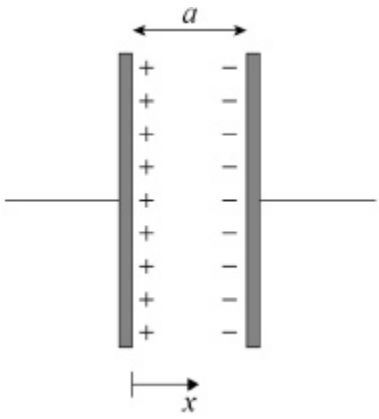
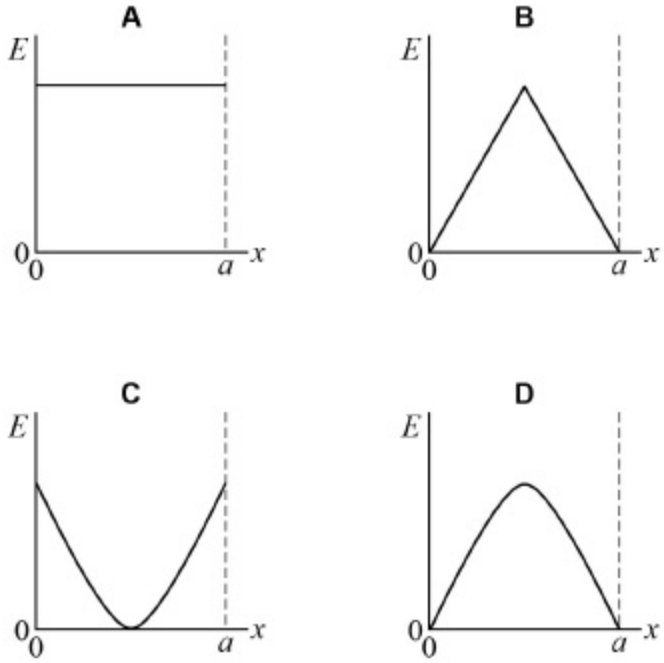
1 Two parallel metal plates of separation a carry equal and opposite charges.



Which graph best represents how the electric field strength E varies with the distance x in the space between the two plates?



A ⬭

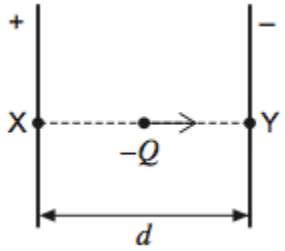
B ⬭

C ⬭

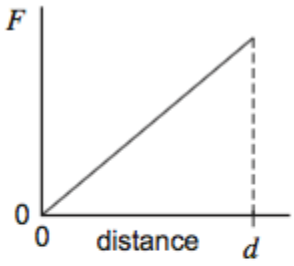
D ⬭

(Total 1 mark)

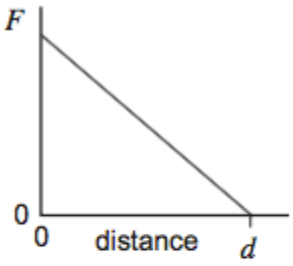
2 The diagram shows a charge $-Q$ being moved from point X to point Y between two charged parallel plates separated by a distance d.



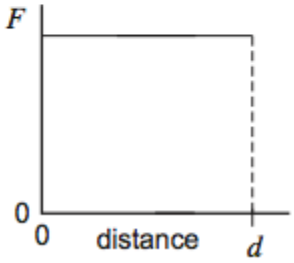
Which one of the following graphs best illustrates how the magnitude of force F on the charge varies with distance as it moves towards Y?



