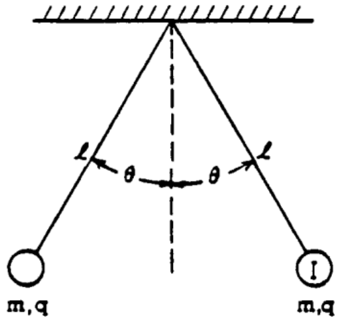
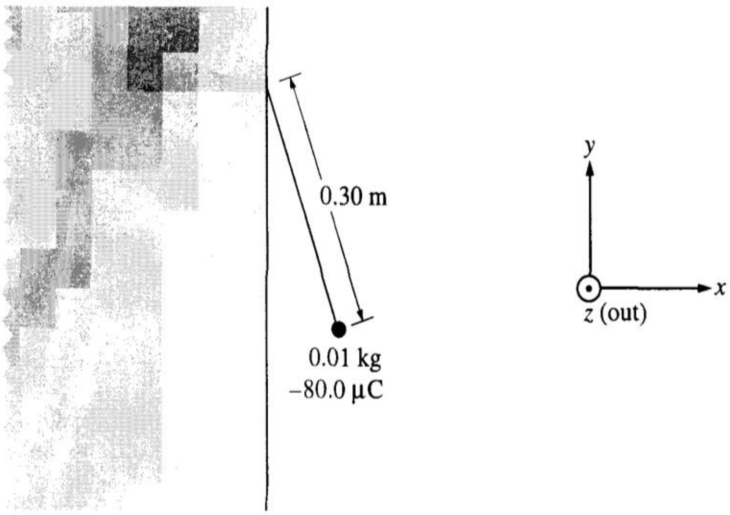


1979B7. Two small spheres, each of mass m and positive charge q, hang from light threads of lengths *l*. Each thread makes an angle θ with the vertical as shown above.

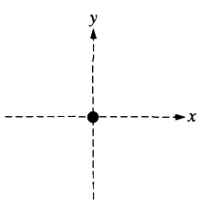
a. On the diagram below draw and label all forces on sphere I.

b. Develop an expression for the charge q in terms of m, l, θ, g, and the Coulomb's law constant.



(15 points) 1998B2. 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 μC 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.



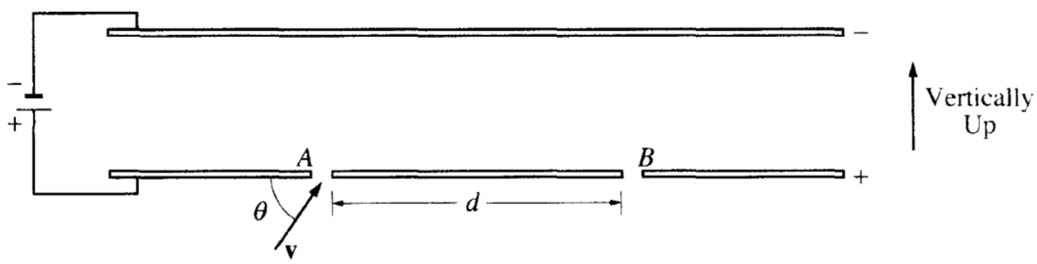
b. Calculate the magnitude of the electric field at the ball's location due to the charged wall, and state its direction relative to the coordinate axes shown.

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.



B2003B4. (15 points) An electric field **E** exists in the region between the two electrically charged parallel plates shown above. A beam of electrons of mass m. charge q and velocity **v** enters the region through a small hole at position A. The electrons exit the region between the plates through a small hole at position B. Express your answers to the following questions in terms of the quantities m, q, **E**, θ, and **v**. Ignore the effects of gravity.

a.
   i. On the diagram of the parallel plates above, draw and label a vector to show the direction of the electric field **E** between the plates.

   ii. On the following diagram, show the direction of the force(s) acting on an electron after it enters the region between the plates.

