PHYS 212 Examination 3

Name (print): ______________________________

Signature ______________________________

Problem 1 ___________________

Problem 2 ___________________

Problem 3 ___________________

Problem 4 ___________________

Problem 5 ___________________

Total ___________________

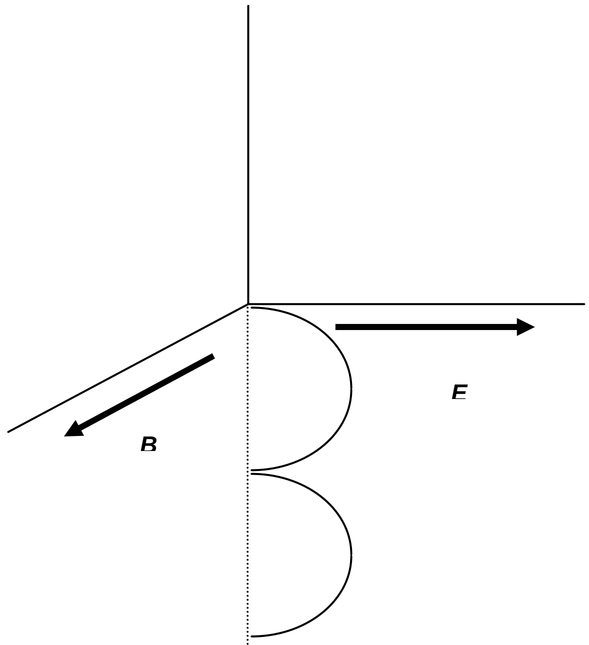
Directions: This exam contains five problems worth 20 points each for a possible 100 points. Your solutions should be written as neatly as possible and arranged in a logical manner. Credit will be awarded on the basis of thought, compactness, and neatness of the written solution. Remember to use basic physical principles in solving the problems. Show all of your work. I will not award full points for a problem with a solution that I am unable to decipher even if the answer is correct.

An equation sheet has been provided. CRC handbooks are allowed. Calculator rule is in effect. Good Luck!

Problem 1.

- A proton is released from rest at the origin of the coordinate system shown below. A uniform $\vec{E}$ field exists in the + $\hat{j}$ direction. A uniform $\vec{B}$ field exists in the $+\hat{i}$ direction. Sketch the path of this particle.

  Cycloid along $-\hat{k}$ axis



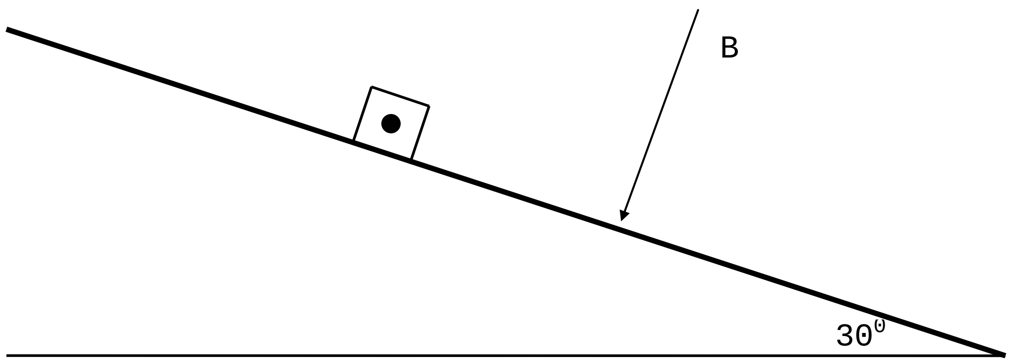
- A proton enters a magnetic field ***B*** = 3***i*** – 2***j*** +***k*** with a velocity of ***v*** = 3***i*** - 2***j*** -***k***. What is the magnitude and direction of the resulting force on the proton?

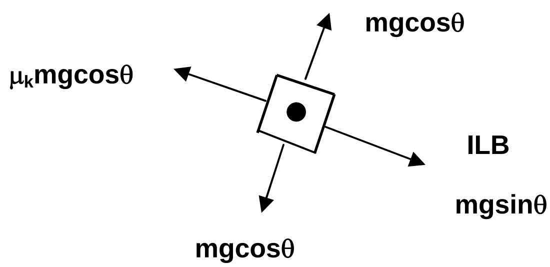
$$\vec{v}\times\vec{B}=\left(3\hat{i}-2\hat{j}-\hat{k}\right)\times\left(3\hat{i}-2\hat{j}+\hat{k}\right)=\begin{matrix} i & j & k & i & j \\ 3 & -2 & -1 & 3 & -2 \\ 3 & -2 & 1 & 3 & -2 \end{matrix}$$

$$=\left(-2\hat{i}-3\hat{j}-6\hat{k}\right)-\left(-6\hat{k}+2\hat{i}+3\hat{j}\right)$$

$$=-4\hat{i}-6\hat{j}\Rightarrow\vec{F}=\left[q\left(-4\hat{i}-6\hat{j}\right)\right]N$$

Problem 2. A 0.5 kg metal rod lies across twin metal rails 1 meter apart as shown below (side view). The rails are inclined at an angle of 30^0 to the horizontal. The coefficient of static friction between the rails and the metal rod is 0.6. If a magnetic field of 10 Tesla is directed *downward* at an angle of 60^0 to the horizontal, the current flows through the bar out of the plane of the page, what must the magnitude of the current be in order to get the rod to move? In what direction does the bar move? What is its acceleration?



