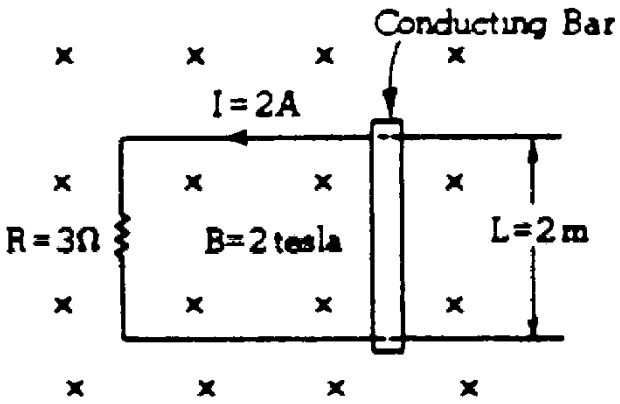
ELECTROMAGNETISM

1978 Q4



4. Two parallel conducting rails, separated by a distance L of 2 meters, are connected through a resistance R of 3 ohms as shown above. A uniform magnetic field with a magnitude B of 2 teslas points into the page. A conducting bar with mass m of 4 kilograms can slide without friction across the rails.

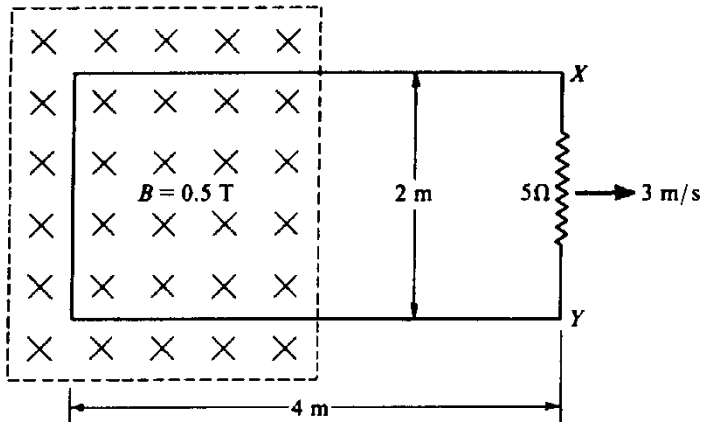
   (a) Determine at what speed the bar must be moved, and in what direction to induce a counterclockwise current I of 2 amperes as shown.

(b) Determine the magnitude and direction of the external force that must be applied to the bar to keep it moving at this velocity.

(c) Determine the rate at which heat is being produced in the resistor and determine the mechanical power being supplied to the bar.

(d) Suppose the external force is suddenly removed from the bar. Determine the energy in joules dissipated in the resistor before the bar comes to rest.

1986 Q4



4. 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.

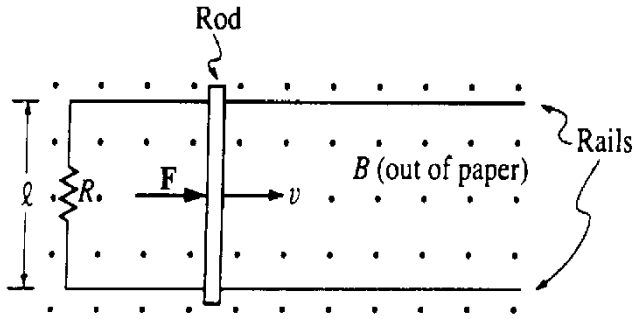
(a) Determine the potential difference induced between points *X* and *Y*.

(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.

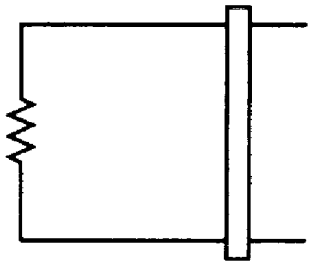
(d) Determine the rate at which work must he done to keep the loop moving at 3 meters per second.

