1. Electric Charges and Fields	2. Electrostatic Potential and Capacitance	3. Current Electricity	4. Moving Charges and Magnetism	5. Magnetism and Matter
6. Electromagnetic Induction	7. Alternating Current	8. Electromagnetic Waves	9. Ray Optics and Optical Instruments	10. Wave Optics
11. Dual Nature of Radiation and Matter	12. Atoms	13. Nuclei	14. Semiconductor Electronics	15. All physics Constants

'ELECTRIC CHARGES & FIELDS'

BASICS & COULOMB'S LAW

Electric Charge (Q): [cite: 4, 5, 6]

Quantization: $Q = ne$

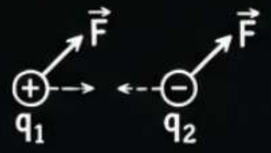
Conservation of Charge: Total charge of isolated system is constant.

Coulomb's Law: [cite: 4, 5, 6]

Force between two point charges.

$$F = k\frac{|q_1 q_2|}{r^2}$$

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



Superposition Principle: [cite: 4, 5, 6]

Total force $\vec{F}_{net} = \sum \vec{F}_i$ (vector sum)

Continuous Charge Distribution:

Linear (λ), Surface (σ), Volume (ρ)

ELECTRIC FIELD & DIPOLE

Electric Field (E): [cite: 4, 5, 6]

Force per unit charge. $E = \frac{F}{q_0}$

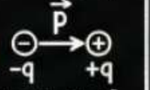
E due to Point Charge: [cite: 4, 5, 6]

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

Electric Field Lines: Imaginary lines showing direction of E. Never cross. Start (+) → End (-). [cite: 4, 5, 6]

Electric Dipole: [cite: 4, 5, 6]

Dipole Moment (p): $p = q(2a)$



E due to Dipole (Axial): [cite: 4, 5, 6]

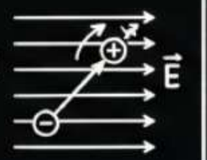
$$E_{axial} = \frac{2kp}{r^3}$$

E due to Dipole (Equatorial): [cite: 4, 5, 6]

$$E_{equatorial} = \frac{kp}{r^3}$$

Torque on Dipole: [cite: 4, 5, 6]

$$\tau = p\vec{E}\sin\theta$$

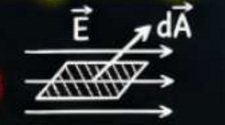


ELECTRIC FLUX & GAUSS'S LAW

Electric Flux (Φ_E): [cite: 4, 5, 6]

Number of field lines passing through area.

$$\Phi_E = \int \vec{E}\cdot d\vec{A} = EA\cos\theta$$



Gauss's Theorem: [cite: 4, 5, 6]

Statement: $\Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{Q_{enclosed}}{\varepsilon_0}$

Applications of Gauss's Law: [cite: 4, 5, 6]

Infinitely Long Wire:

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

Uniformly Charged Sheet:

$$E = \frac{\sigma}{2\varepsilon_0}$$

Spherical Shell (Radius R):

Inside (r < R): $E_{in} = 0$

Outside (r > R): $E_{out} = \frac{kQ}{r^2}$

'ELECTROSTATIC POTENTIAL & CAPACITANCE'

ELECTRIC POTENTIAL (V)

Work done per unit charge.

$$V = \frac{W}{q_0}$$

Potential Difference (ΔV): $V_B - V_A = \frac{W_{AB}}{q_0}$

V due to Point Charge (q): $V = \frac{kq}{r}$

V due to System of Charges: $V_{total} = \Sigma V_i$

V due to Dipole: $V = \frac{kp\cos\theta}{r^2}$

Equipotential Surfaces: Surfaces with same potential.

Electric Potential Energy (U): $U = \frac{kq_1q_2}{r}$

PE of Dipole in E-field:

$$U = -p\vec{E}\cos\theta = -\vec{p}\cdot\vec{E}$$

CONDUCTORS, INSULATORS & DIELECTRICS

Conductors: Free charges.

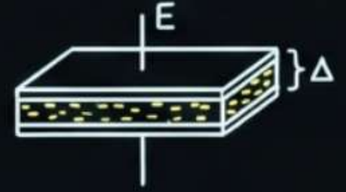
Insulators: Bound charges.

Inside Conductor: E=0, V=constant.

Dielectrics: Insulators that can be polarized.

Electric Polarization (P): Dipole moment per unit volume.

