NCERT Physics Formula Book
Classes 11 & 12

Compiled from NCERT Textbooks

Physical Constants and Units

Fundamental Physical Constants

Constant	Symbol	Value
Speed of light in vacuum	c	3×10^{8} m/s
Gravitational constant	G	6.674×10^{-11} N m^2/kg^2
Planck's constant	h	6.626×10^{-34} J s
Boltzmann constant	k_B	1.381×10^{-23} J/K
Avogadro's number	N_A	6.022×10^{23} mol^{-1}
Charge of electron	e	1.602×10^{-19} C
Mass of electron	m_e	9.109×10^{-31} kg
Mass of proton	m_p	1.673×10^{-27} kg
Permittivity of free space	ϵ_0	8.854×10^{-12} C^2/N m^2
Permeability of free space	μ_0	$4\pi \times 10^{-7}$ T m/A
Universal gas constant	R	8.314 J/mol K
Stefan-Boltzmann constant	σ	5.670×10^{-8} W/m^2 K^4

Unit Prefixes and Conversions

Prefix	Symbol	Value
pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
kilo	k	10^{3}
mega	M	10^{6}
giga	G	10^{9}

Chapter 1

Class 11 Physics Formulas

1.1 Physical World and Measurement

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

Definition: Expression showing how and which fundamental quantities represent a physical quantity.

Dimensional Analysis: Principle of homogeneity

Definition: Physical equation is dimensionally correct if dimensions of all terms are same.

Significant Figures Rules:

- All non-zero digits are significant
- Zeros between non-zero digits are significant
- Leading zeros are not significant
- Trailing zeros with decimal are significant

Absolute Error: $\Delta a = |a_{\text{mean}} - a_i|$

Definition: Magnitude of difference between individual measurement and true value.

Relative Error: $\dfrac{\Delta a}{a_{\text{mean}}}$

Definition: Ratio of absolute error to true value.

Percentage Error: $\dfrac{\Delta a}{a_{\text{mean}}} \times 100\%$

Definition: Relative error expressed as percentage.

1.2 Kinematics

Displacement: $\Delta x = x_2 - x_1$

Definition: Change in position of an object; vector quantity.

Velocity: $v = \dfrac{dx}{dt}$

Definition: Rate of change of displacement with time.

Acceleration: $a = \dfrac{dv}{dt} = \dfrac{d^2x}{dt^2}$

Definition: Rate of change of velocity with time.

First Equation of Motion: $v = u + at$

Definition: Final velocity equals initial velocity plus acceleration times time.

Second Equation of Motion: $s = ut + \dfrac{1}{2}at^2$

Definition: Displacement equals initial velocity times time plus half acceleration times time squared.

Third Equation of Motion: $v^2 = u^2 + 2as$

Definition: Square of final velocity equals square of initial velocity plus twice acceleration times displacement.

Position Vector: $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

Definition: Vector representing position of particle in coordinate system.

Velocity Vector: $\vec{v} = \dfrac{d\vec{r}}{dt}$

Definition: Rate of change of position vector.

Acceleration Vector: $\vec{a} = \dfrac{d\vec{v}}{dt}$

Definition: Rate of change of velocity vector.

Horizontal Position (Projectile): $x = u\cos\theta \cdot t$

Definition: Horizontal distance covered by projectile.

Vertical Position (Projectile): $y = u\sin\theta \cdot t - \dfrac{1}{2}gt^2$

Definition: Vertical distance covered by projectile.

Time of Flight: $T = \dfrac{2u \sin \theta}{g}$

Definition: Total time projectile remains in air.

Maximum Height: $H = \dfrac{u^2 \sin^2 \theta}{2g}$

Definition: Maximum vertical height reached by projectile.

Range: $R = \dfrac{u^2 \sin 2\theta}{g}$

Definition: Horizontal distance covered during time of flight.

1.3 Laws of Motion

Newton's First Law: $\sum \vec{F} = 0 \Rightarrow \vec{v} = \text{constant}$

Definition: A body continues in its state of rest or uniform motion unless compelled by external force.

Newton's Second Law: $\vec{F} = m\vec{a}$

Definition: Force equals mass times acceleration; rate of change of momentum.

Newton's Third Law: $\vec{F}_{AB} = -\vec{F}_{BA}$

Definition: To every action, there is equal and opposite reaction.

Friction: $f \leq \mu N$

Definition: Force opposing relative motion between surfaces; μ is coefficient of friction.

Centripetal Force: $F_c = \dfrac{mv^2}{r} = m\omega^2 r$

Definition: Force directed towards center for circular motion.

1.4 Work, Energy and Power

Work: $W = \vec{F} \cdot \vec{s} = Fs \cos \theta$

Definition: Dot product of force and displacement; scalar quantity.

