JEE Mains Physics Formulas

Check Important Formulas List

Topic - 1: Vectors

- The Resultant Vector is written as $\vec{??} = A + \vec{??}$ or $\vec{??} = \sum_{k=1} A_k$
- The Resultant Vector in Cartesian Form is $R = \sqrt{A^2 + B^2 + 2AB\cos\theta}$ where θ is the angle between the two vectors.
- If $A = Ax\,?? + Ay\hat{j} + Az\,??$ then the Direction Cosines are $\cos\alpha = A_x/A, \cos\beta = A_y/A$ and $\cos\gamma = Az/A$
- Dot Product: $A \cdot \vec{??} = AB\cos\theta$ where θ is the angle between the two vectors
- If $A = Ax\,?? + Ay\hat{j} + Az\,??$ and $\vec{??} = Bx\hat{i} + By\hat{j} + Bz\,??$ then the Dot-Product is $A \cdot \vec{??} = A_xB_x + A_yB_y + AzBz$
- Cross Product: $A \times \vec{??} = ABsin\theta\, ??$ where $??$ is a Unit Vector perpendicular to both A and $\vec{??}$
- If $A = Ax\,?? + Ay\hat{j} + Az\,??$ and $\vec{??} = Bx\hat{i} + By\hat{j} + B??z$ then the Cross-Product is given by the Determinant

$$\vec{A} \times \vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

- $\hat{i} \times \hat{j} = ??, \hat{j} \times ?? = \hat{i}$ and $?? \times \hat{i} = \hat{j}$
- $$\frac{d}{dt}(\vec{A} \cdot \vec{B}) = \frac{d\vec{A}}{dt} \cdot \vec{B} + \vec{A} \cdot \frac{d\vec{B}}{dt}$$
- $$\frac{d}{dt}(\vec{A} \times \vec{B}) = \frac{d\vec{A}}{dt} \times \vec{B} + \vec{A} \times \frac{d\vec{B}}{dt}$$

Topic - 2: Kinematics

- $v = dr/dt$ and $a = dv/dt$ and $a = d^2r/dt^2$
- For 1-D Motion: $a = v(dv/dx)$
- $v = \vec{??} + at, s = \vec{??}t + (1/2)at^2$ and $v^2 = u^2 + 2as$
- $s_n - s_{n-1} = \vec{??} + (a/2)(2n-1)$
- $v(relative) = v(actual) - v(reference)$
- Projectile Motion Initial Horizontal Velocity is $u_x = u\cos\theta$
- Projectile Motion Initial Vertical Motion is $u_y = u\sin\theta$
- Velocity at any instant of a Projectile Motion is $v = u\cos\theta\,\hat{i} + (u\sin\theta - gt)\,\hat{j}$
- Horizontal Distance at any time is $x = ut\cos\theta$
- Time of Flight is $T = 2u\sin\theta/g$
- Maximum Height of the Projectile is $H = u^2\sin\theta^2/2g$
- Horizontal Range is $R = u^2\sin 2\theta/g$
- Equation of Trajectory is $y = x\tan\theta - gx^2/(2u^2\cos\theta^2)$
- Time of Flight for the Horizontal Projection from a cliff is $T = \sqrt{2h/g}$
- Horizontal Range for the Horizontal Projectile from a cliff is $R = uT$

- Angle of velocity at any instant for Horizontal Projection from a cliff is $\alpha = arctan(gt/u)$

Topic - 3: Laws of Motion and Friction

- Fundamental Forces of Nature are Gravitational Force, Electromagnetic Force, Weak Nuclear Force and Strong Nuclear Force.
- $F = dp/dt$ and $F = ma$ is mass is constant
- Impulse $j = F\Delta t$ in discrete case and $j = \int_{t1}^{2} F\, dt$
- Acceleration of Pulley when both masses are downwards is $a = |m1 - m2| g/(m1 + m2)$
- Tension in the string of a Pulley System when masses are downwards is $T = 2m1m2g/(m1 + m2)$
- Man in a lift going upwards: $Fnet = m(g+a)$
- Man in a lift going upwards: $Fnet = m(g-a)$
- Centripetal Force is $F = mv2/r = m\omega 2r$
- Static Frictional Force is $f = \mu sN$ where N is the Normal Force on the object
- Kinetic Frictional Force is $f = \mu kN$ where N is the Normal Force on the object
- Angle of Friction is $arctan\mu$
- Block sliding on an incline with angle of Repose α: $f = mgsin\theta$ and $N = mgcos\theta$

Topic - 4: Work Power and Energy

- Work Done $W = F\cdot d$ when distance is non-variable and $W = \int_a^b F\cdot s$ when distance is variable
- Kinetic Energy $K = mv2/2$
- Potential Energy $U = mgh+h$ where h is the height from the reference line
- Conservative Force $F = -\nabla U$, in 1-D, it is $F = -dU/dx$
- Work Energy Theorem: $W(all\ forces) = \Delta K = Kf - Ki$
- Power $P = F\cdot v$ or $P = W/t$

Topic - 5: Circular Motion

- Time Period $T = 1/f$ is reciprocal of Frequency
- $\theta = l/r, \omega = d\theta/dt = 2\pi/T = 2\pi f$ and $\alpha = d\omega/dt$
- $\omega = v/r$ or $v = ?\vec{?}\vec{} \times r$
- Net acceleration $a = \alpha \times r + ?\vec{?}\vec{} \times v$ and $a = \sqrt{(\omega 2r)2 + (\alpha r)2}$
- Maximum velocity without skidding is $v = \sqrt{\mu Rg}$
- Maximum velocity for banked road is $v = \sqrt{Rg\left(\frac{\mu + tan\theta}{1 - \mu\, tan\theta}\right)}$
- Bending of a Cyclist: $v \le \sqrt{r * g * tan\,\theta}$
- Condition to complete the vertical circle is $u \ge \sqrt{5gR}$
- Condition for Oscillation is $u \le \sqrt{2gR}$ and the Tension in the string is $T = mgcos\theta + mv2/R$
- Condition for leaving path is $\sqrt{2gR} < u < \sqrt{5gR}$