Dielectric Constant (K): $K = \frac{E_0}{E} > 1$



CAPACITORS & CAPACITANCE (C)

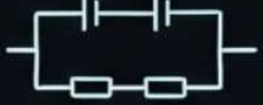
Capacitance: Ability to store charge.

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

Parallel Plate Capacitor: $C = \frac{\varepsilon_0 A}{d}$

With Dielectric (K): $C' = KC = \frac{K\varepsilon_0 A}{d}$

Series Combination: $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$



Parallel Combination: $C_p = C_1 + C_2$

Energy Stored in Capacitor (U):

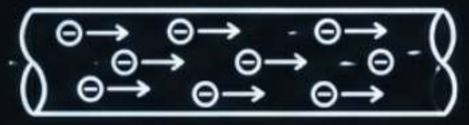
$$U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV$$

'CURRENT ELECTRICITY'

CURRENT & DRIFT VELOCITY

Electric Current (I): Rate of flow of charge.

$$I = \frac{q}{t}$$



Drift Velocity (v_d): Avg. velocity of electrons.

$$v_d = \left(\frac{e\vec{E}}{m}\right)\tau$$

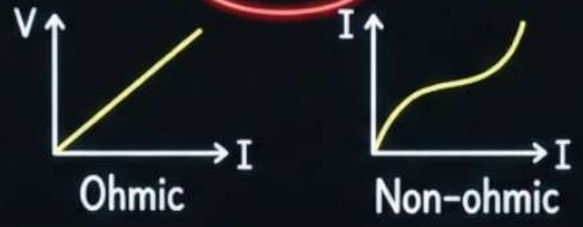
Relation: $I = nAv_d e$

Mobility (μ): $\mu = \frac{v_d}{E}$

OHM'S LAW & RESISTANCE

Ohm's Law: $V \propto I$ (at const. temp).

$$V = IR$$



Resistance (R): Opposition to current.

$$R = \frac{\rho L}{A}$$

Resistivity (ρ) & Conductivity (σ):

$$\sigma = \frac{1}{\rho}$$

Temp. Dependence: $R_t = R_0(1 + \alpha\Delta T)$

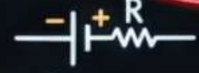
POWER, CELLS & CIRCUITS

Electrical Power (P): $P = VI = I^2R = \frac{V^2}{R}$

Energy: $E = P \cdot t$

EMF (ε) & Internal Resistance (r):

Terminal V: $V = \varepsilon - Ir$ (Discharging)



Cells in Series: $\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$, $r_{eq} = r_1 + r_2$

Cells in Parallel: $\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}$

Kirchhoff's Rules:

1. Junction ($\Sigma I = 0$)
2. Loop ($\Sigma \Delta V = 0$)

Wheatstone Bridge (Balanced):

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

'MAGNETIC EFFECTS OF CURRENT & MAGNETISM'

OERSTED'S & BIOT-SAVART

Oersted's Discovery: Current produces magnetic field ($\vec{B}$).

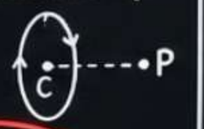
Biot-Savart Law ($d\vec{B}$): Field due to element $d\vec{\ell}$.

$$dB = \frac{\mu_0}{4\pi}\frac{(I\,d\vec{\ell}\times\vec{r})}{r^3}$$

$$dB \propto \frac{I\,d\ell\sin\theta}{r^2}$$

Application: Circular Loop (Radius R)

At Center: $B = \frac{\mu_0 I}{2R}$



On Axis (dist x): $B = \frac{\mu_0 I R^2}{2(R^2+x^2)^{3/2}}$

AMPERE'S LAW & FORCES

Ampere's Law: $\oint \vec{B}\cdot d\vec{\ell} = \mu_0 I_{enclosed}$

Long Straight Wire: $B = \frac{\mu_0 I}{2\pi r}$

Solenoid (Qualitative): B is uniform inside, B≈0 outside.

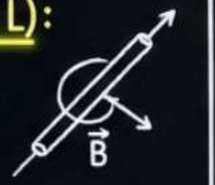
Lorentz Force ($\vec{F}$): Force on q with velocity $\vec{v}$.

In B-field: $\vec{F} = q(\vec{v}\times\vec{B})$

In E & B fields: $\vec{F}_{total} = q\vec{E} + q(\vec{v}\times\vec{B})$

Force on Conductor (Length L):

$$\vec{F} = I(\vec{L}\times\vec{B})$$



INTERACTIONS & INSTRUMENTS

Force b/w Parallel Conductors: Force/length (f).

