Electric Fields Past Paper Questions
Jan 2002—Jan 2010 (old spec)

Q4 Jan 2002

4 (a) An electron moves parallel to, but in the opposite direction to, a uniform electric field, as shown in **Figure 1**.

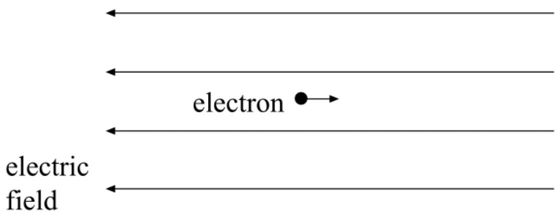

Figure 1

(i) State the direction of the force that acts on the electron due to the electric field.

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(ii) What is the effect of this force on the motion of the electron?

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(2 marks)

(b) An electron, which is travelling in a horizontal path at constant speed, enters a uniform vertical electric field as shown in **Figure 2**.

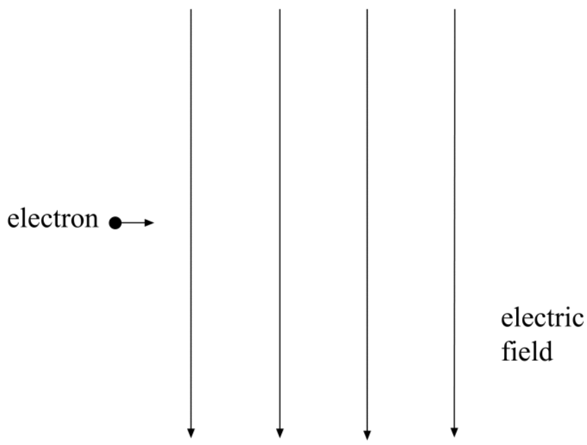

Figure 2

(i) Sketch on **Figure 2** the path followed by the electron.

(ii) Explain the motion of the electron whilst in this field.

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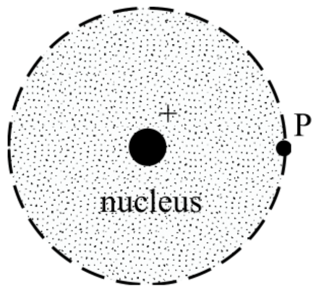
(3 marks)

3 The mass of the nucleus of an isolated copper atom is 63 u and it carries a charge of $+29e$. The diameter of the atom is 2.3×10^{-10} m.

P is a point at the outer edge of the atom.

Q3 Jan 2003



(a) Calculate

(i) the electric field strength at P due to the nucleus,

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(ii) the gravitational potential at P due to the nucleus.

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(5 marks)

(b) Draw an arrow on the above diagram to show the direction of the electric field at the point P.

(1 mark)

2 (a) Complete the table of quantities related to fields. In the second column, write an SI unit for each quantity. In the third column indicate whether the quantity is a scalar or a vector.

Q2 Jan 2004

quantity	SI unit	scalar or vector
gravitational potential		
electric field strength		
magnetic flux density		

(3 marks)

(b) (i) A charged particle is held in equilibrium by the force resulting from a vertical electric field. The mass of the particle is 4.3×10^{-9} kg and it carries a charge of magnitude 3.2×10^{-12} C. Calculate the strength of the electric field.

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(ii) If the electric field acts upwards, state the sign of the charge carried by the particle.

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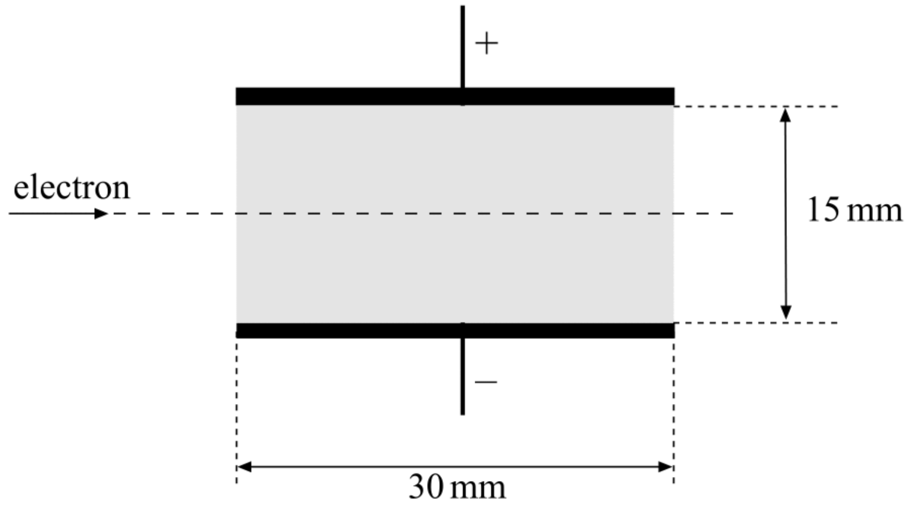
(3 marks)

5 (a) An electron travels at a speed of $3.2 \times 10^7\,\text{m s}^{-1}$ in a horizontal path through a vacuum. The electron enters the uniform electric field between two parallel plates, 30 mm long and 15 mm apart, as shown in **Figure 2**. A potential difference of 1400 V is maintained across the plates, with the top plate having positive polarity. Assume that there is no electric field outside the shaded area.

