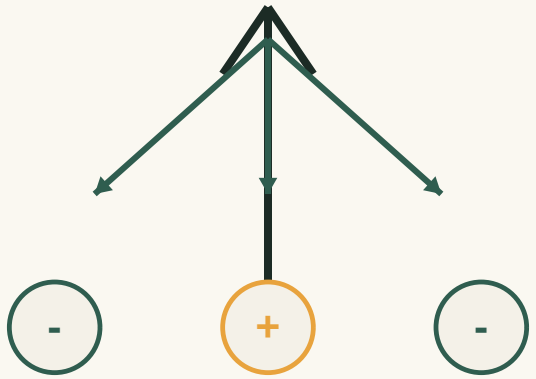
ELECTROSTATICS

Static Electricity: Control & Use

How moving charges reach balance, create hazards, and do useful work.

ESSENTIAL QUESTION

How can the same electric charge be dangerous, safely blocked, or deliberately useful?



control the path of charge

LESSON MAP

Follow charge from motion to purpose.

Four ideas explain both electrostatic safety and electrostatic technology.

01

BALANCE

Free electrons move until the field inside a conductor is zero.

02

CONCENTRATE

Charge crowds at sharp points and can ionise air.

03

SHIELD

A conducting shell redirects charge around a protected region.

04

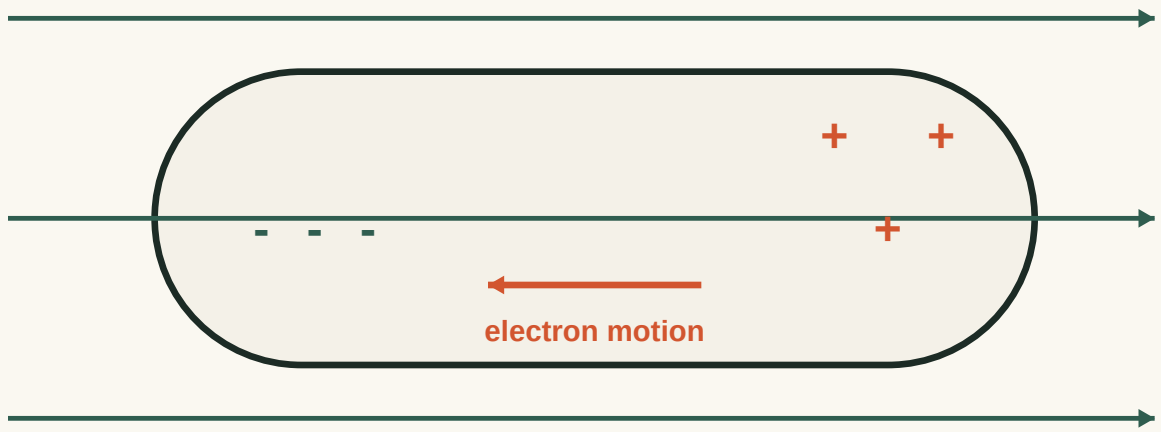
APPLY

Electric forces route dust, paint, and toner.

OBSERVE

Free electrons move when a conductor enters a field.

The applied field pushes mobile electrons opposite to the field direction.



1 **The external field acts on free electrons.**

They begin to drift through the metal.

2 **Opposite charges appear at opposite ends.**

This is electrostatic induction.

3 **Separated charges create an opposing field.**

That field slows further movement.

MODEL

Charge stops moving when the internal field reaches zero.

Electrostatic equilibrium is a balance of fields, not a disappearance of charge.

INSIDE THE CONDUCTOR

$$E_{net} = E_{ext} + E_{ind} = 0$$

With no net field, electrons have no reason to keep drifting.

Equilibrium is established extremely quickly.

CHECK

Electrostatic equilibrium leaves four clear signatures.

These rules let us predict what every conductor will do.

01

NO FIELD INSIDE

E = 0 everywhere in the conducting material.