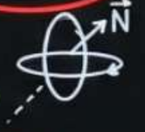
$$f = \frac{\mu_0 I_1 I_2}{2\pi d}$$

Definition of Ampere: I for which $f = 2\times10^{-7}$ N/m.

Torque on Current Loop ($\vec{\tau}$): $\tau = N\,I\,A\,B\sin\theta$

Magnetic Dipole Moment ($\vec{m}$): $m = N\,I\,A$

$$\vec{\tau} = \vec{m}\times\vec{B}$$



Moving Coil Galvanometer (MCG):

Principle is torque.

Current Sensitivity (I_s): $I_s = \frac{\theta}{I} = \frac{NAB}{k}$

Voltage Sensitivity (V_s): $V_s = \frac{\theta}{V} = \frac{I_s}{R_g}$

Conversion to Ammeter:

Connect shunt S in parallel. $S = \frac{I_g R_g}{I - I_g}$

Conversion to Voltmeter:

Connect R in series. $R = \frac{V}{I_g} - R_g$

'MAGNETISM AND MATTER'

BAR MAGNET & DIPOLE

Bar Magnet: Has North (N) & South (S) poles.

Field Lines: Closed loops, never cross.

Equivalent Solenoid (Qualitative):
Circular currents behave like a magnet.

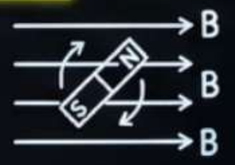
Field due to Dipole (Bar Magnet, Qualitative):

On Axis (End-on): $B_{axial} \approx \frac{2\mu_0 m}{4\pi r^3}$

On Equator (Broad-side): $B_{equatorial} \approx \frac{\mu_0 m}{4\pi r^3}$

Torque in Uniform B-field (Qualitative):

$\tau = m \times B$



MAGNETIC PROPERTIES & MATERIALS

Types of Magnetic Substances:

1. **Diamagnetic**: Feebly repelled by magnet. χ is small & negative $(-1 < \chi < 0)$. $\mu_r < 1$.
   Examples: Bi, Cu, Water.

2. **Paramagnetic**: Feebly attracted. χ is small & positive $(\chi > 0)$. $\mu_r > 1$.
   Examples: Al, Na, O_2 (liquid).

3. **Ferromagnetic**: Strongly attracted. χ is very large & positive $(\chi \gg 1)$. $\mu_r \gg 1$.
   Examples: Fe, Ni, Co.

MAGNETIZATION & TEMPERATURE EFFECT

Magnetization (M): Net magnetic moment per unit volume. $M = \frac{m_{net}}{V}$

Magnetic Intensity (H): $H = \frac{B_0}{\mu_0}$

Total Field (B): $B = B_0 + B_m = \mu_0(H + M)$

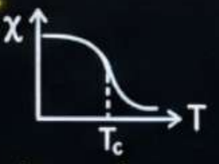
Magnetic Susceptibility (χ): $M = \chi H$

$\chi = \frac{M}{H}$

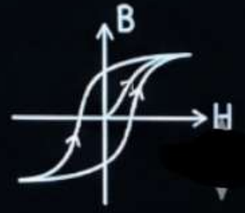
Effect of Temperature (Curie's Law):

For Para: $\chi \propto \frac{1}{T}$ or $\chi = \frac{C}{T}$

Curie Temp (T_c): Ferro becomes Para above T_c.



Hysteresis Loop (Ferro):
Energy loss during magnetization cycles.



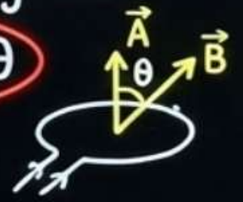
'ELECTROMAGNETIC INDUCTION'

EMI & FARADAY'S LAWS

Electromagnetic Induction (EMI): Generating induced EMF by changing magnetic flux.

Magnetic Flux (Φ_B): Measure of field lines crossing area.

$$\Phi_B = \vec{B}\cdot\vec{A} = BA\cos\theta$$



Faraday's Laws:

1. Change in Φ_B induces EMF.
2. Magnitude is rate of change.

Induced EMF ($|\vec{\mathcal{E}}|$):

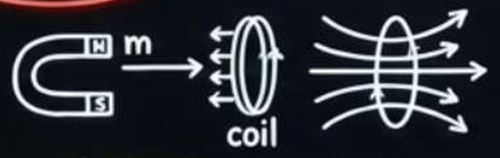
$$|\vec{\mathcal{E}}| = \left|\frac{d\Phi_B}{dt}\right|$$

For N turns: $|\vec{\mathcal{E}}| = N\left|\frac{d\Phi_B}{dt}\right|$

LENZ'S LAW & MOTIONAL EMF

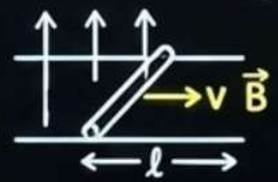
Lenz's Law: Direction of induced EMF opposes the change in flux.

