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Formula Sheet for Physics

Physical Constants

Speed of light	$C = 3\times10^{8}\ m/s$
Plank constant	$h = 6.63\times10^{-34}\ Js$
Gravitation Constant	$G = 6.67\times10^{-11}\ m^3 kg^{-1} s^{-2}$
Boltzmann Constant	$k = 1.38\times10^{-23}\ J/K$
Molar gas Constant	$R = 8.314\ J/mol\,K$
Avagadro's Number	$N_A = 6.023\times10^{23}\ mol^{-1}$
Charge of electron	$e = 1.602\times10^{-19}\ C$
Vacuum permeability	$\mu_0 = 4\pi\times10^{-7}\ N/A^2$
Vacuum permitivity	$\varepsilon_0 = 8.85\times10^{-12}\ F/m$
Coulomb Constant	$1/4\pi\varepsilon_0 = 9\times10^{9}\ N m^2/C^2$
Faraday Constant	$F = 96485\ C/mol$
Mass of electron	$m_e = 9.1\times10^{-31}\ kg$
Mass of proton	$m_p = 1.672\times10^{-27}\ kg$
Mass of neutron	$m_n = 1.674\times10^{-27}\ kg$
At. mass unit	$u = 1.66\times10^{-27}\ kg$
	$u = 931.49\ MeV/c^2$
Stefan Boltzman Const.	$\sigma = 5.67\times10^{-8}\ W/m^2K^4$
Rydberg Constant	$R_\infty = 1.097\times10^{7}\ m^{-1}$
Bohr magneton	$\mu_B = 9.27\times10^{-24}\ J/T$
Bohr radius	$a_0 = 0.529\times10^{-10}\ m$
Standard atmosphere	$atm = 1.01325\times10^{5}\ Pa$
Wien displacement Const.	$b = 2.9\times10^{-3}\ mK$

1 MECHANICS

1.1 Vectors

* Notation $\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$
* Magnitude $a = |\vec{a}| = \sqrt{a_x^2 + a_y^2 + a_z^2}$
* Dot product $\vec{a} \cdot \vec{b} = a_x b_x + a_y b_y + a_z b_z$
$= ab \cos\theta$
* Cross product
$\vec{a} \times \vec{b} = (a_y b_z - a_z b_y)\hat{i} + (a_z b_x - a_x b_z)\hat{j} + (a_x b_y - a_y b_x)\hat{k}$
$|\vec{a} \times \vec{b}| = ab \sin\theta$

1.2 Kinematics

* Average and Instantaneous Vel and Accel.

$\vec{V}_{av} = \frac{\Delta \vec{r}}{\Delta t}$ $\vec{V}_{inst} = \frac{d\vec{r}}{dt}$

$\vec{a}_{av} = \frac{\Delta \vec{V}}{\Delta t}$ $\vec{a}_{inst} = \frac{d\vec{V}}{dt}$

* Motion in a straight line with Const. a

$V = u + at$

$s = ut + \frac{1}{2}at^2$

$V^2 = u^2 + 2as$

* Relative Velocity $\vec{V}_{A/B} = \vec{V}_A - \vec{V}_B$
* Projectile Motion

$x = ut\cos\theta$ $y = ut\sin\theta - \frac{1}{2}gt^2$

$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$

$T = \frac{2u\sin\theta}{g}$ $R = \frac{u^2 \sin 2\theta}{g}$ $H = \frac{u^2\sin^2\theta}{2g}$

1.3 Newton's Laws and Friction

* Linear momentum $\vec{p} = m\vec{v}$
* Newton's 1st Law : Inertial frame.
* Newton's 2nd law $\vec{F} = \frac{d\vec{p}}{dt}$, $\vec{F} = m\vec{a}$
* Newton's 3rd Law $\vec{F}_{AB} = -\vec{F}_{BA}$
* Frictional force $f_{static} = \mu_s N$

  $f_{kinetic} = \mu_k N$
* Banking angle $\frac{v^2}{rg} = \tan\theta$.

