

2ND PUC PHYSICS EXAM PREPARATION GUIDE

Important Questions, Step-by-Step Derivations, Diagrams & Practice Test
with Answer Key

Chapter 1: Electric Charges and Fields

*A focused exam-preparation guide covering key concepts, formulas, derivations and question types,
with practice tests and answer keys*

How to Use This Book

This guide is built around how marks are actually awarded in a Physics examination, not just around what a formula looks like. To get the most from it, follow this sequence for every topic:

- First understand the concept — read the explanation before trying to memorize anything.
- Learn the required formula — know it cold, including every symbol in it.
- Study the diagram — note exactly what must be drawn and labelled.
- Memorize the important answer points — use the checklists provided for each question.
- Practice writing the answer — don't just read it silently.
- Practice derivations without looking at the solution — attempt from memory, then check where you got stuck.
- Check SI units — omitting a required unit can lose marks, depending on the marking scheme.
- Revise using the Final Revision Checklist before your examination.

Each question in this book is tagged by its typical mark value (2, 3, or 5 marks) and comes with a clear answer-writing checklist so you know exactly what an examiner expects — not just the right answer, but the complete answer.

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CHAPTER 1

ELECTRIC CHARGES AND FIELDS

Electric Charges and Fields is the foundation chapter of the electrostatics unit, and it regularly produces high-value questions in Class 12 / 2nd PUC Physics examinations. The topics in this chapter — Coulomb's law, electric field lines, the electric dipole, and Gauss's law — appear frequently across unit tests, mid-terms, and final examinations, though exact patterns vary by school and board.

What makes this chapter especially scoring is that the questions follow recognizable patterns. The same core ideas are tested repeatedly, in 2-mark, 3-mark, and 5-mark formats, often as direct statements, sometimes as combined questions, and sometimes disguised with unfamiliar phrasing (for example, describing a dipole as “two equal and unlike charges separated by a small distance” instead of using the word “dipole” directly). Students who recognize these patterns and prepare complete, well-structured answers are better positioned to demonstrate their knowledge clearly in examinations, rather than relying on memorized final formulas alone.

Chapter at a Glance

Use this one-page overview for a fast first pass before you begin, or for a last look the night before the exam. Each topic below is covered in full in the numbered sections that follow.

Topic	Must Know
Charge	Properties (additivity, conservation, quantization $q = ne$)
Coulomb's Law	Scalar form (magnitudes) and vector form (signed charges)
Electric Field	Definition $E = F/q_0$; field due to a point charge
Field Lines	Properties (never intersect, no closed loops) + standard diagrams
Dipole	Moment $p = q(2a)$; axial and equatorial field expressions
Torque on Dipole	$\tau = pE \sin\theta$ (vector form $\tau = p \times E$)
Electric Flux	$\Phi = E \cdot A \cdot \cos\theta$ (surface integral of E , not just "field-line count")
Gauss's Law	$\Phi = q(\text{enclosed})/\epsilon_0$; applications to shell, wire, sheet
Charge Densities	Linear (λ), surface (σ) — definitions and units
Gaussian Surfaces	Sphere (point charge/shell), cylinder (line charge), pillbox (sheet)

Quick Formula Sheet

$$F = (1/4\pi\epsilon_0) \cdot (q_1q_2/r^2) \quad \text{— Coulomb's law (magnitude)}$$

$$E = (1/4\pi\epsilon_0) \cdot (q/r^2) \quad \text{— Field due to a point charge}$$

$$p = q \times (2a) \quad \text{— Dipole moment}$$

$$\tau = pE \sin\theta \quad \text{— Torque on a dipole in a uniform field}$$

$$\Phi = E \cdot A \cdot \cos\theta \quad \text{— Electric flux through a surface}$$

$$\Phi = q(\text{enclosed}) / \epsilon_0 \quad \text{— Gauss's law}$$

$$E(\text{line}) = \lambda / (2\pi\epsilon_0 r) \quad \text{— Infinite line charge}$$

$$E(\text{sheet}) = \sigma / (2\epsilon_0) \quad \text{— Infinite plane sheet}$$

$$E(\text{axial}) \approx (1/4\pi\epsilon_0) \cdot (2p/r^3) \quad \text{— Dipole, axial line } (r \gg a)$$

$$E(\text{equatorial}) \approx (1/4\pi\epsilon_0) \cdot (p/r^3) \quad \text{— Dipole, equatorial line } (r \gg a)$$

Note: This page is a quick index, not a substitute for the worked derivations, diagrams, and exam-writing guidance in the sections that follow — start there if a formula doesn't immediately make sense on its own.

