Name_____

Physics 111 Quiz #4, February 11, 2022

Please show all work, thoughts and/or reasoning in order to receive partial credit. The quiz is worth 10 points total.

I affirm that I have carried out my academic endeavors with full academic honesty.

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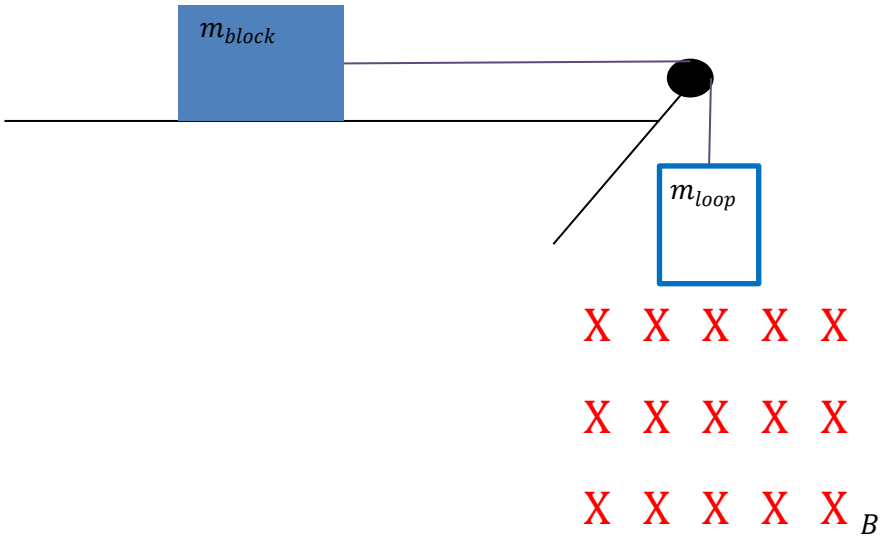
A square metal loop of mass $m_{loop} = 25mg$, resistance $R = 0.1\Omega$, and sides of length $L = 10cm$ is connected by a massless rope around a massless pulley to a block of mass $m_{block} = 20mg$. The square metal loop is released from rest and falls through a magnetic field of magnitude $B = 50mT$ pointing into the page. Friction exists between the block and the horizontal surface it is on with coefficient of friction $\mu = 0.87$. Assume that the square loop reaches terminal speed as soon as it enters the magnetic field.



1. What is the magnitude of the tension force in the rope?

Assuming a standard cartesian coordinate system, we have:

From the forces on the mass in the vertical direction:

$F_N - F_W = ma_y = 0 \rightarrow F_N = F_{W_{block}} = m_{block}g$

From the forces on the block in the horizontal direction:

$F_T - F_{fr} = ma = 0 \rightarrow F_T = F_{Fr} = \mu F_N = \mu m_{block}g$

$F_T = \mu m_{block}g = 0.87 \times \left(20mg \times \frac{1g}{1000mg} \times \frac{1kg}{1000g}\right) \times 9.8\frac{m}{s^2} = 1.7 \times 10^{-4}N$

2. What is the magnitude and direction of the current induced in the wire loop?

   The magnetic flux is increasing into the loop of wire so a current is induced in the wire. The current flows CCW to generate a magnetic field to undo the change in magnetic flux.

   From the forces that act on the wire loop, assuming it has reached its termina speed:

   $$F_T + F_B - F_{W_{loop}} = m_{loop}a_y = 0 \rightarrow F_B = F_{W_{loop}} - F_T = m_{loop}g - \mu m_{block}g$$

   $$F_B = ILB \rightarrow I = \frac{F_B}{LB} = \frac{m_{loop}g - \mu m_{block}g}{LB} = \frac{\left(25g \times \frac{1g}{1000mg} \times \frac{1kg}{1000g}\right) \times 9.8\frac{m}{s^2} - 1.7 \times 10^{-4}N}{0.1m \times 50 \times 10^{-3}T} = 0.015A$$

3. What is the magnitude of the potential difference induced across the wire loop?

   $$\varepsilon = IR = 0.015A \times 0.1\Omega = 0.0015V$$

4. What is the terminal speed of the wire loop?

   $$\varepsilon = BLv \rightarrow v = \frac{\varepsilon}{BL} = \frac{0.0015V}{0.1m \times 50 \times 10^{-3}T} = 0.3\frac{m}{s}$$

5. What is the power dissipated as heat across the wire loop?

   $$P = I^2R = (0.015A)^2 \times 0.1\Omega = 2.25 \times 10^{-5}W$$