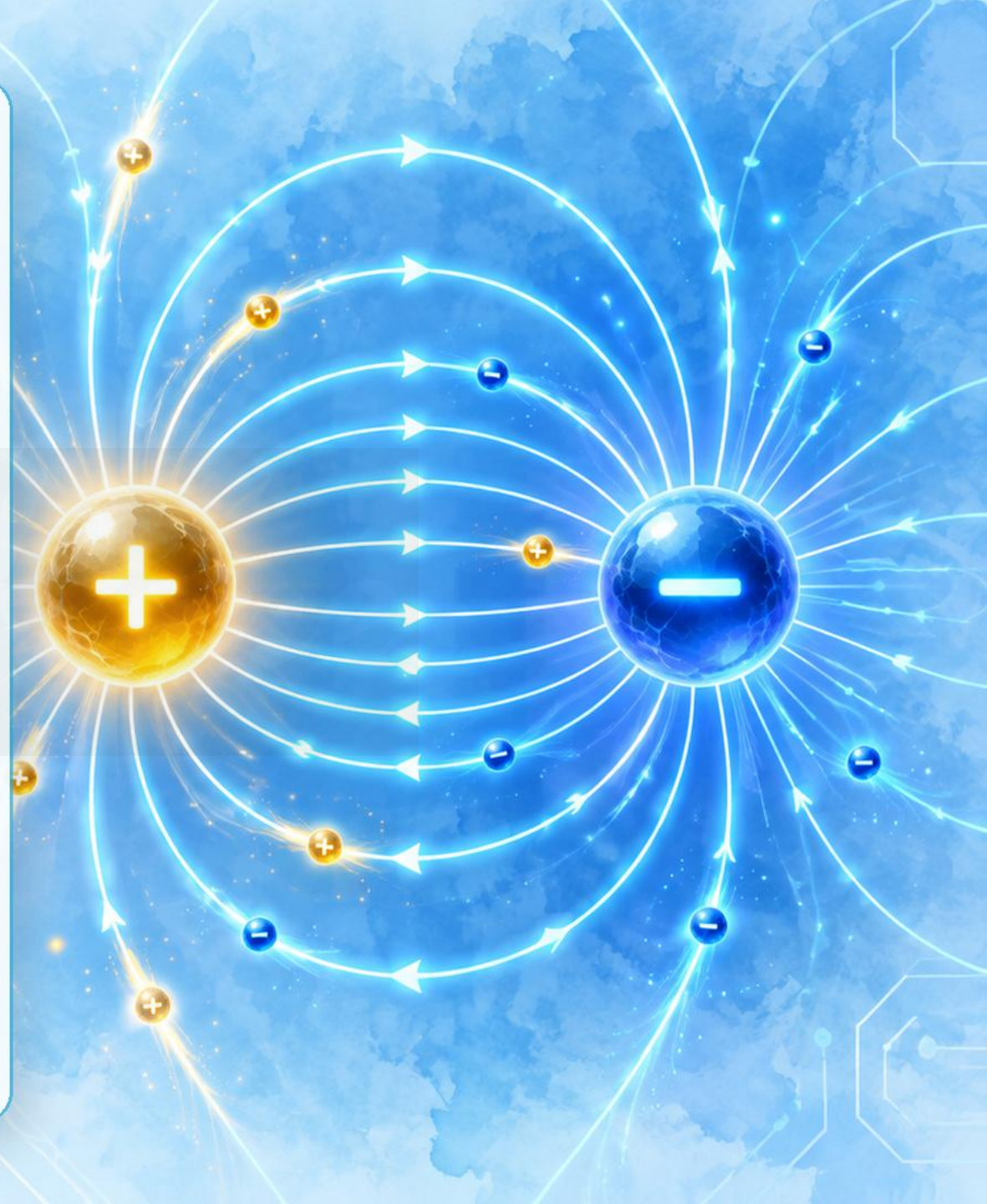


PHYSICS • CLASS 12

CHAPTER 1

Electric Charges and Fields

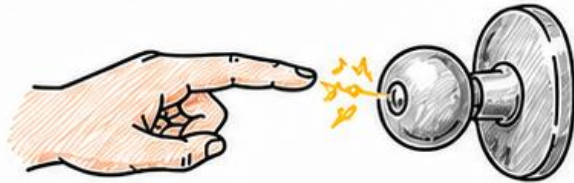
CHAPTER NOTES



ELECTRIC CHARGES AND FIELDS

Electrostatics studies electric charges at rest and the forces and fields they produce.

SPARK FROM A KNOB



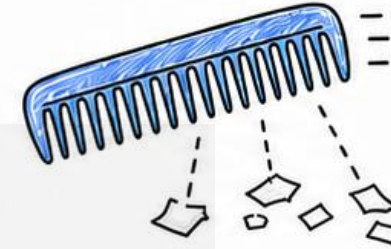
Charge builds up and a tiny spark occurs.