1994 Q6



6. 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

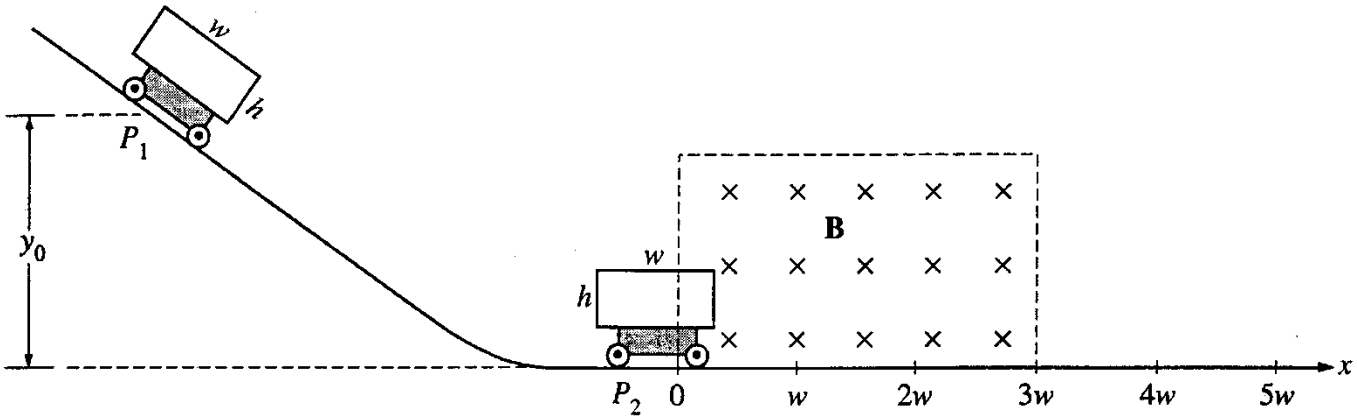
(c) The electric field in the rod

(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*

1999 Q3 (15 points)



A rectangular conducting loop of width w, height *h*, and resistance *R* is mounted vertically on a non-conducting cart as shown above. The cart is placed on the inclined portion of a track and released from rest at position P_1 at a height y_0 above the horizontal portion of the track. It rolls with negligible friction down the incline and through a uniform magnetic field **B** in the region above the horizontal portion of the track. The conducting loop is in the plane of the page, and the magnetic field is directed into the page. The loop passes completely through the field with a negligible change in speed. Express your answers in terms of the given quantities and fundamental constants.

(a) Determine the speed of the cart when it reaches the horizontal portion of the track.

(b) Determine the following for the time at which the cart is at position P_2, with one third of the loop in the magnetic field.

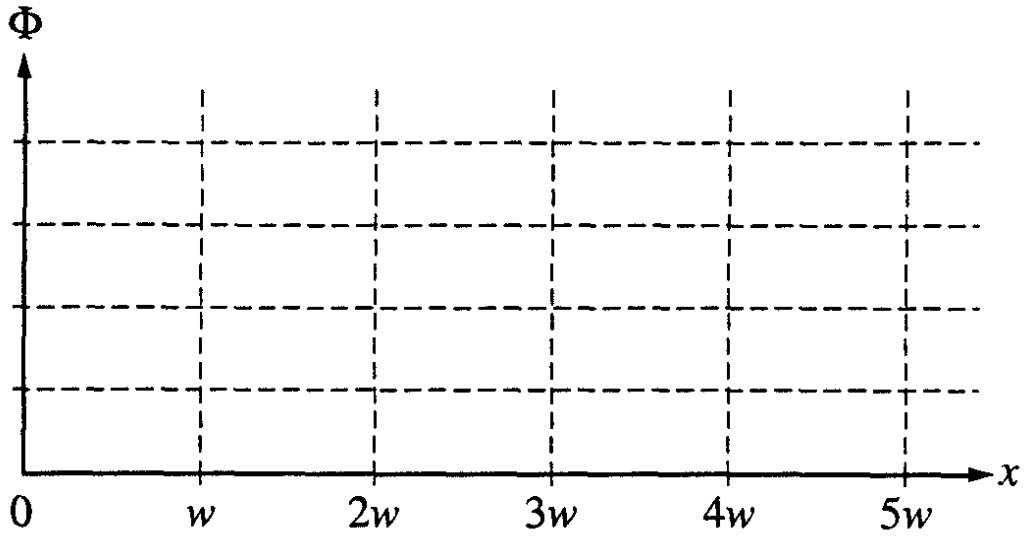
i. The magnitude of the emf induced in the conducting loop

