CIRCULAR MEASURE

Linear Displacement:- Displacement in a straight line

Linear Velocity:- Rate of change of angular displacement

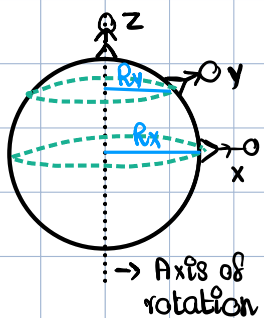
Angular Displacement:- Angle subtended at the centre when an object moves from positon A to position B on a circular track.

Angular Velocity:- Rate of change of angular displacement. $\omega = \theta / t$

For 1 complete revolution $\longrightarrow$ $\omega = 2\pi / T$ | $\omega = 2\pi f$

$v = r\omega \rightarrow$ linear velocity = radius x angular velocity

---



- $R_x > R_y > R_z$
- X, Y, Z have the same angular velocity
- $V_x > V_y > V_z$ as $V = r\omega$ considering the radius ratio

Centripetal Force:- Force required for an object to move in a circle. Is directed towards the centre of the circle.

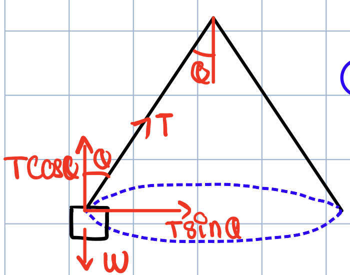
$F_c = \frac{mv^2}{r}$ | $F_c = mr\omega^2$ | $F_c = mv\omega$

Centripetal Acceleration $F = ma$

$ma = (mv^2)/r$, $a = v^2/r$ | $ma = mr\omega^2$, $a = r\omega^2$ | $ma = mv\omega$, $a = v\omega$

Radian:- Angle suspended at the centre of a circle by an arc equal to its radius

Conical Pendulum



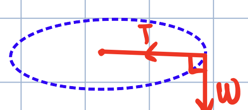
① $F_c = T\sin\theta$
$T = F_c / \sin\theta$

② $W = T\cos\theta$
$T = W / \cos\theta$

$$\frac{W}{\cos\theta} = \frac{F_c}{\sin\theta} \rightarrow \frac{F_c}{mg} = \tan\theta$$

$$\frac{mv^2/r}{mg} = \tan\theta \rightarrow \frac{v^2}{rg} = \tan\theta$$

Horizontal Circular Motion



$F_c = T$

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

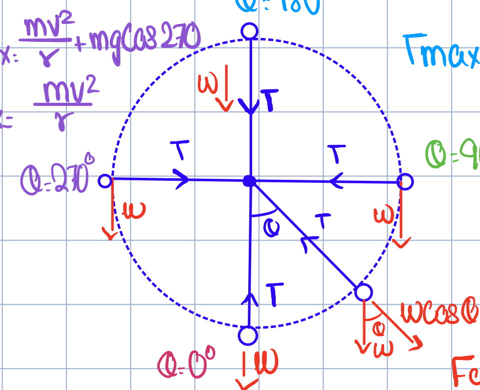
Vertical Circular Motion

$\theta = 180°$ $T_{max} = \frac{mv^2}{r} + mg\cos(180)$

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

$T_{max} = \frac{mv^2}{r} + mg\cos 270$

$T_{max} = \frac{mv^2}{r}$



$\theta = 90°$ $T_{max} = \frac{mv^2}{r} + mg\cos 90$

$T_{max} = \frac{mv^2}{r}$

$F_c = T - W\cos\theta$

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

$T_{max} = \frac{mv^2}{r} + mg\cos(0)$

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

GRAVITATION

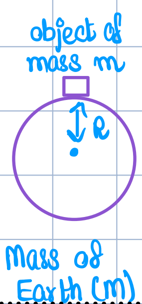
Newton's Law of Gravitation:- Force of attraction b/w two point masses is directly proportional to the product of the masses and inversely proportional to the square of the distance b/w their centres. $F_G = \frac{G M_1 M_2}{R^2}$

Relationship b/w g and G

$W = \frac{G M (m)}{R^2}$

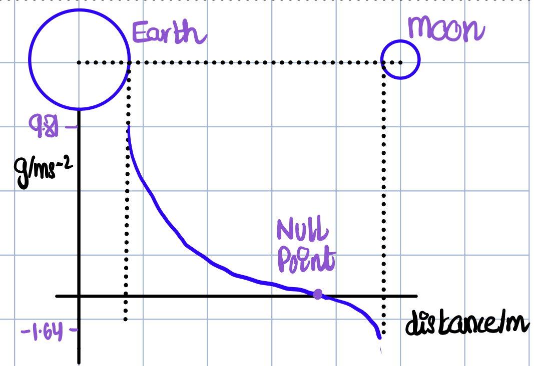
$m(g) = \frac{G M (m)}{R^2}$

$g = \frac{G M}{R^2}$



Null Point

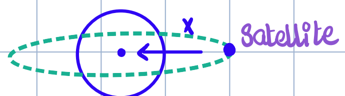
At the null point $F_E = F_M$



Gravitational Field:- Region of space where a mass experiences a force.

Gravitational Field Strength (g):- Force of attraction experienced by a unit mass placed within the field

Satellite orbiting a planet



$F_C = F_G$

$\frac{mv^2}{x} = \frac{GMm}{x^2}$ $\quad m x \omega^2 = \frac{GMm}{x^2}$

$v = \sqrt{\frac{GM}{x}}$ $\quad \omega = \sqrt{\frac{GM}{x^3}}$

$K.E = 0.5 mv^2$ $\quad \frac{2\pi}{T} = \sqrt{\frac{GM}{x^3}}$

$K.E = 0.5 m \left(\sqrt{\frac{GM}{x}}\right)^2$

$K.E = \frac{GMm}{2x}$ $\quad T = 2\pi \sqrt{\frac{x^3}{GM}}$

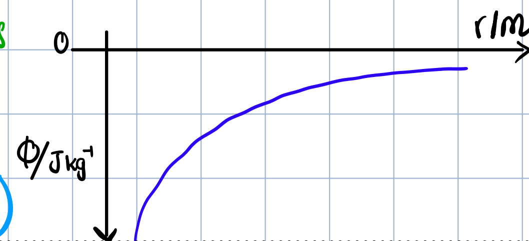
Geostationary Orbit:-
- equitorial orbit / above equator
- satellite moves from west to east / same direction as Earth
- period is 24 hours / same period as spinning on Earth

Gravitational Potential:- $\phi = -\frac{GM}{r}$
- ϕ at infinity is zero - away from infinity it becomes -ve
- work is done by the field to move unit mass towards the source mass