Kinetic Energy: $K = \frac{1}{2}mv^2$

Definition: Energy possessed by body due to its motion.

Potential Energy: $U = mgh$ (gravity)

Definition: Energy possessed by body due to its position or configuration.

Work-Energy Theorem: $W = \Delta K$

Definition: Work done by net force equals change in kinetic energy.

Conservation of Mechanical Energy: $K_i + U_i = K_f + U_f$

Definition: Total mechanical energy remains constant in conservative system.

Power: $P = \frac{dW}{dt} = \vec{F} \cdot \vec{v}$

Definition: Rate of doing work; work done per unit time.

1.5 Motion of System of Particles and Rigid Body

Center of Mass: $\vec{R}_{CM} = \frac{\sum m_i \vec{r}_i}{\sum m_i}$

Definition: Point where entire mass can be considered concentrated.

Linear Momentum: $\vec{p} = m\vec{v}$

Definition: Product of mass and velocity; vector quantity.

Angular Momentum: $\vec{L} = \vec{r} \times \vec{p}$

Definition: Rotational analogue of linear momentum.

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

Definition: Moment of force; causes rotational motion.

Moment of Inertia: $I = \sum m_i r_i^2$

Definition: Measure of resistance to rotational motion.

Parallel Axis Theorem: $I = I_{CM} + Md^2$

Definition: Moment of inertia about any axis equals that about parallel axis through CM plus mass times square of distance between axes.

Perpendicular Axis Theorem: $I_z = I_x + I_y$

Definition: For laminar objects, moment of inertia about z-axis equals sum of moments about x and y axes.

Kinetic Energy of Rotation: $K = \frac{1}{2}I\omega^2$

Definition: Energy due to rotational motion.

1.6 Gravitation

Newton's Law of Gravitation: $F = G\frac{m_1 m_2}{r^2}$

Definition: Every particle attracts every other particle with force proportional to product of masses and inversely proportional to square of distance.

Gravitational Field: $E = \frac{F}{m} = -\frac{GM}{r^2}\hat{r}$

Definition: Force per unit mass experienced by test mass.

Gravitational Potential: $V = -\frac{GM}{r}$

Definition: Work done in bringing unit mass from infinity to that point.

Gravitational Potential Energy: $U = -\frac{GMm}{r}$

Definition: Work done in assembling system against gravitational force.

Escape Velocity: $v_e = \sqrt{\frac{2GM}{R}}$

Definition: Minimum velocity required to escape gravitational field.

Orbital Velocity: $v_o = \sqrt{\frac{GM}{r}}$

Definition: Velocity required for satellite to maintain circular orbit.

Kepler's Third Law: $\frac{T^2}{R^3} = \text{constant}$

Definition: Square of orbital period proportional to cube of semi-major axis.

1.7 Properties of Bulk Matter

Stress: $\sigma = \dfrac{F}{A}$

Definition: Restoring force per unit area; measured in $\mathrm{N/m^2}$ or Pascal.

Strain: $\epsilon = \dfrac{\Delta L}{L}$

Definition: Ratio of change in dimension to original dimension; dimensionless.

Young's Modulus: $Y = \dfrac{\text{Stress}}{\text{Strain}}$

Definition: Ratio of tensile stress to tensile strain; measures stiffness.

Hooke's Law: $F = -kx$

Definition: Force proportional to displacement; valid within elastic limit.

Pressure: $P = \dfrac{F}{A}$

Definition: Normal force per unit area.

Pascal's Law: $P_1 = P_2$

Definition: Pressure applied to enclosed fluid transmitted undiminished to every portion.

Bernoulli's Equation: $P + \dfrac{1}{2}\rho v^2 + \rho g h = \text{constant}$

Definition: For ideal fluid flow, sum of pressure, kinetic and potential energy per unit volume remains constant.

Viscosity: $F = \eta A \dfrac{dv}{dx}$

Definition: Internal friction in fluids; η is coefficient of viscosity.

Stoke's Law: $F = 6\pi\eta r v$

Definition: Drag force on sphere moving through viscous fluid.

Thermal Expansion: $\Delta L = \alpha L \Delta T$

Definition: Change in length proportional to original length and temperature change.

Heat Transfer: $Q = mc\Delta T$

Definition: Heat energy equals mass times specific heat times temperature change.

Calorimetry Principle: $m_1 c_1 \Delta T_1 = m_2 c_2 \Delta T_2$

Definition: Heat lost equals heat gained in thermal equilibrium.

Stefan's Law: $P = \sigma A e T^4$

Definition: Power radiated proportional to fourth power of absolute temperature.