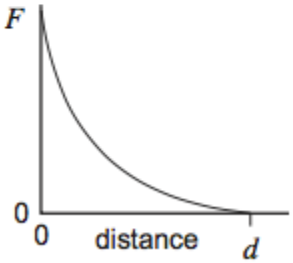
A



B



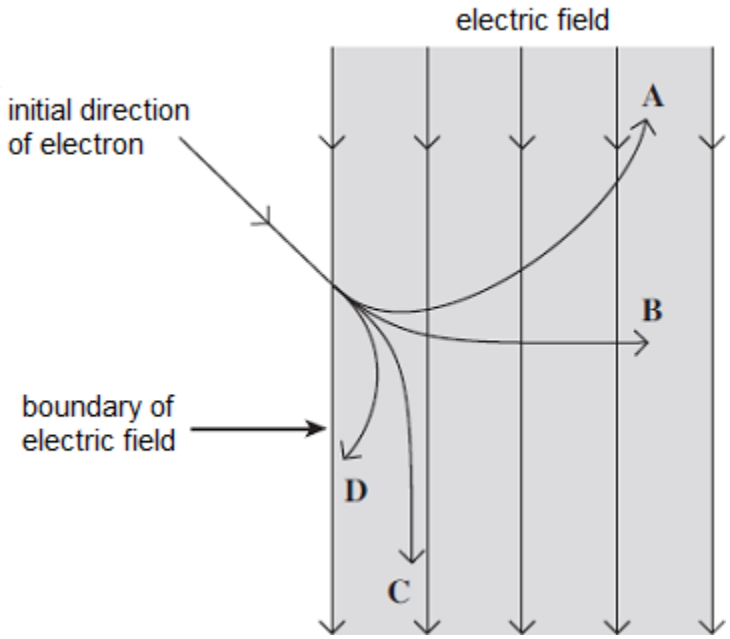
C



D

(Total 1 mark)

3 Which path, **A** to **D**, shows how an electron moves in the uniform electric field represented in the diagram?



(Total 1 mark)

4 Which one of the following statements is correct?

When a negative ion is projected into an electric field

A the field can change the magnitude of the velocity but not its direction

B the field can change the direction of the velocity but not its magnitude

C the field can change both the magnitude and the direction of the velocity

D the ion will accelerate in the direction of the field

(Total 1 mark)

5 A particle of mass m and charge q is accelerated through a potential difference V over a distance d.

What is the average acceleration of the particle?

A $\frac{qV}{md}$ ⬭

B $\frac{mV}{qd}$ ⬭

C $\frac{V}{mqd}$ ⬭

D $\frac{dV}{mq}$ ⬭

(Total 1 mark)

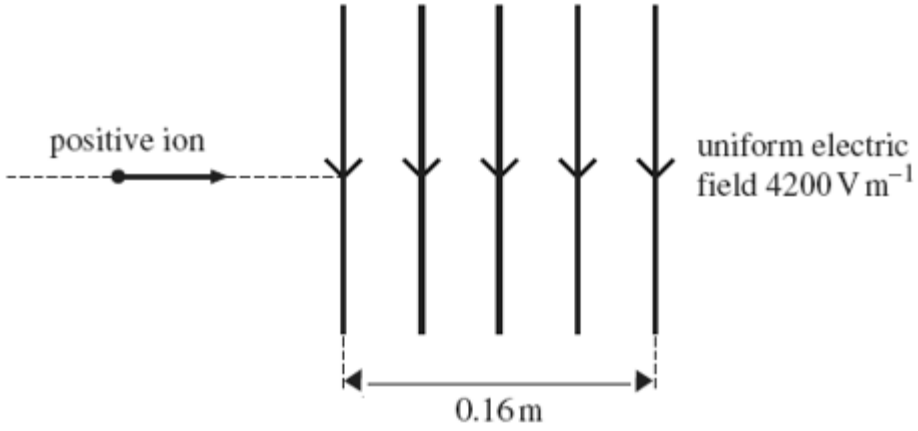
6 Two horizontal parallel plate conductors are separated by a distance of 5.0 mm in air. The lower plate is earthed and the potential of the upper plate is +50 V.

Which line, **A** to **D**, in the table gives correctly the electric field strength, *E*, and the potential, *V*, at a point midway between the plates?

	electric field strength *E* / Vm^{-1}	**potential *V* / V**
A	1.0×10^4 upwards	25
B	1.0×10^4 downwards	25
C	1.0×10^4 upwards	50
D	1.0×10^4 downwards	50

(Total 1 mark)

7



An ion carrying a charge of $+4.8 \times 10^{-19}$C travels horizontally at a speed of 8.0×10^{5}ms^{-1}. It enters a uniform vertical electric field of strength 4200 V m^{-1}, which is directed downwards and acts over a horizontal distance of 0.16m. Which one of the following statements is **not** correct?

A The ion passes through the field in 2.0×10^{-7}s.

B The force on the ion acts vertically downwards at all points in the field.

C The magnitude of the force exerted on the ion by the field is 1.6×10^{-9} N.

D The horizontal component of the velocity of the ion is unaffected by the electric field.

