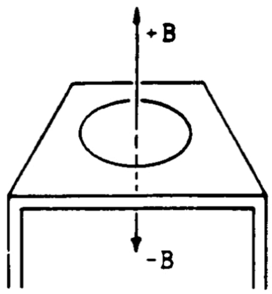
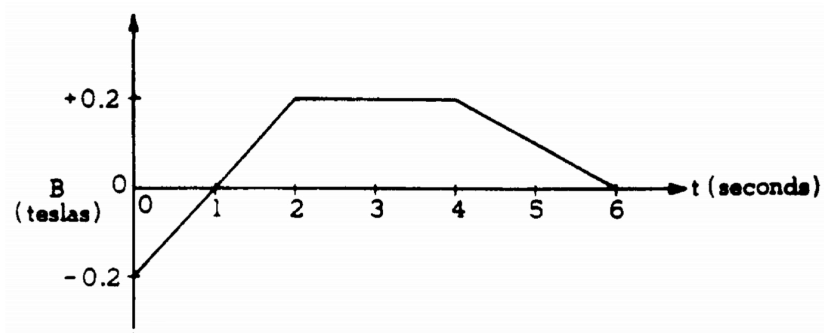
A circular loop of wire of resistance 0.2 Ω encloses an area 0.3 square meter and lies flat on a wooden table as shown below. A magnetic field that varies with time t as shown below is perpendicular to the table. A positive value of *B* represents a field directed up from the surface of the table; a 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) Graph the current *I* through the coil as a function of time *t*. Use the convention that positive values of *I* represent counterclockwise current as viewed from above.

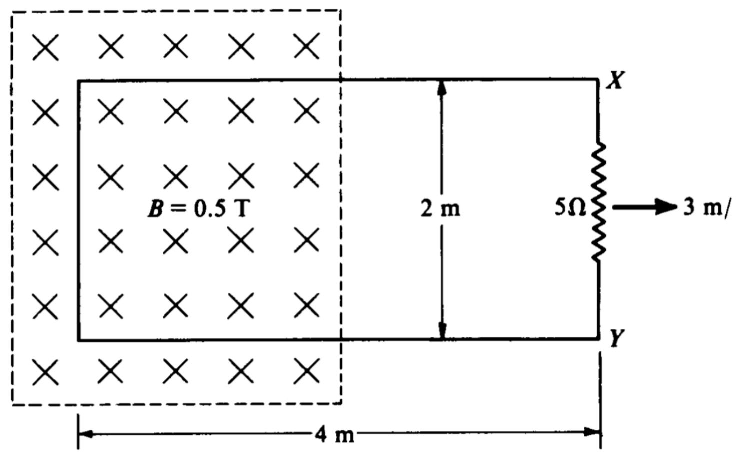
A wire loop, 2 meters by 4 meters, of negligible resistance is in the plane of the page with its left end in a uniform 0.5-tesla magnetic field directed into the page, as shown below. A 5-ohm resistor is connected between points *X* and *Y*. The field is zero outside the region enclosed by the dashed 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*.

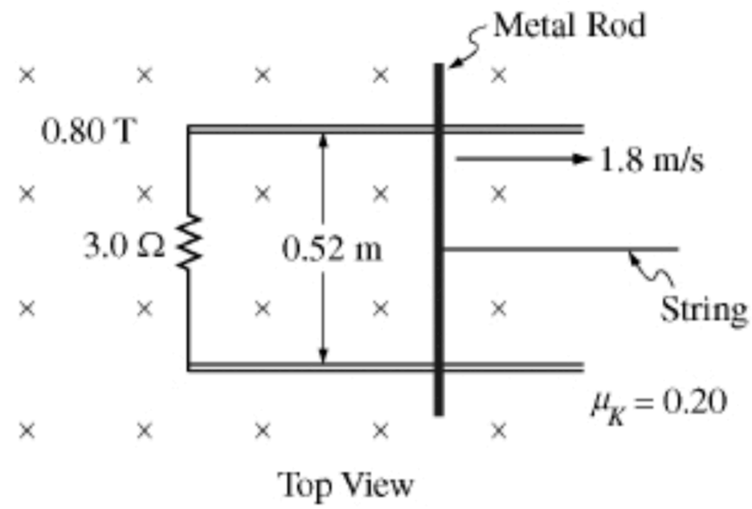
b) Determine the direction of the current induced in the resistor.

