

Student: _____

Max. Marks : 25 Marks

Time : 25 Minutes

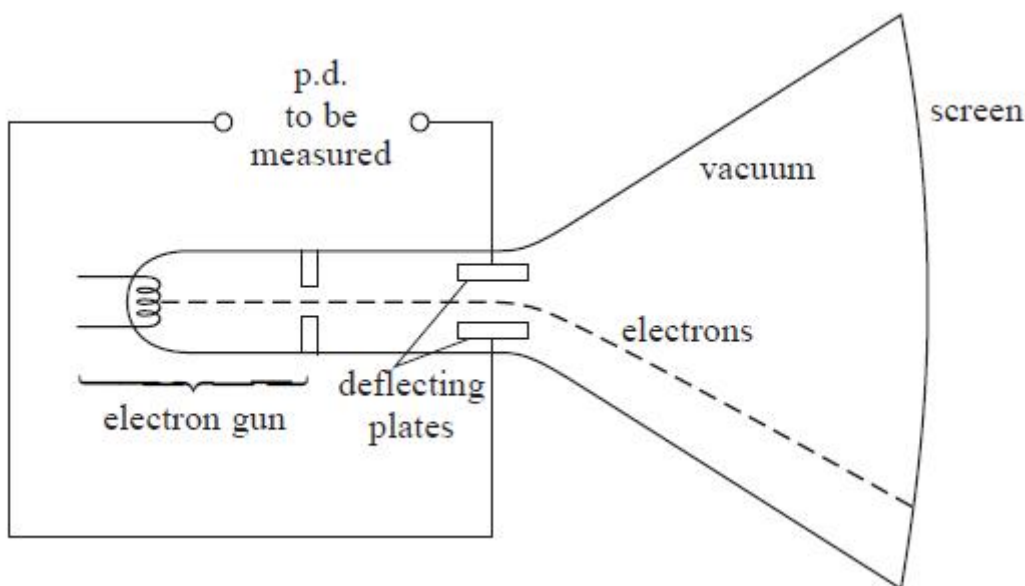
Q1.

Cathode ray tubes are used in oscilloscopes.



The diagram shows a simplified cathode ray tube that can be used to determine the magnitude and polarity of a potential difference (p.d.).

The cathode ray tube consists of an electron gun, a pair of deflecting plates and a fluorescent screen.



(a) The electron gun includes a filament. When this filament is heated, electrons are released and are accelerated by a p.d. of 1.5 kV to form an electron beam.

(i) Name the process by which electrons are released from the heated filament.

(1)

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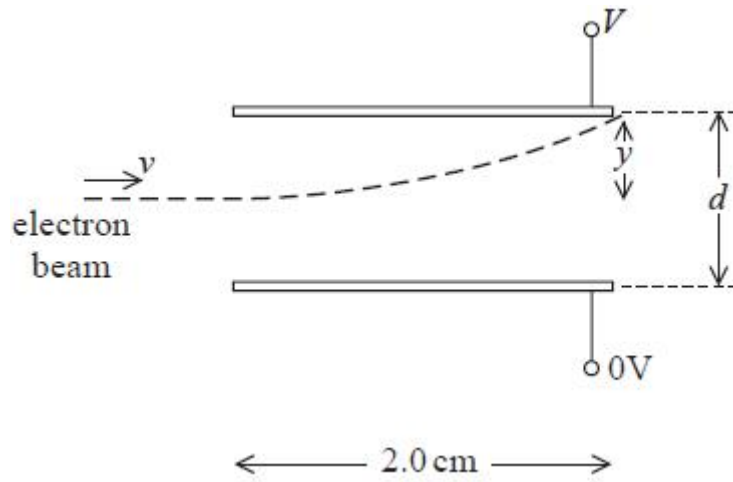
(ii) Show that the maximum velocity of the electrons is about $2 \times 10^7 \text{ m s}^{-1}$.

(2)

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(b) The electron beam then enters a uniform electric field between the two parallel horizontal deflecting plates. The magnitude and direction of the deflection is determined by the p.d. V that is applied across the plates. The diagram shows one possible path of the electron beam as it passes between the plates.



(i) Show that the acceleration of an electron, of mass m and charge Q , is given by

$$\frac{VQ}{dm}$$

(2)

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(ii) Calculate the magnitude of the vertical deflection y of the beam as it leaves the plates.

$V = 50 \text{ V}$
 $d = 0.01 \text{ m}$

(5)

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$y = \dots\dots\dots$

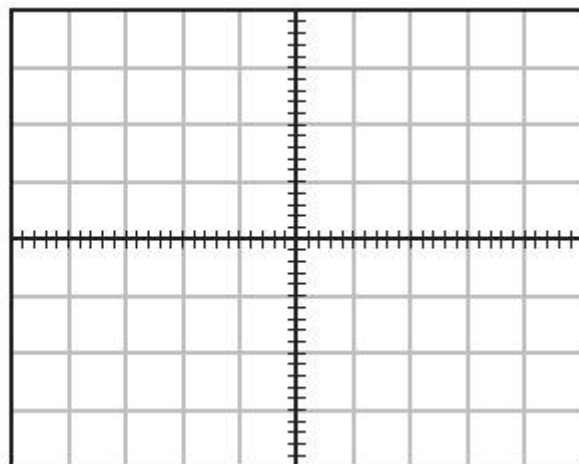
(c) A laboratory oscilloscope with the time base turned off operates in the same way as this simplified cathode

ray tube. A student uses an oscilloscope in this way to monitor an alternating p.d. of $53 V_{\text{rms}}$

On the grid, draw the trace that would be seen on the screen.

