Electrostatics

Matthew Williams • Physics • May 20, 2026

Electrostatics

Electrostatics deals with electric charges that are at rest.

Electric Charge

Matter contains protons (positive charge) and electrons (negative charge). A neutral object has equal numbers of each. When objects gain or lose electrons, they become charged:

- **Positive charge:** object has fewer electrons than protons (electrons removed).
- **Negative charge:** object has more electrons than protons (electrons gained).

Only electrons transfer during charging of solids, protons remain fixed in the nucleus.

Law of Electrostatics

The law of electrostatics states that like charges repel each other and unlike (opposite) charges attract each other.

Charging by Friction

When two different insulating materials are rubbed together, electrons transfer from one to the other:

- A polythene rod rubbed with wool: electrons transfer from wool to polythene, polythene becomes negatively charged, wool becomes positively charged.
- A glass rod rubbed with silk: electrons transfer from glass to silk, glass becomes positive, silk becomes negative.

The charge is created by electron transfer, not by creating or destroying charge (conservation of charge).

Charging by Induction

A neutral conductor can be charged without contact using a charged object:

- 1. Bring a negatively charged rod near (but not touching) a neutral metal sphere.
- 2. Free electrons in the sphere are repelled to the far side, the near side becomes positive, the far side negative.
- 3. **Connect the sphere to earth (ground)**, electrons flow away from the sphere to earth, leaving the sphere with a positive charge.
- 4. Remove the earth connection, then remove the rod.
- 5. The sphere is now positively charged, opposite to the inducing charge.

Electric Fields

An **electric field** is a region in which a charged particle experiences a force. Electric field lines show the direction a positive test charge would move:

- Lines point **from positive to negative**.
- Closer spacing indicates a stronger field.
- Field lines never cross.

Patterns of Electric Field Lines

Isolated point charge:

- Positive charge: field lines radiate outward in all directions.
- Negative charge: field lines point inward from all directions.

Two opposite point charges (electric dipole):

- Field lines go from the positive charge to the negative charge, curving between them.

Two parallel plates (uniform field):

- Field lines are straight, parallel, and evenly spaced between the plates.
- The field is uniform (same magnitude and direction at every point between the plates).

<ParallelPlatesFieldDiagram />

Electrostatic Applications

Application	Principle
Photocopier / laser printer	Charged drum attracts toner particles to form an image
Electrostatic precipitator (air filter)	Charged plates attract dust and smoke particles, cleaning industrial exhaust
Spray painting	Charged paint droplets are attracted to earthed metal object, reduces waste and gives even coating
Lightning conductor	Pointed conductor on a building provides a preferential path for charge to flow safely to earth

Dangers of Electrostatics

Static charge can build up when flammable fuels are pumped through pipes or when aircraft move through air. If the charge discharges as a spark, it can ignite vapour. Aircraft are earthed when refuelling; fuel tanker trucks use bonding cables.

> 📝 **Exam Tip**
> When explaining charging by friction, always state that electrons (not protons) are transferred. Identify which object gains electrons (negative charge) and which loses them (positive charge).
>
> For charging by induction, always state that the sphere is connected to earth before the rod is removed, this is the step that causes the net charge to appear.