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Topic - 6: Center of Mass

- The Center of Mass along the $x-axis$ is $X_{CM} = (1/M)\sum_{i=1}^{n} m_i x_i$ where M is the total mass
- The Center of Mass along the $y-axis$ is $Y_{CM} = (1/M)\sum_{i=1}^{n} m_i y_i$ where M is the total mass
- The Center of Mass along the $z-axis$ is $Z_{CM} = (1/M)\sum_{i=1}^{n} m_i z_i$ where M is the total mass
- The Center of Mass for Continuous Distribution is $R_{CM} = (1/M)\int r\, dm$
- If the total mass is M and a small part of mass m is removed then the Center of Mass is given by $X_{CM} = (Mx - m\chi)/(M-m), Y_{CM} = (My - m\gamma)/(M-m)$ and $Z_{CM} = (Mz - m\zeta)/(M-m)$
- The Center of Mass when the object is moving with some velocity is $v_{CM} = (1/M)\sum_{i=1}^{n} m_i v_i$
- The Center of Mass when the object is moving with some acceleration is $a_{CM} = (1/M)\sum_{i=1}^{n} m_i a_i$
- Coefficient of Restitution is $e = (v_2 - v_1) \div (u_1 - u_2)$
- Law of Conservation of Linear Momentum: $\sum_{i=1}^{n} m_i u_i = \sum_{j=1}^{n} m_j v_j$
- Loss of Kinetic Energy in inelastic collision is $\Delta K = (1/2M)[mm(1-e^2)(u_1 - u_2)^2]$
- Law of Conservation of Linear Momentum for Oblique Collision is $\sum_{i=1}^{n} m_i \vec{u}_i = \sum_{j=1}^{n} m_j \vec{v}_j$
- Thrust Force on a Rocket is $v_r(-dm/dt)$
- Velocity of a Rocket at any time is $v = u - gt + v_1 \ln(m_0/m)$

Topic - 7: Rotational Motion

- Angular Momentum $\vec{L} = \vec{r} \times \vec{p} = I\vec{\omega}$ where I is the Moment of Inertia
- Torque $\vec{\tau} = \vec{r} \times \vec{F} = d\vec{L}/dt$
- Rotational Kinetic Energy $K = I\omega^2/2 = L^2/2I$
- Rotational Power $P = \vec{\tau} \cdot \vec{\omega}$
- Equations of Motion are $\omega = \omega_0 + \alpha t, \theta = \omega_0 t + \alpha t^2/2$ and $\omega^2 = \omega_0^2 + 2\alpha\theta$
- The nth angular displacement is $\theta_n - \theta_{n-1} = \omega_0 + \alpha(2n-1)/2$
- Moment of Inertia $I = \sum_{i=1}^{n} m_i r_i^2$ in discrete case and $I = \int r^2 dm$
- Radius of Gyration is $k = \sqrt{I/M}$
- Parallel Axis Theorem $I_{axis} = I_{CM} + Md^2$
- Perpendicular Axis Theorem $I_z = I_x + I_y$
- Moment of Inertia of some common objects -
  - Rod of mass M and length L along its center $I = ML^2/12$
  - Rod of mass M and length L along its corner $I = ML^2/3$
  - Rectangular Lamina of mass M, length L and width W along its width $I = ML^2/12$
  - Rectangular Lamina of mass M, length L and width W along its length $I = MW^2/12$
  - Rectangular Lamina of mass M, length L and width W along its center $I = M(L^2 + W^2)/12$
  - Ring of radius R along a normal to the plane passing through the center $I = MR^2$
  - Disc of radius R along a normal to the plane passing through the center $I = MR^2/2$
  - Circular Hollow Disc of inner radius r and outer radius R along a normal to the plane passing through the center $I = M(r^2 + R^2)/2$
  - Hollow Cylinder of radius R along its length passing through the center $I = MR^2$
  - Hollow Cylinder of length L and radius R along the normal to its length and passing through the center $I = M(L^2 + 6R^2)/12$
  - Solid Cylinder of radius R along its length $I = MR^2/2$

- Solid Cylinder of length L and radius R along the normal to its length and passing through the center $I=M(L^2+3R^2)/12$
- Hollow Sphere of radius R along its center $I=2MR^2/3$
- Solid Sphere of radius R along its center $I=2MR^2/5$

- Total Kinetic Energy of Rolling Motion is $K=[mv_{CM}^2+I\omega^2]/2$
- Total Angular Momentum of Rolling Motion is $L=mv_{CM}R+I\omega$
- Pure Rolling without slipping on stationary surface -
  - $v_{CM}=R\omega$ and $a_{CM}=R\alpha$
  - Forward Slipping happens when $v_{Cm}>R\omega$
  - Backward Slipping happens when $v_{CM}<R\omega$
  - Total Kinetic Energy is $K=(1/2)mv_{CM}^2(1+k^2/R^2)$
- Formulas for Pure Rolling Motion in Inclined Plane with mass M, radius R and inclination θ -
  - Acceleration $a=gR^2\sin\theta/(k^2+R^2)$
  - Minimum Frictional Coefficient $\mu=k^2\tan\theta/(k^2+R^2)$
- Work Done by Torque is $W=\int\tau\cdot d\theta$