Field lines of an isolated positive point charge

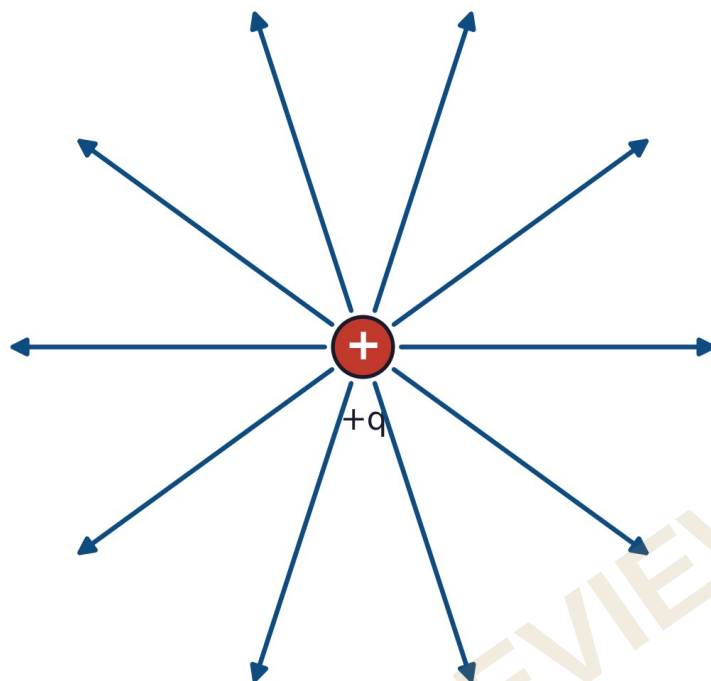


Diagram specification: A single point labelled $+q$ at the centre, with several straight lines radiating outward from it in all directions, each line ending in an arrowhead pointing away from the charge.

Common Mistake: Drawing the lines but forgetting the arrowheads. Field-line diagrams without a marked direction are treated as incomplete, even if the shape is correct.

Q5. Sketch electric field lines due to a system of two positive charges.

What the Examiner Expects: A diagram showing the characteristic pattern where field lines repel away from each other between the two like charges, with a null point between them — the point where the resultant electric field is zero.

Field lines of two equal positive charges

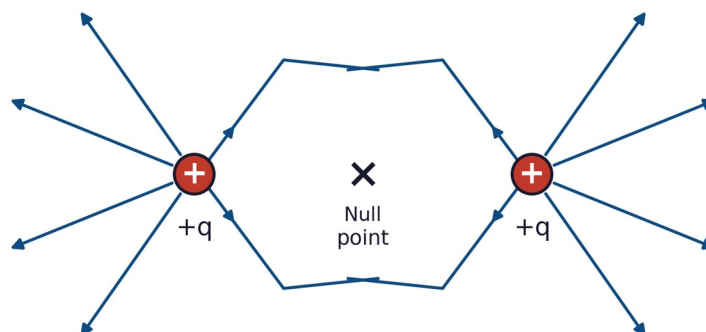


Diagram specification: Two points labelled $+q$, placed apart, with field lines radiating outward from each and curving away from one another in the region between the charges; a null point (the point where the resultant field is zero) marked on the line joining them.

Q6. Sketch electric field lines due to an electric dipole.

What the Examiner Expects: Field lines that begin on the positive charge and curve around to terminate on the negative charge.

Field lines of an electric dipole

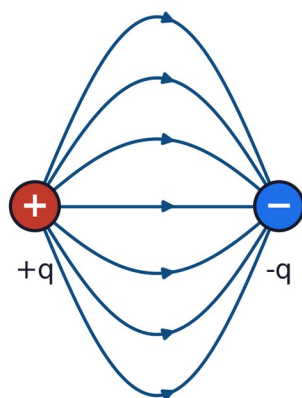


Diagram specification: Two points labelled $+q$ and $-q$ placed close together, with curved lines starting at $+q$ and curving around to end at $-q$, arrowheads pointing from $+$ to $-$.