02

ONE POTENTIAL

The whole conductor is an equipotential.

03

SURFACE CHARGE

Any excess charge sits on the outer surface.

04

NORMAL FIELD

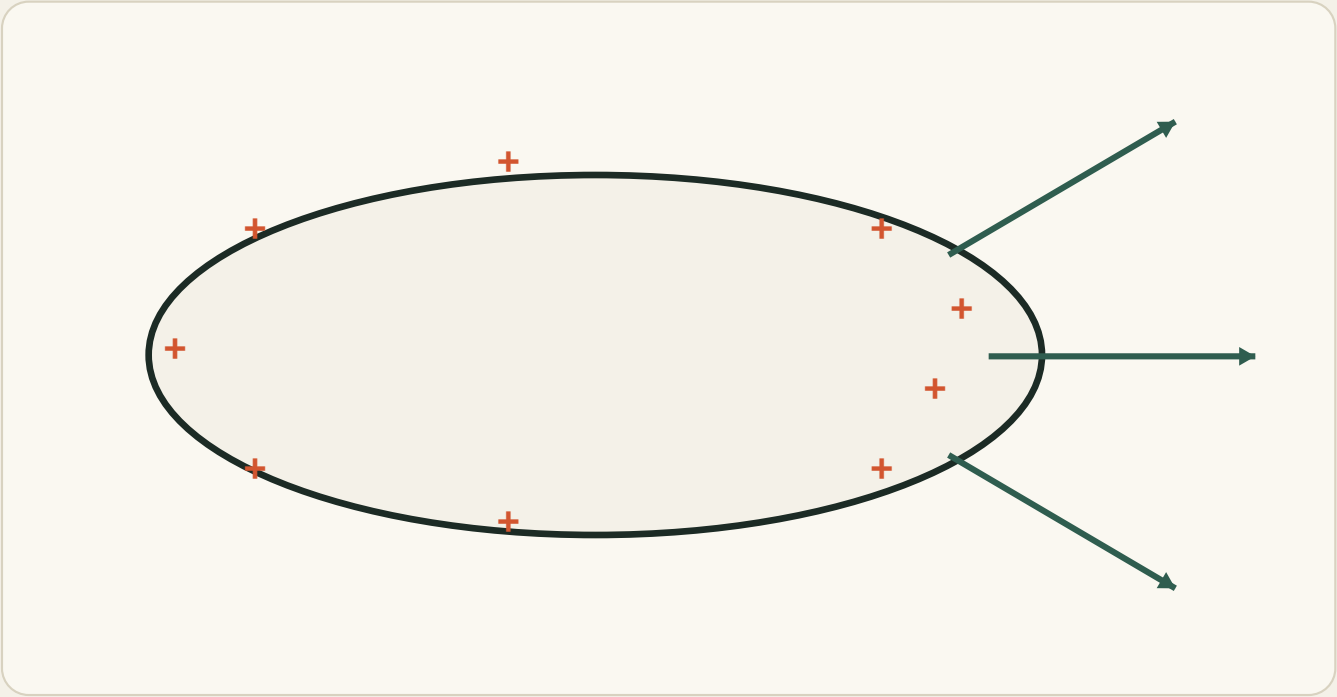
Just outside, the field is perpendicular to the surface.

Inside the metal is field-free; outside need not be.

COMPARE

Charge crowds where a surface is sharp.

A small radius of curvature produces a larger surface charge density and a stronger nearby field.



R — **Sharper point**

Smaller radius of curvature.

σ — **More surface charge**

More charge per unit area.

