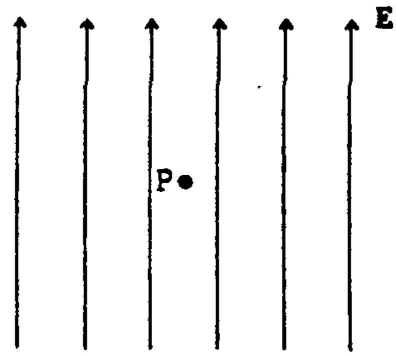
MAGNETIC FIELDS

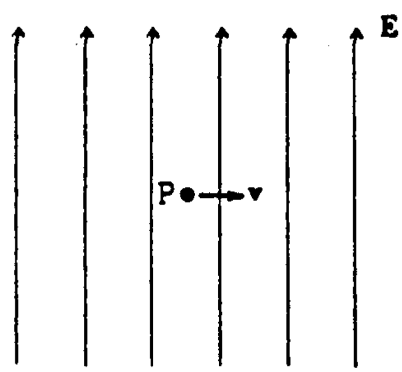
1979 Q4

Determine the magnitude and direction of the force on a proton in each of the following situations. Describe qualitatively the path followed by the proton in each situation and sketch the path on each diagram. Neglect gravity.

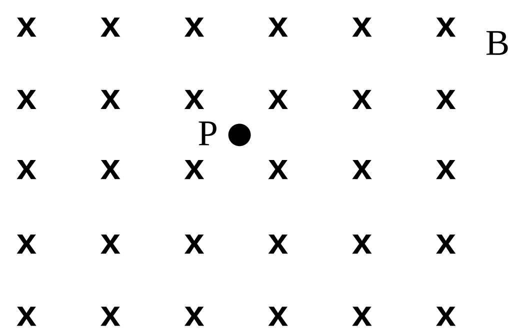
(a) The proton is released from rest at the point P in an electric field **E** having intensity 10^4 newtons per coulomb and directed up in the plane of the page as shown below.



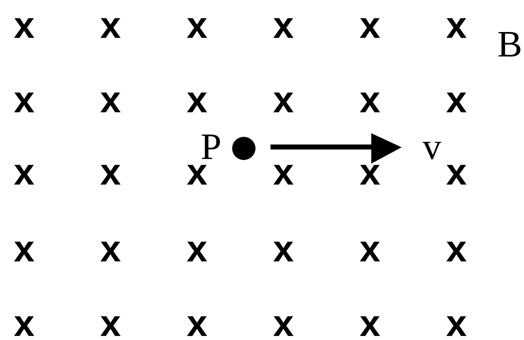
(b) In the same electric field as in part (a), the proton at point P has velocity **v** = 10^5 meters per second directed to the right as shown below.



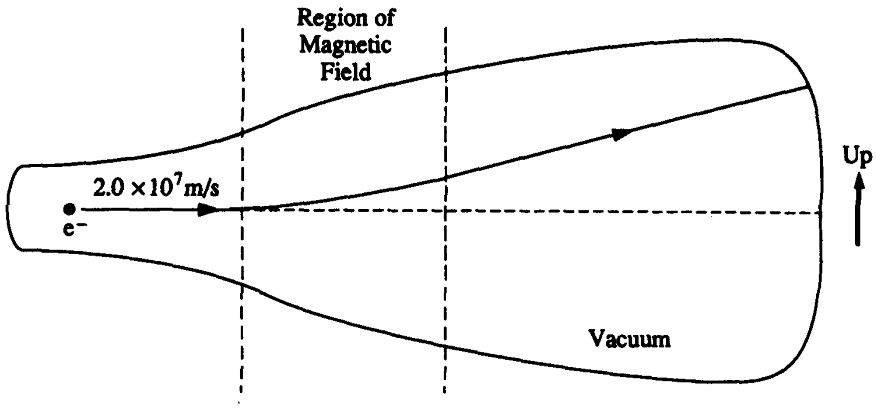
(c) The proton is released from rest at point P in a magnetic field **B** having intensity 10^{-1} tesla and directed into the page as shown below.



(d) In the same magnetic field as in part (c), the proton at point P has velocity **v** = 10^5 meters per second directed to the right as shown below.