  $\frac{v^2}{rg} = \frac{\mu + \tan\theta}{1 - \mu\tan\theta}$
* Centripetal force

  $F_c = \frac{mv^2}{r}$ $a_c = \frac{v^2}{r}$
* Pseudo force $\vec{F}_{pseudo} = -m\vec{a}_0$

  $F_{centrifugal} = \frac{mv^2}{r}$
* Minimum speed to complete vertical circle

  $V_{min, bottom} = \sqrt{5gl}$

  $V_{min, top} = \sqrt{gl}$
* Conical pendulum $T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$

1.4 Work, Power and Energy

* Work $W = \vec{F}\cdot\vec{s}$

  $= Fs\cos\theta$

  $= \int \vec{F}\, d\vec{s}$

* $KE = \frac{1}{2}mv^2 = \frac{p^2}{2m}$

* $PE = F = -\frac{dU}{dx}$

$U_{gravitational} = mgh$

$U_{spring} = \frac{1}{2}kx^2$

* Workdone by Conservative force

$\oint \vec{F}_{conservative} \cdot d\vec{r} = 0$

* Work Energy theorm

$W = \Delta K$.

* Mechanical energy

$E = U + K$

* Power

$P_{av} = \frac{\Delta W}{\Delta t}$ $P_{inst} = \vec{F} \cdot \vec{v}$

1.5 Centre of Mass and Collision

* Centre of mass

$x_{cm} = \frac{\sum x_i m_i}{\sum m_i}$

$x_{cm} = \frac{\int x \, dm}{\int dm}$

* CM of few useful configurations

1. m_1, m_2 Separated by r

$\frac{m_2 r}{m_1 + m_2}$, $\frac{m_1 r}{m_1 + m_2}$

2. Triangle

$y_c = \frac{h}{3}$

3. Semicircular ring
$$y_c = \frac{2r}{\pi}$$

4. Semicircular disc $y_c = \frac{2r}{\pi}$

5. Hemispherical Shell $y_c = \frac{r}{2}$

6. Solid Hemisphere $y_c = \frac{3r}{8}$

7. Cone $\frac{h}{3}, \frac{h}{4}$

* Motion of CM

$$M = \Sigma m_i$$

$$\vec{V}_{cm} = \frac{\Sigma m_i \vec{v}_i}{M} \qquad \vec{P}_{cm} = M\vec{V}_{cm}$$

$$\vec{a}_{cm} = \frac{\vec{F}_{ext}}{M}$$

* Impulse $\vec{J} = \int \vec{F}\, dt = \Delta \vec{p}$

1.6 Rigid Body Dynamics

* Angular Velocity

$$\omega_{av} = \frac{\Delta\theta}{\Delta t} \qquad \omega = \frac{d\theta}{dt} \qquad \vec{v} = \vec{\omega} \times \vec{r}$$

* Angular Acceleration

$$\alpha_{av} = \frac{\Delta\omega}{\Delta t} \qquad \alpha = \frac{d\omega}{dt} \qquad \vec{a} = \vec{\alpha} \times \vec{r}$$

* Rotation about an axis with α Const

$$\omega = \omega_0 + \alpha t$$

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

$$\omega^2 - \omega_0^2 = 2\alpha\theta$$

* Moment of Inertia

$$I = \sum_i m_i r_i^2$$

$$I = \int r^2 \, dm$$

ring $= mr^2$
disk $= \frac{1}{2} mr^2$
shell $= \frac{2}{3} mr^2$
sphere $= \frac{2}{5} mr^2$
rod $= \frac{1}{12} ml^2$
hollow $= mr^2$
solid $= \frac{1}{2} mr^2$
rectangle $= \frac{m(a^2+b^2)}{12}$

* Parallel axes theorem

$$I_{\parallel} = I_{cm} + md^2$$

* Perp. Axes Theorem

$$I_z = I_x + I_y$$

* Radius of Gyration

$$K = \frac{\sqrt{I}}{\sqrt{m}}$$

* Angular momentum

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

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

* Torque

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

* Conservation of $\vec{L}$

$$\vec{\tau}_{ext} = 0$$

$$\vec{L} = \text{Const}$$

* Equilibrium condition

$$\sum \vec{F} = \vec{0}$$

$$\sum \vec{\tau} = \vec{0}$$

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1.7 Gravitation

* $F = \frac{Gm_1m_2}{r^2}$
* $U = -\frac{GMm}{r}$
* $g = \frac{GM}{R^2}$
* $g_{inside} \approx g\left(1 - \frac{h}{R}\right)$
* $g_{outside} \approx g\left(1 - \frac{2h}{R}\right)$
* Orbital Velocity of Satellite
  $V_o = \sqrt{\frac{GM}{R}}$
* Escape Velocity $V_e = \sqrt{\frac{2GM}{R}}$

