IMPORTANT FACTS AND FORMULAE FOR JEE

INDEX

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AIEEE – PHYSICS

UNITS & MEASUREMENT

1. If $x = a^m b^n c^p$,

then fractional error in 'x' can be calculated as

$$\frac{\Delta x}{x} = m\frac{\Delta a}{a} + n\frac{\Delta b}{b} + p\frac{\Delta c}{c}.$$

2. For vernier callipers, least count = s – v.

(s = length of one division on main scale, v = length of one division on vernier scale.)

3. Length measured by vernier calliper = reading of main scale + reading of vernier scale × least count.

4. For Screw Gauge, least count = $\dfrac{\text{pitch of the screw}}{\text{no. of divisions on the circular scale}}$.

where, Pitch = $\dfrac{\text{distance travelled on the pitch scale}}{\text{no. of rotations}}$.

5. Length measured by screw gauge = Reading of main scale + Reading of circular scale × least count.

MOTION IN ONE DIMENSION

t_1	=	initial time,	t_2	=	final time
u	=	initial velocity,	v	=	final velocity
v_{av}	=	average velocity	a	=	acceleration
s	=	net displacement/distance			

1. Average speed, $v_{av} = \dfrac{\text{total distance travelled}}{t_2 - t_1}$

2. Instantaneous speed, $v = \left|\lim_{\Delta t \to \infty}\left(\dfrac{\Delta s}{\Delta t}\right)\right| = \left|\dfrac{ds}{dt}\right|$

3. Displacement = $\int_{t_1}^{t_2} \vec{v}\, dt$

4. Total distance = $\int_{t_1}^{t_2} |v|\, dt$

5. $a = \frac{dv}{dt} = v\frac{dv}{ds} = \frac{d^2s}{dt^2}$

6. When acceleration is constant,

$V = u + at, \quad s = ut + \frac{1}{2}at^2 \quad \& \quad v^2 = u^2 + 2as$

MOTION IN TWO AND THREE DIMENSION

ω = angular velocity, α = angular acceleration,

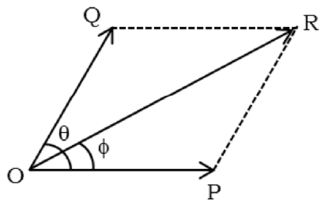
a_τ = tangential acceleration, a_N = normal acceleration

R = radius of curvature

Vectors

1. $|\vec{R}| = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

Where 'θ' is angle between the vectors and direction of $\vec{R}$ from $\vec{P}$,



$\phi = \tan^{-1}\frac{Q\sin\theta}{P + Q\cos\theta}$

2. Two vectors $\vec{a}\left(a_1\hat{i} + a_2\hat{j}a_3\hat{k}\right)$ and $\vec{b}\left(b_1\hat{i} + b_2\hat{j}b_3\hat{k}\right)$ are equal if :

$a_1 = b_1,$

$a_2 = b_2$ and

$a_3 = b_3$

3. If angle between two vectors $\vec{a}$ and $\vec{b}$ is 'θ'

$\vec{a} \cdot \vec{b} = ab\cos\theta$ and

$\vec{a} \times \vec{b} = (ab\sin\theta)\hat{n}$, ($\hat{n}$ is unit vector perpendicular to both $\hat{a}$ and $\hat{b}$)

4. Velocity of 'B' with respect to 'A',

$\overline{V}_{BA} = \vec{V}_B - \vec{V}_A$

Projectile Motion

5. Time of flight, $t_0 = \dfrac{2u\sin\theta}{g}$

6. Range, $R = \dfrac{u^2\sin 2\theta}{g}$

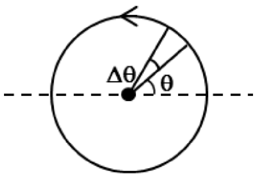
7. Maximum height, $H = \dfrac{u^2\sin^2\theta}{2g}$

8. $(x, y) = \left(u\cos\theta t, u\sin\theta t - \frac{1}{2}gt^2\right)$

9. Equation of projectile, $y = x\tan\theta - \dfrac{gx^2}{2u^2\cos^2\theta}$

Circular Motion

10. $\omega = \lim_{\Delta t \to 0}\dfrac{\Delta\theta}{\Delta t} = \dfrac{d\theta}{dt}$



$\alpha = \dfrac{d\omega}{dt} = \dfrac{d^2\theta}{dt^2}$

11. $a_\tau = \dfrac{dv}{dt}$

$a_N = \dfrac{V^2}{R}$

$a_{Total} = \sqrt{a_\tau^2 + a_N^2}$

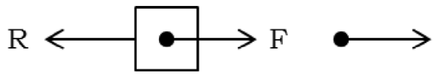
12. R at (x, y) $= \dfrac{\left(1+\left(\dfrac{dt}{dx}\right)^2\right)^{3/2}}{\dfrac{d^2y}{dx^2}}$

13. Banking of roads,

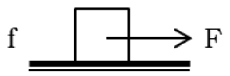
$\tan\theta = \dfrac{v^2}{rg}$

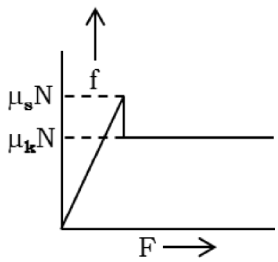
14. Centripetal force $= \dfrac{mv^2}{r} = mr\omega^2$

LAWS OF MOTION

1. 

$F - R = ma$

2. 



where f is the frictional force.

3. $\dfrac{\Delta p}{\Delta t} = F$

4. $\vec{P} = \sum m_i \vec{V_i}$

WORK, ENERGY AND POWER

1. Total energy = kinetic energy + potential energy

2. Kinetic Energy = $\frac{1}{2}mv^2$, Potential Energy = mgh

3. $\int dW = \int_i^f \vec{F} \cdot d\vec{r}$

4. Conservative forces : spring force, electrostatic force, gravitation force

Non-conservative forces : frictional force, viscous force

5. For elastic collision.

$$M_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

6. For perfectly inelastic collision,

$$V = \frac{m_1u_1 + m_2u_2}{m_1 + m_2}$$

7. If coefficient of restitution is e (0 < e < 1),

Velocity of separation = e (velocity of approach)

8. Impulse $= \int_{t_1}^{t_2} \vec{F}\,dt = \vec{P}_2 - \vec{P}_1$

ROTATIONAL MOTION AND MOMENT OF INERTIA

τ = torque, F = force

I = moment of inertia α = angular acceleration

L = angular momentum a_{CM} = acceleration of centra of mass

1. $\vec{R}_{CM} = \frac{\sum_i m_i \vec{r}_i}{M}$

2. $r_{CM} = \frac{1}{M}\int r\,dm$

3. $\vec{\tau} = \vec{r} \times \vec{F}$

4. Moment of inertia,

$$I = \sum_i m_i r_i^2 = \int r^2 \, dm$$

$$\overrightarrow{\tau_{ext}} = I\,\vec{\alpha}$$

5. Angular momentum,

$$\vec{L} = \vec{r} \times \vec{p}$$

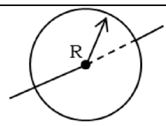
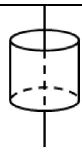
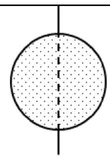
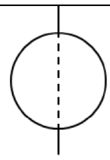
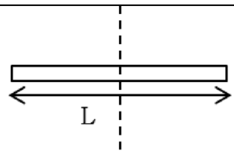
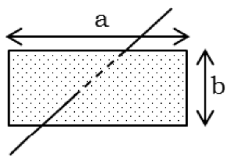
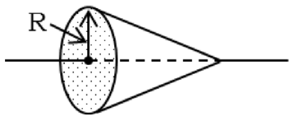
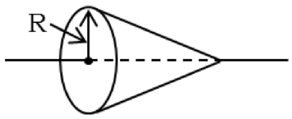
$$\vec{L} = I\,\vec{\omega}$$

6. $$\frac{d\vec{L}}{dt} = \overrightarrow{\tau_{ext}}$$

7.