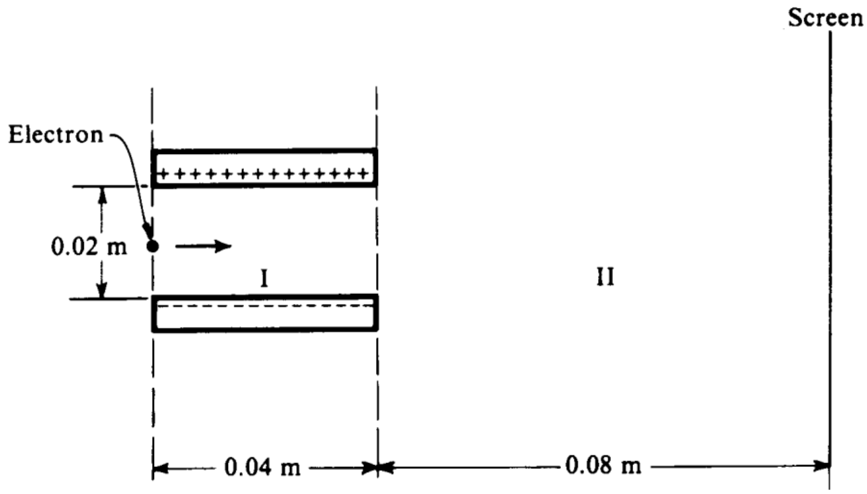
   iii. On the diagram of the parallel plates above, show the trajectory of an electron that will exit through the small hole at position B.

b. Determine the magnitude of the acceleration of an electron after it has entered the region between the parallel plates.

c. Determine the total time that it takes the electrons to go from position A to position B.

d. Determine the distance d between positions A and B.

e. Now assume that the effects of gravity cannot be ignored in this problem. How would the distance d change for an electron entering the region at A and leaving at B Explain your reasoning?



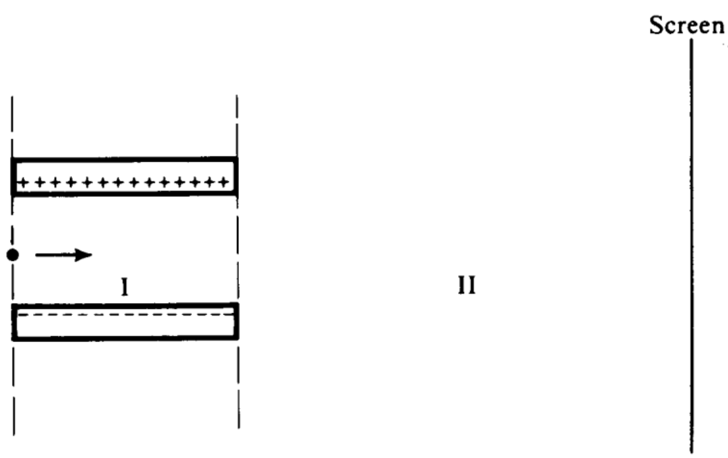
1985B3. An electron initially moves in a horizontal direction and has a kinetic energy of 2.0 x 10^3 electron-volts when it is in the position shown above. It passes through a uniform electric field between two oppositely charged horizontal plates (region I) and a field-free region (region II) before 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.

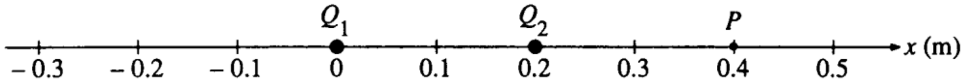
a. Calculate the initial speed of the electron as it enters region I.

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

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 shape of the path.





1989B2. 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.

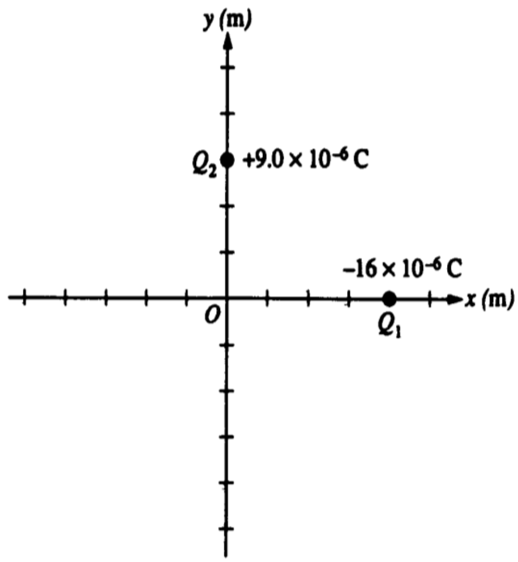
a. Determine the magnitude and sign of charge Q_2.

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?



