Complete List of Class 12 Physics Derivations – CBSE / NCERT

Here is a chapter-wise checklist of important derivations for Class 12 Physics, useful for **CBSE Boards, JEE and NEET**.

I have arranged them according to the NCERT chapter sequence so that you can use this as a revision checklist.

Chapter 1: Electric Charges and Fields

1. Derivation of electric field due to a point charge.
2. Electric field due to an electric dipole on the axial line.
3. Electric field due to an electric dipole on the equatorial line.
4. Torque experienced by an electric dipole in a uniform electric field.
5. Derivation of electric flux.
6. Gauss's law and its mathematical expression.
7. Electric field due to an infinitely long straight charged wire using Gauss's law.
8. Electric field due to an infinite plane sheet of charge using Gauss's law.
9. Electric field due to a uniformly charged thin spherical shell (inside and outside).

Chapter 2: Electrostatic Potential and Capacitance

1. Electric potential due to a point charge.
2. Electric potential due to an electric dipole.
3. Electric potential due to a system of charges.
4. Relation between electric field and potential.
5. Potential energy of a system of two point charges.
6. Potential energy of an electric dipole in a uniform electric field.

7. Capacitance of a parallel plate capacitor.
8. Capacitance of a parallel plate capacitor with a dielectric slab.
9. Combination of capacitors in series.
10. Combination of capacitors in parallel.
11. Energy stored in a capacitor.
12. Energy density of an electric field.

Chapter 3: Current Electricity

1. Derivation of current in terms of drift velocity.
2. Relation between drift velocity and electric field.
3. Derivation of Ohm's law using drift velocity.
4. Relation between current density and electric field.
5. Derivation of resistivity in terms of relaxation time.
6. Combination of resistors in series.
7. Combination of resistors in parallel.
8. Cells in series – equivalent EMF and internal resistance.
9. Cells in parallel – equivalent EMF and internal resistance.
10. Wheatstone bridge balance condition.
11. Meter bridge principle.
12. Potentiometer principle.
13. Comparison of EMFs using a potentiometer.
14. Determination of internal resistance of a cell using a potentiometer.

Chapter 4: Moving Charges and Magnetism

1. Magnetic force on a moving charge.
2. Radius of the circular path of a charged particle in a uniform magnetic field.
3. Time period and frequency of a charged particle moving in a magnetic field.
4. Force on a current-carrying conductor in a magnetic field.
5. Biot–Savart law and magnetic field due to a circular current loop.
6. Magnetic field at the centre of a circular current loop.
7. Ampere's circuital law.
8. Magnetic field due to an infinitely long straight current-carrying wire.
9. Magnetic field inside a long solenoid.

10. Force between two parallel current-carrying conductors.
11. Torque on a current loop in a uniform magnetic field.
12. Moving coil galvanometer – principle and working.
13. Conversion of galvanometer into an ammeter.
14. Conversion of galvanometer into a voltmeter.

Chapter 5: Magnetism and Matter

1. Magnetic field on the axial line of a bar magnet.
2. Magnetic field on the equatorial line of a bar magnet.
3. Torque on a magnetic dipole in a uniform magnetic field.
4. Potential energy of a magnetic dipole in a uniform magnetic field.
5. Relation between magnetic susceptibility and relative permeability.

Chapter 6: Electromagnetic Induction

1. Faraday's law of electromagnetic induction.
2. Motional EMF induced in a straight conductor moving in a uniform magnetic field.
3. EMF induced in a rotating rod.
4. Self-inductance of a long solenoid.
5. Mutual inductance of two coaxial solenoids.
6. Energy stored in an inductor.
7. AC generator – derivation of instantaneous EMF.

Chapter 7: Alternating Current

1. Derivation of mean value of alternating current.
2. Derivation of RMS value of alternating current.
3. AC through a pure resistor.
4. AC through a pure inductor.
5. AC through a pure capacitor.
6. Series LCR circuit – impedance.
7. Phase angle in a series LCR circuit.
8. Resonance condition in a series LCR circuit.
9. Average power in an AC circuit.
10. Power factor.