(Total 1 mark)

8

An electron moves through a distance of 0.10 m parallel to the field lines of a uniform electric field of strength 2.0 kN C^{-1}.

What is the work done on the electron?

A zero ⬭

B 1.6×10^{-17} J ⬭

C 3.2×10^{-17} J ⬭

D 1.6×10^{-21} J ⬭

(Total 1 mark)

9 An electron moving with constant speed enters a uniform electric field at right angles to the direction of the field.

What is true about the force acting on the electron?

A It is at right angles to the direction of the field. ⬭

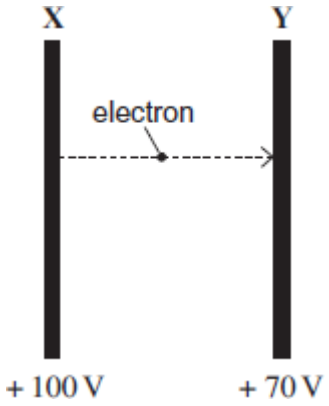
B It is in the opposite direction to the direction of the field. ⬭

C It causes the electron to continue in the same direction with its speed increasing steadily. ⬭

D It causes the electron to continue in the same direction with its speed decreasing steadily. ⬭

(Total 1 mark)

10 Two fixed parallel metal plates **X** and **Y** are at constant potentials of + 100 V and + 70 V respectively. An electron travelling from **X** to **Y** experiences a change of potential energy ΔE_p.

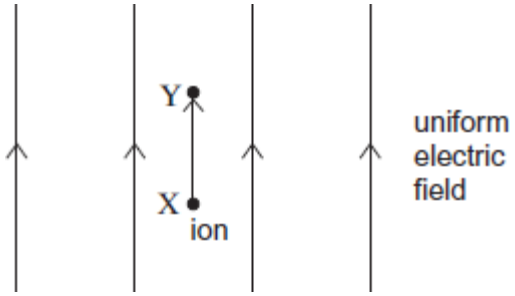


Which line, **A** to **D**, in the table shows correctly the direction of the electrostatic force F on the electron and the value of ΔE_p?

	Direction of F	ΔE_p
A	towards **X**	+ 30 eV
B	towards **Y**	– 30 eV
C	away from **X**	+ 30 eV
D	away from **Y**	– 30 eV

(Total 1 mark)

11 A uniform electric field of electric field strength E is aligned so it is vertical. An ion moves vertically through a small distance Δd from point X to point Y in the field.
There is a uniform gravitational field of field strength g throughout the region.

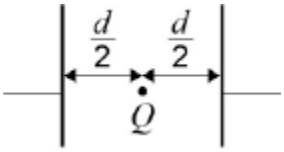


Which line, **A** to **D**, in the table correctly gives the gravitational potential difference, and the electric potential difference, between X and Y?

	Gravitational potential difference	**Electric potential difference**
A	$g\Delta d$	$E\Delta d$
B	$g\Delta d$	$\frac{E}{\Delta d}$
C	$\frac{g}{\Delta d}$	$E\Delta d$
D	$\frac{g}{\Delta d}$	$\frac{E}{\Delta d}$

(Total 1 mark)

12 Two parallel metal plates are separated by a distance d and have a potential difference V across them. Which expression gives the magnitude of the electrostatic force acting on a charge Q placed midway between the plates?



A $\frac{2VQ}{d}$ ⬭

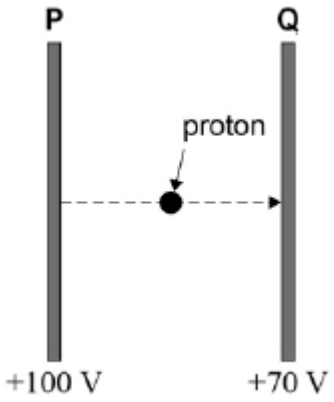
B $\frac{VQ}{d}$ ⬭

C $\frac{VQ}{2d}$ ⬭

D $\frac{Qd}{v}$ ⬭

(Total 1 mark)

13 Two fixed parallel metal plates **P** and **Q** are at constant electrical potentials of +100 V and +70 V respectively. A proton travelling from **P** to **Q** experiences a force F due to the electric field between **P** and **Q**, and a change of potential energy of ΔE_p.



Which line, **A** to **B**, in the table gives the direction of F and the value of ΔE_p?

