



JEE & Engineering | JEE Main

December 23, 2025

Most Important Physics Formulas For JEE Main

Units And Measurements (High-Scoring Chapter)

- Percentage error: $\% \text{ Error} = \frac{\Delta x}{x} \times 100$
- Absolute error: $\Delta x = |x_{\text{measured}} - x_{\text{true}}|$
- Mean Absolute Error: $\Delta x_{\text{mean}} = \frac{\Delta x_1 + \Delta x_2 + \dots + \Delta x_n}{n}$
- Propagation of Error (Sum / Difference): $\Delta Z = \Delta A + \Delta B$ for $Z = A \pm B$
- Propagation of Error (Product / Division):

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Use: Most repeated error formula in JEE Main.

$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

$$\text{for } Z = AB \text{ or } \frac{A}{B}$$

- Propagation of Error – Power: Used in density, energy, resistance, etc.

$$\frac{\Delta Z}{Z} = n \frac{\Delta A}{A}$$

$$\text{for } Z = A^n$$

- Dimensional Formula of a Physical Quantity: The formula is used to check the correct

$$[Q] = M^a L^b T^c$$



Dimensional Consistency Condition : Dimensions of LHS = Dimensions of RHS

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$$\text{Density : } \rho = \frac{m}{V}$$

- Least Count : $\text{Least Count} = \frac{\text{Smallest division on scale}}{\text{Total number of divisions}}$

Note: Direct questions from Vernier & screw gauge basics.

- Order of Magnitude: Order of magnitude = nearest power of 10
- SI Base Units (Must Memorise)

Quantity	Unit
Length	Metre (m)
Mass	Kilogram (kg)
Time	Second (s)
Current	Ampere (A)
Temperature	Kelvin (K)
Amount of substance	Mole (mol)
Luminous intensity	Candela (cd)

Kinematics

[Skip to main content](#) (n):

1. Average velocity: $v_{\text{avg}} = \frac{\text{Total displacement}}{\text{Total time}}$

2. Acceleration: $a = \frac{v-u}{t}$

3. First equation of motion: $v = u + at$

4. Second equation of motion: $s = ut + \frac{1}{2}at^2$

5. Third equation of motion: $v^2 = u^2 + 2as$

6.

$$\text{Distance in } n^{\text{th}} \text{ second: } s_n = u + \frac{a}{2}(2n-1)$$

- Relative motion:



$$\text{Relative velocity: } \vec{v}_{A/B} = \vec{v}_A - \vec{v}_B$$

- Projectile motion:

1. Time of flight: $T = \frac{2u \sin \theta}{g}$

2. Maximum height: $H = \frac{u^2 \sin^2 \theta}{2g}$

3. Horizontal range: $R = \frac{u^2 \sin 2\theta}{g}$

4. Trajectory equation: $y = x \tan \theta - \frac{gx^2}{2u^2 \cos^2 \theta}$

- Circular motion:

1. Centripetal acceleration: $a_c = \frac{v^2}{r} = \omega^2 r$

2. Centripetal force: $F_c = \frac{mv^2}{r}$

3. Angular velocity relation: $v = \omega r$

4. Time period in circular motion: $T = \frac{2\pi r}{v} = \frac{2\pi}{\omega}$

- Graph-based kinematics:

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Displacement from $v-t$ graph: Displacement = Area under $v-t$ graph

2. Velocity from $s-t$ graph: $v = \frac{ds}{dt}$

3. Acceleration from $v-t$ graph: $a = \frac{dv}{dt}$

Laws Of Motion

- Newton's law and momentum

1. Linear momentum: $p = mv$ 

Use: Collision, impulse & force-based questions.

2. Newton's second law : $F = \frac{dp}{dt} = ma$

• Impulse

1.
$$J = F\Delta t = \Delta p$$

2. Law of conservation of momentum: $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

Use: 1D collision PYQs (most repeated).

• Friction

1. Limiting friction : $f_{\max} = \mu_s N$

2. Kinetic friction: $f_k = \mu_k N$

3. Angle of friction : $\mu = \tan \theta$

4. Force on inclined plane : $mg \sin \theta$

$$N = mg \cos \theta$$

• Equilibrium of forces

1. Condition of translational equilibrium:

$$\sum F_x = 0$$

$$\sum F_y = 0$$

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Specific application of NLM)

1. Centripetal force : $F = \frac{mv^2}{r}$

2. Banking without friction : $\tan \theta = \frac{v^2}{rg}$

3. Maximum speed on level road : $v_{\max} = \sqrt{\mu rg}$

• Tension in string systems

1. Atwood machine acceleration : $a = \frac{(m_1 - m_2)g}{m_1 + m_2}$



Use: Two-mass pulley system.

2. Tension in Atwood's acceleration : $T = \frac{2m_1m_2}{m_1 + m_2}g$

Use: Repeated pulley numbers.

Work, Energy, And Power

- Work

1. **Work by constant force:** Used when force and displacement are constant and straight-line motion is given.

$$W = Fs \cos \theta$$

2. **Work by variable force:** Used in spring force, non-uniform force, and graph-based questions.

$$W = \int \vec{F} \cdot d\vec{r}$$

- Energy

1. **Kinetic energy (KE):** Energy due to motion; directly used in work-energy theorem.

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

2. **Gravitational potential energy:** Used in vertical motion and conservation of energy problems.

$$U = mgh$$

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3. **Spring potential energy:** Used for compressed or stretched springs in energy conservation.

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

- Work, Energy, Theorem and Conservation

1. **Work, energy theorem:** Net work equals change in kinetic energy; avoids force calculation.

$$W_{\text{net}} = \Delta K$$

2. **Mechanical energy conservation:** Used when only conservative forces are present (gravity + spring).

$$K + U = \text{constant}$$

- Power



$$\text{Average power: } P_{\text{avg}} = \frac{W}{t}$$

2. Instantaneous power : $P = \vec{F} \cdot \vec{v}$

- Collisions (high-weightage)

1. **Coefficient of restitution:** Measures elasticity of collision; used directly in 1D collision questions

$$e = \frac{v_2 - v_1}{u_1 - u_2}$$

2. **Momentum conservation in collision:** Always used with the concept of restitution in collision problems.

$$m_1 u_1 + m_2 u_2 = m_1 v_1 + m_2 v_2$$

3. **Loss of kinetic energy in an inelastic collision:** Used to directly calculate energy loss after impact.

