

Physics · Last-Hour Cram Sheet

CBSE Class 12 Physics (042) · 2026-27 · Theory

70 + Practical 30 · read this in the last hour,
nothing else

A. The Paper at a Glance

MARKS BY UNIT — straight from the official course structure

Marks	Units	Chapters
16	I Electrostatics + II Current Electricity	1, 2, 3
17	III Magnetic Effects + IV EMI and AC	4, 5, 6, 7
18	V EM Waves + VI Optics	8, 9, 10
12	VII Dual Nature + VIII Atoms and Nuclei	11, 12, 13
7	IX Electronic Devices	14

Optics is the single biggest block. If time is short, Ch 9 and 10 buy the most marks per hour.

B. Every Formula in One Place

ELECTROSTATICS

$$F = kq_1q_2/r^2 \cdot E = kq/r^2 \cdot V = kq/r \cdot E = -dV/dr$$

$$\text{Dipole: } E_{\text{axial}} = 2kp/r^3 \cdot E_{\text{eq}} = kp/r^3 \cdot \tau = pE \sin\theta \cdot U = -pE \cos\theta$$

Gauss: $\varphi = q/\epsilon_0$ · wire $\lambda/2\pi\epsilon_0 r$ · sheet $\sigma/2\epsilon_0$ · shell 0 inside

Capacitor: $C = \epsilon_0 A/d$ · $C' = KC$ · $U = \frac{1}{2}CV^2 = Q^2/2C$

CURRENT ELECTRICITY

$I = neAv_d$ · $v_d = eE\tau/m$ · $R = \rho L/A$ · $\rho = m/ne^2\tau$

$\epsilon = V + Ir$ · $I = \epsilon/(R+r)$ · $P = I^2R = V^2/R$ · Wheatstone $P/Q = R/S$

MAGNETISM, EMI AND AC

$B = \mu_0 I/2\pi r$ (wire) · $\mu_0 NI/2R$ (loop centre) · $\mu_0 nI$ (solenoid)

$F = qvB \sin\theta$ · $F = BIL \sin\theta$ · $r = mv/qB$ · $\tau = NIAB \sin\theta$

$\epsilon = -N d\varphi/dt$ · $\epsilon = Blv$ · $L = \mu_0 n^2 A l$ · $U = \frac{1}{2}LI^2$

$X_L = \omega L$ · $X_C = 1/\omega C$ · $Z = \sqrt{R^2 + (X_L - X_C)^2}$ · $\omega_0 = 1/\sqrt{LC}$

$P = V_{rms} I_{rms} \cos\varphi$ · $V_s/V_p = N_s/N_p = I_p/I_s$

OPTICS

$1/v + 1/u = 1/f$ (mirror, $m = -v/u$) · $1/v - 1/u = 1/f$ (lens, $m = v/u$)

$1/f = (\mu - 1)(1/R_1 - 1/R_2)$ · $P = 1/f$ · $\mu = 1/\sin C$

$$\mu = \sin[(A+D_m)/2]/\sin(A/2) \cdot m_{\text{telescope}} = f_o/f_e$$

$$\beta = D\lambda/d \cdot \text{bright } n\lambda \cdot \text{dark } (2n-1)\lambda/2$$

MODERN PHYSICS

$$h\nu = \varphi_0 + K_{\max} \cdot K_{\max} = eV_0 \cdot \lambda = h/\sqrt{2mqV} \cdot \lambda = 12.27/\sqrt{V} \text{ \AA}$$

$$r_n \propto n^2 \cdot v_n \propto 1/n \cdot E_n = -13.6/n^2 \text{ eV} \cdot 1/\lambda = R(1/n_f^2 - 1/n_i^2)$$

$$R = R_0 A^{1/3} \cdot BE = \Delta m \times 931.5 \text{ MeV}$$

C. Constants Worth Memorising

THE NUMBERS THAT SAVE TIME

k = 1/4πε₀	9×10 ⁹ N m ² C ⁻²
ε₀	8.854×10 ⁻¹² C ² N ⁻¹ m ⁻²
μ₀	4π×10 ⁻⁷ T m A ⁻¹
e	1.6×10 ⁻¹⁹ C
h	6.63×10 ⁻³⁴ J s
hc	1240 eV nm — the single most useful shortcut
c	3×10 ⁸ m s ⁻¹
1 u	931.5 MeV
Bohr radius	0.53 Å

D. Rules You Must Not Get Wrong

THE TEN THAT COST MOST MARKS

1. Axial dipole field is **TWICE** equatorial, and opposite in direction.
2. On the equatorial line $V = 0$ but $E \neq 0$.
3. Capacitors: series adds **reciprocals** — the opposite of resistors.
4. Dielectric with battery **connected** $\rightarrow V$ fixed. **Disconnected** $\rightarrow Q$ fixed.
5. Metals: ρ **ris**es with T . Semiconductors: ρ **fall**s.
6. Magnetic force does **no work**; speed never changes.
7. Parallel currents in the **same** direction **attract**.
8. Lenz's minus sign **is** conservation of energy.
9. Photoelectric: **intensity** $\rightarrow$ number, **frequency** $\rightarrow$ energy.
10. An n-type semiconductor is **electrically neutral**.

E. What the Syllabus Cut — do not waste time

Energy stored in a capacitor	Formulae only , no derivation
Straight solenoid	Qualitative only
Bar magnet as equivalent solenoid; dipole field; torque	Qualitative only
Transverse nature of EM waves	Qualitative only
YDSE fringe width	Final expression only , no derivation
Single-slit central maximum width	Qualitative only
Hydrogen line spectra	Qualitative only
Energy bands	Qualitative only
Transistors, logic gates, Zener, LED	Not listed — confirm with your teacher

F. How to Write for Marks

- 1. Derivations:** state the starting principle in words first (Gauss's theorem, Coulomb = centripetal, Faraday's law). That sentence is usually worth its own mark.
- 2. Diagrams:** ray diagrams, phasor triangles, circuit diagrams and the BE curve all carry marks on their own. Draw them even when not explicitly asked.
- 3. Signs:** write u , v and f with their signs on a separate line before substituting.
- 4. Units:** every final answer needs one. A correct number without a unit is not a correct answer.
- 5. Direction:** if a question asks for a force, field or current,

state the direction as well as the magnitude.

6. Graphs: label both axes and mark the intercept or slope the question asks about.

Chapter 1 · Electric Charges and Fields

CBSE Class 12 Physics (042) · Unit I Electrostatics ·

Unit I + II = 16 marks · Ultimate Revision Sheet

60-SECOND RECALL

Coulomb's law	$\mathbf{F} = kq_1q_2/r^2$, $k = 9 \times 10^9 \text{ N m}^2\text{C}^{-2}$ · in a medium divide by K
Field of a point charge	$\mathbf{E} = kq/r^2 \rightarrow$ falls as $1/r^2$
Dipole moment	$\mathbf{p} = q \times 2a$, direction $-q \rightarrow +q$
Dipole field	Axial $2kp/r^3$ · Equatorial $kp/r^3 \rightarrow$ axial = 2 × equatorial, both $1/r^3$
Torque on dipole	$\tau = pE \sin\theta$ ($\tau = p \times E$)
Gauss's theorem	$\varphi = q_{\text{enclosed}} / \epsilon_0$
The three Gauss results	Wire $\lambda/2\pi\epsilon_0 r$ · Sheet $\sigma/2\epsilon_0$ · Shell kq/r^2 outside, ZERO inside

1. Charge — the three properties

WRITE THIS VERBATIM

Quantisation: charge exists only as an integral multiple of the elementary charge, $q = ne$, where $e = 1.6 \times 10^{-19} \text{ C}$.

Conservation: the total charge of an isolated system remains constant — charge is neither created nor destroyed, only transferred.

Additivity: total charge is the **algebraic** sum of individual charges (signs included).

2. Coulomb's Law

FORMULAS

$$F = (1/4\pi\epsilon_0) \cdot q_1 q_2 / r^2 \quad k = 1/4\pi\epsilon_0 = 9 \times 10^9 \text{ N m}^2 \text{ C}^{-2}$$

$$\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2} \quad (\text{permittivity of free space})$$

$$\text{In a medium: } F_{\text{medium}} = F_{\text{vacuum}} / K \quad K = \text{dielectric constant (relative permittivity)}$$

Vector form: $F_{21} = k q_1 q_2 \hat{r}_{21} / r^2$ — the force is along the line joining the charges, and $F_{12} = -F_{21}$ (Newton's third law).

SUPERPOSITION PRINCIPLE

The force on any one charge due to several charges is the **vector sum** of the forces due to each one taken separately. The **presence of other charges does not change the pairwise force**.

TRAP

Coulomb's law as written applies to **point charges at rest**. For an extended body, r is the **distance between centres** only when the bodies are uniformly charged spheres.

A dielectric **always weakens** the force, because $K > 1$ for every medium ($K = 1$ for vacuum, ≈ 1.00059 for air).

3. Electric Field

FORMULAS

$$\mathbf{E} = \mathbf{F} / q_0 \quad \text{units } \text{N C}^{-1} \text{ or } \text{V m}^{-1}$$

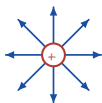
$$\mathbf{E} = kq/r^2 \quad (\text{point charge}) \quad \cdot \quad \mathbf{F} = q\mathbf{E} \quad \text{on a charge placed in the field}$$

ELECTRIC FIELD LINES — the properties asked 1.

Start at **positive**, end at **negative**; for a single charge they end at infinity.

2. They are *continuous curves without breaks* and never form closed loops (electrostatic field is conservative).
3. *Two field lines never cross* — if they did, the field would have two directions at one point, which is impossible.
4. They are *closer together where the field is stronger*.
5. They are always *perpendicular to the surface of a conductor*.

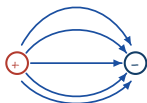
(a) single $+q$ — lines go OUT



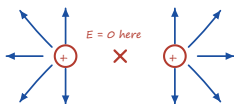
(b) single $-q$ — lines come IN



(c) dipole — $+$ to $-$, none cross



(d) two $+q$ — note the neutral point



Lines start on $+$, end on $-$, never cross, never form closed loops, and meet a conductor surface at 90° . Crowding means a stronger field.

4. Electric Dipole

DEFINITION Two equal and opposite charges separated by a small distance $2a$.
Dipole moment $p = q \times 2a$, a vector directed from $-q$ to $+q$, unit $C\ m$.

FIELD OF A DIPOLE — the two standard results

Axial (end-on): $E = 2kp / r^3$ direction: same as p

Equatorial (broadside-on): $E = kp / r^3$ direction: opposite to p

Exact expressions (before the $r \gg a$ approximation):

Axial $E = 2kpr/(r^2 - a^2)^2$ · Equatorial $E = kp/(r^2 + a^2)^{3/2}$

TORQUE IN A UNIFORM FIELD

$$\tau = pE \sin\theta \quad \tau = \mathbf{p} \times \mathbf{E}$$

Net force is ZERO in a uniform field (the two forces are equal and opposite), so the dipole only *rotates*, it does not translate.

$\theta = 0 \rightarrow \tau = 0$, *stable equilibrium* · $\theta = 90^\circ \rightarrow \tau$ is *maximum* = pE · $\theta = 180^\circ \rightarrow \tau = 0$, *unstable equilibrium*.

THE TRAP THAT COSTS MOST MARKS

Axial field is **TWICE** the equatorial field at the same distance, and the two point in **opposite** directions.

A dipole field falls as $1/r^3$, faster than a point charge's $1/r^2$, because the two opposite charges increasingly cancel as you move away.

In a **non-uniform** field a dipole experiences **both a torque and a net force**.

5. Electric Flux and Gauss's Theorem

WRITE THIS VERBATIM

Electric flux is the total number of electric field lines crossing a surface normally. $\phi = \mathbf{E} \cdot \mathbf{A} = EA \cos\theta$, a scalar, unit $\text{N m}^2 \text{C}^{-1}$.

Gauss's theorem: the total electric flux through a closed surface equals $1/\epsilon_0$ times the **net charge** enclosed by it.

STATEMENT

$$\phi = \oint \mathbf{E} \cdot d\mathbf{A} = q_{\text{enclosed}} / \epsilon_0$$

Charges **outside** the closed surface contribute **nothing** to the net flux —

whatever enters also leaves.

THE THREE APPLICATIONS THE SYLLABUS NAMES

Charge distribution	Field	Key point
Infinitely long straight wire linear density λ	$E = \lambda / 2\pi\epsilon_0 r$	Falls as 1/r . Gaussian surface: a cylinder ; the flat ends contribute no flux.
Uniformly charged infinite plane sheet surface density σ	$E = \sigma / 2\epsilon_0$	Independent of distance — the field is uniform. Gaussian surface: a cylinder through the sheet.
Uniformly charged thin spherical shell	Outside: $E = kq/r^2$ Surface: $E = kq/R^2$ Inside: $E = 0$	From outside the shell behaves as if all charge sat at the centre .

TRAP $E = 0$ inside a shell but the **POTENTIAL** is not zero — it is constant and equal to the surface value kq/R . Zero field means **no change** in potential, not zero potential.

For the sheet, E does not depend on r at all. Students routinely write $\sigma/2\epsilon_0 r$.

Flux depends **only on enclosed charge**, never on the shape or size of the Gaussian surface.