Q5 Jan 2006

Figure 2



(i) Show that the electric field strength between the plates is $9.3 \times 10^4\,\text{V m}^{-1}$.

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(ii) Calculate the time taken by the electron to pass through the electric field.

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(iii) Show that the acceleration of the electron whilst in the field is $1.6 \times 10^{16}\,\text{m s}^{-2}$ and state the direction of this acceleration.

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(5 marks)

(b) Determine the magnitude and direction of the velocity of the electron at the point where it leaves the field.

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(3 marks)

3 (a) (i) Define the *electric field strength*, E, at a point in an electric field.

Q3 Jun 2006

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(ii) State whether E is a scalar or a vector quantity.

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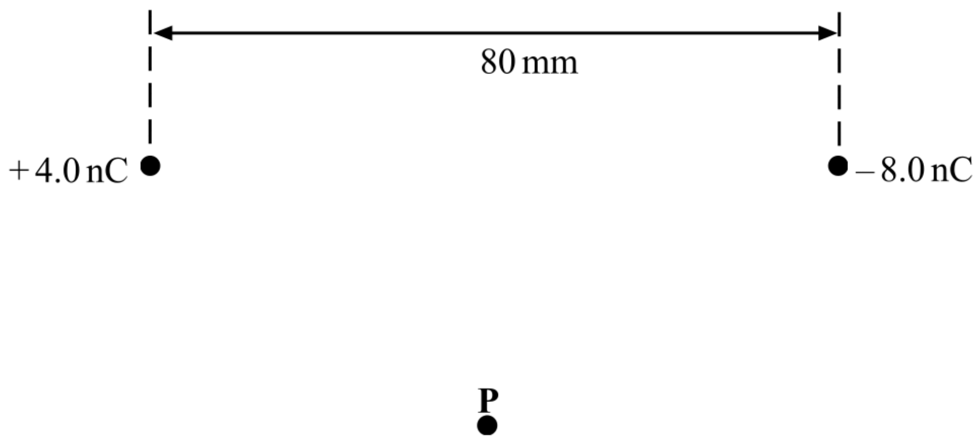
(3 marks)

(b) Point charges of +4.0 nC and – 8.0 nC are placed 80 mm apart, as shown in **Figure 2**.

Figure 2



(i) Calculate the magnitude of the force exerted on the +4.0 nC charge by the – 8.0 nC charge.

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(ii) Determine the distance from the +4.0 nC charge to the point, along the straight line between the charges, where the electric potential is zero.

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(4 marks)

(c) Point **P** in **Figure 2** is equidistant from the two charges.

(i) Draw two arrows on **Figure 2** at **P** to represent the directions and relative magnitudes of the components of the electric field at **P** due to each of the charges.

(ii) Hence draw an arrow, labelled **R**, on **Figure 2** at **P** to represent the direction of the resultant electric field at **P**. *(3 marks)*

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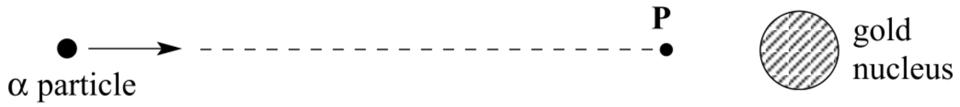
Figure 4

Q4 Jun 2007



In a Rutherford scattering experiment, an α particle approaches a gold nucleus along the straight line joining their centres and comes momentarily to rest at point **P**, as shown in **Figure 4**.
The α particle then returns along its previous path.

(a) The distance from the centre of the gold nucleus $^{197}_{79}$Au, to the point **P** is 3.0×10^{-14} m.

For the point **P**

(i) show that the strength of the electric field associated with the charge of the nucleus is 1.3×10^{20} V m^{-1},

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(ii) calculate the magnitude of the force acting on the α particle,

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(iii) calculate the electric potential due to the charge of the nucleus.

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(5 marks)

(b) (i) State the energy changes of the α particle during its interaction with the gold nucleus.

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(ii) Calculate the initial kinetic energy, in J, of the α particle, explaining your reasoning.

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(4 marks)

3 (a) Electrons experience forces in electric fields. In each of the following cases, state the direction of the force that acts on a moving electron, and describe and explain the electron's subsequent motion.