Topic - 8: Gravitation

- Newton's Law of Gravitation is $F=Gm_1m_2/R^2$ where $G\approx 6.67*10^{-11}\,Nm^2/kg^2$
- Gravitational Field is GM/R^2
- Gravitational Field outside a Spherical Shell is $-GM/r^2$ where $r>R$
- Gravitational Field on the Surface of the Spherical Shell is $-GM/R^2$
- Gravitational Field inside the Spherical Shell is 0
- Gravitational Field outside a Solid Sphere is $-GM/r^2$ where $r>R$
- Gravitational Field inside a Solid Sphere is $-GMr/R^3$ where $r<R$
- Acceleration due to gravity is $g=GM/R^2$
- Acceleration due to gravity at height h above the surface is $g_h=g(1-2h/R)$ when $h<<<R$
- Acceleration due to gravity at depth d from the surface is $g_d=g(1-d/R)$
- Acceleration due to gravity at latitude λ is $g_\lambda=g-\omega^2R\cos^2\lambda$
- Gravitational Potential due to a point mass is $V=-GM/r$
- Gravitational Potential inside a Spherical Shell is 0
- Gravitational Potential outside the Spherical Shell is $V=-GM/r$ where $r>R$
- Gravitational Potential inside a Solid Sphere is $V=-GM(3R^2-r^2)/2R^3$ where $r<R$
- Potential of a thin ring on the axis at a distance r is $V=-GM/\sqrt{R^2+r^2}$
- Escape Velocity from a planet is $v=\sqrt{2GM/R}$
- Orbital Velocity of a satellite is $v=\sqrt{GM/r}$ where $r>R$
- Time Period of a satellite is $T=2\pi*r\sqrt{r}/\sqrt{GM}$
- Potential Energy of a point mass at a distance from the center of object is $U=-GMm/r$
- Kinetic Energy of a satellite is $K=GMm/2r$
- Mechanical Energy of a satellite is $E=-GMm/2r$
- Kepler's 3rd Law of Planetary Motion is $T^2=ka^3$ where a is the length of semi-major axis

Topic- 9: Solid Mechanics

- Stress is the Ratio of Internal Restoring Force per unit Area of Cross-Section
- Strain is the Ratio of change in size of the object to its original size

- Hooke's Law within elastic limit is $Stress \propto Strain$
- Young's Modulus $Y=(F/A)/(\Delta L/L)$
- Increment in length due to its own weight $\Delta L=\rho g l^2/2Y$
- Bulk Modulus $\kappa=-\Delta P/(\Delta V/V)$
- Compressibility is the reciprocal of Bulk Modulus
- Modulus of Rigidity $\eta=(F/A)/\phi$
- Poisson's Ratio $\sigma=Lateral\ Strain/Longitudinal\ Strain=-(\Delta D/D)\div(\Delta L/L)$
- Work Done on a wire is $W=(1/2)*Stress*Strain*Volume=F\Delta L/2$

Topic - 10: Fluid Mechanics

- Mass Density is $\rho=Mass\div Volume$
- Specific Weight is $Weight\div Volume=\rho g$
- Relative Density is $Density\ of\ Liquid\div Density\ of\ Pure\ Water\ at\ 4C^O$
- Density of a mixture with variable Volume is $\rho=\sum_{k=1}^{n} m_k\div\sum_{k=1}^{n}(m/\rho)_k$
- Density of a mixture with variable Mass is $\rho=\sum_{k=1}^{n} V_k\rho_k\div\sum_{k=1}^{n} V_k$
- Pressure $P=Normal\ Force\div Area$
- Difference of Pressure in depth h is $\Delta P=h\rho g$
- Gauge Pressure at depth h of a liquid when placed in an elevator is $\Delta P=h\rho(g\pm a)$
- Gauge Pressure between two points on same level at a distance of l when the liquid is accelerated by a is $\Delta P=\rho l a$
- Rotating Cylinder along the length and passing through the center, th extra height is $h=(\omega r)^2/2g$
- Pascal's Law: $F_1\div A_1=F_2\div A_2$
- $Absolute\ Pressure=Atmospheric\ Pressure+Gauge\ Pressure$
- Atmospheric Pressure is $P_{atm}=101325\ N/m^2$
- Buoyant Force is the Weight of Displaced Fluid, $BF=V\rho g$
- Equation of Continuity is $A_1v_1=A_2v_2$
- Bernoulli's Theorem is $P+\rho v^2/2+\rho gh=Constant$
- Principle of Venturimeter is $v=A_2\sqrt{2gh/(A_1^2-A_2^2)}$
- Velocity of Efflux is $v=\sqrt{2gh}$
- Horizontal Range of Efflux is $R=2\sqrt{h(H-h)}$
- Surface Tension is Force per unit Length, $T=F/l$
- Surface Energy is $S=T\Delta A$
- Excess Pressure for water droplet is $2T/R$
- Excess Pressure for soap bubble is $4T/R$
- Height of Capillary Rise $h=2T\cos\theta/\rho rg$
- Height of Capillary Rise after correction $h=[2T\cos\theta/\rho rg]-(r/3)$
- Newton's Law of Viscosity is $F=\eta A(dv/dx)$
- Stoke's Law is $F=6\pi\eta rv$
- Poiseuille's Formula is $Q=\pi pr^4/(8\eta L)$
- Terminal Velocity is $v_T=2r^2(\rho-\sigma)g/9\eta$
- Reynold's Number is $R_e=\rho vd/\eta$