	Direction of F	ΔE_p	
A	towards **P**	+30 eV	⬭
B	towards **Q**	+30 eV	⬭
C	towards **Q**	−30 eV	⬭
D	towards **P**	−30 eV	⬭

(Total 1 mark)

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

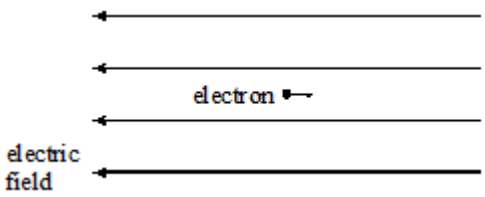


Figure 1

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

_____

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

_____

_____

(2)

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

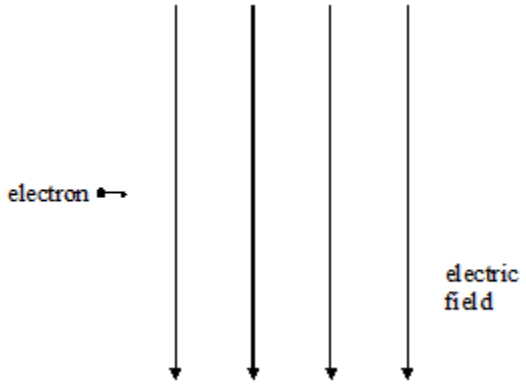


Figure 2

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

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

_____

_____

_____

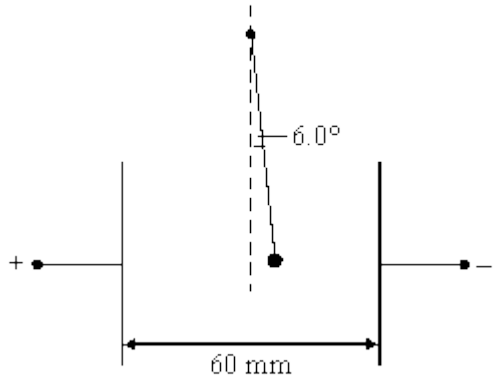
_____

_____

(3)

(Total 5 marks)

15 A small charged sphere of mass 2.1×10^{-4} kg, suspended from a thread of insulating material, was placed between two vertical parallel plates 60 mm apart. When a potential difference of 4200 V was applied to the plates, the sphere moved until the thread made an angle of 6.0° to the vertical, as shown in the diagram below.



(a) Show that the electrostatic force F on the sphere is given by

$F = mg \tan 6.0°$

where m is the mass of the sphere.

(3)

(b) Calculate

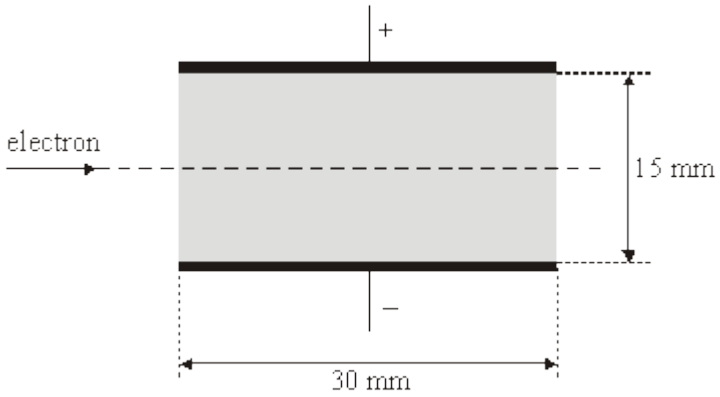
(i) the electric field strength between the plates,

(ii) the charge on the sphere.

(3)

(Total 6 marks)

16 (a) An electron travels at a speed of 3.2×10^7 ms^{-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 the figure below. 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.



(i) Show that the electric field strength between the plates is 9.3×10^4 Vm^{-1}.

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

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

(5)

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

(3)

(Total 8 marks)

17 (a) **Figure 1** shows the electron gun that accelerates electrons in an electron microscope.

