Chapters Removed from JEE Main Syllabus 2025

Candidates can check the chapters removed from the Physics, Chemistry, and Mathematics of JEE Main Syllabus 2025 in the table below.

Chapters Removed from JEE Main Syllabus 2025	
Subject	**Removed Chapters**
Physics	• Capacitors and Capacitance • Communication Device • A few topics are removed from the Experimental Skills
Chemistry	• Physical quantities and their measurements in Chemistry, precision, and accuracy, significant figures • States of Matter • Thomson and Rutherford's atomic models and their limitations • Surface Chemistry • s-Block Elements • General Principles and Processes of Isolation of Metals • Hydrogen • Environmental Chemistry • Polymers • Chemistry in Everyday Life
Mathematics	• Mathematical Induction • Mathematical Reasoning • A few topics are removed from Three Dimensional Geometry.

UNITS AND MEASUREMENTS

- The **SI system :** It is the international system of units. At present internationally accepted for measurement. In this system there are seven fundamental and two supplementary quantities and their corresponding units are:

Quantity	Unit	Symbol
1. Length	metre	m
2. Mass	kilogram	kg
3. Time	second	s
4. Electric current	ampere	A
5. Temperature	kelvin	K
6. Luminous intensity	candela	cd
7. Amount of substance	mole	mol
Supplementary		
1. Plane angle	radian	rad
2. Solid angle	steradian	sr

- Dimensions : These are the powers to which the fundamental units are raised to get the unit of a physical quantity.
- Uses of dimensions
  - (i) To check the correctness of a physical relation.
  - (ii) To derive relationship between different physical quantities.
  - (iii) To convert one system of unit into another.

$$n_1u_1 = n_2u_2$$

$$n_1[M_1^aL_1^bT_1^c] = n_2[M_2^aL_2^bT_2^c]$$

- Significant figures : In any measurement, the reliable digits plus the first uncertain digit are known as significant figures.
- Error : It is the difference between the measured value and true value of a physical quantity or the uncertainty in the measurements.
- Absolute error : The magnitude of the difference between the true value and the measured value is called absolute error.

$$\Delta a_1 = \bar{\mathbf{a}} - a_1,\ \Delta a_2 = \bar{\mathbf{a}} - a_2,\ \Delta a_n = \bar{\mathbf{a}} - a_n$$

Mean absolute error

$$\Delta\bar{\mathbf{a}} = \frac{|\Delta a_1| + |\Delta a_2| + ... + |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n}|\Delta a_i|$$

- Relative error : It is the ratio of the mean absolute error to its true value

or relative error $= \frac{\Delta\bar{\mathbf{a}}}{\bar{a}}$

- Percentage error : It is the relative error in per cent.

$$\text{Percentage error} = \left(\frac{\Delta\bar{a}}{a_{mean}}\right)\times 100\%$$

MOTION IN A STRAIGHT LINE

- Average speed, $V_{av} = \frac{s_1 + s_2 + s_3}{t_1 + t_2 + t_3}$
- Average acceleration, $a_{av} = \frac{a_1t_1 + a_2t_2}{t_1 + t_2}$
- The area under the velocity-time curve is equal to the displacement and slope gives acceleration.
- If a body falls freely, the distance covered by it in each subsequent second starting from first second will be in the ratio 1 : 3 : 5 : 7 etc.
- If a body is thrown vertically up with an initial velocity u, it takes u/g second to reach maximum height and u/g second to return, if air resistance is negligible.
- If air resistance acting on a body is considered, the time taken by the body to reach maximum height is less than the time to fall back the same height.
- For a particle having zero initial velocity if $s \propto t^\alpha$, where $\alpha > 2$, then particle's acceleration increases with time.
- For a particle having zero initial velocity if $s \propto t^\alpha$, where $\alpha < 0$, then particle's acceleration decreases with time.
- Kinematic equations :
  $v = u + a_t(t)$; $v^2 = u^2 + 2a_t(s)$

  $$S = ut + \frac{1}{2}a_t(t)^2;\ S_n = u + \frac{a}{2}(2n-1)$$

  applicable only when $|\vec{a}_t| = a_t$ is constant.
  a_t = magnitude of tangential acceleration, S = distance
- If acceleration is variable use calculus approach.
- Relative velocity : $\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$

