SUBJECT

Physics

MODULE

Class 11 & 12 Formula Vault & Numerical Shortcuts

WEIGHTAGE

180 Marks Complete Compendium

CURRICULUM

NCERT Rationalized

NEET 2027 Physics Master Formula & Shortcut Handbook

Prepared by NEETnova Academic Council & Kota Senior Faculty Panel * 100% Aligned with Official NTA & NMC Guidelines

1. EXECUTIVE OVERVIEW & STRATEGIC FOUNDATION

This master handbook condenses all essential formulas, standard results, derivations, and numerical shortcuts across Class 11 and 12 Physics into an actionable, high-yield compendium. Specially formulated for NEET 2027 aspirants, it enables rapid daily active recall, dimensional analysis shortcuts, and negative marking elimination in the 45 physics numericals.

2. NCERT LINE-BY-LINE COMPREHENSIVE STUDY MODULE

2.1 Kinematics & Mechanics Golden Results

Mechanics forms the backbone of physics. For constant acceleration: $v = u + at$, $s = ut + 0.5at^2$, $v^2 = u^2 + 2as$. For motion under gravity, stopping distance d is proportional to u^2. For a projectile launched at angle θ with speed u: Maximum Height $H = (u^2 \sin^2\theta)/(2g)$, Time of flight $T = (2u \sin\theta)/g$, Horizontal Range $R = (u^2 \sin 2\theta)/g$. Range is identical for complementary angles θ and $(90° - \theta)$.

- Kinematics: $v = u + at$, $s = ut + (1/2)at^2$, $v^2 = u^2 + 2as$, $s_{nth} = u + (a/2)(2n - 1)$
- Projectile Motion: $H = (u^2 \sin^2\theta)/(2g)$, $T = (2u \sin\theta)/g$, $R = (u^2 \sin 2\theta)/g$
- Complementary Angles: Range $R(\theta) = R(90° - \theta)$; at $\theta = 45°$, $R_{max} = u^2/g$ and $H = R_{max} / 4$
- Relative Velocity: $v_{AB} = v_A - v_B$; Minimum distance of approach when relative velocity is perpendicular

NCERT LINE HIGHLIGHT: Projectile range is maximum at $\theta = 45°$, where $R_{max} = u^2 / g$ and $H = R_{max} / 4$.

2.2 Laws of Motion, Friction & Circular Dynamics

Newton Second Law: $F = dp/dt = m(dv/dt) + v(dm/dt)$ (rocket propulsion). Friction: $f_s <= \mu_s * N$, $f_k = \mu_k * N$. Angle of repose equals angle of friction: $\tan(\theta) = \mu$. Centripetal force $F_c = mv^2/r = m\omega^2 r$. Safe banking speed without friction: $v = \sqrt{(rg \tan \theta)}$; with friction: $v_{max} = \sqrt{[rg (\mu + \tan \theta)/(1 - \mu \tan \theta)]}$.

- Newton Laws: $F_{net} = dp/dt$; Impulse $J = \Delta p = \int F\, dt = F_{avg} * \Delta t$
- Friction: Static friction is self-adjusting up to $f_{max} = \mu_s N$; Kinetic friction $f_k = \mu_k N$

- Circular Banking: $v_{opt} = \sqrt{rg \tan \theta}$; Conical pendulum period $T = 2\pi \sqrt{L \cos \theta / g}$
- Vertical Circle: Minimum speed at bottom for full loop $v_{bot} = \sqrt{5gr}$; at top $v_{top} = \sqrt{gr}$

NCERT LINE HIGHLIGHT: Work done by static friction on a pure rolling body without slipping is strictly zero.

2.3 Work, Energy, Power & Rotational Mechanics

Work-Energy Theorem states $W_{net} = \Delta K = 0.5m(v^2 - u^2)$, valid for both conservative and non-conservative forces. Conservative force relation: $F = -dU/dx$. Potential energy of spring: $U = 0.5kx^2$. Rotational dynamics: Torque $\tau = I\alpha = r \times F$. Angular momentum $L = I\omega = r \times p$. Conservation of angular momentum holds when external torque is zero.