(i)	Pure translation	$\rightarrow$	$\overrightarrow{\tau_{CM}} = 0$
(ii)	Rotation	$\rightarrow$	$\overrightarrow{\tau_{CM}} \neq 0$
(iii)	Pure rotation	$\rightarrow$	$\sum \vec{F} = 0, \overrightarrow{\tau_{CM}} \neq 0$
(iv)	Translation	$\rightarrow$	$\sum \vec{F} \neq 0$
(v)	Rolling	$\rightarrow$	$a_{CM} = \alpha r, V_{CM} = \omega r$
(vi)	Sliding or sliding	$\rightarrow$	$a_{CM} \neq \alpha r, V_{CM} \neq \omega r$

Table for standard moments of inertia :

1.	Very thin circular hoop		MR^2
2.	Uniform solid cylinder about it's symmetry axis		$\frac{1}{2}MR^2$
3.	Uniform solid sphere about it's diameter		$\frac{2}{5}MR^2$
4.	Uniform hollow sphere about it's diameter		$\frac{2}{3}MR^2$
5.	Uniform thin rod about it's centre and perpendicular to it		$\frac{M\ell^2}{12}$
6.	Thin rectangular sheet about an axis perpendicular to sheet and passing through it's centre		$\frac{M(a^2+b^2)}{12}$
7.	Uniform solid right cone about it's axis		$\left(\frac{3}{10}\right)MR^2$
8.	Uniform hollow right cone about it's axis		$\frac{1}{2}MR^2$

GRAVITATION

G = Universal gravitational constant,

U = Gravitational potential energy

V = Gravitational potential,

E = Gravitational field

F = Gravitational force

1. $F = G\frac{Mm}{r^2}$ (attraction force)

2. Gravitational potential energy, $V = -G\frac{m_1 m_2}{r}$

3. $U_f - U_i = -\int_i^f \vec{F} \cdot d\vec{r}$

4. Gravitational potential, $V = -\frac{GM}{r}$

5. Gravitational field, $E = \frac{F}{m} = \frac{GM}{r^2}$

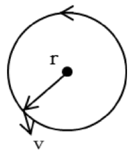
6. Escape velocity, $u \geq \sqrt{\frac{2GM}{R}}$

7. (i) $g' = g\left(1 - \frac{h}{R_e}\right)$, where 'h' is depth from the earth's surface.

(ii) $g' = \frac{g}{\left(1 + \frac{h}{R_e}\right)^2}$, where 'h' is height from the earth's surface.

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

9. $T = 2\pi\sqrt{\frac{r^3}{GM}}$



10. K.E. $= \frac{GMm}{2a}$, PK.E. $= -\frac{GMm}{a}$ $\Rightarrow$ $E = -\frac{GMm}{2a}$

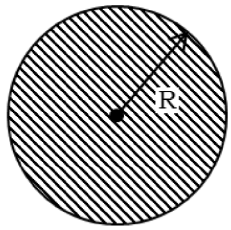
11. Gravitational field, $E = \frac{F}{m} = \frac{GM}{r^2}$

(i) Uniform solid sphere

$$E(r) = \frac{GMr}{R^3}, \quad r < R$$

$$E(r) = \frac{GM}{R^2}, \quad r = R$$

$$E(r) = \frac{GM}{r^2}, \quad r > R$$



$$V(r) = -\frac{GM}{R}\left[\frac{3}{2} - \frac{1}{2}\frac{r^2}{R^2}\right], \quad r < R$$

$$V(r) = -\frac{GM}{R}, \quad r = R$$

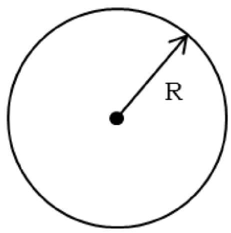
$$V(r) = -\frac{GM}{r}, \quad r > R$$

(ii) Uniform spherical shell

$$E(r) = 0, \quad r < R$$

$$E(r) = \frac{GM}{R^2}, \quad r = R$$

$$E(r) = \frac{GM}{r^2}, \quad r > R$$

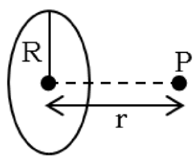


$$V(r) = -\frac{GM}{R}, \quad r \le R$$

$$V(r) = -\frac{GM}{r}, \quad r > R$$

(iii) Uniform circular ring at point on axis :

$$E(r) = \frac{GMr}{\left(R^2 + r^2\right)^{3/2}}$$



$$V(r) = -\frac{2GM}{R^2}\left[\sqrt{R^2 + r^2} - P\right]$$

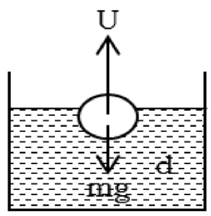
SOLIDS AND FLUIDS

p	=	pressure,	ρ	=	density
V	=	volume of solids,	v	=	volume immersed
D	=	density of solid,	d	=	density of liquid
A	=	cross section area	U	=	upthrust
Y	=	Young's modulus,	σ	=	stress
ε	=	strain	B	=	Bulk modulus
F	=	force	A	=	cross section area
ℓ	=	initial length	$\Delta\ell$	=	change in length
T	=	surface tension,	R	=	radius of the bubble/drop
r	=	radius of the tube	θ	=	angle of contact
η	=	coefficient of viscosity,	F	=	force

1. $p = \lim\limits_{\Delta S \to c} \frac{F}{\Delta S}$

2. Variation of pressure with height, $dP = -\rho\, g\, dh$

3. Archimedes Principle, $mg = v\,dg$ or $VD = dv$



4. Equation of continuity, $A_1v_1 = A_2v_2$

5. Bernoulli's equation, $P + \frac{1}{2}pv^2 + \rho gh = \text{constant}$

6. $Y = \frac{\sigma}{\varepsilon} = \frac{F\ell}{A\,\Delta\ell}$

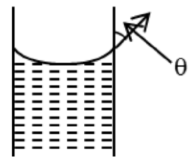
7. Bulk modulus, $B = -\frac{\Delta P}{\Delta v / V}$