MOTION IN A PLANE

- If T is the time of flight, h maximum height, R horizontal range of a projectile, α its angle of projection, then the relations among these quantities.

$$h = \frac{gT^2}{8} \quad ......(1);$$

$$gT^2 = 2R\tan\alpha \quad ......(2);$$

$$R\tan\alpha = 4h \quad ......(3)$$

- $T = \frac{2u\sin\theta}{g}; h = \frac{u^2\sin^2\theta}{2g}$

  $R = \frac{u^2\sin 2\theta}{g}$; $R_{max} = \frac{u^2}{g}$ when $\theta = 45°$
- For a given initial velocity, to get the same horizontal range, there are two angles of projection α and $90° - \alpha$.
- The equation to the parabola traced by a body projected horizontally from the top of a tower of height y, with a velocity u is $y = gx^2/2u^2$, where x is the horizontal distance covered by it from the foot of the tower.
- Equation of trajectory is $y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$, which is parabola.
- Equation of trajectory of an oblique projectile in terms of range (R) is $y = x\tan\theta\left(1 - \frac{x}{R}\right)$
- Maximum height is equal to n times the range when the projectile is launched at an angle $\theta = \tan^{-1}(4n)$.
- In a uniform circular motion, velocity and acceleration are constants only in magnitude. Their directions change.
- In a uniform circular motion, the kinetic energy of the body is a constant. $W = 0$, $\vec{a} \neq 0$, $\vec{P} \neq$ constant, $\vec{L}$=constant
- Centripetal acceleration, $a_r = \omega^2 r = \frac{v^2}{r} = \omega v$ (always applicable)

  $\vec{a}_r = \vec{\omega} \times \vec{v}$

LAWS OF MOTION

- Newton's first law of motion or law of inertia : It is resistance to change.
- Newton's second law : $\vec{F} = m\vec{a}$, $\vec{F} = d\vec{p}/dt$
- Impulse : $\Delta\vec{p} = \vec{F}\Delta t$, $p_2 - p_1 = \int_1^2 F\,dt$
- Newton's third law : $\vec{F}_{12} = -\vec{F}_{21}$
- Frictional force $f_s \leq (f_s)_{max} = \mu_s R$; $f_k = \mu_k R$
- Circular motion with variable speed. For complete circles, the string must be taut in the highest position, $u^2 \geq 5ga$. Circular motion ceases at the instant when the string becomes slack, i.e., when T = 0, range of values of u for which the string does go slack is $\sqrt{2ga} < u < \sqrt{5ga}$.
- Conical pendulum : $\omega = \sqrt{g/h}$ where h is height of a point of suspension from the centre of circular motion.
- The acceleration of a lift

  $a = \frac{\text{actual weight} - \text{apparent weight}}{\text{mass}}$

  If 'a' is positive lift is moving down, and if it is negative the lift is moving up.
- On a banked road, the maximum permissible speed V_{max}

  $= \left(R_g \frac{u_s + \tan\theta}{1 - u_s\tan\theta}\right)^{1/2}$

WORK, ENERGY AND POWER

- Work done $W = FS\cos\theta$
- Relation between kinetic energy E and momentum, $P = \sqrt{2mE}$

  K.E. $= \frac{1}{2}mV^2$; P.E. $= mgh$
- If a body moves with constant power, its velocity (v) is related to distance travelled (x) by the formula $v \propto x^{3/2}$.
- Power $P = \frac{W}{t} = F.V$
- Work due to kinetic force of friction between two contact surfaces is always negative. It depends on relative displacement between contact surfaces. $W_{FK} = -F_K(S_{rel})$.
- $\Sigma W = \Sigma \Delta K$, $\Sigma W \Rightarrow$ total work due to all kinds of forces, $\Sigma \Delta K \Rightarrow$ total change in kinetic energy.
- $\Sigma W_{conservative} = -\Sigma \Delta U$; $\Sigma W_{conservative} \Rightarrow$ Total work due to all kinds of conservative forces.

  $\Sigma \Delta u \Rightarrow$ Total change in all kinds of potential energy.
- Coefficient of restitution $e = \frac{\text{velocity of separation}}{\text{velocity of approach}}$
- The total momentum of a system of particles is a constant in the absence of external forces.