1.8 Simple Harmonic Motion

* Hooke's law $F = -kx$
* Acceleration $a = \frac{d^2x}{dt^2} = -\frac{k}{m}x = -\omega^2 x$
* Time $T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{m}{k}}$
* displacement $x = A\sin(\omega t + \phi)$
* $PE = \frac{1}{2}kx^2 = U$
* $KE = \frac{1}{2}mv^2$

* Totalenergy $E = U + K$
$= \frac{1}{2} m \omega^2 A^2$

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

* $T = 2\pi \sqrt{\frac{I}{mgl}}$ Physical pendulum

* $T = 2\pi \sqrt{\frac{I}{k}}$ Torsional pendulum

* Spring
Series $\frac{1}{K_{eq}} = \frac{1}{K_1} + \frac{1}{K_2}$
Parallel $K_{eq} = K_1 + K_2$

1.9 Properties of matter

* Rigidity modulus $Y = \frac{F/A}{\Delta l / l}$
$B = -V \frac{\Delta P}{\Delta V}$
$\eta = \frac{F}{\Delta \theta}$

* Compressibility $K = \frac{1}{B} = -\frac{1}{V} \frac{dV}{dP}$

* Poisson's ratio $= \frac{\Delta D / D}{\Delta l / l}$

* Elastic Energy
$U = \frac{1}{2}$ stress x strain x Volume

* Surface tension $S = F / l$

* Surface energy $U = SA$

* Capillary rise $h = \frac{2S\cos\theta}{r\rho g}$

* Hydrostatic pr: $P = \rho g h$

* Buoyant force $F_B = \rho V g$

* Equation of Continuity
$$A_1V_1 = A_2V_2$$

* Bernoulli's equation
$$P + \frac{1}{2}\rho V^2 + \rho g h = \text{Constant}$$

* Torricelli's theorem $V_{efflux} = \sqrt{2gh}$

* Viscous force $F = -\eta A \frac{dV}{dx}$

* Stoke's law $F = 6\pi\eta r v$

* Poiseuille's equation: $\frac{\text{Volume flow}}{\text{time}}$

* Terminal Velocity $V_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$

2 WAVES

2.1 Waves Motion

* General eq $\frac{d^2y}{dx^2} = \frac{1}{V^2}\frac{d^2y}{dt^2}$

* $T = \frac{1}{\nu} = \frac{2\pi}{\omega}$ $\nu = V\lambda$

$k = \frac{2\pi}{\lambda}$

* Progressive wave

$$y = f\left(t - \frac{x}{v}\right) \rightsquigarrow +x$$

$$y = f(t + x/v) \rightsquigarrow -x$$

* Progressive Sine wave

$$y = A\sin(kx - \omega t)$$
$$= A\sin(2\pi(x/\lambda - t/T))$$

2.2 Waves on a String

* $V = \sqrt{\frac{T}{\mu}}$

* $P_{av} = 2\pi^2 \mu v A^2 \nu^2$

* Interference

$$y_1 = A_1 \sin(kx - \omega t)$$
$$y_2 = A_2 \sin(kx - \omega t + \delta)$$

$$y = y_1 + y_2 = A\sin(kx - \omega t + \theta)$$

$$\tan\theta = \frac{A_2 \sin\theta}{A_1 + A_2\cos\theta}$$

* Standing waves

$$y_1 = A_1 \sin(kx - \omega t)$$
$$y_2 = A_2 \sin(kx + \omega t)$$

$$y = y_1 + y_2 = (2A\cos kx)\sin\omega t$$

* String fixed at both end

1. Boundary Conditions
   $y = 0$ at $x = 0$ at $x = L$
2. Allowed freq.
   $L = n\frac{\lambda}{2}$ $\quad \nu = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$ $\quad n = 1, 2, 3 \ldots$
3. Fundamental
   1st harmonics $\quad \nu_0 = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$
4. 1st overtone
   2nd harmonic $\quad \nu_1 = \frac{2}{2L}\sqrt{\frac{T}{\mu}}$
5. 2nd Overtone
   3rd harmonic $\quad \nu_2 = \frac{3}{2L}\sqrt{\frac{T}{\mu}}$
6. All harmonics are present

