Name $\qquad$
Physics 111 Quiz \#5, October 22, 2021
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.

1. Suppose that a rectangular loop of wire of length $L=10 \mathrm{~cm}$, width $W=4 \mathrm{~cm}$, and resistance $R=$ $0.3 \Omega$, is mounted to a block of wood of mass $m=500 \mathrm{~g}$. The system is released from rest at a height $h=50 \mathrm{~cm}$ above the ground and slides down the ramp towards the ground. On the ground, the horizontal portion of the track, there is a region of uniform magnetic field with magnitude $B=5 T$. Assuming all surfaces are frictionless, what is the speed of the block at the bottom of the ramp? If you cannot determine a value, use $v=3 \frac{\mathrm{~m}}{\mathrm{~s}}$.


By using energy

$$
\begin{aligned}
& \Delta E=\Delta K+\Delta U_{g}=\left(\frac{1}{2} m v_{f}^{2}-\frac{1}{2} m v_{i}^{2}\right)+\left(m g y_{f}-m g y_{i}\right)=0 \\
& 0=\frac{1}{2} m v_{f}^{2}-m g h \rightarrow v_{f}=\sqrt{2 g h}=\sqrt{2 \times 9.8 \frac{\mathrm{~m}}{s^{2}} \times 0.5 m}=3.1 \frac{\mathrm{~m}}{\mathrm{~s}}
\end{aligned}
$$

By using forces

$$
\begin{aligned}
& F_{W x}=m a \rightarrow m g \sin \theta=m a \rightarrow a=g \sin \theta \\
& v_{f x}^{2}=v_{i x}^{2}+2 a_{x} \Delta x=2 g \sin \theta \Delta x=2 g h \rightarrow v_{f}=\sqrt{2 g h}=\sqrt{2 \times 9.8 \frac{\mathrm{~m}}{s^{2}} \times 0.5 \mathrm{~m}}=3.1 \frac{\mathrm{~m}}{\mathrm{~s}}
\end{aligned}
$$

2. What is the direction of the current induced in the wire loop as soon as the loop enters the magnetic field? Be sure to explain your answer fully.

When the loop of wire enters the magnetic field, the magnetic flux through the loop of wire increases. To undo this increase in magnetic flux, a current will be generated in the wire loop to produce a magnetic field that points out of the page. To produce this magnetic field, the current must flow counterclockwise.
3. When the loop is one-half of the way into the magnetic field, what is the magnitude of the induced current in the wire loop?

$$
I=\frac{\varepsilon}{R}=\frac{1}{R} \times\left|-N \frac{\Delta \phi_{b}}{\Delta t}\right|=\frac{1}{R} \times\left|B \frac{\Delta A}{\Delta t}\right|=\frac{B L v}{R}=\frac{5 T \times 0.04 \mathrm{~m} \times 3.1 \frac{\mathrm{~m}}{s}}{0.3 \Omega}=2.1 \mathrm{~A}
$$

4. What is the magnetic force on the loop when it is one-half of the way into the magnetic field? $F=I W B=2.1 A \times 0.04 \mathrm{~m} \times 5 T=0.413 \mathrm{~N}=413 \mathrm{mN}$ in magnitude.

The direction, by the right-hand rule is to the left to oppose the velocity of the block, where the current is vertically upward in the right-hand side of the wire loop and the magnetic field pointing into the page. The top and bottom segments of wire feel no net force.
5. What is the magnitude and direction of the induced electric field in the right-hand side of the wire loop when the loop is one-half of the way into the magnetic field?
$E=-\frac{\Delta V}{\Delta y}=-\frac{-\varepsilon}{y}=\frac{\varepsilon}{y}=\frac{B W v}{W}=B v=5 T \times 3.1 \frac{m}{s}=15.5 \frac{V}{m}$ vertically upward in the righthand side of the wire