- Work-Energy Theorem: $W_{conservative} + W_{non\text{-}conservative} + W_{external} = \Delta K$
- Power: $P = dW/dt = F \cdot v$; Average power P_{avg} = Total Work / Total Time
- Moment of Inertia: Parallel axis theorem $I = I_{cm} + Md^2$; Perpendicular axis theorem $I_z = I_x + I_y$ (planar bodies)
- Rolling Kinetic Energy: $K_{total} = K_{trans} + K_{rot} = (1/2)Mv^2 [1 + k^2/R^2]$

NCERT LINE HIGHLIGHT: For a body rolling down an incline of angle θ: Acceleration $a = (g \sin \theta) / (1 + k^2/R^2)$.

2.4 Gravitation, Fluid Mechanics & Thermal Physics

Gravitational field: $g(h) = g(1 - 2h/R)$ for $h << R$; $g(d) = g(1 - d/R)$ at depth d. Escape velocity $v_e = \sqrt{2GM/R} = \sqrt{2gR} \approx 11.2$ km/s. Orbital velocity $v_o = \sqrt{GM/R} = v_e / \sqrt{2}$. Kepler Third Law: $T^2 \propto r^3$. Fluid dynamics: Continuity equation $A_1v_1 = A_2v_2$; Bernoulli theorem $P + 0.5\rho v^2 + \rho gh$ = constant. Thermal physics: First law of thermodynamics $\Delta Q = \Delta U + \Delta W = n C_v \Delta T + P \Delta V$.

- Gravitation: $F = GMm/r^2$; Potential energy $U = -GMm/r$; Escape speed $v_e = \sqrt{2gR}$
- Fluids: Terminal velocity $v_t = 2r^2(\rho - \sigma)g / (9\eta)$; Excess pressure in soap bubble $\Delta P = 4T/R$ (drop: $2T/R$)
- Thermodynamics: Work in isothermal $W = nRT \ln(V_2/V_1)$; Work in adiabatic $W = (P_1V_1 - P_2V_2) / (\gamma - 1)$
- Molar Heat Capacities: $C_p - C_v = R$ (Mayer relation); $\gamma = C_p / C_v = 1 + 2/f$ (f: degrees of freedom)

NCERT LINE HIGHLIGHT: Internal energy of an ideal gas depends solely on temperature: $\Delta U = n C_v \Delta T$ regardless of the process path.

2.5 Electrostatics, Current Electricity & Circuits

Coulomb Law: $F = (1/(4\pi\varepsilon_0)) * (q_1q_2/r^2)$. Electric field of dipole on axial line: $E_{axial} = (2kp)/r^3$, on equatorial line: $E_{eq} = kp/r^3$. Capacitance: $C = \varepsilon_0 A/d$; with dielectric slab of constant K: $C = K*C_0$. Current electricity: $I = nA e v_d$. Resistivity: $\rho = m / (n e^2 \tau)$. Kirchhoff Current Law (KCL) conserves charge; Kirchhoff Voltage Law (KVL) conserves energy. Wheatstone bridge balanced when $P/Q = R/S$.

- Coulomb Law: $F = kq_1q_2/r^2$ where $k = 1/(4\pi\varepsilon_0) = 9 \times 10^9$ N m^2 C^{-2}
- Capacitor Energy: $U = (1/2)CV^2 = Q^2/(2C) = (1/2)QV$; Energy density $u = (1/2)\varepsilon_0 E^2$
- Drift Velocity: $v_d = eE\tau/m$; Current $I = n A e v_d$; Conductivity $\sigma = n e^2 \tau / m$
- Cells in Series & Parallel: $E_{eq} = (E_1/r_1 + E_2/r_2)/(1/r_1 + 1/r_2)$ for parallel combination of cells

NCERT LINE HIGHLIGHT: Drift velocity of electrons v_d is on the order of 10^{-4} m/s, yet electrical signals propagate at nearly the speed of light.