11. Transformer – relation between primary and secondary voltage and current.

Chapter 8: Electromagnetic Waves

1. Displacement current – concept and expression.
2. Modified Ampere's circuital law.
3. Relation between speed of electromagnetic waves and electric and magnetic constants:

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

Chapter 9: Ray Optics and Optical Instruments

1. Relation between focal length and radius of curvature of a spherical mirror.
2. Derivation of mirror formula.
3. Magnification produced by a spherical mirror.
4. Refraction at a spherical surface.
5. Derivation of lens maker's formula.
6. Derivation of thin lens formula.
7. Magnification produced by a thin lens.
8. Combination of thin lenses in contact.
9. Power of a combination of lenses.
10. Critical angle and total internal reflection.
11. Refraction through a prism.
12. Relation between angle of deviation and angle of incidence.
13. Derivation of prism formula at minimum deviation.
14. Magnifying power of a simple microscope.
15. Magnifying power of a compound microscope.
16. Magnifying power of an astronomical telescope (normal adjustment).

Chapter 10: Wave Optics

1. Huygens' principle.
2. Laws of reflection using Huygens' principle.
3. Laws of refraction using Huygens' principle.

4. Young's double-slit experiment.
5. Derivation of path difference in YDSE.
6. Derivation of fringe width in YDSE.
7. Effect of introducing a thin transparent sheet in one path of YDSE.
8. Conditions for constructive and destructive interference.
9. Single-slit diffraction – condition for minima.
10. Width of the central maximum in single-slit diffraction.

Chapter 11: Dual Nature of Radiation and Matter

1. Einstein's photoelectric equation.
2. Relation between stopping potential and frequency.
3. de Broglie wavelength of a moving particle.
4. de Broglie wavelength of an electron accelerated through a potential difference.

Chapter 12: Atoms

1. Distance of closest approach in Rutherford's scattering experiment.
2. Bohr's radius of the nth orbit.
3. Velocity of an electron in the nth orbit.
4. Energy of an electron in the nth orbit.
5. Derivation of the energy difference between two energy levels.
6. Derivation of the Rydberg formula for hydrogen spectrum.

Chapter 13: Nuclei

1. Relation between nuclear radius and mass number.
2. Mass defect and binding energy.
3. Binding energy per nucleon.
4. Radioactive decay law.
5. Relation between half-life and decay constant.
6. Relation between mean life and decay constant.
7. Energy released in nuclear reactions.

Chapter 14: Semiconductor Electronics

1. Formation of depletion region in a p-n junction.
2. Working of a p-n junction diode under forward bias.
3. Working of a p-n junction diode under reverse bias.
4. V-I characteristics of a p-n junction diode.
5. Working of a diode as a rectifier.

Important derivations to prioritise for board examinations

These are particularly important for numerical applications and conceptual understanding:

Chapter	High-priority derivations
Electric Charges and Fields	Dipole field, Gauss's law applications
Electrostatic Potential	Parallel plate capacitor, energy stored
Current Electricity	Drift velocity, Ohm's law, Wheatstone bridge
Moving Charges and Magnetism	Circular loop, solenoid, galvanometer
Magnetism and Matter	Bar magnet as a dipole
Electromagnetic Induction	Motional EMF, self-inductance
Alternating Current	RMS value, LCR impedance, transformer
Ray Optics	Lens maker's formula, lens formula, prism
Wave Optics	YDSE fringe width, diffraction
Dual Nature	Einstein's equation, de Broglie wavelength
Atoms	Bohr radius, velocity and energy
Nuclei	Radioactive decay law, half-life