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$ (Negative sign is Lenz's Law)



Motional EMF: Conductor moving in $\vec{B}$-field.

$$\mathcal{E} = Bv\ell \quad (\vec{v}\perp\vec{B}\perp\ell)$$



Induced Current (I):

$$I = \frac{\mathcal{E}}{R} = -\frac{1}{R}\left(\frac{d\Phi_B}{dt}\right)$$

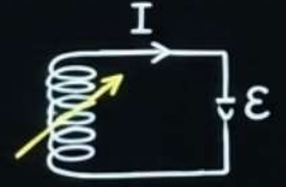
Induced Charge (ΔQ):

$$\Delta Q = \frac{|\Delta\Phi_B|}{R}$$

SELF & MUTUAL INDUCTION

Self Induction: EMF in a coil due to changing its own current.

$$\Phi_B = LI$$



Back EMF:

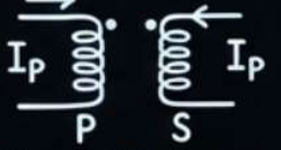
$$\mathcal{E} = -L\frac{dI}{dt}$$

Mutual Induction: EMF in secondary coil due to changing current in primary.

$$\Phi_S = M I_P$$

Induced EMF in Secondary:

$$\mathcal{E}_S = -M\left(\frac{dI_P}{dt}\right)$$

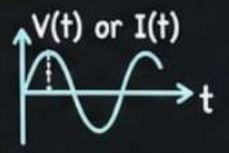


Reciprocity: $M_{12} = M_{21} = M$

'ALTERNATING CURRENT'

AC BASICS & RMS VALUES

Alternating Current (AC): Varies sinusoidally with time.



$I_{inst} = I_0 \sin \omega t$

Peak Value (I_0, V_0): Maximum value.

RMS Value (I_{rms}, V_{rms}): Effective value, heats like DC.

$$I_{rms} = \frac{I_0}{\sqrt{2}} \qquad V_{rms} = \frac{V_0}{\sqrt{2}}$$

Inductive Reactance (X_L): Opposition by Inductor.

$$X_L = \omega L = 2\pi f L$$

Capacitive Reactance (X_C): Opposition by Capacitor.

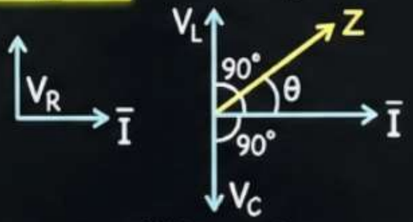
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

LCR SERIES CIRCUIT & RESONANCE

LCR Series Impedance (Z): Total opposition.

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

Phasor Diagram: Shows phase angles.

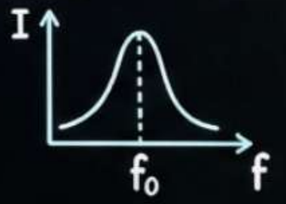


Resonance: Condition when current is Maximum (Z is min).

Condition: $X_L = X_C$

Resonant Frequency (f_0):

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$



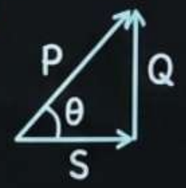
POWER, POWER FACTOR & DEVICES

Power in AC (P): Average power.

$$P = V_{rms}\, I_{rms} \cos\phi$$

Power Factor ($\cos\phi$):

$$\cos\phi = \frac{R}{Z}$$



Wattless Current: Current component in pure L or C, consumes NO power ($\phi = 90°$).

AC Generator: Converts mechanical to electrical energy (principle: EMI).

Transformer: Changes voltage level (Step-up/down). Works on Mutual Induction.