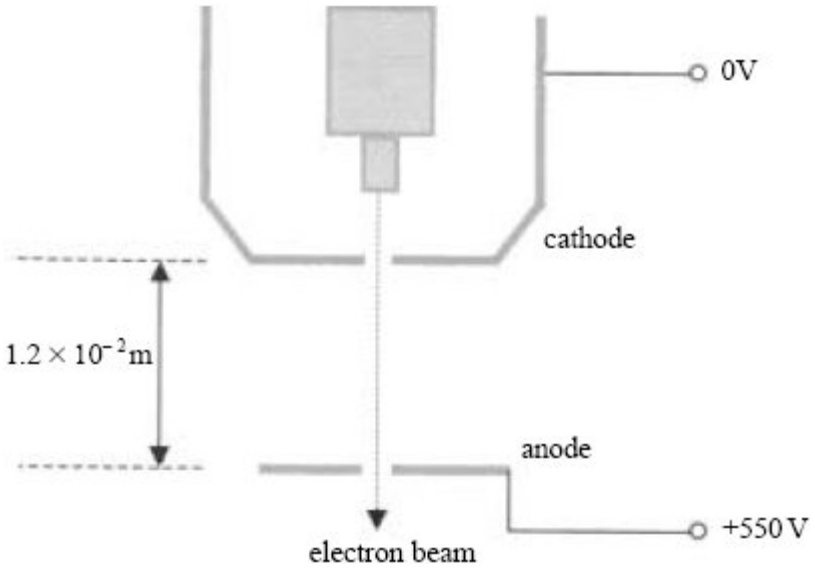


Figure 1

(i) Draw, on **Figure 1**, electric field lines and lines of equipotential in the region between the anode and cathode. Assume that there are no edge effects and that the holes in the plates do not affect the field.
Clearly label your diagram.

(3)

(ii) Calculate the kinetic energy, speed and momentum of an electron as it passes through the hole in the anode.

mass of an electron = 9.1×10^{-31} kg
charge of an electron = -1.6×10^{-19} C

(4)

(b) By calculating the de Broglie wavelength of electrons coming through the anode of this device, state and explain whether or not they will be suitable for the investigation of the crystal structure of a metal.

Planck constant = 6.6×10^{-34} J s

(4)

(Total 11 marks)

18 (a) Describe how a beam of fast moving electrons is produced in the cathode ray tube of an oscilloscope.

_____

_____

_____

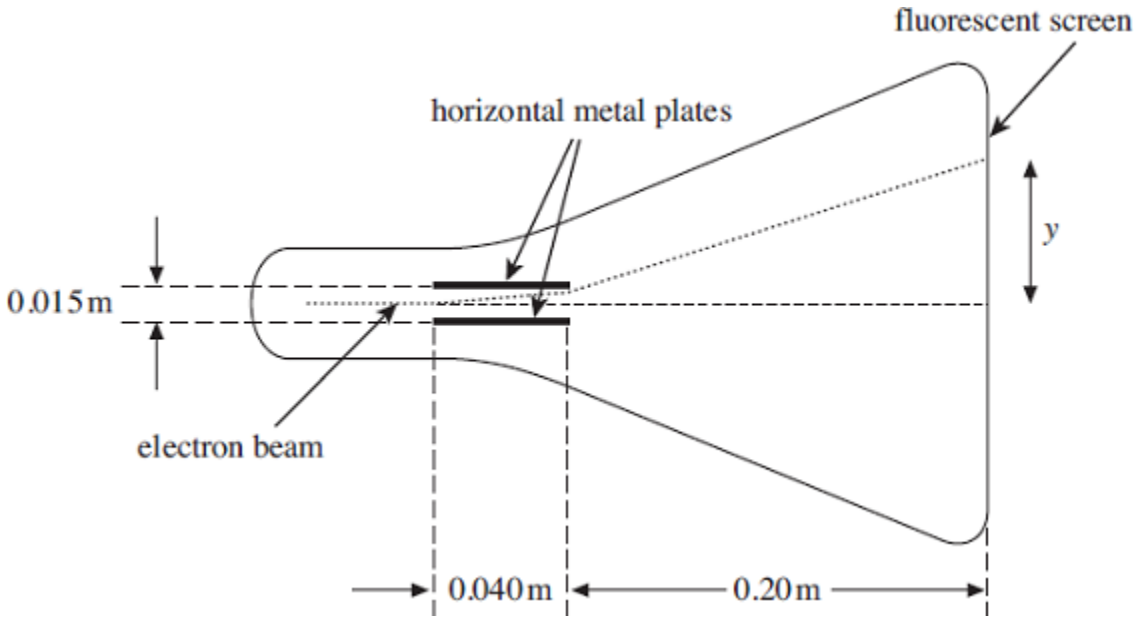
_____

_____

_____

(3)

(b) The figure below shows the cathode ray tube of an oscilloscope. The details of how the beam of electrons is produced are not shown.