You may be awarded additional marks to those shown in brackets for the quality of written communication in your answer. **Q3 Jan 2008**

(i) An electron enters a uniform electric field that is directed at right angles to the electron's velocity at the point of entry.

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(ii) An electron enters a uniform electric field whose direction is the same as that of the electron's velocity at the point of entry.

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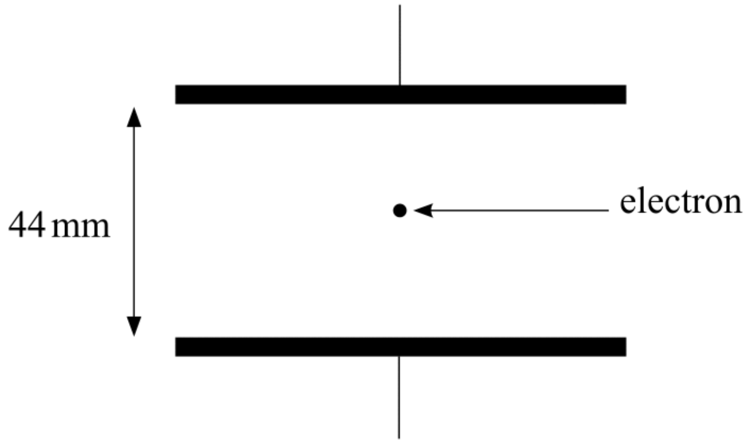
(5 marks)

(b) **Figure 2** shows two parallel metal plates, 44 mm apart, which have a pd of 110 V applied across them, with an electron between them.

Figure 2



Calculate

(i) the electric field strength between the plates,

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(ii) the magnitude of the force on the electron when it is between the plates,

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(iii) the kinetic energy, in J, that is gained by the electron when it starts from rest at one plate and crosses to the other plate.

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(4 marks)

4 (a) In order for fusion of two nuclei to take place, they have to be brought together to a separation of about 2 fm.

Q4 Jan 2008

(i) Show that the electrostatic potential energy of a system consisting of two deuterium ($^{2}_{1}H$) nuclei at a separation of 2 fm is about 1×10^{-13} J.

Note this question is a little off topic but maybe useful for other modules

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(ii) Two deuterium nuclei may be brought to this separation by causing them to collide with equal and opposite velocities. Calculate the minimum speed required by **each** nucleus for the system to have the potential energy calculated in part (a)(i).

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(5 marks)

(b) One reaction that can occur when deuterium nuclei undergo fusion is

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{3}_{1}H + ^{1}_{1}p$$

(i) Calculate the energy released, in J, by this reaction.

mass of $^{2}_{1}H$ nucleus = 2.01355 u

mass of $^{3}_{1}H$ nucleus = 3.01550 u

mass of proton = 1.00728 u

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(ii) How much energy is released, in J, from 1 kg of reactant in the above fusion reaction?

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(4 marks)

(c) State **two** reasons why fusion reactions would be preferable to fission reactions as an energy resource, provided the necessary conditions required for continuous fusion could be maintained.

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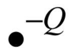
(2 marks)

4 (a) (i) With the aid of a diagram, describe the electric field around an isolated point negative charge (shown below as $-Q$).

Q4 Jun 2009



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4 (a) (ii) Draw a dashed line (- - - - - - - - - - - -) on your diagram, along which a small charge could be moved without changing its potential energy. Label this line **L**.

(4 marks)

4 (b) (i) Point P is 40 mm from a point charge of –0.80 nC.

Calculate the magnitude of the electric field strength at P.

