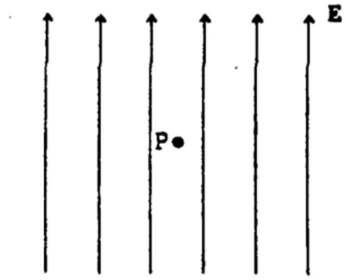
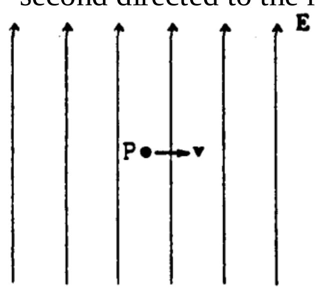
1979B4. Determine the magnitude and direction of the force on a proton in each of the following situations. Describe qualitatively the path followed by the proton in each situation and sketch the path on each diagram. Neglect gravity.

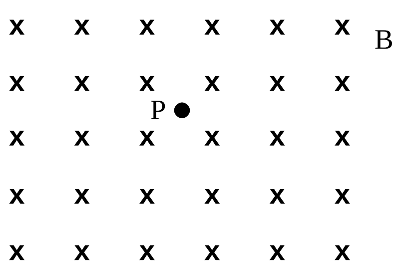
a. The proton is released from rest at the point P in an electric field E having intensity 10^4 newtons per coulomb and directed up in the plane of the page as shown below.



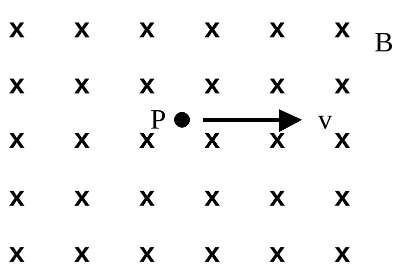
b. In the same electric field as in part (a), the proton at point P has velocity $v = 10^5$ meters per second directed to the right as shown below.

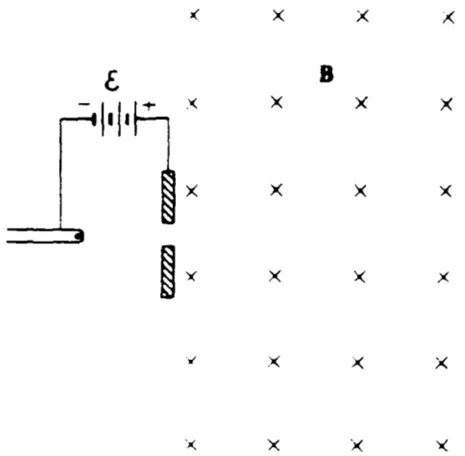


c. The proton is released from rest at point P in a magnetic field B having intensity 10^{-1} tesla and directed into the page as shown below.



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.





1984B4. 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.

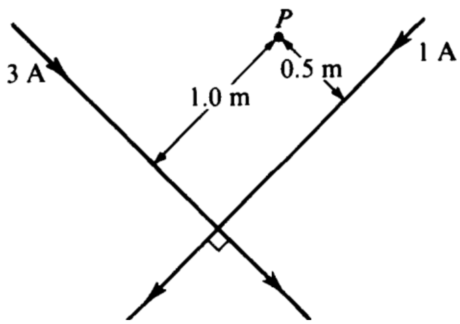
b. On the diagram above, sketch the path of the electron in the magnetic field.

e. 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.



1988B4. 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?

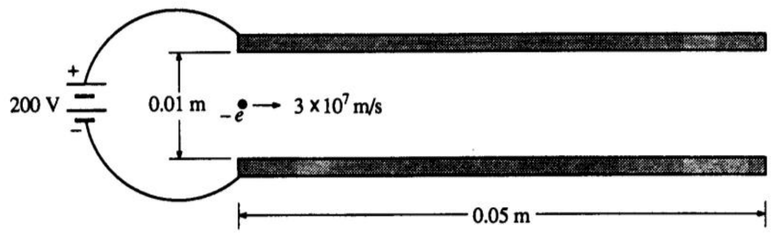
b. Determine the magnitude of the net magnetic field at P due to the currents.