* String fixed at one end

1. Boundary conditions $y = 0$ at $x = 0$
2. Allowed freq.
   $L = (2n+1)\frac{\lambda}{4}$ $\quad \nu = \frac{2n+1}{4L}\sqrt{\frac{T}{\mu}}$
3. Fundamental
   1st harmonic $\quad \nu_0 = \frac{1}{4L}\sqrt{\frac{T}{\mu}}$
4. 1st Overtone
   2nd harmonic $\quad \nu_1 = \frac{3}{4L}\sqrt{\frac{T}{\mu}}$
5. 2nd Overtone
   3rd harmonic $\quad \nu_2 = \frac{5}{4L}\sqrt{\frac{T}{\mu}}$
6. Only odd harmonics are present

Sonometer

$\nu \propto \frac{1}{L}$, $\nu \propto \sqrt{T}$, $\nu \propto \frac{1}{\sqrt{\mu}}$ $\quad \nu = \frac{n}{2L}\sqrt{\frac{T}{\mu}}$

2.3 Sound waves

* Displacement wave $s = s_0 \sin \omega(t - x/v)$

* P% wave $p = P_0 \cos \omega(t - x/v)$

* Speed of sound wave

$V_{liquid} \sqrt{\frac{B}{\rho}}$ $V_{solid} \sqrt{\frac{Y}{\rho}}$ $V_{gas} = \sqrt{\frac{\gamma P}{\rho}}$

* Intensity

$$I = \frac{2\pi^2 B s_0^2 \nu^2}{v}$$

* Closed Organ pipe

1. Boundary Condition $y = 0$ at $x = 0$
2. Allowed freq.

$L = (2n+1)\frac{\lambda}{4}$, $\nu = (2n+1)\frac{v}{4L}$ $n = 1, 2, 3 \ldots$

3. Fundamental $\nu_0 = \frac{v}{4L}$
   1st harmonic
4. 1st Overtone $\nu_1 = 3\nu_0 = \frac{3v}{4L}$
   3rd harmonic
5. 2nd Overtone $\nu_2 = 5\nu_0 = \frac{5v}{4L}$
   5th harmonics
6. Only odd harmonics are present

* Open Organ pipe

1. Boundary Condition
   $y = 0$ at $x = 0$
2. Allowed freq.

$L = n\frac{\lambda}{2}$, $\nu = n\frac{v}{4L}$ $n = 1, 2, 3, \ldots$

3. Fundamental $\nu_0 = \frac{v}{2L}$
   1st harmonics
4. 1st Overtone $\nu_1 = 2\nu_0 = \frac{2v}{2L}$
   2nd harmonic
5. 2nd Overtone $\nu_2 = 3\nu_0 = \frac{3v}{2L}$
   3rd harmonic
6. All harmonic are present.

* Resonance column

$$L_1 + d = \frac{\lambda}{2} \qquad L_2 + d = \frac{3\lambda}{4}$$

* Doppler Effect

$$\nu = \frac{v + u_0}{v - u_s}\nu_0$$

2.4 Light waves

* Plane wave $E = E_0 \sin \omega(t - x/v)$

$$I = I_0$$

* Spherical wave $E = \frac{aE_0}{r} \sin \omega\left(t - \frac{r}{v}\right)$

* Young's double slit experiment

* Path difference $\Delta x = \frac{dy}{D}$

* Phase difference $\delta = \frac{2\pi}{\lambda}\Delta x$

* Interference Conditions.

$$\delta = \begin{cases} 2n\pi & \text{Constructive.} \\ (2n+1)\pi & \text{destructive} \end{cases}$$

$$\Delta x = \begin{cases} n\lambda & \text{Constructive} \\ \left(n + \frac{1}{2}\right)\lambda & \text{destructive.} \end{cases}$$

* Fringe width $w = \frac{\lambda D}{d}$

* Optical path $\Delta x' = \mu \Delta x$

* Interference of waves transmitted through thin film
$$\Delta x = 2\mu d = \begin{cases} n\lambda \\ (n+1/2)\lambda \end{cases}$$