$$\Delta K = \frac{1}{2} \frac{m_1 m_2}{m_1 + m_2} (u_1 - u_2)^2$$

- Motion in a vertical circle

1. Critical minimum speed at top: Minimum speed needed to maintain circular motion at the highest point.

$$v_{\text{top}} = \sqrt{gr}$$

2. Minimum speed at bottom:

$$v_{\text{bottom}} = \sqrt{5gr}$$

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Rotational Motion

- Torque and angular momentum

1. Torque – Rotational effect of a force about a fixed axis; used in equilibrium and rotation start problems.

$$\tau = rF \sin \theta$$

2. Angular momentum of a particle- Measure of rotational motion of a particle about a point.

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

3. Angular momentum of a rigid body – Used when a body rotates about a fixed axis.



$$L = I\omega$$

4. Conservation of angular momentum – Applied when no external torque acts on the system.

$$I_1\omega_1 = I_2\omega_2$$

- Moment of inertia (MOI)

1. General expression for moment of inertia – Used to calculate the moment of inertia of a system of particles.

$$I = \sum mr^2$$

2. Radius of gyration – Represents how mass is distributed from the axis.

$$I = Mk^2$$

3. Parallel axis theorem – Used when the axis is shifted parallel to the centre of mass axis.

$$I = I_{cm} + Md^2$$

4. Perpendicular axis theorem – Used only for planar lamina (disc, ring, plate).

$$I_z = I_x + I_y$$

- Rotational dynamics

1. Torque angular acceleration relation – Rotational form of Newton's second law.

$$\tau = I\alpha$$

2. Rotational kinetic energy – Energy possessed by a rotating body.

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$$K = \frac{1}{2}I\omega^2$$

3. Work done in rotation – Rate of doing rotational work.

$$W = \tau\theta$$

- Rotational kinematics

1. Angular velocity relation – Connects linear and angular speed.

$$v = \omega r$$

2. Angular acceleration relation – Used to find tangential acceleration.

$$a_t = \alpha r$$

3. Centripetal acceleration in rotation – Radial acceleration in circular motion.



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

4. First equation of rotational motion – Angular velocity after time t.

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

5. Second equation of rotational motion – Angular displacement after time t.

$$\theta = \omega_0 t + \frac{1}{2} \alpha t^2$$

6. Third equation of rotational motion – Eliminates time in angular motion problems.

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

- Rolling motion

1. Condition for pure rolling – Used when no slipping occurs.

2. Acceleration of a rolling body on an inclined plane

- Standard moments of inertia

1. **Ring** – Used in rolling and energy comparison problems.

$$I = MR^2$$

2. **Solid disc** – Frequently used in rolling and torque problems.

$$I = \frac{1}{2} MR^2$$

3. **Rod about Centre** – Used in oscillation and torque questions.

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$$I = \frac{1}{12} ML^2$$

4. **Rod about end** – Used with the parallel axis theorem.

$$I = \frac{1}{3} ML^2$$

5. **Solid sphere** – Common in rolling motion numerals.

$$I = \frac{2}{5} MR^2$$

6. **Hollow sphere** – Used in comparison of rolling accelerations.

$$I = \frac{2}{5}MR^2$$



- **Newton's law of gravitation:** Used to calculate the attractive force between two masses

$$F = G \frac{m_1 m_2}{r^2}$$

- **Gravitational field intensity** – Field strength due to a mass:

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

- **Gravitational potential** – Potential due to a point mass:

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

- **Relation Between g and Potential:** Shows that g is the gradient of potential

$$g = - \frac{dV}{dr}$$

- **Gravitational Potential Energy:** Energy stored due to gravitational interaction

$$U = - \frac{GMm}{r}$$

- **Escape Velocity:** Minimum speed needed to leave Earth

$$v_e = \sqrt{\frac{2GM}{R}}$$

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- **Orbital velocity of satellite:** Speed of satellite in a stable orbit

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

- **Time period of satellite:** Satellite's revolution time around Earth

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

- **Kepler's Third Law:** Relation between time period and orbit radius

$$T^2 \propto r^3$$

- **Acceleration Due to Gravity on Earth's Surface:** g from Earth's mass



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

- **Variation of g with height:** g decreases above the surface

$$g_h = g \left(1 - \frac{2h}{R} \right)$$

- **Variation of g with Depth:**

$$g_d = g \left(1 - \frac{d}{R} \right)$$

- **Variation of g with latitude:** Due to Earth's rotation

$$g_\phi = g - \omega^2 R \cos^2 \phi$$

- **Total Energy of Satellite:** constant negative energy in orbit

$$E = - \frac{GMm}{2r}$$

- **Binding Energy of Satellite:** Energy needed to free the satellite

$$E_b = \frac{GMm}{2r}$$

- **Gravitational Self-Energy of a Solid Sphere:** Gravitational energy of a uniform sphere

$$U = - \frac{3GM^2}{5R}$$

P [Skip to main content](#) Solids And Liquids

- **Stress:** Stress measures force acting per unit area; used in elasticity and breaking-stress problems.

$$\text{Stress} = \frac{F}{A}$$

- **Strain:** Ratio of change in length to original length; dimensionless and used in Hooke's law.

$$\text{Strain} = \frac{\Delta L}{L}$$

- **Hooke's law:** Defines the elastic behaviour of solids and introduces Young's modulus.

$$\text{Stress} = Y \times \text{Strain}$$

- **Young's modulus (Y):** Used for elongation of wires under load.



$$Y = \frac{FL}{A\Delta L}$$

- **Bulk modulus (K):** Shows resistance to volume change under pressure; used in fluid compression problems.

$$K = -\frac{\Delta P}{\Delta V/V}$$

- **Modulus of Rigidity (η):** Used in twisting problems involving rods and shafts.

$$\eta = \frac{\text{Shear Stress}}{\text{Shear Strain}}$$

- **Relation Between Elastic Constants:** Used to convert between Young's modulus, rigidity modulus, and Poisson's ratio.

$$Y = 2\eta(1 + \sigma)$$

$$K = \frac{Y}{3(1 - 2\sigma)}$$

- **Poisson's Ratio (σ):** Used when solids contract/expand in perpendicular directions.

$$\sigma = -\frac{\text{Lateral Strain}}{\text{Longitudinal Strain}}$$

- **Hydraulic Press:** Pascal's principle—used in pressure-multiplication question.