Chapter	Topic	CBSE requirement
Electrostatic Potential	Energy stored in capacitor	Formula only
Moving Charges	Magnetic field inside solenoid	Qualitative treatment
Magnetism and Matter	Bar magnet field derivations	Qualitative treatment
Electromagnetic Waves	Transverse nature	Qualitative treatment
Wave Optics	YDSE fringe width	Final expression only
Wave Optics	Width of central maximum	Qualitative treatment
Atoms	Hydrogen line spectra	Qualitative treatment
Semiconductors	Energy bands	Qualitative treatment

Class 12 Physics – Complete Chapter-Wise Formula Sheet

For CBSE Boards + JEE + NEET

This formula collection follows the Class 12 NCERT chapter sequence. I have arranged formulas chapter-wise, including important constants, definitions, relationships and numerical formulas.

Chapter 1: Electric Charges and Fields

1. Electric Charge

Quantity	Formula
Quantisation of charge	$q = ne$
Charge on electron	$e = 1.6 \times 10^{-19}\, C$
Conservation of charge	$Q_{\text{initial}} = Q_{\text{final}}$

2. Coulomb's Law

$$F = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2}$$

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

Where:

$$k = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9$$

In a medium:

$$F = \frac{1}{4\pi\epsilon_0 K}\frac{|q_1 q_2|}{r^2}$$

3. Electric Field

$$E = \frac{F}{q_0}$$

Electric field due to a point charge:

$$E = \frac{1}{4\pi\epsilon_0}\frac{|q|}{r^2}$$

Force on a charge:

$$F = qE$$

4. Electric Dipole

Dipole moment:

$$p = q(2a)$$

Direction: negative charge to positive charge.

Axial electric field (far-field approximation):

$$E_{\text{axial}} = \frac{1}{4\pi\epsilon_0}\frac{2p}{r^3}$$

Equatorial electric field (far-field approximation):

$$E_{\text{equatorial}} = \frac{1}{4\pi\epsilon_0}\frac{p}{r^3}$$

The equatorial field is opposite to the dipole moment.

Torque:

$$\tau = pE\sin\theta$$

$$\vec{\tau} = \vec{p} \times \vec{E}$$

5. Electric Flux

$$\Phi_E = EA\cos\theta$$

For a non-uniform field:

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

6. Gauss's Law

$$\boxed{\oint \vec{E} \cdot d\vec{A} = \frac{q_{\text{enclosed}}}{\epsilon_0}}$$

Applications:

Infinite straight charged wire

$$E = \frac{\lambda}{2\pi\epsilon_0 r}$$

Infinite plane sheet

$$E = \frac{\sigma}{2\epsilon_0}$$

Two oppositely charged parallel sheets

$$E = \frac{\sigma}{\epsilon_0}$$

(between the sheets)

Uniformly charged thin spherical shell

Outside:

$$E = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^2}$$

Inside:

$$E = 0$$

Chapter 2: Electrostatic Potential and Capacitance

1. Electric Potential

$$V = \frac{W}{q}$$

Potential due to a point charge:

$$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$$

Potential due to multiple charges:

$$V = \frac{1}{4\pi\epsilon_0}\sum_i \frac{q_i}{r_i}$$

Potential due to an electric dipole:

$$V = \frac{1}{4\pi\epsilon_0}\frac{p\cos\theta}{r^2}$$

(far-field approximation)

2. Relation Between Electric Field and Potential

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

In vector form:

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

3. Potential Energy

Two point charges:

$$U = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r}$$

Electric dipole in uniform electric field:

$$U = -pE\cos\theta$$

4. Capacitance

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

Parallel plate capacitor:

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

With dielectric medium:

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

With dielectric slab of thickness t:

$$C = \frac{\epsilon_0 A}{d - t + \frac{t}{K}}$$

5. Combination of Capacitors

Series combination

$$\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$$

For two capacitors:

$$C_s = \frac{C_1 C_2}{C_1 + C_2}$$

Parallel combination

$$C_p = C_1 + C_2 + C_3 + \cdots$$

6. Energy Stored in a Capacitor

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

$$U = \frac{1}{2}QV$$

$$U = \frac{Q^2}{2C}$$

Energy density:

$$u = \frac{1}{2}\epsilon_0 E^2$$

With dielectric:

$$u = \frac{1}{2}K\epsilon_0 E^2$$

Chapter 3: Current Electricity

1. Electric Current

$$I = \frac{Q}{t}$$

Instantaneous current:

$$I = \frac{dQ}{dt}$$

2. Drift Velocity

$$I = neAv_d$$

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

Drift velocity:

$$v_d = \frac{eE\tau}{m}$$

Current density:

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

$$J = nev_d$$

3. Ohm's Law

$$V = IR$$

Resistance:

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

Conductivity:

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

Microscopic form:

$$J = \sigma E$$

Resistivity:

$$\rho = \frac{m}{ne^2\tau}$$

Mobility:

$$\mu = \frac{v_d}{E} = \frac{e\tau}{m}$$

4. Temperature Dependence of Resistance

$$R_T = R_0[1 + \alpha(T - T_0)]$$

$$\rho_T = \rho_0[1 + \alpha(T - T_0)]$$

5. Combination of Resistors

Series:

$$R_s = R_1 + R_2 + R_3$$

Parallel:

$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

For two resistors:

$$R_p = \frac{R_1 R_2}{R_1 + R_2}$$

6. Electric Power

$$P = VI$$

$$P = I^2 R$$

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

Electrical energy:

$$W = VIt = I^2 Rt$$

7. Cells

Terminal voltage during discharge:

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

During charging:

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

Current:

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

Cells in series (identical cells):

$$\mathcal{E}_{\text{eq}} = n\mathcal{E}$$

$$r_{\text{eq}} = nr$$

Cells in parallel (identical cells):

$$\mathcal{E}_{\text{eq}} = \mathcal{E}$$

$$r_{\text{eq}} = \frac{r}{n}$$

8. Kirchhoff's Laws

Junction rule:

$$\sum I = 0$$

Loop rule:

$$\sum \Delta V = 0$$

9. Wheatstone Bridge

At balance:

$$\frac{P}{Q} = \frac{R}{S}$$

10. Meter Bridge

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

11. Potentiometer

$$V = kl$$

Comparison of EMFs:

$$\frac{\mathcal{E}_1}{\mathcal{E}_2} = \frac{l_1}{l_2}$$

Internal resistance of a cell:

$$r = R\left(\frac{l_1 - l_2}{l_2}\right)$$

Chapter 4: Moving Charges and Magnetism

1. Magnetic Force

Force on a moving charge:

$$F = qvB\sin\theta$$

Lorentz force:

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

Force on a current-carrying conductor:

$$F = BIl\sin\theta$$

2. Motion of Charged Particle in Magnetic Field

Radius of circular path:

$$r = \frac{mv}{qB}$$

Angular velocity:

$$\omega = \frac{qB}{m}$$

Time period:

$$T = \frac{2\pi m}{qB}$$

Frequency:

$$f = \frac{qB}{2\pi m}$$

If velocity has parallel and perpendicular components, the particle follows a helical path.

Pitch of helix:

$$P = v_{\parallel} T$$

3. Biot–Savart Law

$$dB = \frac{\mu_0}{4\pi} \frac{I\, dl \sin\theta}{r^2}$$

Magnetic field at the centre of a circular loop:

$$B = \frac{\mu_0 N I}{2R}$$

At a distance x on the axis:

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

4. Ampere's Circuital Law

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

Magnetic field due to a long straight wire:

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

Magnetic field inside a long solenoid:

$$B = \mu_0 n I$$

where $n = N/l$.

5. Force Between Two Parallel Conductors

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

Same direction currents attract; opposite direction currents repel.