6. Question Triggers

what the wording is really asking

If the question says...	Use
"force between two charges"	Coulomb's law; divide by K if a medium is named
"net force due to several charges"	Superposition — resolve into components, then add as vectors
"derive the field on the axis of a dipole"	Axial result $2kp/r^3$
"dipole placed in a uniform field"	Net force zero, torque $pE \sin\theta$
"flux through a closed surface / a cube"	Gauss. For a charge at the centre of a cube, each face gets $q/6\epsilon_0$
"field due to a long wire / sheet / shell"	Quote Gauss, then the standard result
"field inside a conductor or a shell"	ZERO

WORKED EXAMPLE — the standard flux question A

charge of $8.85 \times 10^{-6} \text{ C}$ is placed at the centre of a cube. Find the flux through one face.

$$\text{Total flux} = q/\epsilon_0 = (8.85 \times 10^{-6}) /$$

$$(8.85 \times 10^{-12}) = 1 \times 10^6 \text{ N m}^2 \text{ C}^{-1}$$

By symmetry the six faces share it equally:

$$\text{Flux through one face} = 1 \times 10^6 / 6 = 1.67 \times 10^5 \text{ N m}^2 \text{ C}^{-1}$$

MOST-ASKED BOARD QUESTIONS

1. [3M] Using Gauss's theorem, derive the field due to a uniformly charged infinite plane sheet.
2. [3M] Derive the electric field on the axial line of an electric dipole.
3. [3M] Derive the field due to an infinitely long straight charged wire using Gauss's theorem.
4. [2M] Show that the field inside a uniformly charged spherical shell is zero.

5. [2M] Derive the **torque** acting on a dipole in a uniform electric field.
6. [1M] Why can two electric field lines **never intersect**?
7. [1M] Name the physical quantity whose SI unit is N C^{-1} . → **Electric field intensity**

THE HABIT THAT SCORES — In every derivation, state the **Gaussian surface you chose and why** before writing a single equation. Examiners give a separate mark for the choice of surface, and it is the easiest mark in the chapter to lose by rushing.

Chapter 2 · Electrostatic Potential and Capacitance

CBSE Class 12 Physics (042) · Unit I Electrostatics ·

Unit I + II = 16 marks · Ultimate Revision Sheet

**SCOPE ALERT — CHECKED AGAINST THE OFFICIAL
2026-27 SYLLABUS**

Energy stored in a capacitor is "formulae only, no derivation". Learn the three forms; do not spend time deriving them. The syllabus names capacitance of a parallel plate capacitor with and without a dielectric — that one is derivable and is asked.

60-SECOND RECALL

Potential	$V = kq/r$ (scalar, signed) · $V = W/q_0$
Relation with field	$E = -dV/dr \rightarrow$ field points from high V to low V
Dipole potential	Axial kp/r^2 · Equatorial ZERO
PE of two charges	$U = kq_1q_2/r$
Dipole PE	$U = -pE \cos\theta$ · minimum at $\theta = 0$
Parallel plate C	$C = \epsilon_0 A/d$ · with dielectric $C = K\epsilon_0 A/d$
Combination	Series $1/C = \Sigma 1/C_i$ · Parallel $C = \Sigma C_i$ (opposite of resistors)
Energy	$U = \frac{1}{2}CV^2 = \frac{1}{2}QV = Q^2/2C$

1. Electric Potential

WRITE THIS VERBATIM *Electric potential at a point is the work done per unit positive test charge in bringing it from infinity to that point, without acceleration. $V = W/q_0$, unit volt ($J\ C^{-1}$), a scalar.*

FORMULAS

$V = kq/r$ (point charge — carries the **sign** of q)

$V_{\text{total}} = \Sigma kq_i/r_i$ (**algebraic** sum, not vector)

$E = -dV/dr$ the negative of the potential gradient

Dipole potential: axial $V = kp/r^2$.

equatorial $V = 0$. general $V = kp \cos\theta/r^2$

THE CONTRAST EXAMINERS TEST

Potential is a **SCALAR** and adds algebraically; field is a **VECTOR** and adds by components.

On the equatorial line of a dipole, $V = 0$ but $E \neq 0$. At the midpoint between two equal like charges, $E = 0$ but $V \neq 0$. Zero of one never implies zero of the other.

2. Equipotential Surfaces

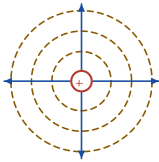
THE FOUR PROPERTIES

1. Potential is the same at every point, so no work is done moving a charge along one.
2. They are always perpendicular to the field lines.
3. They never intersect — a point cannot have two potentials.
4. They are closer together where the field is stronger (since $E = -dV/dr$).

Shapes: point charge $\rightarrow$ concentric spheres
· uniform field $\rightarrow$ parallel planes.

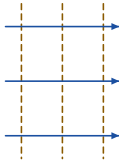
Equipotentials (dashed) are ALWAYS perpendicular to field lines (solid)

(a) point charge



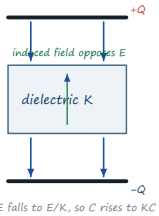
spheres · $V \propto 1/r$

(b) uniform field



equally spaced planes

(c) dielectric slab



No work is done moving a charge along an equipotential, because V does not change — that is the one-line reason they sit at 90° to $\mathbf{E}$.

3. Potential Energy

FORMULAS

Two charges: $U = kq_1q_2/r$

Three charges: $U = k[q_1q_2/r_{12} + q_2q_3/r_{23} + q_1q_3/r_{13}]$

Dipole in a field: $U = -pE \cos\theta = -\mathbf{p} \cdot \mathbf{E}$

Work done in rotating a dipole from θ_1 to θ_2 : $W = pE(\cos\theta_1 - \cos\theta_2)$

TRAP $\theta = 0^\circ \rightarrow U = -pE$, minimum energy, **STABLE**. $\theta = 180^\circ \rightarrow U = +pE$, maximum, **UNSTABLE**. $\theta = 90^\circ \rightarrow U = 0$. The sign matters: U is **negative** for unlike charges (attractive, bound) and **positive** for like charges.

4. Conductors and Dielectrics

INSIDE A CONDUCTOR — the five facts

1. $E = 0$ everywhere inside.
2. The whole conductor is at **one potential** (equipotential).
3. Any excess charge resides entirely on the **outer surface**.
4. The field just outside is σ/ϵ_0 and **perpendicular** to the surface.
5. There is **no net charge** inside the body.

DIELECTRICS A dielectric has **no free charges**. In a field its molecules develop **induced dipole moments** — this is **polarisation**. The induced field **opposes** the applied field, so the net field **reduces** to E_0/K .

Polar molecules (HCl , H_2O) have a

permanent dipole moment; **non-polar** (H_2 , O_2 , CO_2) acquire one only in a field.

5. Capacitance

FORMULAS

$$C = Q/V \quad \text{unit farad (F)} = C V^{-1}$$

$$\text{Parallel plate: } C = \epsilon_0 A / d$$

$$\text{With a dielectric filling the gap: } C = K\epsilon_0 A / d = KC_0$$

$$\text{With a slab of thickness } t \text{ (} t < d \text{): } C = \epsilon_0 A / [d - t(1 - 1/K)]$$

Capacitance depends only on geometry and the medium — never on the charge or the voltage applied.

COMBINATIONS — the opposite of resistors

	SERIES	PARALLEL
Formula	$1/C_s = 1/C_1 + 1/C_2 + \dots$	$C_p = C_1 + C_2 + \dots$
Same for all	Charge Q	Voltage V
Divides	Voltage, as $V \propto 1/C$	Charge, as $Q \propto C$
Result	Less than the smallest	More than the largest

6. Energy Stored

FORMULAE ONLY — the syllabus says no derivation

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

$$\text{Energy density } u = \frac{1}{2}\epsilon_0 E^2 \text{ (energy per unit volume)}$$

THE TWO CASES YOU MUST SEPARATE When a

dielectric is inserted, what stays constant decides everything.

Battery still connected (V constant): $C \rightarrow KC$, so Q increases K times and U increases K times.

Battery disconnected (Q constant): $C \rightarrow KC$, so V falls to V/K and U falls to U/K .

Read the question for the words "battery remains connected" or "after disconnecting" — they are there on purpose.

WORKED EXAMPLE

Two capacitors $3\ \mu\text{F}$ and $6\ \mu\text{F}$ are joined in *series* across $90\ \text{V}$.

$$1/C_s = 1/3 + 1/6 = 3/6 \Rightarrow C_s = 2\ \mu\text{F}$$

$$Q = C_s V = 2 \times 90 = 180\ \mu\text{C} \text{ (same through both)}$$

$$V_3 = 180/3 = 60\ \text{V} \cdot V_6 = 180/6 = 30\ \text{V}$$

$$\text{check: } 60 + 30 = 90\ \checkmark$$

$$\text{Energy} = \frac{1}{2} C_s V^2 = \frac{1}{2} \times 2 \times 10^{-6} \times 8100 = 8.1 \times 10^{-3}\ \text{J}$$

7. Question Triggers

what the wording is really asking

If the question says...	Use
"work done in moving a charge between two points"	$W = q(V_B - V_A)$
"work done along an equipotential surface"	ZERO
"potential due to several charges"	Algebraic sum of kq/r
"dielectric inserted, battery connected"	V fixed $\rightarrow$ Q and U rise K times
"dielectric inserted after disconnecting"	Q fixed $\rightarrow$ V and U fall K times
"energy lost when two charged capacitors are joined"	Common potential first, then compare total U before and after

"field just outside a charged conductor"

$$\sigma/\epsilon_0$$

MOST-ASKED BOARD QUESTIONS

1. [3M] Derive the **capacitance of a parallel plate capacitor** with a dielectric slab between the plates.
2. [3M] Derive an expression for the **potential due to a point charge / an electric dipole**.
3. [3M] Two capacitors in series/parallel — find equivalent C , charge, voltage and energy.
4. [2M] Define an **equipotential surface** and give two properties.
5. [2M] Derive the **potential energy of a dipole** in a uniform electric field.
6. [1M] Why is the electrostatic potential **constant inside** a charged conductor?
7. [1M] Where on a dipole is the potential zero but the field non-zero? →
Equatorial line

THE HABIT THAT SCORES — In every capacitor problem, write down first whether Q or V is the quantity being

held constant. Almost every mark lost in this chapter comes from carrying the wrong one through an otherwise perfect calculation.

Chapter 3 · Current Electricity

CBSE Class 12 Physics (042) · Unit II · Unit I + II =

16 marks · Ultimate Revision Sheet

60-SECOND RECALL

Drift velocity	$v_d = eE\tau/m \cdot I = neAv_d$
Ohm's law	$V = IR$ · microscopic form $J = \sigma E$
Resistance	$R = \rho L/A \cdot \rho = m/ne^2\tau$
Temperature	Metals $\rho \uparrow$ with T · Semiconductors $\rho \downarrow$ with T
EMF vs terminal V	$V = \varepsilon - Ir$ (discharging) · $V = \varepsilon + Ir$ (charging)
Kirchhoff	Junction = charge conservation · Loop = energy conservation
Wheatstone	Balanced when $P/Q = R/S \rightarrow$ galvanometer reads zero

1. Current and Drift Velocity

DEFINITIONS Electric current is the rate of flow of charge, $I = q/t$, a scalar, unit ampere.

Drift velocity is the average velocity gained by free electrons along the conductor under an applied field. Typical value: $\sim 10^{-4} \text{ m s}^{-1}$ — very slow.

Relaxation time τ is the average time between two successive collisions of an electron with the lattice ions.

FORMULAS

$$v_d = eE\tau/m = eV\tau/mL$$

$$I = n e A v_d \quad n = \text{number density of free electrons}$$

$$\text{Mobility } \mu = v_d/E = e\tau/m \quad \text{unit } \text{m}^2 \text{V}^{-1} \text{s}^{-1}$$

$$\text{Current density } J = I/A = n e v_d = \sigma E$$

TRAP Drift velocity is tiny, yet a bulb lights instantly — because the **electric field** is set up through the wire at nearly the speed of light, and **every** electron in the circuit starts drifting at once.

$v_d \propto I$, and current density J is a **vector** while current I is a **scalar**.

2. Resistance and Resistivity

FORMULAS

$$R = \rho L/A \cdot \rho = m / ne^2\tau \cdot \sigma = 1/\rho = ne^2\tau/m$$

$$R_T = R_0(1 + \alpha\Delta T) \quad \alpha = \text{temperature coefficient of resistance}$$

WHY TEMPERATURE ACTS OPPOSITELY IN THE TWO MATERIALS

Metals: n is fixed; heating makes the ions vibrate more, so τ falls $\rightarrow \rho$ rises. α is **positive**.

Semiconductors: heating frees many more carriers, so n rises sharply — this outweighs the fall in $\tau \rightarrow \rho$ falls. α is **negative**.

Stretching a wire keeps its volume

constant: if length becomes n times, R becomes n^2 times.

3. EMF, Terminal Voltage and Cells

THE DISTINCTION EMF (ϵ) is the potential difference across the cell when **no current is drawn** (open circuit). Terminal voltage (V) is the potential difference when **current flows**.

FORMULAS

$$\epsilon = V + Ir \rightarrow V = \epsilon - Ir \text{ (cell discharging)}$$

$$V = \epsilon + Ir \text{ (cell being charged)}$$

$$I = \epsilon / (R + r) \text{ internal resistance } r$$

Cells in series: $\epsilon_{eq} = \epsilon_1 + \epsilon_2$, $r_{eq} = r_1 + r_2$

— use when r is small compared with R .

Cells in parallel: $\epsilon_{eq} = (\epsilon_1 r_2 + \epsilon_2 r_1) / (r_1 + r_2)$, $1/r_{eq} = 1/r_1 + 1/r_2$ — use when r is large.