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

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- **Pressure in a Liquid:** Calculates fluid pressure at a depth; one of the most used formulas in liquid mechanics.

$$P = h\rho g$$

- **Buoyant Force (Archimedes' Principle):** Provides upward force on submerged objects—used in floatation problems.

$$F_B = \rho gV$$

- **Condition for Floating:** Basic rule for floatation, often combined with Archimedes' theorem.

$$\rho_{\text{object}} < \rho_{\text{fluid}}$$

- **Equation of Continuity:** States that volume flow rate is constant; used in fluid flow and pipe problems.



$$A_1 v_1 = A_2 v_2$$

- **Bernoulli's Equation:** Relates pressure, speed, and height of flowing fluid—common in venturi meter and lift questions.

$$P + \frac{1}{2}\rho v^2 + \rho gh = \text{constant}$$

- **Surface Tension:** Force per unit length acting along a liquid surface; used in capillarity & bubble films.

$$T = \frac{F}{2L}$$

- **Excess Pressure Inside a Liquid Drop / Bubble:** Used to compare pressures inside droplets, bubbles, and cavities.

For liquid drop: (a)

$$\Delta P = \frac{2T}{r}$$

For soap bubble: (b)

$$\Delta P = \frac{4T}{r}$$

- **Capillary Rise / Fall:** Determines the height of liquid rise/fall in a narrow tube.

$$h = \frac{2T \cos \theta}{r \rho g}$$

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Law): Used in terminal velocity and viscous drag problems.

$$F = 6\pi\eta r v$$

- **Terminal Velocity:** The speed at which net force on a falling particle becomes zero.

$$v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$$

- **Reynold's Number:** Determines laminar vs turbulent flow—important for flow-type questions.

$$Re = \frac{\rho v D}{\eta}$$

Thermodynamics



$$T_A = T_B = T_C$$

- **First Law of Thermodynamics:** Relation between heat, work, and internal energy

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

- **Work Done in Expansion/Compression:** Mechanical work by the gas.

$$W = \int P dV$$

- **Work Done at Constant Pressure (Isobaric):**

$$W = P\Delta V$$

- **Work Done in Isothermal Process (PV = constant):**

$$W = nRT \ln\left(\frac{V_2}{V_1}\right)$$

- **Work done in an adiabatic process (no heat exchange):**

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

- **Adiabatic Condition – Key relation for adiabatic changes:**

$$PV^\gamma = \text{constant}$$

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- **Ideal gas – depends only on temperature:**

$$U = \frac{f}{2}nRT$$

- **Molar heat capacities:**

At constant volume –

$$C_V = \left(\frac{\partial Q}{\partial T}\right)_V$$

At constant pressure –

$$C_P = \left(\frac{\partial Q}{\partial T} \right)_P$$



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Maxwell's Relation - Connects Cp and Cv:

$$C_P - C_V = R$$

- **Ratio of Heat Capacities (Gamma) – Used in adiabatic equations:**

$$\gamma = \frac{C_P}{C_V}$$

- **Heat Transfer (General Formula):**

$$Q = mc\Delta T$$

- **Latent Heat – Heat absorbed during phase change:**

$$Q = mL$$

- **Ideal Gas Equation – Base equation for all thermodynamic processes:**

$$PV = nRT$$

- **Second Law of Thermodynamics – Direction of heat flow:**

$$\Delta S \geq 0$$

- **Entropy change for isothermal process:**

$$\Delta S = nR \ln \left(\frac{V_2}{V_1} \right)$$

- **Efficiency of Heat Engine – Maximum usable work:**

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$$\eta = \frac{W}{Q_H}$$

- **Carnot Engine Efficiency – Maximum possible efficiency:**

$$\eta = 1 - \frac{T_C}{T_H}$$

- **Refrigeration Coefficient of Performance (COP):**

$$\text{COP} = \frac{Q_C}{W}$$

- **RMS Speed of Gas Molecules – Used in kinetic theory concepts:**

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



- **Pressure of an Ideal Gas (Kinetic Interpretation):** Relates gas pressure to molecular motion — foundation of KTG.

$$P = \frac{1}{3} m n \overline{c^2}$$

- **Mean Kinetic Energy per Molecule:** Shows that average kinetic energy depends ONLY on temperature.

$$\overline{E_k} = \frac{3}{2} k_B T$$

- **Total Internal Energy of an Ideal Gas:** Internal energy depends on temperature and degrees of freedom.

$$U = \frac{f}{2} n R T$$

- **RMS Speed of Gas Molecules:** Most used formula in KTG numericals.

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

- **Average Speed of Gas Molecules:** Used rarely, but it is conceptually important.

$$v_{avg} = \sqrt{\frac{8RT}{\pi M}}$$

- **Most Probable Speed:** Speed at which the maximum number of molecules exist.

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$$v_{mp} = \sqrt{\frac{2RT}{M}}$$

- **Relation Between Speeds:**

$$v_{mp} < v_{avg} < v_{rms}$$

- **Pressure–Volume–Temperature (Ideal Gas Equation):** The backbone of all kinetic theory applications.

$$PV = nRT$$

- **Mean Free Path:** Average distance travelled between collisions.

$$\lambda = \frac{1}{\sqrt{2\pi d} \cdot n}$$



MATRIX

Degrees of Freedom for Common Gases: Needed for internal energy, gamma, and kinetic relations.

$$f = \begin{cases} 3 & \text{(monoatomic)} \\ 5 & \text{(diatomic)} \\ 6 & \text{(polyatomic)} \end{cases}$$

- **Gamma (Ratio of Heat Capacities):** Important in adiabatic & KTG problems.

$$\gamma = \frac{C_P}{C_V}$$

- **Law of Equipartition of Energy:** Energy is equally distributed among degrees of freedom.

$$E = \frac{f}{2} k_B T$$

- **Root Mean Square Force Relation:** Relates macroscopic pressure to microscopic collisions.

$$P = \frac{2}{3} n \overline{E_k}$$

- **Pressure Due to 'N' Molecules in Volume V:**

$$P = \frac{1}{3} \frac{N m \overline{c^2}}{V}$$

- **Energy of n Moles (Derived from molecular KE):** Appears in combined KTG + thermodynamics problems

$$U = \frac{3}{2} n R T$$

Sound Waves

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SIMPLE HARMONIC MOTION (SHM)

- **Condition of simple harmonic motion:** Restoring force is directly proportional to displacement.

$$F = -kx$$

- **Time Period of Spring–Mass System – Most used SHM formula:** Gives the oscillation time of a mass attached to a spring.

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

- **Time Period of Simple Pendulum:** Shows that the oscillation time depends mainly on length.



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

- **Angular Frequency** – Used to convert between time and displacement formulas

$$\omega = \sqrt{\frac{k}{m}}$$

- **Displacement Equation of SHM** – Base equation for position at time t:

$$x(t) = A \cos(\omega t + \phi)$$

- **Velocity in SHM** – Used where speed varies during oscillation; Maximum at the mean, zero at the extremes.