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.



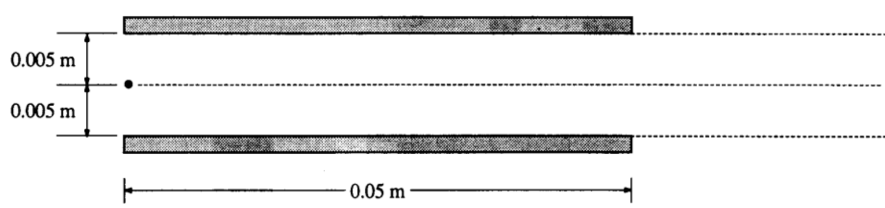
1990B2. A pair of square parallel conducting plates, having sides of length 0.05 meter, are 0.01 meter apart and are connected to a 200-volt power supply, as shown above. An electron is moving horizontally with a speed of 3×10^7 meters per second when it enters the region between the plates. Neglect 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.

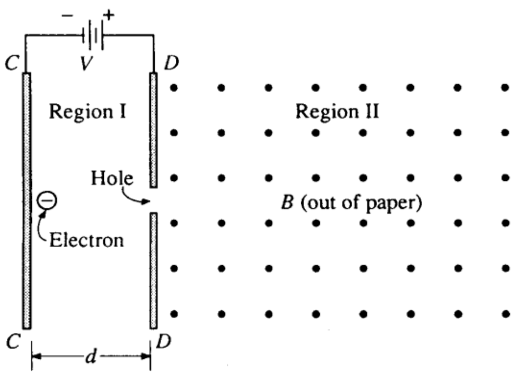
b. Determine the magnitude and direction of the acceleration of the electron in the region between the plates.

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.



1991B2. 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.

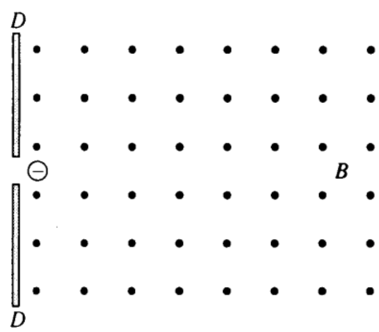
i. The speed v_0 of the electron as it emerges from the hole in plate D

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

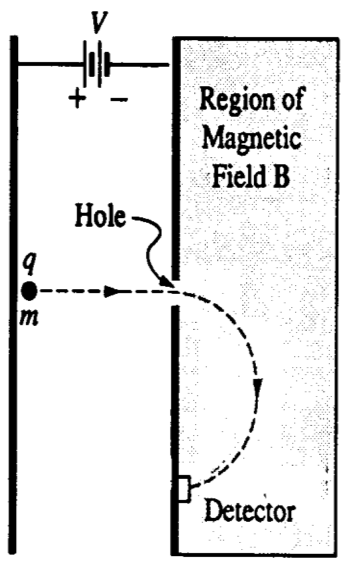
b. On the diagram below do the following.

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.



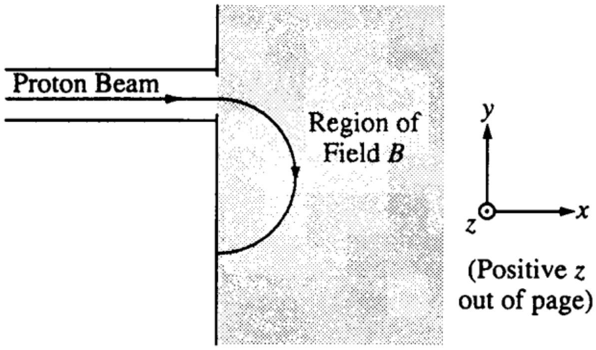
c. In terms of e, B. V, and m, determine the magnitude of the acceleration of the electron in region II.



1993B3. 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



1994B4. In a linear accelerator, protons are accelerated from rest through a potential difference to a speed of approximately 3.1 x 10^6 meters per second. The resulting proton beam produces a current of
2 x 10^{-6}ampere.