SYSTEMS OF PARTICLES AND ROTATIONAL MOTION

- The centre of mass of a system of particles is defined as the point whose position vector is $R = \frac{\sum m_i r_i}{M}$
- The angular momentum of a system of n particles about the origin is $L = \sum_{i=1}^{n} r_i \times p_i$;

  $L = mvr = I\omega$
- The torque or moment of force on a system of n particles about the origin is $\tau = \sum_i r_i \times F_i$
- The moment of inertia of a rigid body about an axis is defined by the formula $I = \sum m_i r_i^2$
- The kinetic energy of rotation is $K = \frac{1}{2}I\omega^2$
- The theorem of parallel axes : $I'_z = I_z + Ma^2$

  Theorem of perpendicular axes : $I_z = I_x + I_y$

- For rolling motion without slipping $v_{cm} = R\omega$. The kinetic energy of such a rolling body is the sum of kinetic energies of translation and rotation : $K = \frac{1}{2}mv_{cm}^2 + \frac{1}{2}I\omega^2$
- A rigid body is in mechanical equilibrium if
(a) It is translational equilibrium i.e., the total external force on it is zero : $\Sigma F_i = 0$.
(b) It is rotational equilibrium i.e., the total external torque on it is zero : $\Sigma \tau_i = \Sigma r_i \times F_i = 0$.
- If a body is released from rest on rough inclined plane, then for pure rolling $\mu_r \geq \frac{n}{n+1}\tan\theta$ $(I_c = nmr^2)$
Rolling with sliding $0 < \mu_s < \left(\frac{n}{n+1}\right)\tan\theta$;
$\frac{g\sin\theta}{n+1} < a < g\sin\theta$

GRAVITATION

- Newton's universal law of gravitation
Gravitational force $F = \frac{Gm_1m_2}{r^2}$
$G = 6.67 \times 10^{-11} \frac{Nm^2}{kg^2}$
- The acceleration due to gravity.
(a) at a height h above the Earth's surface
$g(h) = \frac{GM_E}{(R_E + h)^2} = g\left(1 - \frac{2h}{R_E}\right)$ for $h << R_E$
$g(h) = g(0)\left(1 - \frac{2h}{R_E}\right)$ where $g(0) = \frac{GM_E}{R_E^2}$
(b) at depth d below the Earth's surface is
$g(d) = \frac{GM_E}{R_E^2}\left(1 - \frac{d}{R_E}\right) = g(0)\left(1 - \frac{d}{R_E}\right)$
(c) with latitude λ $g^1 = g - R\omega^2\cos^2\lambda$
- Gravitational potential $V_g = -\frac{GM}{r}$
- Intensity of gravitational field $I = \frac{GM}{r^2}$
- The gravitational potential energy
$V = -\frac{Gm_1m_2}{r} + \text{constant}$
- The escape speed from the surface of the Earth is $v_e = \sqrt{\frac{2GM_E}{R_E}} = \sqrt{2gR_E}$ and has a value of 11.2 km s^{-1}.
- Orbital velocity, $v_{orbi} = \sqrt{\frac{GM_E}{R_E}} = \sqrt{gR_E}$
- A geostationary (geosynchronous communication) satellite moves in a circular orbit in the equatorial plane at a approximate distance of 4.22×10^4 km from the Earth's centre.
- Kepler's 3rd law of planetary motion.
$T^2 \propto a^3$; $\frac{T_1^2}{T_2^2} = \frac{a_1^3}{a_2^3}$

MECHANICAL PROPERTIES OF SOLIDS

- Hooke's law : stress $\propto$ strain
- Young's modulus of elasticity
$Y = \frac{F\Delta\ell}{A\ell}$
- Compressibility $= \frac{1}{\text{Bulk modulus}}$
- $Y = 3k(1 - 2\sigma)$
- $Y = 2n(1 + \sigma)$
- If S is the stress and Y is Young's modulus, the energy density of the wire E is equal to $S^2/2Y$.
- If α is the longitudinal strain and E is the energy density of a stretched wire, Y Young's modulus of wire, then E is equal to $\frac{1}{2}Y\alpha^2$
- Thermal stress $= \frac{F}{A} = Y\alpha\Delta\theta$