LIGHTNING

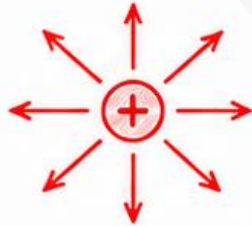


Charge separation in clouds and ground causes a powerful discharge.

RUBBED COMB



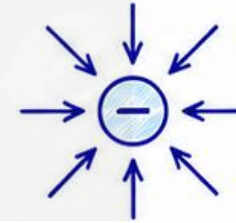
Rubbing gives the comb excess charge; it attracts light paper bits.



Field lines point outward from + charge.

charges $\rightarrow$ forces $\rightarrow$ fields

fields act on charges



Field lines point inward toward - charge.

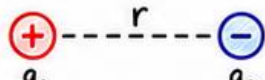
ELECTRIC CHARGE



Fundamental property of matter.

How is charge transferred?

COULOMB'S LAW


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

How do charges interact?

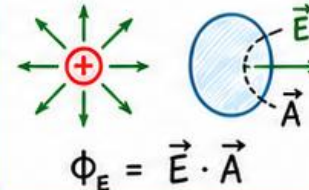
ELECTRIC FIELD

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

(due to source charge)

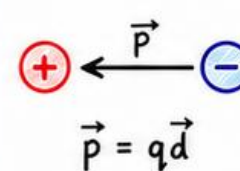
What force would act on a positive test charge?

FIELD LINES & FLUX



How do we visualize and measure fields?

ELECTRIC DIPOLE



How does a dipole create a field?

GAUSS'S LAW

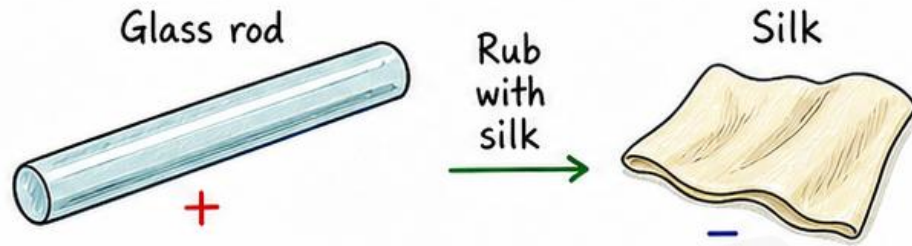
$$\Phi_E = \frac{Q_{\text{enc}}}{\epsilon_0}$$

Relates flux to enclosed charge.

How do symmetry and flux simplify field calculations?

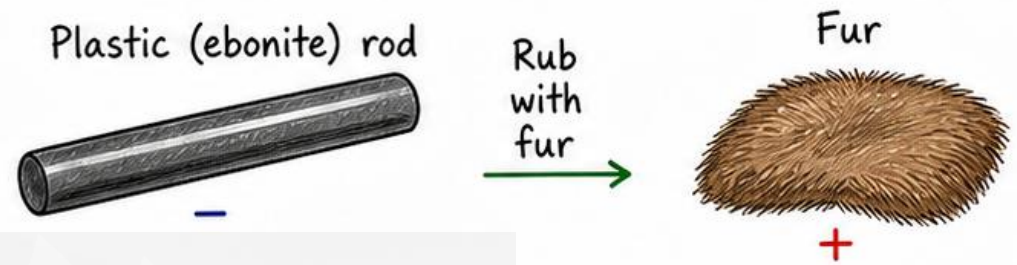
CHARGING AND TWO KINDS OF CHARGE

1) FRICTIONAL CHARGING: GLASS AND SILK



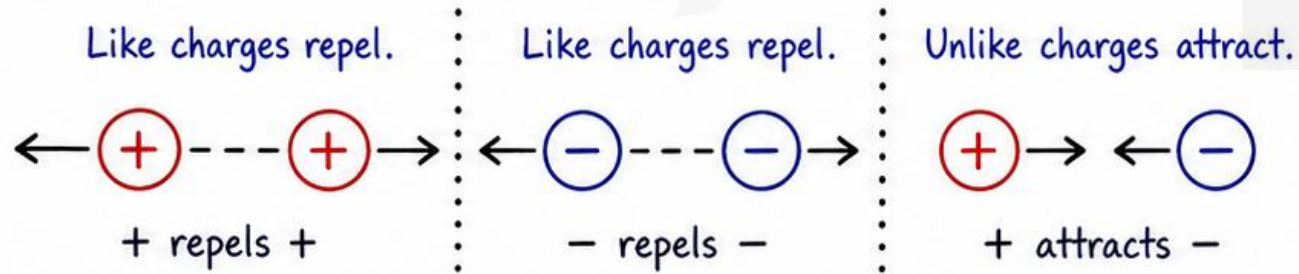
Electrons move from glass to silk.
Glass becomes positive (+); silk becomes negative (-).