Topic - 11: Thermal Physics and Thermodynamics

- Linear Expansion $l=l0(1+\alpha\Delta T)$
- Areal Expansion $A=A0(1+\beta\Delta T)$
- Volume Expansion $V=V0(1+\gamma\Delta T)$
- Fractional Change in Time Period of a Simple Pendulum is $\alpha\Delta T/2$
- Thermal Strain $\Delta l/l=\alpha\Delta T$
- Thermal Stress $F/A=Y\alpha\Delta T$
- Coefficient of Volume Expansion in Gases is $\gamma=1/T$
- Heat Capacity of a body is $H=Q/\Delta T$
- Specifc Heat Capacity is $s=Q/m\Delta T$
- Molar Heat Capacity is $Q/n\Delta T$
- Latent Heat $L=Q/m$
- Rate of Heat Flow is $\frac{dQ}{dt}=-KA\frac{dT}{dx}$
- Thermal Resistance $RT=l/KA$
- Coefficient of Thermal Conduction in Series Connection is $K=\sum_{i=1}^{n} l_i \div \sum_{i=1}^{n} l_i/K_i$
- Coefficient of Thermal Conduction in Parallel Connection is $K=\sum_{i=1}^{n} K_iA_i \div \sum_{i=1}^{n} A_i$
- Stefan-Boltzmann's Law says $I=e\sigma T^4$ where I is the Intensity and $e\in[0,1]$
- Prevost's Theory of Heat Enrgy Exchange is $I_{net}=e\sigma(T^4-T_0^4)$
- Newton's law of Cooling is $-dT/dt\propto(T-T_0)$ or $T=T_0+(T_i-T_0)exp(-kt)$
- Newton's Law of Cooling for small temerature difference is $\frac{T1-T2}{t}=k[\frac{T_1+T_2}{2}-T0]$
- Wien's Displacement Law $\lambda_{max}=b/T$ where $b\approx2.89\times10^{-3}mK$
- Solar Constant $S=(R/r)^2\sigma T^4$
- Mayer's Formula $CP=Cv+R$
- Average Distance between two consecutive collisions is $\lambda=\frac{1}{\sqrt{2}\pi d^2 n}$
- Mixture of Non-Reacting Gases -
  - Molecular Weight $M_{mix}=\sum_{k=1}^{N} n_kW_k\div\sum_{k=1}^{N} n_k$
  - Specific Heat Capacity at constant Volume is $s_V=\sum_{k=1}^{N} n_k(s_V)_k\div\sum_{k=1}^{N} n_k$
  - Specific Heat Capacity at constant Pressure is $s_V=\sum_{k=1}^{N} n_k(s_P)_k\div\sum_{k=1}^{N} n_k$
  - $\frac{n}{\gamma-1}=\frac{n1}{\gamma1-1}+\frac{n2}{\gamma2-1}+\frac{n3}{\gamma3-1}+\ldots+\frac{n_k}{\gamma k-1}$
- Molar Heat Capacity for any polytropic process is $C=C_V+\frac{R}{1-x}$
- First Law of Thermodynamics is $Q_{supplied}=W_{by\ system}+\Delta U$
- Work Done by the System is $W=\int_{V1}^{V2} P\,dV$
- For Adiabatic Process $PV^\gamma=Constant$ and $W=(P1V1-P2V2)/(\gamma-1)$
- For Isothermal Process $PV=Constant$ and $W=nRTln(V2/V1)$
- For Isobaric Prcess $W=nR\Delta T$
- Efficiency of a Carnot Cycle is $\eta=1-\frac{T_1}{T_2}$
- Coefficient of Performance is $\beta=\frac{T_2}{T_1-T_2}$

- Isothrmal Bulk Modulus of Gases is $\kappa = -V \frac{\partial P}{\partial V}$
- Adiabatic Bulk Modulus of Gases is $\kappa = -\gamma V \frac{\partial P}{\partial V}$

Topic - 12: Oscillations and Waves

- Angular Frequency $\omega = \sqrt{\frac{k}{m}}$
- Equation for Linear SHM is $\frac{d^2 x}{dt^2} + \omega^2 x = 0$
- Equation for Angular SHM is $\frac{d^2 \theta}{dt^2} + \omega^2 \theta = 0$
- Displacement in SHM is $x = A\sin(\omega t + \phi)$
- Velocity of a particle in SHM is $v = A\omega\cos(\omega t + \phi) = \omega\sqrt{A^2 - x^2}$
- Acceleration of a particle in SHM is $a = -A\omega^2\sin(\omega t + \phi) = -\omega^2 x$
- Kinetic Energy of a particle in SHM is $K = kA^2\cos^2(\omega t + \phi)/2$
- Potential Energy ofa particle in SHM is $U = kA^2\sin^2(\omega t + \phi)$
- Total Energy of a particle in SHM is $E = K + U = (1/2)kA^2$
- Time Period in a Spring Block System is $T = 2\pi\sqrt{\frac{m}{k}}$
- Time Period in a Combined Spring Block System is $T = 2\pi\sqrt{\frac{\mu}{k}}$ where μ is the reduced mass
- Time Period in a Series combination of springs is $T = 2\pi\sqrt{\frac{m}{??}}$ where ?? is the effective Spring Constant, that is $\frac{1}{??} = \frac{1}{k1} + \frac{1}{k2} + \frac{1}{k_3} + \ldots + \frac{1}{kn}$
- Time Period in a Series combination of springs is $T = 2\pi\sqrt{\frac{m}{??}}$ where ?? is the effective Spring Constant, that is $?? = k1 + k2 + k3 + \ldots + kn$
- Time Period of a Simple Pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$
- Time Period of a Physics Pendulum is $T = 2\pi\sqrt{\frac{\lambda l}{g}}$ where $\lambda = \frac{Moment\ of\ Inertia}{ml^2}$
- Time Perod of a Conical Penduum is $T = 2\pi\sqrt{\frac{l\cos\theta}{g}}$
- Time Period of a Tortional Pendulum is $T = 2\pi\sqrt{\frac{I}{k}}$