TRAP Terminal voltage is less than EMF while discharging, and MORE than EMF while charging. A question that says "the cell is being charged" is testing exactly this sign.

$V = \mathcal{E}$ only when $I = 0$, which is why a voltmeter must have very high resistance.

4. Power and Energy

FORMULAS

$$P = VI = I^2R = V^2/R$$

In series the current is common, so use $P = I^2R$ — the largest R dissipates most.

In parallel the voltage is common, so use $P = V^2/R$ — the smallest R dissipates most.

5. Kirchhoff's Rules

STATE THEM WITH THEIR CONSERVATION LAW — that is a separate mark

Junction rule: the algebraic sum of currents at any junction is zero ($\Sigma I = 0$). It follows from the conservation of charge.

Loop rule: the algebraic sum of changes in potential around any closed loop is zero

($\Sigma \Delta V = 0$). It follows from the conservation of energy.

WHEATSTONE BRIDGE

Balanced when $P/Q = R/S$ → current through the galvanometer is **zero**

At balance the bridge is **independent of the cell's EMF** and of the galvanometer's resistance, which is why it measures an unknown resistance so accurately.

Sensitivity is greatest when all four resistances are of the same order.

WORKED EXAMPLE A cell of EMF **2 V** and internal resistance **0.5Ω** drives a **4.5Ω** resistor.

$$I = \varepsilon / (R + r) = 2 / (4.5 + 0.5) = \mathbf{0.4 \text{ A}}$$

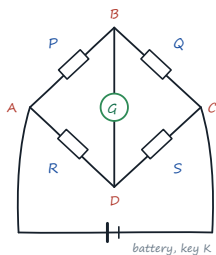
$$\text{Terminal voltage } V = \varepsilon - Ir = 2 - (0.4 \times 0.5) = \mathbf{1.8 \text{ V}}$$

$$\text{Check with } V = IR = 0.4 \times 4.5 = \mathbf{1.8 \text{ V} \checkmark}$$

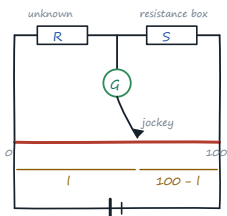
$$\text{Power in the resistor} = I^2 R = 0.16 \times 4.5 = \mathbf{0.72 \text{ W}}$$

$$\text{Power wasted inside the cell} = I^2 r = 0.16 \times 0.5 = \mathbf{0.08 \text{ W}}$$

(a) Wheatstone bridge



(b) Metre bridge



$$R / S = l / (100 - l)$$

At balance **$P/Q = R/S$** . The galvanometer reading zero is the condition — it is **not** that no current flows anywhere, only that none flows through G.

6. Question Triggers

what the wording is really asking

If the question says...	Use
"wire is stretched to n times its length"	R becomes n^2R (volume constant)
"resistance of a semiconductor on heating"	Decreases — n rises sharply
"galvanometer shows no deflection"	Wheatstone balance , $P/Q = R/S$
"terminal voltage is greater than EMF"	The cell is being charged
"complex network, several cells"	Kirchhoff's rules
"maximum power / which bulb glows brighter"	Series $\rightarrow I^2R$, parallel $\rightarrow V^2/R$
"drift velocity when current doubles"	$v_d \propto I$ $\rightarrow$ also doubles

MOST-ASKED BOARD QUESTIONS

1. [3M] Derive $I = neAv_d$, and hence deduce **Ohm's law** in the form $\rho = m/ne^2\tau$.
2. [3M] State Kirchhoff's rules and use them to solve a two-loop network.
3. [3M] Draw a **Wheatstone bridge** and derive its balance condition.
4. [2M] Distinguish between **EMF** and **terminal voltage**.
5. [2M] Explain why resistivity **rises** for a metal but **falls** for a semiconductor when heated.
6. [1M] Define **mobility** and give its SI unit.
7. [1M] Is current a scalar or a vector? $\rightarrow$ **Scalar** (current density is the vector)

THE HABIT THAT SCORES — In any Kirchhoff problem, mark the assumed current direction on the diagram **before** writing equations, and keep it even if the answer comes out negative. A negative answer simply means the real current flows the other way — it is not a mistake, and redrawing mid-solution is how sign errors creep in.

Chapter 4 · Moving Charges and Magnetism

CBSE Class 12 Physics (042) · Unit III · Unit III + IV

= 17 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS Biot–

Savart law is applied to a *circular loop* only. Ampere's law is applied to an *infinitely long straight wire*; the *straight solenoid* is qualitative treatment only. Do not memorise a solenoid derivation.

60-SECOND RECALL

Biot–Savart	$dB = (\mu_0/4\pi) I dl \sin\theta / r^2 \cdot \mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}
Circular loop (centre)	$B = \mu_0 NI / 2R \cdot \text{on axis}$ $\mu_0 NI R^2 / 2(R^2 + x^2)^{3/2}$
Long straight wire	$B = \mu_0 I / 2\pi r$
Solenoid	$B = \mu_0 nI \text{ (qualitative only)}$
Force on charge	$F = qvB \sin\theta \cdot F = q(\mathbf{v} \times \mathbf{B})$
Force on wire	$F = BIL \sin\theta$
Two parallel wires	$F/L = \mu_0 I_1 I_2 / 2\pi d \text{ — same direction attract}$
Torque on loop	$\tau = NIAB \sin\theta = mB \sin\theta, m = NIA$

1. Biot-Savart Law

WRITE THIS VERBATIM

The magnetic field due to a small current element is *directly proportional to the current, the length of the element and $\sin\theta$, and inversely proportional to the square of the distance from it.*

FORMULAS

$$dB = (\mu_0/4\pi) \cdot I dl \sin\theta / r^2 \quad \mu_0/4\pi = 10^{-7} \text{ T m A}^{-1}$$

$$\text{Centre of a circular loop: } B = \mu_0 NI / 2R$$

$$\text{On the axis: } B = \mu_0 NI R^2 / 2(R^2 + x^2)^{3/2}$$

BIOT-SAVART vs COULOMB — a favourite comparison

Both fall as $1/r^2$ and both obey superposition. But the electric field is along the line joining, while the magnetic field is *perpendicular to both dl and r* (a cross product), and there is *no magnetic monopole* — a current element cannot exist in isolation.

2. Ampere's Circuital Law

STATEMENT AND THE ONE DERIVATION ASKED

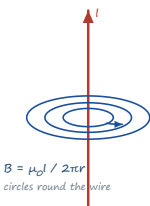
$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{\text{enclosed}}$$

Infinitely long straight wire: choose a circular loop of radius r around the wire; B is constant and along it, so $B(2\pi r) = \mu_0 I$ giving

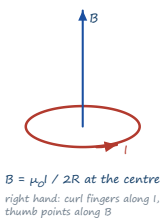
$$B = \mu_0 I / 2\pi r$$

Solenoid (qualitative): the field inside is uniform and parallel to the axis, $B = \mu_0 n I$, and is nearly zero outside.

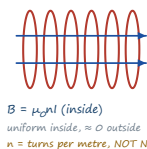
(a) straight wire



(b) circular loop



(c) solenoid



Three standard Biot-Savart / Ampère results. The syllabus wants the **solenoid qualitatively only**, so learn the field shape and the formula — not the derivation.

3. Force on a Moving Charge

FORMULAS

$$\mathbf{F} = q(\mathbf{v} \times \mathbf{B}) \rightarrow F = qvB \sin\theta$$

$$\text{Lorentz force: } \mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

$$\text{Circular path: } r = mv/qB \cdot T = 2\pi m/qB$$

(independent of speed)

THE THREE FACTS ABOUT THE MAGNETIC FORCE 1.

It is **zero** when the charge is at rest, or when v is **parallel** to B .

2. It is always **perpendicular** to v , so it does **NO** work and the **speed never changes** — only the direction does.

3. Velocity selector: when $qE = qvB$, the particle goes straight through $\rightarrow v = E/B$.

4. Force Between Currents — the definition of the ampere

FORMULA AND DEFINITION

$$F/L = \mu_0 I_1 I_2 / 2\pi d$$

Currents in the same direction **ATTRACT**; opposite directions **REPEL**. (The opposite of charges — worth saying aloud.)

One ampere is that current which, flowing in each of two infinitely long parallel conductors **1 m apart** in vacuum,

produces a force of 2×10^{-7} N per metre between them.

5. Current Loop and the Moving Coil Galvanometer

TORQUE ON A LOOP

$$\tau = NIAB \sin\theta \quad \cdot \quad \text{magnetic moment } m = NIA \rightarrow \tau = m \times B$$

The **net force is zero** in a uniform field; only a torque acts. A current loop therefore behaves as a **magnetic dipole**.

GALVANOMETER — the parts that carry marks

At equilibrium the magnetic torque balances the restoring torque of the spring: $NIAB = k\phi$, so

$$\phi = (NAB/k) I \rightarrow \text{deflection is directly proportional to current}$$

$$\text{Current sensitivity} = \phi/I = NAB/k \cdot$$

$$\text{Voltage sensitivity} = \phi/V = NAB/kR$$

A **radial magnetic field** (concave pole pieces + soft iron core) keeps the plane of the coil always parallel to B , so $\sin\theta = 1$ and the scale is **linear**.

CONVERSION — both formulas

To an **AMMETER**: shunt **S** in **PARALLEL**, $S = I_g G / (I - I_g)$ — small resistance

To a **VOLTMETER**: **R** in **SERIES**, $R = V/I_g - G$ — large resistance

An *ideal ammeter* has zero resistance and goes in *series*; an *ideal voltmeter* has *infinite* resistance and goes in *parallel*.

TRAP Increasing N raises current sensitivity but **NOT** necessarily voltage sensitivity, because adding turns also increases the coil's resistance R . This exact reasoning is asked as a 2-marker.

WORKED EXAMPLE A galvanometer of resistance $G = 60 \Omega$ gives full-scale deflection at $I_g = 1 \text{ mA}$. Convert it to an ammeter reading up to 1 A .

$$\begin{aligned} S &= I_g G / (I - I_g) = (0.001 \times 60) / (1 - 0.001) \\ &= 0.06 / 0.999 = 0.06 \Omega \text{ approximately,} \\ &\text{connected in parallel.} \end{aligned}$$

6. Question Triggers

what the wording is really asking

If the question says...	Use
"field at the centre of a circular coil"	$\mu_0 NI/2R$
"field near a long straight wire"	$\mu_0 I/2\pi r$ (Ampere)
"charged particle enters perpendicular to B"	Circular path, $r = mv/qB$
"speed of the particle changes?"	No — magnetic force does no work
"two parallel wires carrying current"	$\mu_0 I_1 I_2 / 2\pi d$; same direction → attract
"why radial field in a galvanometer"	Keeps $\sin\theta = 1$ → linear scale
"convert galvanometer to ammeter"	Shunt in parallel , $S = I_g G / (I - I_g)$

MOST-ASKED BOARD QUESTIONS

1. [3M] State Biot–Savart law and derive the field at the *centre of a circular current loop*.
2. [3M] Using Ampere's law, find the field due to an *infinitely long straight wire*.
3. [3M] Derive the *torque* on a current loop in a uniform magnetic field, and define magnetic moment.

4. [3M] Describe a **moving coil galvanometer** and derive $\phi \propto I$. Why a radial field?
5. [2M] Derive the **force per unit length** between two parallel current-carrying wires and define the ampere.
6. [2M] Convert a galvanometer into an ammeter / voltmeter (numerical).
7. [1M] Does the magnetic force change a particle's kinetic energy? $\rightarrow$ **No**

THE HABIT THAT SCORES — Draw the direction before you calculate. Right-hand thumb rule for the field around a wire, $F = qv \times B$ for a charge — a correct magnitude with the wrong direction still loses the mark, and direction is the part that takes five seconds to check.

Chapter 5 · Magnetism and Matter

CBSE Class 12 Physics (042) · Unit III · Unit III + IV = 17

marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS This

chapter has been cut hard. **Qualitative treatment only** for: bar magnet as an equivalent solenoid, the field of a magnetic dipole along its axis and perpendicular to it, and the torque on a bar magnet in a uniform field.

What remains examinable in full: magnetic field lines, and the **magnetic properties of materials** — dia-, para- and ferromagnetism, magnetisation, and the effect of temperature. Spend your time there.

60-SECOND RECALL

Bar magnet $\approx$ solenoid	Both have a dipole field; $\mathbf{m} = \mathbf{NIA}$ (qualitative)
Dipole field	Axial $\mu_0 2\mathbf{m}/4\pi r^3$ · Equatorial $\mu_0 \mathbf{m}/4\pi r^3$ (qualitative)
Torque / PE	$\tau = mB \sin\theta$ · $U = -mB \cos\theta$
Magnetisation	$\mathbf{M} = \mathbf{m}_{\text{net}}/V$ · $\chi = M/H$ · $\mu_r = 1 + \chi$
Diamagnetic	χ small negative · repelled · water, bismuth, copper
Paramagnetic	χ small positive · weakly attracted · aluminium, oxygen
Ferromagnetic	χ large positive · strongly attracted · iron, cobalt, nickel
Curie law	$\chi \propto 1/T$ · above Curie temperature ferro $\rightarrow$ para

1. Bar Magnet and Magnetic Field Lines

FIELD LINES — the properties asked

1. They form *continuous closed loops* — outside the magnet $N \rightarrow S$, inside the magnet $S \rightarrow N$.
2. They *never intersect*.
3. Their density indicates field strength.
4. The tangent at any point gives the field direction.

