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Electric Charges and Fields: Chapter Introduction

1. The comb experiment

Run a plastic comb through dry hair and bring it near small bits of paper: they jump up and stick to it without being touched.

2. Electric charge

- **Charging by rubbing:** electrons move from one body to the other. The comb gains electrons (negative); the hair loses them (positive). Only electrons move; protons stay in the nuclei.
- **Two kinds:** positive and negative. **Like charges repel, unlike charges attract.**
- SI unit: coulomb (C). Charge is quantised ($q = ne$, $e = 1.6 \times 10^{-19}$ C) and conserved.

3. Why neutral paper is attracted: induction

The paper has no net charge. Near the negative comb its charges shift slightly: positive charge nearer the comb, negative charge farther away. The nearer attraction is stronger than the farther repulsion, so the net force pulls the paper to the comb.

4. Coulomb's law

$F = k\, q_1 q_2 / r^2$, with $k = 1/(4\pi\varepsilon_0) \approx 9 \times 10^9$ N m² C^{-2}. The force is along the line joining the charges.

Change	New force
Double one charge	2F
Double both charges	4F
Double the distance	F/4
Halve the distance	4F

Solved example. Two charges of 1 μC each, 0.3 m apart in air:
$F = 9 \times 10^9 \times (1 \times 10^{-6})^2 / (0.3)^2 = 9 \times 10^{-3} / 0.09 =$ **0.1 N** (repulsive).

5. Electric field and field lines

Electric field $E = F / q_0$: the force per unit positive test charge (unit N/C). A charge creates a field around itself; any other charge placed there feels $F = qE$. This is how the comb acts on the paper without touching it.

- Field lines start on positive charges and end on negative charges (they point into a negative charge such as the comb).
- The tangent gives the direction of E; crowded lines mean a stronger field.

- Two field lines never cross.
- Dipole: equal and opposite charges a small distance apart; lines run from + to −.

6. Chapter map

Electric charge → Coulomb's law → electric field → field lines → electric dipole → electric flux → Gauss's law and its applications.

Key takeaways

- Rubbing transfers electrons.
- Like repel, unlike attract; neutral bodies are attracted by induction.
- $F \propto q_1 q_2 / r^2$.
- Fields let charges act at a distance; lines go from + to −.

Practice questions (CBSE style)

1. (MCQ) A comb run through dry hair becomes negative because it (a) loses protons (b) gains electrons (c) loses electrons (d) gains protons
2. (MCQ) Doubling the distance between two charges makes the force (a) 2F (b) F/2 (c) F/4 (d) 4F
3. (Very short) Why can two field lines never cross?
4. (Very short) State the SI unit of electric field.
5. (Short) Explain why a charged comb attracts a neutral bit of paper.
6. (Numerical) Two charges repel with 36 N. Find the force when the distance is tripled.
7. (Numerical) Find the force on a 2 μC charge in a field of 5×10^3 N/C.
8. (Application) A glass rod rubbed with silk becomes positive. Which way did the electrons move?

Answer key

1. (b).
2. (c) F/4.
3. At a crossing the field would have two directions at one point, which is impossible.
4. N/C (newton per coulomb).
5. Charges in the paper shift: opposite charge comes nearer the comb, like charge moves away; the nearer attraction is stronger, so the paper is pulled (induction).
6. $F' = 36 / 3^2 = 4$ N.
7. $F = qE = 2 \times 10^{-6} \times 5 \times 10^3 = 0.01$ N.
8. From the glass rod to the silk: the rod lost electrons.

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