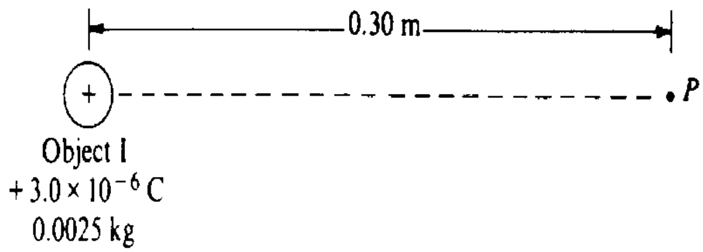
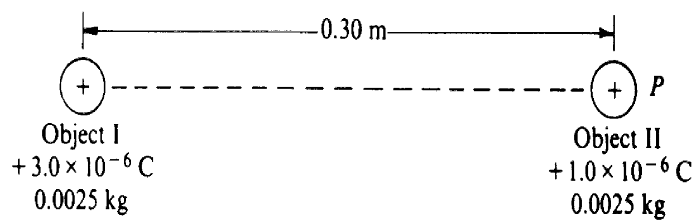
1987 Q2



Object I, shown above, has a charge of $+3 \times 10^{-6}$ coulomb and a mass of 0.0025 kilogram.

(a) What is the electric potential at point *P*, 0.30 meter from object I?



Object II, of the same mass as Object I, But having a charge of $+ 1 \times 10^{-6}$ coulomb, is brought from infinity to point *P*, as shown above.

(b) How much work must be done to bring the object II from infinity to point *P*?

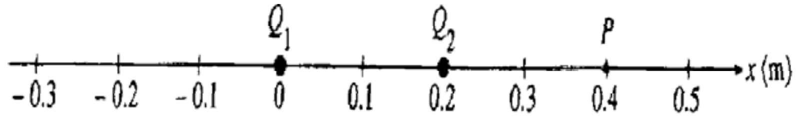
(c) What is the magnitude of the electric force between the two objects when they are 0.30 meter apart?

(d) What are the magnitude and direction of the electric field at the point midway between the two objects?

The two objects are then released simultaneously and move apart due to the electric force between them. No other forces act on the objects.

(e) What is the speed of object I when the objects are very far apart?

1989 Q2



Two point charges, Q_1 and Q_2, are located a distance 0.20 meter apart, as shown above. Charge $Q_1 = + 8.0\ \mu C$. The net electric field is zero at point P, located 0.40 meter from Q_1 and 0.20 meter from Q_2.

(a) Determine the magnitude and sign of charge Q_2.

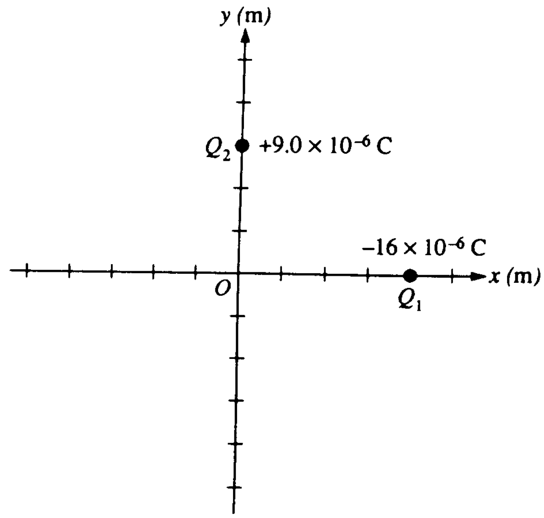
(b) Determine the magnitude and direction of the net force on charge Q_1.

(c) Calculate the electrostatic potential energy of the system.

(d) Determine the coordinate of the point *R* on the *x*-axis between the two charges at which the electric potential is zero.

(e) How much work is needed to bring an electron from infinity to point *R*, which was determined in the previous part?