MECHANICAL PROPERTIES OF FLUIDS

- Pascal's law : A change in pressure applied to an enclosed fluid is transmitted undiminished to every point of the fluid and the walls of the containing vessel.
Pressure exerted by a liquid column $P = h\rho g$
- Bernoulli's principle
$P + \rho v^2/2 + \rho gh = \text{constant}$
- Surface tension is a force per unit length (or surface energy per unit area) acting in the plane of interface.
- Stokes' law states that the viscous drag force F on a sphere of radius a moving with velocity v through a fluid of viscosity η $F = -6\pi\eta av$.
- Terminal velocity $V_T = \frac{2}{9}\frac{r^2(\rho - \sigma)g}{\eta}$
- The surface tension of a liquid is zero at boiling point. The surface tension is zero at critical temperature.
- If a drop of water of radius R is broken into n identical drops, the work done in the process is $4\pi R^2 S(n^{1/3} - 1)$ and fall in temperature $\Delta q = \frac{3T}{J}\sqrt{\frac{1}{r} - \frac{1}{R}}$
- Two capillary tubes each of radius r are joined in parallel. The rate of flow is Q. If they are replaced by single capillary tube of radius R for the same rate of flow, then $R = 2^{1/4}r$.
- Ascent of a liquid column in a capillary tube $h = \frac{2s\cos\phi}{r\rho g}$
- Coefficient of viscosity, $n = -\frac{F}{A\left(\frac{dv}{dx}\right)}$
- Velocity of efflux $V = \sqrt{2gh}$

THERMAL PROPERTIES OF MATTER

- Relation between different temperature scales :

$$\frac{C}{100} = \frac{F-32}{100} = \frac{K-273}{100}$$

- The coefficient of linear expansion (α_ℓ), superficial (β) and volume expansion (α_v) are defined by the relations :

$$\frac{\Delta \ell}{\ell} = \alpha_\ell \Delta T \ ; \ \frac{\Delta A}{A} = \beta \Delta T \ ; \ \frac{\Delta V}{V} = \alpha_V \Delta T$$

$\alpha_v = 3\alpha_\ell$; $\beta = 2\alpha_\ell$

- In conduction, heat is transferred between neighbouring parts of a body through molecular collisions, without any flow of matter. The rate of flow of heat $H = KA\frac{T_C - T_D}{L}$, where K is the thermal conductivity of the material of the bar.
- Convection involves flow of matter within a fluid due to unequal temperatures of its parts.
- Radiation is the transmission of heat as electromagnetic waves.
- Stefan's law of radiation : $E = \sigma T^4$, where the constant σ is known as Stefan's constant $= 5.67 \times 10^{-8}\ wm^{-2} k^{-4}$.
- Wein's displacement law : $\lambda_m T$ = constant, where constant is known as Wein's constant $= 2.898 \times 10^{-3}$ mk.
- Newton's law of cooling: $\frac{dQ}{dt} = -k\,(T_2 - T_1)$; where T_1 is the temperature of the surrounding medium and T_2 is the temperature of the body.
- Heat required to change the temperature of the substance, $Q = mc\Delta\theta$
  c = specific heat of the substance
- Heat absorbed or released during state change $Q = mL$
  L = latent heat of the substance
- Mayer's formula $c_p - c_v = R$

THERMODYNAMICS

- First law of thermodynamics: $\Delta Q = \Delta U + \Delta W$, where ΔQ is the heat supplied to the system, ΔW is the work done by the system and ΔU is the change in internal energy of the system.
- In an isothermal expansion of an ideal gas from volume V_1 to V_2 at temperature T the heat absorbed (Q) equals the work done (W) by the gas, each given by

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

- In an adiabatic process of an ideal gas $PV^\gamma = TV^{\gamma-1}$ $= \frac{T^\gamma}{P^{\gamma-1}}$ = constant, where $\gamma = \frac{C_p}{C_v}$.
- Work done by an ideal gas in an adiabatic change of state from (P_1, V_1, T_1) to (P_2, V_2, T_2) is $W = \frac{nR\,(T_1 - T_2)}{\gamma - 1}$
- The efficiency of a Carnot engine is given by

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

- **Second law of thermodynamics:** No engine operating between two temperatures can have efficiency greater than that of the Carnot engine.
- Entropy or disorder $S = \frac{\delta Q}{T}$