(4)

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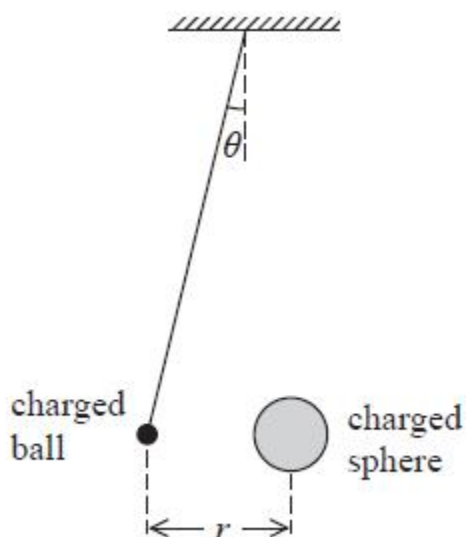
1 square = 25 V

(Total for question = 14 marks)

Q2.

A student carries out an experiment to investigate the force acting between two charged objects. A lightweight negatively-charged ball is freely suspended from the ceiling by an insulating thread. The ball is repelled by a negatively-charged sphere that is placed near it on an insulated support.

The angle of deflection is θ and r is the distance between the centres of the ball and the sphere.



(a) (i) Draw a free-body force diagram for the suspended ball.

(2)



(ii) The weight of the suspended ball is W .

Show that the force of repulsion F on the suspended ball is given by

$$F = W \tan \theta$$

(2)

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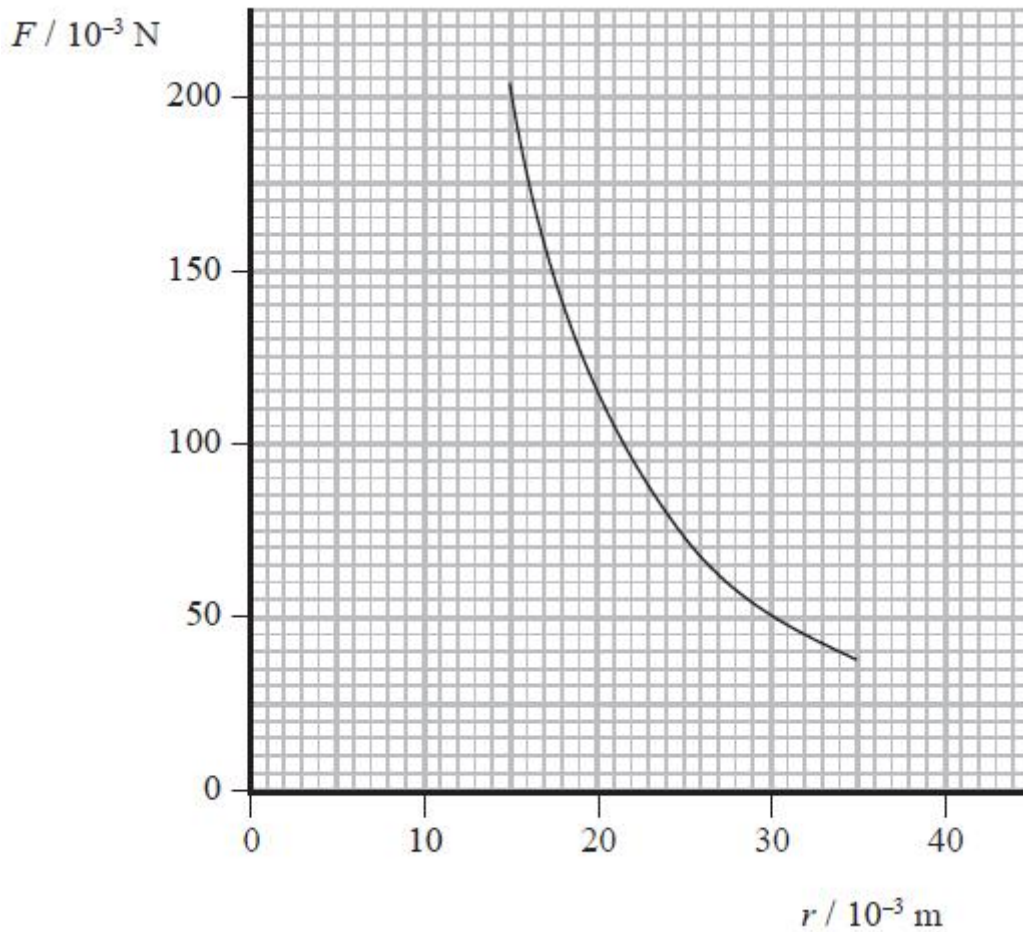
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(b) (i) The student can increase the magnitude of the force by moving the sphere towards the suspended ball. She takes pairs of measurements of r and θ and calculates the magnitude of the force F . She then plots a graph of F against r .



Use readings from the graph to demonstrate that the relationship between F and r obeys an inverse square law.

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(ii) The charge on the sphere is 100 times greater than the charge on the ball.
Calculate the charge on the ball.

(3)

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Charge =

(Total for question = 11 marks)