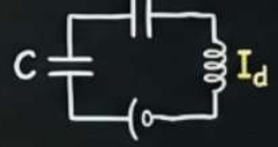
Turns Ratio:

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

'ELECTROMAGNETIC WAVES'

DISPLACEMENT CURRENT & EM WAVE SOURCE

Ampere's Law Inconsistency:



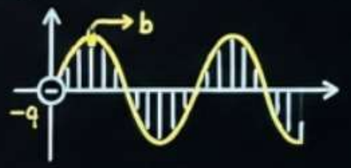
Displacement Current (I_d): Changing Electric Flux produces Magnetic Field.

$$I_d = \varepsilon_0 \left(\frac{d\Phi_E}{dt}\right)$$

Modified Ampere's Law:

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 (I_c + I_d)$$

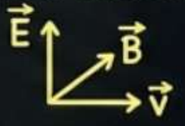
Source of EM Waves: Accelerated Charges.



EM WAVES: CHARACTERISTICS & NATURE

Electromagnetic Waves: Oscillating E and B fields propagating through space.

Transverse Nature: $\vec{E} \perp \vec{B} \perp$ propagation direction ($\vec{v}$).



Speed in Vacuum (c):

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} \approx 3 \times 10^8 \text{ m/s}$$

Relation between Fields:

$$c = \frac{E_0}{B_0}$$

Energy Density (u):

$$u_{avg} = \frac{1}{2}\varepsilon_0 E_0^2 = \frac{1}{2}\left(\frac{B_0^2}{\mu_0}\right)$$

Momentum (p): $p = \frac{U}{c}$

ELECTROMAGNETIC SPECTRUM & USES

EM Spectrum: Ordered by frequency (f) or wavelength (λ).

↳ Increasing f, E ⟶ Increasing λ

1. Radio Waves (Longest λ):
   Uses: Broadcasting, Communication.
2. Microwaves:
   Uses: Radar, Cooking, WiFi.
3. Infrared (IR):
   Uses: Remotes, Thermal Imaging.
4. Visible Light:
   Uses: Vision, Optical Fibers.
5. Ultraviolet (UV):
   Uses: Sterilization, Tanning.
6. X-rays:
   Uses: Medical Imaging, Security.
7. Gamma Rays (γ) (Highest f):
   Uses: Cancer Treatment, Nuclear studies.

'RAY OPTICS & OPTICAL INSTRUMENTS'

REFLECTION & SPHERICAL MIRRORS

Law of Reflection: $i = r$.

Spherical Mirrors: Concave (Converging), Convex (Diverging).

Mirror Formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Magnification (m): $m = \frac{h'}{h} = -\frac{v}{u}$

REFRACTION & SNELL'S LAW

Refraction: Bending of light at interface.

Snell's Law: $n_1 \sin(i) = n_2 \sin(r)$

Refractive Index (n): $n = \frac{c}{v}$

$$n_{21} = \frac{n_2}{n_1} = \frac{v_1}{v_2}$$

TIR & PRISMS

Total Internal Reflection (TIR):

Light from dense to rare, $i > i_c$.

Critical Angle (i_c): $\sin(i_c) = \frac{1}{n}$

Optical Fibers: Based on TIR.

Prism: Deviation (δ). $A + \delta = i + e$.

Min Deviation (δ_m): $n = \frac{\sin\left(\frac{(A+\delta_m)}{2}\right)}{\sin\left(\frac{A}{2}\right)}$

REFRACTION AT SPHERICAL SURFACES

Formula: $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$

LENSES & INSTRUMENTS

Thin Lens Formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Lens Maker's Formula: $\frac{1}{f} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

Magnification (m): $m = \frac{v}{u}$

Power of Lens (P): $P = \frac{1}{f}$ (in m).

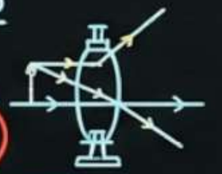
Unit: Dioptre (D).

Combination in Contact: $P_{eq} = P_1 + P_2 + \ldots$

OPTICAL INSTRUMENTS

Compound Microscope:

$m = m_o \times m_e \approx \left(\frac{L}{f_o}\right)\left(\frac{D}{f_e}\right)$



Astronomical Telescope (Refracting):

$m = \frac{f_o}{f_e}$ (normal adjustment)

Reflecting Telescope (Newtonian/Cassegrain):
Uses mirrors, no chromatic aberration.

'WAVE OPTICS'

WAVEFRONTS & HUYGEN'S PRINCIPLE

Wavefront: Locus of all points vibrating in the same phase.

Huygen's Principle: Each point on a wavefront acts as a source of secondary wavelets, spreading out in all directions.
New wavefront is the tangential surface to these secondary wavelets.

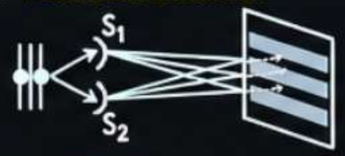
Reflection & Refraction: Can be explained using Huygen's construction.