1992 Q5



Cross Section of Cathode Ray Tube

The figure above shows a cross section of a cathode ray tube. An electron in the tube initially moves horizontally in the plane of the cross section at a speed of 2.0×10^7 meters per second. The electron is deflected upward by a magnetic field that has a field strength of 6.0×10^{-4} tesla.

(a) What is the direction of the magnetic field?

(b) Determine the magnitude of the magnetic force acting on the electron.

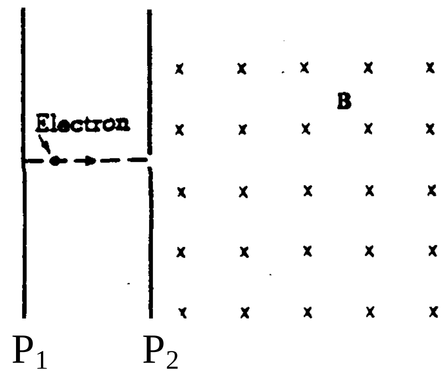
(c) Determine the radius of curvature of the path followed by the electron while it is in the magnetic field.

An electric field is later established in the same region as the magnetic field such that the electron now passes through the magnetic and electric fields without deflection.

(d) Determine the magnitude of the electric field.

(e) What is the direction of the electric field?

1977 Q3



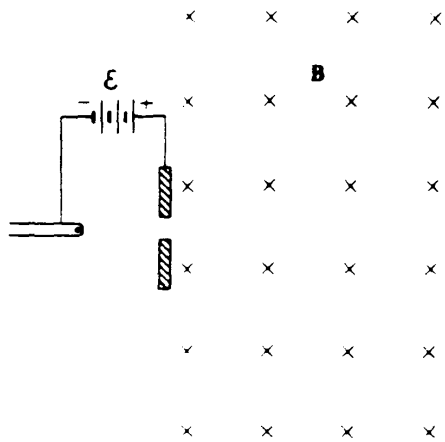
An electron is accelerated from rest through a potential difference of magnitude V between infinite parallel plates P_1 and P_2. The electron then passes into a region of uniform magnetic field strength B which exists everywhere to the right of plate P_2. The magnetic field is directed into the page.

(a) On the diagram above, clearly indicate the direction of the electric field between the plates.
(b) In terms of V and the electron's mass and charge, determine the electron's speed at plate P_2.

(c) Describe in detail the motion of the electron through the magnetic field and explain why the electron moves this way.

(d) If the magnetic field remains unchanged, what could be done co cause the electron to follow a straight-line path to the right of plate P_2?

1984 Q4



An electron from a hot filament in a cathode ray tube is accelerated through a potential difference ε. It then passes into a region of uniform magnetic field **B**, directed into the page as shown above. The mass of the electron is m and the charge has magnitude *e*.

(a) Find the potential difference ε necessary to give the electron a speed v as it enters the magnetic field.

(b) On the diagram above, sketch the path of the electron in the magnetic field.

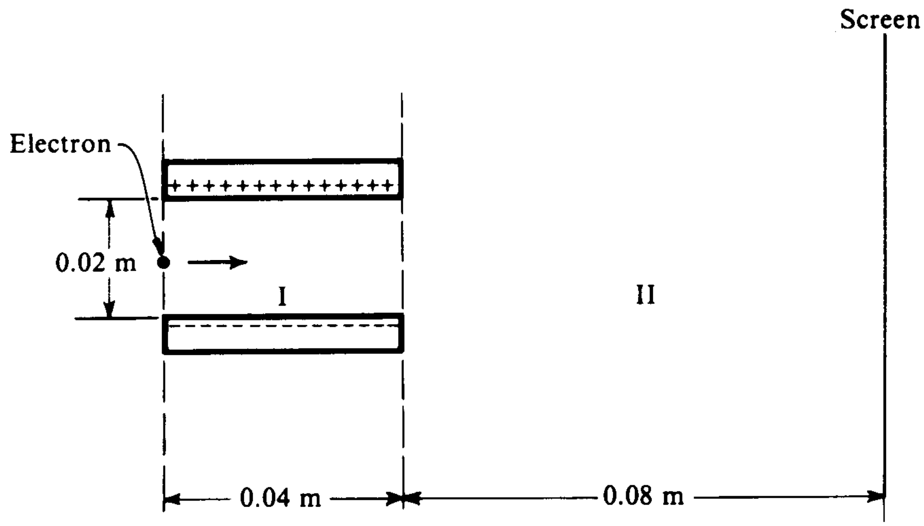
(c) In terms of mass *m*, speed *v*, charge *e*, and field strength *B*, develop an expression for *r*, the radius of the circular path of the electron.