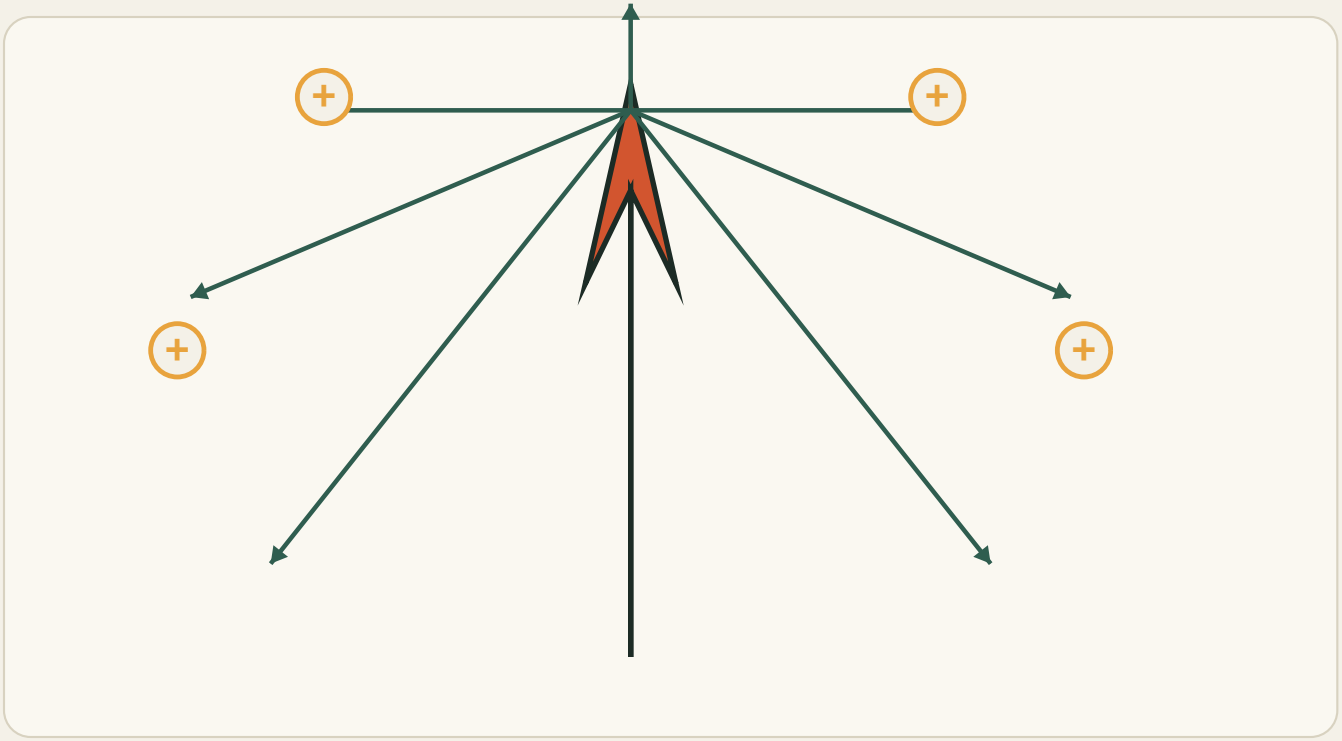
E — **Stronger nearby field**

Strong enough to affect air.

APPLY

A sharp point can turn air into a conductor.

A strong field ionises nearby air; moving ions then carry charge away.



USE IT

Lightning rods provide a controlled, grounded path.