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.



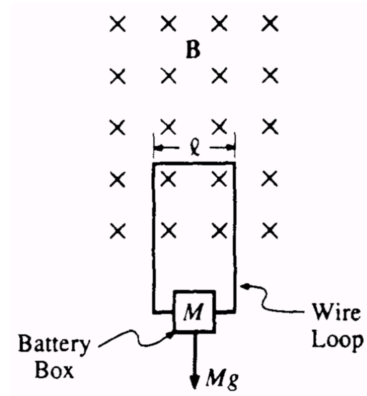
A metal rod of mass 0.22 kg lies across two parallel conducting rails that are a distance of 0.52 m apart on a tabletop, as shown in the top view. A 3.0 Ω resistor is connected across the left ends of the rails. The rod and rails have negligible resistance but significant friction with a coefficient of kinetic friction of 0.20.



There is a magnetic field of 0.80 T perpendicular to the plane of the tabletop. A string pulls the metal rod to the right with a constant speed of 1.8 m/s.

a) Calculate the magnitude of the current induced in the loop formed by the rod, the rails, and the resistor, and state its direction.
b) Calculate the magnitude of the force required to pull the rod to the right with constant speed.
c) Calculate the energy dissipated in the resistor in 2.0 s.
d) Calculate the work done by the string pulling the rod in 2.0 s.
e) Compare your answers to parts c) and d). Provide a physical explanation for why they are equal or unequal.

A uniform magnetic field of magnitude B is directed into the page in a rectangular region of space, as shown. A light, rigid wire loop, with one side of width ℓ, has current I. The loop is supported by the magnetic field and hangs vertically, as shown. The wire has resistance R and supports a box that holds a battery to which the wire loop is connected. The total mass of the box and its contents is M.



a) What is the direction of the current in the loop?

The loop remains at rest. In terms of any or all of the quantities B, ℓ, M, R, and appropriate constants, determine expressions for

b) the current I in the loop;

c) the emf of the battery, assuming it has negligible internal resistance.

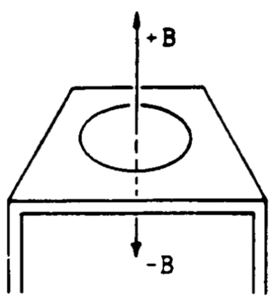
An amount of mass Δm is removed from the box and the loop then moves upward, reaching a terminal speed v in a very short time, before the box reaches the field region. In terms of v and any or all of the original variables, determine expressions for

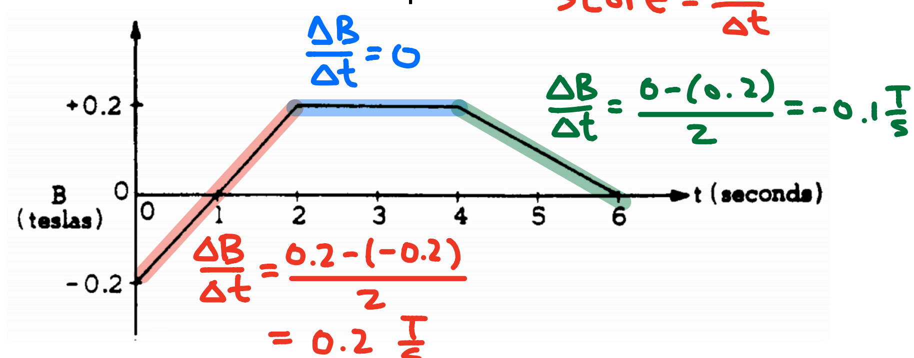
d) the magnitude of the induced emf;

e) the current I' in the loop under these new conditions

f) the amount of mass Δm removed.