2) FRICTIONAL CHARGING: PLASTIC/EBONITE AND FUR



Electrons move from fur to the plastic rod.
Plastic rod becomes negative (-); fur becomes positive (+).

3) INTERACTION RULE



- Rubbing transfers electrons; it does not create net charge.
- A positive body has an electron deficit; a negative body has an electron excess.
- By convention: glass rubbed with silk is positive; silk is negative.
- Contact of equal opposite charges can neutralise their observable effect.

CONSERVATION OF CHARGE (IN FRICTION):

charge lost by one body

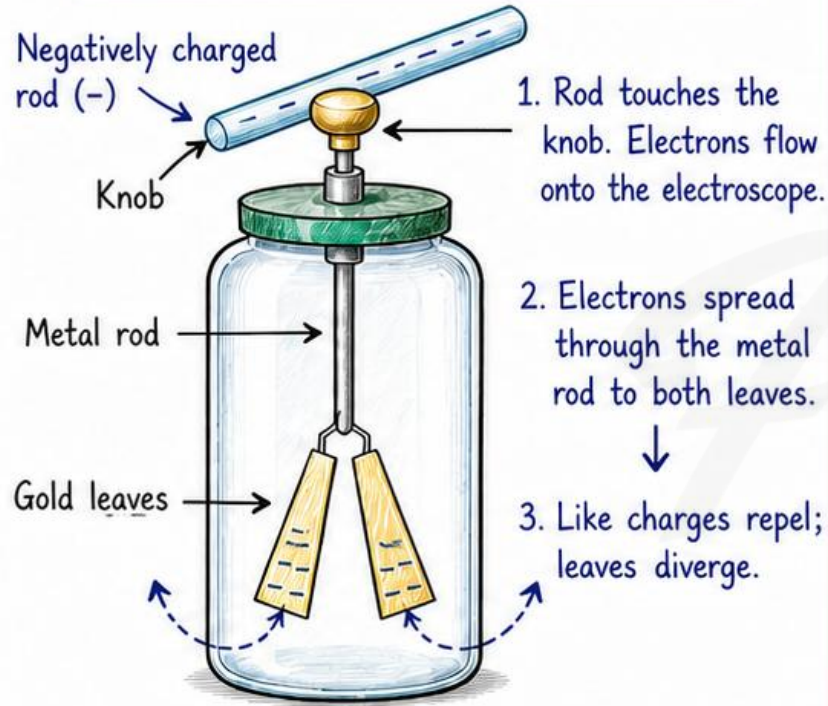
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charge gained by the other

Total charge of the system remains constant.

ELECTROSCOPE, CONDUCTORS AND INSULATORS

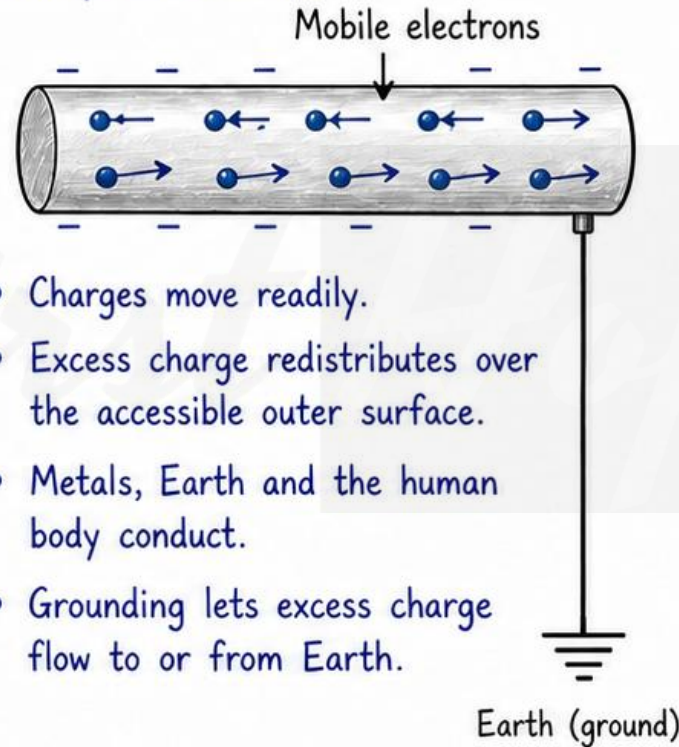
GOLD-LEAF ELECTROSCOPE



Note: Divergence detects charging; it is not a universal linear charge scale.