WHY MAGNETIC MONOPOLES DO NOT EXIST

Because the lines are *closed loops*, the net flux through any closed surface is **zero**: $\oint \mathbf{B} \cdot d\mathbf{A} = 0$. Cutting a bar magnet in half simply produces **two shorter magnets**, each with its own N and S pole.

QUALITATIVE RESULTS — know the form, not the derivation

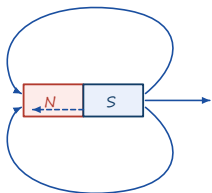
Bar magnet as a solenoid: a solenoid of N turns carrying current I behaves like a bar magnet of moment $\mathbf{m} = NIA$.

Axial field: $B = \mu_0 2m / 4\pi r^3$ · **Equatorial field:**

$B = \mu_0 m / 4\pi r^3$ — axial is twice equatorial, exactly as for an electric dipole.

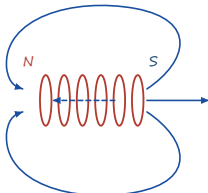
Torque: $\boldsymbol{\tau} = \mathbf{m} \times \mathbf{B}$ · **Potential energy:** $U = -\mathbf{m} \cdot \mathbf{B} = -mB \cos\theta$.

(a) bar magnet



outside $N \rightarrow S$, inside $S \rightarrow N$ (dashed)
so the lines form **CLOSED** loops

(b) the same field, from a solenoid



identical pattern — this is WHY a magnet behaves as a dipole, $\mathbf{m} = NIA$

A bar magnet is equivalent to a solenoid. Because the lines close on themselves, **$\Phi_{\mathbf{B}}$ through any closed surface is zero** — there is no magnetic monopole.

2. Magnetisation and the Three Quantities

FORMULAS

Magnetisation M = net magnetic moment / volume *unit*
 $A\ m^{-1}$

Magnetic susceptibility $\chi = M / H$ *a pure number*

Relative permeability $\mu_r = 1 + \chi$ · $\mu = \mu_0 \mu_r$

$B = \mu_0(H + M)$

3. The Three Magnetic Materials

THE COMPARISON TABLE — this is the 3-marker

Property	DIAMAGNETIC	PARAMAGNETIC	FERROMAGNETIC
Susceptibility χ	Small and NEGATIVE ($-1 \leq \chi < 0$)	Small and positive	Large and positive (thousands)
μ_r	Slightly less than 1	Slightly more than 1	Very much greater than 1
In a non-uniform field	Moves to the weaker field	Moves to the stronger field	Strongly to the stronger field
Atomic moment	Zero without a field	Permanent, but randomly oriented	Permanent, aligned in domains
Effect of heating	No effect	χ falls as $1/T$ (Curie law)	Becomes paramagnetic above the Curie temperature
Examples	Bismuth, copper, water, gold, all superconductors	Aluminium, oxygen, platinum, sodium	Iron, cobalt, nickel, gadolinium

TRAP Only the *diamagnetic* susceptibility is *negative*, and only *diamagnetism* is *unaffected* by temperature.

A *superconductor* is a *perfect diamagnet* ($\chi = -1$) — it expels the field completely. This is the Meissner effect and is a favourite one-marker. Above its Curie temperature a ferromagnet does *not* become non-magnetic; it becomes *paramagnetic*.

4. Question Triggers what the wording is really asking

If the question says...	The answer is...
"repelled by a magnet" / "moves to the weaker field"	Diamagnetic
"susceptibility falls as temperature rises"	Paramagnetic , Curie law $\chi \propto 1/T$
"loses its magnetism above a certain temperature"	Ferromagnetic , above the Curie temperature
" μ_r slightly less than 1"	Diamagnetic
"field lines inside the magnet"	S to N — loops are closed
"a bar magnet is cut in half"	Two magnets , each with N and S; moment halves

MOST-ASKED BOARD QUESTIONS

1. [3M] Compare *dia-*, *para-* and *ferromagnetic* substances on susceptibility, behaviour in a non-uniform field, and effect of temperature.

2. [2M] Define **magnetisation** and **magnetic susceptibility**, and relate μ_r to χ .
3. [2M] Why do magnetic field lines form **closed loops**, unlike electric field lines?
4. [2M] State and explain **Curie's law**.
5. [1M] Why is a **superconductor** called a perfect diamagnet?
6. [1M] What happens to a ferromagnet above its Curie temperature? → **It becomes paramagnetic**

THE HABIT THAT SCORES — This is the lightest chapter in the unit, and almost every mark sits in one table. Learn the three materials row by row — sign of χ , direction of motion in a non-uniform field, effect of heat, one example each — and you have the chapter.

Chapter 6 · Electromagnetic Induction

CBSE Class 12 Physics (042) · Unit IV · Unit III + IV

= 17 marks · Ultimate Revision Sheet

60-SECOND RECALL

Magnetic flux	$\phi = BA \cos\theta$ · unit weber (Wb)
Faraday's law	$\epsilon = -N d\phi/dt$
Lenz's law	The minus sign — induced effect opposes the change that caused it
Motional EMF	$\epsilon = Blv$
Self-inductance	$\epsilon = -L di/dt$ · solenoid $L = \mu_0 n^2 Al$
Mutual inductance	$\epsilon_2 = -M di_1/dt$ · $M_{12} = M_{21}$
Energy in an inductor	$U = \frac{1}{2} LI^2$

1. Magnetic Flux

DEFINITION Magnetic flux through a surface is the product of the field and the area perpendicular to it: $\phi = B \cdot A = BA \cos\theta$. It is a scalar; SI unit the weber, where $1 \text{ Wb} = 1 \text{ T m}^2$.

TRAP θ is measured between **B** and the **NORMAL** to the surface, not the surface itself. When the plane of the coil is **parallel** to **B**, $\theta = 90^\circ$ and the flux is **zero**, not maximum.

2. Faraday's Laws and Lenz's Law

WRITE THIS VERBATIM **First law:** whenever the magnetic flux linked with a circuit changes, an **EMF is induced** in it, and it lasts only as long as the change continues. **Second law:** the magnitude of the induced EMF is equal to the rate of change of magnetic flux. **Lenz's law:** the induced current flows in such a direction that it **opposes the change producing it**.

FORMULAS

$$\epsilon = -N \frac{d\phi}{dt} \quad N = \text{number of turns}$$

$$\text{Induced current } I = \epsilon/R \quad \cdot \quad \text{Induced charge } q = N\Delta\phi/R \quad (\text{independent of time taken})$$

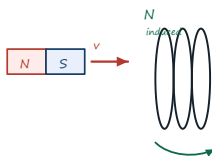
LENZ'S LAW IS CONSERVATION OF ENERGY If the induced current helped the change instead

of opposing it, the motion would accelerate on its own and produce energy from nothing. The **minus sign** in Faraday's law **is** the statement of energy conservation — say this sentence, it is the mark.

Approaching N pole → the near face becomes **N** (repels) → current **anticlockwise** as seen from the magnet.

Receding N pole → the near face becomes **S** (attracts) → current **clockwise**.

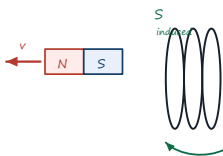
(a) magnet moving TOWARDS the coil



anticlockwise seen from the magnet

Coil face turns N → it **REPELS** the magnet.
Your work becomes the electrical energy.

(b) magnet moving AWAY



clockwise — direction flips

Coil face turns S → it **ATTRACTS** the magnet.
Either way the coil **OPPOSES** what you are doing

Lenz's law is the minus sign in $\mathbf{e} = -\mathbf{N} \, d\Phi/dt$, and it is a statement of **conservation of energy** — say that sentence in the answer, it is the marked point.

3. Motional EMF

FORMULA AND ITS ORIGIN

$\mathbf{e} = \mathbf{Blv}$ rod of length l moving with velocity v
perpendicular to B

Force needed to keep it moving: $F = B^2 l^2 v / R$ · Power delivered: $P = B^2 l^2 v^2 / R = \varepsilon^2 / R$

The work done against this opposing force is exactly the electrical energy produced — another statement of Lenz's law.

4. Self and Mutual Inductance

SELF-INDUCTANCE

$$\varphi = LI \quad \cdot \quad \varepsilon = -L \, dI/dt \quad \text{unit henry (H)}$$

$$\text{Solenoid: } L = \mu_0 n^2 A l = \mu_0 N^2 A / l$$

$$\text{Energy stored: } U = \frac{1}{2} L I^2$$

Self-inductance is called *electrical inertia* — it opposes any *change* in current, just as mass opposes change in motion.

MUTUAL INDUCTANCE

$$\varphi_2 = M I_1 \quad \cdot \quad \varepsilon_2 = -M \, dI_1/dt$$

$$\text{Two coaxial solenoids: } M = \mu_0 n_1 n_2 A l$$

$M_{12} = M_{21}$ always — the mutual inductance of a pair does not depend on which coil carries the current.

M depends on the *geometry, separation,*

orientation of the coils and the **core material** — an iron core raises it greatly.

WORKED EXAMPLE A coil of **500 turns** has its flux changed from **0.1 Wb** to **0.02 Wb** in **0.1 s**. Coil resistance **20 Ω** .

$$\Delta\phi = 0.02 - 0.1 = -0.08 \text{ Wb}$$

$$\varepsilon = -N \Delta\phi / \Delta t = -500 \times (-0.08) / 0.1 = 400 \text{ V}$$

$$I = \varepsilon / R = 400 / 20 = 20 \text{ A}$$

$$\text{Charge } q = N\Delta\phi / R = 500 \times 0.08 / 20 = 2 \text{ C}$$

5. Question Triggers

what the wording is really asking

If the question says...	Use
"magnet pushed towards a coil"	Lenz — near face becomes N, current opposes approach
"rod moving on rails in a field"	$\varepsilon = Blv$
"charge that flows", time not given	$q = N\Delta\phi / R$ — time cancels out
"EMF induced in a coil by current in another"	Mutual inductance
"opposes growth of current when switched on"	Self-inductance

"plane of the coil parallel to B"

$\phi = 0$ ($\theta = 90^\circ$ with the normal)

"why does the minus sign appear"

Conservation of energy

MOST-ASKED BOARD QUESTIONS

1. [3M] State Faraday's laws and **Lenz's law**; show that Lenz's law follows from conservation of energy.
2. [3M] Derive an expression for the **self-inductance of a long solenoid**.
3. [3M] Derive **motional EMF** $\varepsilon = Blv$ and find the power required to keep the rod moving.
4. [2M] Define **mutual inductance** and list the factors it depends on.
5. [2M] Numerical on induced EMF, current and charge.
6. [1M] Give the SI unit of magnetic flux and of inductance. $\rightarrow$ **weber, henry**

THE HABIT THAT SCORES — Whenever a question asks for a **direction**, answer it in two steps: first say which way the flux is changing, then say the induced current opposes

that change. Writing the reasoning, not just "anticlockwise", is what earns the second mark.

Chapter 7 · Alternating Current

CBSE Class 12 Physics (042) · Unit IV · Unit III + IV

= 17 marks · LCR by phasors only · Ultimate Revision Sheet

60-SECOND RECALL

RMS values	$I_{\text{rms}} = I_0/\sqrt{2} = 0.707 I_0$ · same for V
Reactances	$X_L = \omega L$ · $X_C = 1/\omega C$
Impedance	$Z = \sqrt{R^2 + (X_L - X_C)^2}$
Phase angle	$\tan\phi = (X_L - X_C)/R$
Resonance	$X_L = X_C \rightarrow \omega_0 = 1/\sqrt{LC}$, $Z = R$ minimum, I maximum
Power	$P = V_{\text{rms}} I_{\text{rms}} \cos\phi$ · power factor $\cos\phi = R/Z$
Transformer	$V_s/V_p = N_s/N_p = I_p/I_s$

1. RMS and Peak Values

DEFINITION The RMS (virtual) value of an alternating current is that steady current which produces the same heating effect in a given resistance in the same time.

FORMULAS

$$I = I_0 \sin \omega t \cdot I_{\text{rms}} = I_0/\sqrt{2} \cdot V_{\text{rms}} = V_0/\sqrt{2}$$

Average value over a full cycle = ZERO; over a half cycle = $2I_0/\pi$

Indian mains: 220 V is the RMS value, so the peak is $220\sqrt{2} \approx 311$ V. Frequency 50 Hz.

2. AC Through R, L and C Separately

THE THREE CASES — phase is the whole point

Element	Opposition	Phase	Power consumed
Resistor R	R	V and I in phase	Yes, $V_{\text{rms}}I_{\text{rms}}$
Inductor L	$X_L = \omega L = 2\pi fL$	Voltage LEADS current by $\pi/2$	Zero
Capacitor C	$X_C = 1/\omega C = 1/2\pi fC$	Current LEADS voltage by $\pi/2$	Zero

Memory hook: "ELI the ICE man." In an L, E (voltage) comes before I. In a C, I comes before E.

TRAP — frequency behaviour $X_L \propto f$ — an

inductor **blocks high frequencies** and passes DC (at $f = 0$, $X_L = 0$).

$X_C \propto 1/f$ — a capacitor **blocks DC** (infinite reactance at $f = 0$) and passes high frequencies.

A pure L or pure C consumes **no power**, because $\phi = 90^\circ$ and $\cos 90^\circ = 0$. The current in that case is called **wattless current**.

3. Series LCR Circuit (phasors only)

FORMULAS

$$Z = \sqrt{R^2 + (X_L - X_C)^2} \cdot I_{\text{rms}} = V_{\text{rms}}/Z$$

$$\tan\phi = (X_L - X_C)/R$$

$X_L > X_C \rightarrow$ circuit is **inductive**, voltage leads current.