The electron beam passes between two horizontal metal plates and goes on to strike a fluorescent screen at the end of the tube. The plates are 0.040 m long and are separated by a gap of 0.015 m. A potential difference of 270 V is maintained between the plates.An individual electron takes 1.5×10^{-9} s to pass between the plates.The distance between the right-hand edge of the plates and the fluorescent screen is 0.20 m.

(i) Show that the vertical acceleration of an electron as it passes between the horizontal metal plates is approximately 3.2×10^{15} ms^{-2}.

(3)

(ii) Show that the vertical distance travelled by an electron as it passes between the horizontal metal plates is approximately 3.6 mm.

(2)

(iii) Show that the vertical component of velocity achieved by an electron in the beam by the time it reaches the end of the plates is approximately 4.7×10^6 m s^{-1}.

(2)

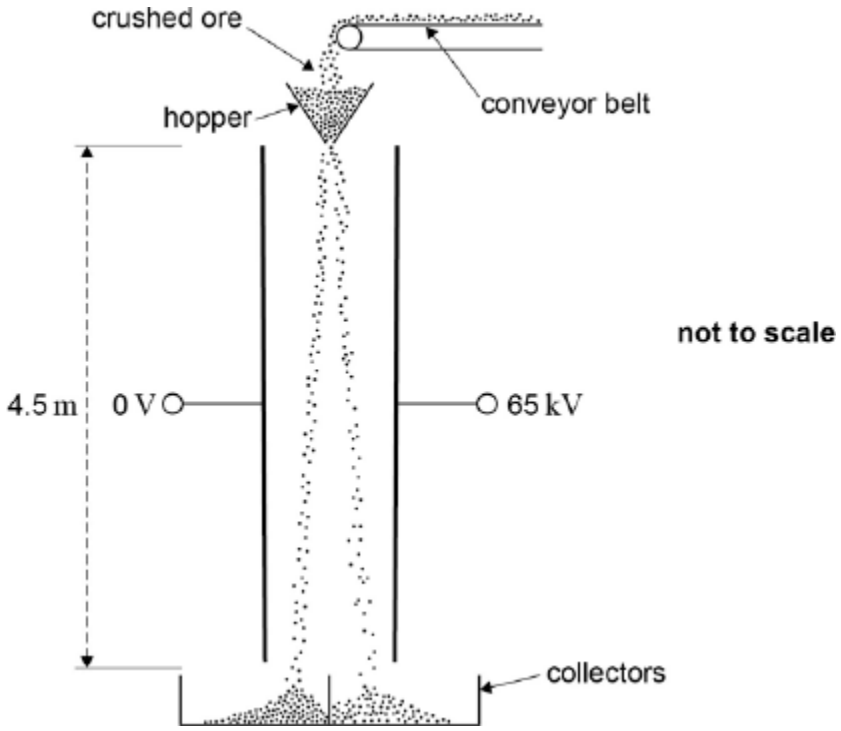
(iv) Calculate the vertical displacement, *y*, of the electron beam from the centre of the screen. Give your answer in m.

vertical displacement _____ m

(3)

(Total 13 marks)

19 The figure below shows a system that separates two minerals from the ore containing them using an electric field.



The crushed particles of the two different minerals gain opposite charges due to friction as they travel along the conveyor belt and through the hopper. When they leave the hopper they fall 4.5 metres between two parallel plates that are separated by 0.35 m.

(a) Assume that a particle has zero velocity when it leaves the hopper and enters the region between the plates.

Calculate the time taken for this particle to fall between the plates.

time taken = _____s

(2)

(b) A potential difference (pd) of 65 kV is applied between the plates.

Show that when a particle of specific charge 1.2×10^{-6} C kg^{-1} is between the plates its horizontal acceleration is about 0.2 m s^{-2}.

(3)

(c) Calculate the total horizontal deflection of the particle that occurs when falling between the plates.

horizontal deflection = _____m

(1)

(d) Explain why the time to fall vertically between the plates is independent of the mass of a particle.

_____

_____

_____

_____

(2)

(e) State and explain **two** reasons, why the horizontal acceleration of a particle is different for each particle.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 12 marks)