Electric Fields

Name _____ Date _____

By the end of this topic I can…

- define electric field strength and draw electric field lines
- use $E = V/d$ for a uniform field
- analyse a charge in equilibrium or deflected in a uniform field

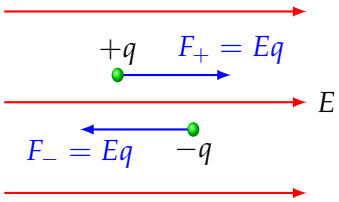
Electric forces and fields

- like charges _____; opposite charges _____

An **electric field** is a region of space in which a _____.

Electric field strength is the _____:

$[E] =$ _____ $=$ _____



- E is a _____: its direction is that of the force on a _____ test charge, so force on a charge is $F =$ _____
- fields from several sources add as _____

Example 13.1 An electron is at a point where the electric field strength is 1500 N C^{-1}, what is the electric force acting on the electron?

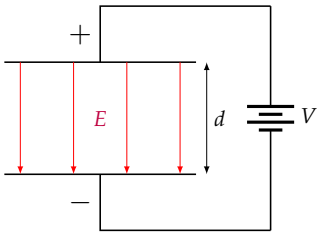
Field lines

• the tangent to a line gives the _____ of E; closer lines mean a _____ field

• lines start on _____ charge (or infinity) and end on _____ charge (or infinity)

• lines never _____, and meet the surface of a conductor at _____

Uniform electric fields



Two parallel plates with p.d. V and separation d produce a **uniform field** between them (parallel, equally spaced field lines):

• the field points from the _____ to the _____ potential

Example 13.2 Find the field strength between plates at potentials -50 V and $+30$ V separated by 10 cm.

Example 13.3 Two horizontal parallel plate conductors are separated by 1.5 cm in air. A potential difference of 36 V is applied across the plates. Compare the electric force and gravitational force acting on a proton between the plates.

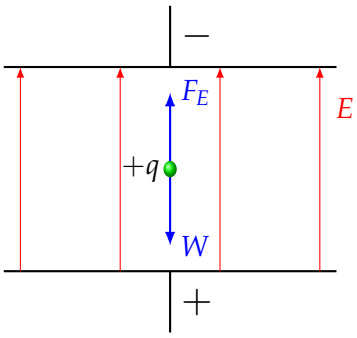
Charge in equilibrium

- a charged particle is held stationary when $F_E = W$:

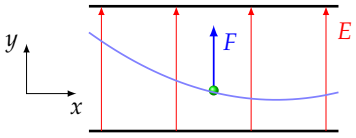
with $E = \dfrac{V}{d}$

- the electric force must act _____, so for a _____ charge the field points _____

Example 13.4 An oil droplet of mass 0.040 g and charge -20 nC is at rest between plates 8.0 cm apart. (a) Find the strength and direction of the field. (b) What p.d. is needed? (c) What happens if the plate separation is reduced?



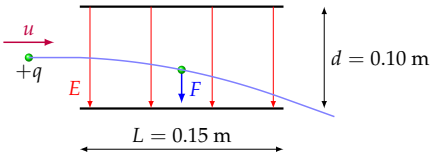
Deflection of a charged particle



- perpendicular to the field: _____, $x = u_x t$
- along the field: _____ $a = \dfrac{F}{m} = \dfrac{Eq}{m}$

(weight is negligible for sub-atomic particles), so $y = \frac{1}{2}at^2$

- the path is a _____, like projectile motion



Example 13.5 A proton enters a uniform field of strength 1.0×10^4 N C^{-1} at an initial velocity of 5.0×10^5 m s^{-1}. The initial direction of motion is at right angles to the field. The dimensions of the field are shown in the diagram. (a) What is the time taken for the proton to pass through the field? (b) What is the deviation in the direction of the field during this time? (c) If an electron enters the field with the same initial velocity, describe how the deflection of the electron compares with that of the proton.

Practice questions

Question 13.1 A charge of $+2.0$ nC experiences a force of 6.0×10^{-5} N in a field. Find the field strength.

Question 13.2 Two plates 2.0 cm apart have a p.d. of 500 V. Find (a) the field strength, (b) the force on an electron between them, (c) its acceleration.

Question 13.3 An oil droplet of mass 1.0×10^{-14} kg is held at rest between plates 1.0 cm apart with a p.d. of 600 V. Find its charge and the number of excess electrons.

Question 13.4 An electron enters a uniform field of strength $3.0 \times 10^{3}\ \mathrm{N\,C^{-1}}$ at $2.0 \times 10^{7}\ \mathrm{m\ s^{-1}}$ at right angles to the field. The field region is 5.0 cm long. Find (a) the time in the field, (b) the sideways deflection.