ii. The magnitude of the current induced in the conducting loop

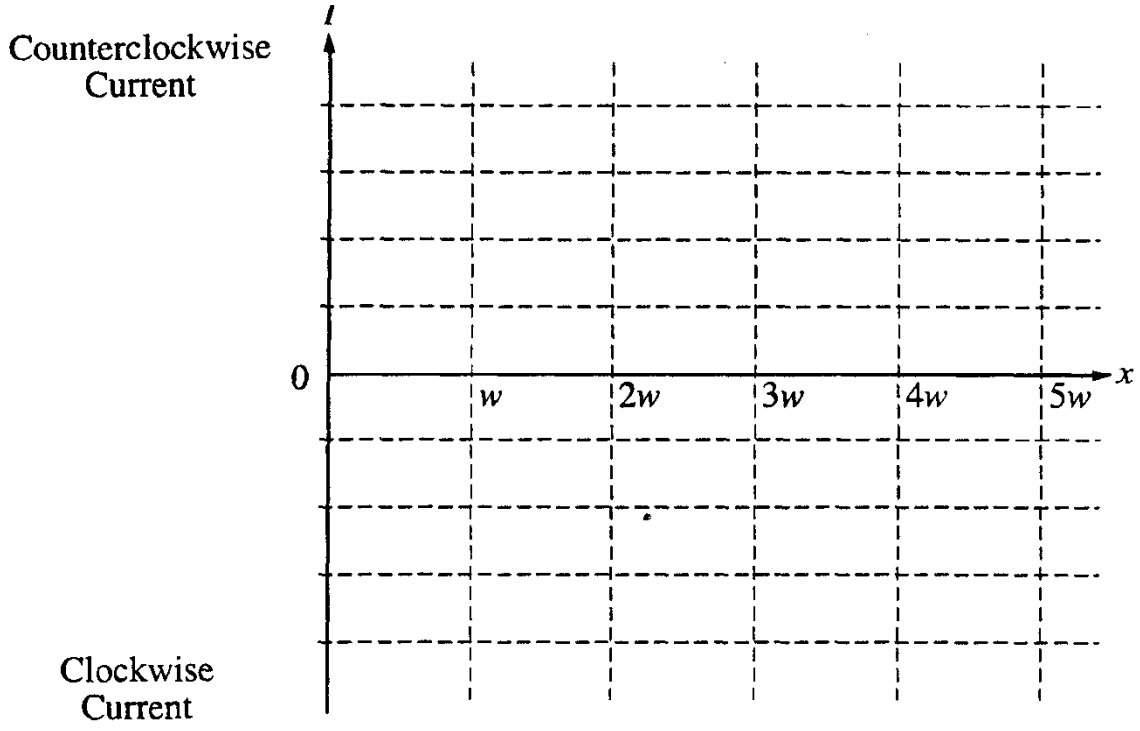
(c) On the following diagram of the conducting loop, indicate the direction of the current when it is at position P_2.