$X_C > X_L \rightarrow$ circuit is **capacitive**, current leads voltage.

$X_L = X_C \rightarrow$ **resonance**, circuit behaves as purely resistive.

RESONANCE — the standard 3-marker

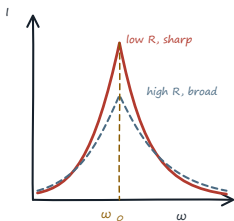
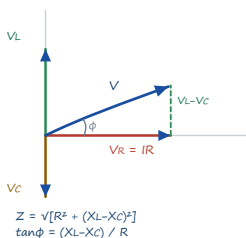
$$\omega_0 = 1/\sqrt{LC} \rightarrow f_0 = 1/2\pi\sqrt{LC}$$

At resonance: Z is minimum and equals R , current is maximum, $\phi = 0$ and the power factor is 1.

A series LCR circuit at resonance is called an **acceptor circuit** — it is used to tune a radio to one station.

Sharpness = quality factor $Q = \omega_0 L/R = (1/R)\sqrt{L/C}$. Smaller $R \rightarrow$ sharper resonance.

(a) Phasor diagram, series LCR (taking $V_L > V_C$) (b) Resonance curve



At resonance $X_L = X_C$, $Z = R$ (minimum), I is maximum and $\phi = 0$.

Resonance needs **both L and C** — an RL or RC circuit never resonates. Sharpness is measured by $Q = \omega_0 L/R$: smaller R , sharper peak.

4. Power in AC Circuits

FORMULAS

$P_{\text{avg}} = V_{\text{rms}} I_{\text{rms}} \cos\phi$ $\cos\phi = R/Z$ is the **power factor**

Pure resistive: $\cos\phi = 1$, full power. Pure L or C: $\cos\phi = 0$, zero power — wattless current.

At resonance: $\cos\phi = 1$, maximum power.

5. AC Generator and Transformer

AC GENERATOR Works on *electromagnetic induction*: a coil rotating in a magnetic field changes the flux linked with it.

$$\epsilon = NBA\omega \sin\omega t \rightarrow \epsilon_0 = NBA\omega$$

Uses *slip rings* (a DC generator uses a split-ring commutator instead).

TRANSFORMER Works on *mutual induction*. Changes AC voltage; *cannot work on DC*, because DC produces no changing flux.

$$V_s/V_p = N_s/N_p = I_p/I_s \quad \text{ideal: } V_p I_p = V_s I_s$$

Step-up: $N_s > N_p$, voltage up, current down. *Step-down*: the reverse. Power is never stepped up.

THE FOUR ENERGY LOSSES — and how each is reduced

1. *Copper loss* (I^2R heating in windings) $\rightarrow$ use *thick copper wire*.

2. Iron / eddy current loss → use a laminated core.

3. Hysteresis loss → use a soft iron core with a narrow hysteresis loop.

4. Flux leakage → wind the coils one over the other on the same core.

WHY POWER IS TRANSMITTED AT HIGH VOLTAGE

Power loss in the line is I^2R . Stepping the voltage **up** makes the current **small** for the same power, and since the loss goes as the **square** of the current, it falls dramatically. This is the standard 2-marker.

WORKED EXAMPLE

A series LCR circuit has $R = 30 \, \Omega$, $X_L = 60 \, \Omega$, $X_C = 20 \, \Omega$, supply $V_{\text{rms}} = 200 \, \text{V}$.

$$Z = \sqrt{30^2 + (60 - 20)^2} = \sqrt{900 + 1600} = \sqrt{2500} = 50 \, \Omega$$

$$I_{\text{rms}} = 200/50 = 4 \, \text{A}$$

$$\text{Power factor } \cos\phi = R/Z = 30/50 = 0.6$$

$$P = V_{\text{rms}} I_{\text{rms}} \cos\phi = 200 \times 4 \times 0.6 = 480$$

W

Since $X_L > X_C$, the circuit is **inductive** and voltage **leads** the current.

6. Question Triggers

what the wording is really asking

If the question says...	The answer is...
"current is maximum / impedance minimum"	Resonance , $\omega_0 = 1/\sqrt{LC}$
"power consumed by a pure inductor"	Zero — wattless current
"device blocks DC but passes AC"	Capacitor
"device passes DC but blocks high frequency"	Inductor
"can a transformer work on DC?"	No — no changing flux

"why laminated core"	To reduce eddy current loss
"tuning a radio"	Series resonance (acceptor circuit)
"220 V mains, find peak voltage"	$V_0 = \sqrt{2} \times 220 \approx 311 \text{ V}$

MOST-ASKED BOARD QUESTIONS

1. [3M] Draw the **phasor diagram** for a series LCR circuit and obtain Z and $\tan\phi$.
2. [3M] Explain **resonance**, derive $\omega_0 = 1/\sqrt{LC}$, and sketch I against ω for two values of R .
3. [3M] Describe a **transformer**: principle, working, and the four energy losses with remedies.
4. [2M] Define **power factor** and **wattless current**.
5. [2M] Why is electric power transmitted at **high voltage**?
6. [2M] Numerical on Z , I , power factor and average power.
7. [1M] What is the average value of AC over one full cycle? $\rightarrow$ **Zero**

THE HABIT THAT SCORES — Draw the phasor triangle before any LCR numerical: R along the reference, X_L up, X_C down. Once the triangle is on paper, Z , ϕ and the power factor all read straight off it, and you cannot mix up which quantity leads.

Chapter 8 · Electromagnetic Waves

CBSE Class 12 Physics (042) · Unit V · Unit V + VI

= 18 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS Only

a *basic idea* of displacement current is required, and the *transverse nature* is *qualitative*. The heavy marks here sit in the *electromagnetic spectrum* and the *elementary facts about each band's uses* — that is where to spend your time.

60-SECOND RECALL

Displacement current	$I_d = \epsilon_0 d\phi_E/dt$ — exists wherever the electric field changes
Speed in vacuum	$c = 1/\sqrt{\mu_0\epsilon_0} = 3 \times 10^8 \text{ m s}^{-1}$
In a medium	$v = 1/\sqrt{\mu\epsilon}$ · always less than c
E and B	Perpendicular to each other AND to the direction of travel — transverse
Ratio	$E_0/B_0 = c$
Order (increasing frequency)	Radio → Microwave → Infrared → Visible → Ultraviolet → X-rays → Gamma

1. Displacement Current

THE IDEA — why Maxwell needed it During the charging of a capacitor, **no conduction current flows between the plates**, yet a magnetic field is observed there. Ampere's law gave two different answers depending on the surface chosen.

Maxwell resolved it by proposing that a **changing electric field** also produces a magnetic field. The equivalent current is the **displacement current**.

FORMULAS

$$I_d = \epsilon_0 d\phi_E/dt$$

$$\text{Ampere-Maxwell law: } \oint \mathbf{B} \cdot d\mathbf{l} = \mu_0(I_c + I_d)$$

Inside a charging capacitor $I_d = I_c$, so the total current is continuous through the circuit.

2. Properties of Electromagnetic Waves

THE PROPERTIES ASKED

1. Produced by an accelerated charge.

2. Transverse — E and B are mutually perpendicular and both perpendicular to

the direction of propagation.

3. They travel in **vacuum**, needing **no material medium**.

4. E and B oscillate in **phase**, with $E_0/B_0 = c$.

5. They carry **energy and momentum**; the energy is shared equally between the electric and magnetic fields.

6. They are **not deflected** by electric or magnetic fields (they are uncharged).

FORMULAS

$$c = 1/\sqrt{\mu_0\epsilon_0} \cdot c = \nu\lambda$$

$$\text{Energy density: } u = \frac{1}{2}\epsilon_0 E^2 + \frac{B^2}{2\mu_0}$$

$$\text{Momentum delivered: } p = U/c \text{ (total absorption)}$$

3. The Electromagnetic Spectrum

THE TABLE THAT CARRIES THE MARKS

Band	Wavelength	How it is produced	Uses
Radio waves	> 0.1 m	Accelerated charge in aerials	Radio, TV, cellular communication

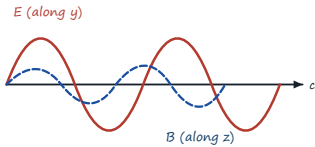
Microwaves	0.1 m – 1 mm	Klystron , magnetron, Gunn diode	RADAR , microwave ovens, satellite links
Infrared	1 mm – 700 nm	Vibrating molecules of hot bodies	Remote controls, night vision, physiotherapy, greenhouse effect
Visible	700 – 400 nm	Electron transitions in atoms	The only band the eye detects ; photosynthesis
Ultraviolet	400 – 1 nm	Sun, arcs, mercury lamps	Sterilising water, LASIK; absorbed by the ozone layer
X-rays	1 nm – 10^{-3} nm	Fast electrons hitting a metal target	Medical imaging, cancer treatment, crystallography
Gamma rays	$< 10^{-3}$ nm	Radioactive nuclei , nuclear reactions	Treating cancer, sterilising equipment

TRAP All electromagnetic waves travel at the same speed c in vacuum — only frequency and wavelength differ.

Higher frequency $\rightarrow$ **higher energy** ($E = h\nu$) and **shorter wavelength**.

Know these three by heart: **microwaves** $\rightarrow$ **RADAR**, **infrared** $\rightarrow$ **greenhouse effect**, **ultraviolet** $\rightarrow$ **ozone absorbs it**. One-markers come straight from this list.

EM waves are TRANSVERSE: $E \perp B \perp c$



E and B are **in phase**, peak together, and $E_0/B_0 = c$. Direction of travel is along $E \times B$.

Syllabus: transverse nature is **QUALITATIVE** only.

Spectrum

frequency increasing $\uparrow$

Radio — broadcasting
Microwave — radar, oven
Infrared — heat, remotes
Visible — 400–700 nm
Ultraviolet — ozone absorbs
X-rays — imaging
Gamma — nuclear origin

Order is worth a mark on its own.
All travel at c in vacuum.

Displacement current $i_d = \epsilon_0 d\Phi_E/dt$ is what Maxwell added, and it is why the field between capacitor plates is continuous with the wire current.

4. Question Triggers

name the radiation

If the question describes...	The answer is...
"used in RADAR and satellite communication"	Microwaves
"responsible for the greenhouse effect"	Infrared
"absorbed by the ozone layer"	Ultraviolet
"produced by fast electrons striking a metal target"	X-rays
"emitted by radioactive nuclei"	Gamma rays
"used in remote controls / night vision"	Infrared
"highest frequency / shortest wavelength"	Gamma rays
"changing electric field produces this"	Displacement current

MOST-ASKED BOARD QUESTIONS

1. [3M] Arrange the electromagnetic spectrum in order of **increasing frequency** and give one use of each band.
2. [2M] What is **displacement current**?
Write the Ampere–Maxwell law.
3. [2M] List four **properties** of electromagnetic waves.
4. [2M] Identify the radiation from a described use (very common as an assertion–reason or MCQ).
5. [1M] Which EM wave is used to **sterilise surgical instruments**? → **Gamma rays** (UV for water)
6. [1M] What is the relation between E_0 and B_0 ? → $E_0/B_0 = c$

THE HABIT THAT SCORES — This is the cheapest chapter in the paper: almost all of it is recall. Learn the spectrum table in the order **radio** → **gamma**, with one production method and one use each, and you have covered nearly every question that has ever been set on it.

Chapter 9 · Ray Optics and Optical Instruments

CBSE Class 12 Physics (042) · Unit VI Optics · Unit

V + VI = 18 marks (the largest block) · Ultimate Revision Sheet

60-SECOND RECALL

Mirror formula	$1/v + 1/u = 1/f$ · $f = R/2$ · $m = -v/u$
Lens formula	$1/v - 1/u = 1/f$ · $m = v/u$
Lens maker	$1/f = (\mu - 1)(1/R_1 - 1/R_2)$
Power	$P = 1/f$ (metres), diopetre · combination $P = P_1 + P_2$
Refraction at a surface	$\mu_2/v - \mu_1/u = (\mu_2 - \mu_1)/R$
Critical angle	$\mu = 1/\sin C$
Prism	$A + D = i + e$ · $\mu = \sin[(A + D_m)/2] / \sin(A/2)$
Telescope	$m = f_o/f_e$, length $f_o + f_e$

1. Sign Convention — get this right or lose everything

THE CARTESIAN CONVENTION

1. All distances are measured from the pole (mirror) or optical centre (lens).
2. Distances measured in the direction of

the incident light are **POSITIVE**; against it, **negative**.

3. Heights **above** the principal axis are positive, **below** negative.

Consequences: object distance u is always **negative**; concave mirror and convex lens have f **negative** and **positive** respectively; a real image has v **positive** for a lens and **negative** for a mirror.

2. Spherical Mirrors

FORMULAS

$$1/v + 1/u = 1/f \quad \cdot \quad f = R/2$$

$$\text{Magnification } m = h'/h = -v/u$$

m **negative** $\rightarrow$ real and inverted $\cdot$ m **positive** $\rightarrow$ virtual and erect.

Concave: converging, f negative. **Convex:** diverging, f positive, image always **virtual, erect, diminished** — which is why it is used as a rear-view mirror (wider field of view).