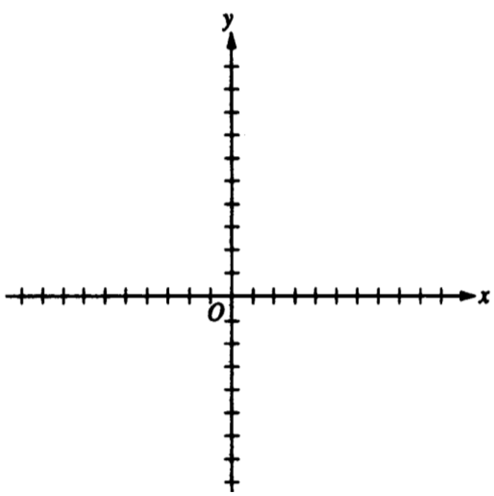
1993B2. A charge $Q_1 = -1.6 \times 10^{-6}$ coulomb is fixed on the x-axis at +4.0 meters, and a charge $Q_2 = +9 \times 10^{-6}$ coulomb is fixed on the y-axis at + 3.0 meters, as shown on the diagram above.

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 E_1 and E_2 due to each charge,

and also indicate the resultant electric field E at the origin.

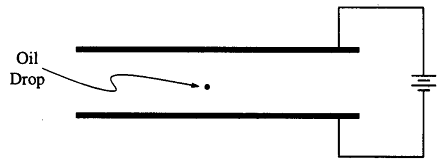


b. Calculate the electric potential V at the origin.

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.



1996B6 (10 points) Robert Millikan received a Nobel Prize for determining the charge on the electron. To do this, he set up a potential difference between two horizontal parallel metal plates. He then sprayed drops of oil between the plates and adjusted the potential difference until drops of a certain size remained suspended at rest between the plates, as shown above. Suppose that when the potential difference between the plates is adjusted until the electric field is 10,000 N/C downward, a certain drop with a mass of 3.27×10^{-16} kg remains suspended.

a. What is the magnitude of the charge on this drop?

b. The electric field is downward, but the electric force on the drop is upward. Explain why.

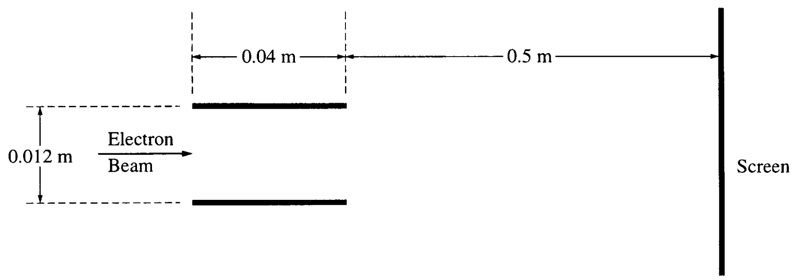
c. If the distance between the plates is 0.01 m, what is the potential difference between the plates?

d. The oil in the drop slowly evaporates while the drop is being observed, but the charge on the drop remains the same. Indicate whether the drop remains at rest, moves upward, or moves downward. Explain briefly.

1999B2. 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 m 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.

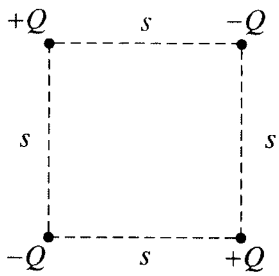
c. Considering only an electron's motion as it moves through the space between the plates, compute the following.

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

ii. 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.

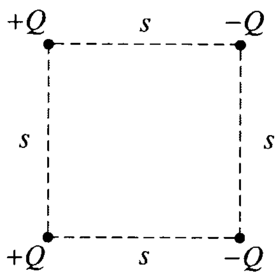
e. Still neglecting gravity, describe the path of the electrons from the time they leave the plates until they strike the screen. State a reason for your answer.



Arrangement 1

2001B3. 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

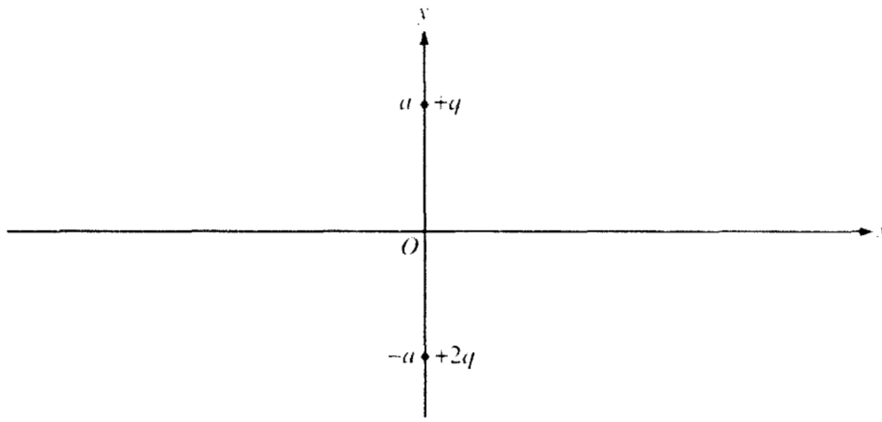
The bottom two charged particles are now switched to form Arrangement 2, shown above, in which the positively charged particles are on the left and the negatively charged particles are on the right.