(d) An electric field **E** is now established in the same region as the magnetic field, so that the electron passes through the region undeflected.

i. Determine the magnitude of **E**.

ii. Indicate the direction of **E** on the diagram above.

1985 Q3



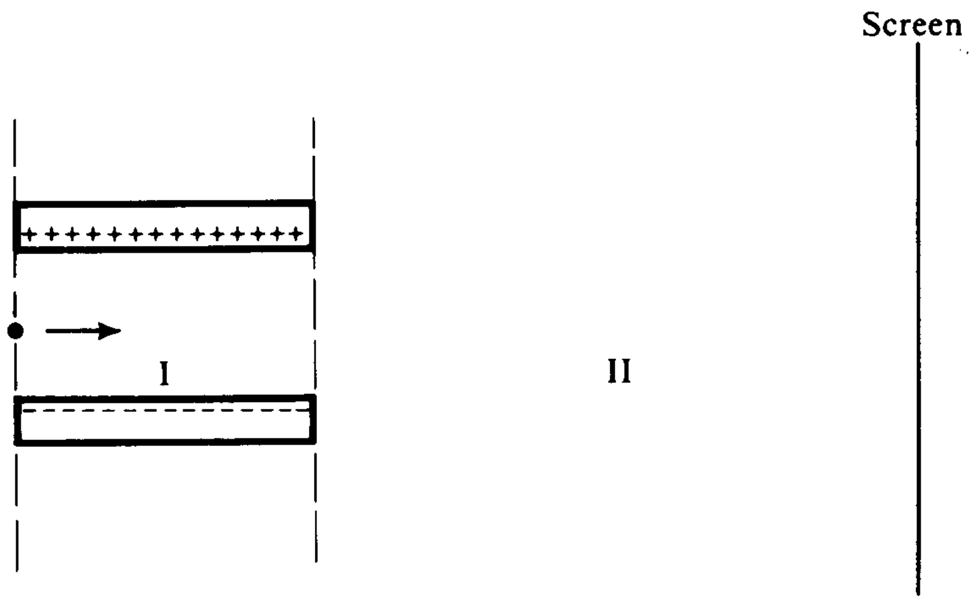
An electron initially moves in a horizontal direction and has a kinetic energy of 2.0×10^3 electron-volts when it is in the position shown above. It passes through a uniform electric field between two oppositely charged horizontal plates (region I) and a field-free region (region II) before eventually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

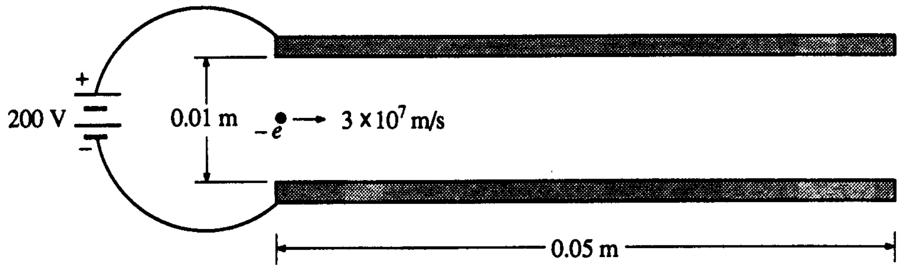
(b) Calculate the magnitude of the electric field E between the plates, and indicate its direction on the diagram above.

(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.



1990 Q2



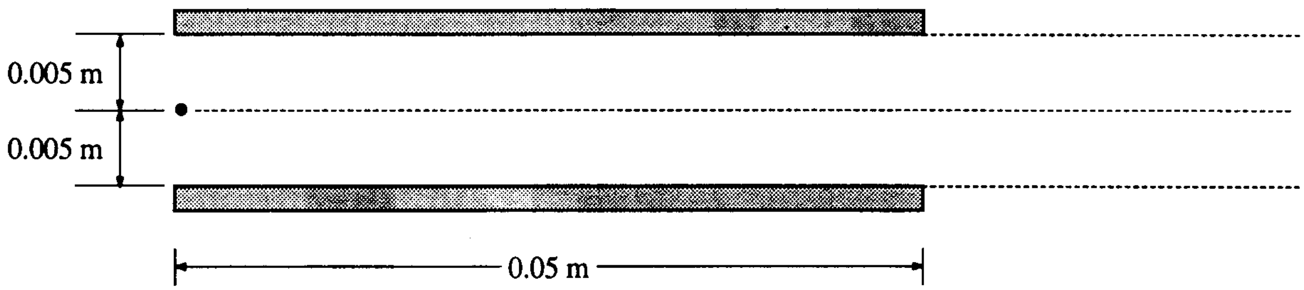
A pair of square parallel conducting plates, having sides of length 0.05 meter, are 0.01 meter apart and are connected to a 200-volt power supply, as shown above. An electron is moving horizontally with a speed of 3×10^7 meters per second when it enters the region between the plates. Neglect gravitation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