3. Refraction and Total Internal Reflection

FORMULAS

Snell's law: $\mu = \sin i / \sin r = c/v = \lambda_{\text{vacuum}} / \lambda_{\text{medium}}$

Real depth / apparent depth = μ

Refraction at a spherical surface: $\mu_2/v - \mu_1/u = (\mu_2 - \mu_1)/R$

TOTAL INTERNAL REFLECTION — the two conditions

1. Light must travel from a *denser* to a *rarer* medium.
2. The angle of incidence must *exceed* the *critical angle C*, where $\mu = 1/\sin C$.

Applications: optical fibres (light stays trapped by repeated TIR), sparkle of diamond (*C* is only 24°), mirage, totally reflecting prisms in periscopes and binoculars.

4. Lenses

FORMULAS

$1/v - 1/u = 1/f \cdot m = v/u = h'/h$

Lens maker's formula: $1/f = (\mu - 1)(1/R_1 - 1/R_2)$

Power $P = 1/f$ (f in metres, unit **diopetre**)

Thin lenses in contact: $1/F = 1/f_1 + 1/f_2 \rightarrow P = P_1 + P_2$

TRAP A convex lens in **water** has a **longer focal length**, because $(\mu - 1)$ becomes smaller when the surrounding medium is denser. If $\mu_{\text{lens}} = \mu_{\text{medium}}$ the lens **disappears** — f becomes infinite.
Convex lens: f positive, P positive. **Concave lens:** f negative, P negative.

5. Prism

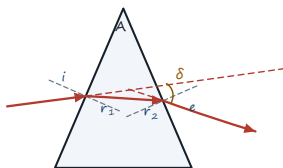
FORMULAS

$$A + D = i + e \quad r_1 + r_2 = A$$

At minimum deviation: $i = e$, $r_1 = r_2$, and the ray passes symmetrically

$$\mu = \sin[(A + D_m)/2] / \sin(A/2)$$

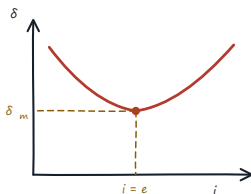
The graph of D against i falls to a single minimum and rises again — for any other deviation there are **two** possible angles of incidence.



$$r_1 + r_2 = A$$

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

The ray always bends TOWARDS the base.



Exactly ONE angle gives δ_m
every other δ is given by two.

At minimum deviation the ray inside runs parallel to the base and $i = e$, which is what makes $\mu = \sin[(A + \delta_m)/2] \div \sin(A/2)$ valid — that formula works at δ_m only.

6. Optical Instruments

COMPOUND MICROSCOPE

$$m = m_o \times m_e = (v_o/u_o)(1 + D/f_e) \quad (\text{image at near point})$$

$$m \approx (L/f_o)(D/f_e) \quad (\text{image at infinity, } L = \text{tube length, } D = 25 \text{ cm})$$

Both f_o and f_e are SHORT, and $f_o < f_e$. The objective forms a real, inverted, magnified image which the eyepiece then magnifies further.

ASTRONOMICAL TELESCOPE

$$m = f_o/f_e \quad (\text{normal adjustment}) \quad \cdot \quad \text{length} = f_o + f_e$$

$$m = (f_o/f_e)(1 + f_e/D) \quad (\text{image at near point})$$

f_o is LARGE and f_e is small — the exact opposite of the microscope.

A large objective aperture gives greater light-gathering power and better resolution.

WHY REFLECTING TELESCOPES ARE PREFERRED 1.

No **chromatic aberration** (mirrors do not disperse light). 2. Large mirrors are easier and cheaper to make than large lenses. 3. A mirror can be supported from behind, so it does not sag under its own weight. 4. Higher **resolving power** for the same cost.

WORKED EXAMPLE An object is 15 cm in front of a **concave mirror** of focal length 10 cm.

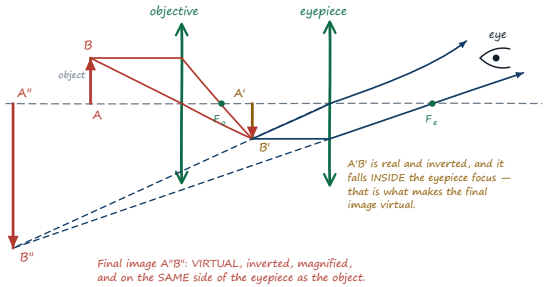
$$u = -15 \text{ cm}, f = -10 \text{ cm}$$

$$\begin{aligned} 1/v &= 1/f - 1/u = (-1/10) - (-1/15) = \\ &= -1/10 + 1/15 = (-3 + 2)/30 = -1/30 \end{aligned}$$

$v = -30 \text{ cm} \rightarrow$ image is 30 cm in front of the mirror, so it is **real**.

$$m = -v/u = -(-30)/(-15) = -2 \rightarrow \text{inverted and twice the size.}$$

Compound microscope — ray diagram



$m = (v_o/u_o)(1 + D/f_e)$ with the image at the near point $D = 25 \text{ cm}$, or
 $m = (L/f_o)(D/f_e)$ with it at infinity. A microscope wants a **short** f_o ; a telescope ($m = f_o/f_e$) wants a **long** one — mixing those up is the commonest slip in this chapter.

7. Question Triggers

what the wording is really asking

If the question says...	Use
"rear-view mirror / wide field of view"	Convex mirror — virtual, erect, diminished
"light trapped inside a fibre"	Total internal reflection
"apparent depth of a coin in water"	$\mu = \text{real depth} / \text{apparent depth}$
"focal length of a lens in water"	Lens maker's formula with μ_{relative}
"angle of minimum deviation"	$\mu = \sin[(A + D_m)/2] / \sin(A/2)$
"two lenses in contact"	$P = P_1 + P_2$
"why reflecting telescope"	No chromatic aberration , cheaper large mirrors

"objective of a telescope vs microscope"

Telescope f_o **large**; microscope f_o **small**

MOST-ASKED BOARD QUESTIONS

1. [3M] Derive the **lens maker's formula**, or the relation for refraction at a single spherical surface.
2. [3M] Draw a ray diagram of a **compound microscope / astronomical telescope** and derive its magnifying power.
3. [3M] Derive $\mu = \sin[(A+D_m)/2]/\sin(A/2)$ for a prism.
4. [2M] State the conditions for **total internal reflection** and give two applications.
5. [2M] Numerical using the mirror or lens formula with magnification.
6. [2M] Why is a **reflecting telescope** preferred over a refracting one?
7. [1M] Define the **power** of a lens and give its unit. $\rightarrow P = 1/f$, diopetre

THE HABIT THAT SCORES — Write the sign of every quantity **before** substituting, in a single line: $u = -\dots$, $f =$

-.... Most lost marks in this chapter are not conceptual at all — they are a dropped minus sign in the second line of working.

Chapter 10 · Wave Optics

CBSE Class 12 Physics (042) · Unit VI Optics · Unit

V + VI = 18 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS

Fringe width: final expression only, NO derivation. Learn $\beta = D\lambda/d$ and how to use it.

Single-slit diffraction and the width of the central maximum: qualitative treatment only.

What IS fully examinable: Huygens' principle, and the proof of the laws of reflection and refraction using wavefronts. That proof is the big derivation of this chapter.

60-SECOND RECALL

Huygens' principle	Every point on a wavefront is a source of secondary wavelets ; their common tangent gives the new wavefront
Fringe width	$\beta = D\lambda/d$ (formula only)
Bright fringe	Path difference = $n\lambda$
Dark fringe	Path difference = $(2n - 1)\lambda/2$
Intensity	$I \propto a^2 \cdot I_{\max}/I_{\min} = (a_1 + a_2)^2 / (a_1 - a_2)^2$
Coherent sources	Constant phase difference and the same frequency
Single slit	Central maximum is twice as wide as the others (qualitative)

1. Wavefront and Huygens' Principle

DEFINITIONS A **wavefront** is the locus of all points vibrating **in the same phase**. A ray is simply the direction **perpendicular** to the wavefront.

Shapes: point source $\rightarrow$ **spherical**; line source $\rightarrow$ **cylindrical**; source at infinity $\rightarrow$ **plane**.

WRITE THIS VERBATIM**Huygens' principle:**

every point on a given wavefront acts as a source of secondary wavelets which spread out in the forward direction with the speed of the wave; the envelope (common tangent) of these wavelets at a later instant gives the new position of the wavefront.

THE TWO PROOFS — the main derivation of this chapter

Reflection: constructing the reflected wavefront gives two congruent right triangles, and therefore $i = r$.

Refraction: in the same time, the wave covers $v_1 t$ in medium 1 and $v_2 t$ in medium 2, so

$$\sin i / \sin r = v_1/v_2 = \mu_2/\mu_1 \quad \text{— Snell's law}$$

The frequency never changes on refraction; the wavelength and speed do. This one-liner is a frequent 1-marker.

2. Interference and Young's Double Slit

COHERENT SOURCES

Two sources are **coherent** if they emit waves of the **same frequency** with a **constant phase difference**. Two independent bulbs can never be coherent, which is why YDSE uses **one source split into two**.

CONDITIONS AND FORMULAS

Constructive (bright): path difference = $n\lambda$, $n = 0, 1, 2, \dots$

Destructive (dark): path difference = $(2n - 1)\lambda/2$

Fringe width β = $D\lambda/d$ *final expression only — no derivation required*

Position of n^{th} bright fringe: $y_n = nD\lambda/d$

$$I = 4I_0 \cos^2(\varphi/2) \cdot I_{\max}/I_{\min} = (a_1 + a_2)^2 / (a_1 - a_2)^2$$

WHAT CHANGES β — asked constantly $\beta \propto \lambda \rightarrow$

red fringes are **wider** than blue.

$\beta \propto D \rightarrow$ moving the screen back widens the fringes.

$\beta \propto 1/d \rightarrow$ bringing the slits closer widens them.

In water the wavelength falls to λ/μ , so β

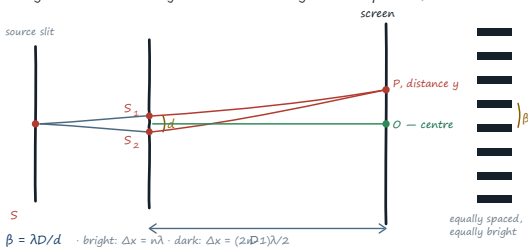
decreases by a factor μ .

In white light the centre is white and the surrounding fringes are coloured, with violet nearest the centre.

TRAP Interference does not create or destroy energy — it only redistributes it. The energy missing from the dark fringes appears in the bright ones, so the average intensity is unchanged. That sentence is the whole answer to "does interference violate conservation of energy?"

If one slit is covered, the interference pattern disappears and only a broad single-slit pattern remains.

Young's double slit — the syllabus wants the fringe-width expression, not its derivation



Interference gives **equally spaced, equally bright** fringes. Diffraction does not — its central maximum is twice as wide and the rest fade. That contrast is the usual 1-mark question.

3. Diffraction at a Single Slit qualitative only

WHAT TO KNOW

Light bends around the edges of an obstacle comparable in size to its wavelength. The pattern has a **wide bright central maximum** flanked by much weaker maxima.

Minima at: $a \sin \theta = n\lambda$ · Half-angular width $\theta = \lambda/a$ · Width of the central maximum = $2D\lambda/a$

The central maximum is twice as wide as any other, and grows wider as the slit is made narrower.

INTERFERENCE vs DIFFRACTION — the comparison asked

Basis	Interference	Diffraction
Arises from	Two coherent sources	Secondary wavelets from the same wavefront
Fringe width	All equal	Central is widest , others shrink
Intensity of maxima	All equal	Falls off rapidly
Dark fringes	Perfectly dark	Not perfectly dark

WORKED EXAMPLE

In a YDSE, $d = 0.5 \text{ mm}$,
 $D = 1 \text{ m}$, $\lambda = 500 \text{ nm}$.

$$\beta = D\lambda/d = (1 \times 500 \times 10^{-9}) / (0.5 \times 10^{-3}) \\ = 1 \times 10^{-3} \text{ m} = 1 \text{ mm}$$

Distance of the **3rd bright fringe** from the centre = $3\beta = 3 \text{ mm}$

If the whole apparatus is immersed in water ($\mu = 4/3$), $\beta' = \beta/\mu = 0.75 \text{ mm}$

4. Question Triggers

what the wording is really asking

If the question says...	The answer is...
"prove the laws of reflection / refraction"	Huygens' construction
"fringe width when screen is moved back"	$\beta \propto D \rightarrow$ increases
"apparatus immersed in water"	β decreases by a factor μ
"white light used in YDSE"	Central fringe white , rest coloured
"does interference violate energy conservation?"	No — energy is redistributed
"central maximum is twice as wide"	Single-slit diffraction
"what changes on refraction"	Speed and wavelength; frequency stays the same

MOST-ASKED BOARD QUESTIONS

1. [3M] State Huygens' principle and use it to prove the laws of reflection / refraction.
2. [3M] In YDSE, discuss how the fringe width changes with λ , D , d and the medium (numerical).
3. [2M] Write the conditions for constructive and destructive interference.
4. [2M] Distinguish between interference and diffraction.
5. [2M] What are coherent sources, and why are two separate bulbs never coherent?
6. [1M] How does the frequency of light change when it enters glass? → It does not

THE HABIT THAT SCORES — The syllabus removed the fringe-width derivation but kept the Huygens proofs. So practise **drawing** the two wavefront constructions until they are automatic — and do not waste a single revision minute deriving $\beta = D\lambda/d$.