KINETIC THEORY

- Ideal gas equation $PV = nRT$
- Kinetic theory of an ideal gas gives the relation $P = \frac{1}{3}nm\overline{v}^2$, Combined with the ideal gas equation it yields a kinetic interpretation of temperature.

$$\frac{1}{2}nm\overline{v}^2 = \frac{3}{2}k_B T\ ,\ v_{rms} = (\overline{v}^2)^{1/2} = \sqrt{\frac{3k_B T}{m}}$$

- The law of equipartition of energy is stated thus: the energy for each degree of freedom in thermal equilibrium is $1/2\,(k_B T)$
- The translational kinetic energy $E = \frac{3}{2}k_B NT$. This leads to a relation $PV = \frac{2}{3}E$.
- Degree of freedom : Number of directions in which it can move freely.
- Root mean square (rms) velocity of the gas

$$C = \sqrt{\frac{3RT}{M}} = \sqrt{\frac{3P}{\rho}}$$

- Most probable speed $V_{mp} = \sqrt{\frac{2RT}{M}} = \sqrt{\frac{2KT}{m}}$
- Mean free path $\lambda = \frac{KT}{\sqrt{2}\pi d^2 P}$

OSCILLATIONS

- Displacement in SHM : $Y = a \sin \omega t$
  or, $y = a \cos \omega t$
- The particle velocity and acceleration during SHM as functions of time are given by,

  $v(t) = -\omega A \sin(\omega + \phi)$ (velocity),
  $a(t) = -\omega^2 A \cos(\omega t + \phi) = -\omega^2 x(t)$ (acceleration)

Velocity amplitude $v_m = \omega A$ and acceleration amplitude $a_m = \omega^2 A$.

- A particle of mass m oscillating under the influence of a Hooke's law restoring force given by $F = -k\,x$ exhibits simple harmonic motion with $\omega = \sqrt{\frac{k}{m}}$ (angular frequency),

$$T = 2\pi\sqrt{\frac{m}{k}} \text{ (period)}$$

Such a system is also called a linear oscillator.

- Time period for conical pendulum $T = 2\pi\sqrt{\left(\frac{\ell\cos\theta}{g}\right)}$ where θ angle between string & vertical.
- Energy of the particle $E = k + u = \frac{1}{2}m\omega^2 A^2$

WAVES

- The displacement in a sinusoidal wave $y(x, t) = a \sin(kx - \omega t + \phi)$ where ϕ is the phase constant or phase angle.
- Equation of plane progressive wave :

$$= a \sin 2\pi\left(\frac{t}{T} - \frac{x}{V}\right)$$

- Equation of stationary wave :

$$Y = 2a \sin \frac{2\pi t}{T} \cos \frac{2\pi x}{\lambda}$$

- The speed of a transverse wave on a stretched string $v = \sqrt{T/\mu}$.
- Sound waves are longitudinal mechanical waves that can travel through solids, liquids, or gases. The speed v of sound wave in a fluid having bulk modulus B and density μ is $v = \sqrt{B/\rho}$.
- The speed of longitudinal waves in a metallic bar is $v = \sqrt{Y/\rho}$

  For gases, since $B = \gamma P$, the speed of sound is $v = \sqrt{\gamma P/\rho}$
- The interference of two identical waves moving in opposite directions produces standing waves. For a string with fixed ends, standing wave $y(x, t) = [2a \sin kx] \cos \omega t$
- The separation between two consecutive nodes or antinodes is $\lambda/2$.
- A stretched string of length L fixed at both the ends vibrates with frequencies $f = \frac{1}{2}\frac{v}{2L}$.

  The oscillation mode with lowest frequency is called the fundamental mode or the first harmonic.
- A pipe of length L with one end closed and other end open (such as air columns) vibrates with frequencies given by

$$f = \left(n + \frac{1}{2}\right)\frac{v}{2L}, n = 0, 1, 2, 3, ...$$

  The lowest frequency given by v/4L is the fundamental mode or the first harmonic.