8. Elastic potential energy $= \frac{1}{2} \times$ stress $\times$ strain $\times$ volume

9. Excess pressure inside a drop, $\Delta P = \frac{2T}{R}$

10. Excess pressure inside a soap bubble, $\Delta P = \frac{4T}{R}$

11. Rise of liquid in a capillary tube, $h = \frac{2T\cos\theta}{r\,\rho g}$



12. $F = -\eta A \frac{dv}{dz}$

13. Stoke's law, $F = 6\pi r\eta v$

14. Terminal velocity, $v_0 = \frac{2r^2(\rho-\sigma)g}{9\eta}$

where, v = velocity, σ = density of liquid, ρ = density of solid

15. Velocity of efflux = $V = \sqrt{2gh}$

OSCILLATIONS

ω = angular frequency, I = moment of inertia

T = time period, ℓ = length of pendulum

1. $\frac{d^2x}{dt^2} + \omega^2 x = 0$

2. $T = \frac{2\pi}{\omega}$

3. Simple pendulum,

$T = 2\pi\sqrt{\ell/g}$, $\omega = \sqrt{g/\ell}$

4. Angular simple harmonic motion,

$T = 2\pi\sqrt{I/k}$, $\omega = \sqrt{\frac{k}{I}}$

5. Physical pendulum

$T = 2\pi\sqrt{\frac{I}{mg\ell}}$, $\omega = \sqrt{\frac{mg\ell}{I}}$

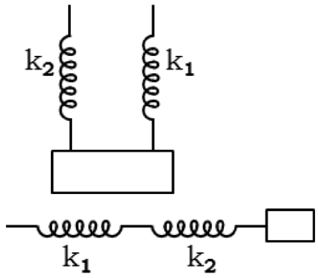
6. Effective spring constant

i) Parallel $K_{eff} = K_1 + K_2$

7. Effective spring constant

i) Parallel

$k_{eff} = k_1 + k_2$



ii) Series

$$\frac{1}{k_{eff}} = \frac{1}{k_1} + \frac{1}{k_2}$$

WAVES

A	=	amplitude	μ	=	mass per unit length
y	=	displacement	ω	=	angular frequency
$\Delta\phi$	=	phase difference	Δx	=	path difference
ν	=	frequency	λ	=	wavelength
L	=	length of the wire			

1. Equation of wave,

$$y = A \sin \omega\left(t - \frac{x}{v}\right)$$

2. Velocity of a wave on a string,

$$v = \sqrt{\frac{F}{\mu}}$$ (μ = mass per unit length)

3. $P_{av} = 2\pi^2 \mu v A^2 \gamma^2$

4. $y_1 = a_1 \sin \omega t$, $y_2 = a_2 \sin(\omega t + \phi)$

resultant wave, $y = y_1 + y_2$

consecutive interference, $\Delta\phi = 2n\pi$ or $\Delta x = n\lambda$

destructive interference, $\Delta\phi = (2n-1)\pi$ or $\Delta x = \left(n - \frac{1}{2}\right)\lambda$

5. $\nu_0 = \frac{1}{2L}\sqrt{\frac{F}{\mu}}$, ($\nu_0$ = fundamental frequency)

6. Speed of sound in fluid = $\sqrt{\frac{B}{\rho}}$ (B = Bulk modules ρ = density)

7. Speed of sound in solid = $\sqrt{\frac{Y}{\rho}}$ (Y = Young's modules ρ = density)

8. Speed of sound in gas = $\sqrt{\frac{\gamma P}{\rho}}, v \alpha \sqrt{T}$

9. Closed organ pipe, $\nu = (2n+1)\frac{v}{4\ell}$

10. Open organ pipe, $\nu = \frac{nv}{\ell}$

11. Frequency of beats $= |\nu_1 - \nu_2|$

12. Doppler effect, $\nu = \frac{v + u_0}{v - u_s}\,\nu_0$

HEAT AND THERMODYNAMICS

P	=	pressure	V	=	volume
n	=	no. of moles	T	=	temperature
R	=	universal gas constant	α	=	coefficient of linear expansion
β	=	coefficient of superficial expansion	γ	=	coefficient of volume expansion
Q	=	heat taken/supplied	s	=	specific heat
m	=	mass	$\Delta\theta$	=	change in temperature
L	=	latent heat of state change per mass	W	=	work done by gas
U	=	internal energy	V_i	=	initial volume
V_f	=	final volume	P_i	=	initial pressure
P_f	=	final pressure			

1. Ideal gas equation, PV = n R T

2. Thermal expansion, $\alpha = \frac{1}{L}\frac{dL}{dT}$; $\gamma = \frac{1}{V}\frac{dV}{dT}$

3. $v_{rms} = \sqrt{\frac{3PV}{M}} = \sqrt{\frac{3RT}{M_0}}$

Translational kinetic energy,

$k = \frac{3}{2}PV$

$\bar{v} = \sqrt{\frac{8RT}{\pi M_0}}$; $v_p = \sqrt{\frac{2RT}{M_0}}$

4. Vander Waals equation :

$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT$

5. $Q = ms\,\Delta\theta$

6. Latent heat of state change,

Q = mL

7. dQ = dW + dU

8. Work done by a gas,

$W = \int_{V_1}^{V_2} P\,dV$

9. Work done on an ideal gas :

isothermal process, $W = nRT\,\ell n\left(\frac{V_f}{V_i}\right)$

isobaric process, $W = P(V_f - V_i)$

isochoric process, $W = 0$

adiabatic process, $W = \frac{P_i V_i - P_f V_f}{\gamma - 1}$

10. Entropy,

$$\Delta S = \frac{\Delta Q}{T}$$

11. Efficiency of an ideal reversible heat engine,

$$\eta = 1 - \frac{T_2}{T_1}$$

12. $C_v = \left(\frac{\Delta Q}{n\Delta T}\right)$ constant volume

$C_P = \left(\frac{\Delta Q}{n\Delta T}\right)$ constant pressure

13. $dU = nC_v dT$

14. $C_p - C_v = R$, $\frac{C_p}{C_v} = \gamma$

15. Adiabatic process, PV^{γ} = constant

TRANSFERENCE OF HEAT

e	=	Coefficient of emission	σ	=	Stefan's constant
K	=	Coefficient of thermal conductivity	A	=	Area

1. $\frac{\Delta Q}{\Delta t} = K\frac{A(T_1 - T_2)}{x} \quad = -KA\frac{dT}{dx}$

2. Thermal resistance, $R = \frac{x}{KA}$

Heat current, $I = \frac{T_1 - T_2}{R}$

3. Series connection, $R = R_1 + R_2$

Parallel connection, $1/R = 1/R_1 + 1/R_2$

4. $U = e\sigma AT^4$, (U = energy emitted per second)

5. Newton's law of cooling,

$\frac{d\theta}{dt} = -K(\theta - \theta_0)$ (θ taken in Celsius scale)

ELECTROSTATICS

Facts :

1. Charge is quantized.

2. Charge is conversed, net charge does not change.

3. The tangent to a line of force at any point gives the direction of electric filed at that point.

4. No electric filed exists inside conductors.

5. Electric fields at surfaces of conductors are perpendicular to surface.

6. All points on or inside a conductors are at the same potential.

7. In isolated capacitor, charge does not change.

8. Capacitors in series have equal amount of charges.

9. The voltage across two capacitor connected in parallel is same.

10. In steady state no current flows through a capacitor.

F	=	force	q	=	charge
λ	=	linear charge density	C	=	capacitance
V	=	electric potential	E	=	electric filed
σ	=	surface charge density	ρ	=	volume charge density
U	=	electrical potential energy	r	=	distance
q_{enc}	=	charge enclosed	p	=	dipole moment

1. Coulombs law : The force between two point charges at rest,

$$\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$$

2. Electric field :

$$\vec{F} = q\vec{E}$$

3. Electric Potential :

$$\Delta V = -E\,\Delta\,r\cos\theta$$

$$V = -\int_{\infty}^{r}\vec{E}.d\vec{r}$$

4. Electric Potential Energy :

$$U = \frac{1}{4\pi\varepsilon_0} \sum_{i<j} \frac{q_i q_j}{r_{ij}}$$

5. Fields for a point charge :

$$E = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2},$$

$$V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r},$$

Gauss's law : net electric flex through any closed surface is equal to the net charge enclosed by thee surface divided by ε_0.

$$\oint_s \vec{E}.\vec{ds} = \frac{q_{enc}}{\varepsilon_0}$$

Electric Dipole : It is a combination of equal and opposite charges.