Laws of Reflection (i=r) & Refraction (Snell's Law) are proved using this principle.

INTERFERENCE & YDSE

Interference: Phenomenon of superposition of waves, resulting in redistribution of energy.

Conditions for Sustained Interference: Sources must be Coherent (constant phase difference) & Monochromatic.



Young's Double Slit Experiment (YDSE):

- Path Difference (Δx): $\Delta x = d\sin\theta \approx \frac{dy}{D}$
- Constructive Interference (Bright Fringe):
  $\Delta x = n\lambda \quad (n=0, 1, 2...)$
- Destructive Interference (Dark Fringe):
  $\Delta x = (n+\frac{1}{2})\lambda \quad (n=0, 1, 2...)$

Fringe Width (β): Separation between consecutive bright or dark fringes.

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

DIFFRACTION (SINGLE SLIT)

Diffraction: Bending of light around corners of obstacles or apertures.

Single Slit Diffraction Pattern: Central maximum is broadest & brightest.

- Condition for Minima (Dark):
  $a\sin\theta = n\lambda \quad (n=1, 2, 3...)$
- Condition for Secondary Maxima (Bright):
  $a\sin\theta = (n+\frac{1}{2})\lambda \quad (n=1, 2, 3...)$

Width of Central Maxima: Angular width $2\theta \approx \frac{2\lambda}{a}$.

Linear width $\approx \frac{2\lambda D}{a}$

'DUAL NATURE OF RADIATION & MATTER'

DUAL NATURE & PHOTOELECTRIC

Dual Nature: Radiation exhibits both wave & particle aspects.

Photoelectric Effect: Emission of electrons from a metal surface when light of suitable frequency strikes it.

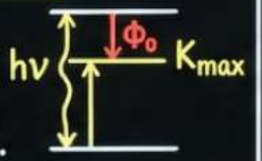
Hertz & Lenard's Observations:
Ejected electrons depend on frequency, not just intensity.

EINSTEIN'S EQUATION & EXPERIMENT

Particle Nature of Light: Light consists of discrete packets called Photons, Energy $E = h\nu$.

Einstein's Photoelectric Equation:

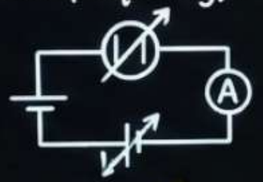
$$K_{max} = h\nu - \Phi_0$$



Where $K_{max} = \frac{1}{2}mv_{max}^2 = eV_0$
(V_0 is stopping potential).

$\Phi_0 = h\nu_0$ (Work Function, ν_0 is threshold frequency).

Experimental Study:



Graphs:

Current vs Intensity (at const ν, V): Linear.

Current vs Potential (V) (for different I, ν): Shows saturation current & stopping potential V_0.

V_0 vs ν: Straight line with slope h/e.

MATTER WAVES (DE-BROGLIE)

Matter Waves: Particles like electrons also exhibit wave-like properties.

Wave Nature of Particles.

De-Broglie Relation:

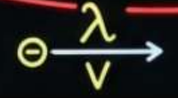
Wavelength $\lambda = \frac{h}{p} = \frac{h}{mv}$

For a particle with KE K:

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

For an electron accelerated by potential V ($K = eV$):

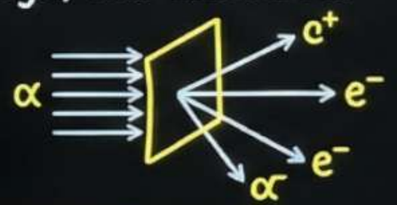
$$\lambda_e = \frac{h}{\sqrt{2meV}} \approx \frac{1.227}{\sqrt{V}} \text{ nm}$$



'ATOMS'

ALPHA SCATTERING & RUTHERFORD'S MODEL

Alpha-particle scattering experiment: Gold foil, Most passed through, few deflected.



Rutherford's Model: Nuclear model. Tiny, massive +ve nucleus, electrons orbit like planets.

Drawback: Unstable (classical physics predicts energy loss & collapse).