  Open organ pipe $n_1 : n_2 : n_3$ .... 1, 2, 3......., $n = \frac{V}{2l}$
- Beats arise when two waves having slightly different frequencies, f_1 and f_2 and comparable amplitudes, are superposed. The beat frequency $f_{beat} = f_1 - f_2$
- The Doppler effect is a change in the observed frequency of a wave when the source S and the observer O moves relative to the medium. $f = f_0\left(\frac{v \pm v_0}{v \pm v_s}\right)$

ELECTRO-STATICS

- Coulomb's Law : $\vec{F}_{21}$ = force on q_2 due to $q_1 = \frac{k(q_1 q_2)}{r_{21}^2}\hat{r}_{21}$ where $k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ Nm}^2 \text{C}^{-2}$
- Electric field due to a point charge q has a magnitude $|q|/4\pi\varepsilon_0 r^2$
- Field of an electric dipole in its equatorial plane

$$E = \frac{-\vec{p}}{4\pi\varepsilon_0}\frac{1}{(a^2 + r^2)^{3/2}} \cong \frac{-\vec{p}}{4\pi\varepsilon_0 r^3}, \quad \text{for } r >> a$$

  Dipole electric field on the axis at a distance r from the centre:

$$\vec{E} = \frac{2\vec{p}r}{4\pi\varepsilon_0(r^2 - a^2)^2} \cong \frac{2\vec{p}}{4\pi\varepsilon_0 r^3} \text{ for } r >> a$$

  Dipole moment $\vec{p} = q2a$
- In a uniform electric field $\vec{E}$, a dipole experiences a torque $\vec{\tau}$ given by $\vec{\tau} = \vec{p} \times \vec{E}$ but experiences no net force.

  The flux $\Delta\phi$ of electric field $\vec{E}$ through a small area element $\Delta\vec{S}$ is given by $\Delta\phi = \vec{E}.\Delta\vec{S}$
- Gauss's law: The flux of electric field through any closed surface S is $1/\varepsilon_0$ times the total charge enclosed i.e., Q
- Thin infinitely long straight wire of uniform linear charge density λ : $\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{n}$
- Infinite thin plane sheet of uniform surface charge density σ

$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$$

- Thin spherical shell of uniform surface charge density σ :

$$\vec{E} = \frac{\sigma}{4\pi\varepsilon_0 r^2}\hat{r} \quad (r \geq R) \;;\; \vec{E} = 0 \quad (r < R)$$

- Electric Potential : $V(\vec{r}) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$.
- An equipotential surface is a surface over which potential has a constant value.
- Potential energy of two charges q_1, q_2 at $\vec{r}_1, \vec{r}_2$ is given by $U = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}}$, where r_{12} is distance between q_1 and q_2.
- Capacitance C = Q/V, where Q = charge and V = potential difference
- For a parallel plate capacitor (with vacuum between the plates), $C = \varepsilon_0 \frac{A}{d}$.
- The energy U stored in a capacitor of capacitance C, with charge Q and voltage V is

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

- For capacitors in the series combination,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$$

  In the parallel combination, $C_{eq} = C_1 + C_2 + C_3 + ...$ where $C_1, C_2, C_3 ...$ are individual capacitances.

CURRENT ELECTRICITY

- Electric current, $I = \frac{q}{t}$
- Current density j gives the amount of charge flowing per second per unit area normal to the flow, $\vec{J} = nqv_d$
- Mobility, $\mu = \frac{V_d}{E}$ and $V_d = \frac{I}{Ane}$
- Resistance $R = \rho\frac{\ell}{A}$, ρ = resistivity of the material
- Equation $\vec{E} = \rho\vec{J}$ another statement of Ohm's law, ρ= resistivity of the material.
- Ohm's law $I \propto V$ or $V = RI$
- (a) Total resistance R of n resistors connected in series $R = R_1 + R_2 + ... + R_n$
  (b) Total resistance R of n resistors connected in parallel $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + ... + \frac{1}{R_n}$.
- Kirchhoff's Rules – (a) Junction rule: At any junction of circuit elements, the sum of currents entering the junction must equal the sum of currents leaving it.
  (b) Loop rule: The algebraic sum of changes in potential around any closed loop must be zero.
- The Wheatstone bridge is an arrangement of four resistances R_1, R_2, R_3, R_4. The null-point condition is given by $\frac{R_1}{R_2} = \frac{R_3}{R_4}$
- The potentiometer is a device to compare potential differences. The device can be used to measure potential difference; internal resistance of a cell and compare emf's of two sources. Internal resistance $r = R\left(\frac{\ell_1}{\ell_2} - 1\right)$
- RC circuit : During charging : $q = CE\,(1 - e^{-t/RC})$
  During discharging : $q = q_0 e^{-t/RC}$
- According 'to Joule's Heating law, $H = I^2Rt$