1993 Q2

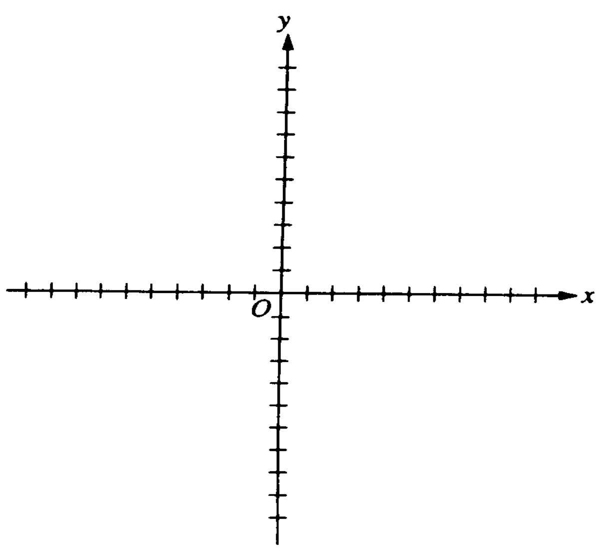


A charge $Q_1 = -16 \times 10^{-6}$ coulomb is fixed on the x-axis at +4.0 meters, and a charge $Q_2 = +9 \times 10^{-6}$ coulomb is fixed on the y-axis at + 3.0 meters, as shown on the diagram above.

(a) i. Calculate the magnitude of the electric field E_1 at the origin O due to charge Q_1.

ii. Calculate the magnitude of the electric field E_2 at the origin O due to charge Q_2.

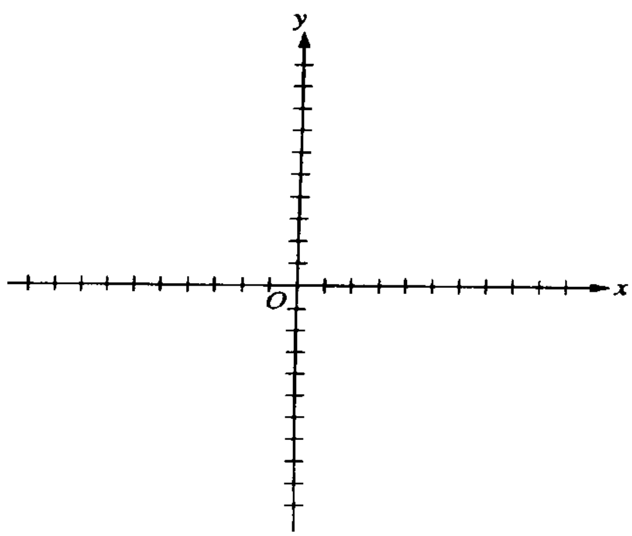
iii. On the axes below, draw and label vectors to show the electric fields $\mathbf{E}_1$ and $\mathbf{E}_2$ due to each charge, and also indicate the resultant electric field $\mathbf{E}$ at the origin.



(b) Calculate the electric potential V at the origin.

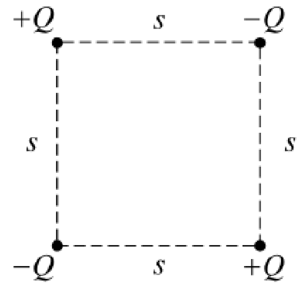
A charge $Q_3 = -4 \times 10^{-6}$ coulomb is brought from a very distant point by an external force and placed at the origin.

(c) On the axes below, indicate the direction of the force on Q_3 at the origin.



(d) Calculate the work that had to be done by the external force to bring Q_3 to the origin from the distant point.

2001 Q3 (15 points)



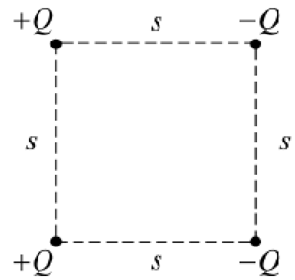
Arrangement 1

Four charged particles are held fixed at the corners of a square of side *s*. All the charges have the same magnitude *Q*, but two are positive and two are negative. In Arrangement 1, shown above, charges of the same sign are at opposite corners. Express your answers to parts (a) and (b) in terms of the given quantities and fundamental constants.

(a) For Arrangement 1, determine the following.

i. The electrostatic potential at the center of the square

ii. The magnitude of the electric field at the center of the square



Arrangement 2

The bottom two charged particles are now switched to form Arrangement 2, shown above, in which the positively charged particles are on the left and the negatively charged particles are on the right.

(b) For Arrangement 2, determine the following.

i. The electrostatic potential at the center of the square

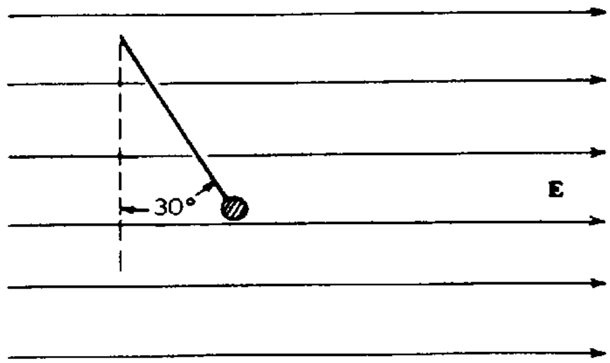
ii. The magnitude of the electric field at the center of the square

(c) In which of the two arrangements would more work be required to remove the particle at the upper right corner from its present position to a distance a long way away from the arrangement?

