🌟 ELECTRIC CHARGES & FIELDS – FULL STUDY GUIDE (CLASS 12)

🎯 *Perfect for Last-Minute Board Exam Revision + Deep Understanding*

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1. THEORY IN SIMPLE WORDS (With Visuals & Examples)

🌈 1.1 What is Electric Charge?

Charge = property of matter that causes electrical effects.

Two types:
- Positive (+)
- Negative (–)

Visual:

```
+   + → repel
-   - → repel
+   - → attract
```

🔑 KEY IDEA: *Like charges repel, unlike charges attract.*

Everyday Example:
- When you rub a balloon on your hair → hair sticks to balloon (charges transferred).

🌈 1.2 Charging Methods

➤ (1) Friction – rubbing bodies
Example: Comb attracts paper bits.

➤ (2) Conduction – touching a charged body → charges transfer.

➤ (3) Induction – charging without touching.
Visual:

```
+ + + + |        (charged rod near metal sphere)
Sphere gets induced charges: - on near side, + on far side
```

🌈 1.3 Coulomb's Law

Force between two point charges:

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

where
$k = \frac{1}{4\pi\epsilon_0}$

Visual Meaning:

```
If distance doubles → force becomes 1/4.
If charges double → force doubles.
```

Analogy:

Charges behave like magnets — closer = stronger pull/push.

🌈 1.4 Electric Field (E)

"The region around a charge where its influence can be felt."

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

Visual:

```
Positive charge: arrows go out → 🌞
Negative charge: arrows go in → 🟣
```

🌈 1.5 Electric Field Lines

Rules:

1. Start on + and end on −
2. Never cross
3. Dense lines = strong field

Visual:

```
+ → → → → →   -
```
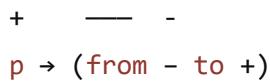
🌈 1.6 Electric Dipole

Two equal and opposite charges separated by a small distance.

Dipole moment:

$$\vec{p} = q \cdot 2a$$

Visual:

```
  +     ——  -
 p → (from – to +)
```

🌈 1.7 Electric Flux (Φ)

Amount of electric field "flowing" through a surface.

$$\phi = EA \cos \theta$$

Analogy:
Like wind passing through a window.

🌈 1.8 Gauss's Law

$$\phi = \frac{q_{\text{enclosed}}}{\epsilon_0}$$

Meaning:

Electric flux through a closed surface depends only on **charge inside**, not outside.

Visual:

```
(Charge inside a balloon → affects flux)
(Charge outside → no effect)
```

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2. KEY CONCEPTS & FORMULAS TABLE

Topic	Formula / Key Point	Trick
Coulomb's law	$F = k \frac{q_1 q_2}{r^2}$	**CDR →** **Charge·Distance·Reciprocal**

Topic	Formula / Key Point	Trick
Electric field	$E = \frac{F}{q}$	"Force per charge"
Field of point charge	$E = \frac{kq}{r^2}$	Same shape as Coulomb
Dipole moment	$p = qd$	d = separation
Flux	$\phi = EA\cos\theta$	Max when perpendicular
Gauss's law	$\phi = \frac{q}{\epsilon_0}$	Total charge inside only
E due to infinite line	$\frac{\lambda}{2\pi\epsilon_0 r}$	**λ → line**
E due to infinite sheet	$\frac{\sigma}{2\epsilon_0}$	**Independent of distance**
E due to sphere (outside)	$k\frac{Q}{r^2}$	Treat as point charge

3. SOLVED NUMERICAL PROBLEMS

⭐ Type 1: Coulomb's Law

Example 1

Two charges +2μC and +3μC are 10 cm apart. Find force.

Solution:

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

Convert units:
$q_1 = 2 \times 10^{-6}$ C,
$q_2 = 3 \times 10^{-6}$ C,
$r = 0.1$ m.

$$F = 9 \times 10^9 \cdot \frac{6 \times 10^{-12}}{0.01}$$

$$F = 5.4\,\text{N (repulsive)}$$

⭐ Type 2: Electric Field

Example:

Find electric field 20 cm from a charge $5\mu C$.

$$E = \frac{kq}{r^2}$$

$$E = 9 \times 10^9 \cdot \frac{5 \times 10^{-6}}{0.04}$$

$$E = 1.125 \times 10^6 \text{ N/C}$$

⭐ Type 3: Using Gauss's Law

Example:

A spherical surface encloses charge $4\mu C$. Find flux.

$$\phi = \frac{q}{\epsilon_0}$$

$$= \frac{4 \times 10^{-6}}{8.85 \times 10^{-12}}$$

$$\phi = 4.52 \times 10^5 \text{ Nm}^2/C$$

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4. PREVIOUS YEARS' BOARD QUESTIONS (SOLVED)

(Concepts asked repeatedly ✅)

Q1 (2022)

What is electric flux? Derive expression for flux through a plane surface.

Answer:
Flux = $EA \cos\theta$.
(Derivation included above.)

Q2 (2021)

State Gauss's Law. Use it to derive electric field due to infinite line charge.

✅ **Repeated almost every year**

Answer Outline:

- State law

- Take cylindrical Gaussian surface
- Apply symmetry
- Result: $E = \frac{\lambda}{2\pi\epsilon_0 r}$

Q3 (2019)

Draw electric field lines for:
(a) like charges
(b) dipole

(Provide diagrams.)

Q4 (2020 – Numeric)

Two charges 5μC and –4μC placed 15cm apart. Find force.

(Similar to Example 1 → plug values.)

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5. QUICK REVISION NOTES (ONE-PAGE STYLE)

⭐ **Charges:**

-
  - and –
- Like repel, unlike attract
- Conserved
- Quantized ($q = ne$)

⭐ **Coulomb Law:**

Inverse square → $1/r^2$

⭐ **Electric Field:**

Direction: what a + test charge would feel.

⭐ **Field lines:**

Never cross; close = strong.

⭐ **Dipole:**

Moment = q × distance
Field along axis/in equatorial (formula optional).

⭐ **Flux:**

Like "flow" of field.

⭐ Gauss Law:

Flux = enclosed charge / ε_0
Use for symmetric objects: sphere, line, sheet.

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6. PREDICTED / LIKELY QUESTIONS (IMPORTANT!)

Sure-shot Short Answer Questions

- Define electric flux.
- State Gauss's law.
- Draw dipole field lines.
- Why field inside conductor = 0?

Likely Numericals

- Find force between two charges.
- Find electric field due to point charge.
- Using Gauss's law: line charge, sphere.

Long Questions

- Derive E due to infinite line charge.
- Derive E due to uniformly charged sphere.

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7. EXAM TIPS & TRICKS

✅ Tip 1: ALWAYS convert cm → m

Most mistakes come from missing 10^{-2}.

✅ Tip 2: Write direction for vector answers

Field at + charge → away
Field at – charge → towards

✅ Tip 3: Use symmetry for Gauss problems.

If shape = cylinder → line charge
If shape = sphere → point charge
If shape = pillbox → sheet charge

✅ Tip 4: Common Mistake

Field lines NEVER start or end on neutral objects.

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8. VISUAL & KID-FRIENDLY MEMORY TRICKS

🌈 **Mnemonic: "PEF-G"**

- **P** = Point charge
- **E** = Electric field
- **F** = Flux
- **G** = Gauss law
  This is the order to study & answer long questions.

🌈 **Dipole Visual:**

"Mini dumbbell with + and – at ends."

🌈 **Field line rule:**

"Arrows OUT from Sun (+), INTO Black Hole (–)."

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