$\Delta\phi = \phi_f - \phi_i$

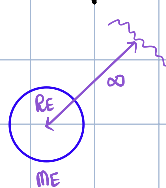
$\Delta\phi = -\frac{GM}{R_f} - \left(-\frac{GM}{R_i}\right)$

$\Delta\phi = GM\left(\frac{1}{R_i} - \frac{1}{R_f}\right)$



Gravitational Potential Energy:- Work done in moving a point mass from infinity to a point within the gravitational field. $\Delta U = \phi \cdot m$

Escape Velocity



Gain in GPE = loss in KE

$GM\left(\frac{1}{R_i} - \frac{1}{R_f}\right) \cdot \cancel{m} = \frac{1}{2} \cancel{m} V_{esc}^2$

$GM\left(\frac{1}{R_E} - \frac{1}{\infty}\right) = \frac{1}{2} V_{esc}^2$

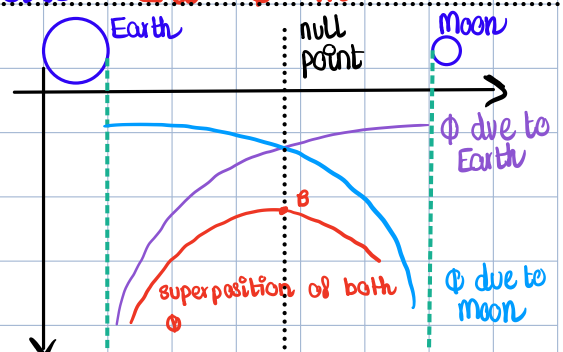
$\sqrt{\frac{2GM_E}{R_E}} = V_{esc}$

∴ at surface

$g = \frac{GM}{R_E^2} \Rightarrow gR_E^2 = GM_E$

$V_{esc} = \sqrt{2 g R_E^2 / R_E}$

$V_{esc} = \sqrt{2 g R_E}$



Derevation of GPE = mgh

$E = \Delta\phi \cdot m$

$E = Gm\left(\frac{1}{R_i} - \frac{1}{R_f}\right) \cdot m$

$E = Gm\left(\frac{1}{R_E} - \frac{1}{R_{E+h}}\right) \cdot m$

$E = Gm\left(\frac{h}{R_E(R_{E+h})}\right) \cdot m$

$E = (gR_E^2)\left(\frac{h}{R_E^2}\right) \cdot m$

$E = mgh$

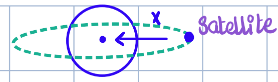
$h <<< R_E$

$R_{E+h} \approx R_E$

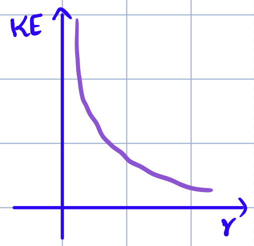
$g = \frac{Gm}{R_E^2}$

$gR_E^2 = Gm$

Satellite orbiting a planet



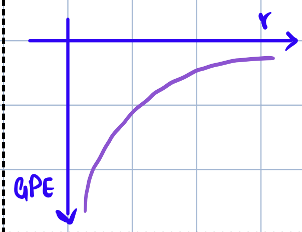
$E_K = \frac{GM_Em}{2r}$



$GPE = \Delta\phi \cdot m$

$GPE = -\frac{GM_E}{r} \cdot m$

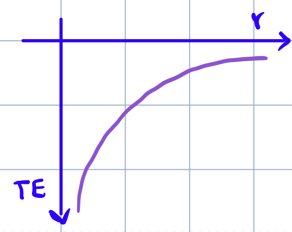
$GPE = (-GM_Em)/r$



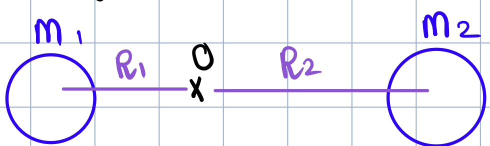
$T.E = KE + GPE$

$T.E = GM_Em/2r - GM_Em/r$

$T.E = -GM_Em/2r$



Binary Star System



m_1

$F_G = F_c$

$\frac{Gm_1m_2}{(R_1+R_2)^2} = m_1R_1\omega^2$

m_2

$F_G = F_c$

$\frac{Gm_1m_2}{(R_1+R_2)^2} = m_2R_2\omega^2$

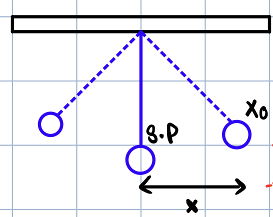
$m_1R_1\omega^2 = m_2R_2\omega^2$

$\frac{m_1}{m_2} = \frac{R_2}{R_1}$

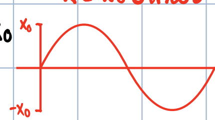
SIMPLE HARMONIC MOTION

Relation:- $a \propto -x$

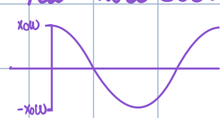
- SHM is oscillatory motion
- Acceleration and displacement proportional
- Acceleration and displacement in opposite directions