- Time Period for an SHM in a U-Tube Manometer is $T=2\pi\sqrt{\frac{h}{g}}$ where h is the height
- Time Period of a particle in SHM in a tunnel inside te Earth is $T=2\pi\sqrt{\frac{R}{g}}$
- Equation of a Damped Oscillation is $\frac{d^2x}{dt^2} + \omega^2 x + \frac{b}{m} v = 0$
- Displacement due to Damped Oscillation is $x=A\exp(-bt/2m)\sin(??t+\phi)$
- Angular Velocity in Damped Oscillation is ?? = $\sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$
- Total Energy in Damped Oscillation is $E=(1/2)kA^2\exp(-bt/m)$
- Equation of any wave in 2-D is $\frac{\partial^2 y}{\partial t^2} = v^2 \frac{\partial^2 y}{\partial x^2}$
- Equation of a Plane Progressive Wve in 2-D is $y=A\sin(\omega t-kx)$ where $k=2\pi/\lambda$
- Velocity of a wave is $v=\omega/k$
- Velocity of the particle is $v_P=\partial y/\partial t=A\omega\cos(\omega t-kx)$
- $v_P= -v(dy/dx)$
- Particle Acceleration is $\partial^2 y/\partial t^2= -A\omega^2\sin(\omega t-kx)$
- Relation between Phase Difference, Path Difference and Time Difference is $\frac{\Delta\phi}{2\pi} = \frac{\Delta\lambda}{\lambda} = \frac{\Delta T}{T}$
- Kinetic Energy per unit volume is $(1/2)\rho v^2$

$P=(1/2)\rho\omega A^2\cos^2(\omega t-kx)$

- Potential Energy per unit volume is $(1/2)\rho\omega^2A^2\cos^2(\omega t-kx)$
- Total Energy per unit volume is $\rho\omega^2A^2\cos^2(\omega t-kx)$
- Power of a wave is $P=(1/2)\rho\omega^2A^2vS$ where S is the Area of Cross-Section
- Intensity of a wave is $(1/2)\rho\omega^2A^2v$
- Speed of a transverse wave on string $v=\sqrt{T/\mu}$
- Interference of two waves -
  - For amplitude $A=\sqrt{A_1^2+A_2^2+2A_1A_2\cos\varphi}$
  - For intensity $I=I_1+I_2+2\sqrt{I_1I_2}\cos\varphi$
  - For constructive Interference, $\Delta\lambda=n\lambda$ or $\Delta\varphi=2n\pi$ and $I_{max} = (\sqrt{I_1}+\sqrt{I_2})^2$
  - For Destructive Interference, $\Delta\varphi=(2n+1)\pi$ and $I_{min} =(\sqrt{I_1}-\sqrt{I_2})^2$
  - Degree of Hearing is $\frac{(I_{max}/I_{min})-1}{(I_{max}/I_{min})+1}\times 100$ where ν is the frequency
- Amplitude of Reflected Wave is $A_r = \frac{v_2-v_1}{v_2+v_1}A_i$
- Amplitude of Trnasmitted Wave is $A_t = \frac{2v_2}{v_2+v_1}A_i$
- nth harmonic in stationary string wave is $f=nv/2l$ (fixed at both ends)
- $(2k-1)$th harmonic in stationary wave is $f=(2k-1)v/4l$ (fixed at one end)
- Velocity of Sound Wave with elasticity E is $v=\sqrt{E/\rho}$
- Newton’s Formula for Sound Waves $v=\sqrt{P/\rho}$

- Laplace Correction to Newton's Fomula $v=\sqrt{\gamma P/\rho}$
- Equation of a Pressure Wave is $p=ABk\cos(\omega t-kx)$
- Frequency in a Closed End Organ Pipe is $f=(2k-1)v/4l$ for $(2k-1)^{th}$ *harmonic*
- Error Correction in Closed End Organ Pipe is 1 $f=v/4(l+0.6R)$
- Frequency of an Open End organ Pipe is $f=nv/2l$ for *nth harmonic*
- Error Correction in Open End Organ Pipe is 1 $f=v/2(l+1.2R)$
- Wavelength of a Resonating Tube is $\lambda=2(l_2-l_1)$
- End Correction in a Resonating Tube is $e=(l_2-3l_1)/2$
- Loudness of Sound (in dB) is $\beta = 10\log(I/I_0)$
- Doppler's Effect $f'=\frac{v+v_0}{v-v_s}\times f$

Topic - 13: Electrostatics

- Coulomb's Law $F=\frac{1}{4\pi\epsilon_0}\cdot\frac{q_1q_2}{r^2}$
- Principle of Supreposition $\vec{F}=\vec{F}_1+\vec{F}_2+\vec{F}_3+...+\vec{F}_n$
- Electric Field $\vec{E}=\vec{F}/q$
- Electric Field due to a point charge is $\vec{E}=\frac{1}{4\pi\epsilon_0}\cdot\frac{q}{r^2}\hat{r}$
- Equilibrium of charges for an Equilateral Triangle is $q_0=-q/\sqrt{3}$
- Equilbrium of charges for a Square is $q_0=-q(2\sqrt{2}+1)/4$
- Equilbrium of two charges hanging from a point through thread $T\cos\theta=mg$ *and* $T\sin\theta=Fe$
- Electric Potential $V=-\int_{-\infty}^{a}\vec{E}\cdot d\vec{r}$ or $\vec{E}=-\vec{\nabla}V$
- Electric Potential for a point charge is $V=\frac{1}{4\pi\epsilon_0}\frac{q}{r}$
- Electric Potential Energy of two charges $U=\frac{1}{4\pi\epsilon_0}\cdot\frac{q_1q_2}{r}$
- Electric Dipole Moment $p=q\times2a$ where $2a$ is the total length of the dipole
- Torque on an electric dipole in a uniform electric field is $\vec{\tau}=\vec{p}\times\vec{E}$
- Potential Energy stored in a dipole in a uniform electric field is $U=-\vec{p}\cdot\vec{E}$
- Electric Field at Axial Point is $\vec{E}=\frac{1}{4\pi\epsilon_0}\cdot\frac{2\vec{p}}{r^3}$
- Electric Field at Equitorial Point is $\vec{E}=\frac{1}{4\pi\epsilon_0}\cdot\frac{-\vec{p}}{r^3}$
- Electric Field at any point due to an electric dipole is $E=\frac{1}{4\pi\epsilon_0}\cdot\frac{p\sqrt{1+3\cos^2\theta}}{r^3}$
- Electric Potential at any point due to an electric dipole is $V=\frac{1}{4\pi\epsilon_0}\cdot\frac{p\cos\theta}{r^2}$
- Total Potential Energy due to many charges is $U=U_{self}+\sum_{i\neq j=1}^{n}\frac{1}{4\pi\epsilon_0}\cdot\frac{q_iq_j}{r}$

