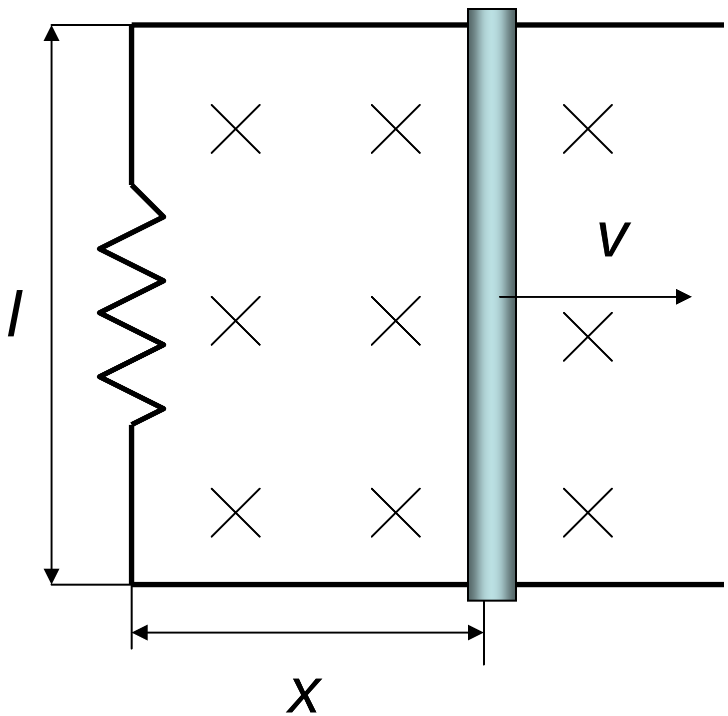
# Review for Quiz 8




**Problem similar to 43 Chapter 33**

A 20-cm-long, zero-resistance slide moves outward, on zero-resistance rails, at a steady speed of $v$=10 m/s in a 0.1 T magnetic field. On the opposite side, a 1.0 $\Omega$ carbon resistor completes the circuit by connecting the two rails. The mass of the resistor is 50 mg.

a) What is the induced $\varepsilon$?
b) What is the direction of the induced $I$?
c) What is the magnitude of $I$?
d) How much force is needed to pull the wire at this speed?
e) If the wire is pulled for 10s, what is the temperature increase of the carbon? The specific heat of carbon is 710 J/kgC$^0$.

Note Title 11/1/2005

Let us solve this problem using Faraday's and Lenz's Laws

a) Faraday's Law: $\mathcal{E} = \left| \frac{d\Phi_B}{dt} \right|$

$\Phi_B = A \cdot B = x \cdot l \cdot B$

$\mathcal{E} = \left| \frac{d\Phi_B}{dt} \right| = \left| \frac{d(x \cdot l \cdot B)}{dt} \right| = l \cdot B \cdot \left| \frac{dx}{dt} \right| = l \cdot B \cdot v =$

$= 0.2 \cdot 0.1 \cdot 10 = 0.2\ V$

b) To find the direction of the induced current let us apply Lenz's Law:

$x \uparrow \Rightarrow A = x \cdot l \uparrow \Rightarrow \Phi_B = x \cdot l \cdot B \uparrow$

Conclusion: <u>Flux increases</u>

Lenz's Law: The direction of the induced current is such that $\bar{B}_{induced}$ opposes the change in the flux.

Since the flux of $\bar{B}_{external}$ increases in the page the direction of $\bar{B}_{induced}$ is out of the page.

As a result using right hand rule we find that $I_{induced}$ is counterclockwise.

c) $I = \frac{\mathcal{E}}{R} = \frac{0.2\,V}{1\,\Omega} = 0.2\,A$

d) $\bar{F} = I \cdot \bar{L} \times \bar{B}$, since $\bar{L} \perp \bar{B} \Rightarrow$

$F = I \cdot l \cdot B = 0.2 \cdot 0.2 \cdot 0.1 = 4 \cdot 10^{-3}\,N$

e) Dissipated power:

$$P = I^2 \cdot R = (0.2)^2 \cdot 1 = 0.04\,W = 0.04\,\frac{J}{s}$$

During $\Delta t = 10\,s$ the energy dissipated by the current is:

$$Q = P \cdot \Delta t = 0.04 \cdot 10 = 0.4\,J$$

This energy is related to the temperature rise ($\Delta T$) by: $Q = m \cdot c \cdot \Delta T$,

where $c$ – specific heat of carbon

Thus $$\Delta T = \frac{Q}{m \cdot c} = \frac{0.4}{5 \cdot 10^{-5} \cdot 710} \approx 11\,^\circ C$$