6. Torque on Current Loop

$$\tau = NIAB\sin\theta$$

Magnetic dipole moment:

$$M = NIA$$

$$\tau = MB\sin\theta$$

7. Moving Coil Galvanometer

Current sensitivity:

$$\frac{\theta}{I} = \frac{NAB}{k}$$

Voltage sensitivity:

$$\frac{\theta}{V} = \frac{NAB}{kG}$$

Here G is galvanometer resistance and k is torsional constant.

Conversion into ammeter:

$$S = \frac{I_g G}{I - I_g}$$

Conversion into voltmeter:

$$R = \frac{V}{I_g} - G$$

Chapter 5: Magnetism and Matter

1. Magnetic Dipole

Magnetic dipole moment of a bar magnet:

$$M = m(2l)$$

where m is pole strength and $2l$ is magnetic length.

2. Magnetic Field of a Bar Magnet

For a short bar magnet at a distant point:

Axial line:

$$B_{\text{axial}} = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$$

Equatorial line:

$$B_{\text{equatorial}} = \frac{\mu_0}{4\pi}\frac{M}{r^3}$$

3. Torque and Potential Energy

$$\tau = MB\sin\theta$$

$$U = -MB\cos\theta$$

4. Magnetic Properties of Materials

Magnetisation:

$$M = \frac{\text{Magnetic moment}}{\text{Volume}}$$

Magnetic susceptibility:

$$\chi_m = \frac{M}{H}$$

Relative permeability:

$$\mu_r = 1 + \chi_m$$

Magnetic field:

$$B = \mu_0(H + M)$$

$$B = \mu_0\mu_r H$$

Chapter 6: Electromagnetic Induction

1. Magnetic Flux

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

For a non-uniform magnetic field:

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

2. Faraday's Law

Induced EMF:

$$\boxed{\varepsilon = -\frac{d\Phi_B}{dt}}$$

For a coil of N turns:

$$\varepsilon = -N\frac{d\Phi_B}{dt}$$

Average induced EMF:

$$\varepsilon_{\text{avg}} = -N\frac{\Delta\Phi_B}{\Delta t}$$

Induced current:

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

3. Motional EMF

For a rod moving perpendicular to magnetic field:

$$\varepsilon = Blv$$

If the rod makes an angle:

$$\varepsilon = Blv\sin\theta$$

4. Self-Inductance

$$\varepsilon = -L\frac{dI}{dt}$$

Self-inductance of a long solenoid:

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

With a magnetic core:

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

5. Mutual Inductance

$$\varepsilon_2 = -M \frac{dI_1}{dt}$$

Mutual inductance of two long coaxial solenoids:

$$M = \frac{\mu_0 N_1 N_2 A}{l}$$

6. Energy Stored in an Inductor

$$U = \frac{1}{2} L I^2$$

Energy density:

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

7. AC Generator

Instantaneous EMF:

$$\varepsilon = \varepsilon_0 \sin \omega t$$

Maximum EMF:

$$\varepsilon_0 = NBA\omega$$

Chapter 7: Alternating Current

1. Alternating Current and Voltage

$$I = I_0 \sin \omega t$$

$$V = V_0 \sin \omega t$$

Angular frequency:

$$\omega = 2\pi f$$

Time period:

$$T = \frac{1}{f}$$

2. Mean Value

For a complete cycle:

$$I_{\text{avg}} = 0$$

For half cycle:

$$I_{\text{avg}} = \frac{2I_0}{\pi}$$

3. RMS Value

$$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

4. Pure Resistive Circuit

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{R}$$

Voltage and current are in the same phase.

5. Pure Inductive Circuit

Inductive reactance:

$$X_L = \omega L$$

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{X_L}$$

Current lags voltage by 90°.

6. Pure Capacitive Circuit

Capacitive reactance:

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

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{X_C}$$

Current leads voltage by 90°.

