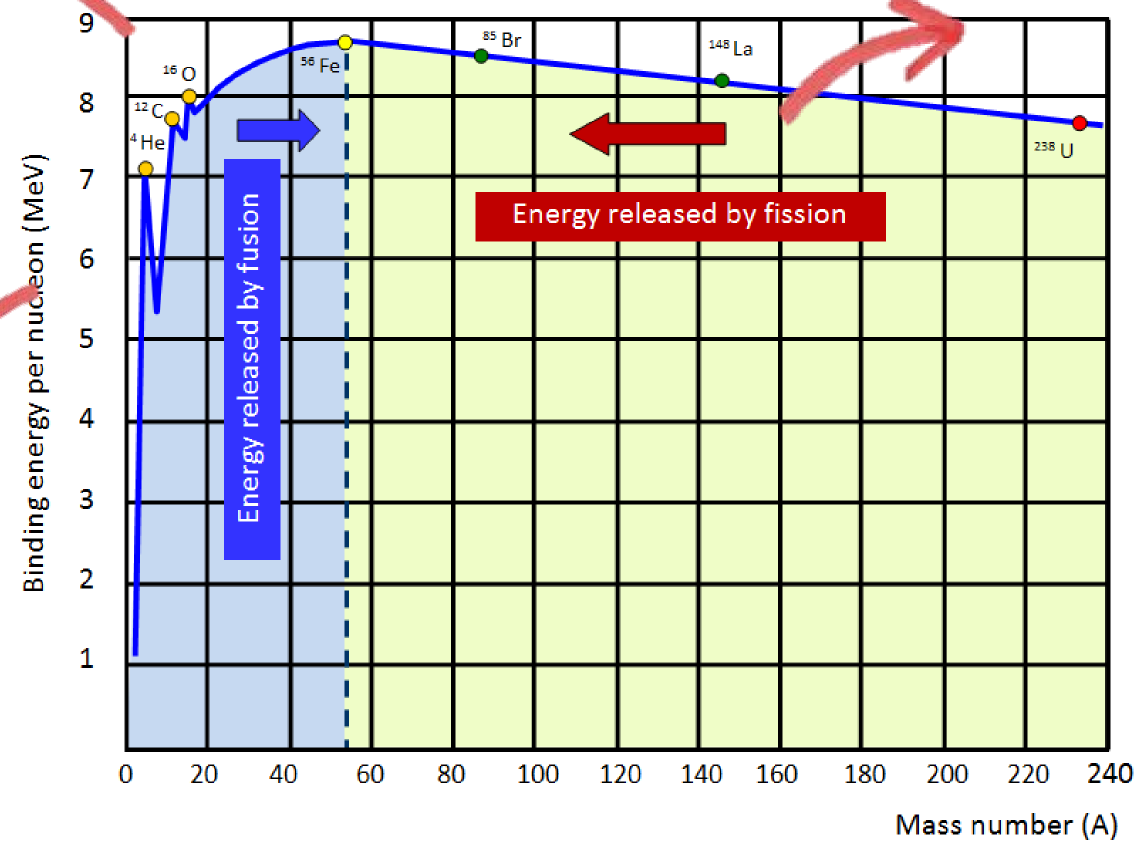
The half life of a radioactive substance is the time taken for the activity/ number of radioactive nuclei present to half

Key
Blue equation– *Given formulae*
Red equation – *Not given formulae*

NUCLEAR PHYSICS

Nucleons with a mass number less than the peak (Fe-56) release energy through nuclear fusion

Nucleons with a mass number greater than the peak release energy (Fe-56) through nuclear fission.



Fusion: two light nuclei fuse together to form a larger, more stable nucleus

Fission: In this process, a large unstable nucleus is split into two lighter, more stable nuclei.

$$E_{\text{bind } per\ N} = \frac{mc^2}{A}$$

Oxygen-16, Carbon -12 and He-4 are very stable isotopes

The binding energy per nucleon is the average work done per nucleon to remove all the nucleons from a nucleus. It is a measure of the stability of a nucleus.

Neutrons have ZERO binding energy

Key
Blue equation– *Given formulae*
Red equation – *Not given formulae*

MEDICAL PHYSICS

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{V}$$

The lens equation
f is the focal length
u is the **object** distance from the lens
v is the **image** distance from the lens

$$P = \frac{1}{f}$$

Diverging lenses have a negative power
Converging lenses have a positive power

$$m = \frac{v}{u}$$

Magnification of a lens

$$I = \frac{P}{A}$$

The intensity of a sound wave is the energy transferred per second per metre squared perpendicular to the direction of wave travel. Measured in Wm^{-2}

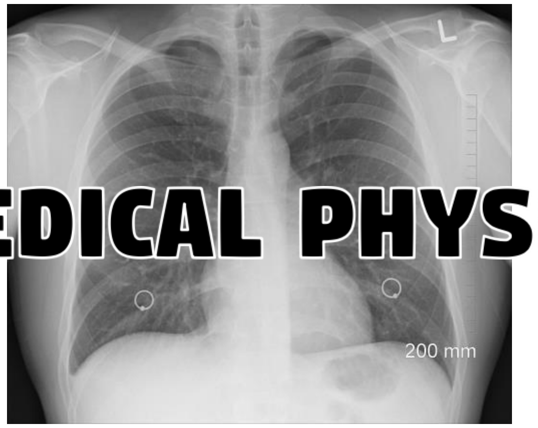
$$\frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1}\right)^2$$

$$Z = pc$$

The larger the difference in acoustic impedance between two materials, the higher the intensity of the reflected ultrasound wave, I_r

$$I_0 = 1.0 \times 10^{-12} Wm^{-2}$$

The threshold of hearing is the lowest intensity sound which the human ear can hear at a frequency 1kHz



$$I = I_0 e^{-\mu x}$$

The intensity of X-rays through a material follows an exponential decay relationship

$$intensity\ level = 10 \log \frac{I}{I_0}$$

The intensity of sound can also be measured in decibels (dB). The intensity level follows a logarithmic scale. This is for going from intensity in Wm^{-2} to decibels

$$x_{1/2} = \frac{Ln2}{\mu}$$

The half value thickness is the thickness of a material needed to reduce the intensity of an X-ray beam to half its original value

$$\mu_m = \frac{\mu}{\rho}$$

The mass attenuation coefficient is a measure of how much radiation is absorbed per unit mass of a material

$$I = I_0\, x\, 10^{0.1(dB)}$$

Converting decibels back to Wm^{-2}

$$\Delta L \propto \log\left(\frac{I_2}{I_1}\right)$$

Perceived loudness in decibels is proportional logarithmically to the ratio of intensity before and after

$$\frac{1}{T_E} = \frac{1}{T_B} + \frac{1}{T_P}$$

The effective half life of a radioactive tracer depends on the physical half life of the substance and the biological half life which is how long the body's biological processes take to remove the substance

Key
Blue equation – *Given formulae*
Red equation – *Not given formulae*