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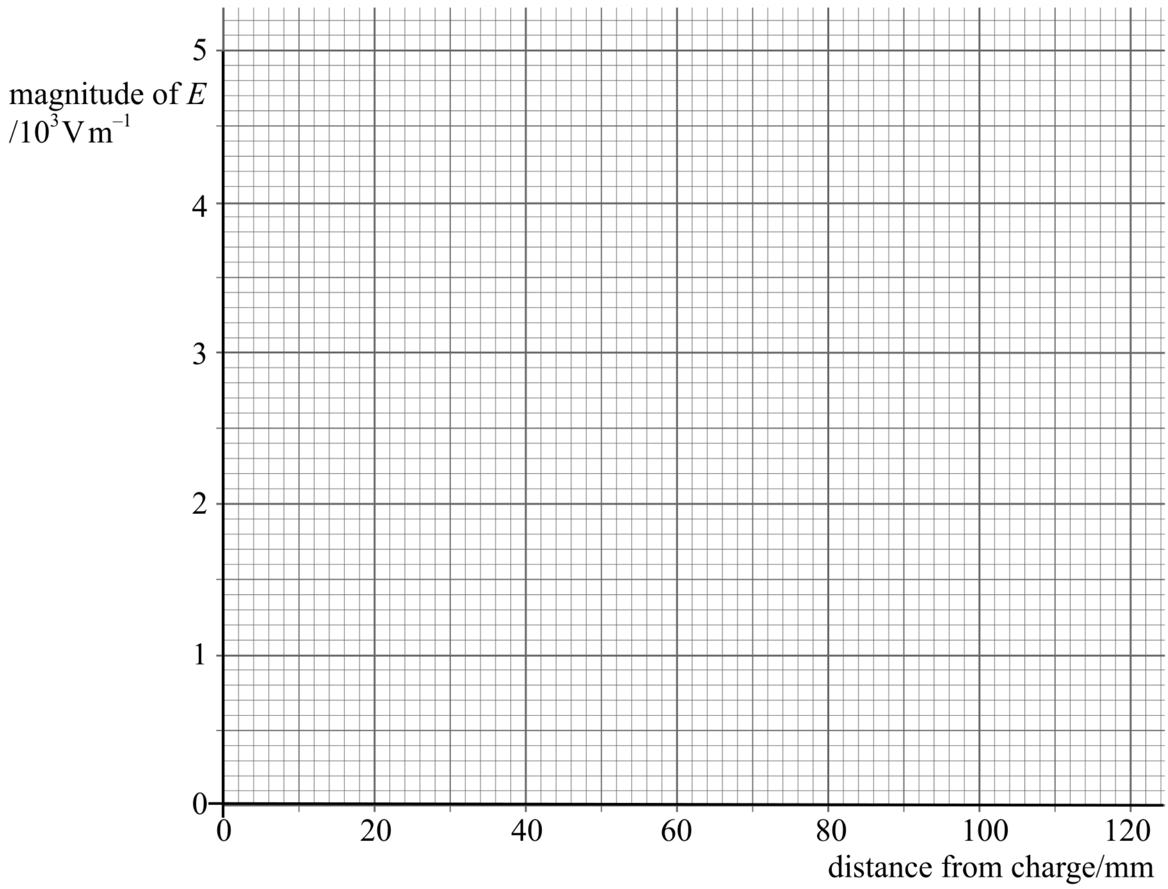
4 (b) (ii) Insert your value for the electric field strength at P, from part (b)(i), on **Figure 4**. Then complete, as accurately as you can, a graph on **Figure 4** to show how the magnitude of the electric field strength varies with distance, for points which are at distances greater than 40 mm from the –0.80 nC charge.

Figure 4

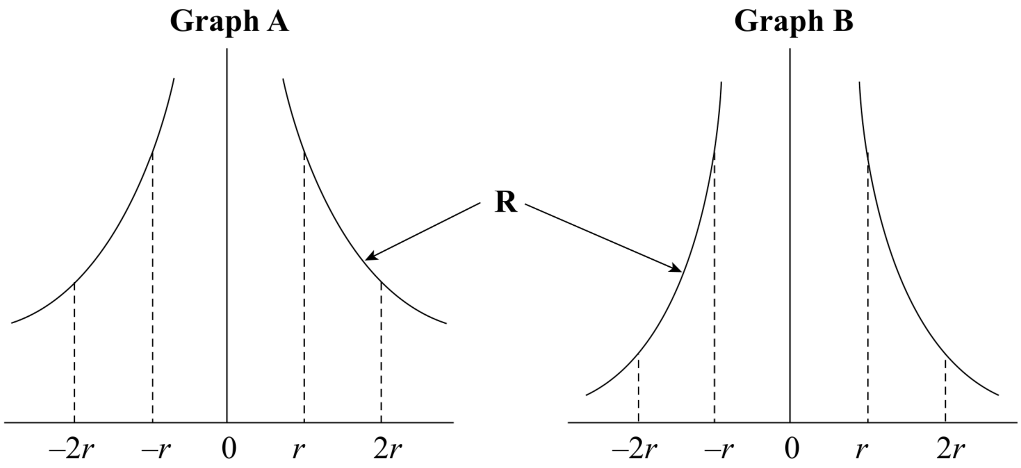


(5 marks)

2 **Figure 3** shows graphs of the electric field strength and of the electric potential caused by a point charge. On each graph the vertical axis has a linear scale.

Q2 Jan 2010

Figure 3



2 (a) Which of the graphs, **A** or **B**, shows the variation of *electric field strength* against distance?

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(1 mark)

2 (b) State why, in the regions marked **R**, the shapes of the graphs are different from each other.

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(2 marks)

2 (c) At a point where the distance, r, from the point charge is 40 mm, the electric field strength is 3.6×10^4 V m^{-1}. Calculate the potential at this point.

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(2 marks)