* Resolution $\sin\theta = \frac{1.22\lambda}{b}$

* Law of malus $I = I_0 \cos^2\theta$

3 OPTICS

3.1 Reflexion of Light

* Law of reflexion
$$\hat{i} = \hat{r}$$

* Spherical mirror
  1. Focal length $f = R/2$
  2. Mirror Equation $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$
  3. Magnification $m = -\frac{v}{u}$

3.2 Refraction of Light

* Refractive index
$$\mu = \frac{\text{Speed of light in Vaccum}}{\text{Speed of light in medium}} = \frac{c}{v}$$

* Snells law $\frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$

* Aparent depth

$$\mu = \frac{\text{real depth}}{\text{apparent depth}} = \frac{d}{d'}$$

* Critical angle $\theta_c = \sin^{-1}\frac{1}{\mu}$

* Deviation of prism

$$\delta = i + i' - A \quad \text{, general result}$$

$$\mu = \frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin\frac{A}{2}} \quad i = i' \text{ mini deviation}$$

$$\delta m = (\mu - 1)A$$

* Refraction at spherical surface

$$\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}, \quad m = \frac{\mu_1 v}{\mu_2 u}$$

* Lens makers formula

$$\frac{1}{f} = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

* lens formula

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

* Power of lens

$$P = \frac{1}{f}$$ P in diopter if f in metre

3.3 Optical Instruments

* Simple microscope

$m = \frac{D}{f}$ in normal adjustment

* Compound microscope

1. Magnification $m = \frac{v}{u}\frac{D}{f_e}$

2. Resolving power $R = \frac{1}{\Delta d}$

$R = \frac{2\mu \sin\theta}{\lambda}$

* Astronomical telescope

1. In Normal $m = -\frac{f_o}{f_e}$ $L = f_o + f_e$

2. Resolving power $R = \frac{1}{\Delta\theta}$

$R = \frac{1}{1.22\lambda}$

3.4 Dispersion

* Cauchy's eqn: $\mu = \mu_0 + \frac{A}{\lambda^2}$ $A > 0$

* Dispersion by prism with small A & i

1. Mean deviation $\delta_y = (\mu_y - 1)A$
2. Angular dispersion $\theta = (\mu_v - \mu_r)A$

* Dispersion power

$\omega = \frac{\mu_v - \mu_r}{\mu_y - 1} \simeq \frac{\theta}{\delta_y}$

4 HEAT AND THERMODYNAMICS

4.1 Heat and Temperature

* Tempr. scales $F = 32 + \frac{9}{5} C$

  $K = C + 273.16$

* Ideal gas eqn: $pV = nRT$

* Van der Waal eqn: $\left(p + \frac{a}{V^2}\right)(V - b) = nRT$

* Thermal expansion

  $L = L_0(1 + \alpha \Delta T)$

  $A = A_0(1 + \beta \Delta T)$

  $V = V_0(1 + \gamma \Delta T)$

  $\gamma = 2\beta = 3\alpha$

* Thermal stress of a material

  $\frac{F}{A} = Y \frac{\Delta l}{l}$

4.2 Kinetic Theory of Gases

* General $M = mN_A$,

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

* RMS speed

  $V_{rms} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M}}$

* Average speed

  $\bar{V} = \sqrt{\frac{8kT}{\pi m}} = \sqrt{\frac{8RT}{\pi M}}$

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* Most probable speed

$$V_p = \sqrt{\frac{2kT}{m}}$$

* P^r: $P = \frac{1}{3} \rho V_{rms}^2$

* Equipartition of energy $K = \frac{1}{2} kT$

$$K = \frac{f}{2} kT$$

* Internal Energy $U = \frac{f}{2} nRT$

4.3 Specific Heat

* Specific heat $s = \frac{Q}{m \Delta T}$

* Latent heat $L = \frac{Q}{m}$

* Specific heat at Const Vol^m: $C_V = \left.\frac{\Delta Q}{n \Delta T}\right|_V$

* Specific heat at Const p^r: $C_P = \left.\frac{\Delta Q}{n \Delta T}\right|_P$

* Relation b/w C_P and C_V

$$C_P - C_V = R$$

* Ratio of Specific heat $\gamma = \frac{C_P}{C_V}$

* Relation b/w U & C_V

$$\Delta U = n C_V \Delta T$$

* Specific heat of gas mixture

$$C_V = \frac{n_1 C_{V1} + n_2 C_{V2}}{n_1 + n_2} \qquad \gamma = \frac{n_1 C_{P1} + n_2 C_{P2}}{n_1 C_{V1} + n_2 C_{V2}}$$