Note: This question is sometimes phrased indirectly as “Draw electric field lines due to two equal and unlike charges separated by a small distance” instead of using the word “dipole.” Recognize that this is describing a dipole and answer accordingly.

$$\mathbf{F}_{12} \text{ (vector)} = (1/4\pi\epsilon_0) \cdot (q_1q_2 / r^2) \cdot \hat{\mathbf{r}}_{12}$$

Here F_{12} is the force on charge 1 due to charge 2, r is the distance between them, and $\hat{\mathbf{r}}_{12}$ is the unit vector directed from charge 2 towards charge 1. In this vector form, q_1 and q_2 are signed charges (positive or negative) — using their signs, rather than only their magnitudes, is what makes the equation itself correctly give repulsion for like charges and attraction for unlike charges.

Common Mistake: Writing only the scalar form and skipping the vector form. This exact combination — statement, scalar expression, AND vector form — is a frequently seen 3-mark question.

Q11. State Gauss's law of electrostatics and write its mathematical expression.

$$\Phi = q / \epsilon_0$$

Φ = total electric flux through a closed surface

q = total charge enclosed by the surface

ϵ_0 = permittivity of free space

Statement: The total electric flux through any closed surface is equal to $1/\epsilon_0$ times the total charge enclosed by that surface.

Exam Tip: If a 3-mark question only asks for an APPLICATION of Gauss's law (a specific derivation), you generally do not need to repeat the full statement — just proceed directly to the derivation. If it is a 5-mark question, always begin with the statement and expression first, THEN do the derivation.

Q12. Give any three properties of electric charge.

See Q8 for the full list — for 3 marks, write any three of the four properties listed there.

Q13. Give any three properties of electric field lines.

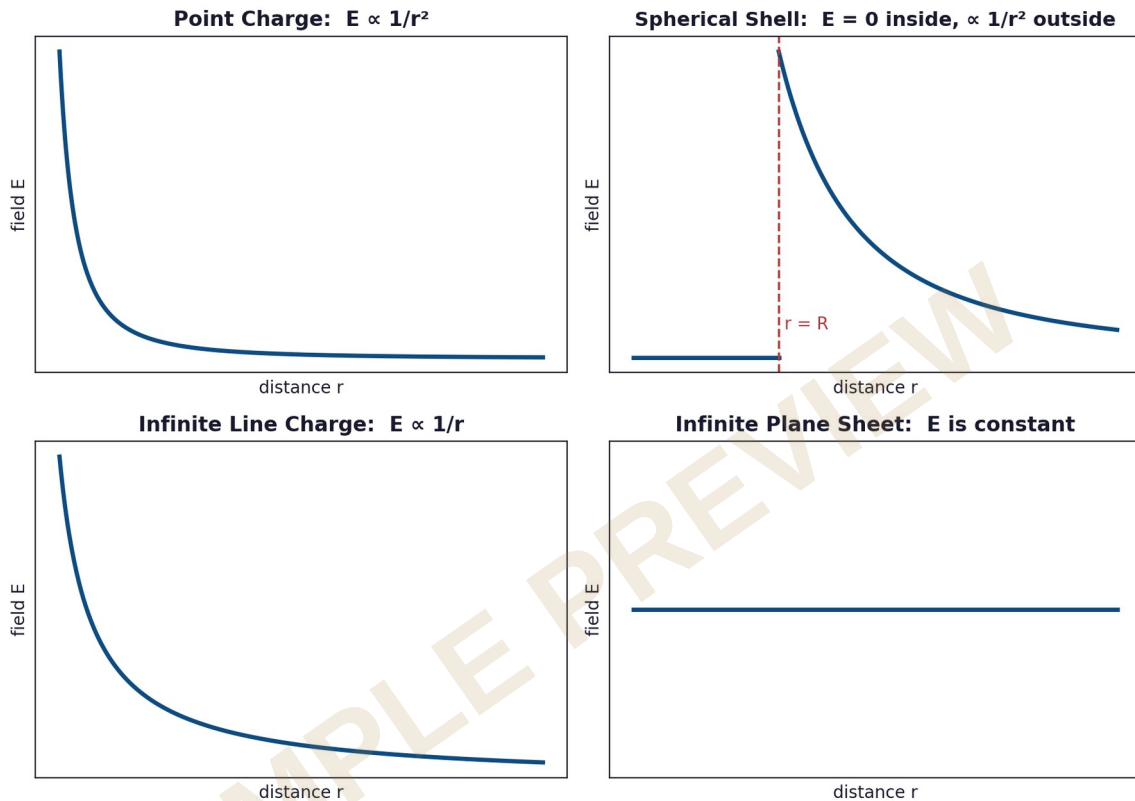
See Q9 for the full list — for 3 marks, write any three of the four properties listed there.