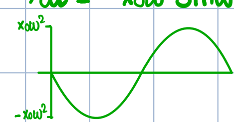
$x = x_0 \sin\omega t$



(velocity) $dx/dt = x_0\omega\cos\omega t$



(acceleration) $dv/dt = -x_0\omega^2\sin\omega t$

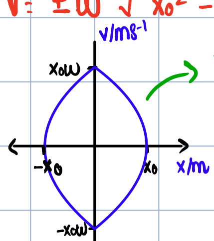


Link ⇒ $a = -\omega^2(x_0\sin\omega t) \Longrightarrow a = -\omega^2x$

Velocity at SHM :- $v = \pm\omega\sqrt{x_0^2 - x^2}$

x_0 : maximum displacement x = displacement from mean position

$v = \pm\omega\sqrt{x_0^2 - x^2}$



Kinetic Energy

$K.E = \frac{1}{2}mv^2$

$K.E = \frac{1}{2}m\left(\omega\sqrt{x_0^2 - x^2}\right)^2$

$K.E = \frac{1}{2}m\omega^2(x_0^2 - x^2)$

Total Energy

$T.E = \text{Max } KE$

$x = 0$ at Max KE

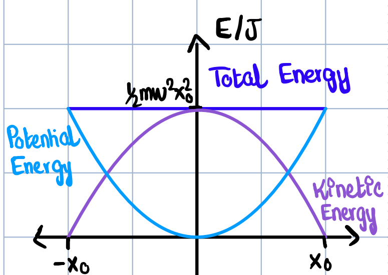
$T.E = \frac{1}{2}m\omega^2x_0^2$

Potential Energy

$T.E = KE + P.E$

$T.E - KE = P.E$

$PE = \frac{1}{2}m\omega^2x^2$



Graphs for KE, PE and TE against time

$K.E = \frac{1}{2}m\omega^2(x_0^2 - x^2)$

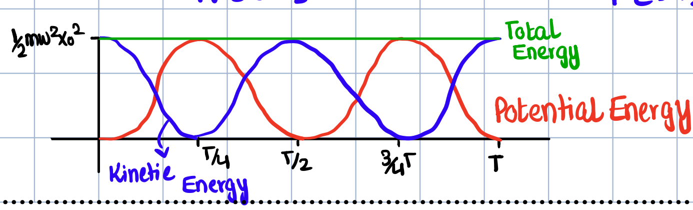
$K.E = \frac{1}{2}m\omega^2(x_0^2 - x_0^2\sin^2\omega t)$

$K.E = \frac{1}{2}m\omega^2x_0^2(1 - \sin^2\omega t)$

$K.E = \frac{1}{2}m\omega^2x_0^2\cos^2\omega t$

$P.E = \frac{1}{2}m\omega^2x^2$

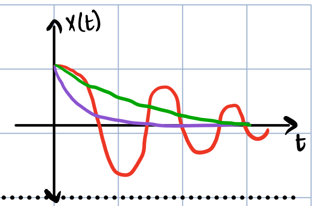
$P.E = \frac{1}{2}m\omega^2x_0^2\sin^2\omega t$



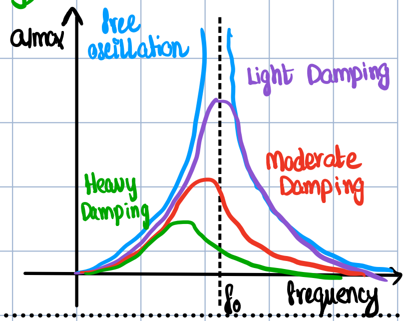
Free Oscillations :- Oscillations occuring in the absence of a resistive medium

Damped Oscillations :- Oscillations occuring in the presence of a resistive medium

↳ Light Damping (air) Moderate Damping (water) Heavy Damping (Honey)



Resonance :- Every mechanical system has its natural frequency of oscillation (fundamental frequency). If frequency of a forced oscillator = fundamental frequency which results in a maximum transfer of energy and the amplitude of the mechanical system reaches max value



THERMAL PHYSICS

Boyle's Law :- $P \propto 1/V$ Charles' Law :- $V \propto T$ Gay Lussac's Law :- $P \propto T$

Universal Gas Constant

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

Ideal Gas Formula :- $PV = nRT$

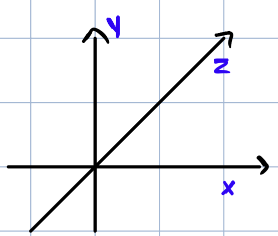
n = Moles of gas R = Universal Gas Constant (8·31)

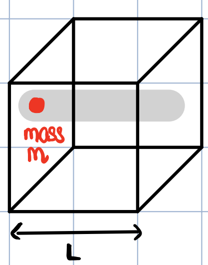
P = Pressure V = Volume of Gas T = Temperature (Kelvin)

Ideal Gas Assumptions :- 1) Molecules move in constant and random motion
2) Collisions between molecules and container walls are completely elastic
3) Pressure is due to collisions between molecules and container walls
4) Ideal Gas molecules are free of any intermolecular forces of attraction
5) Volume of molecules is negligible in comparasion to the container volume

Pressure of Ideal Gas : $P = \frac{1}{3} \rho \langle c^2 \rangle$

Derevation





$$F = \frac{\Delta p}{t}$$

$$F = \frac{2c_x m}{2L/c_x}$$

$$F = \frac{c_x^2 m}{L}$$

C = velocity

For molecule m :-

$\Delta p = (m)(\Delta c_x)$

$\Delta p = (m)(2c_x)$

$\Delta p = 2c_x m$

Time

$t = \frac{2L}{c_x}$

$$P = \frac{c_x^2 m / L}{A}$$

$$P = \frac{c_x^2 m}{V} \qquad P = N\left(\frac{\langle c_x^2 \rangle m}{V}\right)$$

$m = Nm$

$$P = \frac{\langle c_x^2 \rangle M}{V}$$

$\langle c^2 \rangle = \langle c_x^2 \rangle + \langle c_y^2 \rangle + \langle c_z^2 \rangle$

$\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$

$\langle c^2 \rangle = 3 \langle c_x^2 \rangle$

$\langle c^2 \rangle / 3 = \langle c_x^2 \rangle$

$$P = \frac{1}{3} \rho \langle c^2 \rangle$$

Total Kinetic Energy

$\frac{1}{2} Mv^2 = \frac{1}{2} m \langle c^2 \rangle$

$P = \frac{1}{3} \rho \langle c^2 \rangle$

$P = \frac{1}{3} (m/V) \langle c^2 \rangle$

$3PV = m \langle c^2 \rangle$

$\frac{3}{2} PV = \frac{1}{2} m \langle c^2 \rangle$

$K.E = \frac{3}{2} PV$

$\longrightarrow \frac{3}{2} nRT$

Average Kinetic Energy

$\frac{3}{2} nRT = \frac{1}{2} m \langle c^2 \rangle$

$\frac{3}{2} nRT = N (\frac{1}{2} m \langle c^2 \rangle)$

$\frac{3}{2} \frac{n}{N} RT = \frac{1}{2} m \langle c^2 \rangle$

$\frac{3}{2} R/N_A \, T = \frac{1}{2} m \langle c^2 \rangle$

N_A : Avogadro's Constant

$\frac{3}{2} kT = \frac{1}{2} m \langle c^2 \rangle$

k: Boltzmann Constant

Avg KE $= \frac{3}{2} kT$

PV = Nkt

$\frac{3}{2} nRT = \frac{1}{2} m \langle c^2 \rangle$

$\frac{3}{2} nRT = N (\frac{1}{2} m \langle c^2 \rangle)$

$\frac{3}{2} (PV) = N (\frac{3}{2} kT)$

$PV = NkT$

Croot mean speed and Temperature

$PV = nRT$

$(\frac{1}{3} \rho \langle c^2 \rangle) V = nRT$

$\langle c^2 \rangle = \frac{3nR}{\rho V} \times T$

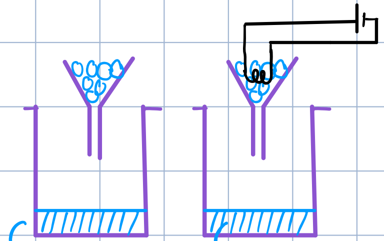
$\langle c^2 \rangle \propto T$

$C_{r.m.s} \propto \sqrt{T}$

Specific Heat Capacity ($Q = mc\Delta T$) :- Energy required to raise the temperature of 1kg of a substance by 1°C / 1 K.