* Molar internal energy of an ideal gas

$U = \frac{f}{2} RT$ $\quad f = 3$ for monatomic

$f = 5$ for diatomic

4.4 Thermodynamic processes

* First law of thermodynamics

$$\Delta Q = \Delta U + \Delta W$$

* Work done by the gas

$\Delta W = p\Delta V$ $\quad W = \int_{V_1}^{V_2} p\,dV$

$$W_{isothermal} = nRT \log\left(\frac{V_2}{V_1}\right)$$

$$W_{isobaric} = p(V_2 - V_1)$$

$$W_{adiabatic} = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

$$W_{isochoric} = 0$$

* Efficiency of heat engine

$$\eta = \frac{\text{Workdone by engine}}{\text{heat applied to it}} = \frac{Q_1 - Q_2}{Q_1}$$

$$\eta_{carnot} = 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

* Coefficient of performance of refrigera-tor

$$COP = \frac{Q_2}{W} - \frac{Q_2}{Q_1 - Q_2}$$

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

* Adiabatic process $\Delta Q = 0$ $\quad pV^{\gamma} = \text{Const}$

4.5 Heat Transfer

* Condection $\frac{\Delta Q}{\Delta t} = -KA\frac{\Delta T}{x}$

* Thermal resistance $R = \frac{x}{KA}$

$R_{series} = R_1 + R_2 = \frac{1}{A}\left(\frac{x_1}{K_1} + \frac{x_2}{K_2}\right)$

$\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{x}$

* Kirchhoff's law

$E_{blackbody} = \frac{E_{body}}{a_{body}} = \frac{\text{Emissive power}}{\text{absorptive power}}$

* Wien's displacement law

$\lambda_m T = b$

* Stefan-Boltzmann law

$\frac{\Delta Q}{\Delta t} = \sigma e A T^4$

* Newton's law of Cooling

$\frac{dT}{dt} = -bA(T - T_0)$

5 ELECTRICITY AND MAGNETISM

5.1 Electrostatics

* Coulombs Law

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

* Electric field $\vec{E}(\vec{r}) = \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \hat{r}$

* Electrostatic energy $U = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r}$

* Electrostatic potential $V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r}$

* Ele. dipole moment $\vec{p} = q\vec{d}$
* Potential of dipole $V = \frac{1}{4\pi\varepsilon_0} \frac{p \cos\theta}{r^2}$

* field of a dipole $E_r = \frac{1}{4\pi\varepsilon_0} \frac{2p\cos\theta}{r^3}$

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

* Torque on a dipole placed in

$\vec{E} = \frac{1}{4\pi\varepsilon_0} \frac{p\sin\theta}{r^3}$

$\vec{E} : \vec{\tau} = \vec{p} \times \vec{E}$

* P.E of dipole placed in $\vec{E}$: $U = -\vec{p}\,\vec{E}$

5.2 Gauss's Law and its Applications

* Ele flux $\phi = \cdot\ \phi = \oint \vec{E}\, d\vec{s}$

* Gauss law $\oint \vec{E}\, d\vec{s} = \frac{q_{in}}{\varepsilon_0}$

* field of a uniformly charged ring

$$E_p = \frac{1}{4\pi\varepsilon_0} \frac{qx}{(a^2+x^2)^{3/2}}$$

* E & V of a uniformly charged Sphere

$$E = \begin{cases} \dfrac{1}{4\pi\varepsilon_0} \dfrac{Qr}{R^3} & \text{for } r < R \\ \dfrac{1}{4\pi\varepsilon_0} \dfrac{Q}{r^2} & \text{for } r \geq R \end{cases}$$

$$V = \begin{cases} \dfrac{Q}{8\pi\varepsilon_0 R}\left(3 - \dfrac{r^2}{R^2}\right), & \text{for } r < R \\ \dfrac{1}{4\pi\varepsilon_0} \dfrac{Q}{r} & \text{for } r \geq R \end{cases}$$

