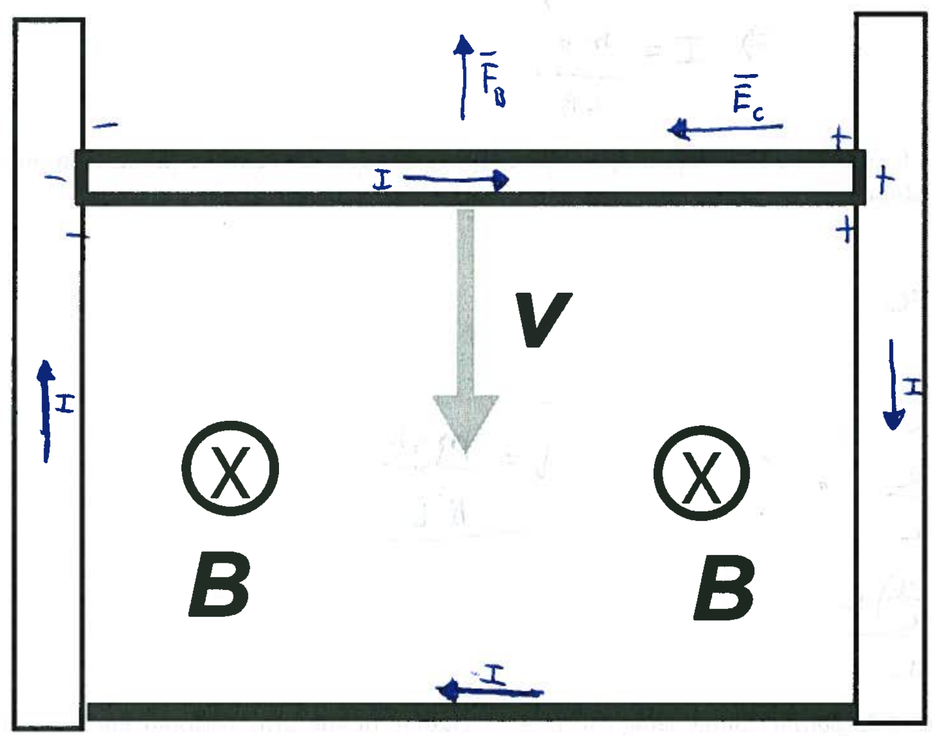
Physics 2212 Fall 2014 Lab Quiz #6

Name: Key Section: ____________

Show all work clearly and in order, and box your final answers.

A metal rod of length L and mass M slides with negligible friction but with good electrical contact down between two vertical metal posts. After speeding up initially, the bar falls at a constant speed (zero acceleration). The vertical metal posts and connecting wire at the bottom all have negligible electrical resistance. The rod has resistance R. Throughout the entire region there is a uniform magnetic field B directed into the page.



1. (*10 points*) On the diagram above, draw the charge separation on the two ends of the bar.

2. (*10 points*) On the diagram above, draw the direction of the coulomb electric electric field in the falling rod due to this charge separation. Label this arrow $\vec{E}_C$.

3. (*10 points*) On the diagram above, draw the direction of the conventional current around the loop made by the rod, post and connecting wire. Label this I.

4. (*10 points*) On the diagram above, draw The magnetic force on the falling bar. Label this $\vec{F}_B$.

5. (*30 points*) Calculate the magnitude of the current I in terms of the known quantities given in the problem statement.

Net force is zero $\Rightarrow \bar{F}_{net} = 0$

$\Rightarrow \bar{F}_B + \bar{F}_g = 0$

$\Rightarrow \bar{F}_B = -\bar{F}_g$

$\Rightarrow |\bar{F}_B| = |\bar{F}_g|$

$\Rightarrow ILB = mg$

$\Rightarrow I = \frac{mg}{LB}$

$$\boxed{I = \frac{mg}{LB}}$$

6. (*30 points*) Calculate the constant speed v of the falling rod in terms of the known quantities given in the problem statement.

$\Delta V = 0$

$\Rightarrow \mathcal{E}mf - IR = 0$

$\Rightarrow \mathcal{E}mf = IR$

$\Rightarrow BLv = IR$

$\Rightarrow v = \frac{IR}{BL}$

$\Rightarrow v = \frac{\left(\frac{mg}{BL}\right)R}{BL}$

$$\boxed{v = \frac{mgR}{B^2L^2}}$$

Extra Credit. (*20 points*) Show that the rate of change of the gravitational energy of the Universe is equal to the rate of energy dissipated in the resistor.

Gravitational energy (on Earth): mgy

Recall power is $P = \frac{dW}{dt}$

Power through a resistor $P_R = VI = BLvI$

$P_g = \frac{dW}{dt} = \frac{d}{dt}(mgy) = mg\frac{dy}{dt} = mgv$

$P_g = mgv$

$= (ILB)v$ $\qquad I = \frac{mg}{LB} \Rightarrow mg = ILB$

$= BLvI$

$= P_R$

$\therefore P_g = P_R$ as desired