Specific Latent Heat ($Q = mL$) :- Energy required for a 1 kg substance to undergo a change in state.

Elimination of error (Latent Heat of Fusion)



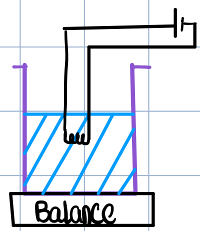
m_2 kg (Setup A)

m_1 kg (Setup B)

$Q = (m_1 - m_2) L$

$L = \frac{Q}{m_1 - m_2}$

Elimination of error (Latent Heat of Vaporisation)



$Q - k = mL$

$P_1 t - k = m_1 L$

$P_1 t - m_1 L = k$

$P_2 t - k = m_2 L$

$P_2 t - m_2 L = k$

$P_1 t - m_1 L = P_2 t - m_2 L$

$\frac{t(P_1 - P_2)}{m_1 - m_2} = L$

Internal Energy of Gases

Total Energy = K.E + P.E

Ideal Gases :- Total Energy = KE

Work done by gas $P \times \Delta V$

	ΔW (By)	ΔW (On)
Compression	−	+
Expansion	+	−

First Law of Thermodynamics

$\Delta Q = \Delta U + \Delta W(By)$

ΔU = Internal Energy

ΔQ = Energy supplied to gas

ELECTROSTATICS

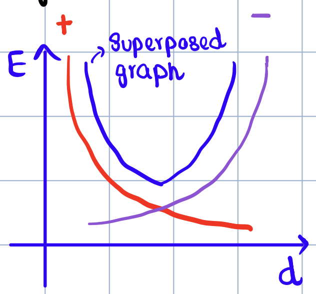
Coloumb's Law :- Force of attraction between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between their centres

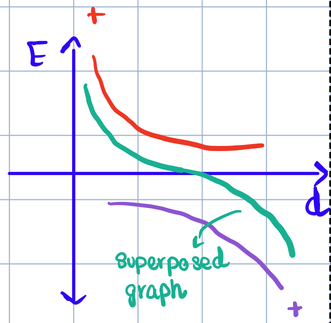
$F = \frac{1}{4\pi\varepsilon_0} \times \frac{Q_1 Q_2}{R^2}$

ε_0: Permitivity of free space

Electric Field Strength :- Force per unit positive charge $E = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{R^2}$

Graphs of Electric Field Strength against distance



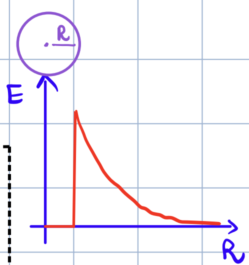


Electric Potential:- Work done to move a unit positive charge from infinity to a point within the electric field

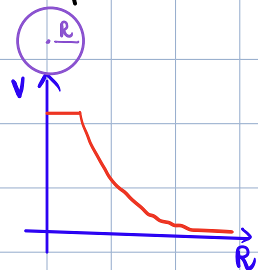
$V = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{r}$

∴ Sign is considered. −ve charge means work done by the field

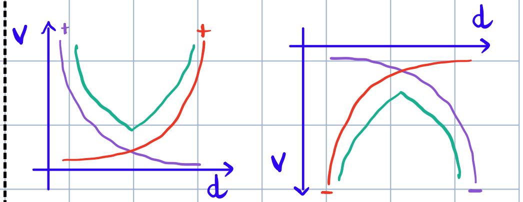
Graph of E vs R for a conductor



Graph of V vs R



Graphs of Electric Potential against distance



Establishing a link :-

$V = \frac{Q r^{-1}}{4\pi\varepsilon_0}$

$\frac{dV}{dr} = \frac{-Q}{4\pi\varepsilon_0 r^2}$

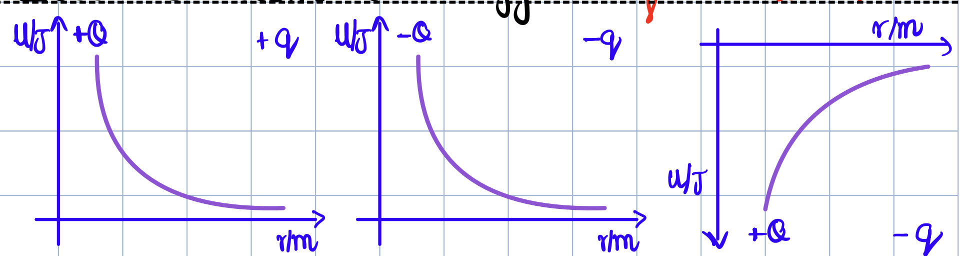
$\frac{dV}{dr} = -(E)$

∴ Gradient of V vs r graph is −E (Electric Field Strength)

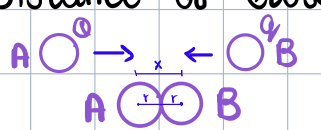
For an accelerating electron

gain in EPE = loss in KE ⇒ $Vq = \frac{1}{2}mv^2$ ⇒ $v = \sqrt{\frac{2Vq}{m}}$

Electric Potential Energy :- Vq ⇒ $\frac{1}{4\pi\varepsilon_0} \times \frac{Qq}{r}$



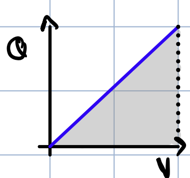
Distance of closest approach



loss in KE = gain in EPE ⇒ $mv^2 = \frac{Qq}{4\pi\varepsilon_0 x}$ ⇒ $x = \frac{Qq}{4\pi\varepsilon_0 mv^2}$

$2\left(\frac{1}{2}mv^2\right) = q\left(\frac{1}{4\pi\varepsilon_0} \times \frac{Q}{x}\right)$

CAPACITANCE



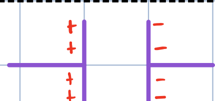
Capacitance:- Ratio of the amount of charge stored on the plate with potential energy ($Q = CV$)