7. Series LCR Circuit

Impedance:

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

$$Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$$

Current:

$$I_{\text{rms}} = \frac{V_{\text{rms}}}{Z}$$

Phase angle:

$$\tan\phi = \frac{X_L - X_C}{R}$$

Power factor:

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

8. Resonance

Resonance condition:

$$X_L = X_C$$

Resonant angular frequency:

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

Resonant frequency:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

At resonance:

$$Z = R$$

$$I_{\max} = \frac{V_{\text{rms}}}{R}$$

9. AC Power

Average power:

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

For a resistor:

$$P = I_{\text{rms}}^2 R$$

Wattless current:

$$P = 0$$

10. Transformer

Ideal transformer:

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

$$\frac{I_s}{I_p} = \frac{N_p}{N_s}$$

Power:

$$V_p I_p = V_s I_s$$

Efficiency:

$$\eta = \frac{\text{Output power}}{\text{Input power}} \times 100$$

Chapter 8: Electromagnetic Waves

1. Displacement Current

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

For a parallel plate capacitor:

$$I_d = \epsilon_0 A \frac{dE}{dt}$$

2. Total Current

$$I = I_c + I_d$$

3. Speed of Electromagnetic Waves

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

$$c = 3 \times 10^8 \; m/s$$

4. Relation Between Electric and Magnetic Fields

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

$$E_0 = cB_0$$

5. Wave Equation

$$c = f\lambda$$

$$c = \nu\lambda$$

6. Energy Density

Electric energy density:

$$u_E = \frac{1}{2}\epsilon_0 E^2$$

Magnetic energy density:

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

For an electromagnetic wave:

$$u_E = u_B$$

Chapter 9: Ray Optics and Optical Instruments

1. Reflection by Spherical Mirrors

Mirror formula:

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

Relation between focal length and radius:

$$f = \frac{R}{2}$$

Magnification:

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

2. Refraction of Light

Refractive index:

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

Snell's law:

$$\mu_1 \sin i = \mu_2 \sin r$$

Relative refractive index:

$$\mu_{21} = \frac{\mu_2}{\mu_1}$$

Apparent depth:

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

3. Total Internal Reflection

Critical angle:

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

For two media:

$$\sin C = \frac{\mu_2}{\mu_1}$$

where $\mu_1 > \mu_2$.

4. Refraction at Spherical Surface

$$\boxed{\frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}}$$

Magnification:

$$m = \frac{h_i}{h_o} = \frac{\mu_1 v}{\mu_2 u}$$

5. Thin Lens Formula

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

Magnification:

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

6. Lens Maker's Formula

For a lens in air:

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

For a lens in a medium:

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

7. Power of Lens

$$P = \frac{1}{f}$$

Here focal length is in metres and power is in dioptres (D).

Combination of lenses in contact:

$$P = P_1 + P_2 + P_3$$

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2}$$

8. Prism

Angle of prism:

$$A = r_1 + r_2$$

Angle of deviation:

$$\delta = i + e - A$$

At minimum deviation:

$$i = e$$

$$r_1 = r_2 = \frac{A}{2}$$

Refractive index:

$$\boxed{\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}}$$

For a thin prism:

$$\delta = (\mu - 1)A$$

9. Simple Microscope

Magnifying power for final image at infinity:

$$M = \frac{D}{f}$$

For final image at near point:

$$M = 1 + \frac{D}{f}$$

10. Compound Microscope

Normal adjustment:

$$M = \frac{L}{f_o} \times \frac{D}{f_e}$$

Final image at near point:

$$M = \frac{L}{f_o}\left(1 + \frac{D}{f_e}\right)$$

11. Astronomical Telescope

Normal adjustment:

$$M = \frac{f_o}{f_e}$$

Length of telescope:

$$L = f_o + f_e$$

Final image at near point:

$$M = \frac{f_o}{f_e}\left(1 + \frac{f_e}{D}\right)$$

Here:

- $D = 25\,cm$ (least distance of distinct vision).
- f_o = focal length of objective.
- f_e = focal length of eyepiece.
- L = length of microscope or telescope, as applicable.