* E and V of a uniformly charged spherical Shell

$$E = \begin{cases} 0, & \text{for } r < R \\ \dfrac{1}{4\pi\varepsilon_0} \dfrac{Q}{r^2} & \text{for } r \geq R \end{cases}$$

$$V = \begin{cases} \dfrac{1}{4\pi\varepsilon_0} \dfrac{Q}{R} & \text{for } r < R \\ \dfrac{1}{4\pi\varepsilon_0} \dfrac{Q}{r} & \text{for } r \geq R \end{cases}$$

* field of a line Charge $E = \dfrac{\lambda}{2\pi\varepsilon_0 r}$

* field of an infinite sheet $E = \dfrac{\sigma}{2\varepsilon_0}$

* field in Vicinity of conducting Surface $E = \dfrac{\sigma}{\varepsilon_0}$

* Capacitance $C = \dfrac{q}{V}$

* Parallel plate Capacitor

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

* Spherical Capacitor $C = \frac{4\pi\varepsilon_0 r_1 r_2}{r_2 - r_1}$

* Cylindrical capacitor $C = \frac{2\pi\varepsilon_0 l}{\log(r_2/r_1)}$

* Capacitors in parallel

$$C_{eq} = C_1 + C_2$$

* Capacitors in Series

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

* Force b/w plates of parallel plate Capacitor

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

* Energy stored in Capacitor

$$U = \frac{1}{2}CV^2 = \frac{Q^2}{2C}$$

* Energy density in Ele. field

$$E = \frac{U}{V} = \frac{1}{2}\varepsilon_0 E^2$$

* Capacitor with dielectric

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

5.4 Current Electricity

* Current density $j = \frac{i}{A} = \sigma E$

* Drift Velocity $V_d = \frac{1}{2}\frac{eET}{m} = \frac{i}{meA}$

* Ele Power $P = \frac{V^2}{R} = \frac{I^2}{R} = IV$

* Thomson effect
emf $e = \frac{\Delta H}{\Delta Q} = \sigma \Delta T$

* Faradays law of electrolysis
$m = Zit = \frac{1}{F} Eit$

5.5 Magnetism

* Lorentz force $\vec{F} = q\vec{v} \times \vec{B} + q\vec{E}$

* force on current carring wire
$\vec{F} = i\vec{l} \times \vec{B}$

* Magnetic moment of current loop
$\vec{M} = i\vec{A}$

* Torque on magnetic dipole $\vec{\tau} = \vec{M} \times \vec{B}$

* Hall effect $V_w = \frac{Bi}{ned}$

5.6 Magnetic field due to Current

* Biot-Savart law $d\vec{B} = \frac{\mu_0}{4\pi} \frac{i d\vec{l} \times \vec{r}}{r^3}$

* field due to straight Conductor
$B = \frac{\mu_0 i}{4\pi d} (\cos\theta_1 - \cos\theta_2)$

* Force b/w parallel wire $\frac{dF}{dl} = \frac{\mu_0 i_1 i_2}{2\pi d}$

* field on axis of a ring
$B_p = \frac{\mu_0 i a^2}{2(a^2+d^2)^{3/2}}$

* Time Const of LR $\tau = L/R$
* Energy in inductor $U = \frac{1}{2} L i^2$
* Energy density of B field $u = \frac{U}{V} = \frac{B^2}{2\mu_0}$
* Mutual inductance $\phi = Mi$ $e = -M \frac{di}{dt}$
* EMF induced in rotating Coil
$e = NBA\omega \sin \omega t$
* AC $i = i_0 \sin(\omega t + \phi)$
$T = 2\pi/\omega$
* Average in AC $\bar{i} = \frac{1}{T} \int_0^T i\, dt = 0$
* Rms Current $i_{rms} = \left[\frac{1}{T} \int_0^T i^2 dt\right]^{1/2}$
* Energy $E = i_{rms}^2 RR$
* Capacitive reactance $X_C = \frac{1}{\omega C}$
* Inductive reactance
$X_L = \omega L$
* Impedence $Z = \frac{e_0}{i_0}$
* RC circuit $Z = \sqrt{R^2 + (1/\omega C)^2}$
$\tan \phi = 1/\omega CR$
* LR Circuit $Z = \sqrt{R^2 + \omega^2 L^2}$
$\tan \phi = \omega L/R$
* LCR Circuit $Z = \sqrt{R^2 + \left(\frac{1}{\omega C} - \omega L\right)^2}$
$\tan \phi = \frac{\frac{1}{\omega C} - \omega L}{R}$
* Power factor $P = e_{rms} i_{rms} \cos \phi$
* Transformer $\frac{N_1}{N_2} = \frac{e_1}{e_2}$, $e_1 i_1 = e_2 i_2$