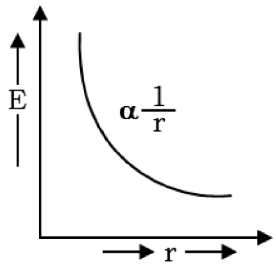
Electric dipole moment $\vec{P} = q\vec{d}$, where d is the separation between the two point charges.

Electric field due to various charge distribution :

a) If the line charge is 'λ' then

i) electric field outside cylinder (Radius 'R')

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$



ii) electric filed on the surface

$$E = \frac{\lambda}{2\pi\varepsilon_0 R}$$

iii) Electric filed inside at a distance 'r' from the axis

$$E = \frac{\lambda r}{2\pi\varepsilon_0 R^2}$$

b) Plane sheet of charge :

$E = \frac{\sigma}{2\varepsilon_0}$, where σ is the surface charge density.

c) Near a charge conducting surface :

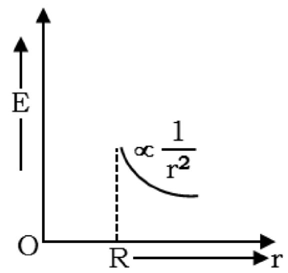
$E = \frac{\sigma}{\varepsilon_0}$

d) Charged conducting spherical shell :

$\vec{E}_{in} = 0, r < R$

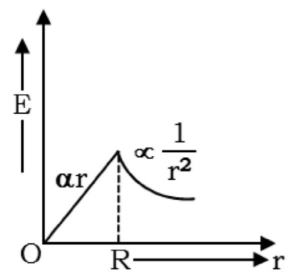
$\vec{E}_{out} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}, r > R$

$\vec{E}_{sur} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}, r = R$



e) Non conducting charged solid sphere :

$E_{in} = \frac{1}{4\pi\varepsilon_0}\frac{qr}{R^3}, r < R$



$\vec{E}_{out} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}, r > R$

$\vec{E}_{sur} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}, r = R$

f) Charged ring :

Special cases :-

$$E_{axial} = \frac{1}{4\pi\varepsilon_0}\frac{qx}{(R^2+x^2)^{3/2}}$$

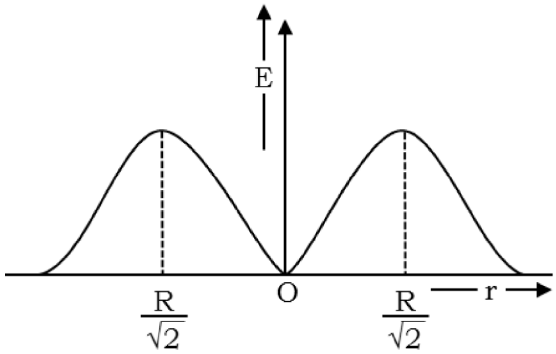
i) If $x < R$ and $x^2 << R^2$,

$$E = \frac{1}{4\pi\varepsilon_0}\frac{qx}{R^3},$$

ii) If $x > R$ and $x^2 >> R^2$,

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{x^2}$$

Note : E_{max} at $r = R/\sqrt{2}$.



g) Dipole :

In terms of polar coordinates,

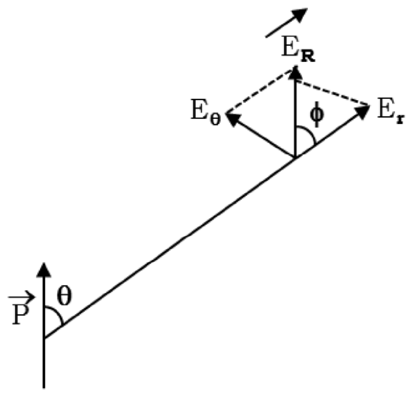
$$E_r = \frac{1}{4\pi\varepsilon_0}\frac{2P\cos\theta}{r^3}$$

$$E_\theta = \frac{1}{4\pi\varepsilon_0}\frac{P\sin\theta}{r^3}$$

$$E_R = \sqrt{E_r^2 + E_\theta^2}$$

$$E_R = \frac{P}{4\pi\varepsilon_0 r^3}\sqrt{1+3\cos^2\theta}$$

Its direction, $\phi = \tan^{-1}\left(\frac{\tan\theta}{2}\right)$



Torque on a dipole :

$\vec{\tau} = \vec{P} \times \vec{E}$

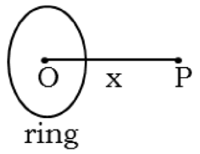
Potential energy of Dipole :

$U = -\vec{P}.\vec{E}$

Electric Potential due to various charge distribution :

a) Charged ring :

i) At the centre:- $V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{R}$

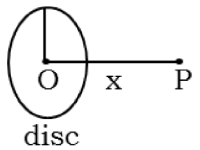


ii) On the axis at a distance x from the centre:- $V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{\sqrt{R^2 + x^2}}$

b) Uniformly charged disc :

i) At a distance x from the centre,

$V = \dfrac{\sigma}{2\varepsilon_0}\left[\sqrt{R^2 + x^2} - x\right]$



ii) At the centre,

$V = \dfrac{\sigma R}{2\varepsilon_0}$

iii) At a large distance x $(>> R)$,

$V = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{x}$

Here, the disc behaves as a point charge.

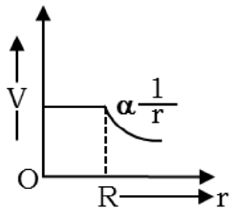
iv) At the edge of the disc,

$V = \dfrac{\sigma R}{\varepsilon_0}$

c) Spherical shell :

$$V_{in} = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}$$

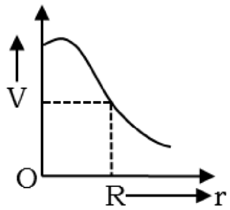
$$V_{out} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$



d) Nonconducting sphere :

$$V_{in} = \frac{1}{4\pi\varepsilon_0}\frac{q}{R}\left[\frac{3}{2} - \frac{r^2}{2R^2}\right]$$

$$V_{sur} = \frac{1}{4\pi\varepsilon_0}\frac{q}{R};\ V_{out} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$$



6. Capacitance of a parallel plate capacitor,

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

7. Voltage across capacitor,

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

8. Elements in series :

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2},\ R = R_1 + R_2$$

9. Elements in parallel :

$$C = C_1 + C_2\ ;\ \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

10. If a dielectric is placed inside the capacitor,

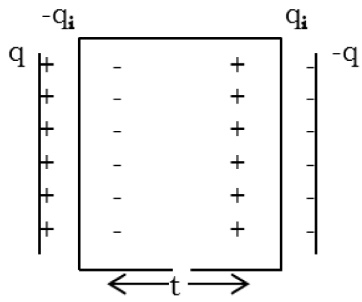
$$E = \frac{E_0}{K},\ V = \frac{V_0}{K}$$