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

- **Acceleration in SHM** – Defines the restoring nature of SHM: Acceleration increases with displacement.

$$a = -\omega^2 x$$

- **Total Energy of SHM** – Always constant, used in energy method problems; Energy depends only on amplitude.

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

- **Energy Distribution:** Potential and kinetic energy are split during motion.

$$U = \frac{1}{2}kx^2, \quad K = \frac{1}{2}k(A^2 - x^2)$$

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DA TIONS

- **Damped Oscillation Equation:** Amplitude decreases exponentially over time; Used to identify the decay of amplitude.

$$A(t) = A_0 e^{-\beta t}$$

- **Resonance Condition:** Crucial for wave & sound resonance questions; Amplitude is maximum when driving frequency matches natural frequency.

$$\omega = \omega_0$$

WAVES (MECHANICAL WAVES)

• Wave Speed: Most important wave formula; Speed depends on medium properties



$$v = f\lambda$$

- **Speed of Wave on a String:** Shows tension and mass density control wave speed.

$$v = \sqrt{\frac{T}{\mu}}$$

- **Displacement of a Wave:** Used for writing wave function; represents a travelling wave moving in the +x direction.

$$y(x, t) = A \sin(kx - \omega t)$$

- **Wave Number:** Defines the spatial periodicity of a wave.

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

- **Angular Frequency of Wave:** Links time periodicity to motion; Appears in wave functions and energy formulas.

$$\omega = 2\pi f$$

- **Intensity of Wave:** Used in sound level & power questions; Proportional to the square of amplitude.

$$I \propto A^2$$

SOUND WAVES

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Depends on temperature only (for air).

$$v = \sqrt{\gamma \frac{P}{\rho}}$$

- **Beats Frequency:** Difference of two close frequencies produces beats.

$$f_{beats} = |f_1 - f_2|$$

- **Doppler Effect General Formula:** Explains frequency change due to relative motion.

$$f' = f \left(\frac{v \pm v_o}{v \mp v_s} \right)$$

STANDING WAVES (STRING & AIR COLUMNS)



MATRIX

• **String Fundamental Frequency:** Lowest frequency of vibration of a stretched string.

$$f_1 = \frac{v}{2L}$$

- **Closed Pipe Fundamental:** Used in organ pipes and resonance tubes; Closed pipes produce only odd harmonics.

$$f_1 = \frac{v}{4L}$$

- **Open Pipe Fundamental:** Used in resonance and tuning fork questions.

$$f_1 = \frac{v}{2L}$$

- **Harmonics for String/Open Pipe:** General harmonic formula.

$$f_n = n f_1$$

- **Harmonics for Closed Pipe:**

$$f_n = (2n - 1) f_1$$

Electrostatics

- **Coulomb's Law:** Fundamental force between point charges. The electrostatic force between two point charges is directly proportional to the product of charges and inversely proportional to the square of the distance between them

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

- **Electric Field due to Point Charge:** Relates force and test charge. Electric field at a point is the force experienced by a unit positive charge placed at that point.

$$E = \frac{F}{q} = k \frac{Q}{r^2}$$

- **Electric Field due to Continuous Charge Distribution:** Used to calculate the E-field for line, surface, or volume charge distributions using integration.

$$E = \frac{1}{4\pi\epsilon_0} \int \frac{dq}{r^2} \hat{r}$$

- **Electric Potential (Voltage):** Work done per unit charge. Potential is the energy per unit charge required to bring a charge from infinity to a point in the field.



$$V = k \frac{Q}{r}$$

- **Relation between Electric Field and Potential:** Shows that the electric field is the negative gradient of potential; connects two core concepts.

$$\vec{E} = -\nabla V$$

- **Potential Energy of a System of Point Charges:** Useful in energy-based questions and equilibrium problems.

$$U = k \frac{q_1 q_2}{r}$$

- **Work Done in Moving a Charge in an Electric Field:** Essential for understanding energy changes in moving charges.

$$W = q\Delta V$$

- **Capacitance of a Capacitor:** Stores charge per unit voltage – Defines how much charge a capacitor can hold for a given potential difference.

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

- **Capacitance of a Parallel Plate Capacitor:** Most common type in problems; depends on area, distance, and dielectric.

$$C = \frac{\epsilon_0 A}{d}$$

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Capacitor: Useful for numerical and derivations – Shows energy is stored in the electric field between plates.

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

- **Electric Flux:** Measures field lines passing through a surface – Important for Gauss's law applications.

$$\Phi_E = \vec{E} \cdot \vec{A}$$

- **Gauss's Law:** Relates flux to enclosed charge – Extremely useful for symmetry-based E-field calculations.

$$\oint \vec{E} \cdot d\vec{A} = \frac{q_{enc}}{\epsilon_0}$$

- **Relation between Surface Charge Density and E-Field:** Used for plane sheets and conducting surfaces.



$$E = \frac{\sigma}{2\epsilon_0} \quad (\text{for infinite sheet})$$

- **Polarisation and Dielectric Effect on Capacitance:** Dielectrics reduce the effective field and increase capacitance by a factor K.

$$C = KC_0$$

- **Series and Parallel Combination of Capacitors:** Required for circuit-based questions; Series decreases total capacitance; parallel increases it.

$$\text{Series: } \frac{1}{C_{eq}} = \sum \frac{1}{C_i},$$

$$\text{Parallel: } C_{eq} = \sum C_i$$

- **Electric Field on Axis of Ring/Disc:** Important for integration-based numericals

$$E = \frac{1}{4\pi\epsilon_0} \frac{Qx}{(x^2 + R^2)^{3/2}}$$

- **Potential on Axis of Ring/Disc:** Energy viewpoint of distributed charge; Gives potential due to a charged ring or disc at any axial point.

$$V = \frac{1}{4\pi\epsilon_0} \frac{Q}{\sqrt{x^2 + R^2}}$$

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Electrostatics: Surface field; The electric field inside a conductor is zero; all excess charge

$$E_{inside} = 0$$

Current Electricity

- **Ohm's Law:** Fundamental relation in circuits. Relates current through a conductor to voltage across it and resistance; it forms the basis of all DC circuit calculations.

$$V = IR$$

- **Resistance of a Conductor:** Connects material, geometry, and resistance; Resistance depends on resistivity, length, and cross-sectional area.



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

- **Resistivity and Conductivity:** Material property of conduction; Resistivity quantifies how strongly a material opposes current; conductivity is its inverse.