PREVENT IT

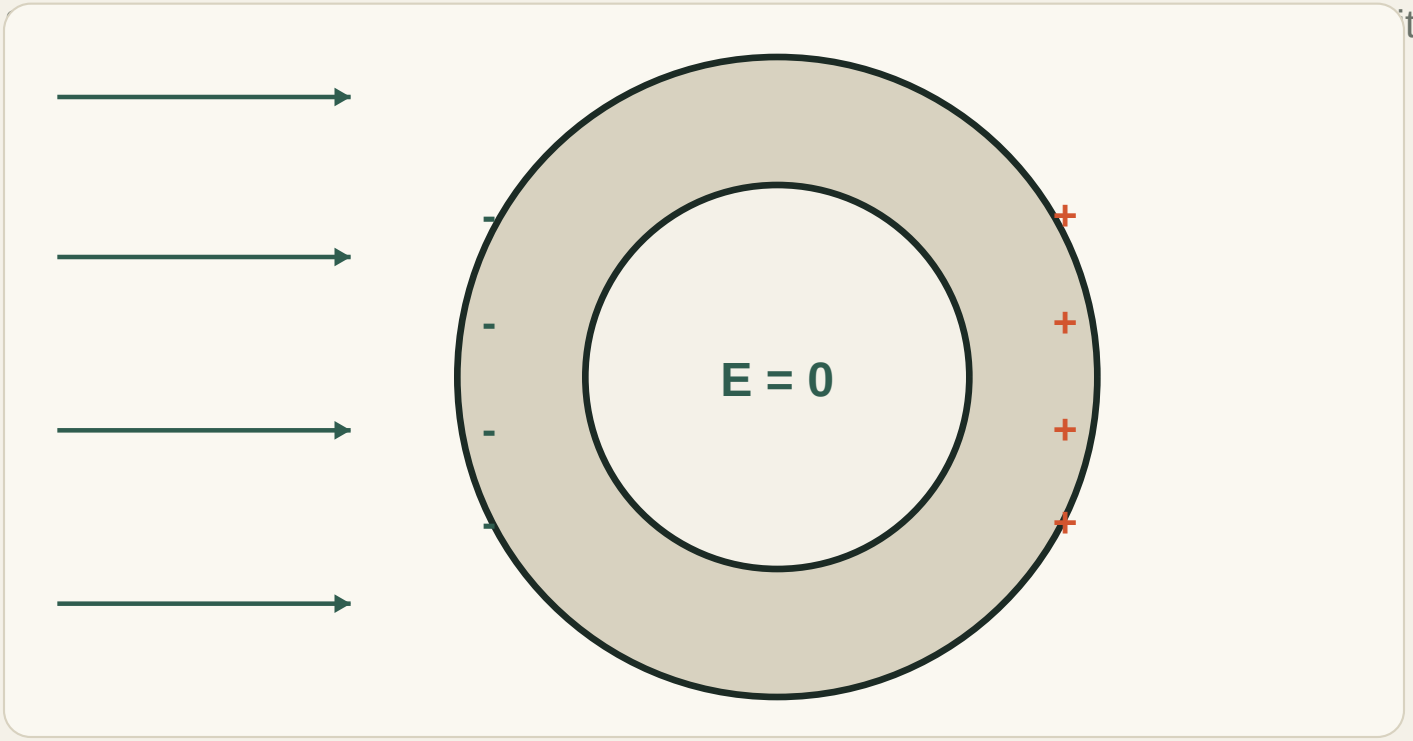
High-voltage conductors are smooth to reduce leakage.

RECOGNISE IT

Gas igniters and corona glow use the same effect.

SHIELD

A conducting shell keeps an external field outside.



FARADAY-CAGE LOGIC

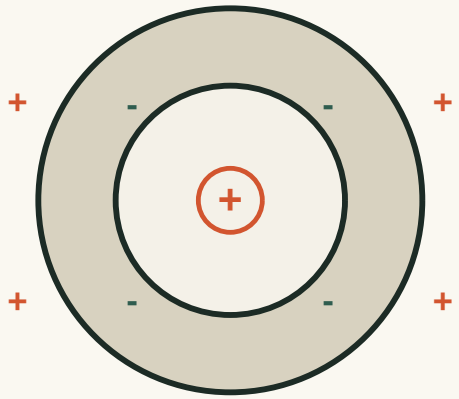
The shell is not blocking field lines like a wall. Its mobile charges create the cancelling field.

COMPARE

Grounding decides whether an internal field leaks out.