11. Induced charged in the dielectric,

$$q_i = q\left(1 - \frac{1}{K}\right)$$

12. Capacitance of a capacitor partially filled with dielectric of thickness t,

$$C = \frac{\varepsilon_0 A}{\left(d - t + \frac{t}{K}\right)}$$

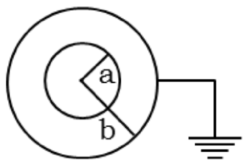


13. Force between the plates of a capacitor

$$F = \frac{Q^2}{2\varepsilon_0 A}$$

14. Capacitance of a spherical capacitor,

$$C = \frac{4\pi\varepsilon_0 \, ab}{(b - a)}$$

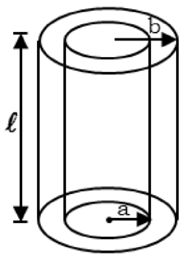


15. Capacitance of a parallel plate capacitor,

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

16. Capacitance of a cylindrical capacitor,

$$C \text{ (per unit length)} = \frac{2\pi\varepsilon_0}{\text{In}\left(\frac{b}{a}\right)}$$



Numbers :

Electronic charge, $e = 1.6 \times 10^{-19}$

$$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \ Nm^2 / C^2$$

$$\varepsilon_0 = 8.85 \times 10^{-12} C^2 / Nm^2$$

Units :

Quantity	Units	Conversion
Electric field	N/C, V/m	1 N/C = 1V/m
Charge	C	$1e = 1.6 \times 10^{-19} C$
Voltage	V, J/C	1V = 1 J/C

CURRENT ELECTRICITY

Facts:

1. Sum of currents into a node is zero.

2. Sum of voltage around closed loop is zero.

3. The temperature coefficient of resistivity is negative for semiconductor.

Q = charge	v_d = drift velocity
i, I = current	j = current density
ρ = resistivity	R = resistance
t = thickness	K = dielectric constant

Formulae :

1. Electric current,
$I = n\,q\,A\,v_d$

2. Resistance of a wire,
$$R = \rho \frac{L}{A}$$

3. Current density,
$$J = \frac{I}{A} = n q v_d$$

4. Voltage across the resistor,
V = IR

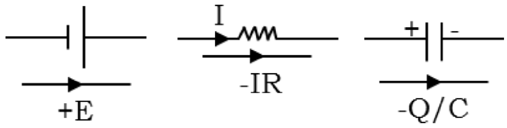
5. Ohm's law,
$E = \rho J$

6. Power dissipated in resistor :
$$P = I^2 R = \frac{V^2}{R}$$

7. Charge on a capacitor in an RC – circuit,
$Q(t) = Q_0 (I - e^{-t/RC})$ where Q_0 is the charge at t = 0

8. Current through a resistor in an RC – circuit,

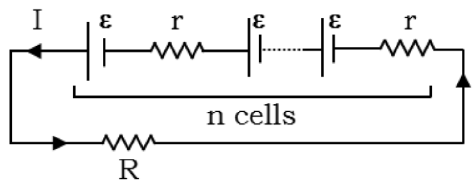
$I(t) = I_0 e^{-t/\tau}$, where $\tau = RC$



9. Grouping of cells :

a) Series combination :-

$$I = \frac{n\varepsilon}{(nr + R)}$$

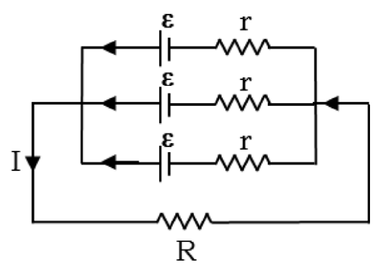


If the polarity of 'm' cells is reversed.

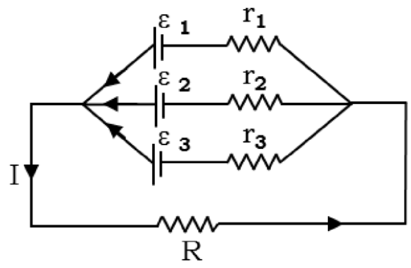
$$I = \frac{(n - 2m)\varepsilon}{(R + nr)}$$

b) Parallel combination :-

i) $I = \dfrac{\varepsilon}{(R + r / n)}$



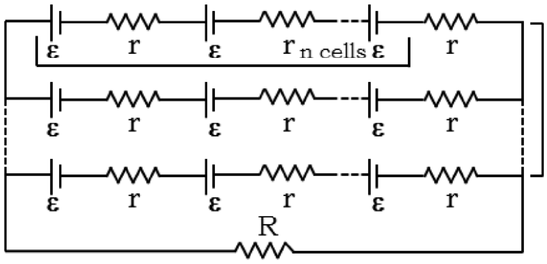
ii) $$I = \frac{\sum \frac{E}{r}}{1 + R\sum\left(\frac{1}{r}\right)}$$



c) Mixed combination :-

$$I = \frac{nE}{\left(R + \frac{nr}{m}\right)}$$

Current will be maximum when $R = \frac{nr}{m}$



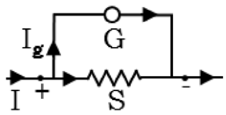
m rows

Ammeter :

$$S = \left(\frac{I_g}{I - I_g}\right)G$$

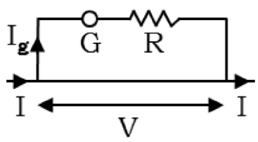
Percentage error in measuring current through an ammeter,

$$\%\text{Error} = \left(\frac{R'}{R + R'}\right) \times 100 \text{ where } R' = \frac{GS}{G + S}$$



Voltmeter :

$$R = \frac{V}{I_g} - G$$



$$\%\text{Error} = \left(\frac{1}{1 + \frac{r}{(R + G)}}\right) \times 100$$

Potentiometer :

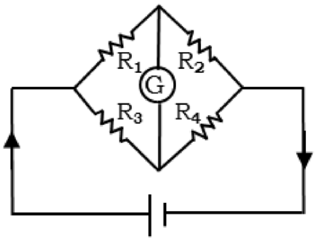
Comparing the emf of the cells, $\frac{\varepsilon_1}{\varepsilon_2} = \frac{\ell_1}{\ell_2}$

Internal resistance of a battery, $r = R\left(\frac{\ell}{\ell'} - 1\right)$

Wheatstone Bridge :

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$

Under the above condition there will be no current through Galvanometer.



Units :

Quantity	Units	Conversion
Capacitance	F	I F = IC/V
Current	A	I A = IC/S
Resistance	Ω	$I\Omega = IV / A$

THERMAL EFFECTS OF CURRENTS

Joules law of heating :

Heat produced in a resistor,
$H = I^2Rt$

Seeback Effect :

Thermo emf, $E = \alpha t + \beta t^2$

MAGNETIC EFFECTS OF CURRENTS

B = magnetic induction	ϕ = flux
q = charge	V = velocity
F = force	N = no. of turns
I = current	μ = magnetic dipole moment

Facts :

1. Force on a moving charge in magnetic filed is $\perp^r$ to both $\vec{v}$ and $\vec{B}$.
2. Net magnetic force acting on any closed current loop in a uniform magnetic field is zero.
3. Magnetic filed of long straight wire circles around wire.
4. Parallel wires carrying current in the same direction attract each other.