2.6 Optics: Geometric Ray Optics & Wave Optics

Mirror formula: $1/f = 1/v + 1/u$. Lens formula: $1/f = 1/v - 1/u$. Lens Maker Formula: $1/f = (\mu - 1)[(1/R_1) - (1/R_2)]$. Power of lens: $P = 1/f$(in meters) in Diopters. Prism minimum deviation: $\mu = \sin((A + \delta_m)/2) / \sin(A/2)$. Wave optics: Young Double Slit Experiment (YDSE) fringe width $\beta = (\lambda * D) / d$. Fringe width is independent of order of fringe.

- Lens Maker Formula: $1/f = (\mu_{lens}/\mu_{med} - 1)[1/R_1 - 1/R_2]$; Sign conventions mandatory
- Combination of Lenses: $P_{eq} = P_1 + P_2 - d \cdot P_1 \cdot P_2$ (in contact: $P_{eq} = P_1 + P_2$)
- Total Internal Reflection: Critical angle $\sin(\theta_c) = \mu_{rarer} / \mu_{denser}$
- YDSE: Fringe width $\beta = \lambda D/d$; Angular fringe width $\theta = \lambda/d$; Phase difference $\varphi = (2\pi/\lambda) \Delta x$

NCERT LINE HIGHLIGHT: When YDSE apparatus is immersed in liquid of refractive index μ, fringe width decreases: $\beta_{new} = \beta / \mu$.

2.7 Modern Physics: High-Scoring Formula Vault

Photoelectric equation: $E = h\nu = W_0 + K_{max} = h\nu_0 + eV_0$. de Broglie wavelength: $\lambda = h / p = h / \sqrt{2mE} = 12.27 / \sqrt{V}$ Å (for electron). Bohr Model: Radius $r_n = 0.529 * (n^2 / Z)$ Å; Energy $E_n = -13.6 * (Z^2 / n^2)$ eV. Nuclear binding energy: $\Delta E = \Delta m * c^2 = (\Delta m$ in amu$) * 931.5$ MeV. Radioactive decay: $N = N_0 e^{(-\lambda t)}$, $t_{1/2} = 0.693 / \lambda$.

- Photoelectric Effect: $K_{max} = eV_0 = h\nu - \varphi_0$; Slope of V_0 vs ν graph is h/e (universal constant)
- de Broglie Wavelength: $\lambda_{electron} = 12.27 / \sqrt{V}$ Å; $\lambda_{proton} = 0.286 / \sqrt{V}$ Å; $\lambda_{neutron} = 0.286 / \sqrt{E}$ (eV) Å
- Bohr Hydrogen Atom: Velocity $v_n = (c/137)(Z/n)$; Frequency of revolution $f_n \propto Z^2/n^3$

- Hydrogen Spectrum: $1/\lambda = R_H Z^2 [1/n_1^2 - 1/n_2^2]$; Lyman (UV, $n_1=1$), Balmer (Visible, $n_1=2$), Paschen (IR, $n_1=3$)

NCERT LINE HIGHLIGHT: Modern Physics accounts for 6 to 8 direct formula-based questions in NEET with the highest score-to-time ratio.

TABLE 2.1: ROTATIONAL MECHANICS MOMENT OF INERTIA MASTER TABLE

Rigid Body Geometry	Axis of Rotation	Moment of Inertia (I)	Radius of Gyration (k)
Circular Ring / Hoop	Central axis perpendicular to plane	$I = M R^2$	$k = R$
Circular Ring / Hoop	Along any diameter	$I = (1/2) M R^2$	$k = R / \sqrt{2}$
Circular Disc	Central axis perpendicular to plane	$I = (1/2) M R^2$	$k = R / \sqrt{2}$
Circular Disc	Along any diameter	$I = (1/4) M R^2$	$k = R / 2$
Solid Sphere	Along any diameter passing through centre	$I = (2/5) M R^2$	$k = \sqrt{(2/5)} R$
Hollow Thin Sphere	Along any diameter passing through centre	$I = (2/3) M R^2$	$k = \sqrt{(2/3)} R$
Thin Uniform Rod (L)	Perpendicular to rod through centre of mass	$I = (1/12) M L^2$	$k = L / \sqrt{12}$
Thin Uniform Rod (L)	Perpendicular to rod through one end	$I = (1/3) M L^2$	$k = L / \sqrt{3}$