MAGNETISM

- The total force on a charge q moving with velocity v i.e., Lorentz force. $\vec{F} = q\,(\vec{v} \times \vec{B} + \vec{E})$.
- A straight conductor of length ℓ and carrying a steady current I experiences a force $\vec{F}$ in a uniform external magnetic field $\vec{B}$, $\vec{F} = I\vec{\ell} \times \vec{B}$, the direction of ℓ is given by the direction of the current.
- Biot-Savart law $d\vec{B} = \frac{\mu_0}{4\pi} I \frac{d\vec{\ell} \times \vec{r}}{r^3}$.
- The magnitude of the magnetic field due to a circular coil of radius R carrying a current I at an axial distance x from the centre is $B = \frac{\mu_0 IR^2}{2\,(x^2 + R^2)^{3/2}}$.
- The magnitude of the field B inside a long solenoid carrying a current I is : $B = \mu_0 nI$. For a toroid one obtains, $B = \frac{\mu_0 NI}{2\pi r}$.
- Ampere's Circuital Law : $\oint_C \vec{B}.d\vec{\ell} = \mu_0 I$, where I refers to the current passing through S.
- Force between two long parallel wires $F = \frac{\mu_0 I_1 I_2}{2\pi a}\,Nm^{-1}$.
  The force is attractive if currents are in the same direction and repulsive currents are in the opposite direction.
- For current carrying coil $\vec{M} = NI\vec{A}$; torque = $\vec{\tau} = \vec{M} \times \vec{B}$
- Conversion of (i) galvanometer into ammeter, $S = \left(\frac{I_g}{I - I_g}\right)G$
  (ii) galvanometer into voltmeter, $S = \frac{V}{I_g} - G$
- The magnetic intensity, $\vec{H} = \frac{\vec{B}_0}{\mu_0}$.
- The magnetisation $\vec{M}$ of the material is its dipole moment per unit volume. The magnetic field B in the material is, $\vec{B} = \mu_0(\vec{H} + \vec{M})$
- For a linear material $\vec{M} = \chi\vec{H}$. So that $\vec{B} = \mu\vec{H}$ and χ is called the magnetic susceptibility of the material.
  $\mu = \mu_0\mu_r$; $\mu_r = 1 + \chi$.

ELECTRO-MAGNETIC INDUCTION

- The magnetic flux $\phi_B = \vec{B}.\vec{A} = BA\cos\theta$, where θ is the angle between $\vec{B}$ & $\vec{A}$.
- Faraday's laws of induction : $\varepsilon = -N\frac{d\phi_B}{dt}$
- Lenz's law states that the polarity of the induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produces it.
- The induced emf (motional emf) across ends of a rod $\varepsilon = B\ell v$
- The self-induced emf is given by, $\varepsilon = -L\frac{dI}{dt}$
  L is the self-inductance of the coil.
  $L = \frac{\mu_0 N^2 A}{\ell}$
- A changing current in a coil (coil 2) can induce an emf in a nearby coil (coil 1).
  $\varepsilon_1 = -M_{12}\frac{dI_2}{dt}$, M_{12} = mutual inductance of coil 1 w.r.t coil 2.
  $M = \frac{\mu_0 N_1 N_2 A}{\ell}$
- Growth of current in an inductor, $i = i_0[1 - e^{-Rt/L}]$
  For decay of current, $i = i_0 e^{Rt/L}$

ALTERNATING CURRENT

- For an alternating current $i = i_m \sin \omega t$ passing through a resistor R, the average power loss P (averaged over a cycle) due to joule heating is $(1/2)i^2{}_m R$.