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

- **Combination of Resistors:** Series and Parallel; Essential for simplifying circuits and calculating net resistance.

$$\text{Series: } R_{\text{eq}} = \sum R_i, \quad \text{Parallel: } \frac{1}{R_{\text{eq}}} = \sum \frac{1}{R_i}$$

- **Drift Velocity:** Microscopic view of current; Average velocity of charge carriers under an electric field; connects current, charge density, and cross-section.

$$v_d = \frac{I}{nqA}$$

- **Current Density:** Describes current per unit area; Useful in relating electric field and conductivity in a material.

$$J = \sigma E = \frac{I}{A}$$

- **Power in Electrical Circuit:** Rate of energy transfer; Power dissipated or delivered by a resistor or device.

$$P = VI = I^2 R = \frac{V^2}{R}$$

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- **EMF of a Cell:** Source of potential difference; defines the energy supplied per unit charge by a source like a battery.

$$\mathcal{E} = \text{Work done per unit charge}$$

- **Internal Resistance of Cell:** Realistic battery model; Accounts for voltage drop inside the battery when current flows.

$$V = \mathcal{E} - Ir$$

- **Kirchhoff's Laws:** For solving complex circuits; Used to analyse currents and voltages in multi-loop circuits.

$$KCL(\text{Current Law}) : \sum I_{\text{in}} = \sum I_{\text{out}}$$



MATRIX

$$KVL(\text{Voltage Law}) : \sum V_{\text{around loop}} = 0$$

(Joule's Law): Connects energy dissipation and temperature rise; Energy is dissipated as heat when current flows through resistance.

$$H = I^2 R t$$

- **Potential Drop along a Uniform Wire:** Used in voltage divider problems; the voltage drop is proportional to the resistance of that section.

$$V = IR_{\text{section}}$$

- **Wheatstone Bridge Condition:** Used in precise resistance measurements; The bridge is balanced when no current flows through the galvanometer.

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

- **Metre Bridge Formula:** Practical application of Wheatstone Bridge; Used in labs to measure unknown resistances.

$$R_x = \frac{l}{L-l} R_{\text{known}}$$

- **Combination of EMF Cells:** Series and Parallel Connections: Calculates net EMF and internal resistance in multiple batteries.

$$\text{Series: } \mathcal{E}_{\text{eq}} = \sum \mathcal{E}_i, r_{\text{eq}} = \sum r_i$$

Skip to main content

$$\text{Parallel: } \frac{1}{\mathcal{E}_{\text{eq}}} = \sum \frac{1}{\mathcal{E}_i}, r_{\text{eq}} = \frac{1}{\sum 1/r_i}$$

Magnetic Effects Of Current And Magnetism

- **Biot-Savart Law:** Fundamental formula for the magnetic field due to a current element. Calculates the magnetic field at a point due to a small current-carrying element; crucial for wire, loop, and arc problems.

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

- **Magnetic Field on Axis of Circular Loop:** Magnetic field at the centre or along the axis of a current loop.

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



MATRIX

Useful for symmetric current distributions. Relates the magnetic field around a closed loop to the net current passing through it.

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enclosed}}$$

- **Magnetic Field Inside Solenoid:** The magnetic field is uniform inside a long solenoid; key for magnetic flux calculations.

$$B = \mu_0 n I$$

- **Magnetic Field of Toroid:** Common in numerical problems; the magnetic field inside a toroidal coil depends on the number of turns and the current.

$$B = \frac{\mu_0 N I}{2\pi r}$$

- **Force on a Moving Charge in a Magnetic Field:** Core concept in magnetism; Charge experiences a force perpendicular to both velocity and magnetic field.

$$\vec{F} = q\vec{v} \times \vec{B}$$

- **Lorentz Force:** Combined electric and magnetic field force; Used in problems where both fields act simultaneously on a charged particle.

$$\vec{F} = q(\vec{E} + \vec{v} \times \vec{B})$$

- **Force on a Current:** Carrying Conductor in Magnetic Field – Key to motor principle; Conductor experiences force proportional to current, length, and field.

Skip to main content

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

- **Torque on a Current Loop in Uniform Magnetic Field:** Basis of galvanometer and motor; Torque aligns current loop with magnetic field; used in electromechanical devices.

$$\tau = N I A B \sin \theta$$

- **Magnetic Moment of a Current Loop:** Measures the magnetic strength of a loop; Defines how strongly the loop behaves like a tiny magnet.

$$\vec{\mu} = N I A \hat{n}$$

- **Cyclotron Frequency / Radius:** Circular motion of charge in B-field; Important for particle accelerators

and circular motion problems.



$$\text{Radius : } r = \frac{mv}{qB}$$

$$\text{Cyclotron frequency : } f = \frac{qB}{2\pi m}$$

- **Force Between Two Parallel Currents:** Ampere's force law; Gives force per unit length between two long parallel wires.

$$F/L = \frac{\mu_0 I_1 I_2}{2\pi d}$$

- **Magnetic Energy Density:** Energy stored in a magnetic field; Essential for magnetic energy calculations in inductors or field regions.

$$u_B = \frac{B^2}{2\mu_0}$$

- **Hall Effect:** Charge carrier properties and B-field measurement; Useful for determining carrier density, mobility, and polarity of semiconductors.

$$V_H = \frac{IB}{nqt}$$

- **Ampere's Law for Solenoids and Toroids:** Simplified formula for uniform field; Directly gives B for solenoid/toroid using n-turns density.

$$B_{\text{solenoid}} = \mu_0 nI, \quad B_{\text{toroid}} = \frac{\mu_0 NI}{2\pi r}$$

EM Skip to main content c Induction And Alternating Currents

- **Faraday's Law of Electromagnetic Induction:** Core principle of EMI; Induced emf is generated whenever magnetic flux through a coil changes with time; basis of generators, induction coils.

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

- **Magnetic Flux:** Measures how much magnetic field passes through an area; Used in all EMI problems to calculate induced emf due to motion or field change.

$$\Phi_B = BA \cos \theta$$

- **Lenz's Law (Negative Sign):** Determines direction of induced current; Induced emf always opposes the change that produces it—helps decide current direction in loops.



$$\mathcal{E} = -\frac{d\Phi}{dt}$$

- **Motional EMF:** Important for rod sliding problems on rails; Emf is induced in a conductor moving in a magnetic field; very common in JEE.

$$\mathcal{E} = BLv$$

- **Induced Current in a Loop:** Used when resistance is given; Useful for problems involving energy loss or power dissipated in circuits.

$$I = \frac{\mathcal{E}}{R}$$

- **Power Dissipated During Induction:** Energy loss due to induced current; Used in rod-rail problems and flux-changing circuits.

$$P = I^2 R$$

- **Self-Inductance:** Property of a coil to oppose change in its own current; Induced emf in the same coil resists current variation; key concept for inductors.