Chapter 11 · Dual Nature of Radiation and Matter

CBSE Class 12 Physics (042) · Unit VII · Unit VII +

VIII = 12 marks · Ultimate Revision Sheet

60-SECOND RECALL

Einstein's equation	$h\nu = \varphi_0 + K_{\max}$
Max KE	$K_{\max} = h\nu - \varphi_0 = eV_0$
Threshold	$\varphi_0 = h\nu_0 = hc/\lambda_0$
Stopping potential	Depends on frequency , NOT on intensity
Photocurrent	Depends on intensity , NOT on frequency
de Broglie	$\lambda = h/p = h/mv \cdot \lambda = h/\sqrt{2mK}$
Accelerated electron	$\lambda = 12.27/\sqrt{V} \text{ \AA}$
h	$6.63 \times 10^{-34} \text{ J s}$

1. The Photoelectric Effect

DEFINITIONS

Photoelectric effect: the emission of electrons from a metal surface when light of suitable frequency falls on it.
Work function ϕ_0 : the minimum energy required to free an electron from the metal surface.

Threshold frequency ν_0 : the minimum frequency below which no emission occurs, however intense the light.

Stopping potential V_0 : the negative potential at which the photocurrent becomes zero.

THE FOUR EXPERIMENTAL LAWS

1. Emission is **instantaneous** — no time lag (less than 10^{-9} s).
2. For a given metal, emission occurs only above the **threshold frequency**.
3. The **photocurrent $\propto$ intensity** (more photons $\rightarrow$ more electrons).
4. The **maximum kinetic energy $\propto$ frequency**, and is independent of intensity.

EINSTEIN'S EQUATION

$$h\nu = \phi_0 + K_{\max} \rightarrow K_{\max} = h\nu - h\nu_0 = eV_0$$

$$eV_0 = h\nu - \phi_0 \rightarrow V_0 = (h/e)\nu - \phi_0/e$$

The graph of V_0 against ν is a straight line of slope h/e — the same slope for every metal — with intercept $-\phi_0/e$. This graph is asked repeatedly.

THE TRAP THAT SEPARATES GRADES Intensity

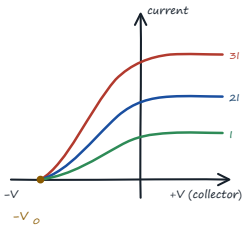
controls the NUMBER of electrons;
frequency controls their ENERGY.

Doubling the intensity doubles the photocurrent but leaves the stopping potential unchanged.

Raising the frequency raises the stopping potential but leaves the saturation current unchanged.

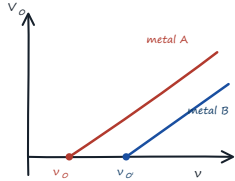
Wave theory failed on exactly three points: it could not explain the threshold frequency, the instantaneous emission, or why $K_{\max}$ is independent of intensity.

(a) Photocurrent vs collector plate potential



Same stopping potential for all three:
intensity changes NUMBER, not energy.

(b) Stopping potential vs frequency



Both lines have the SAME slope = h/e .
Only the threshold v_0 shifts, because
the work function differs.

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

The whole chapter is in these two graphs: **intensity** → **more electrons**, **frequency** → **more energy per electron**. Below v_0 nothing happens however bright the light.

2. Photons

PROPERTIES

Energy $E = h\nu = hc/\lambda$ · **Momentum** $p = h\nu/c = h/\lambda$

Photons have **zero rest mass**, travel at c , are **electrically neutral** (so undeflected by electric or magnetic fields), and in a collision with an electron both **energy and momentum are conserved**.

The number of photons emitted per second by a source of power P is $n = P/h\nu$.

3. Matter Waves — de Broglie

FORMULAS

$$\lambda = h/p = h/mv$$

$$\lambda = h/\sqrt{2mK} \quad (K = \text{kinetic energy})$$

$$\lambda = h/\sqrt{2mqV} \rightarrow \text{for an electron, } \lambda = 12.27/\sqrt{V} \text{ \AA}$$

(V in volts)

TRAP $\lambda \propto 1/\sqrt{m}$ at the same kinetic energy — so at equal energy a **proton** has a **shorter wavelength** than an electron, and a cricket ball's wavelength is far too small to observe. That is precisely why matter waves are invisible in daily life. The **Davisson–Germer experiment** confirmed matter waves by observing electron **diffraction** from a nickel crystal.

WORKED EXAMPLE

Light of wavelength **400 nm** falls on a metal of work function **2.0 eV**. Find $K_{\max}$ and the stopping potential.

$$E = hc/\lambda = (1240 \text{ eV nm})/(400 \text{ nm}) = \mathbf{3.1 \text{ eV}}$$

(using $hc = 1240 \text{ eV nm}$ saves time)

$$K_{\max} = E - \phi_0 = 3.1 - 2.0 = \mathbf{1.1 \text{ eV}}$$

$$\text{Stopping potential } V_0 = K_{\max}/e = \mathbf{1.1 \text{ V}}$$

$$\text{Threshold wavelength } \lambda_0 = 1240/2.0 = \mathbf{620 \text{ nm}}$$

4. Question Triggers

what the wording is really asking

If the question says...	The answer is...
"intensity is doubled"	Photocurrent doubles; V_0 unchanged
"frequency is increased"	V_0 and $K_{\max}$ rise ; saturation current unchanged
"no emission however bright the light"	Frequency is below threshold
"slope of the V_0 vs ν graph"	h/e — same for all metals
"wavelength of an accelerated electron"	$\lambda = 12.27/\sqrt{V} \text{ \AA}$
"which has shorter λ at the same KE"	The heavier particle

"experiment confirming the wave nature of electrons"

Davisson-Germer

MOST-ASKED BOARD QUESTIONS

1. [3M] State Einstein's photoelectric equation and explain the laws of photoelectric emission with it.
2. [3M] Sketch and explain the graphs of photocurrent vs intensity, photocurrent vs potential, and V_0 vs v .
3. [2M] Define work function, threshold frequency and stopping potential.
4. [2M] Derive the de Broglie wavelength of an electron accelerated through V volts.
5. [2M] Numerical on $K_{\max}$, V_0 and λ_0 .
6. [1M] Name the experiment that verified the wave nature of electrons. →
Davisson-Germer

THE HABIT THAT SCORES — Memorise $hc = 1240 \text{ eV nm}$. Every photoelectric numerical in the paper collapses to one line with it, and you avoid converting joules to electron-volts under time pressure.

Chapter 12 · Atoms

CBSE Class 12 Physics (042) · Unit VIII · Unit VII +

VIII = 12 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS

Hydrogen line spectra: qualitative treatment only. Know the series names and which region each falls in — do not spend time on detailed spectral calculations.

Fully examinable: the alpha-particle scattering experiment, Rutherford's model, Bohr's postulates, and the expressions for radius, velocity and energy of the n^{th} orbit.

60-SECOND RECALL

Bohr quantisation	$mvr = nh/2\pi$
Radius	$r_n \propto n^2 \cdot r_1 = 0.53 \text{ \AA}$ (Bohr radius)
Velocity	$v_n \propto 1/n \cdot v_1 = c/137$
Energy	$E_n = -13.6/n^2 \text{ eV}$
Transition	$h\nu = E_f - E_i$
Rydberg	$1/\lambda = R(1/n_f^2 - 1/n_i^2)$, $R = 1.097 \times 10^7 \text{ m}^{-1}$
Ionisation energy (H)	13.6 eV

1. Alpha-Particle Scattering and Rutherford's Model

THE OBSERVATIONS AND WHAT EACH PROVED

Observation	Conclusion
Most α -particles passed straight through	The atom is mostly empty space
A small fraction were deflected through large angles	There is a heavy, positively charged centre
About 1 in 8000 bounced straight back	The nucleus is very small and very dense

Nucleus size $\approx 10^{-15} \text{ m}$ against an atom $\approx 10^{-10} \text{ m}$ — a factor of 10^5 .

Distance of closest approach: $r_0 =$

$2kZe^2/K$, where K is the α -particle's kinetic energy.

WHY RUTHERFORD'S MODEL FAILED — a guaranteed 2-marker

1. **Stability:** an electron in a circular orbit is **accelerating**, so by classical electromagnetism it must **continuously radiate energy**, spiral inward and collapse into the nucleus within about 10^{-8} s. Atoms are in fact stable.
2. **Spectrum:** as it spiralled, the frequency would change continuously, giving a **continuous spectrum**. Real atoms emit a **line spectrum**.

2. Bohr's Model

THE THREE POSTULATES — write them in this order

1. **Stable orbits:** an electron revolves only in certain **stationary orbits** in which it does **not radiate** energy.
2. **Quantisation:** the angular momentum is an integral multiple of $h/2\pi$: $mvr = nh/2\pi$.
3. **Transition:** energy is emitted or absorbed **only when an electron jumps** between orbits, with $h\nu = E_f - E_i$.

THE THREE EXPRESSIONS — derive from Coulomb force = centripetal force

$$r_n = n^2 h^2 \epsilon_0 / \pi m Z e^2 \rightarrow r_n \propto n^2 / Z, r_1 = 0.53 \text{ \AA} \text{ for hydrogen}$$

$$v_n = Ze^2 / 2\epsilon_0 n h \rightarrow v_n \propto Z/n, v_1 = c/137$$

$$E_n = -13.6 Z^2 / n^2 \text{ eV} \rightarrow E_n \propto -1/n^2$$

$$KE = -E_n \cdot PE = 2E_n \cdot \text{Total } E = KE + PE = E_n$$

TRAP — the meaning of the minus sign E_n is

negative because the electron is **bound**.

Energy must be **supplied** to free it. $E = 0$ corresponds to the electron just escaping ($n = \infty$).

Ionisation energy of hydrogen = **+13.6 eV** (from $n = 1$ to $n = \infty$). The first **excitation** energy is $13.6 - 3.4 = 10.2 \text{ eV}$ — these two are not the same thing.

As n increases the orbits get farther apart in radius but the energy levels crowd together.

3. Hydrogen Spectrum qualitative only

THE FIVE SERIES — learn the landing level and the region

Series	Transitions to	Region
Lyman	$n = 1$	Ultraviolet
Balmer	$n = 2$	VISIBLE — the only visible series
Paschen	$n = 3$	Infrared
Brackett	$n = 4$	Infrared
Pfund	$n = 5$	Infrared

$$1/\lambda = R(1/n_f^2 - 1/n_i^2)$$

Within a series, the line from the **next** level is the **longest wavelength** and the one from $n = \infty$ is the **series limit** (shortest wavelength).

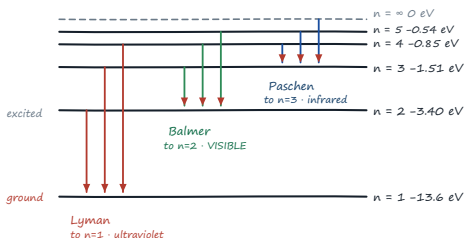
WORKED EXAMPLE Find the energy and wavelength emitted when an electron falls from $n = 3$ to $n = 2$ in hydrogen.

$$E_3 = -13.6/9 = -1.51 \text{ eV} \cdot E_2 = -13.6/4 = -3.40 \text{ eV}$$

$$\Delta E = -1.51 - (-3.40) = 1.89 \text{ eV}$$

$\lambda = 1240/1.89 = 656 \text{ nm} \rightarrow \text{red}$, and it belongs to the **Balmer** series (lands on $n = 2$), which is why it is visible.

Hydrogen energy levels — $E_n = -13.6/n^2 \text{ eV}$ (spacing shrinks as n grows)



$h\nu = E_i - E_f$ · ionisation energy = 13.6 eV · only Balmer is visible

Energies are **negative** because the electron is bound; zero is taken at $n = \infty$. The syllabus wants **hydrogen line spectra qualitatively only** — know which series lands where, not the Rydberg derivation.

4. Question Triggers

what the wording is really asking

If the question says...	The answer is...
"most α -particles went straight through"	Atom is mostly empty
"few bounced straight back"	Nucleus is small, heavy, dense
"why is Rutherford's atom unstable"	Accelerating electron radiates and spirals in
"visible lines of hydrogen"	Balmer series ($n_f = 2$)
"energy needed to remove the electron"	Ionisation energy = 13.6 eV
"radius of the n^{th} orbit"	$r \propto n^2$, $r_1 = 0.53 \text{ \AA}$
"ratio of KE to total energy"	KE = $-E$, so the ratio is -1

MOST-ASKED BOARD QUESTIONS

1. [3M] State Bohr's postulates and derive the expression for the **radius of the n^{th} orbit**.
2. [3M] Derive the expression for the **energy of an electron in the n^{th} orbit** and draw the energy level diagram.
3. [2M] Describe the **α -particle scattering experiment** and its conclusions.
4. [2M] Why did **Rutherford's model fail?**
Give both reasons.

5. [2M] Numerical on transition energy and emitted wavelength.
6. [1M] Which series of hydrogen lies in the **visible** region? → **Balmer**

THE HABIT THAT SCORES — Start every Bohr derivation from the same single line: **Coulomb force = centripetal force**, then bring in $mvr = nh/2\pi$. Radius, velocity and energy all fall out of those two equations, so you never need to memorise three separate results.

Chapter 13 · Nuclei

CBSE Class 12 Physics (042) · Unit VIII · Unit VII +

VIII = 12 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS

The chapter is now: *composition and size of the nucleus, nuclear force, mass-energy relation, mass defect, binding energy per nucleon and its variation with mass number, nuclear fission and fusion.*

Radioactivity and the decay law are NOT in the list — confirm with your teacher before skipping, since schools often still test them internally.

