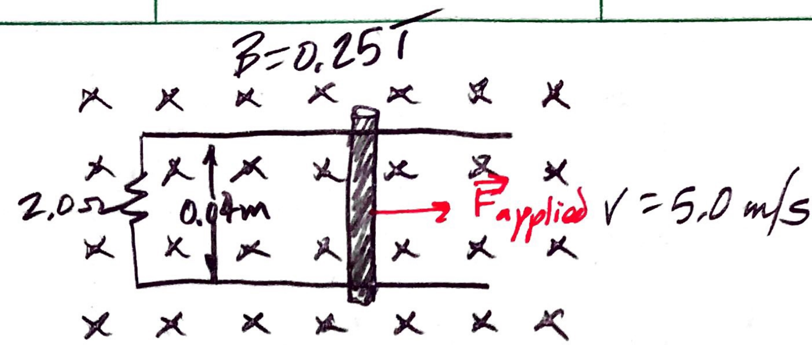
13.46



a) Find emf in circuit.

$$\mathcal{E} = B l v = (0.25\,T)(0.04\,m)(5\,m/s) = \boxed{0.050\,V}$$

b) Induced current $I = \frac{\mathcal{E}}{R} = \frac{0.050}{2\,\Omega} = \boxed{0.025\,A}$

Current circles the circuit counterclockwise (result of Lenz's Law analysis on increasing flux.)

c) $\vec{F} = ?$

If bar is traveling at constant velocity, there must be F_B opposing Fapplied, & they are equal in magnitude.

$$F_{app} = F_B = I_{rod} l B$$
$$= (0.025A)(0.04m)(0.25T)$$
$$= \boxed{2.5e-4\,N}$$

d) Power output of Fapplied $= F \cdot v$

$$= (2.5e-4N)(5\,m/s)$$
$$= \boxed{1.25e-3\,W}$$

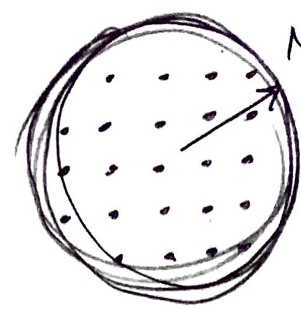
Power dissipated by resistor $= I^2 R$

$$= (0.025\,A)^2 (2)$$
$$= \boxed{0.00125\,W}$$

!

Same thing!

13.47



$N = 50$ turns

$r = 0.075\,m$

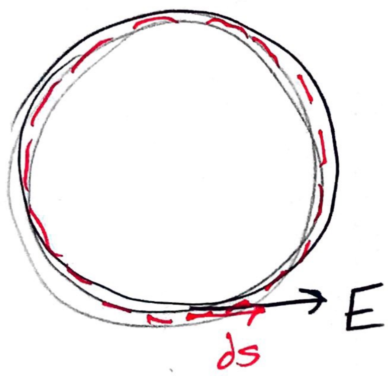
$B_{initial} = 0.50T$

$B_f = 0$ after $\Delta t = 0.10s$

Find induced electric field.

$$\oint E \cdot ds = -N \frac{d\Phi_B}{dt}$$

Important point. This "induced electric field" is different from the Electric field ~~___~~ present in static situations. The induced electric field is <u>non-conservative</u>: net Work is done by moving charges through the field in a circle. (That's different from the conservative electric force in a static situation.)



$$\oint E \cdot ds = -N \frac{d\Phi_B}{dt}$$

parallel, so

$$E \oint ds = -N \frac{dB}{dt} A$$

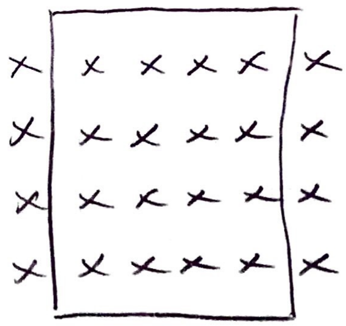
$$E(2\pi r) = -N \frac{dB}{dt} A$$

$$E = \frac{(-50)(0-0.50T)\,\cancel{\pi}(0.075)^{\cancel{2}}}{(2)(\cancel{\pi})(0.1s)\cancel{(0.075)}}$$

$$= \boxed{9.38\,V/m}$$

13.76

$m = 0.50\,kg$



$B = 1.5\,T$

$\downarrow v_{terminal} = 2.0\,m/s$

a) Net magnetic force on sheet at terminal velocity?

$\uparrow F_B$ $\quad \Sigma F = 0$ (at terminal velocity, $a = 0$)

$F_B + -F_g = 0$

$\downarrow F_g$ $\quad F_B = F_g = mg = (0.50\,kg)(9.8\,\tfrac{m}{s^2}) = \boxed{4.90\,N}$

b) The mechanism responsible for this force is eddy currents induced in the sheet of copper.

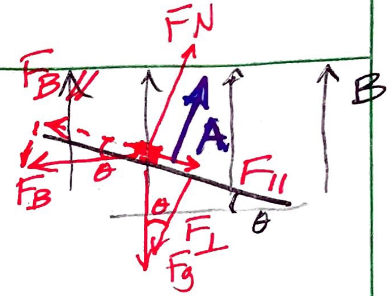
c) Power dissipated by this "Joule heating" is

$P = F \cdot v$

$= (4.90\,N)(2\,m/s) = \boxed{9.8\,W}$

13.83-

Side view



a) Show that
$$V_{terminal} = \frac{mgR\sin\theta}{B^2 l^2 \cos^2\theta}$$

$F_{\parallel} = mg\sin\theta$

$F_{B\parallel} = F_B\cos\theta$

1. $\mathcal{E} = -\frac{d\Phi_B}{dt}$, where $\Phi = \vec{B}\cdot\vec{A} = BA\cos\theta$

$\mathcal{E} = -\frac{d}{dt}B\,l\,x\cos\theta$ where $dA = l\,dx$ as bar slides down ramp

$IR = Blv\cos\theta$, where $\mathcal{E} = IR$ & $\frac{dx}{dt} = v$

$I = \frac{Blv}{R}\cos\theta$

2. Bar w/ current I experiences force $F = I\,l\times B$.
l & B are $\perp$, so $F_B = \left(\frac{Blv}{R}\cos\theta\right)lB$
$= \frac{B^2 l^2 v}{R}\cos\theta$

3. At $v_{terminal}$ $a = 0$, so $F_{B\parallel} = F_{g\parallel}$
$$\left(\frac{B^2l^2v}{R}\cos\theta\right)\cos\theta = mg\sin\theta$$
Solve for $v_T = \boxed{\frac{mgR\sin\theta}{B^2l^2\cos^2\theta}}$

b. Power $= \frac{\text{Work}}{\text{time}} = F\cdot v = \boxed{(mg\sin\theta)V_T}$