Chapter 10: Wave Optics

1. Wave Equation

$$v = f\lambda$$

For light in vacuum:

$$c = f\lambda$$

2. Phase Difference and Path Difference

$$\phi = \frac{2\pi}{\lambda}\Delta x$$

$$\Delta x = \frac{\lambda\phi}{2\pi}$$

3. Young's Double-Slit Experiment (YDSE)

Path difference:

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

For small angles:

$$\Delta x = \frac{dy}{D}$$

Position of bright fringe:

$$y_n = \frac{n\lambda D}{d}$$

Position of dark fringe:

$$y_n = \frac{(2n-1)\lambda D}{2d}$$

Fringe width:

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

Where:

- D = distance between slit and screen.
- d = distance between two slits.
- λ = wavelength.

4. Constructive Interference

$$\Delta x = n\lambda$$

$$\phi = 2n\pi$$

5. Destructive Interference

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

$$\phi = (2n+1)\pi$$

6. Intensity of Interference

For two waves:

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

Maximum intensity:

$$I_{\max} = (\sqrt{I_1} + \sqrt{I_2})^2$$

Minimum intensity:

$$I_{\min} = (\sqrt{I_1} - \sqrt{I_2})^2$$

For equal intensities:

$$I_{\max} = 4I_0$$

$$I_{\min} = 0$$

7. Single-Slit Diffraction

Condition for minima:

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

Width of central maximum:

$$W = \frac{2D\lambda}{a}$$

Angular width:

$$\theta = \frac{2\lambda}{a}$$

The diffraction-width formulas are useful for JEE/NEET; CBSE specifies qualitative treatment of central maximum width.

Chapter 11: Dual Nature of Radiation and Matter

1. Photon Energy

$$E = h\nu$$

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

Momentum of photon:

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

2. Einstein's Photoelectric Equation

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

$$h\nu = \phi + \frac{1}{2}mv_{\max}^2$$

Maximum kinetic energy:

$$K_{\max} = h\nu - \phi$$

Also:

$$K_{\max} = eV_0$$

Therefore:

$$eV_0 = h\nu - \phi$$

3. Work Function

$$\phi = h\nu_0$$

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

Threshold frequency:

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

Threshold wavelength:

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

4. de Broglie Wavelength

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

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

For a non-relativistic particle:

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

5. Electron Accelerated Through Potential Difference

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

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

For an electron:

$$\boxed{\lambda = \frac{12.27}{\sqrt{V}}\ \mathring{A}}$$

Here V is in volts.

Chapter 12: Atoms

1. Rutherford's Model

Distance of closest approach for a head-on collision:

$$r_0 = \frac{1}{4\pi\epsilon_0}\frac{Zze^2}{K}$$

For an alpha particle:

$$z = 2$$

2. Bohr's Quantisation Condition

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

$$mvr = n\hbar$$

3. Radius of nth Orbit

For hydrogen-like atoms:

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

Where:

$$a_0 = 0.529\ \mathring{A}$$

4. Velocity of Electron

$$v_n = \frac{Z}{n} v_0$$

$$v_0 = 2.18 \times 10^6\ m/s$$

5. Energy of Electron

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

For hydrogen:

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

Kinetic energy:

$$K = -E_n$$

Potential energy:

$$U = 2E_n$$

Total energy:

$$E = K + U = -K$$

6. Energy Difference

$$\Delta E = E_f - E_i$$

Energy of emitted or absorbed photon:

$$h\nu = |E_f - E_i|$$

7. Frequency and Wavelength

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

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

Rydberg formula for hydrogen spectrum (useful for entrance examinations):

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

where $n_2 > n_1$.