- Electric Flux and Gauss's Law $\phi = \oint_S \vec{E} \cdot d\vec{A} = \frac{q_{enclosed}}{\epsilon_0}$
- Electric Field due to a charged spherical shell when $r \geq R$ is $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{r^2}$
- Electric Field due to a charged spherical shell when $r<R$ is $E=0$
- Electric Field due to a non-conducting sphere when $r \geq R$ is $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{r^2}$
- Electric Field due to a non-conducting sphere when $r < R$ is $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q r}{R^3}$
- Electric Potential due to a charged spherical shell when $r \geq R$ is $V = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$
- Electric Potential due to a charged spherical shell when $r<R$ is $V = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q}{R}$
- Electric Potential due to a non-conducting spherical when $r \geq R$ is $V = \frac{1}{4\pi\epsilon_0 r} \cdot Q$
- Electric Potential due to a non-conducting spherical when $r < R$ is $V = \frac{1}{4\pi\epsilon_0} \cdot \frac{Q(3R^2 - r^2)}{2R^3}$
- Electric Field due to a charged ring at Axial Point is $E = \frac{1}{4\pi\epsilon_0} \cdot \frac{q x}{(x^2 + R^2)^{3/2}}$
- Electric Potential due to a charged ring at Axial Point is $V = \frac{1}{4\pi\epsilon_0} \cdot \frac{q}{\sqrt{x^2 + R^2}}$
- Electric Field due to a charged infinite cylinder is $E = \frac{1}{4\pi\epsilon_0} \frac{2\lambda}{r}$ where $r \geq R$ and λ is the Linear Charge Density
- Electric Field due to an infinite charged plane is $E=\sigma/2\epsilon_0$ where σ is the Surface Charge Density
- Energy Density in Elctric Field is $u_E = \epsilon_0 E^2/2$
- Electric Field just outside any conductor is $E=\sigma/\epsilon_0$

Topic - 14: Capacitance and Capacitors

- Capacitance $C=Q/V$
- Capacitance of an isolated sphere $C=4\pi\epsilon R$
- Capacitance of a Spherical Capacitor is $C=4\pi\epsilon\, ab/(b-a)$
- Capacitance of a Parallel Plate Capacitor is $C=\epsilon A/d$
- Capacitance of a Parallel Plate capacitors when Dielectric of thickness t is used is $C = \frac{\epsilon_0 A}{d-(t-t/\kappa)}$ where κ is the Dielectric Constant
- Capacitance of a Parallel Plate Capacitor with different dielctrics is $$C = \frac{\epsilon_0 A}{\sum_{p=1}^{n} t_p/\kappa_p}$$
- Capacitance of a cylindrical capacitor is $C = \frac{2\pi\epsilon}{ln(b/a)}$

- Capacitance of capacitors in series is $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots + \frac{1}{C_n}$
- Capacitance of a capacitors in parallel is $C = C1 + C2 + C3 + \ldots + Cn$
- Energy stored in charged capacitor is $U = CV2/2 = QV/2 = Q2/2C$
- Common Potential du to sharing of charges between two capacitors is $V = \frac{\sum_{k=1}^{n} C_k V_k}{\sum_{k=1}^{n} C_k}$
- Force of Attraction between two capacitor plates is $F = Q2/(2\epsilon 0A)$

Topic - 15: Current Electricity

- Charge $I = Q/t$ or $= dq/dt$
- Charge Density $J = I/A$ or $I = \int J \cdot dA$ or $J = \sigma$?→?→
- Drift Velocity $v_d = \mu E$
- Drift Current $I = neAv_d$
- Resistivity $\rho = RA/l$
- Dependence of Resistance on Temperature $R = R0(1 + \alpha\theta)$
- Ohm's Law $V = IR$
- Kirchhoff's Current Law $\sum I_{inwards} = \sum Ioutwards$
- Kirchhoff's Voltage Law $\sum Voltage = 0$
- Resistance in Series $R = R_1 + R_2 + R_3 + \ldots + R_n$
- Resistance in Parallel $\frac{1}{R} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R_3} + \ldots + \frac{1}{Rn}$
- EMF of a cell with its internal resistance is $VAB = \frac{E}{R+r}$
- Cells in Series Connection $I = \frac{nE}{R+nr}$
- Cells in Parallel Connection $I = \frac{E}{R+(r/m)}$
- Cells in Series and Parallel Connection $I = \frac{mE}{R+(mr/n)}$
- Principle of Wheatstone Bridge is $\frac{P}{Q} = \frac{R}{S}$
- Meter Bridge Principle $S = \frac{100-l}{l} \cdot R$
- Potentiometer Principle $\frac{E_1}{E_2} = \frac{l_1}{l_2}$
- Shunt Resistance for Ammeter is $S = \frac{IgRg}{I-Ig}$
- Shunt Resistance for Voltmeter is $S = \frac{V}{Ig} - G$
- Electrical Power is $P = VI = V^2/R = I^2 R$
- Joule's Law of Heating $W = VIt = I^2Rt$ or $W = \int_0^t I^2 R \, dt$