Formulae :

1. Force on a charged Particle, $\vec{F} = q\left(\vec{v} \times \vec{B}\right)$

$$F = qvB(\sin\theta)$$

2. When a particle enters into a $\perp^r$ magnetic field, it describe a circle. Radius of the circular path,

$$r = \frac{mv}{qB} = \frac{\sqrt{2Km}}{qB}$$

3. Time period, $T = \frac{2\pi m}{qB}$

4. Magnetic force on a segment of wire,

$$\vec{F} = I\vec{\ell} \times \vec{B}$$

5. Force between parallel current carrying wires,

$$\frac{F}{\ell} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

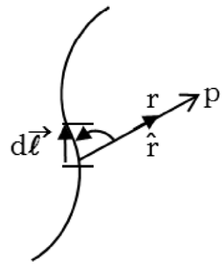
6. A current carrying loop behaves as a magnetic dipole of magnetic dipole moment,

$$\vec{\mu} = NI\vec{A}$$

7. Torque on a current loop, $\vec{\tau} = \vec{\mu} \times \vec{B}$

8. Magnetic field due to a current currying wire,

$$\vec{B} = \frac{\mu_0 I}{4\pi}\int \frac{\vec{d\ell} \times \hat{r}}{r^2}$$



9. Ampere's law

$$\oint \vec{B}.\vec{d\ell} = \mu_0 \, I_{enc}$$

Magnetic Field due to various current distributions :

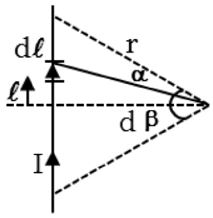
1) Current in a straight wire :-

$$B = \frac{\mu_0 I}{4\pi b}(\sin\alpha + \sin\beta)$$

2) For an infinitely long straight wire :-

$\alpha = \beta = \pi / 2$

$$B = \frac{\mu_0 I}{4\pi b}$$

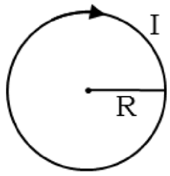


3) On the axis of a circular coil :-

$$B = \frac{\mu_0 NIR^2}{2(R^2 + x^2)^{3/2}}$$

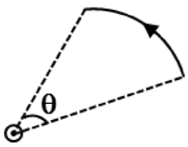
4) At the centre of the circular coil :-

$$B = \frac{\mu_0 I}{2R}$$



5) For a circular arc,

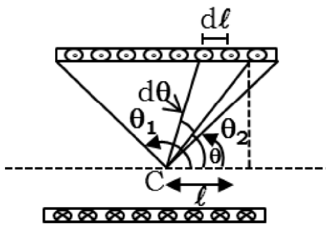
$$B = \frac{\mu_0 I}{4\pi R}\theta$$



6) Along the axis of a solenoid,

$$B_C = \frac{\mu_0 nI}{2}(\cos\theta_2 - \cos\theta_1)$$

where $n = \frac{N}{\ell}$ (No. of turns per unit length)

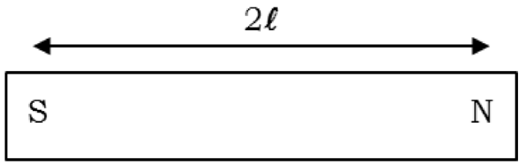


7) For a very long solenoid, $B_C = \mu_0 nI$

8) At then end of a long solenoid, $B = \frac{\mu_0 nI}{2}$

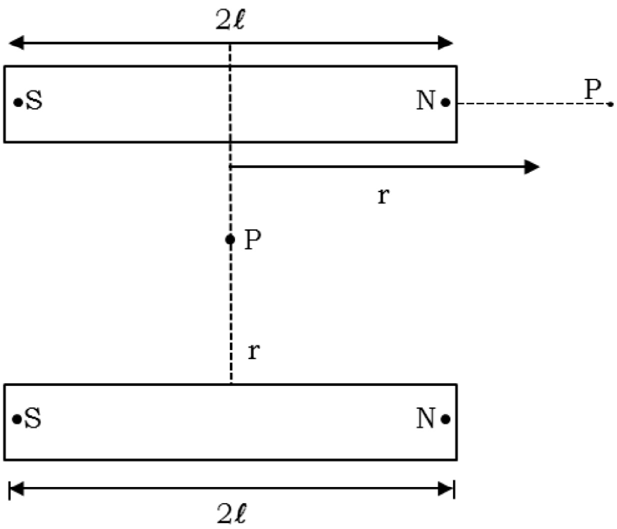
MAGNETOSTATICS

1. Magnetic – Moment of a bar magnet :
$M = m \times 2\ell$ where 'm' is the pole Strength.



2. Force between two poles of strength m_1 and m_2 separated by a distance 'r' is given by, $F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}$ where 'r' is in metre and m in Amp-metre.

3. Torque on a bar magnet placed in a magnetic field,
$\vec{\tau} = \vec{M} \times \vec{B}$
and the potential energy, 0
$U = \vec{M}.\vec{B}$



4. Magnetic field due to a bar magnet,

i) $B_p = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$

ii) $B_p = \frac{\mu_0}{4\pi}\frac{M}{(r^2 + \ell^2)^{3/2}}$

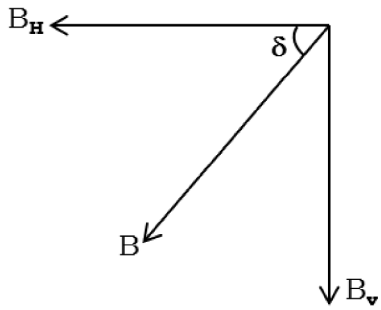
If $r >> \ell$

$B = \frac{\mu_0}{4\pi}\frac{M}{r^3}$

5. Earth's magnetic field,

$$\frac{B_H}{B} = \cos\delta$$

Where B_H is the horizontal Component of the earth's magnetic field and 'δ' is the angle of dip.



6. Magnetic intensity,

$$\vec{H} = \frac{\vec{B}}{\mu_0} - \vec{I}\text{ , where } I = \frac{M}{V}$$

7. $\vec{B} = -\mu\vec{H}$

8. $I = \chi\vec{H}$, where χ is the magnetic susceptibility.

9. Curie's law : $\chi = \frac{C}{T}$

ELECTROMAGNETIC – INDUCTION AND ALTERNATING CURRENTS

B	=	magnetic induction	ϕ	=	flux
q	=	charge	V	=	velocity
F	=	force	N	=	no. of turns
I	=	current	L	=	coefficient of self inductance
M	=	coefficient of mutual inductance	ε	=	induced emf

1. Induced emf,

$$\varepsilon = -N\frac{d\Phi}{dt} = -NA\frac{dB}{dt}$$ where a is the area of a loop.

2. Induced current, $I = \frac{\varepsilon}{R}$

3. Induced electric field, $\oint \vec{E}.d\vec{\ell} = -\frac{d\Phi}{dt}$

4. Self-inductance,

$$N\Phi = LI; \qquad \varepsilon = -L\frac{dI}{dt}$$

5. Inductance of a solenoid, $L = \mu_0 n^2 A\ell$

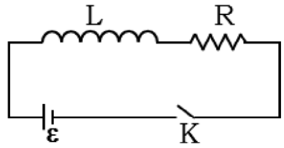
where 'n' is the number of turns per unit length.