6 MODERN PHYSICS

6.1 Photoelectric effect

* Photon's energy $E = h\nu = \frac{hc}{\lambda}$
* Photon's momentum $p = h/\lambda = E/c$
* KE_{max} of ejected photoelectron $= h\nu - \phi$
* Threshold freq. $\nu_0 = \phi/h$
* Stopping potential $V_0 = \frac{hc}{e}\left(\frac{1}{\lambda}\right) - \frac{\phi}{e}$
* de-Broglie Wavelength $\lambda = h/p$

6.2 The Atom

* Energy in n^{th} Bohr's orbit

$$E_n = \frac{mZ^2e^4}{8\varepsilon_0^2 h^2 n^2} \qquad E_n = -\frac{13.6Z^2}{n^2} eV$$

* Radius of n^{th} Bohr's Orbit

$$r_n = \frac{\varepsilon_0 h^2 n^2}{\pi m Z e^2} \qquad r_n = \frac{n^2 a_0}{Z}$$

* Quantization of angular momentum

$$l = \frac{nh}{2\pi}$$

* Photon energy in state transition

$$E_2 - E_1 = h\nu$$

* Wavelength of emitted radiation

$$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n^2} - \frac{1}{m^2}\right]$$

* X ray spectrum

$$\lambda_{min} = \frac{hc}{eV}$$

* Moseley's law $\sqrt{\nu} = a(Z-b)$

* X-ray diffraction

$$2d \sin\theta = n\lambda$$

* Heisenberg uncertainty principle

$$\Delta p \Delta x \geq \frac{h}{2\pi}$$

$$\Delta E \Delta t \geq \frac{h}{2\pi}$$

6.3 The Nucleus

* Nuclear radius

$$R = R_0 A^{1/3}$$

$$R_0 \approx 1.1 \times 10^{-15} \text{ m}$$

* Decay rate $\frac{dN}{dt} = -\lambda N$

* Half life $t_{1/2} = \frac{0.693}{\lambda}$

* Average life $t_{av} = \frac{1}{\lambda}$

* Mass defect

$$\Delta m = [Z m_p + (A-Z) m_n] - M$$

* Binding Energy

$$B = [Z m_p + (A-Z) m_n - M] c^2$$

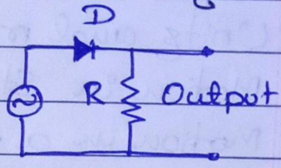
* Q Value $Q = U_i - U_f$

* Energy released in nuclear reaction

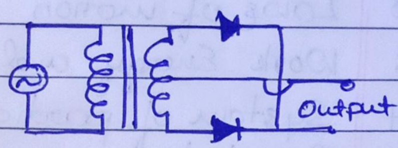
$$\Delta E = \Delta m c^2$$

6.4 Vacuum tubes and semiconductors

* Half wave rectifier



* Full wave rectifier



* plate resistance of triode $r_p = \frac{\Delta V_p}{\Delta i_p}\Big|_{\Delta V = 0}$

* Transconductance of triode
$$g_m = \frac{\Delta i_p}{\Delta V_g}\Big|_{\Delta V_p = 0}$$

* Amplification of triode $\mu = -\frac{\Delta V_p}{\Delta V_g}\Big|_{\Delta i_p = 0}$

* Current in transistor $I_e = I_b + I_c$

* α & β parameters of transistor
$$\alpha = \frac{I_c}{I_e} \qquad \beta = \frac{I_c}{I_b} \qquad \beta = \frac{\alpha}{1-\alpha}$$

* Transconductance $g_m = \frac{\Delta I_c}{\Delta V_{be}}$

* Logic Gates

		AND	OR	NAND	NOR	XOR
A	B	AB	A+B	$\overline{AB}$	$\overline{A+B}$	AB+AB
0	0	0	0	1	1	0
0	1	0	1	1	0	1
1	0	0	1	1	0	1
1	1	1	1	0	0	0

"THE END"