1.8 Thermodynamics

First Law of Thermodynamics: $\Delta U = Q - W$

Definition: Change in internal energy equals heat added minus work done by system.

Work: $W = \int P dV$

Definition: Work done in volume change; area under P-V curve.

Isothermal Process: $PV = \text{constant}$

Definition: Process at constant temperature.

Adiabatic Process: $PV^\gamma = \text{constant}$

Definition: Process with no heat exchange.

Efficiency: $\eta = 1 - \dfrac{Q_2}{Q_1}$

Definition: Ratio of work output to heat input in heat engine.

1.9 Kinetic Theory of Gases

Pressure: $P = \dfrac{1}{3}\rho \bar{v}^2$

Definition: Pressure due to molecular collisions with walls.

Kinetic Energy: $\dfrac{1}{2} m \bar{v}^2 = \dfrac{3}{2} k_B T$

Definition: Average kinetic energy per molecule proportional to absolute temperature.

RMS Speed: $v_{rms} = \sqrt{\dfrac{3 k_B T}{m}}$

Definition: Root mean square speed of gas molecules.

Mean Free Path: $\lambda = \dfrac{1}{\sqrt{2}\pi d^2 n}$

Definition: Average distance traveled by molecule between successive collisions.

1.10 Oscillations and Waves

Simple Harmonic Motion: $x = A\sin(\omega t + \phi)$

Definition: Motion where acceleration proportional to displacement and directed towards mean position.

Velocity in SHM: $v = \omega\sqrt{A^2 - x^2}$

Definition: Velocity as function of displacement.

Acceleration in SHM: $a = -\omega^2 x$

Definition: Acceleration proportional to negative displacement.

Spring Period: $T = 2\pi\sqrt{\dfrac{m}{k}}$

Definition: Time period for mass-spring system.

Pendulum Period: $T = 2\pi\sqrt{\dfrac{l}{g}}$

Definition: Time period for simple pendulum.

Wave Equation: $y = f(x \pm vt)$

Definition: General equation representing wave motion.

Progressive Wave: $y = A\sin(kx \pm \omega t)$

Definition: Wave traveling through medium.

Wave Number: $k = \dfrac{2\pi}{\lambda}$

Definition: Spatial frequency of wave.

Angular Frequency: $\omega = 2\pi f$

Definition: Rate of change of phase with time.

Wave Speed: $v = f\lambda$

Definition: Speed at which wave propagates.

Chapter 2

Class 12 Physics Formulas

2.1 Electric Charges and Fields

Coulomb's Law: $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

Definition: Force between two point charges proportional to product of charges and inversely proportional to square of distance.

Electric Field: $\vec{E} = \frac{\vec{F}}{q}$

Definition: Force experienced per unit positive test charge.

Electric Dipole Moment: $\vec{p} = q\vec{d}$

Definition: Product of charge and separation between charges; vector from negative to positive.

Electric Flux: $\phi = \vec{E} \cdot \vec{A}$

Definition: Dot product of electric field and area vector.

Gauss's Law: $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$

Definition: Total electric flux through closed surface equals charge enclosed divided by ϵ_0.

2.2 Electrostatic Potential and Capacitance

Potential: $V = \frac{U}{q}$

Definition: Work done per unit charge in bringing test charge from infinity.

Potential Difference: $V_B - V_A = -\int_A^B \vec{E} \cdot d\vec{l}$

Definition: Work done per unit charge in moving between two points.

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

Definition: Ratio of charge stored to potential difference.

Parallel Plate Capacitor: $C = \frac{\epsilon_0 A}{d}$

Definition: Capacitance for parallel plates separated by distance d.

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

Definition: Work done in charging capacitor.

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

Definition: Reciprocal of equivalent capacitance equals sum of reciprocals.

Parallel Combination: $C_{eq} = C_1 + C_2$

Definition: Equivalent capacitance equals sum of individual capacitances.

2.3 Current Electricity

Electric Current: $I = \frac{dQ}{dt}$

Definition: Rate of flow of charge.

Ohm's Law: $V = IR$

Definition: Potential difference proportional to current; R is constant.

Resistance: $R = \rho\frac{l}{A}$

Definition: Opposition to current flow; ρ is resistivity.

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

Definition: Rate of electrical energy consumption.

Kirchhoff's Junction Rule: $\sum I = 0$

Definition: Algebraic sum of currents at junction is zero.

Kirchhoff's Loop Rule: $\sum V = 0$

Definition: Algebraic sum of potential differences around closed loop is zero.

Wheatstone Bridge: $\frac{P}{Q} = \frac{R}{S}$

Definition: Bridge balanced when ratio of resistances in arms equals.

2.4 Moving Charges and Magnetism

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

Definition: Force on charged particle in electromagnetic field.