A circular loop of wire of resistance 0.2 Ω encloses an area 0.3 square meter and lies flat on a wooden table as shown below. 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.
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c) Graph the current *I* through the coil as a function of time *t*. Use the convention that positive values of *I* represent counterclockwise current as viewed from above.

a) $\Phi = BA = (0.2)(0.3) = \boxed{0.06\ \text{Wb}}$

b) $\mathcal{E} = N\frac{\Delta\Phi}{\Delta t} = \frac{\Delta B}{\Delta t}A = (0.2)(0.3) = \boxed{0.06\ \text{V}}$

c) 0-2 s

$I = \frac{V}{R} = \frac{0.06}{0.2} = 0.3\ \text{A}$ CLOCKWISE

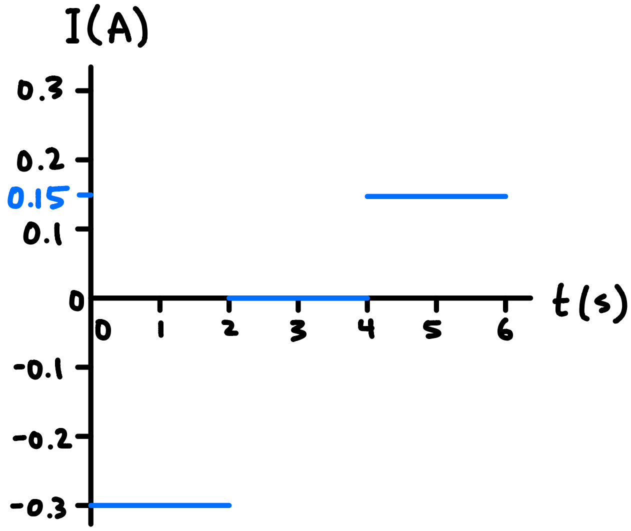
2-4 s

$\mathcal{E} = N\frac{\Delta\Phi}{\Delta t} = \frac{\Delta B}{\Delta t}A = 0 \rightarrow I = 0$

4-6 s

$\mathcal{E} = N\frac{\Delta\Phi}{\Delta t} = \frac{\Delta B}{\Delta t}A = (0.1)(0.3) = 0.03\ \text{V}$

$I = \frac{V}{R} = \frac{0.03}{0.2} = 0.15\ \text{A}$ COUNTERCLOCKWISE


I(A)
0.3
0.2
0.15
0.1
0
-0.1
-0.2
-0.3
0
1
2
3
4
5
6
t(s)

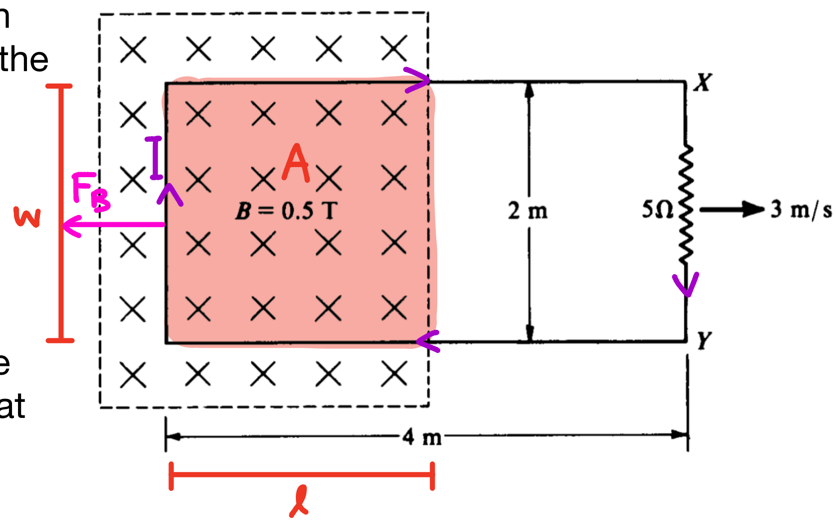
A wire loop, 2 meters by 4 meters, of negligible resistance is in the plane of the page with its left end in a uniform 0.5-tesla magnetic field directed into the page, as shown below. A 5-ohm resistor is connected between points *X* and *Y*. The field is zero outside the region enclosed by the dashed 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) Determine 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.