___ Arrangement 1 ___ Arrangement 2

Justify your answer.

1981 Q3



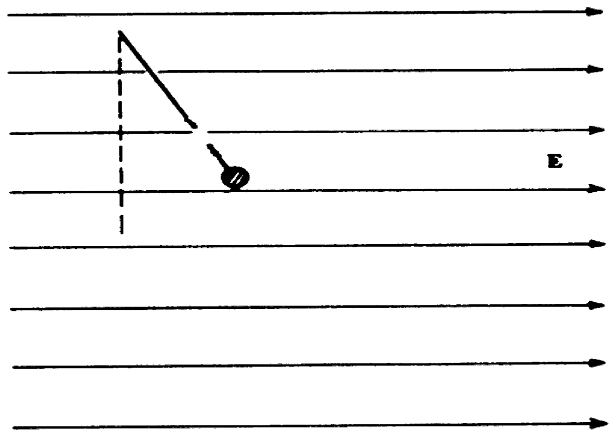
A small conducting sphere of mass 5×10^{-3} kilogram, attached to a string of length 2×10^{-1} meter, is at rest in a uniform electric field **E**, directed horizontally to the right as shown above. There is a charge of 5×10^{-6} coulomb on the sphere. The string makes an angle of 30° with the vertical. Assume g = 10 meters second squared.

$$\left(\sin 30^\circ = \frac{1}{2},\ \cos 30^\circ = \frac{\sqrt{3}}{2},\ \tan 30^\circ = \frac{\sqrt{3}}{3}\right)$$

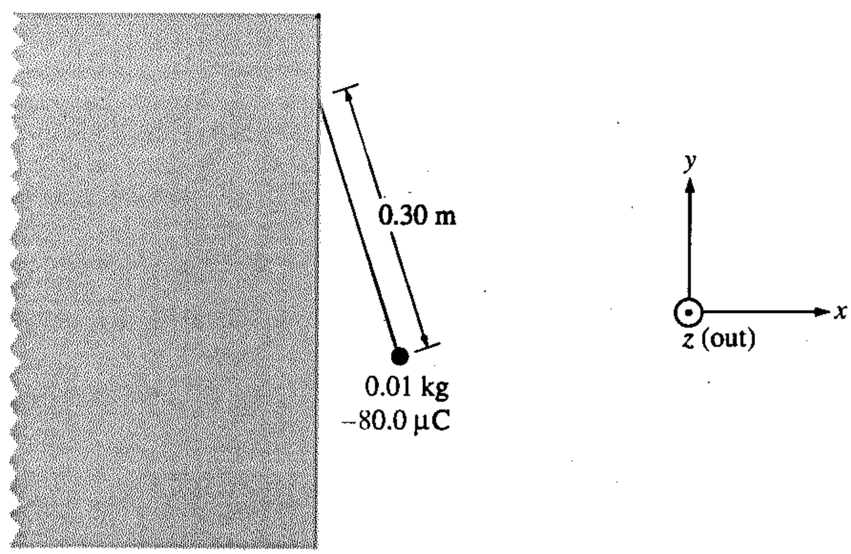
(a) In the space below, draw and label all the forces acting on the sphere.

(b) Calculate the tension in the string and the magnitude of the electric field.

(c) The string now breaks. Describe the subsequent motion of the sphere and sketch on the following diagram the path of the sphere while in the electric field.

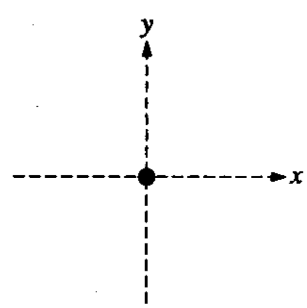


1998 Q2 (15 points)



A wall has a negative charge distribution producing a uniform horizontal electric field. A small plastic ball of mass 0.01 kg, carrying a charge of −80.0 uC, is suspended by an uncharged, nonconducting thread 0.30 m long. The thread is attached to the wall and the ball hangs in equilibrium, as shown above, in the electric and gravitational fields. The electric force on the ball has a magnitude of 0.032 N.

(a) On the diagram below, draw and label the forces acting on the ball.