60-SECOND RECALL

Nuclear radius	$R = R_0 A^{1/3}$, $R_0 = 1.2 \times 10^{-15} \text{ m}$
Density	Independent of A $\approx 2.3 \times 10^{17} \text{ kg m}^{-3}$
Mass defect	$\Delta m = [Zm_p + (A-Z)m_n] - M_{\text{nucleus}}$
Einstein	$E = \Delta mc^2 \cdot 1 \text{ u} = 931.5 \text{ MeV}$
BE per nucleon	Peak $\approx 8.8 \text{ MeV}$ near $A = 56$ (iron) — the most stable
Fission	Heavy nucleus splits $\rightarrow \sim 200 \text{ MeV}$ per event
Fusion	Light nuclei join $\rightarrow$ more energy per nucleon ; powers the Sun

1. Composition and Size

THE BASICS A nucleus contains Z **protons** and $(A - Z)$ **neutrons**, together called **nucleons**.

Isotopes: same Z , different A (^1H , ^2H , ^3H).

Isobars: same A , different Z . **Isotones:** same number of **neutrons**.

$$R = R_0 A^{1/3} \rightarrow \text{volume} \propto A$$

Since mass $\propto A$ and volume $\propto A$, the **nuclear density is the same for every nucleus** — a standard 1-marker.

NUCLEAR FORCE — the four properties 1.

Strongest force in nature, about 100 times the electrostatic force.

2. Extremely short range — effective only within about 10^{-15} m; beyond a few fermi it is negligible.

3. Charge independent — the same between n-n, p-p and n-p.

4. Saturated — each nucleon interacts only with its **immediate neighbours**, which is why BE per nucleon stays roughly constant.

2. Mass Defect and Binding Energy

DEFINITIONS **Mass defect:** the difference between the sum of the masses of the free nucleons and the actual mass of the nucleus.

Binding energy: the energy equivalent of the mass defect — equally, the energy needed to break the nucleus into its free nucleons.

FORMULAS

$$\Delta m = [Zm_p + (A - Z)m_n] - M$$

$$\text{BE} = \Delta m \times c^2 \rightarrow \text{BE (MeV)} = \Delta m \text{ (u)} \times 931.5$$

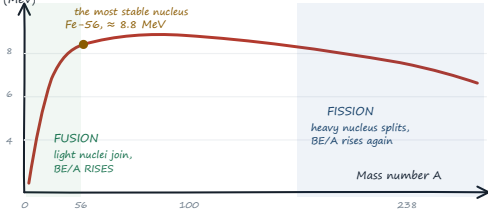
BE per nucleon = BE / A — this, not total BE, measures **stability**

THE BE-PER-NUCLEON CURVE — read all three regions

Rises steeply for light nuclei → peaks at about 8.8 MeV near $A = 56$ (iron region) → falls slowly for heavy nuclei (about 7.6 MeV at uranium).

Light nuclei can **FUSE** to climb the curve; heavy nuclei can **FISSION** to climb it from the other side. Both move towards the peak, and both therefore **release energy**. This single sentence explains the whole chapter.

Binding energy per nucleon vs mass number
BE/A (MeV)



Energy is released when the products sit **HIGHER** on this curve.

Nearly flat from $A \approx 30$ to 170 — the nuclear force is short-range and saturated.

Both processes move nuclei **towards Fe-56**. That single sentence answers "why does fission of heavy nuclei and fusion of light nuclei both release energy?"

3. Fission and Fusion

NUCLEAR FISSION

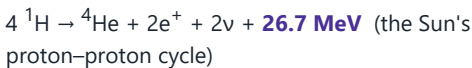
A heavy nucleus splits into two lighter nuclei of comparable mass, releasing neutrons and about **200 MeV** per fission.



The released neutrons can trigger further fissions — a **chain reaction**. Controlled in a **nuclear reactor** using **cadmium or boron control rods** (to absorb neutrons) and a **moderator** such as heavy water or graphite (to slow the fast neutrons).

NUCLEAR FUSION

Light nuclei combine to form a heavier nucleus, releasing energy.



Requires **extremely high temperature** ($\approx 10^7\text{ K}$) to overcome the **Coulomb repulsion** between nuclei, which is why it is called a **thermonuclear** reaction.

TRAP — the comparison examiners want Fission

releases more energy per EVENT (~ 200 MeV); fusion releases more energy per NUCLEON (~ 6 MeV vs ~ 0.85 MeV). A question asking "which releases more energy" is almost always testing which of the two you compare.

Fusion is **cleaner** (no long-lived radioactive waste) and its fuel is abundant, but it is **hard to control** at the required temperatures.

WORKED EXAMPLE Find the binding energy

per nucleon of ${}^4\text{He}$. Given $m_p = 1.00728$ u, $m_n = 1.00867$ u, $M({}^4\text{He nucleus}) = 4.00151$ u.

$$\begin{aligned}\text{Free nucleons} &= 2(1.00728) + \\ &2(1.00867) = 2.01456 + 2.01734 = \\ &4.03190 \text{ u}\end{aligned}$$

$$\Delta m = 4.03190 - 4.00151 = 0.03039 \text{ u}$$

$$\text{BE} = 0.03039 \times 931.5 = 28.3 \text{ MeV}$$

BE per nucleon = $28.3 / 4 = 7.1$ MeV — high for such a light nucleus, which is why the α -particle is exceptionally stable.

4. Question Triggers

what the wording is really asking

If the question says...	The answer is...
"density of the nucleus of different elements"	Same for all — $R \propto A^{1/3}$
"most stable nucleus"	Highest BE per nucleon → near iron, $A = 56$
"why energy is released in fission AND fusion"	Both move towards the peak of the BE curve
"role of the moderator"	Slows fast neutrons (heavy water, graphite)
"role of control rods"	Absorb neutrons (cadmium, boron)
"why fusion needs high temperature"	To overcome Coulomb repulsion
"energy equivalent of 1 u"	931.5 MeV

MOST-ASKED BOARD QUESTIONS

1. **[3M]** Draw the *binding energy per nucleon vs mass number* curve and use it to explain fission and fusion.
2. **[3M]** Define *mass defect* and *binding energy*; calculate BE per nucleon for a given nucleus.
3. **[2M]** State four properties of the *nuclear force*.

4. [2M] Show that nuclear density is independent of mass number.
5. [2M] Distinguish between nuclear fission and fusion.
6. [1M] What is the energy equivalent of 1 atomic mass unit? $\rightarrow 931.5 \text{ MeV}$

THE HABIT THAT SCORES — Draw the BE-per-nucleon curve from memory at the start of any long answer here, and label the peak at $A = 56$. Half the marks in this chapter are explanations that become obvious the moment that curve is on the page.

Chapter 14 · Semiconductor Electronics

CBSE Class 12 Physics (042) · Unit IX · Unit IX = 7

marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS

The chapter has been cut to: energy bands (qualitative), intrinsic and extrinsic semiconductors, p and n type, p-n junction, diode I-V characteristics in forward and reverse bias, and the diode as a rectifier.

Transistors, logic gates, Zener diodes and LEDs are NOT in the 2026-27 list.

Confirm with your teacher before skipping them, since many school tests still include them.

60-SECOND RECALL

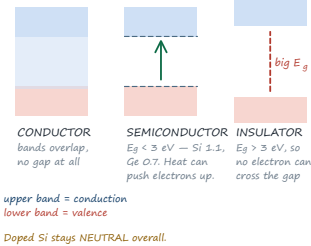
Band gap	Conductor 0 (overlap) · Semiconductor ≈ 1 eV · Insulator >3 eV
Intrinsic	$n_e = n_h = n_i$ · pure Si or Ge
n-type	Pentavalent dopant (P, As, Sb) · electrons majority
p-type	Trivalent dopant (B, Al, In) · holes majority
Mass action	$n_e n_h = n_i^2$
Forward bias	Barrier decreases · resistance low · current in mA
Reverse bias	Barrier increases · resistance high · current in μA
Barrier potential	Si 0.7 V · Ge 0.3 V

1. Energy Bands qualitative only

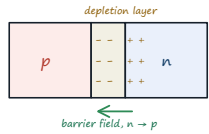
THE THREE MATERIALS

Material	Band gap E_g	Behaviour
Conductor	Zero — valence and conduction bands overlap	Electrons move freely; resistance rises with temperature
Semiconductor	Small, ≈ 1 eV (Si 1.1 eV, Ge 0.7 eV)	Insulator at 0 K; conducts when heated or doped. Resistance falls with temperature
Insulator	Large, > 3 eV	Conduction band effectively empty

(a) Energy bands (qualitative only)



(b) p-n junction



Barrier potential: Si ≈ 0.7 V, Ge ≈ 0.3 V
FORWARD bias (p to +): barrier shrinks, depletion layer narrows, current flows.
REVERSE bias (p to -): barrier grows, layer widens, only tiny leakage current.
The depletion layer has no free carriers — that is exactly why it resists current.

A diode conducts **one way only**, and the reason is the depletion layer widening or narrowing — say that, not just "it allows current in one direction".

2. Intrinsic and Extrinsic Semiconductors

INTRINSIC A pure semiconductor. Breaking a covalent bond creates an electron-hole pair, so $n_e = n_h = n_i$. Conductivity is **very low** at room temperature and rises with temperature.

EXTRINSIC — doping

	n-TYPE	p-TYPE
Dopant	Pentavalent — P, As, Sb	Trivalent — B, Al, In
Called	Donor impurity	Acceptor impurity
Majority carriers	Electrons	Holes
Minority carriers	Holes	Electrons

Energy level created

Donor level just **below** the conduction band

Acceptor level just **above** the valence band

$$n_e n_h = n_i^2 \text{ (law of mass action, holds for both types)}$$

TRAP A doped semiconductor is still electrically **NEUTRAL**. n-type does not mean negatively charged — it means electrons are the majority carriers. This is asked almost every year. Doping raises conductivity by a **factor of thousands** while changing the atom count by about **1 in 10^6** .

3. The p-n Junction

HOW THE JUNCTION FORMS

- 1. Diffusion:** holes diffuse $p \rightarrow n$ and electrons diffuse $n \rightarrow p$, because of the concentration difference.
- 2. Depletion region:** they recombine near the junction, leaving **immobile ions** — a region with **no free carriers**.
- 3. Barrier potential:** these ions set up an electric field (n side positive, p side negative) which **opposes further diffusion**. Si **0.7 V**, Ge **0.3 V**.
- 4. Drift** (minority carriers moving under

the field) balances diffusion, and equilibrium is reached.

BIASING — the comparison that carries the marks

Basis	FORWARD BIAS	REVERSE BIAS
Connection	p to +, n to -	p to -, n to +
Depletion width	Decreases	Increases
Barrier potential	Decreases	Increases
Resistance	Low (~ohms)	High (~MΩ)
Current	mA, by majority carriers	μA, by minority carriers
Special feature	Knee (cut-in) voltage	Breakdown voltage; current is nearly constant until then

A diode therefore conducts well in *one direction only* — it acts as a *switch*, closed in forward bias and open in reverse.

4. The Diode as a Rectifier

THE TWO CIRCUITS

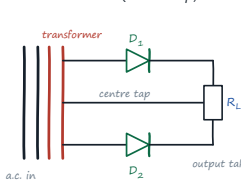
	HALF-WAVE	FULL-WAVE
Diodes used	One	Two (centre-tap transformer)
Output	Only one half of each cycle	Both halves , both made positive

Output frequency	Same as input (50 Hz)	Twice the input (100 Hz)
Efficiency	Low	About twice as high

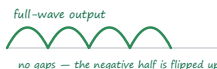
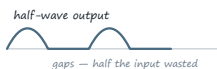
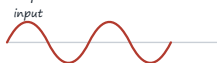
Working: in each half cycle the diode that is **forward biased conducts** and the other blocks, so current through the load always flows in the **same direction**.

A **capacitor filter** across the load smooths the pulsating DC by charging at the peaks and discharging through the load in between.

Full-wave rectifier (centre-tap) — both halves of the input are used



Only **ONE** diode conducts at a time: D_1 on the positive half, D_2 on the negative half — but current through R_L runs the **SAME** way both times.



Both are still pulsating d.c., so a filter capacitor follows in a real supply.

That last line is the whole idea: the two diodes take turns, but the load current never reverses. Output frequency is **2×** the input for full-wave, **1×** for half-wave.

5. Question Triggers

what the wording is really asking

If the question says...

The answer is...

"doped with phosphorus / arsenic"	n-type , donor, electrons majority
"doped with boron / indium"	p-type , acceptor, holes majority
"is an n-type semiconductor negatively charged?"	No — it is electrically neutral
"current of a few μA only"	Reverse bias — minority carriers
"depletion layer becomes thinner"	Forward bias
"output frequency is 100 Hz for 50 Hz input"	Full-wave rectifier
"resistance decreases on heating"	Semiconductor

MOST-ASKED BOARD QUESTIONS

1. [3M] Explain the formation of a **p-n junction**, the depletion region and the barrier potential.
2. [3M] Draw the **I-V characteristics** of a diode in forward and reverse bias and explain them.
3. [3M] Draw a **full-wave rectifier**, explain its working, and sketch input and output waveforms.
4. [2M] Distinguish between **intrinsic** and **extrinsic** semiconductors, and between **n-** and **p-type**.

5. [2M] Compare conductors, semiconductors and insulators on the basis of energy bands.
6. [1M] Give the barrier potential of a silicon diode. $\rightarrow 0.7 \text{ V}$

THE HABIT THAT SCORES — For every diode question, first say which way it is biased, then say what happens to the **depletion width** and the **barrier potential**. Those two phrases appear in the marking scheme for nearly every answer in this chapter.