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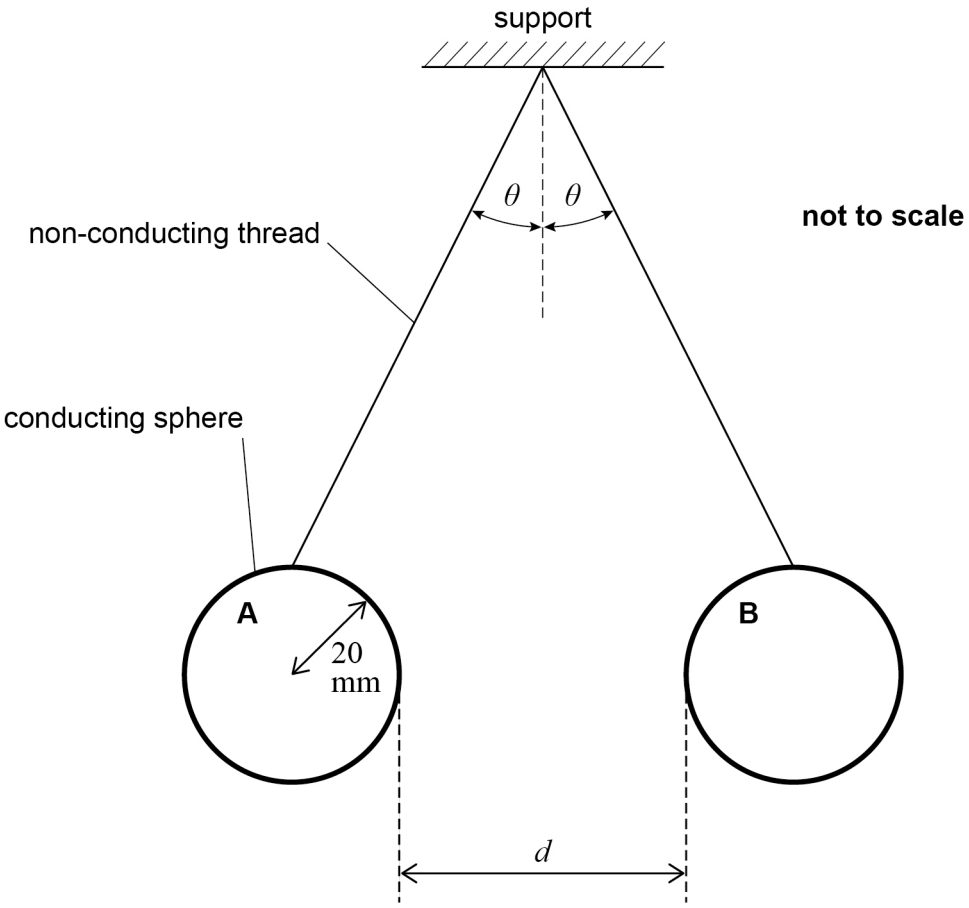
0 4 **Figure 3** shows an arrangement used to investigate the repulsive forces between two identical charged conducting spheres.
The spheres are suspended by non-conducting thread.

Figure 3



Each sphere has a mass of 3.2×10^{-3} kg and a radius of 20 mm.
The distance d is 40 mm.

The capacitance of a sphere of radius r is $4\pi\varepsilon_0 r$.

Each sphere is charged by connecting it briefly to the positive terminal of a high-voltage supply, the other terminal of which is at 0 V.
After this has been done the charge on each sphere is 52 nC.

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0 4 . 1 Calculate the potential of one of the spheres.

[3 marks]

potential = _____ V

0 4 . 2 The charged spheres in **Figure 3** are at equilibrium.

Draw labelled arrows on **Figure 3** to show the forces on sphere **B**.

[2 marks]

0 4 . 3 Suggest a solution to **one** problem involved in the measurement of d in **Figure 3**.

[2 marks]

_____

_____

_____

_____

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_____

Question 4 continues on the next page

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0 4 . 4 Show that the magnitude of the electrostatic force on each sphere is about 4×10^{-3} N.

[3 marks]

0 4 . 5 A student measures the angle θ when the apparatus in **Figure 3** is at equilibrium. The student records θ as 7°.

Discuss whether this measurement is consistent with the other data in this investigation.

[2 marks]

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0 4 . 6 The student says that the gravitational force between the two spheres has no **significant** effect on the angle at which the spheres are in equilibrium.

Deduce with a calculation whether this statement is valid.

[2 marks]

14

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1 3 When an electron is moving at a speed v perpendicular to a uniform magnetic field of flux density B, it follows a path of radius R.

A second electron moves at a speed $\frac{v}{2}$ perpendicular to a uniform magnetic field of flux density $4B$.

What is the radius of the path of the second electron?

[1 mark]

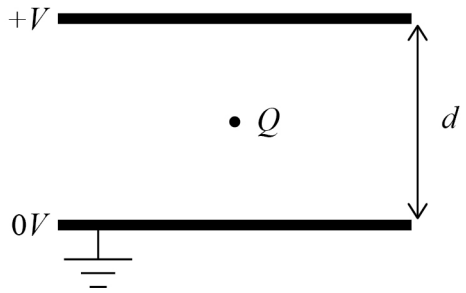
A $\frac{R}{8}$ ⬭

B $\frac{R}{4}$ ⬭

C $2R$ ⬭

D $8R$ ⬭

1 4 A small object of mass m has a charge Q. The object remains stationary in an evacuated space between two horizontal plates. The plates are separated by a distance d and the potential difference between the plates is V.



What is V?

[1 mark]

A $\frac{mQg}{d}$ ⬭

B $\frac{mdg}{Q}$ ⬭

C $\frac{mQ}{d}$ ⬭

D $\frac{md}{Q}$ ⬭

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1 5 $1.5\ \text{mJ}$ of work is done when a charge of $30\ \mu\text{C}$ is moved between two points, **M** and **N**, in an electric field.

What is the potential difference between **M** and **N**?

[1 mark]

A $20\ \text{mV}$ ⬭

B $20\ \text{V}$ ⬭

C $45\ \text{V}$ ⬭

D $50\ \text{V}$ ⬭

1 6 An electric field acts into the plane of the paper. An electron enters the field at $90°$ to the field lines.

The force on the electron is

[1 mark]

A zero. ⬭

B along the direction of the field. ⬭

C at $90°$ to the field. ⬭

D opposite to the direction of the field. ⬭

1 7 The ionisation potential for the atoms of a gas is V. Electrons of mass m and charge e travelling at a speed v can just cause ionisation of atoms in the gas.

What is v?

[1 mark]

A $\dfrac{eV}{2m}$ ⬭

B $\dfrac{2eV}{m}$ ⬭

C $\sqrt{\dfrac{eV}{2m}}$ ⬭

D $\sqrt{\dfrac{2eV}{m}}$ ⬭