Sample Exam 2: Applied Physics III

1. A magnetic field of 0.2 T exists within a solenoid of 500 turns and a diameter of 10.0 cm. How rapidly (that is, in what period of time) must the field be reduced to zero, if the average induced emf with the coil during this time interval is to be 10.0 kV?
   a. 7.85 X 10^-4 s
   b. 9.85 X 10^-8 s
   c. 6.89 X 10^-5 s
   d. 9.99 X 10^-3 s
   e. None of the above.

2. What is the magnetic field in a solenoid with 1000 turns and a length of 1 cm that carries a current of 10.0 amps? (\(\mu_0=4\pi\times10^{-7}\) Tm/A)
   a. 1.256 T
   b. 8.970 T
   c. 8.999 T
   d. 9.767 T
   e. None of the above.

3. An AC generator consists of 10 turns of wire, each of an area of 0.8 square meters, and the total resistance of 15 Ohms. The loops are placed in a magnetic field of 1.2 T and rotated at a rate of 60 Hz. What is the maximum emf induced?
   a. 9.8 kV
   b. 9.0 kV
   c. 3.6 kV
   d. 3.9 kV
   e. None of the above.

4. A proton moves with a velocity of \(\vec{v}=2\frac{m}{s}\hat{i}-4\frac{m}{s}\hat{j}+1\frac{m}{s}\hat{k}\) in a region where the magnet field has a constant value of \(\vec{B}=1T\hat{i}+2T\hat{j}-3T\hat{k}\). What is the magnitude of the magnetic force felt by the proton? (mass of proton is 1.67 X 10^{-27} kg, charge of the proton is +1.6 X 10^{-19} C)
   a. +2.34 X 10^{-18} N
   b. 149 N
   c. -2.34 X 10^{-18} N
   d. -149 N
   e. None of the above.
1. A proton is moving with a velocity of $3.0 \times 10^{-7}$ m/s in the positive x direction when it enters a constant magnetic field of 3.0 T which points in the positive y direction. It then begins to turn in a circle. What is the radius of that circle? (The mass of a proton is $1.67 \times 10^{-27}$ kg and a charge of $1.6 \times 10^{-19}$ C)

a. 0.10 m  
b. 1.0 m  
c. 8.9 m  
d. 4.5 m  
e. None of the above.

$$\mathbf{F} = \frac{q \mathbf{v} \times \mathbf{B}}{r}$$

$$q = 1.6 \times 10^{-19} \text{ C}$$

$$\mathbf{v} = 3.0 \times 10^{-7} \text{ m/s}$$

$$\mathbf{B} = 3.0 \text{ T}$$

$$\theta = 90^\circ$$

$$r = \frac{mv}{qB} = \frac{(1.67 \times 10^{-27} \text{ kg}) \times (3 \times 10^{-7} \text{ m/s})}{(1.6 \times 10^{-19} \text{ C})(3 \text{ T}) \sin 90^\circ} = 0.104 \text{ m}$$

6. A current carrying conductor lies along the x axis carrying a current of 6.0 amps. The conductor is 0.5 meters long. There is a magnetic field of 5.0 T directed into the page. Find the force on the conductor (magnitude and direction).

[Diagram of a current carrying conductor with a magnetic field.]  

\[ B = 5.0 \text{ T} \]

\[ I = 3.0 \text{ A} \]

\[ F = I \cdot B \cdot s \cdot \sin \theta \]

\[ = (6 \times 0.5 \text{ m}) \times 5 \text{ T} \cdot \sin 90^\circ \]

\[ = 15 \text{ N} \]

\[ \Rightarrow \text{use right hand rule} \]
Problem One (20 points):

A 20 V battery, a 40 mF capacitor, a 220 ohm resistor and a switch are connect in series.

a. What is the current the instant the switch is closed?

b. What is the value RC time constant?

c. What is the current through the circuit 1.0 micro second after the switch is closed?

\[ I_{\text{max}} = \frac{V}{R} = \frac{20 \text{ V}}{220 \Omega} = 0.091 \text{ A} = 91 \mu \text{A} = I_0 \]

\[ \tau = RC = (40 \times 10^{-3} \text{ F})(220 \Omega) = 8.8 \text{ s} \]

\[ I = I_0 e^{-t/\tau} = 91 \mu \text{A} e^{-\frac{1 \times 10^5}{8.8}} = 90.99 \mu \text{A} \]
Problem Two (10 points):

A pair of conducting, parallel rails are separated by 20.0 cm and attached to a 20 ohm resistor. A conducting rod is pulled frictionlessly with a velocity of 5 m/s. There is a uniform magnetic field of 0.80 T.

(a) What is the current induced in the circuit?
(b) What is the power dissipated by the resistor?
(c) What is the direction of the induced current and the magnetic force?
(c) At what rate does the pulling force do work on the bar?

\[
E = \frac{\Delta \mathcal{E}}{\Delta t} = \frac{\Delta (B \mathbf{A} \sin \theta)}{\Delta t} = B \mathbf{E} \cdot \mathbf{l} = B \Delta \mathbf{E} = B \Delta (l \mathbf{E}) = B \mathbf{E} \Delta x = B l \mathbf{E} \Delta x = (0.8 \text{T})(0.2 \text{m})(5 \text{m/s}) = 0.8 \text{V}
\]

\[
I = \frac{E}{R} = \frac{0.8 \text{V}}{20 \Omega} = 0.04 \text{A}
\]

\[
P_{\text{res}} = I^2 R = (0.04 \text{A})^2 (20 \Omega) = 0.032 \text{ W}
\]

\[
0.032 \text{ W}
\]

Note: \[ F_B = I l B = (0.04 A)(0.2 \text{ m})(0.80 \text{T}) = 0.0064 \text{ N} \]

\[ F_{\text{app}} = F_B \text{ since } \omega = \text{ const, } \omega = 0 \]

\[ P_{\text{app}} = F_{\text{app}} \omega = (0.0064 \text{ N})(5 \text{ m/s}) = 0.032 \text{ W} \]
Problem Three (10 points):

Use Gauss's Law to find the Electric Field on an infinite line of charge with a line charge density of 30 C/m.

\[ E \cdot A = \frac{q \cdot l}{\varepsilon_0} \]

\[ E = \frac{2k \lambda}{2\pi r} \cdot \frac{l}{\varepsilon_0} \]

\[ E = \frac{2(9 \times 10^9 \ \frac{Nm^2}{C^2}) \times 30 \frac{C}{m}}{r} \]

\[ E = \frac{5.4 \times 10^7 \ \frac{N}{C}}{r} \]