Electric Potential Energy $= \frac{1}{2}QV$

Electric Potential Energy $= \frac{1}{2}CV^2$

Electric Potential Energy $= \frac{Q^2}{2C}$

Series capacitor



- All capacitors have same charge
- Capacitance $\propto \frac{1}{\text{Voltage}}$
- Electric Potential Energy $\propto \frac{1}{\text{Capacitance}}$
- $V_T = V_1 + V_2 + V_3$

$Q_T/C_T = Q_1/C_1 + Q_2/C_2 + Q_3/C_3$

$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

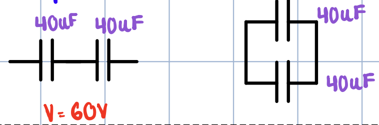
Parallel Capacitors

- All capacitors have same voltage
- Capacitance $\propto$ Voltage
- Electric Potential Energy $\propto$ Capacitance

$$I_T = I_1 + I_2 + I_3$$
$$Q_T = Q_1 + Q_2 + Q_3$$
$$C_TV_T = C_1V_1 + C_2V_2 + C_3V_3$$
$$C_T = C_1 + C_2 + C_3$$

Max Safe Working Voltage

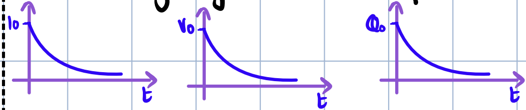
- Capacitor is rated 40uF, 30V



V = 30V

$$V = \frac{1}{4\pi\varepsilon_0} \times \frac{Q}{R}$$
$$\frac{\cancel{Q}}{C} = \frac{1}{4\pi\varepsilon_0} \times \frac{\cancel{Q}}{R}$$
$$C = 4\pi\varepsilon_0 R$$

Discharging of a capacitor



$I = I_0 e^{-t/RC}$ $V = V_0 e^{-t/RC}$ $Q = Q_0 e^{-t/RC}$

Time Constant ($T = RC$)

R = Resistance
C = Capacitance

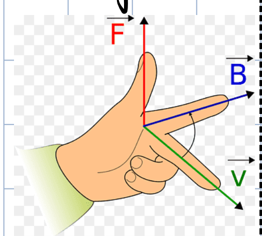
Time taken for a capacitor to discharge

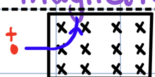
MAGNETISM

Magnetic Field: Region of space where a moving charge experiences a force

$F_m = Bqv$ | B = Magnetic Flux Density | q = charge | v = velocity

Fleming's LHR



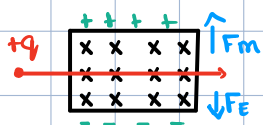


$F_m = F_c$

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

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

Cross Field: Magnetic and Electric Fields are perpendicular



$F_m = F_e$

$Bqv = Eq$

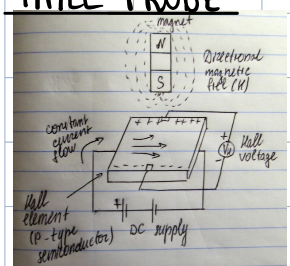
$v = \frac{E}{B}$

if $v > E/B$ $F_m > F_E$

if $v < E/B$ $F_m < F_E$

if $v = E/B$ $F_m = F_E$

HALL PROBE



$F_m = F_E$

$Bqv = Eq$

$Bv = E$

$E = \frac{V_H}{d}$

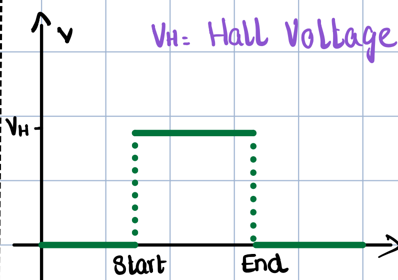
$I = nAve$

$v = \frac{I}{nAe}$

$B\left(\frac{I}{nAe}\right) = \frac{V_H}{d}$

$B\left(\frac{I}{n(dt)e}\right) = \frac{V_H}{d}$

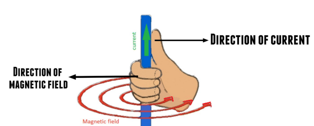
$B = \frac{V_H\,(nte)}{I}$



V_H = Hall Voltage

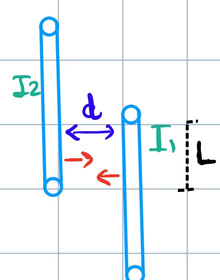
$F_m = BIL$ | Tesla ($B = \frac{F_m}{IL}$) = Tesla is the unit of magnetic flux density. 1 Tesla of magnetic flux density occurs when a straight wire carrying a current of 1A perpendicular to the magnetic field exerts a force of 1 N per metre (unit length).

Torque = $(F_m)(W)$
$\hookrightarrow (BIL)(W)$
$\hookrightarrow BIA$



$B = 2\times10^{-7}\,\frac{I}{d}$ • Magnetic flux density at a point perpendicular from the wire

Force of attraction between 2 wires



$F_m = BIL$

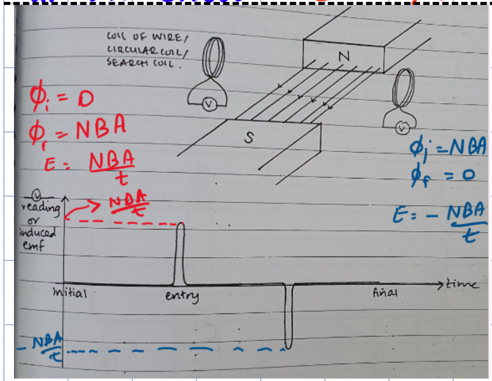
$F_m = \left(2\times10^{-7}\,\frac{I_1}{d}\right)(I_2)(L)$

$F_m = \frac{2\times10^{-7}\,I_1I_2L}{d}$

ELECTROMAGNETIC INDUCTION

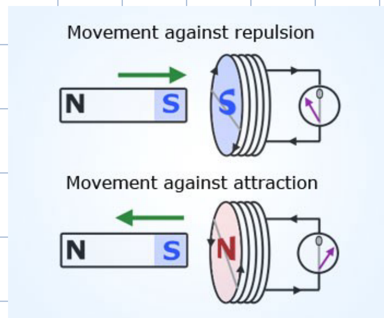
$\Phi = BA$ • for an 'n' number of turns $\Phi = NBA$

Faraday's Law: Rate of change of magnetic flux is the induced EMF / voltage in the circuit $E = \Delta\Phi / t \implies E = (\Phi_f - \Phi_i)/t$ OR $E = d\Phi/dt$

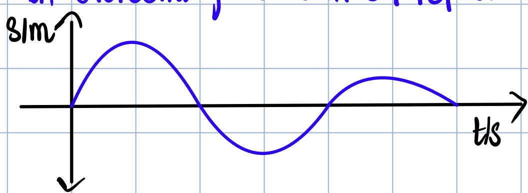


Lenz's Law: Lenz's Law can be used to determine the direction of induced current in a solenoid. Induced current always flows in the direction opposing the change causing it.