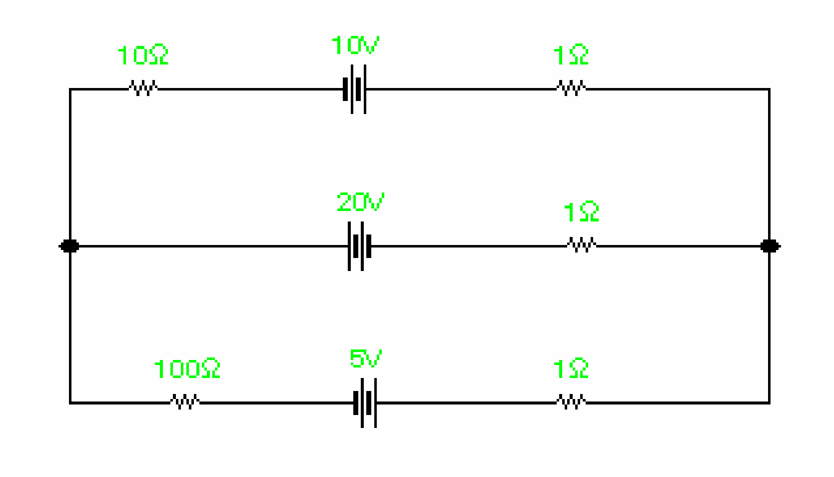


The bar begins to move when $ILB + mg\sin\theta = \mu_k mg\cos\theta = 5N \therefore I = 9.6mA$

The bar moves down the ramp.

The acceleration is zero.

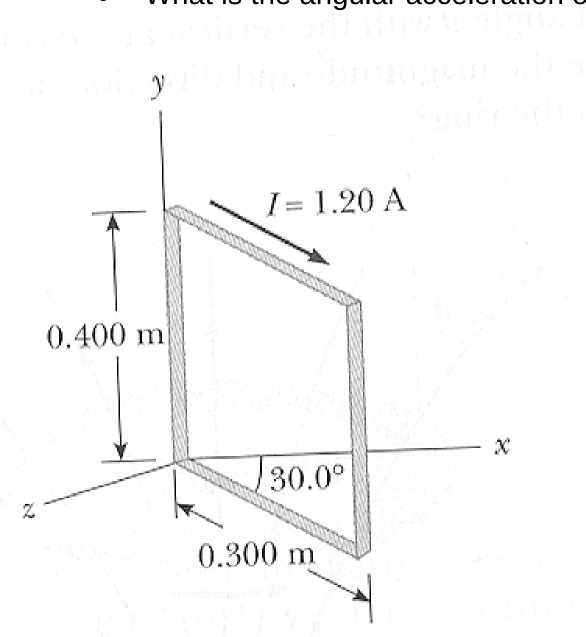
Problem 3. Determine the current that flows through the 100 Ω resistor in the circuit below.



221mA

Problem 4. A rectangular loop consists of 10 turns and has the dimensions given below. The loop is hinged on the *y*-axis, and its plane makes an angle of 30^0 with the *x*-axis. A uniform magnetic field ***B*** = 0.8***i*** T exists in the region of space containing the loop and a current of 1.20 amperes flows through the loop in the indicated direction.

- What is the net force on the loop?
- What is the magnetic moment of the loop?
- What is the torque on the loop?
- What is the angular acceleration of the loop?



- The net force is zero.
- The magnetic moment, *IA*, is 0.144 a/m^2 and is perpendicular to the plane of the loop in the direction of the x-y plane.
- $\Gamma = n\left(m\vec{B}\sin\alpha\right) \approx 1N \cdot m$ ($\alpha = 60^0$). The torque vector points in the direction of $\hat{n} \times \vec{B}\,(-\hat{j})$
- $\Gamma = I\alpha \therefore \dfrac{\Gamma}{I} = \alpha$, so the angular acceleration is the torque divided by the moment of inertia

  and is in the $-\hat{j}$ direction.

Problem 5. A series R-C circuit consists of a switch, a 30 μF capacitor, a 30 Ω resistor, and a 10 V battery.

- Sketch the circuit.
- Find the time constant, τ, for this circuit.

$RC = 0.0009s$ = *0.9 ms*

- When is the voltage across the resistor at its maximum value and what is its value?

The voltage across the resistor is at its maximum value of 0.33 amperes the instant after the switch is closed.

- When is the voltage across the capacitor at its maximum value and what is its value?

The voltage across the capacitor is at its maximum value of 10 volts as $t \to \infty$*.*

- Calculate the current in the circuit and the voltage across the resistor after one time constant has elapsed.

The current is 37% of its initial value or 0.121 amperes. The voltage across the resistor is approximately 3.7 volts.

- Calculate the current in the circuit at t = 500 ms.

$I = I_0 e^{-\frac{t}{\tau}} = 2.48 \times 10^{-24}\, amps$ *or essentially zero. This is approximately 56 time constants.*

- When is the current through the resistor at 2/5 of its maximum value?

$\ln \frac{2}{5} = \ln e^{-\frac{t}{\tau}} \therefore t = 8.2 \times 10^{-4}\, s$ *Or at about 0.82 ms.*