Magnetic Field: $\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \vec{r}}{r^3}$

Definition: Field produced by current element.

Biot-Savart Law

Definition: Magnetic field due to current element proportional to current, length and sine of angle.

Ampere's Circuital Law: $\oint \vec{B} \cdot d\vec{l} = \mu_0 I$

Definition: Line integral of magnetic field around closed path equals μ_0 times current enclosed.

Solenoid Field: $B = \mu_0 n I$

Definition: Magnetic field inside long solenoid.

Torque on Loop: $\tau = NIAB \sin\theta$

Definition: Torque experienced by current loop in magnetic field.

2.5 Magnetism and Matter

Magnetic Moment: $\vec{m} = I\vec{A}$

Definition: Product of current and area vector of loop.

Gauss's Law for Magnetism: $\oint \vec{B} \cdot d\vec{A} = 0$

Definition: Net magnetic flux through any closed surface is zero.

Magnetic Susceptibility: $\chi_m = \frac{M}{H}$

Definition: Ratio of magnetization to magnetic field intensity.

2.6 Electromagnetic Induction

Faraday's Law: $\epsilon = -\frac{d\phi}{dt}$

Definition: Induced emf proportional to rate of change of magnetic flux.

Lenz's Law

Definition: Direction of induced current opposes change producing it.

Motional EMF: $\epsilon = Blv$

Definition: emf induced in conductor moving in magnetic field.

Self Inductance: $\phi = LI$

Definition: Magnetic flux proportional to current through circuit.

Mutual Inductance: $\phi_2 = MI_1$

Definition: Magnetic flux in one coil proportional to current in nearby coil.

2.7 Alternating Current

AC Voltage: $V = V_m \sin \omega t$

Definition: Sinusoidally varying voltage.

AC Current: $I = I_m \sin(\omega t + \phi)$

Definition: Sinusoidally varying current with phase difference.

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

Definition: Total opposition to AC flow.

Resonance: $\omega = \frac{1}{\sqrt{LC}}$

Definition: Condition when inductive and capacitive reactances cancel.

Power Factor: $\cos\phi = \dfrac{R}{Z}$

Definition: Ratio of resistance to impedance; measures power efficiency.

2.8 Electromagnetic Waves

Maxwell's Equations

Definition: Set of four equations describing electricity, magnetism and their relationship.

Speed of EM Waves: $c = \dfrac{1}{\sqrt{\mu_0 \epsilon_0}}$

Definition: Speed of electromagnetic waves in vacuum.

Wave Equation: $\dfrac{\partial^2 E}{\partial x^2} = \mu_0 \epsilon_0 \dfrac{\partial^2 E}{\partial t^2}$

Definition: Differential equation describing wave propagation.

2.9 Ray Optics and Optical Instruments

Reflection Law: $\angle i = \angle r$

Definition: Angle of incidence equals angle of reflection.

Refraction Law: $n_1 \sin i = n_2 \sin r$

Definition: Snell's law relating angles and refractive indices.

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

Definition: Relationship between focal length, object and image distances.

Magnification: $m = \dfrac{h_i}{h_o} = \dfrac{v}{u}$

Definition: Ratio of image height to object height.

Lens Power: $P = \dfrac{1}{f}$

Definition: Ability of lens to converge or diverge light; measured in dioptre.

2.10 Wave Optics

Young's Experiment: $\beta = \dfrac{\lambda D}{d}$

Definition: Fringe width in interference pattern.

Diffraction: $a \sin\theta = n\lambda$

Definition: Condition for minima in single slit diffraction.

Brewster's Law: $\tan i_p = \mu$

Definition: Angle of incidence for complete polarization.

Malus Law: $I = I_0 \cos^2\theta$

Definition: Intensity of polarized light after passing through analyzer.

2.11 Dual Nature of Radiation and Matter

Photoelectric Effect: $h\nu = h\nu_0 + \dfrac{1}{2}mv_{max}^2$

Definition: Einstein's equation: photon energy equals work function plus maximum kinetic energy.

de Broglie Wavelength: $\lambda = \dfrac{h}{p}$

Definition: Wavelength associated with moving particle.

2.12 Atoms and Nuclei

Bohr's Quantization: $mvr = n\dfrac{h}{2\pi}$

Definition: Angular momentum quantized in integral multiples of h/2 .

Rydberg Formula: $\dfrac{1}{\lambda} = R\left(\dfrac{1}{n_1^2} - \dfrac{1}{n_2^2}\right)$

Definition: Formula for wavelengths in hydrogen spectrum.

Binding Energy: $B.E. = [Zm_p + (A-Z)m_n - M]c^2$

Definition: Energy equivalent to mass defect in nucleus.