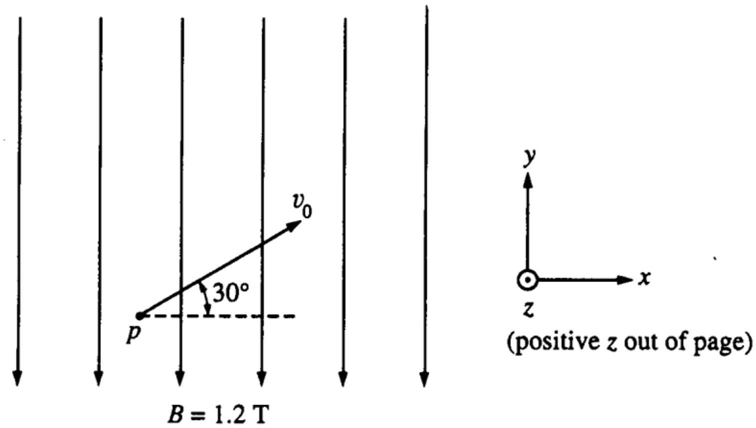
a. Determine the potential difference through which the protons were accelerated.

b. If the beam is stopped in a target, determine the amount of thermal energy that is produced in the target in one minute.

The proton beam enters a region of uniform magnetic field B, as shown above, that causes the beam to follow a semicircular path.

c. Determine the magnitude of the field that is required to cause an arc of radius 0.10 meter.

d. What is the direction of the magnetic field relative to the axes shown above on the right?



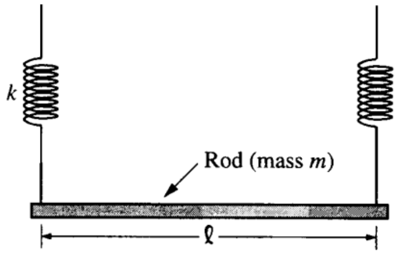
1995B7. (10 points) A uniform magnetic field of magnitude B = 1.2 teslas is directed toward the bottom of the page in the -y direction, as shown above At time t = 0, a proton p in the field is moving in the plane of the page with a speed $v_0 = 4 \times 10^7$ meters per second in a direction 30° above the +x axis.

a. Calculate the magnetic force on the proton at t = 0.

b. With reference to the coordinate system shown above on the right, state the direction of the force on the proton at t = 0.

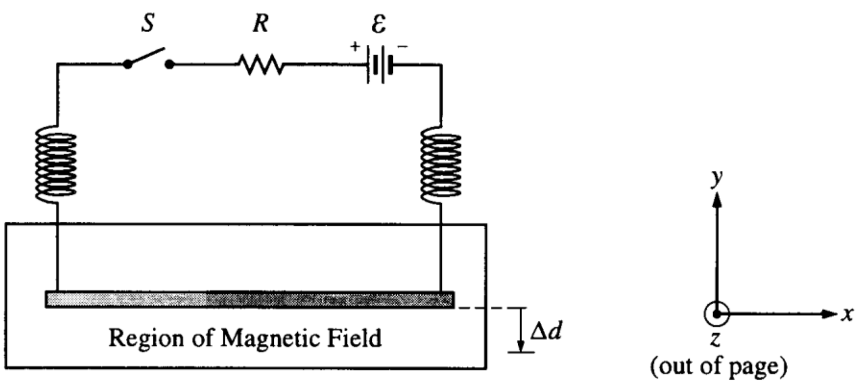
c. How much work will the magnetic field do on the proton during the interval from t = 0 to t = 0.5 second?

d. Describe (but do not calculate) the path of the proton in the field.



1997B3. A rigid rod of mass m and length *l* is suspended from two identical springs of negligible mass as shown in the diagram above. The upper ends of the springs are fixed in place and the springs stretch a distance d under the weight of the suspended rod.

a. Determine the spring constant k of each spring in terms of the other given quantities and fundamental constants.