  E.m.f, $E = E_0 \sin \omega t$
- Root mean square (rms) current

  $$I = \frac{i_m}{\sqrt{2}} = 0.707\, i_m \,.\; E_{rms} = \frac{E_0}{\sqrt{2}}$$
- The average power loss over a complete cycle $P = VI\cos\phi$. The term $\cos\phi$ is called the power factor.
- An ac voltage $v = v_m \sin\omega t$ applied to a pure inductor L, drives a current in the inductor $i = i_m \sin(\omega t - \pi/2)$, where $i_m = v_m/X_L$. $X_L = \omega L$ is called inductive reactance.
- An ac voltage $v = v_m \sin\omega t$ applied to a capacitor drives a current in the capacitor: $i = i_m \sin(\omega t + \pi/2)$. Here,

  $i_m = \frac{v_m}{X_C},\; X_C = \frac{1}{\omega C}$ is called capacitive reactance.
- An interesting characteristic of a series RLC circuit is the phenomenon of resonance. The circuit exhibits resonance, i.e., the amplitude of the current is maximum at the resonant frequency, $\omega_0 = \frac{1}{\sqrt{LC}}\,(X_L = X_C)$.
- Impedance $z = \sqrt{R^2 + (x_L - x_C)^2}$
- Transformation ratio, $K = \frac{N_S}{N_P} = \frac{E_S}{E_P} = \frac{I_P}{I_S}$
- Step up transformer : $N_S > N_P$; $E_S > E_P$; $I_P > I_S$
- Step down transformer $N_P > N_S$; $E_P > E_S$ and $I_P < I_S$
- The quality factor Q defined by $Q = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR}$ is an indicator of the sharpness of the resonance, the higher value of Q indicating sharper peak in the current.

RAY OPTICS

- Reflection is governed by the equation $\angle i = \angle r'$ and refraction by the Snell's law, $\sin i/\sin r = n$, where the incident ray, reflected ray, refracted ray and normal lie in the same plane.
- Mirror equation: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

  Magnification $M = \frac{V}{u} = \frac{I}{O}$
- Prism Formula $n_{21} = \frac{n_2}{n_1} = \frac{\sin[(A + D_m)/2)]}{\sin(A/2)}$, where D_m is the angle of minimum deviation.
- Dispersion is the splitting of light into its constituent colours. The deviation is maximum for violet and minimum for red.
- Scattering $\propto \frac{1}{\lambda^4}$
- Dispersive power $\omega = \frac{\delta_v - \delta_r}{\delta}$, where δ_v, δ_r are deviation of violet and red and δ the deviation of mean ray (usually yellow).
- For refraction through a spherical interface (from medium 1 to 2 of refractive index n_1 and n_2, respectively)

  $$\frac{n_2}{v} - \frac{n_1}{v} = \frac{n_2 - n_1}{R}$$
- Refractive index of a medium $\mu = \frac{C}{V}$ ($C = 3 \times 10^8$ m/s)

  $r = \frac{1}{\sin C}$ (C = Critical angle)
- Condition for TIR : 1. Ray of light must travel from denser to rarer medium 2. Angle of incidence in denser medium > critical angle.
- Lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$
- Lens maker's formula : $\frac{1}{f} = \frac{(n_2 - n_1)}{n_1}\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$
- The power of a lens P = 1/f. The SI unit for power of a lens is dioptre (D): $1\text{ D} = 1\text{ m}^{-1}$.
- If several thin lenses of focal length f_1, f_2, f_3,.. are in contact, the effective focal $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3} + ...$
- The total power of a combination of several lenses $P = P_1 + P_2 + P_3 + ...$
- Chromatic aberration if satisfying the equation

  $\frac{\omega_1}{f_1} + \frac{\omega_2}{f_2} = 0$ or in terms of powers $\omega_1 P_1 + \omega_2 P_2 = 0$.
- For compound microscope $M = \frac{V_0}{u_0}\left(1 + \frac{D}{f_e}\right)$

  when final image at D

  $M = \frac{V_0}{u_0} \cdot \frac{D}{f_e}$ when final image at infinity.

WAVE OPTICS

- Wavefront : It is the locus of all the particles vibrating in the same phase.
- The resultant intensity of two waves of intensity $I_0/4$ of phase difference ϕ at any points $I = I_0 \cos^2\left[\frac{\phi}{2}\right]$,

  where I_0 is the maximum density.
- Intensity $I \propto (\text{amplitude})^2$
- Condition for dark band : $\delta = (2n - 1)\frac{\lambda}{2}$, for bright band : $\delta = m\lambda$

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