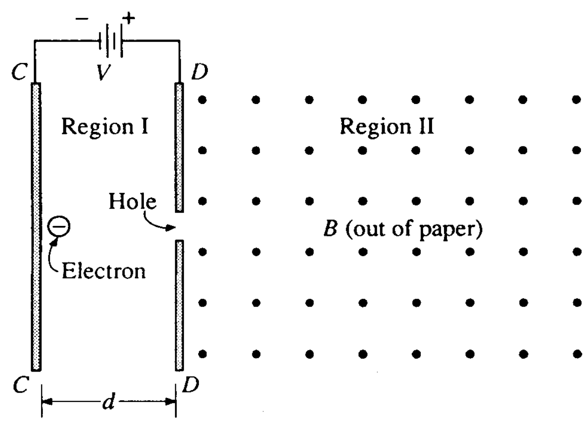
(c) Determine the magnitude of the vertical displacement of the electron for the time interval during which it moves through the region between the plates.

(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.

1991 Q2



In region I shown above, there is a potential difference V between two large, parallel plates separated by a distance d. In region II, to the right of plate D, there is a uniform magnetic field B pointing perpendicularly out of the paper. An electron, charge e and mass m, is released from rest at plate C as shown, and passes through a hole in plate D into region II. Neglect gravity.

(a) In terms of e, V, m, and d, determine the following.

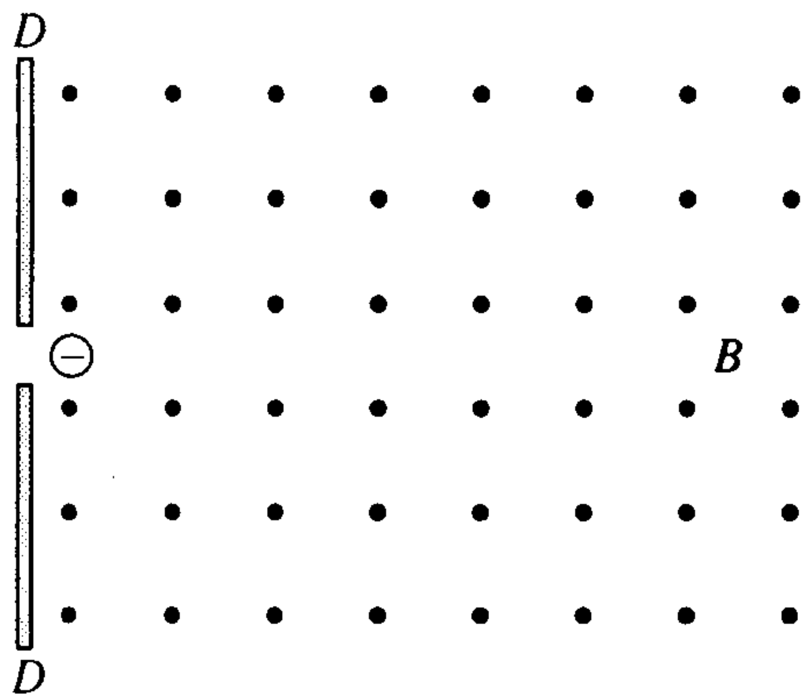
i. The speed V_0 of the electron as it emerges from the hole in plate D

ii. The acceleration of the electron in region I between the plates

(b) On the diagram below do the following.