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

- **Inductance of Solenoid:** Needed for LC, LR circuits; Inductance increases with the number of turns and length.

$$L = \frac{\mu_0 N^2 A}{l}$$

Skip to main content

Inductor: Shows that the magnetic field stores energy in coils.

$$U = \frac{1}{2}LI^2$$

- **Mutual Inductance:** Induction between two coils; Used in transformer principles and coupled circuits.

$$\mathcal{E}_2 = -M\frac{dI_1}{dt}$$

- **AC Voltage & Current:** Base representation; Defines sinusoidal variation of voltage and current—foundation for all AC circuit analysis.

$$v = V_0 \sin \omega t, \quad i = I_0 \sin \omega t$$

- **RMS Values:** Most tested concept in JEE AC chapter; RMS values represent effective or usable values of



$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}, \quad I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

- **Reactance of Inductor** – Opposition of coil to AC; Inductive reactance increases with frequency; key for frequency-based questions.

$$X_L = \omega L$$

- **Reactance of Capacitor:** Opposition of the capacitor to AC; Capacitive reactance decreases with frequency.

$$X_C = \frac{1}{\omega C}$$

- **Impedance of Series RLC Circuit:** Net AC opposition; General formula for total opposition to AC in combined circuits.

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

- **Current in RLC Circuit:** Used in resonance and power factor problems; Peak current depends on impedance.

$$I_0 = \frac{V_0}{Z}$$

- **Resonance Condition:** Most important result of AC; At resonance, inductive and capacitive reactances cancel, and current becomes maximum.

Skip to main content

$$\omega_0 = \frac{1}{\sqrt{LC}}$$

- **Quality Factor (Q-factor):** Measures sharpness of resonance; a higher Q means a sharper resonance peak.

$$Q = \frac{\omega_0 L}{R}$$

- **Average Power in AC:** Used for power factor questions; Shows that only the in-phase component of AC does useful work.

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

- **Power Factor:** Determines efficiency of AC circuits; Defined as cosine of phase angle between voltage and current; crucial in JEE theory questions.



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

- **Transformer Formula:** Induction between two coils; Used for step-up and step-down transformer problems.

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

- **Transformer Efficiency:** Practical transformer questions;

$$\eta = \frac{V_s I_s}{V_p I_p}$$

Electromagnetic Waves

- **Speed of Electromagnetic Waves in Free Space:** Shows that light is an EM wave whose speed depends only on the permittivity and permeability of vacuum.

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$$

- **Wave Relation Between Speed, Frequency, and Wavelength:** Fundamental wave equation used to find wavelength or frequency of any EM wave.

$$c = \lambda \nu$$

- **Maxwell's Displacement Current:** Introduced to maintain continuity of current in varying electric fields; essential in deriving EM waves.

$$I_d = \epsilon_0 \frac{d\Phi_E}{dt}$$

- **Ratio of Electric and Magnetic Field in EM Wave:** Shows that in a propagating EM wave, E-field and B-field have fixed proportionality.

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

- **Instantaneous Electric and Magnetic Fields (Sinusoidal Form):** Represents electric and magnetic fields varying with space and time in an EM wave.

$$E = E_0 \sin(kx - \omega t), \quad B = B_0 \sin(kx - \omega t)$$

- **Wave Number and Angular Frequency:** Used in deriving phase, wavelength, and wave behaviour.



$$k = \frac{2\pi}{\lambda}, \quad \omega = 2\pi\nu$$

- **Intensity of an Electromagnetic Wave:** Measures power delivered per unit area; important in radiation pressure and energy calculations.

$$I = \frac{1}{2} c \epsilon_0 E_0^2$$

- **Poynting Vector:** Direction and rate of EM energy flow; Represents energy transported per unit area per second by an EM wave.

$$\vec{S} = \frac{1}{\mu_0} \vec{E} \times \vec{B}$$

- **Radiation Pressure (Perfect Absorber):** EM waves exert pressure when absorbed; applied in momentum and force questions.

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

- **Radiation Pressure (Perfect Reflector):** Pressure doubles because momentum change is doubled on reflection.

$$P = \frac{2I}{c}$$

- **Energy Density of Electric and Magnetic Fields:** Shows that EM wave energy is shared equally between E-field and B-field.

$$u_E = \frac{1}{2} \epsilon_0 E^2, \quad u_B = \frac{B^2}{2\mu_0}$$

- **Total Energy Density of EM Wave:** Used to relate intensity and amplitude of fields.

$$u = u_E + u_B$$

- **Spectrum Order of EM Waves (Most Asked Theory Question):** From longest wavelength to shortest:

Radio → Microwave → Infrared → Visible → Ultraviolet → X-rays → Gamma rays

- **Frequency Range of Visible Light:** Useful in wavelength-frequency conversion numerically.

$$4 \times 10^{14} \text{ Hz to } 8 \times 10^{14} \text{ Hz}$$

Optics



MATRIX

Light slows down in a medium; used in almost every refraction problem.

$$n = \frac{c}{v}$$

- **Snell's Law of Refraction:** Governs the bending of light at an interface; Relates angles of incidence and refraction between two media.

$$n_1 \sin i = n_2 \sin r$$

- **Absolute Refractive Index in Terms of Angles:** Used when light travels from air to a medium.

$$n = \frac{\sin i}{\sin r}$$

- **Critical Angle:** Condition for total internal reflection (TIR); Beyond this angle, light is completely reflected inside a denser medium.

$$\sin C = \frac{1}{n}$$

- **Apparent Depth:** Optical illusion due to refraction; Explains why objects under water appear raised.

$$\text{Apparent depth} = \frac{\text{Real depth}}{n}$$

- **Refraction at Spherical Surface:** Single surface imaging; Used in lens-maker and mirror derivations.

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

- **Thin Lens Formula:** Central formula of lens problems; Relates object distance, image distance, and focal length.

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

- **Magnification by Lens:** Image size relation; Helps determine the nature and size of the image.

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

- **Lens Maker's Formula:** Design and material property of the lens; Connects focal length with the curvature and refractive index.

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



MATRIX

Power of a Lens: Strength of lens; Used in combination with lenses and eye problems.

$$P = \frac{1}{f} \quad (f \text{ in meters})$$

- **Combination of Lenses:** Multiple lenses in contact; Net power equals the algebraic sum of individual powers.

$$P_{\text{total}} = P_1 + P_2$$

- **Mirror Formula:** Reflection from spherical mirrors; Same mathematical form as the lens formula, but different sign convention.

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

- **Magnification by Mirror:** Image formation property; Determines image nature and orientation.