(b) Calculate the magnitude of the electric field at the ball's location due to the charged wall, and state its direction relative to the coordinate axes shown.

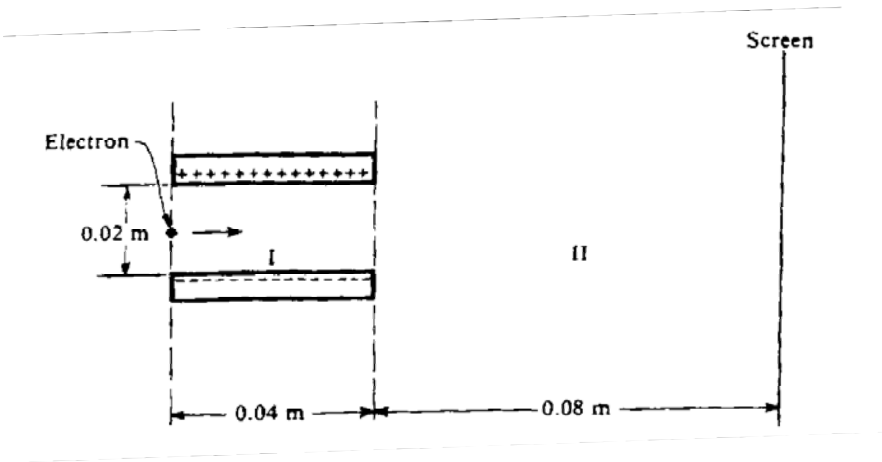
(c) Determine the perpendicular distance from the wall to the center of the ball.

(d) The string is now cut.

i. Calculate the magnitude of the resulting acceleration of the ball, and state its direction relative to the coordinate axes shown.

ii. Describe the resulting path of the ball.

1985 Q3



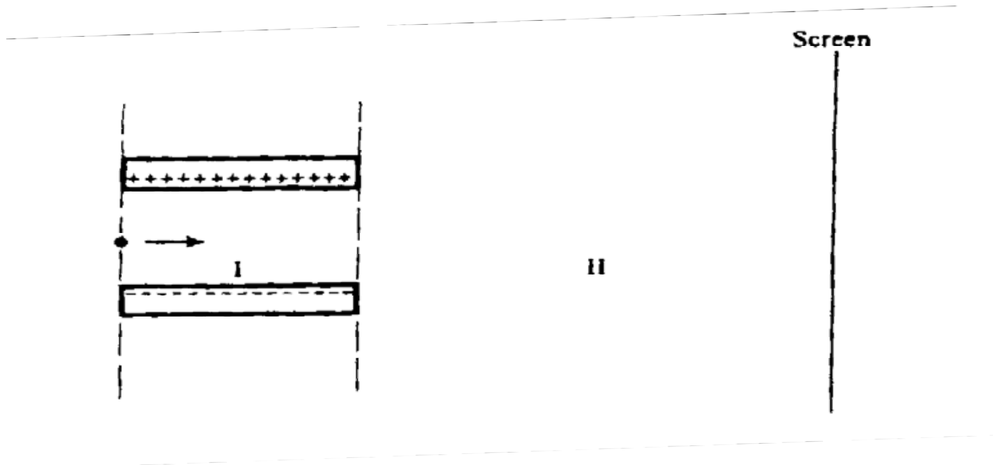
An electron initially moves in a horizontal direction and has a kinetic energy of 2.0×10^3 electron-volts when it is in the position shown above. It passes through a uniform electric field between two oppositely charged horizontal plates (region I) and a field-free region (region II) before eventually striking a screen at a distance of 0.08 meter from the edge of the plates. The plates are 0.04 meter long and are separated from each other by a distance of 0.02 meter. The potential difference across the plates is 250 volts. Gravity is negligible.

(a) Calculate the initial speed of the electron as it enters region I.

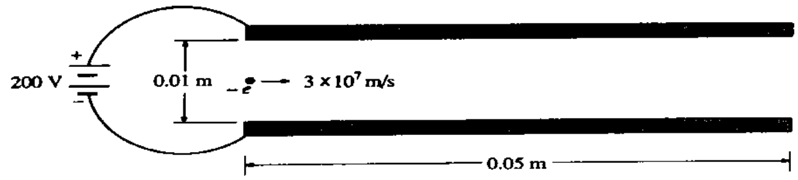
(b) Calculate the magnitude of the electric field *E* between the plates, and indicate its direction on the diagram.

(c) Calculate the magnitude of the electric force *F* acting on the electron while it is in region I.

(d) On the diagram below, sketch the path of the electron in regions I and II. For each region describe the path.