6. Mutual inductance, $N\Phi = MI$

$$\varepsilon = -M\frac{dI}{dt}$$

7. Growth of current in an L-R circuit,

$$I = \frac{\varepsilon}{R}\left(1 - e^{-t/\tau}\right), \tau = \frac{L}{R}$$



8. Decay of current in an L-R circuit,

$$I = \frac{\varepsilon}{R}\left(e^{-t/\tau}\right), \qquad \tau = \frac{L}{R}$$

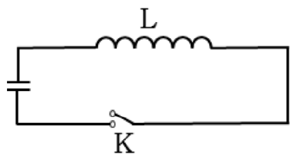
9. Energy stored in an inductor, $U = \frac{1}{2}LI^2$

10. Energy density in a magnetic filed,

$$u = \frac{U}{V} = \frac{B^2}{2\mu_0}$$ (Energy per unit volume)

11. L-C-Oscillations :

$$\frac{d^2q}{dt^2} = -\left(\frac{1}{LC}\right)q$$



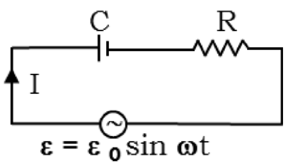
$q = q_0 \cos\omega t$ where, $\omega = \frac{1}{\sqrt{LC}}$

12. R.M.S. current, $I_{rms} = \frac{I_0}{\sqrt{2}}$

13. In RC – circuit

Peak current,

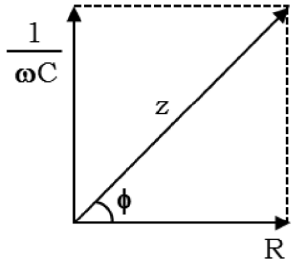
$$I_0 = \frac{\varepsilon_0}{z} = \frac{\varepsilon_0}{\sqrt{R^2 + (1/\omega C)^2}}$$ **14.**



14. Steady state current,

$$I = \frac{\varepsilon_0}{z}\sin(\omega t + \phi)$$

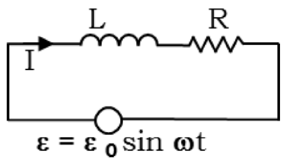
$$\phi = \tan^{-1}\left(\frac{1}{\omega CR}\right)$$

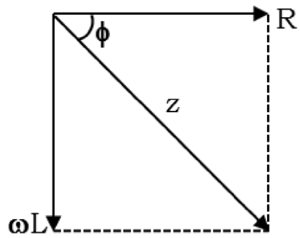


15. In LR – Circuit,
In steady state,

$$I = \frac{\varepsilon_0}{\sqrt{R^2 + \omega^2 L^2}}\sin(\omega t - \phi)$$

$$\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$$

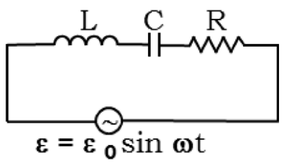


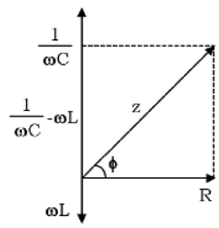


16. In LCR – Circuit :

$$I = \frac{\varepsilon_0}{\sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}}\sin(\omega t - \phi)$$

$$\phi = \tan^{-1}\left(\frac{\frac{1}{\omega C} - \omega L}{R}\right)$$





i) If $\frac{1}{\omega C} > \omega L$, current leads the voltage.

ii) If $\frac{1}{\omega C} < \omega L$, current legs behind the voltage.

iii) If $\frac{1}{\omega C} = \omega L$, current is in phase with the voltage.

iv) In LCR – circuit, peak vale of current,

$$I = \frac{\varepsilon_0}{\sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}}$$

If the angular frequency 'ω' varies then I_0 also varies.

I_0 is maximum, when $\frac{1}{\omega C} - \omega L = 0$

$$\text{or } \omega = \frac{1}{\sqrt{LC}}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

This is called the resonance frequency of the circuit.

17. Power in an A. C. circuit,

$P = V_{rms} I_{rms} \cos\phi$ where $\cos\phi$ is the power factor.

i) For a purely resistive circuit, $\phi = 0$

ii) For a purely reactive circuit, $\phi = \pi/2$, or $-\pi/2$

$\therefore \cos\phi = 0$

18. Transformer :

$\left|\frac{\varepsilon_1}{\varepsilon_2}\right| = \frac{N_1}{N_2}$ where N1 and N_2 are the number of turns in the primary and secondary coils respectively.

Electromagnetic – Induction

Induced electric filed, $\oint \vec{E}.d\vec{\ell} = -\frac{d\Phi}{dt}$

Motional emf = $\varepsilon = \int_a^b (\vec{v} \times \vec{B}).d\vec{\ell}$

Modified Faraday's law

$$\varepsilon = \oint \underbrace{(\vec{v} \times \vec{B}).d\vec{\ell}}_{\substack{\textbf{Motion of a}\\ \textbf{conductor in a}\\ \textbf{stationary}\\ \textbf{magnetic field}}} = -\underbrace{\vec{A}.\frac{d\vec{B}}{dt}}_{\substack{\textbf{Variation of}\\ \textbf{magnetic field}\\ \textbf{in a}\\ \textbf{stationary}\\ \textbf{conductor}}}$$

RAY OPTICS

u = distance of the object from the lens/mirror	
v = distance of the image from the lens/mirror	
m = magnification	i = angle of incident
r = angle of refraction/reflection	n = refractive index
θ_c = critical angle	δ = angle of deviation
R = radius of curvature	P = power

1. Spherical mirrors,

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f}, \qquad m=-\frac{v}{u}$$

2. Refraction at plane surfaces,

$$n = \frac{\sin i}{\sin r}=\frac{\text{real depth}}{\text{apparent depth}}$$

critical angle, $\theta_c = \sin^{-1}\left(\frac{1}{n}\right)$

3. Refraction at spherical surface,

$$\frac{n_2}{v}-\frac{n_1}{u}=\frac{n_2-n_1}{R}, m=\frac{n_1 v}{n_2 u}$$

4. Refraction through thin lenses,

$$\frac{1}{f}=(n-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}, \quad m=\frac{v}{u}$$

$P=\frac{1}{f}$, (f should be in metre)

5. Prism,

r + r’ = A,

$\delta = i + i' - A$

$$n=\frac{\sin\frac{A+\delta_m}{2}}{\sin\frac{A}{2}}$$

6. Refraction at plane surfaces, Normal shift = $\left(1-\frac{1}{n}\right)t$, t is the thickness of the glass slab.

7. For small 'A' and 'I', $\delta = (n-1)A$

8. Combination of lens $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} + \ldots\ldots$

9. When lens are 'd' distance apart $\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$

WAVE OPTICS

c = speed of light,
η = refractive index of the material,
v = speed of light in the material,
Δx = path difference
δ = phase difference
D = distance between the slit and the screen

a = amplitude
I = intensity
W = fringe width
λ = wavelength
d = distance between the slits
t = thickness of glass slab

1. $v = \frac{c}{\eta}$ where

c = speed of light,
η = refractive index of the material and
v = speed of light in that material

2. Young's double slit experiment,

$a = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\delta}$, $I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta$

for bright fringes, $\Delta x = n\lambda$

for dark fringes, $\left.\Delta x = \left(n-\frac{1}{2}\right)\lambda\right\}$ n = 1, 2, 3 ...