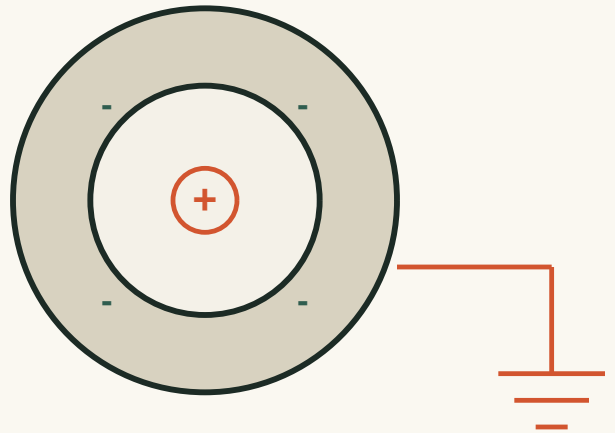
A conductor shields its material; grounding can also remove charge from its outside surface.

ISOLATED SHELL



Inner charge induces equal opposite charge inside and equal charge outside.

GROUNDED SHELL



Ground supplies or removes charge, so the outside field can vanish.

SAFETY

Field-free interiors protect people and signals.

The same equilibrium principle scales from a cable to a live-line worker.

CONDUCTIVE SUIT

Metal fibres form a shielding layer around the worker.

VEHICLE BODY

A closed metal body routes lightning current around passengers.

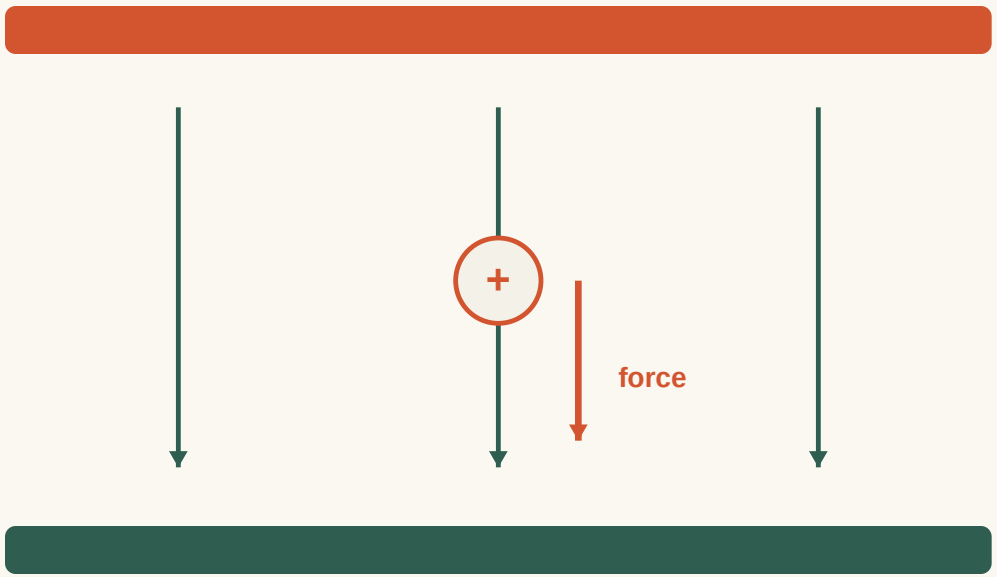
CABLE SCREEN

A grounded metal braid keeps electric noise away from the signal.

ROUTE

An electric field can steer tiny charged particles.

Once a particle carries charge, its path can be designed with the electric force.