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

Wave Optics

- **Path Difference in Young's Double Slit Experiment (YDSE):** Core quantity governing constructive and destructive interference.

$$\Delta x = d \sin \theta$$

- **Condition for Constructive Interference (Bright Fringe):** Maxima occur when the path difference is an integral multiple of the wavelength.

$$\Delta = n\lambda$$

- **Condition for Destructive Interference (Dark Fringe):** Minima occur when the path difference is a half-integral multiple of the wavelength.

$$\Delta = (2n + 1) \frac{\lambda}{2}$$

- **Fringe Width:** Most important YDSE numerical formula; Determines spacing between consecutive bright or dark fringes.

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

- **Diffraction Grating Condition:** Principal maxima; Used to find wavelength or angle of diffraction.



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

- **Single Slit Diffraction:** Angular width of central maximum; Explains spreading of light through a narrow aperture.

$$\theta = \frac{\lambda}{a}$$

- **Polarisation:** Malus' Law; Intensity depends on the angle between the incident polarisation and the analyser.

$$I = I_0 \cos^2 \theta$$

- **Brewster's Law:** Complete polarisation by reflection; at the Brewster angle, reflected light is perfectly polarised.

$$\tan \theta_B = n$$

Dual Nature Of Matter And Radiation

- **Energy of Photon:** Defines the energy carried by a single photon of electromagnetic radiation.

$$E = h\nu$$

- **Photon Energy in Terms of Wavelength:** Used to calculate photon energy directly when the wavelength is given.

$$E = \frac{hc}{\lambda}$$

- **Einstein's Photoelectric Equation:** States that the incident photon energy is used to overcome the work function and provide kinetic energy to the emitted electrons.

$$h\nu = h\nu_0 + K_{\max}$$

- **Maximum Kinetic Energy of Photoelectrons:** Gives the highest kinetic energy of emitted electrons for a given frequency.

$$K_{\max} = h(\nu - \nu_0)$$

- **Stopping Potential Relation:** Relates the maximum kinetic energy of photoelectrons to the stopping potential.

$$K_{\max} = eV_0$$

- **Threshold Frequency:** Minimum frequency of incident radiation required to just eject electrons from a



$$\nu_0 = \frac{\phi}{h}$$

- **Threshold Wavelength:** Maximum wavelength of light capable of causing photoelectric emission.

$$\lambda_0 = \frac{hc}{\phi}$$

- **Work Function:** Minimum energy required to remove an electron from the metal surface.

$$\phi = h\nu_0$$

- **de Broglie Wavelength (General Form):** Shows the wave nature of any moving particle.

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

- **de Broglie Wavelength (Non-relativistic Particle):** Used when mass and velocity of particle are known.

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

de Broglie Wavelength of Electron Accelerated Through Potential V: Most common formula used in JEE numericals involving electrons.

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

- **Practical de Broglie Formula (Electron):** Directly provides the wavelength in angstroms for electrons accelerated through a voltage of V.

$$\lambda(\text{\AA}) = \frac{12.27}{\sqrt{V}}$$

- **Momentum of Photon:** Expresses that photons carry momentum despite having zero rest mass.

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

- **Intensity Effect in Photoelectric Effect:** Photoelectric current depends on intensity, not the kinetic energy of electrons.

Photoelectric current \propto intensity of incident light

- **Frequency Effect in Photoelectric Effect:** The maximum kinetic energy of photoelectrons depends only



Kinetic energy \propto frequency of incident radiation

Atoms And Nuclei

Atoms (Bohr Model & Atomic Structure)

- **Bohr's Quantisation Condition:** Electrons can revolve only in those orbits where their angular momentum is quantised.

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

- **Radius of nth Orbit (Hydrogen Atom):** Gives the allowed orbit radius of an electron in hydrogen-like atoms.

$$r_n = \frac{n^2 a_0}{Z}$$

- **Bohr Radius:** Minimum possible radius of a hydrogen atom in the ground state.

$$a_0 = \frac{4\pi\epsilon_0 h^2}{me^2}$$

- **Velocity of Electron in nth Orbit:** This shows that the electron speed decreases with increasing orbits.

$$v_n = \frac{Ze^2}{2\epsilon_0 h} \frac{1}{n}$$

- **Energy of Electron in nth Orbit:** A negative sign indicates a bound state of an electron in an atom.

$$E_n = -\frac{13.6Z^2}{n^2} \text{ eV}$$

- **Energy Difference Between Two Orbits:** Used to calculate the energy of a photon emitted or absorbed.

$$\Delta E = E_2 - E_1$$

- **Frequency of Emitted/Absorbed Radiation:** Connects the atomic energy transition with the radiation frequency.

$$\nu = \frac{\Delta E}{h}$$

- **Wavelength of Spectral Line:** Used to find the wavelength of emitted or absorbed light.



$$\lambda = \frac{hc}{\Delta E}$$

- **Rydberg Formula (Hydrogen Spectrum):** Gives wavelengths of spectral lines of the hydrogen atom.

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

Nuclei (Radioactivity & Nuclear Physics)

- **Nuclear Radius:** Shows that nuclear size depends on mass number.

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

- **Radioactive Decay Law:** The number of undecayed nuclei decreases exponentially with time.

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

- **Activity of a Radioactive Sample:** Rate of decay of radioactive nuclei.

$$A = \lambda N$$

- **Half-Life:** Time required for half the radioactive nuclei to decay.

$$T_{1/2} = \frac{0.693}{\lambda}$$

- **Mean Life:** Average lifetime of radioactive nuclei.

$$\tau = \frac{1}{\lambda}$$

- **Relation Between Half-Life and Mean Life:** Links two important decay parameters.

$$\tau = \frac{T_{1/2}}{0.693}$$

- **Binding Energy:** Energy required to completely separate nucleons of a nucleus.