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

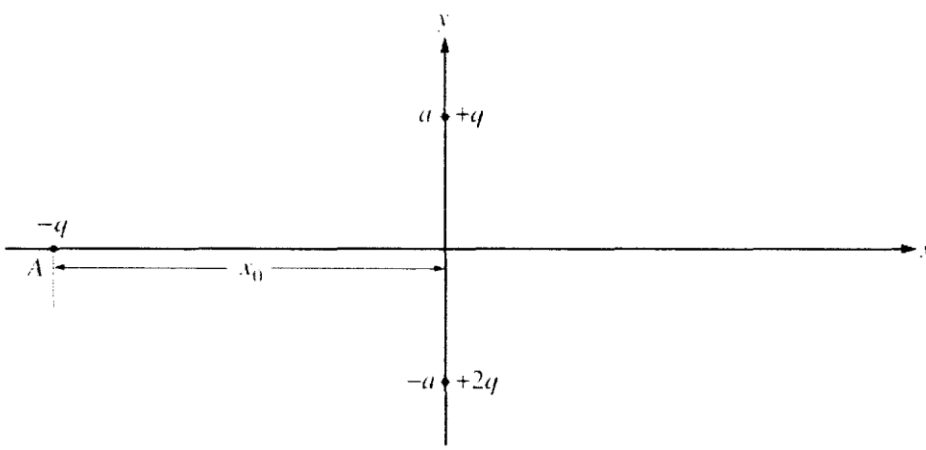


2005B3. (15 points) Two point charges are fixed on the y-axis at the locations shown in the figure above. A charge of +q is located at y = +a and a charge of +2q is located at y = -a. Express your answers to parts (a) and (b) in terms of q. a, and fundamental constants.

(a) Determine the magnitude and direction of the electric field at the origin.

(b) Determine the electric potential at the origin.

A third charge of —q is first placed at an arbitrary point A (x = —x_o) on the x-axis as shown in the figure below.

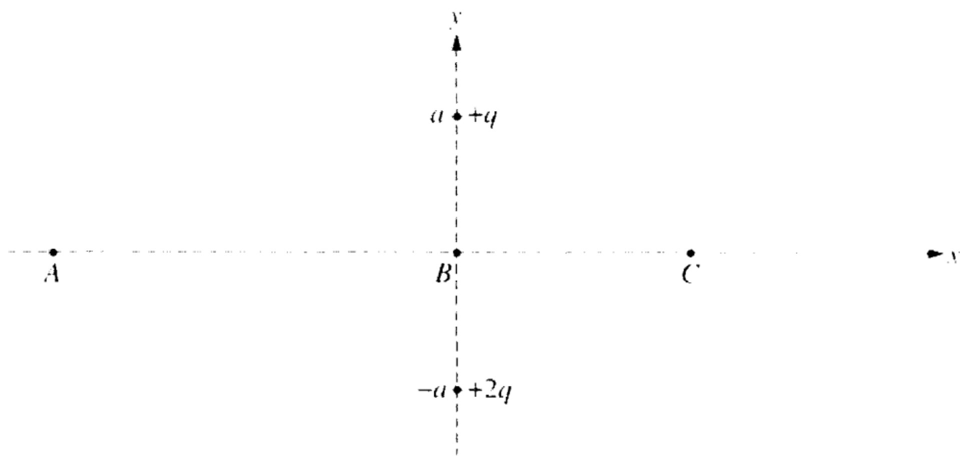


(c) Write expressions in terms of q, a, x_o and fundamental constants for the magnitudes of the forces on the —q charge at point A caused by each of the following.

i. The +q charge

ii. The +2q charge

(d) The —q charge can also be placed at other points on the x-axis. At each of the labeled points (A. B. and C) in the following diagram, draw a vector to represent the direction of the net force on the —q charge due to the other two charges when it is at those points.



y
a
+q
A
B
C
x
−a
+2q