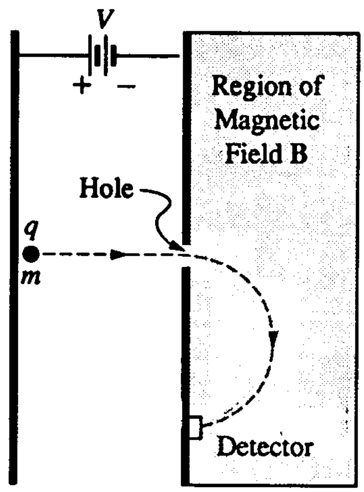
i. Draw and label an arrow to indicate the direction of the magnetic force on the electron as it enters the constant magnetic field.

ii. Sketch the path that the electron follows in region II.



(c) In terms of *e*, *B*. *V*, and *m*, determine the magnitude of the acceleration of the electron in region II.

1993 Q3



A particle of mass *m* and charge *q* is accelerated from rest in the plane of the page through a potential difference *V* between two parallel plates as shown above. The particle is injected through a hole in the right-hand plate into a region of space containing a uniform magnetic field of magnitude *B* oriented perpendicular to the plane of the page. The particle curves in a semicircular path and strikes a detector. Neglect relativistic effects throughout this problem.

(a)

i. State whether the sign of the charge on the particle is positive or negative.

ii. State whether the direction of the magnetic field is into the page or out of the page.

(b) Determine each of the following in terms of *m*, *q*, *V*, and *B*.

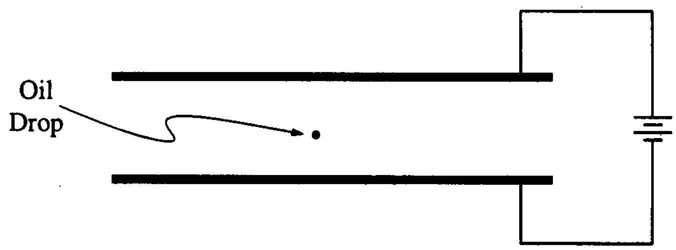
i. The speed of the charged particle as it enters the region of the magnetic field *B*

ii. The force exerted on the charged particle by the magnetic field B

iii. The distance from the point of injection to the detector

iv. The work done by the magnetic field on the charged particle during the semicircular trip

1996 Q6 (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.

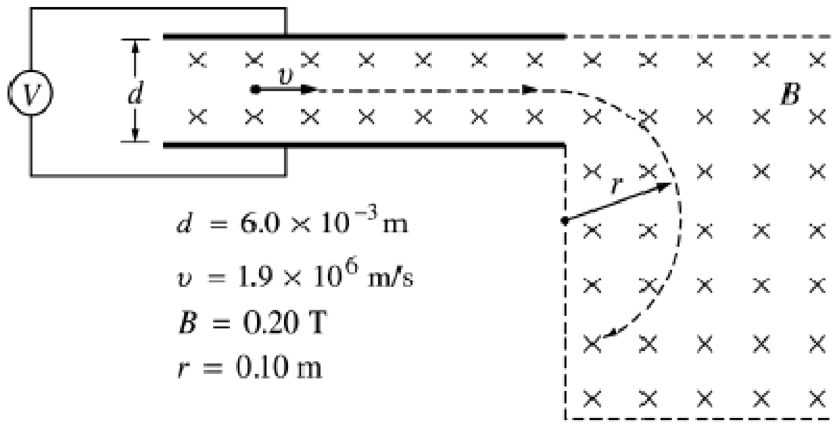
(a) What is the magnitude of the charge on this drop?

(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.

2007 Q7 (10 points)



A particle with unknown mass and charge moves with constant speed $v = 1.9 \times 10^6$ m/s as it passes undeflected through a pair of parallel plates, as shown above. The plates are separated by a distance $d = 6.0 \times 10^{-3}$ m, and a constant potential difference V is maintained between them. A uniform magnetic field of magnitude $B = 0.20$ T directed into the page exists both between the plates and in a region to the right of them as shown. After the particle passes into the region to the right of the plates where only the magnetic field exists, its trajectory is circular with radius $r = 0.10$ m.

(a) What is the sign of the charge of the particle? Check the appropriate space below.