- Power for Series Combination $\frac{1}{P} = \frac{1}{P1} + \frac{1}{P2} + \frac{1}{P3} + \ldots + \frac{1}{Pn}$
- Power for Parallel Connection $P=P_1+P2+P_3+\ldots+P_n$

Topic - 16: Magnetic Effects of Current and Magnetism

- Biot-Savart Law $d?\vec{?} = \frac{\mu}{4\pi} \cdot \frac{I(dl \times ??)}{r^2}$ or $dB = \frac{\mu}{4\pi} \cdot \frac{I \cdot dl \cdot \sin\theta}{r^2}$
- $\mu0=4\pi\times10^{-7}\,H/m$
- For moving charge $d?\vec{?} = \frac{\mu}{4\pi} \cdot \frac{q(?\vec{?} \times ??)}{r^2}$
- Magnetic Field due to current carrying straight conductor is $B = \frac{\mu0I}{4\pi R}(sin\alpha_1 + sin\alpha2)$
- Magnetic Field due to current carrying infinite wire is $B = \frac{\mu0\ I}{2\pi R}$
- Magnetic Field due to circular wire carrying current (at center) is $B = \frac{\mu0\ I}{2R}$
- Magnetic Field due to circular wire carrying current (at axis) is $B = \frac{\mu_0\ IR2}{2(x2+R2)3/2}$
- Magnetic Field due to circular arc at its center is $B = \frac{\mu0}{4\pi}\frac{I}{R}\theta$
- Magnetic Field due to infinite solid cylinder is $B = \frac{\mu0}{4\pi}\frac{2Ir}{R2}$ where $r<R$
- Magnetic Induction due to Solenoid is $B=\mu0nI$ where $n=N/2\pi R$
- Magnetic Field due to a current carrying sheet is $B=\mu0I/2$
- Ampere's Law $\oint_L ?\vec{?} \cdot dl = \mu_0 I_{enclosed}$
- Lorentz Force $F = q?\vec{?} + q(v \times ?\vec{?})$
- When charged particle moves undeviated then $v=E/B$
- Magnetic Force on a moving charge is $F = q(v \times \vec{??})$ $or\ F=q\ B\ vsin\theta$
- Magnetic Force due to current carrying wire is $F = I(l \times \vec{??})$ $or\ F=I\ B\ lsin\theta$
- Force per unit length of parallel wire carrying current is $f = \frac{\mu0}{4\pi}\frac{2I1I2}{d}$
- Torque on a magnetic dipole is $\tau = \vec{??} \times \vec{??}$ where $\vec{??}$ is the magnetic moment of dipole
- For a moving coil galvanometer $I=k\theta/NAB$
- Force on a magnetic dipole in a non-uniform magnetic field is $|F| = |m\ \frac{\partial B}{\partial r}|$
- Current produced by a rotating charge is $I=q\omega/2\pi$
- Magnetic Moment due to a rotting charge is $m=q\omega R2/2$
- Magnetic Field at Axial Position of a magnetic dipole is $?\vec{?} = \frac{\mu_0}{4\pi} \cdot \frac{2?\vec{?}}{r^3}$
- Magnetic Field at Equatorial Point of a magnetic dipole is $?\vec{?} = \frac{\mu_0}{4\pi} \cdot \frac{-?\vec{?}}{r^3}$

- Magnetic Field at any point due to a magnetic dipole is $B = \frac{\mu_0}{4\pi} \cdot \frac{m\sqrt{1+3\cos^2\theta}}{r^3}$
- Magnetic Potential due to magnetic dipole is $V = \frac{\mu_0}{4\pi} \cdot \frac{m\cos\theta}{r^2}$
- Potential Energy of a magnetic dipole in a uniform magnetic field is $U = -?^{\rightarrow}?^{\rightarrow} \cdot ?^{\rightarrow}?^{\rightarrow}$
- Magnetic Induction ?▯?▯ =▯?▯?▯ and Magnetic Permeability ▯=▯/▯
- Magnetic Susceptibility $\chi = \mu_r - 1$
- Curie-Weiss Law says $\chi_m \propto \frac{1}{T - T_C}$ for Ferromagnetic materials
- $\frac{F(magnetic)}{F(electric)} = \frac{v^2}{c^2}$

Topic - 17: Electromagnetic Induction

- Magnetic Flux $\phi = ?? \cdot A$ for uniform Magnetic Field
- Magnetic Flux $\phi = \int$?▯?▯ ▯▯▯ for variable Magnetic Field
- Faraday's Law of Electromagnetic Induction $EMF \propto d\phi/dt$
- Lenz's Law of Electromagnetic Induction $EMF = -d\phi/dt$
- EMF induced in a straight conductor in uniform Magnetic Field is $EMF = Blv\sin\theta$
- EMF induced in a rotating rod is $EMF = B\omega L^2/2$
- Self Inductance $L = \phi/I$
- Self induced EMF is $EMF = -L*dI/dt$
- Series combination of inductors $L = L_1 + L_2 + L_3 ... + L_n$
- Parallel combination of inductors $1/L = 1/L_1 + 1/L_2 + 1/L_3 + ... + 1/L_n$
- For Transformers $EMF \propto Voltage$
- Efficiency of a Transformer is $\eta = Output\ Power \div Input\ Power$
- Magnetic Field due to Solenoid is $B = \mu nI$
- Self Inductance of a Solenoid is $L = \mu_0 n^2 AL$
- Growth of Current in L-R Circuit $I = (EMF \div R)[1 - exp(-Rt/L)]$
- Current Decay $I = I_0\ exp(-Rt/L)$