BOHR MODEL OF HYDROGEN

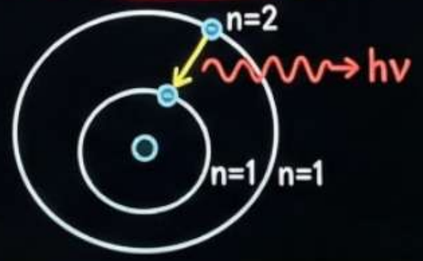
Bohr's Postulates (for H-atom):

1. Angular Momentum is quantized.

$$L = mvr = n\left(\frac{h}{2\pi}\right)$$

2. Electrons orbit in stable, non-radiating 'stationary' orbits.
3. Energy is absorbed/emitted only during transitions.

$$\Delta E = E_2 - E_1 = h\nu$$



ORBITAL PARAMETERS & SPECTRA

Radius of nth orbit (r_n): $r_n \propto n^2$

$$r_n = \frac{n^2h^2\varepsilon_0}{\pi me^2} = n^2a_0$$ ($a_0 \approx 0.529$ Å, Bohr radius).

Velocity in nth orbit (v_n): $v_n \propto \frac{1}{n}$

$$v_n = \frac{e^2}{2nh\varepsilon_0} = \frac{v_1}{n}$$

Total Energy (E_n): $E_n \propto -\frac{1}{n^2}$

$$E_n = -\frac{me^4}{8n^2h^2\varepsilon_0^2} = -\frac{13.6\ \text{eV}}{n^2}$$

Note: $U_n = -2K_n$, $E_n = -K_n$

Hydrogen Line Spectra (Qualitative):
Discrete lines due to transitions.

Rydberg Formula:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$R \approx 1.097 \times 10^7\ m^{-1}$

'NUCLEI'

COMPOSITION & SIZE, NUCLEAR FORCE

Nucleus: Center of atom, contains **Protons** (p, +ve) & **Neutrons** (n, neutral).

Nuclide Representation: $^{A}(X)_{Z}$

(A=Mass No., Z=Atomic No., N=A-Z).

Nuclear Size (Radius R):

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

$R_0 \approx 1.2$ fm (1 fm $= 10^{-15}$ m)

Nuclear Force: Strong, short-range, charge-independent force holding nucleons together.

MASS-ENERGY & BINDING ENERGY

Mass-Energy Relation (Einstein):

$$E = mc^2$$

1 amu ≈ 931.5 MeV

Mass Defect (Δm): Difference between mass of nucleons and nucleus.

$$\Delta m = [Zm_p + (A-Z)m_n] - M_{nucleus}$$

Binding Energy (BE): Energy released when nucleus is formed (or needed to separate).

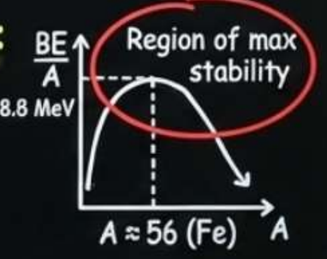
$$BE = \Delta m \times c^2$$

BE = Δm (in amu) × 931.5 MeV

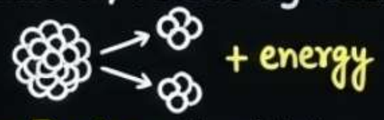
BE/NUCLEON, FISSION & FUSION

Binding Energy per Nucleon (BE/A): Measure of stability.

Variation with A: Sketch of BE/A vs A curve.



Nuclear Fission: Splitting of a heavy nucleus into lighter, more stable nuclei, releasing energy.



Nuclear Fusion: Combining of light nuclei to form a heavier, more stable nucleus, releasing energy.

'SEMICONDUCTOR ELECTRONICS'

ENERGY BANDS & TYPES

Energy Bands (Qualitative): Conduction Band (CB), Valence Band (VB), Energy Gap (E_g).

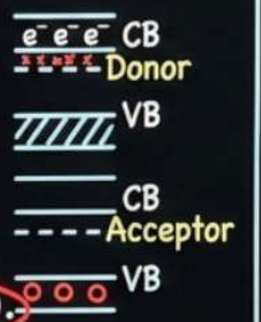
Conductors (Overlap):	Insulators (Large E_g):	Semiconductors (Small E_g):
$E_g \approx 0$	$E_g > 3$ eV	$E_g \sim 1$ eV

Intrinsic (Pure): $n_e = n_h = n_i$

Extrinsic (Doped): Adding impurities.

n-type (Pentavalent):
Donor impurity
Majority e^-.

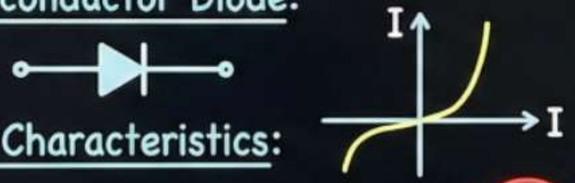
p-type (Trivalent):
Acceptor impurity
Majority holes (h^+).