___ Positive   ___ Negative   ___ Neutral   ___ It cannot be determined from this information.

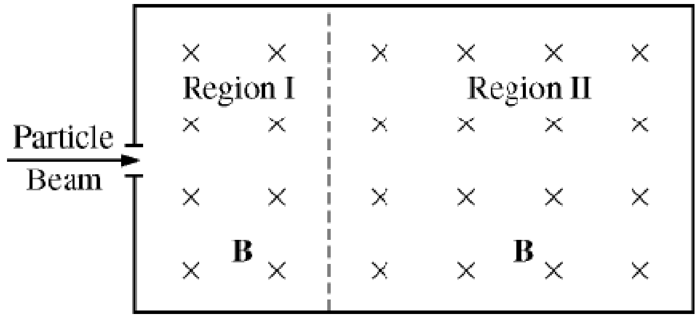
Justify your answer.

(b) On the diagram above, clearly indicate the direction of the electric field between the plates.

(c) Determine the magnitude of the potential difference V between the plates.

(d) Determine the ratio of the charge to the mass (q/m) of the particle.

2007B Q2 (10 points)



A beam of particles of charge $q = +3.2 \times 10^{-19}$ C and mass $m = 6.68 \times 10^{-26}$ kg enters Region I with a range of velocities all in the direction shown in the diagram above. There is a magnetic field in Region I directed into the page with magnitude $B = 0.12$ T. Charged metal plates are placed in appropriate locations to create a uniform electric field of magnitude $E = 4800$ N/C in Region I. As a result, some of the charged particles pass straight through Region I undeflected. Gravitational effects are negligible.

(a)

i. On the diagram above, sketch electric field lines in Region I.

ii. Calculate the speed of the particles that pass straight through Region I.

The particles that pass straight through enter Region II in which there is no electric field and the magnetic field has the same magnitude and direction as in Region I. The path of the particles in Region II is a circular arc of radius *R*.

(b) Calculate the radius *R*.

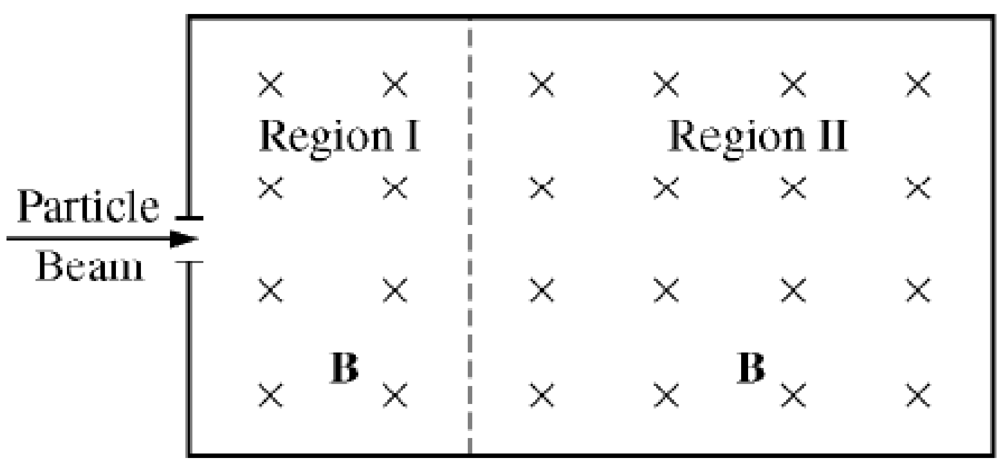
(c) Within the beam there are particles moving slower than the speed you calculated in (a)ii. In what direction is the net initial force on these particles as they enter Region I?

_____To the left _____Toward the top of the page _____Out of the plane of the page

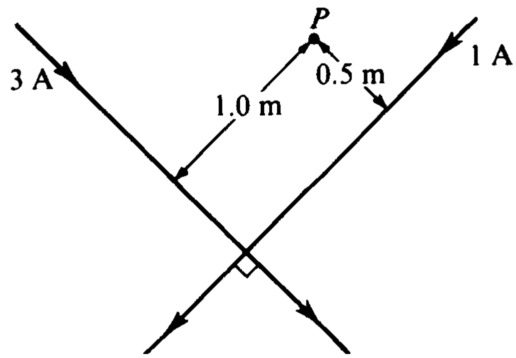
_____To the right _____Toward the bottom of the page _____Into the plane of the page

Justify your answer.

(d) A particle of the same mass and the same speed as in (a)ii but with charge $q = -3.2 \times 10^{-19}$ C enters Region I. On the following diagram, sketch the complete resulting path of the particle.