1990 Q2



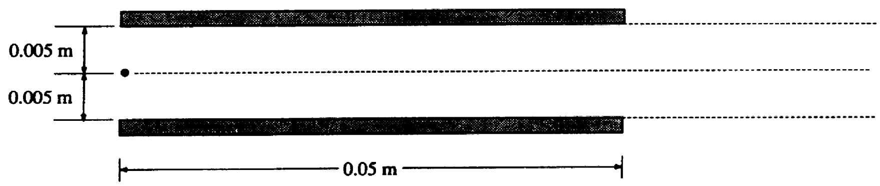
A pair of square parallel conducting plates, having sides of length 0.05 meter, are 0.01 meter apart and are connected to a 200-volt power supply, as shown above. An electron is moving horizontally with a speed of 3×10^7 meters per second when it enters the region between the plates. Neglect gravitation and the distortion of the electric field around the edges of the plates.

(a) Determine the magnitude of the electric field in the region between the plates and indicate its direction on the figure above.

(b) Determine the magnitude and direction of the acceleration of the electron in the region between the plates.

(c) Determine the magnitude of the vertical displacement of the electron for the time interval during which it moves through the region between the plates.

(d) On the diagram below, sketch the path of the electron as it moves through and after it emerges from the region between the plates. The dashed lines in the diagram have been added for reference only.



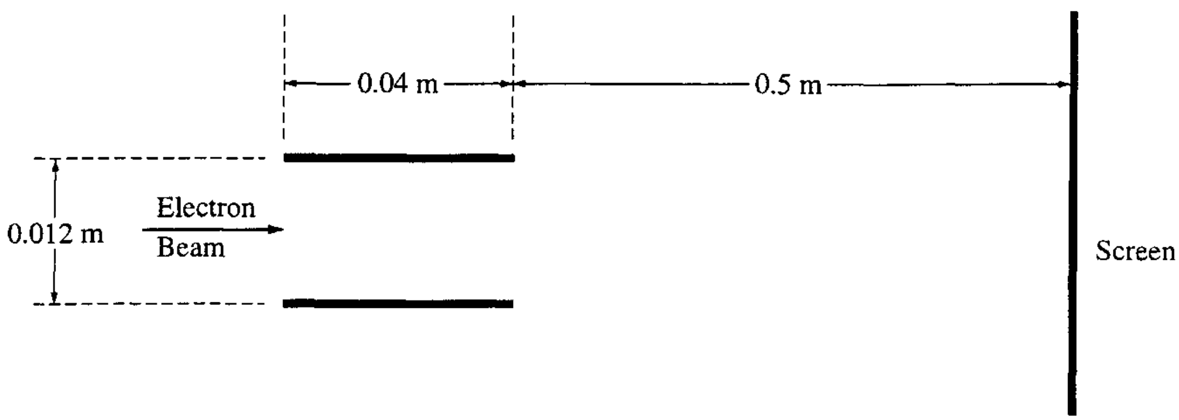
(e) A magnetic field could be placed in the region between the plates which would cause the electron to continue to travel horizontally in a straight line through the region between the plates. Determine both the magnitude and the direction of this magnetic field.

1999 Q2 (15 points)

In a television set, electrons are first accelerated from rest through a potential difference in an electron gun. They then pass through deflecting plates before striking the screen.

(a) Determine the potential difference through which the electrons must be accelerated in the electron gun in order to have a speed of 6.0×10^7 m/s when they enter the deflecting plates.

The pair of horizontal plates shown below is used to deflect electrons up or down in the television set by placing a potential difference across them. The plates have length 0.04 m and separation 0.012 m, and the right edge of the plates is 0.50 in from the screen. A potential difference of 200 V is applied across the plates, and the electrons are deflected toward the top of the screen. Assume that the electrons enter horizontally midway between the plates with a speed of 6.0×10^7 m/s and that fringing effects at the edges of the plates and gravity are negligible.



Note: Figure not drawn to scale.

(b) Which plate in the pair must be at the higher potential for the electrons to be deflected upward? Check the appropriate box below.

☐ Upper plate ☐ Lower plate

Justify your answer.

(c) Considering only an electron's motion as it moves through the space between the plates, compute the following.

i. The time required for the electron to move through the plates

i. The vertical displacement of the electron while it is between the plates

(d) Show why it is a reasonable assumption to neglect gravity in part (c).

(e) Still neglecting gravity, describe the path of the electrons from the time they leave the plates until they strike the screen. State a reason for your answer.