- Denser lines indicate a stronger field.

Graphical Behavior: E vs. Distance

These graphs summarize how the electric field magnitude changes with distance r for each of the standard charge configurations covered in this chapter — useful for spotting graph-based and assertion-reason questions.

How Electric Field Strength Varies with Distance



Note: Only the spherical-shell case is discontinuous at $r = R$ (as derived in Section 3); the other three configurations vary smoothly with r .

Formula Derivation Map

This map shows how the chapter's formulas connect to one another — useful for seeing the "big picture" before you start revising the individual derivations in detail.

Section 13 — Multiple Choice Questions

20 MCQs covering the full chapter. Try each one before checking the answer — MCQs test precision, and the explanations below highlight exactly where students usually slip.

1. SI unit of electric flux is:

- (a) N/C
- (b) $\text{N}\cdot\text{m}^2/\text{C}$
- (c) C/m^2
- (d) $\text{N}\cdot\text{m}$

Answer: (b) $\text{N}\cdot\text{m}^2/\text{C}$ — Flux is field $\times$ area, so its unit is $(\text{N}/\text{C}) \times \text{m}^2 = \text{N}\cdot\text{m}^2/\text{C}$.

2. According to Coulomb's law, if the distance between two charges is doubled, the force between them becomes:

- (a) Double
- (b) Half
- (c) One-fourth
- (d) Four times

Answer: (c) One-fourth — Force varies as $1/r^2$, so doubling r reduces force to $1/4$ of its original value.

3. Electric field lines due to an isolated positive point charge are:

- (a) Circular
- (b) Radially inward
- (c) Radially outward
- (d) Parallel straight lines

Answer: (c) Radially outward — A positive charge is a source of field lines, so they point radially away from it.

4. The electric field inside a uniformly charged thin spherical shell is:

- (a) Zero
- (b) Maximum at the centre
- (c) Same as just outside
- (d) Infinite

Answer: (a) Zero — For a spherical Gaussian surface inside the uniformly charged thin shell, the enclosed charge is zero. By spherical symmetry E is constant over this surface, so Gauss's law gives $E(4\pi r^2) = 0$, hence $E = 0$ inside. (Note: zero enclosed charge alone does not generally guarantee $E = 0$ everywhere on a surface — it's the added spherical symmetry here that lets this conclusion follow.)

5. Which of the following is NOT a property of electrostatic field lines?

- (a) They never intersect
- (b) They start on positive and end on negative charge
- (c) They can form closed loops
- (d) Denser lines indicate a stronger field

Answer: (c) They can form closed loops — Electrostatic field lines never form closed loops — this is a defining feature that distinguishes them from other vector fields.

6. Electric dipole moment is a:

- (a) Scalar quantity
- (b) Vector directed from + to – charge
- (c) Vector directed from – to + charge
- (d) Dimensionless quantity

Answer: (c) Vector directed from – to + charge — By definition $p = q \times d$, with direction taken from the negative charge to the positive charge.

7. The electric field due to an infinite plane sheet of charge:

Final Exam-Day Tips

- Read every question carefully before answering — note whether it asks for “any two” or “any three” points, and whether it specifies axial, equatorial, or a particular charge sign ($q > 0$ or $q < 0$).
- Always draw a diagram when one is relevant, even if not explicitly asked — a correct, labelled diagram may earn marks where the marking scheme allocates credit for it, even if you run out of time to finish the written derivation.
- For any derivation, write out every algebraic step. Skipping steps to save time often costs more marks than it saves.
- Finish every numerical answer with the correct SI unit.
- If you go blank on a full derivation, write down whatever you remember — the correct statement, the correct diagram, or the correct final formula — since partial credit is awarded for partially correct answers.
- In the last few minutes before the exam, run through the Final Revision Checklist in Section 15 one more time.

All the best for your examination.