Field

- a region in space where a force is experienced by:
  - a test mass → gravitational field
  - a test charge → electric field
  - a test pole } → magnetic field
  - a test current element } → magnetic field

Electric Field

A region of space throughout which an electric test charge experiences an electrical force.

The direction of the field is the direction of the force on a positive test charge

Electric Field Strength

The electric field strength $\vec{E}$ at a point in space is defined as the force per unit charge on a small positive test charge placed at that point.

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

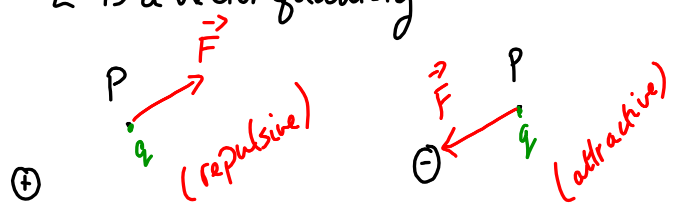
← do not put a sign on q.

Where $\vec{E}$ is the electric field strength $(N\,C^{-1})$

$\vec{F}$ is the force on the test charge due to the field at P. (N)

q is the charge on the small positive test charge (C)

$\vec{E}$ is a vector quantity

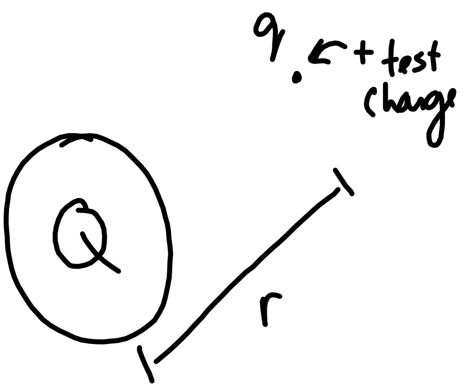


	Gravitational	Electric
Force	$F = \frac{Gm_1m_2}{r^2}$	$F = \frac{kq_1q_2}{r^2}$
Field Strength	$g = \frac{F}{m}$	$E = \frac{F}{q}$

Data Booklet

Field Strength (at a certain point due to a source)	$g = \frac{GM}{r^2}$	$E = \frac{kQ}{r^2}$

Electric Field Strength due to a single point charge:



$$F = \frac{kQq}{r^2}$$

$$E = \frac{\frac{kQq}{r^2}}{q}$$

$$E = \frac{kQ}{r^2}$$

where Q is the source charge.

Acceleration of a charged body in an electric field

Consider an object of mass m and carrying a charge q which is placed in an electric field strength $\vec{E}$:

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

$$\vec{F} = q\vec{E}$$

(the force experienced by charge q)

$$\vec{F}_{net} = m\vec{a}$$

$$q\vec{E} = m\vec{a}$$

$$\vec{a} = \frac{q\vec{E}}{m}$$

Example

Calculate the acceleration of an electron in an electric field of strength 100 NC^{-1}

$q = 1.60 \times 10^{-19} C$

$m = 9.11 \times 10^{-31} kg$

$$a = \frac{qE}{m}$$

$$a = \frac{(1.60 \times 10^{-19} C)(100 NC^{-1})}{(9.11 \times 10^{-31} kg)}$$

$kg \cdot ms^{-2}$

HUGE! $a = 1.76 \times 10^{13} ms^{-2}$

Example

A small oil droplet carries a positive charge of 3.0×10^{-9} C

When the oil droplet is placed in an electric field there is a force on the droplet of 1.5×10^{-5} N to the right.

What is the strength of the electric field at this point?

What is the acceleration of the oil droplet if its mass is 1.5 mg?

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

$$\vec{E} = \frac{1.5\times10^{-5}\,\text{N [R]}}{3.0\times10^{-9}\,\text{C}}$$

$$\vec{E} = 0.50\times10^{4}\,\text{NC}^{-1}\,\text{[R]}$$

$$\vec{E} = 5.0\times10^{3}\,\text{NC}^{-1}\,\text{[R]}$$

$$\vec{F} = m\vec{a}$$

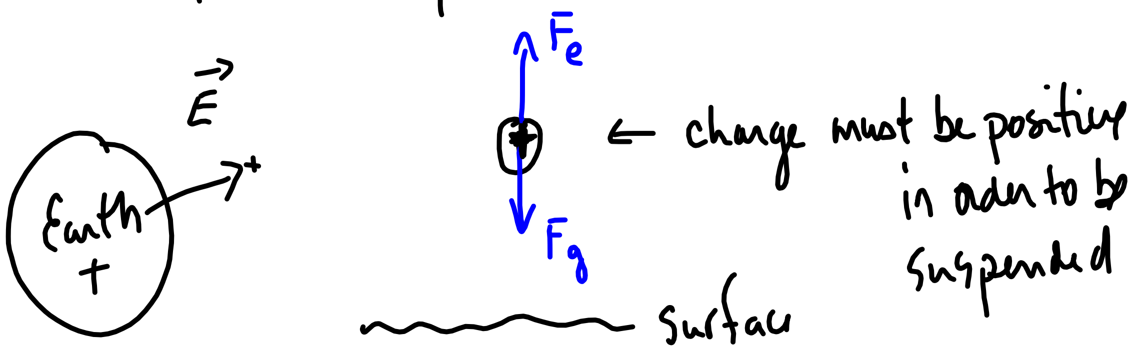
$$\vec{a} = \frac{\vec{F}}{m}$$

$$\vec{a} = \frac{1.5\times10^{-5}\,\text{N [R]}}{1.5\times10^{-6}\,\text{kg}}$$

$$\vec{a} = 10\,\text{ms}^{-2}\,\text{[R]}$$

Example

Delicate measurements indicate that the Earth has an electric field surrounding it similar to that around a positively charged sphere. It's magnitude at the Earth's surface is about $100\,NC^{-1}$. What charge would an oil drop of mass $2.0\times10^{-15}\,kg$ have to have, in order to remain suspended by the Earth's electric field?



$$F_e = F_g$$

$$qE = mg$$

$$q = \frac{mg}{E}$$

$$q = \frac{(2.0\times10^{-15}\,kg)(9.81\,ms^{-2})}{100\,NC^{-1}}$$

$$q = 2.0\times10^{-16}\,C$$