Chapter 13: Nuclei

1. Composition of Nucleus

Number of protons:

$$Z$$

Number of neutrons:

$$N = A - Z$$

Mass number:

$$A = Z + N$$

2. Nuclear Radius

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

Where:

$$R_0 \approx 1.2 \times 10^{-15}\ m$$

3. Nuclear Density

$$\rho = \frac{\text{Mass}}{\text{Volume}}$$

$$\rho = \frac{3m}{4\pi R^3}$$

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

$$\rho = \frac{3m}{4\pi R_0^3 A}$$

4. Mass Defect

Using nuclear masses:

$$\Delta m = Z m_p + (A - Z) m_n - M_{\text{nucleus}}$$

Using atomic masses:

$$\Delta m = Z m_H + (A - Z) m_n - M_{\text{atom}}$$

5. Binding Energy

$$BE = \Delta mc^2$$

In MeV:

$$BE = \Delta m(u) \times 931.5\ MeV$$

Binding energy per nucleon:

$$BE/A = \frac{\text{Total binding energy}}{A}$$

6. Energy Released in Nuclear Reaction

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

$$Q = \Delta m \times 931.5\ MeV$$

Positive Q: energy released.

Negative Q: energy absorbed.

Chapter 14: Semiconductor Electronics

1. Semiconductor Diode

Current:

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

Correction: The correct current relation is:

$$I = \frac{Q}{t}$$

Ohm's law (for an ohmic component):

$$V = IR$$

Static resistance:

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

Dynamic resistance:

$$r_d = \frac{\Delta V}{\Delta I}$$

2. Diode Biasing

Forward bias:

- P-side connected to positive terminal.
- N-side connected to negative terminal.
- Depletion layer becomes thinner.

Reverse bias:

- P-side connected to negative terminal.
- N-side connected to positive terminal.
- Depletion layer becomes wider.

3. Rectifier

For an ideal half-wave rectifier:

Average output current:

$$I_{\mathrm{dc}} = \frac{I_0}{\pi}$$

RMS current:

$$I_{\mathrm{rms}} = \frac{I_0}{2}$$

For an ideal full-wave rectifier:

Average output current:

$$I_{\mathrm{dc}} = \frac{2I_0}{\pi}$$

RMS current:

$$I_{\mathrm{rms}} = \frac{I_0}{\sqrt{2}}$$

Rectifier expressions are useful for JEE/NEET and additional practice; the current CBSE syllabus focuses on the diode as a rectifier.

Additional Formulas for JEE/NEET

These are useful entrance-exam formulas, but some are beyond the current CBSE board syllabus.

Radioactive Decay

Radioactive decay law:

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

Activity:

$$A = \lambda N$$

$$A = A_0 e^{-\lambda t}$$

Half-life:

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

Mean life:

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

Number of nuclei remaining:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

Cyclotron

Cyclotron frequency:

$$f = \frac{qB}{2\pi m}$$

Cyclotron time period:

$$T = \frac{2\pi m}{qB}$$

Maximum kinetic energy:

$$K_{\max} = \frac{q^2 B^2 R^2}{2m}$$

Important Physical Constants

Constant	Value
Electronic charge e	$1.6 \times 10^{-19}\ C$
Mass of electron m_e	$9.1 \times 10^{-31}\ kg$
Mass of proton m_p	$1.67 \times 10^{-27}\ kg$
Permittivity ϵ_0	$8.85 \times 10^{-12}\ C^2/Nm^2$
Permeability μ_0	$4\pi \times 10^{-7}\ Tm/A$
Planck's constant h	$6.626 \times 10^{-34}\ Js$
Speed of light c	$3 \times 10^{8}\ m/s$
Boltzmann constant k_B	$1.38 \times 10^{-23}\ J/K$
Avogadro constant N_A	$6.022 \times 10^{23}\ mol^{-1}$
1 atomic mass unit	$931.5\ MeV/c^2$
Rydberg constant R_H	$1.097 \times 10^{7}\ m^{-1}$