1988 Q4



The magnitude of the magnetic field in teslas at a distance d from a long straight wire carrying a current *I* is given by the relation $B = 2 \times 10^{-7} I/d$. The two long straight wires shown above are perpendicular, insulated from each other, and small enough so that they may be considered to be in the same plane. The wires are not free to move. Point *P*, in the same plane as the wires, is 0.5 meter from the wire carrying a current of 1 ampere and is 1.0 meter from the wire carrying a current of 3 amperes.

(a) What is the direction of the net magnetic field at *P* due to the currents?

(b) Determine the magnitude of the net magnetic field at *P* due to the currents.

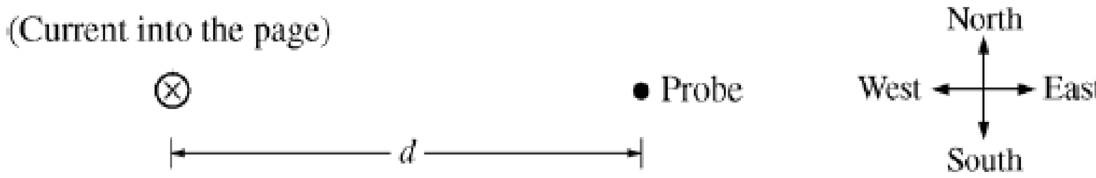
A charged particle at point *P* that is instantaneously moving with a velocity of 10^6 meters per second toward the top of the page experiences a force of 10^{-7} newtons to the left due to the two currents.

(c) State whether the charge on the particle is positive or negative.

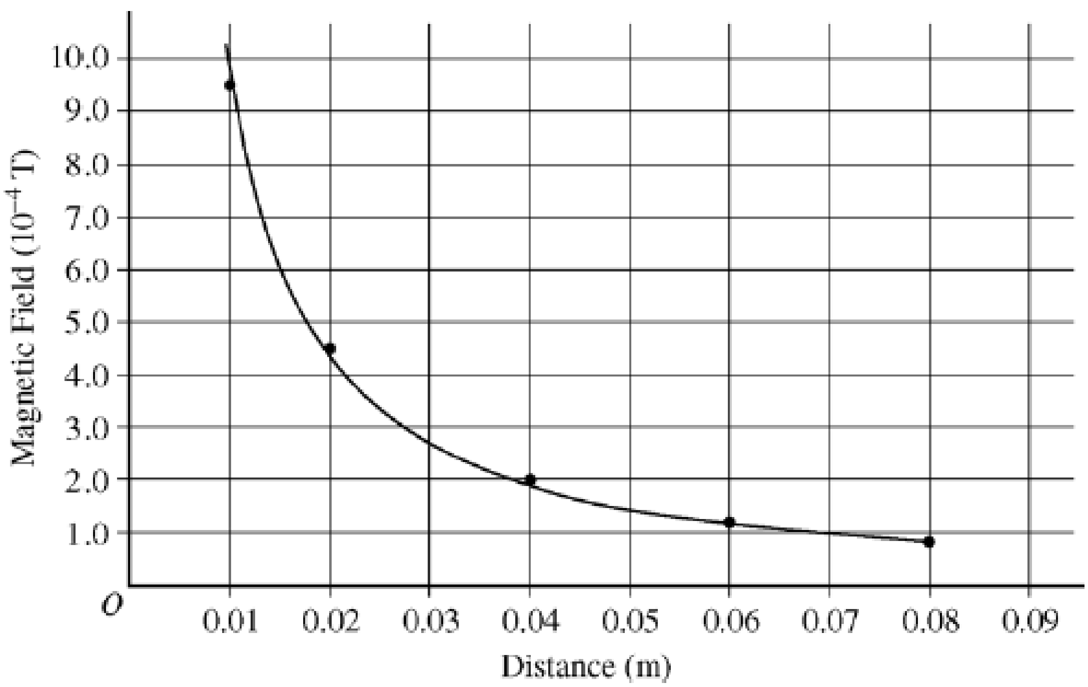
(d) Determine the magnitude of the charge on the particle.

(e) Determine the magnitude and direction of an electric field also at point P that would make the net force on this moving charge equal to zero.