a) $\varepsilon = N\frac{\Delta\Phi}{\Delta t}$

$= B\frac{\Delta A}{\Delta t}$

$= Bw\frac{\Delta \ell}{\Delta t}$

$= Bwv$

$= (0.5)(2)(3)$

$= \boxed{3\text{ V}}$

b) $\boxed{\text{DOWN}}$

c) $F_{NET} = 0$

$F_A = F_B = \overset{w}{\overset{\parallel}{\ell}} I B$ $\qquad I = \frac{V}{R}$

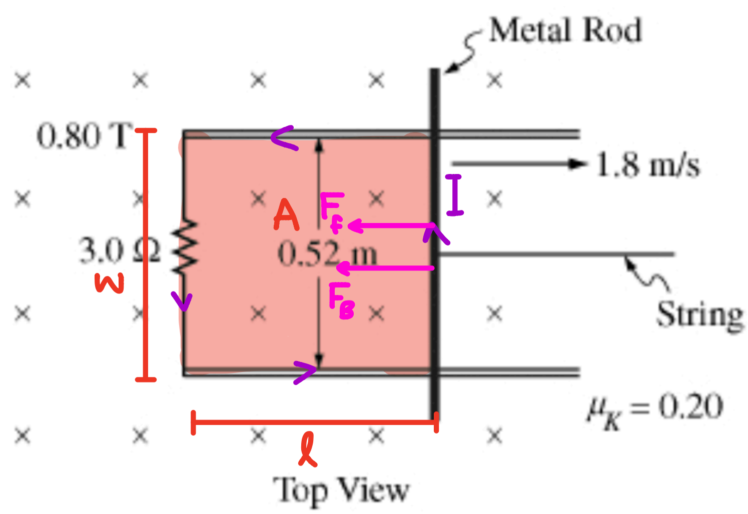
$= w\frac{V}{R}B$

$= (2)\frac{3}{5}(0.5)$

$= \boxed{0.6\text{ N}}$

d) $P = \frac{W}{t} = \frac{Fd}{t} = Fv = (0.6)(3) = \boxed{1.8\text{ W}}$

A metal rod of mass 0.22 kg lies across two parallel conducting rails that are a distance of 0.52 m apart on a tabletop, as shown in the top view. A 3.0 Ω resistor is connected across the left ends of the rails. The rod and rails have negligible resistance but significant friction with a coefficient of kinetic friction of 0.20.



There is a magnetic field of 0.80 T perpendicular to the plane of the tabletop. A string pulls the metal rod to the right with a constant speed of 1.8 m/s.

a) Calculate the magnitude of the current induced in the loop formed by the rod, the rails, and the resistor, and state its direction.
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c) Calculate the energy dissipated in the resistor in 2.0 s.
d) Calculate the work done by the string pulling the rod in 2.0 s.
e) Compare your answers to parts c) and d). Provide a physical explanation for why they are equal or unequal.