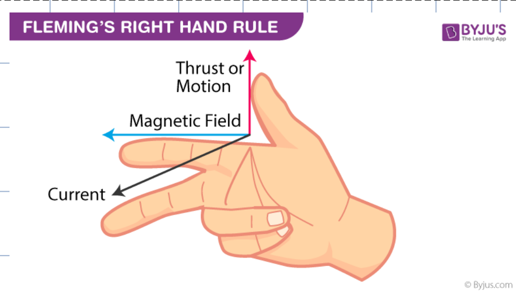
Damping: As the magnet enters / exits the coil, mechanical energy is used up in overcoming attractive / repulsive forces



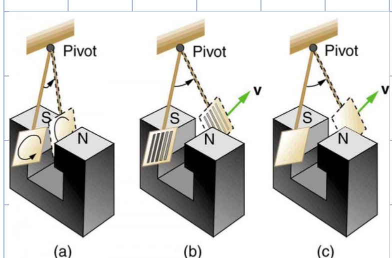
Overcoming Damping
- Use a resistor, as it leads to lesser current therefore lesser opposition



For a wire cutting a magnetic field $E = BLv$

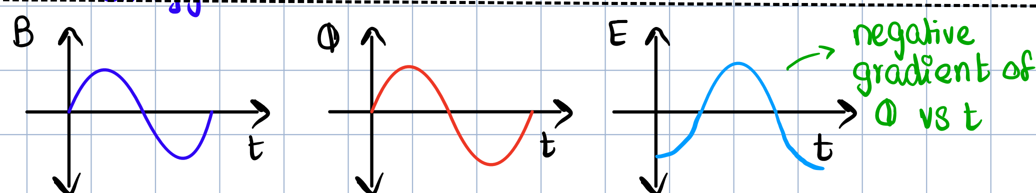


Eddy Currents:- As the disc spins, rate of cutting magnetic flux lines is not the same for every part of the disc. This means differences in EMF induced. This causes eddy currents. These eddy currents dissipate energy therefore they cause a loss in amplitude / energy

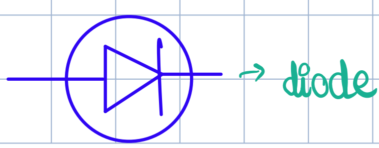


Lenz's + Faraday's Law

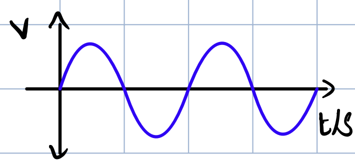
$E \propto -\frac{d\Phi}{dt}$



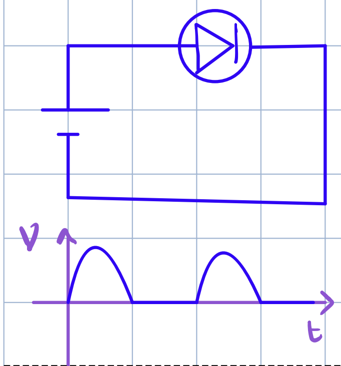
ALTERNATING CURRENTS



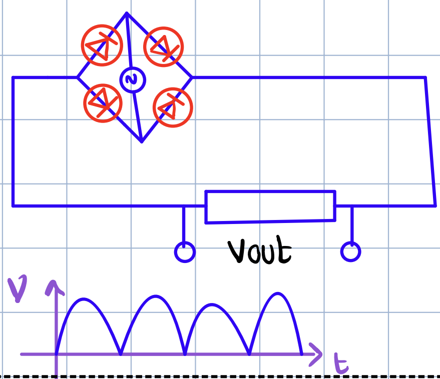
Normal AC Current Wave :-



Half - wave Rectification



Full - wave Rectification



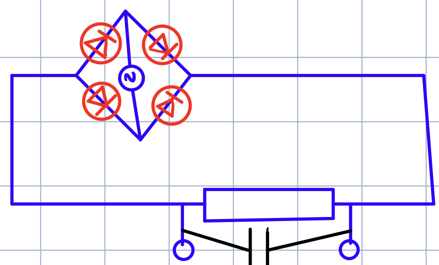
Advantage (Half Wave)
- Lesser complexity

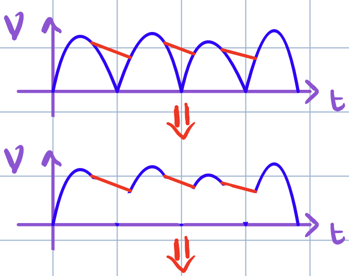
(Full Wave)
- Lesser power loss

Disadvantage (Half wave)
- Greater power loss

(Full Wave)
- More Complex

Smoothing:- A process by which the output voltage does not fall to zero.





- Parallel Capacitor combination means greater smoothing
- Series Capacitor combination means lesser smoothing

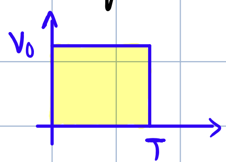
Current / Voltage in AC

$I = I_0 \sin \omega t$ $\quad V = V_0 \sin \omega t$

$I_{rms} = \dfrac{I_0}{\sqrt{2}}$ $\quad V_{rms} = \dfrac{V_0}{\sqrt{2}}$

$P_{rms} = \dfrac{P_0}{2}$

For square waves



Step 1 = Square
Step 2 = Mean
Step 3 = Root

1) V_0^2
2) $\dfrac{V_0^2 \times T}{T} = V_0^2$
3) $\sqrt{V_0^2} \Rightarrow V_0$

here $V_{rms} = V_0$

Transformers

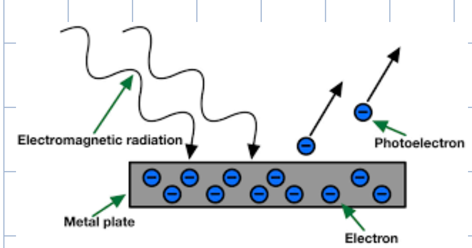
- $\dfrac{V_P}{V_S} = \dfrac{I_S}{I_P}$
- $\dfrac{N_P}{N_S} = \dfrac{V_P}{V_S}$

P = Primary coil
S = Secondary coil
N = Number of turns

QUANTUM PHYSICS

Electron Volt:- The amount of kinetic energy an electron gains as it accelerates through a potential difference of 1 Volt. eV = Work done in Joules $\div 1.6 \times 10^{-19}$