2008B Q3 (15 points)

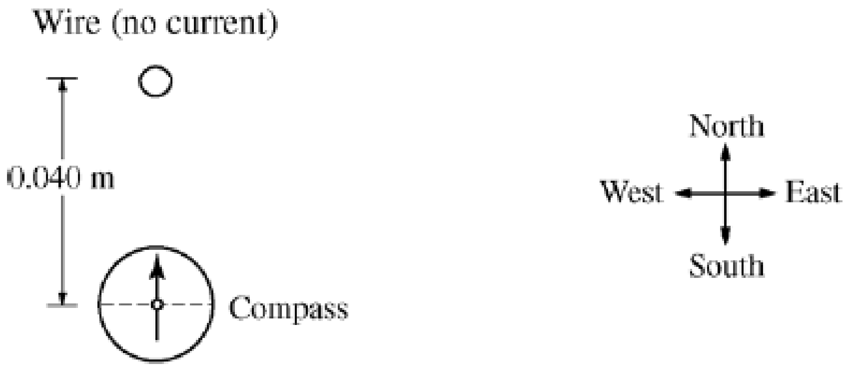


A student is measuring the magnetic field generated by a long, straight wire carrying a constant current. A magnetic field probe is held at various distances *d* from the wire, as shown above, and the magnetic field is measured. The graph below shows the five data points the student measured and a best-fit curve for the data. Unfortunately, the student forgot about Earth's magnetic field, which has a value of 5.0×10^{-5} T at this location and is directed north.



(a) On the graph, plot new points for the field due only to the wire.
(b) Calculate the value of the current in the wire.

Another student, who does not have a magnetic field probe, uses a compass and the known value of Earth's magnetic field to determine the magnetic field generated by the wire. With the current turned off, the student places the compass 0.040 m from the wire, and the compass points directly toward the wire as shown below. The student then turns on a 35 A current directed into the page.



Note: Figure not drawn to scale.

(c) On the compass, sketch the general direction the needle points after the current is established.

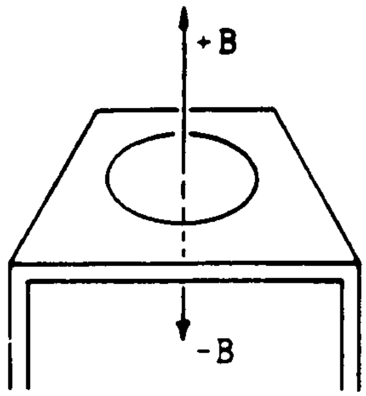
(d) Calculate how many degrees the compass needle rotates from its initial position pointing directly north.

The wire is part of a circuit containing a power source with an emf of 120 V and negligible internal resistance.

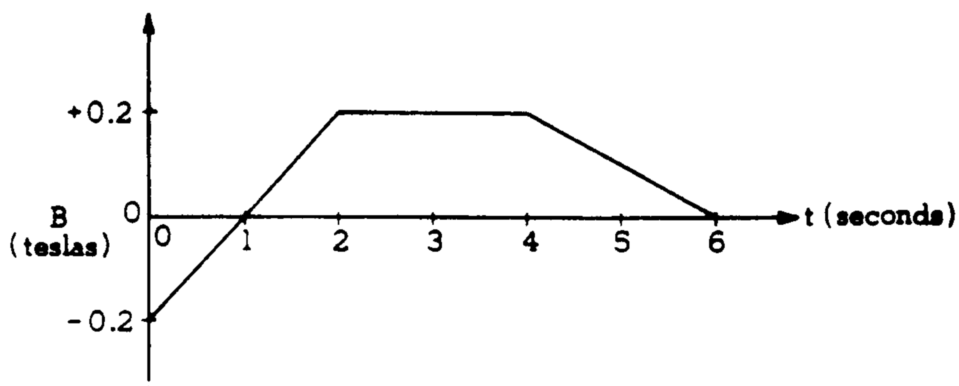
(e) Calculate the total resistance of the circuit.

(f) Calculate the rate at which energy is dissipated in the circuit.

1982 Q5



A circular loop of wire of resistance 0.2 ohm encloses an area 0.3 square meter and lies flat on a wooden table as shown above. A magnetic field that varies with time t as shown below is perpendicular to the table. A positive value of B represents a field directed up from the surface of the table; a negative value represents a field directed into the tabletop.



a. Calculate the value of the magnetic flux through the loop at time t = 3 seconds.

b. Calculate the magnitude of the emf induced in the loop during the time interval t = 0 to 2 seconds.

c. On the axes below, graph the current I through the coil as a function of time t, and put appropriate numbers on the vertical scale. Use the convention that positive values of I represent counterclockwise current as viewed from above.