a)
$$\varepsilon = N\frac{\Delta\Phi}{\Delta t}$$
$$= B\frac{\Delta A}{\Delta t}$$
$$= Bw\frac{\Delta \ell}{\Delta t}$$
$$= Bwv$$
$$= (0.80)(0.52)(1.8)$$
$$= 0.749 \text{ V}$$

$$I = \frac{V}{R}$$
$$= \frac{0.749}{3.0}$$
$$= \boxed{0.250 \text{ A}}$$

$\boxed{\text{COUNTERCLOCKWISE}}$

b) $F_{NET} = 0$

$$F_A = F_B + F_f$$

$$= \ell IB + \mu F_N \quad (\ell = w)$$

$$= wIB + \mu mg$$

$$= (0.52)(0.250)(0.80) + (0.20)(0.22)(9.8)$$

$$= \boxed{0.535\ N}$$

c) $W = Pt = I^2Rt = (0.250)^2(3.0)(2.0) = \boxed{0.374\ J}$

d) $W = Fd = Fvt = (0.535)(1.8)(2.0) = \boxed{1.93\ J}$

e) THE WORK DONE BY THE STRING IS GREATER AS IT HAS TO PROVIDE THE ENERGY TO THE RESISTOR AND ALSO WORK AGAINST FRICTION.

$$W_{FRICTION} = F_f d$$

$$= \mu F_N d$$

$$= \mu mgvt$$

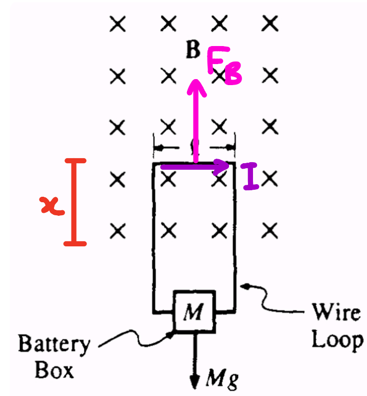
$$= (0.20)(0.22)(9.8)(1.8)(2.0)$$

$$= 1.55\ J$$

$$W_{RESISTOR} + W_{FRICTION} = 0.374 + 1.55 = 1.93\ J$$

A uniform magnetic field of magnitude B is directed into the page in a rectangular region of space, as shown. A light, rigid wire loop, with one side of width ℓ, has current I. The loop is supported by the magnetic field and hangs vertically, as shown. The wire has resistance R and supports a box that holds a battery to which the wire loop is connected. The total mass of the box and its contents is M.

a) What is the direction of the current in the loop?



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An amount of mass Δm is removed from the box and the loop then moves upward, reaching a terminal speed v in a very short time, before the box reaches the field region. In terms of v and any or all of the original variables, determine expressions for

d) the magnitude of the induced emf;

e) the current I' in the loop under these new conditions

f) the amount of mass Δm removed.

a) $\boxed{\text{CLOCKWISE}}$

b) $F_{NET} = 0$

$F_B = F_g$

$\ell I B = Mg$

$$\boxed{I = \frac{Mg}{\ell B}}$$

c) $V = IR$

$$\boxed{\varepsilon = \frac{MgR}{\ell B}}$$

d) $\varepsilon = N\dfrac{\Delta\Phi}{\Delta t}$

$= B\dfrac{\Delta A}{\Delta t}$

$= B\ell\dfrac{\Delta x}{\Delta t}$

$\boxed{\varepsilon = B\ell v}$

COUNTER EMF

e) $V_{EFFECTIVE} = V_{BATTERY} - V_{COUNTER}$

$= \dfrac{MgR}{\ell B} - B\ell v$

$I' = \dfrac{V_{EFFECTIVE}}{R}$

$\boxed{I' = \dfrac{Mg}{\ell B} - \dfrac{B\ell v}{R}}$

f)

$F_{NET} = 0$

$F_B = F_g$

$\ell I' B = (M - \Delta m)g$

$\ell\left(\dfrac{Mg}{\ell B} - \dfrac{B\ell v}{R}\right)B = (M - \Delta m)g$

$\cancel{Mg} - \dfrac{B^2\ell^2 v}{R} = \cancel{Mg} - \Delta m g$

$\Delta m g = \dfrac{B^2\ell^2 v}{R}$

$\boxed{\Delta m = \dfrac{B^2\ell^2 v}{Rg}}$