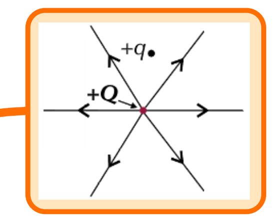
Electric Fields

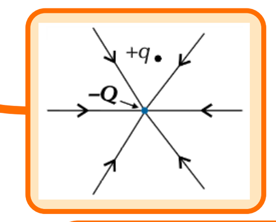
Electric field strength

- the force per unit positive charge
- It's the force that a charge of +1 C would experience if it was placed in an electric field.
- $E = \frac{F}{Q}$
  - E = electric field strength in NC^{-1}
  - F = force on the charged object in N
  - Q = charge of the object in C

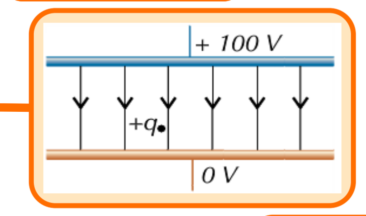
Electric field lines

- are drawn to show the direction of the force that would act on a positive charge.
- Radial field





- Parallel plates

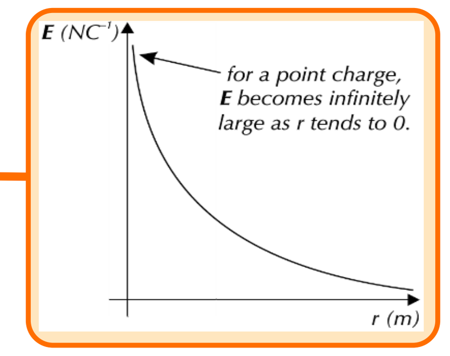


Measuring electric field lines

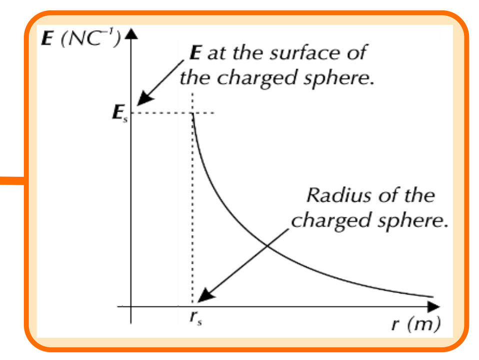
- Conducting paper
  - Used to map out the field line of a 2D electric field.
  - The experiment is set up so that a positive charge is on one edge of the paper and a negative charge is on the opposite edge. A voltmeter is then used to measure the potential difference at different points on the paper. Points with the same voltage can be joined up to show equipotential lines. Equipotential lines are always perpendicular to field lines and so these can be mapped out.
- Electrolytic tank
  - plot the field lines of a 3D electric field
  - The conducting paper is replaced by a tank of water with positive and negative ions dissolved in it. Electrodes are put in the water to create a positive charge on one side of the tank and a negative charge on the other side. A voltmeter is then used to find points within the water where the potential difference is the same. From this, both equipotentials and field lines can be mapped out.

Radial fields

- A point charge or any body that behaves as if all its charge is concentrated at the centre has a radial field.
- In a radial field, the electric field strength, E, depends on the distance r from the point charge Q.
- $E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$
  - E = electric field strength in NC^{-1}
  - Q = point charge in C
  - r = distance from the point charge in m
  - ε_0 = the permittivity of free space $= 8.85 \times 10^{-12}\ Fm^{-1}$
- Another case of inverse square law.
- Point charge

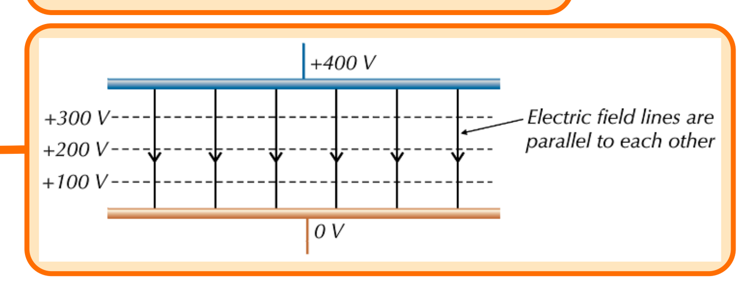


- Sphere



Uniform fields

- A uniform field can be produced by connecting two parallel plates to the opposite poles of a battery.



- $E = \frac{V}{d}$
  - E = electric field strength in Vm^{-1}
  - V = potential difference between the plates in V
  - d = distance between the plates in m

Coulomb's Law

- Force on a charged object in an electric field.
- $F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2}$
  - F = force on the object in N
  - Q_1 and Q_2 = charges of the two objects in C
  - r = distance between Q_1 and Q_2 in m
  - ε_0 = "epsilon-nought", the permittivity of free space $= 8.85 \times 10^{-12}\ Fm^{-1}$

Electric Potential

- All points in an electric field have an absolute electric potential, V.
- Is the electric potential energy that a unit positive charge would have at that point.
- Radial field
  - $V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$
    - V = absolute electric potential in V
    - Q = charge creating the electric field in C
    - r = distance from the charge in m
- Electric potential difference
  - If two points in an electric field have a different absolute electric potential, then there is an electric potential difference between them. This is the energy needed to move a unit charge between those points.
  - $\Delta W = Q\Delta V$
    - ΔW = work done in moving a charge in J
    - Q = the charge being moved in C
    - ΔV = electric potential difference in V
  - $Q\Delta V = Fd$
  - $\Delta W = Q\Delta V$

Electric charge

- Electric charge, Q, is measured in coulombs (C) and can be positive or negative.