CONDUCTORS

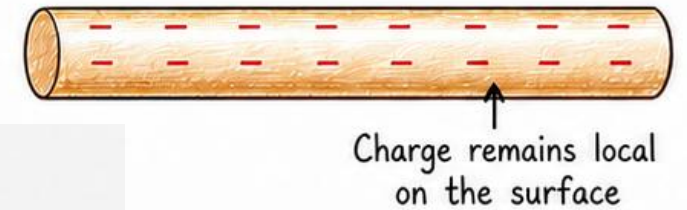
Example: Metal rod



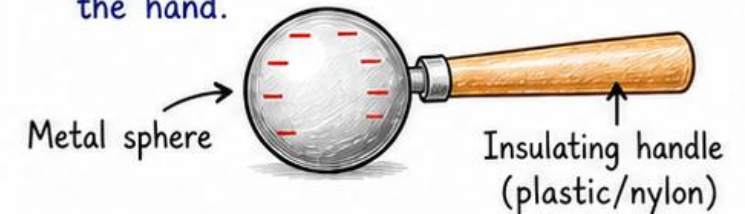
- Charges move readily.
- Excess charge redistributes over the accessible outer surface.
- Metals, Earth and the human body conduct.
- Grounding lets excess charge flow to or from Earth.

INSULATORS

Examples: Plastic rod, Nylon rod, Glass rod



- Charges are strongly bound.
- Deposited charge remains local; it does not spread.
- An insulating handle prevents a metal object discharging through the hand.



CONDUCTOR →

mobile charge carriers;
excess charge redistributes
and can be grounded.

INSULATOR →

charge remains local;
it does not spread
readily.

SEMICONDUCTOR →

intermediate, tunable conductivity;
carrier density depends strongly
on material, doping and temperature.

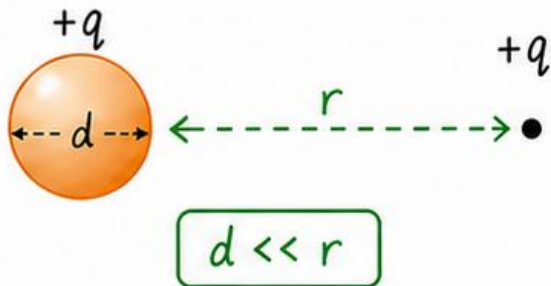
ELECTROLYTE →

BOTH positive ions (cations)
and negative ions (anions)
are mobile charge carriers.

BASIC PROPERTIES OF ELECTRIC CHARGE

A) POINT-CHARGE MODEL

A small charged body of physical size d is treated as a point charge when observed from distances r much larger than its size.



All the charge is assumed to be concentrated at the point.

$+q$
• Represents the point-charge model.

B) ADDITIVITY

The total charge of a system is the algebraic sum of individual charges.

$$Q = q_1 + q_2 + \dots + q_n$$

Charge is a scalar quantity, so use algebraic signs.

Mini-check:

$$(+1) + (+2) + (-3) + (+4) + (-5) = -1$$

Examples:

- Two $+2 \mu\text{C}$ charges $\rightarrow Q = +4 \mu\text{C}$
- $+3 \mu\text{C}$ and $-5 \mu\text{C} \rightarrow Q = -2 \mu\text{C}$
- Three -1 nC charges $\rightarrow Q = -3 \text{ nC}$

C) CONSERVATION

Total charge of an isolated system remains constant.



One electron (e^-) moves from A to B:

$$A: -2 \mu\text{C} \rightarrow -2 \mu\text{C} + e$$

$$B: +2 \mu\text{C} \rightarrow +2 \mu\text{C} - e$$

$$\Delta q_A = +e, \quad \Delta q_B = -e$$

$$\Delta q_A + \Delta q_B = 0$$

Charge may be transferred. Charged particles may be created or destroyed in balanced processes; nevertheless, the algebraic total charge of an isolated system remains constant.

D) QUANTISATION

Electric charge is quantised.

$$q = n e, \quad n = 0, \pm 1, \pm 2, \dots$$

Elementary charge (exact):

$$e = 1.602176634 \times 10^{-19} \text{ C} \quad (\text{exact})$$

Useful conversions:

- $1 \text{ microC} = 10^{-6} \text{ C}$
- $1 \text{ mC} = 10^{-3} \text{ C}$

1 C corresponds to about

$$6.24 \times 10^{18} \text{ elementary charges.}$$

Observable isolated charge occurs in integer multiples of e ; quarks carry fractional charges but are confined. At macroscopic scales, charge appears continuous.

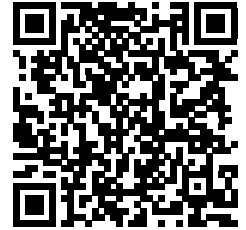


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