Topic - 18: Alternating Current and EM Waves

- $I_{avg} = \frac{\int_0^T I\,dt}{\int_0^T dt}$
- $I_{RMS} = \sqrt{\frac{\int_0^T I^2\,dt}{\int_0^T dt}}$
- If $V = V_0\sin(\omega t)$ then $V_{avg} = 2V_0/\pi$ and $V_{RMS} = V_0/\sqrt{2}$
- If $I = I_0\sin(\omega t)$ then $I_{avg} = 2I_0/\pi$ and $I_{RMS} = I_0/\sqrt{2}$
- Impedance of an LCR Circuit is $Z = \sqrt{R^2 + (X_L - X_C)^2}$
- $Power\ Factor = \cos\phi = R/Z$
- Energy in an LC Circuit is $E = LI^2/2$

- For Series LCR Circuit $\frac{d^2\phi}{dt^2} + \frac{R}{L}\cdot\frac{dq}{dt} + \frac{q}{LC} = \frac{V_0}{L}\cos(\omega t)$
- For Parallel LCR Circuit $\frac{d^2\phi}{dt^2} + \frac{1}{RC}\cdot\frac{d\phi}{dt} + \frac{\phi}{LC} = \frac{V_0}{2C}\sin(\omega t)$
- Poynting Vector $S = (1/\mu_0)(\vec{?}\times\vec{?})$
- Maxwell correction for Ampere's Law is $\oint \vec{?}\cdot dl = \mu_0[I_c + \epsilon_0(d\phi/dt)]$

Topic - 19: Ray Optics and Wave Optics

- Reflection in Vector Form is ??=??–2(??·??)??
- Number of images in inclined mirror is $360^0/n$
- Mirror Formula $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$
- Transverse Magnification $m = h_2/h_1 = -v/u$
- Optical Power $P = 1/f$
- Law of Refraction in Vector Form is $(e \times \vec{?})\cdot r = 0$
- Snell's Law $\mu_{21} = \sin i \div \sin r$
- Lateral Shift is $x = t\sin(i-r) \div \cos r$
- Apparent Shift is $\Delta x = t(1 - 1/\mu)$
- Critical Angle in Total Internal Reflection is $i_C = \sin^{-1}(\mu_r/\mu_i)$
- Angle of Deviation in Prism is $\delta = (i_1 + i_2) - (r_1 + r_2)$ and $A = r_1 + r_2$
- When $\delta = \delta_{min}$ then $i_1 = i_2$ and $r_1 = r_2$, therefore $\mu_{glass} = \frac{\sin[(A+\delta_{min})/2]}{\sin(A/2)}$
- For small angles Prism, $\frac{\delta_v - \delta_r}{\delta_y} = \frac{\mu_v - \mu_r}{\mu - 1}$ where $\mu = (\mu_v + \mu_r)/2$
- For the Refraction at Spherical Surface $\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$
- Lens Makers Formula $\frac{1}{f} = (\mu - 1)[\frac{1}{R_1} - \frac{1}{R_2}]$
- Lens Formula $\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$
- Magnification of Lens is $m = v/u$
- Power of a Lens is $P = 1/f$
- For the combination of Lens placed in contact to each other $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$
- Newton's Formula for Lens $f = \sqrt{Distance\ of\ Object\ from\ Focus * Distance\ of\ Image\ from\ Focus}$

Topic - 20: Modern Physics

- Energy of a Photon is $E = h\nu$
- Linear Momentum of a Photon is $p = h/\lambda$
- Intensity of Light is $I = P/A$
- Pressure on perfectly reflecting surface is $P = 2I/c$
- Pressure on perfectly absorbing surface is $P = I/c$

- Einstein's Photoelectric Equation is $h\nu = K + W_0$
- Stopping Potential $V_0 = K_{max}/e$
- De Broglie wavelength $\lambda = h/mv$
- Kinetic Energy of a particle is $K = p^2/2m$
- Momentum of a particle is $\sqrt{2mK}$
- For Bohr Atomic Model, $mvr = nh/2\pi$
- Radius of nth Circular Orbit is $r = [0.529\, n^2/Z]\, \mathring{A}$
- Energy of an electron in nth orbit is $E = (-13.6\, Z^2/n^2)\, eV$ and Binding Energy is $B = -E$
- The formula for Wave Number is $\underline{\lambda} = R[n^{-2}_1 - n^{-2}_2]$ where R is the Rydberg's constant
- For X-Rays $\lambda_{min} \approx [12400/V]\, \mathring{A}$
- Moseley's Law for Characteristic Spectrum $\sqrt{v} = a(Z-b)$
- Bragg's Law for Diffraction $n\lambda = 2d\sin\theta$
- Mass Defect in nuclear Fusion is $\Delta m = [\text{Mass of Reactants} - \text{Mass of Products}]$
- Law of Radioactive Decay $N = N_0 \exp(-kt)$ where k is the Decay Constant
- Half-Life of a Radioactive material $t = \ln 2/k$
- Number of Nuclei left after n Half-Life is $N = N_0/2^n$
- Mass-Energy Equivalence $E = mc^2$
- Radius of a Nucleus is $R = (1.3 * 10^{-15})A^{1/3}$
- Radioactive Disintegration with Succession $N = (\alpha/k)(1 - \exp(-kt))$

Topic - 21: Semiconductors and Communication System

- Number of Electrons reaching from Valence Band to Conduction Band is $n = AT^{3/2} \exp(-\Delta E/2kT)$
- Mass-Action Law is $n^2 = n_e * n_h$
- Conductivity $\sigma = ne(\mu_e + \mu_h)$
- Form Factor $f = I_{RMS} \div I_{DC}$
- Form Factor for Half Wave Rectifier is $\pi/2$
- Form Factor for Full Wave Rectifier is $\pi/2\sqrt{2}$
- Ripple Factor is $r = I_{AC} \div I_{DC}$
- Ripple Factor for Half Wave Rectifier is $r \approx 1.21$
- Ripple Factor for Half Wave Rectifier is $r \approx 0.48$
- Rectifier Efficiency is $n = P_{DC} \div P_{AC}$