TABLE 2.2: THERMODYNAMICS 4 FUNDAMENTAL PROCESSES COMPARISON

Process Type	Condition	Governing Equation	Work Done (W)	First Law Form (ΔQ)
Isothermal	Temp T = const	P V = constant	$W = n R T \ln(V_2/V_1)$	$\Delta Q = W$ (since $\Delta U = 0$)
Isobaric	Pressure P = const	V / T = constant	$W = P (V_2 - V_1) = n R \Delta T$	$\Delta Q = n C_p \Delta T$
Isochoric	Volume V = const	P / T = constant	W = 0 (No work done)	$\Delta Q = \Delta U = n C_v \Delta T$
Adiabatic	Heat ΔQ = 0	P V^γ = constant	$W = (P_1V_1 - P_2V_2)/(\gamma - 1)$	$W = -\Delta U = -n C_v \Delta T$

TABLE 2.3: OPTICS SIGN CONVENTIONS & CHARACTERISTICS MATRIX

Optical Element	Focal Length (f)	Object Position (u)	Image Nature	Magnification (m)
Concave Mirror	Always Negative (-)	u > 2f (Beyond C)	Real, Inverted, Diminished	-1 < m < 0
Concave Mirror	Always Negative (-)	Between F and Pole	Virtual, Erect, Enlarged	m > +1
Convex Mirror	Always Positive (+)	Anywhere in front	Virtual, Erect, Diminished	0 < m < +1
Convex Lens	Always Positive (+)	u > 2f	Real, Inverted, Diminished	-1 < m < 0
Convex Lens	Always Positive (+)	Between F and Optical centre	Virtual, Erect, Enlarged	m > +1
Concave Lens	Always Negative (-)	Anywhere in front	Virtual, Erect, Diminished	0 < m < +1

4. FORMULA VAULT, KEY EQUATIONS & SHORTCUTS

Kinematics Equations

$$v = u + at, \; s = ut + 0.5at^2, \; v^2 = u^2 + 2as$$

u: initial vel, v: final vel, a: acc, s: disp

Projectile Range & Height

$$R = (u^2 \sin 2\theta)/g, \; H = (u^2 \sin^2\theta)/(2g)$$

Range identical for complementary angles θ, (90°-θ)

Work-Energy Theorem

$$W_{net} = \Delta K = 0.5*m*(v^2 - u^2)$$

Valid for all forces (conservative + dissipative)

Gravitational Escape Velocity

$$v_e = \sqrt{2*G*M / R} = \sqrt{2*g*R}$$

Earth escape velocity = 11.2 km/s

Coulomb Electrostatic Law

$$F = (1/(4\pi\varepsilon_0)) * (q_1 q_2 / r^2)$$

$1/(4\pi\varepsilon_0) = 9 \times 10^9$ N m^2 C^{-2}

Drift Velocity & Current

$$I = n*A*e*v_d,\ v_d = (e*E*\tau)/m$$

n: charge density, A: area, τ: relaxation time

Biot-Savart Long Wire Field

$$B = (\mu_0 * I) / (2*\pi*r)$$

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

Lens Maker Formula

$$1/f = (\mu - 1) * [(1/R_1) - (1/R_2)]$$

Sign convention strictly applied on radii R_1, R_2

YDSE Fringe Width

$$\beta = (\lambda * D) / d$$

D: slit-to-screen dist, d: slit separation

Photoelectric Equation

$$h*\nu = W_0 + K_{max} = h*\nu_0 + e*V_0$$

W_0: work function, V_0: stopping potential

de Broglie Wavelength

$$\lambda = h / p = 12.27 / \sqrt{V}\ \text{Å}$$

Shortcut formula for electron accelerated by V volts

Bohr Hydrogen Energy

$$E_n = -13.6 * (Z^2 / n^2)\ \text{eV}$$

Ground state of Hydrogen (n=1) = -13.6 eV

5. STEP-BY-STEP SOLVED NUMERICALS & ILLUSTRATIONS

Illustration 01: Projectile Motion Range & Maximum Height

Problem: A particle is projected with a speed of 40 m/s at an angle of 30° with the horizontal. Calculate (a) Maximum Height, (b) Time of Flight, and (c) Horizontal Range. (Take g = 10 m/s^2)