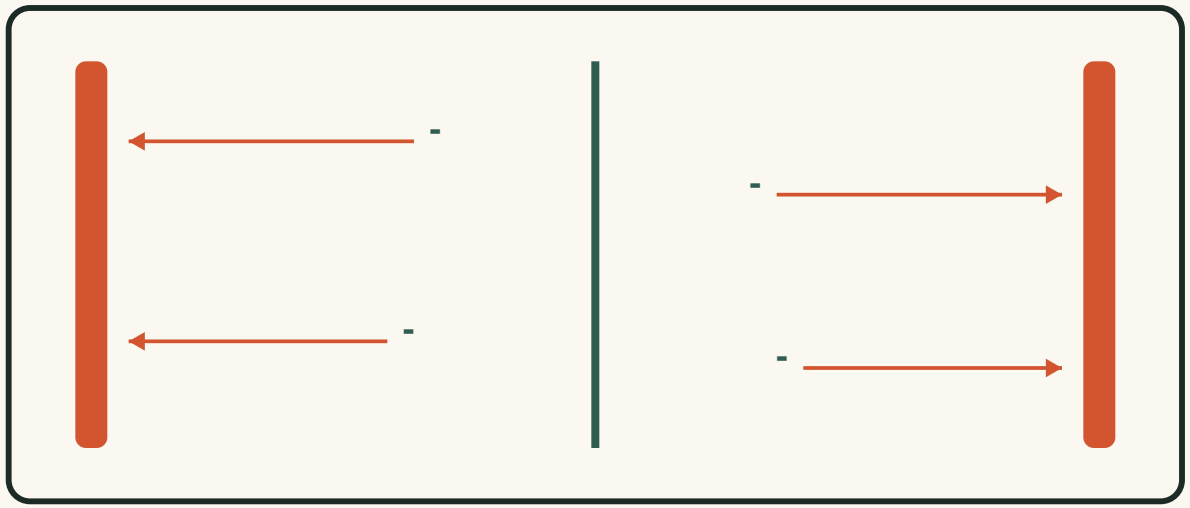
GOVERNING RELATION

$$F = qE$$

More charge or a stronger field gives a larger steering force.

APPLY

An electrostatic precipitator pulls pollution from air.



1 Charge the dust

Ionised air transfers charge to particles.

2 Drive it sideways

Electric force moves dust out of the airflow.

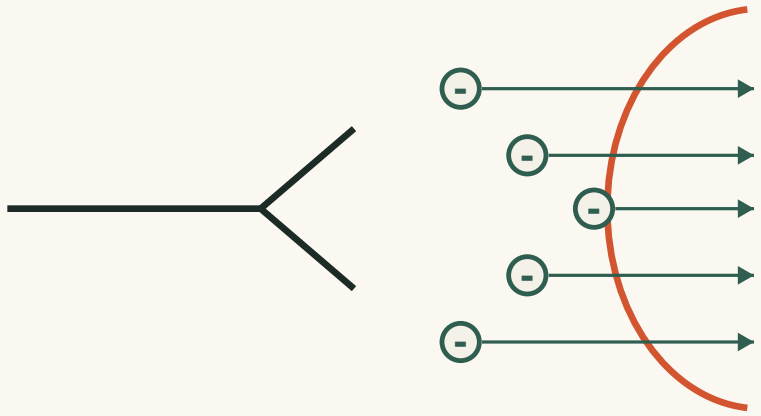
3 Remove and repeat

Clean the collector plates periodically.

DESIGN

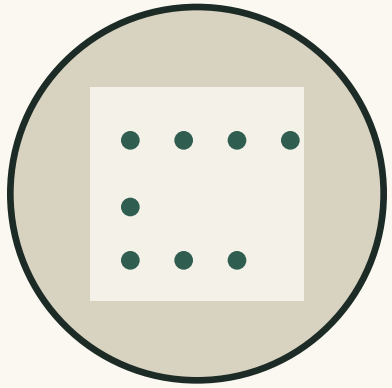
Electrostatic coating makes particles find the target.

SPRAY PAINTING



Charged droplets wrap around an oppositely charged workpiece.

PHOTOCOPYING



Light creates a charge pattern; toner follows it before transfer to paper.

SUMMARY

Static electricity becomes manageable when we control where charge gathers, where fields can exist, and which path charged particles follow.

01

PREVENT

Use smooth surfaces and grounded paths to avoid damaging discharge.

02

PROTECT

Use conducting shells and meshes to create field-free interiors.

03

USE

Charge particles and steer them with F = qE.