(d)

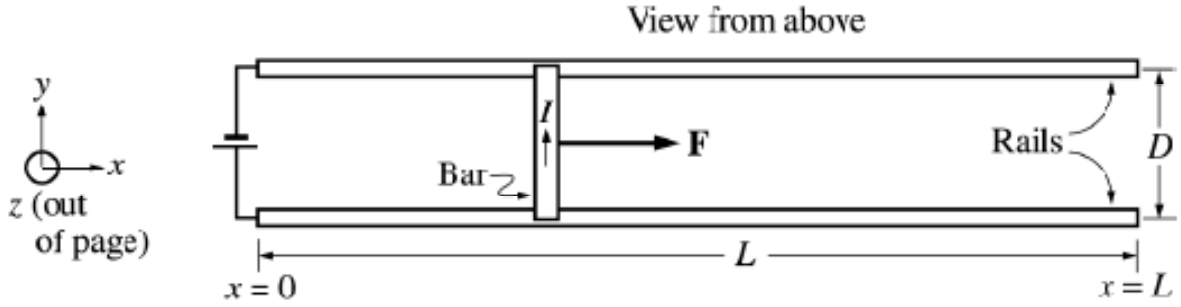
i. Using the axes below, sketch a graph of the magnitude of the magnetic flux Φ through the loop as a function of the horizontal distance x traveled by the cart, letting x = 0 be the position at which the front edge of the loop just enters the field. Label appropriate values on the vertical axis.



ii. Using the axes below, sketch a graph of the current induced in the loop as a function of the horizontal distance x traveled by the cart, letting x = 0 be the position at which the front edge of the loop just enters the field. Let counterclockwise current be positive and label appropriate values on the vertical axis.



2003 Q3 (15 points)



A rail gun is a device that propels a projectile using a magnetic force. A simplified diagram of this device is shown above. The projectile in the picture is a bar of mass *M* and length *D,* which has a constant current *I* flowing through it in the +y-direction, as shown. The space between the thin frictionless rails contains a uniform magnetic field **B**, perpendicular to the plane of the page. The magnetic field and rails extend for a distance *L*. The magnetic field exerts a constant force **F** on the projectile, as shown.

Express all algebraic answers to the following parts in terms of the magnitude F of the constant magnetic force, other quantities given above, and fundamental constants.

(a) Determine the position *x* of the projectile as a function of time *t* while it is on the rail if the projectile starts from rest at $x = 0$ when $t = 0$.

(b) Determine the speed of the projectile as it leaves the right-hand end of the track.

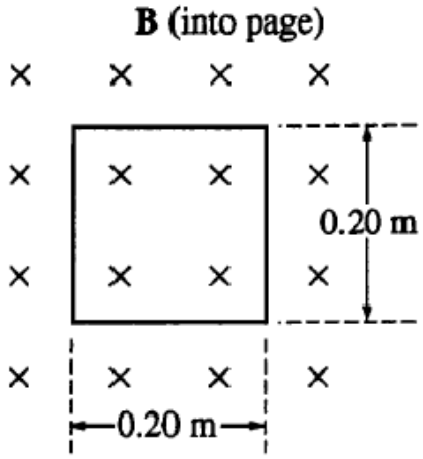
(c) Determine the energy supplied to the projectile by the rail gun.

(d) In what direction must the magnetic field **B** point in order to create the force **F**? Explain your reasoning.

(e) Calculate the speed of the bar when it reaches the end of the rail given the following values.

B=5 T L= 10 m I=200 A M=0.5kg D=10 cm

2004 Q3 (15 points)



A square loop of wire of side 0.20 m has a total resistance of 0.60 Ω. The loop is positioned in a uniform magnetic field **B** of 0.030 **T**. The field is directed into the page, perpendicular to the plane of the loop, as shown above.

(a) Calculate the magnetic flux Φ through the loop.

The field strength now increases uniformly to 0.20 T in 0.50 s.

(b) Calculate the emf $\mathcal{E}$ induced in the loop during this period.

(c)

i. Calculate the magnitude *I* of the current in the loop during this period.

ii. What is the direction of the current in the loop?

_____Clockwise _____Counterclockwise

Justify your answer.

(d) Describe a method by which you could induce a current in the loop if the magnetic field remained constant.