Photon: A photon is a quantum of electromagnetic radiation having a fixed amount of energy $E = hf \Rightarrow h$ = Planck's constant



$E = \Phi + KE$

Φ = work function energy

$hf = hf_0 + KE$

f_0 = threshold frequency

Work function energy:- Energy required to bring electrons to the surface of the metal

Threshold frequency:- Minimum frequency for photoelectric effect

Dual Nature of EMR

- EMR can undergo diffraction proving it exists as waves
- Photoelectric effect need a threshold frequency to happen, proves it exists as particles as in case of waves photoelectric effect would have occured at any frequency

$$\text{Intensity} = \frac{\text{Power}}{\text{Area}} \rightarrow I = \frac{\text{Energy}}{A \times t} \rightarrow I = \frac{np(hf)}{At}$$

- $I\uparrow$ $np\uparrow$ photoelectric current $\uparrow$
- $f\uparrow$ I constant $np\uparrow$ photoelectric current $\downarrow$

∴ Electrons have a dual nature like EMR

De Broglies Equation:- Wavelength of moving particles

$\lambda = \frac{h}{p}$ p = momentum

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

$VQ = \frac{1}{2}mv^2$

$\frac{2VQ}{m} = v^2$

$v = \sqrt{\frac{2Vq}{m}}$

$h = \lambda/p$

$h = \lambda/mv$

$h = \frac{\lambda}{\sqrt{2mVq}}$

$Vq = \frac{1}{2}mv^2$

$Vq = KE(E)$

$h = \frac{\lambda}{\sqrt{2mE}}$

$Fc = Fm$

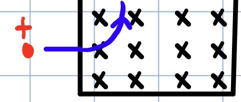
$\frac{mv^2}{r} = Bqv$

$mv = Bqr$

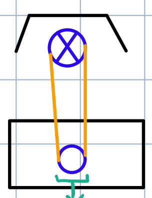
$P = Bqr$

$\lambda = \frac{h}{p}$

$\lambda = \frac{h}{Bqr}$



Photon Pressure



$\lambda = 600$ nm

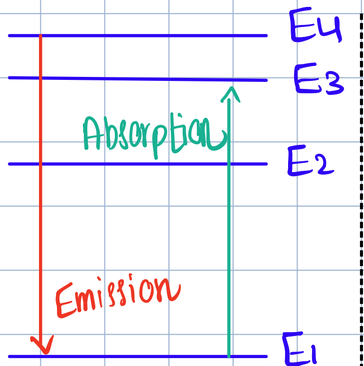
$P = 2$ mW

$T = 1$s

$A = 1.2 \times 10^{-6} m^2$

1) Energy of 1 Photon (3.315×10^{-19} J)
2) No. photons in 1 second (6.0×10^{15})
   → Power $= \frac{np(\text{Energy})}{\text{time}}$
3) Momentum of 1 photon (1.11×10^{-27} Ns)
   → Use De Broglie's equation
4) Total Momentum (6.63×10^{-12} Ns)
   Total Momentum = (np)(Momentum of 1 photon)
5) Force (6.63×10^{-12} N)
   $F = \Delta P \div t$
6) Pressure (5.53×10^{-6} Pa)
   P = Force / Area

Spectral Lines

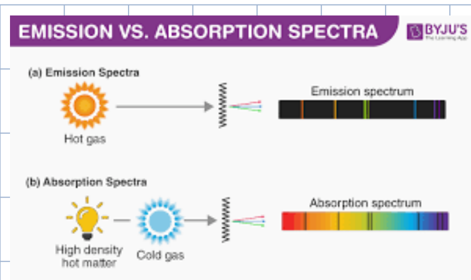


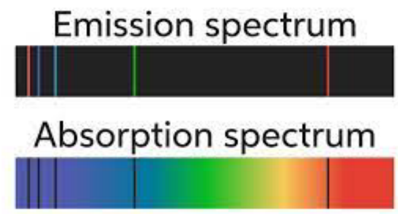
Q) How do spectral lines provide proof of discrete energy levels?

- Spectral lines correspond to discrete wavelengths
- Discrete wavelengths mean photons have a fixed amount of energy
- Photons are emitted due to energy change of electrons
- Fixed energy change means discrete energy levels

Identifying gases through spectral lines :-

- Gases have electrons in energy levels
- Certain wavelengths correspond to certain photons which electrons gain energy to go from a lower to higher energy level
- Electrons then deexcite and emit photons in all directions
- These wavelengths are displayed on the spectrum by dark lines



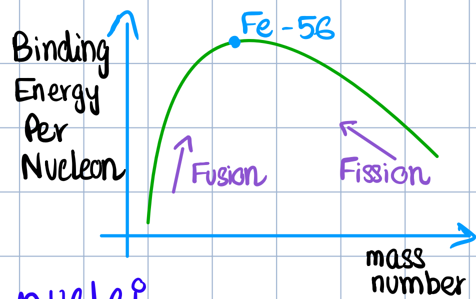


NUCLEAR PHYSICS

Binding Energy:- Energy required to split all nucleons in a nucleus to infinity

$E = \Delta m c^2$ m = mass defect

Binding energy per nucleon $= \dfrac{\text{Binding Energy (eV)}}{\text{Total nucleons}}$



Fission :- Heavy nuclei split into lighter nuclei

Fusion :- Lighter nuclei fuse to form heavy nuclei

Energy Released / Absorbed = Σ Binding Energy Products $-$ Σ Binding Energy Reactants

---

RADIOACTIVITY

Activity (Bq) $= -\lambda N$

Decay Constant (λ)

Probability of decay of a nucleus per unit time

$A = A_0 e^{-\lambda t_{1/2}}$

$m = m_0 e^{-\lambda t_{1/2}}$

$N = N_0 e^{-\lambda t_{1/2}}$

$C = C_0 e^{-\lambda t_{1/2}}$

A = Activity of the sample

m = Mass of sample

N = Number of radioactive particles

C = Count rate

$t_{1/2}$ (half life) = Time taken for the activity of a radioactive sample to half its initial value

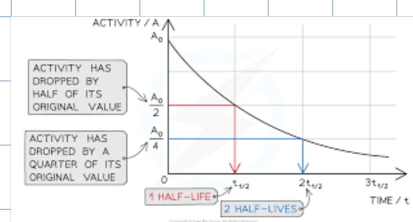
$\frac{A_0}{2} = A_0 e^{-\lambda t_{1/2}}$