Strategic Framework: Apply direct kinematic equations for projectile motion: u = 40 m/s, θ = 30°, sin(30°) = 0.5, cos(30°) = √3/2, g = 10 m/s^2.

1. Step 1: Maximum Height: H = $(u^2 \sin^2\theta) / (2g) = (40^2 \times 0.5^2) / (2 \times 10) = (1600 \times 0.25) / 20 = 400 / 20 = 20$ m.
2. Step 2: Time of Flight: T = $(2u \sin\theta) / g = (2 \times 40 \times 0.5) / 10 = 40 / 10 = 4.0$ seconds.
3. Step 3: Horizontal Range: R = $(u^2 \sin 2\theta) / g = (40^2 \times \sin 60°) / 10 = (1600 \times (\sqrt{3}/2)) / 10 = 80\sqrt{3} \approx 138.56$ m.

FINAL ANSWER: H = 20 m | T = 4.0 s | R = 80√3 m (~138.6 m)

Illustration 02: de Broglie Wavelength of Accelerated Charge

Problem: An electron is accelerated from rest through an electric potential difference of 100 Volts. Determine its de Broglie wavelength in Angstroms and meters.

Strategic Framework: Use the standard shortcut formula for an electron: λ = 12.27 / √V Å, where V is in Volts.

1. Step 1: Identify given potential: V = 100 V.
2. Step 2: Compute square root: √V = √100 = 10.
3. Step 3: Calculate wavelength in Angstroms: λ = 12.27 / 10 = 1.227 Å.
4. Step 4: Convert to standard SI meters: 1 Å = 10^{-10} m, so λ = 1.227×10^{-10} m = 0.1227 nm.

FINAL ANSWER: λ = 1.227 Å = 1.227×10^{-10} m

6. HIGH-YIELD NCERT POINTERS & RAPID FIRE CHECKLIST

- [ ] Dimensional analysis can eliminate 2 out of 4 options in over 70% of NEET physics numericals before performing calculations.
- [ ] In pure rolling on a flat surface, work done by friction is ZERO because the instantaneous contact point is at rest.
- [ ] Electric field inside a hollow charged conducting sphere is strictly ZERO everywhere, while potential is constant (V = kQ/R).
- [ ] When light enters a denser medium, frequency remains constant while velocity and wavelength decrease by a factor of refractive index (v = c/μ).
- [ ] The stopping potential in photoelectric effect depends ONLY on frequency of incident light and work function, NOT on intensity.
- [ ] Nuclear density is constant for all nuclei (~2.3×10^{17} kg/m^3) independent of mass number A.

7. NTA EXAM TRAPS & NEGATIVE MARKING ALERTS

Trap: Sign conventions in Optics. Distances in direction of incident light are positive; opposite are negative. Focal length of concave is always negative.

Trap: Mixing CGS and SI units. E.g., leaving mass in grams instead of kg or distance in cm instead of meters in F = ma.

Trap: Angle with vertical vs horizontal. In projectile problems, NTA often gives "angle with vertical = 30°", which means θ with horizontal is 60°.

Trap: Confusion between intensity and frequency. Intensity affects saturation current; frequency affects stopping potential and kinetic energy.

8. MEMORY HACKS & MNEMONICS FOR RAPID RETENTION

Electromagnetic Spectrum in order of increasing frequency: "R-M-I-V-U-X-G" -> Radio, Microwave, Infrared, Visible, Ultraviolet, X-rays, Gamma rays.

Concave vs Convex Lens: "Cave is Diverging, Vex is Converging" -> Concave lens diverges light (f < 0), Convex lens converges light (f > 0).