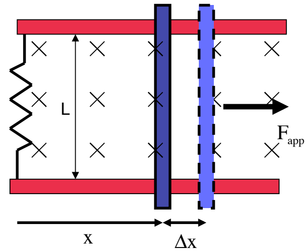
Problem 20.30

At what speed should the bar move to produce a current of .5 amps in the resistor if:

R = 6 Ω, L=1.2 m and

B = 2.5 Teslas into the page.



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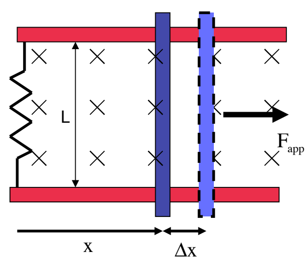


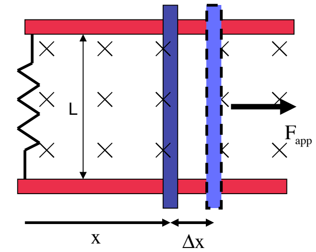
$$\begin{aligned}
\varepsilon_{induced} &= -N\frac{\Delta\phi_B}{\Delta t} \\
&= -(1)\, B \cos 0^{o} \frac{\Delta(A)}{\Delta t} \\
&= -\ B\ \frac{(A_{final} - A_{initial})}{\Delta t} \\
&= -\ B\ \frac{(L(x+\Delta x) - Lx)}{\Delta t} \\
&= -\ B\, L \frac{\Delta x}{\Delta t} \\
&= -\ B\, L\, v \\
&= -\ 3\ v
\end{aligned}$$

$$\begin{aligned}
\varepsilon_{induced} &= i\, R \\
\Rightarrow\ 3\ v &= (.5\ A)(6\ \Omega) \\
\Rightarrow\ v &= 1\ m/s
\end{aligned}$$

Additional questions:

a.) In what direction will the induced flow?

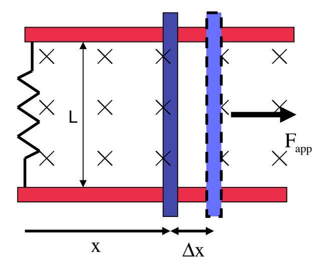
b.) If you want the bar to move with a constant velocity, how large a force would you have to apply to the bar to make that happen?



Additional questions:

a.) In what direction will the induced flow?

According to Lenz's Law: the external B field is into the page; the magnetic flux is increasing, so the induced B field must be out of the page; this will be produced by a current flowing counterclockwise.



b.) If you want the bar to move with a constant velocity, how large a force and in what direction would you have to apply to the bar to make that happen?

The induced current will interact with the external magnetic field as governed by:

$$\begin{aligned}
F &= i\, L \times B \\
&= (.5\ amps)(1.2\ m)(2.5\ tesla) \\
&= 1.5\ newtons
\end{aligned}$$

The cross product, the force on the strip due to the current in the B-field moving through the strip will be to the left, therefore you will have to pull to the right.