Fringes width $= \frac{D\lambda}{d}$

3. $v = \frac{c}{\mu}, c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}, v = \frac{1}{\sqrt{\mu\varepsilon}}$

4. Young's double slit experiment,

$a = \sqrt{a_1^2 + a_2^2 + 2a_1a_2 \cos\delta}$, $I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos\delta$

for bright fringes, $\Delta x = n\lambda$

for dark fringes, $\left.\Delta x = \left(n - \frac{1}{2}\right)\lambda\right\}$ n = 1, 2, 3, ...

$$W = \frac{D\lambda}{d}$$

5. Shifting of fringes : Shift = $\frac{(\mu - 1)tD}{d}$

6. Optical path length = μt

7. Number of fringes shifted $= \frac{\text{shift}}{\text{firing width}} = \frac{(\mu - 1)t}{d}$

8. Dispersive Power, $\omega = \frac{\mu_v - \mu_r}{\mu_y - 1}$

9. Dispersive without average deviation : $\frac{A}{A'} = \frac{\mu'_y - 1}{\mu_y - 1}$

10. Average deviation without dispersion : $\frac{A}{A'} = \frac{\mu'_v - \mu'_r}{\mu'_v - \mu'_r}$

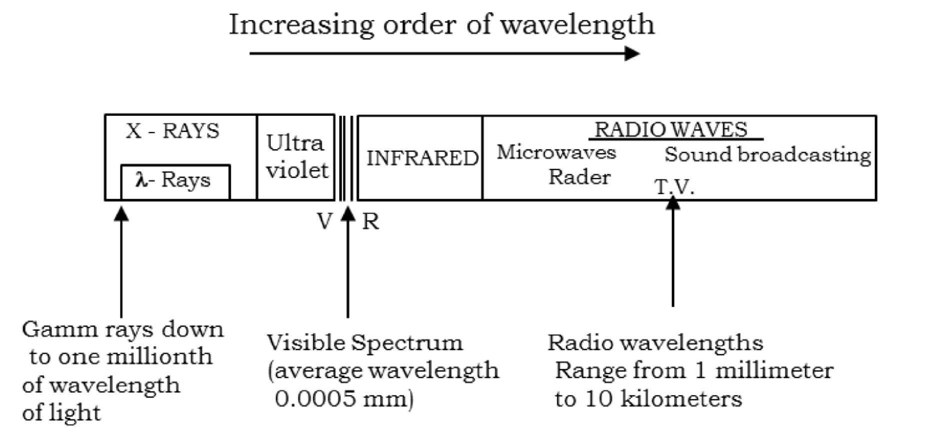
11. Net average deviation $\delta_r = (\mu_y - 1)A\left(1 - \frac{\omega}{\omega_r}\right)$

ELECTROMAGNETIC WAVES

1. Speed of electromagnetic waves, $v = \frac{1}{\mu\varepsilon}$

2. Electromagnetic waves and transverse, E = CB

Wave-Band	Origin	Sources
X-radiation	i) High energy changes in electron structures of atoms ii) Decelerated electrons	X-ray tubes
Gamma radiation	Energy changes in nuclei of atoms	Radioactive substance
Ultraviolet radiation	Fairly high energy changes in electron structure of atoms	i) Very hot bodies, e.g. the electric arc. ii) Electric discharge through gases, particularly, mercury vapour in quartz envelopes
Visible Radiation	Energy changes in electron structure of atoms	Various lamps, flames and anything at or above red-heat
Infrared Radiation	Low energy changes in electron structure of atoms	All Matter over a wide range of temperature from absolute zero upwards
Radio wave	i) High frequency oscillatory electric currents ii) Very low energy changes in electron structure of atoms.	Radio transmitting circuits.



The electromagnetic spectrum

ELECTRONS AND PHOTONS

P = momentum	h = Plank's constant
λ = wavelength	c = speed of light
F = frequency	ϕ = work function

1. Momentum of a photon, $P = \frac{h}{\lambda}$

2. Energy of a photon, $E = hf = \frac{hc}{\lambda}$

3. Photoelectric equation, $KE_{max} = \frac{hC}{\lambda} - \phi$

$$KE_{max} = h(f - f_0)$$

4. To take place photoelectric effect, $\lambda \le \lambda_0$

5. For a one electron atom, $E_n = -13.6\frac{z^2}{n^2}eV$

$$r_n = 5.29\times10^{-11}\frac{n^2}{z}\text{meters}$$

6. If an electron jumps from m^{th} orbit to n^{th} orbit,

$$\frac{1}{\lambda} = Rz^2\left[\frac{1}{n^2} - \frac{1}{m^2}\right], \text{where } m > n$$

7. Mosley's law, $\sqrt{f} = a(z - b)$ where a b are constants.

8. The minimum wavelength of x-rays, $\lambda_{min} = \frac{hc}{eV}$

ATOMS, MOLECULES AND NUCEI

n = no. of nuclei	$t_{1/2}$ = half life
Z = atomic no.	

1. Nuclear radius, $R = R_0A^{1/3}$, $R_0 = 1.1\times10^{-15}$ metre

2. Mass energy equivalence, $\Delta E = \Delta mC^2$

3. Radioactive decay, $N(t) = N_0e^{-\lambda t}$ where λ is the decay constant.

4. Radioactive Half Life, $t^{1/2} = \frac{0.693}{\lambda}$

SOLIDS AND SEMICONDUCTOR DEVICES

1. Intrinsic semiconductors, $n_i = n_e = n_h$

2. Doped semiconductors, $n_i^2 = n_e n_h$

3. Conductivity, $\sigma = e(n_e \mu_h + n_h \mu_h)$

4. Current gains, $\alpha = \dfrac{\beta}{1+\beta}, \beta = \dfrac{\alpha}{1-\alpha}$

5. Alternating current power gain = $\dfrac{\text{output power}}{\text{input power}}$

IMPORTANT FACTS AND FORMULAE FOR JEE
IIT – CHEMISTRY

SOME BASIC CONCEPTS

1. **1 mole** = $N_{Avg} \times$ number of species = 6.023×10^{23} species

i.e., atoms, molecules, ions, etc.

2. **Atomic mass** = Mass of one atom

Gram-atomic mass = Mass of one mole of atoms

= Mass of 6.023×10^{23} atoms in gms.

e.g. Atomic mass of O is 16 amu.

gm-atomic mass of O is 16 gm.

$\therefore$ 16 gm O-contains 6.023×10^{23} oxygen atoms.

$$\text{Atomic mass} = \frac{\text{Average mass of an atom}}{1/12 \times \text{Mass of an atom of } C^{12}}$$

$$\text{Average atomic mass} = \frac{R.A.(1) \times M.No + R.A.(2) \times M.No}{R.A.(1) + R.A.(2)}$$

Here R.A = Relative Abundance, Mass No. = Mass number.

3. **1 amu (atomic mass unit)** $= \dfrac{1}{N_{Avg}}$ = 1 Avogram

$$= \frac{1}{6.023 \times 10^{23}} \text{ gm} = 1.66 \times 10^{-24} \text{ gm} = 1 \text{ Dalton}$$

4. **Molecular weight** = Weight of one molecule

Molar mass or gm-molecular weight = weight of one mole of molecule

= wt. of 6.023×10^{23} molecules

5. **Moles** $= \dfrac{\text{Weight(gm)}}{\text{Molar mass (gm / mole)}} = \dfrac{\text{volume of gas at STP(L)}}{22.4\,\text{lit.}}$

= Molarity $\times$ Volume (in L)