$\frac{1}{2} = e^{-\lambda t_{1/2}}$

$\ln(\frac{1}{2}) = -\lambda t_{1/2}$

$-\ln 2 = -\lambda t_{1/2}$

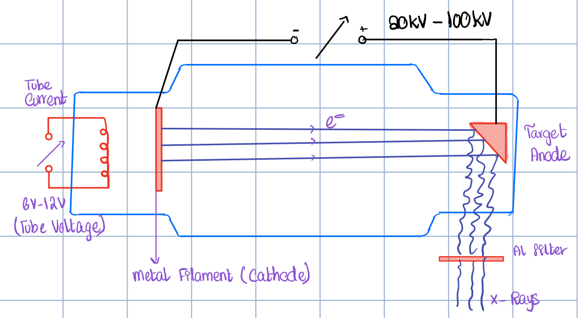
$t_{1/2} = \frac{\ln 2}{\lambda}$



Medical Physics

X-Rays :-

Production :-



- Thermionic emission causes electrons to be emitted from the cathode accelerating to the anode
- Anode collision results in X-Ray photon emission
- Aluminium sheet blocks soft X-Rays (no use for medical purposes)

Attentuation :- Loss in intensity of x-rays due to exposure of living matter

$I = I_0 e^{-u x_{1/2}}$ $\quad x_{1/2} = \ln 2 / u$ $\quad u$ = linear attentuation constant

$x_{1/2}$ = thickness that causes intensity to halve

Contrast (X-Rays) = Varying levels of blackness of different objects in an image

How to increase = - Use artificial contrast - Increase exposure time
- Use flouroscent backing material

Sharpness (X-Rays) = How well edges of different objects in an image can be distinguished

How to increase = - Decrease size of anode plate
- Reduce aperture size

CT Scans (Computed Tomography)

- Uses X-Rays
- Object split into slices
- Image of each slice taken from multiple angles
- Thousands of images of each slice processed to create a 2-D image
- Done for all other slices
- All slices 2D images processed to make 3D-image
- 3-D image can be rotated and observed

Advantages

- Can be done relatively quickly in comparasion to MRI
- Provides good contrast
- Can aid in treatment of brain tumors

Disadvantages

- Quite expensive
- Exposure to large radiation dose

PET Scan (Positron Emission tomography)

- Uses a radioactive tracer thats injected in the patient
- What is a tracer = Substance injected into a patient absorbed by tissues
- How does this help = Prevention of surgery therefore no risk of infection
- Tracer (Flourine -18) emits a positron
- Positron is antimatter, it searches for an electron and both annihilate one another
- Annihilation releases 2 gamma photons of equal energy in opposite directions
- Donut shaped gamma ray detector is placed around the patient
- Time delay between the 2 gamma ray photons travelling to the detector aids in finding exact location of annihilation

Ultrasound

- How is it produced
- Ultrasound detectors contain piezoelectric crystals
- Piezoelectric crystals contain positive and negative silver coated electrodes
- Current applied causes crystals to change shape
- AC current causes crystals to vibrate
- They vibrate at resonating frequency producing ultrasounds

Advantage

- No serious threat as they do not contain ionizing radiations

Disadvantage

- For air filled cavities e.g: lungs, ultrasound is not used because image lacks sufficient details

Specific Acoustic Impedance $(Z = \rho c)$ = Density of medium x speed of ultrasound in the medium

Intensity Reflection Coefficient: $\frac{I_R}{I} = \frac{(Z_1 - Z_2)^2}{(Z_1 + Z_2)^2}$

Attentuation of ultrasound = $I = I_0 e^{-ux/2}$

A - Scan ultrasound

- Ultrasound transmitters emit ultrasound (on the skin of the patient)
- As the ultrasound travels, boundaries reflect a fraction of the ultrasound while the rest penetrates
- The reflected wave is detected by the transmitter where the detected current is amplified and pulses are displayed on a CRO
- The echo time can be used to calculate the thickness of the boundary

B - Scan Ultrasound

A B-Scan is a combination of A-Scan which is taken from a variety of different angles. The individual pulses obtained are gathered analysed and processed by a computer which superimposes these multiple echoes on top of each other thereby gathering a two dimensional image

ASTRONOMY AND COSMOLOGY

Luminosity: (L) It is the absolute measure of the total power of the electromagnetic radiation emitted by a star

Radiant Flux Intensity (F) Luminosity passing normally through a surface per unit area

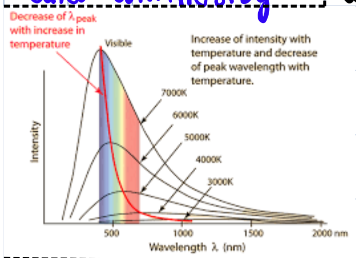
$F = \frac{L}{4\pi d^2}$ | $\frac{F_1}{F_2} = \frac{d_2^2}{d_1^2}$ | $\frac{F_1}{F_2} = \frac{A_2}{A_1}$

Light Year: Distance travelled by light in a vaccum in a time of one year

Standard Candles: It is a class of stellar object which has a known luminosity and whose distance can be determined by calculation using its radiant flux intensity and luminosity

Wien's displacement law: The link b/w observed wavelength of light and temperature $\lambda_{max} \propto 1/T \Rightarrow \lambda_{max} = b/T$

b = Wiens Displacement Constant $(2.898 \times 10^{-3}\ mK)$ → usually calculated



Stefan Boltzmann Law: The luminosity of a star does not depend just on the surface temperature of the star. It also depends on the physical state of the star.

$L = 4\pi \sigma T^4 r^2$

↳ Stefan-boltzmann law for luminosity $\sigma = 5.67 \times 10^{-8}\ Wm^{-2}K^{-4}$

Doppler Red Shift: The increase in observed wavelength of electromagnetic waves due to the recession from the source.

Doppler Blue Shift: The decrease in observed wavelength of electromagnetic waves due to the advancement of the source towards the observer

$\frac{\Delta f}{f} = \frac{\Delta \lambda}{\lambda_0} = \frac{v}{c}$

v = relative velocity of star from Earth c = Speed of light
f = observed frequency from star λ_0 = Wavelength in lab

Hubble's Law: The recessional velocity of a galaxy from Earth is proportional to the distance of the galaxy from Earth.

$v_r \propto d$

$v_r = H_0 d$

H_0 = Hubble's constant (worked out) v_r = recessional speed of galaxy
d = distance of galaxy from Earth

– Through hubble's law, it correctly proves that the universe is constantly expanding. It therefore provides evidence of the Big Bang.

Age of the universe = $1/H_0$

ZEESHAN ALAM KHAN
TEACHER:- SIR AFTAB SAAD