As shown above, the upper end of the springs are connected by a circuit branch containing a battery of emf ε and a switch S so that a complete circuit is formed with the metal rod and springs. The circuit has a total resistance R, represented by the resistor in the diagram. The rod is in a uniform magnetic field directed perpendicular to the page. The upper ends of the springs remain fixed in place and the switch S is closed. When the system comes to equilibrium, the rod is lowered an additional distance Δd.

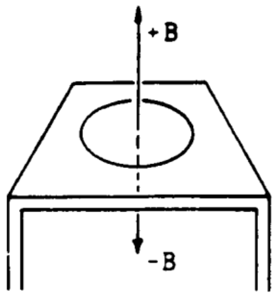
b. What is the direction of the magnetic field relative to the coordinate axes shown on the right in the previous diagram?

c. Determine the magnitude of the magnetic field in terms of m, Q, d, Δd, ε, R, and fundamental constants.

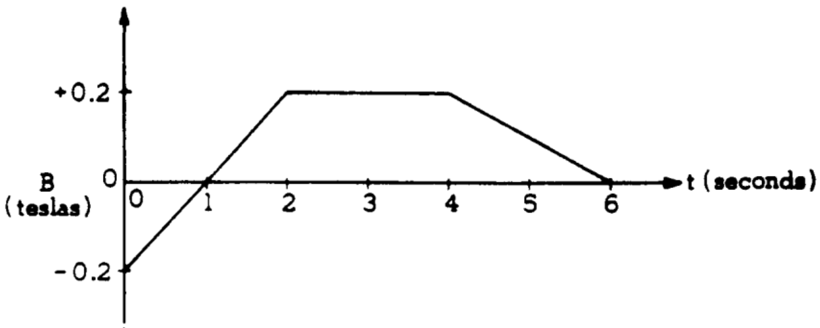
d. When the switch is suddenly opened, the rod oscillates. For these oscillations, determine the following quantities in terms of d, Δd, and fundamental constants:

i. The period

ii. The maximum speed of the rod



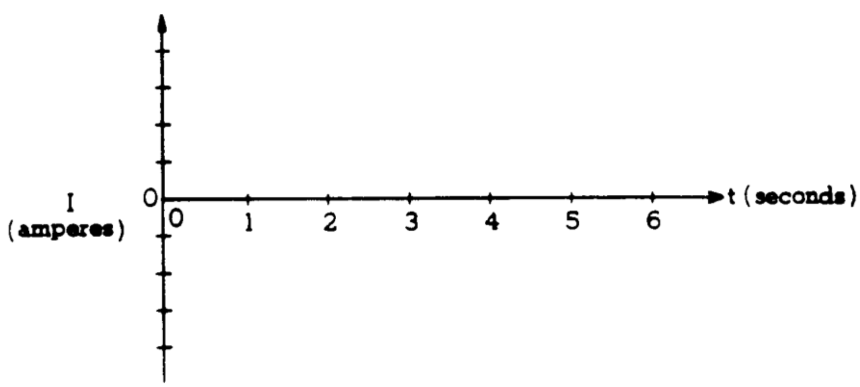
1982B5. A circular loop of wire of resistance 0.2 ohm encloses an area 0.3 square meter and lies flat on a wooden table as shown above. A magnetic field that varies with time t as shown below is perpendicular to the table. A positive value of B represents a field directed up from the surface of the table; a negative value represents a field directed into the tabletop.