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

- **Binding Energy per Nucleon:** Measures the stability of a nucleus.

$$\text{BE per nucleon} = \frac{BE}{A}$$

- **Mass Defect:** The difference between the sum of individual nucleon masses and the actual nuclear mass.



$$\Delta m = (Zm_p + Nm_n) - M$$

- **Energy Released in Nuclear Reaction (Q-Value):** Net energy gained or lost in a nuclear reaction.

$$Q = (m_{\text{initial}} - m_{\text{final}})c^2$$

- **Relation Between Energy and Mass:** Shows the conversion of mass into energy in nuclear processes.

$$E = mc^2$$

Electronic Devices

Semiconductors Basics

- **Energy Band Gap:** Energy difference between the conduction band and valence band that determines the electrical behaviour of the material.

$$E_g = E_c - E_v$$

- **Electrical Conductivity of Semiconductor:** Shows that conductivity depends on the number and mobility of charge carriers.

$$\sigma = nq\mu$$

- **Drift Velocity of Charge Carriers:** Average velocity attained by carriers due to applied electric field.

$$v_d = \mu E$$

- **Current Density:** Relates current flow with charge carrier motion.

$$J = nqv_d$$

PN Junction Diode

- **Barrier Potential:** Built-in potential that opposes further diffusion of charge carriers across the junction.

$$0.7V(Si), 0.3V(Ge)$$

- **Diode Current Equation:** Shows an exponential rise of current in forward bias.

$$I = I_0 \left(e^{\frac{V}{\eta V_T}} - 1 \right)$$



MATRIX

• **Thermal Voltage:** Voltage equivalent of thermal energy at room temperature.

$$V_T = \frac{kT}{q}$$

- **Rectifier Efficiency:** Measures how efficiently AC is converted into DC.

$$\eta = \frac{P_{dc}}{P_{ac}}$$

- **Ripple Factor:** Indicates the amount of AC present in the rectifier output.

$$r = \frac{I_{ac}}{I_{dc}}$$

- **Zener Breakdown Voltage:** Fixed reverse voltage at which the zener energy diode conducts heavily.

$$V = V_Z$$

- **Zener as Voltage Regulator:** Maintains a constant output voltage despite variations in input or load.

$$V_{out} \approx V_Z$$

- **Current Gain (Common Emitter):** Measures the amplification ability of the transistor.

$$\beta = \frac{I_C}{I_B}$$

- **Emitter Current Relation:** Total current conservation in the transistor.

$$I_E = I_C + I_B$$

- **Current Gain (Common Base):** Used in CB configuration problems.

$$\alpha = \frac{I_C}{I_E}$$

- **Relation Between α and β :** Links current gains of CB and CE configurations.

$$\beta = \frac{\alpha}{1-\alpha}$$

- **Transistor as Amplifier:** A small change in base current causes a large change in collector current.

$$\Delta I_C = \beta \Delta I_B$$

- **NOT Gate:** Output is the inverse of the input.



$$Y = \bar{A}$$

- **AND Gate:** Output is HIGH only when all inputs are HIGH.

$$Y = A \cdot B$$

- **OR Gate:** Output is HIGH when any input is HIGH.

$$Y = A + B$$

- **NAND Gate (Universal Gate):** Can implement any logical operation.

$$Y = \overline{A \cdot B}$$

- **NOR Gate (Universal Gate):** Also capable of forming all logic circuits.

$$Y = \overline{A + B}$$

Experimental Skills

- **Mean Value:** Used to reduce random error by averaging repeated measurements.

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{n}$$

- **Absolute Error:** Measures the deviation of a reading from the mean value.

$$\Delta x = |x_i - \bar{x}|$$

- **Mean Absolute Error:** Gives average uncertainty in measurement.

$$\Delta x_{mean} = \frac{\sum |\Delta x|}{n}$$

- **Relative (Fractional) Error:** Used to calculate error in derived quantities.

$$\frac{\Delta x}{x}$$

- **Percentage Error:** Commonly asked in MCQs related to accuracy.

$$\text{Percentage error} = \frac{\Delta x}{x} \times 100$$

- **Error Propagation (Product/Quotient):** Used when quantities are multiplied or divided



$$\frac{\Delta Z}{Z} = \frac{\Delta A}{A} + \frac{\Delta B}{B}$$

- **Least Count (Vernier Callipers):** The smallest length that can be measured accurately.

$$LC = \frac{\text{Value of 1 MSD}}{\text{Number of Vernier divisions}}$$

- **Reading of Vernier Callipers:** Actual length measurement formula.

$$\text{Reading} = \text{MSR} + (\text{VSR} \times \text{LC})$$

- **Zero Error Correction:** Applied when the zero of the vernier and the main scale do not coincide.

$$\text{Correct Reading} = \text{Observed Reading} \pm \text{Zero Error}$$

- **Least Count (Screw Gauge):** Determines the precision of the thickness measurement.

$$LC = \frac{\text{Pitch}}{\text{Number of circular scale divisions}}$$

- **Screw Gauge Reading:** Used to measure very small dimensions like wire diameter.

$$\text{Reading} = \text{PSR} + (\text{CSR} \times \text{LC})$$

- **Pitch:** Linear distance moved by the screw in one complete rotation.

$$\text{Pitch} = \text{Distance moved} / \text{Number of rotations}$$

- **Time Period of the Simple Pendulum:** Used to calculate acceleration due to gravity.

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

- **Value of g Using Pendulum:** A direct experimental formula is asked in MCQs.

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

- **Ohm's Law:** Verifies the linear relationship between voltage and current.

$$V = IR$$

- **Resistance from V-I Graph:** The slope of the V-I graph gives resistance.

$$R = \frac{V}{I}$$

- **Resistivity of Wire:** Used in the metre bridge and resistivity experiments.



$$\rho = \frac{RA}{L}$$

- **Metre Bridge Balance Condition:** Used to find unknown resistance.

$$\frac{R}{X} = \frac{l}{100-l}$$

- **Focal Length of Convex Lens:** Used in the u-v method experiments.

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

- **Magnification of Lens:** Relates image size to object size.

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

- **Diode Forward Bias Behaviour:** Shows an exponential increase in current with voltage. Current increases rapidly after the threshold voltage
- **Zener Diode Regulation:** Used to verify a constant output voltage.

$$V_{out} \approx V_Z$$

Matrix JEE Topper Tips For Physics Formulas

In the year 2025, 2 matrix toppers scored a full 100%ile in the physics section of JEE Main. And 16 students were above 99.99%ilers. One big factor behind such exceptional performance is recalling the right formulas accurately.

The teaching approach used at Matrix Academy Sikar is designed around such strategies. These important physics formulas are not just memorised but taught in a way that students can apply accurately while solving physics problems. Let us discuss Matrix topper tips to achieve a high score in JEE Main physics:

- Siddharth Gora Sir (Matrix JEE Faculty) and Kuldeep Kichar Sir (Matrix JEE Faculty) advise students to develop a strong conceptual understanding behind every important physics formula.
- Jigyasa (99.21 percentile, JEE Main 2020) would solve multiple concept physics numericals and dedicated fixed time to solving them every morning. This helped her recall the physics formulas effortlessly.
- Rishabh Meel (AIR 70, JEE Advanced 2025) followed a specific strategy for JEE Main physics. Rishabh maintained an error notebook and mentioned all important physics formulas along with derivations. This