P-N JUNCTION & DIODE I-V

p-n Junction: p and n regions joined. Forms Depletion Region & Barrier Potential (V_b).

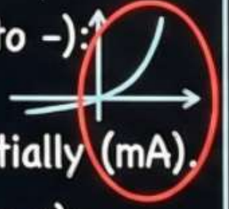
Semiconductor Diode:



I-V Characteristics:

Forward Bias (p to +, n to −):
$V > V_b$
I increases exponentially (mA).

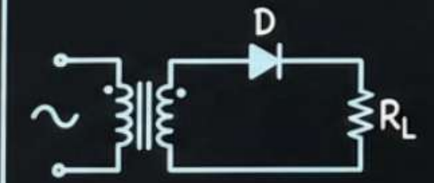
Reverse Bias (p to −, n to +):
$V < 0$
Small saturation current (μA) until Breakdown.

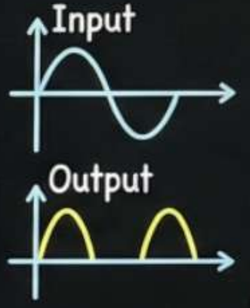


DIODE AS RECTIFIER (AC to DC)

Rectifier: Converts AC to pulsing DC.

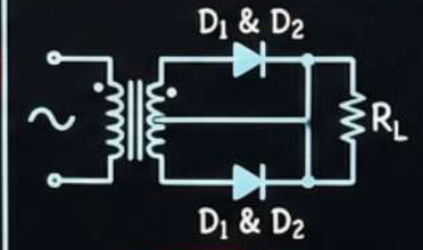
Half-Wave Rectifier:

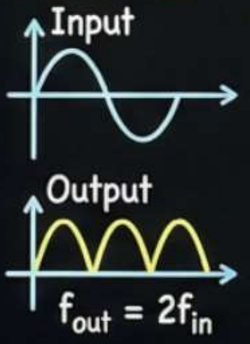




$$V_{dc} = \frac{V_m}{\pi}$$

Full-Wave Rectifier (Center-Tap):





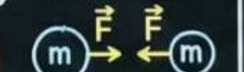
$$V_{dc} = \frac{2V_m}{\pi}$$

'ALL PHYSICS CONSTANTS (CLASS 11, 12, NEET)'

FUNDAMENTAL & MECHANICS

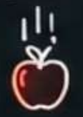
Gravitational Constant (G): [cite: 4, 5]

$G = 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$



Acceleration due to gravity (g): [cite: 4, 5]

$g \approx 9.8\ m/s^2$ (or $10\ m/s^2$)



Speed of Light in vacuum (c): [cite: 4, 5]

$c = 3 \times 10^8\ m/s$

Thermodynamics & Gases: [cite: 2, 3, 4, 5, 10, 15]

Universal Gas Constant (R): $R = 8.314 \frac{J}{mol \cdot K}$

Boltzmann Constant (k_B): $k_B = 1.38 \times 10^{-23} \frac{J}{K}$

Avogadro's Number (N_A):

$N_A = 6.022 \times 10^{23}\ mol^{-1}$

ELECTRICITY & MAGNETISM

Electromagnetic: [cite: 4, 5, 18, 19, 20, 21]

Coulomb's Constant (k):

$k = 9 \times 10^9 \frac{N \cdot m^2}{C^2}$

Permittivity of free space (ε_0):

$\varepsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{N \cdot m^2}$

Permeability of free space (μ_0):

$\mu_0 = 4\pi \times 10^{-7} \frac{T \cdot m}{A}$

Elementary Charge (e):

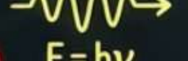
$e = 1.6 \times 10^{-19}\ C$

ATOMIC, QUANTUM & OTHERS

Atomic & Quantum: [cite: 4, 5]

Planck's Constant (h):

$h = 6.63 \times 10^{-34}\ J \cdot s$



Reduced Planck's Const ($\hbar$):

$\hbar = \frac{h}{2\pi} \approx 1.05 \times 10^{-34}\ J \cdot s$

Electron Mass (m_e): $m_e = 9.11 \times 10^{-31}\ kg$

Proton Mass (m_p): $m_p = 1.67 \times 10^{-27}\ kg$

Rydberg Constant (R):

$R = 1.097 \times 10^7\ m^{-1}$

Other Useful Values:

Standard Atm Pressure: $1\ atm = 1.013 \times 10^5\ Pa$

Electron Volt: $1\ eV = 1.6 \times 10^{-19}\ J$