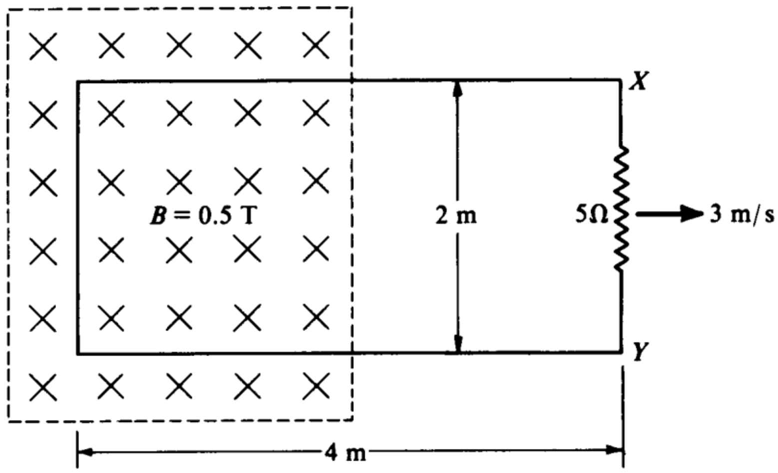


a. Calculate the value of the magnetic flux through the loop at time t = 3 seconds.

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.





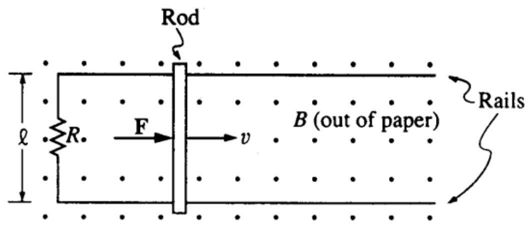
1986B4. A wire loop, 2 meters by 4 meters, of negligible resistance is in the plane of the page with its left end in a uniform 0.5-tesla magnetic field directed into the page, as shown above. A 5-ohm resistor is connected between points X and Y. The field is zero outside the region enclosed by the dashed lines. The loop is being pulled to the right with a constant velocity of 3 meters per second. Make all determinations for the time that the left end of the loop is still in the field, and points X and Y are not in the field.

a. Determine the potential difference induced between points X and Y.

b. On the figure above show the direction of the current induced in the resistor.

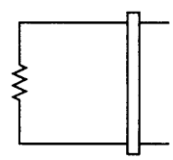
c. Determine the force required to keep the loop moving at 3 meters per second.

d. Determine the rate at which work must be done to keep the loop moving at 3 meters per second.



1994B6. A force F is applied to a conducting rod so that the rod slides with constant speed v over a frictionless pair of parallel conducting rails that are separated by a distance *l*. The rod and rails have negligible resistance, but the rails are connected by a resistance R, as shown above. There is a uniform magnetic field B perpendicular to and directed out of the plane of the paper.

a. On the following diagram, indicate the direction of the induced current in the resistor.



Determine expressions for the following in terms of v, B, *l*, and R.

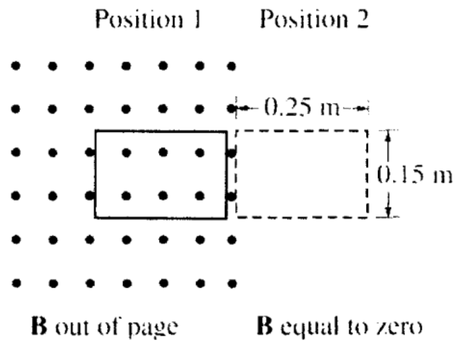
b. The induced emf in the rod

c. The electric field in the rod

d. The magnitude of the induced current in the resistor R

e. The power dissipated in the resistor as the rod moves in the magnetic field

f. The magnitude of the external force F applied to the rod to keep it moving with constant speed v



B2004B4. (15 points) A 20-turn wire coil in the shape of a rectangle, 0.25 m by 0.15 m, has a resistance of 5.0 Ω. In position 1 shown above, the loop is in a uniform magnetic field **B** of 0.20 T. The field is directed out of the page, perpendicular to the plane of the loop. The loop is pulled to the right at a constant velocity, reaching position 2 in 0.50 s. where **B** is equal to zero.

a. Calculate the average emf induced in the 20-turn coil during this period.

b. Calculate the magnitude of the current induced in the 20-turn coil and state its direction.

c. Calculate the power dissipated in the 20-turn coil.

d. Calculate the magnitude of the average force necessary to remove the 20-turn coil from the magnetic field.

e. Identical wire is used to add 20 more turns of wire to the original coil. How does this affect the current in the coil? Justify your answer.