PHY 1304  Test 3  Nov 11, 2008  Name:  KEY

Note: Do all of the 3 problems.

1) A 12 V battery is placed in series with a 10 ohm resistor, a 5 mH inductor and a switch. The switch is closed at time = 0s. a) How much current flows at t = 0 s? b) How much time does it take for the current to attain 1% of its maximum value? [12 pts]

a) at t = 0 => I = 0

b) \[ I = I_{max} (1 - e^{-t/T}) \]

\[ T = \frac{L}{R} = \frac{5 \times 10^{-3}}{10} = 5 \times 10^{-4} \]

\[ 0.01 I_{max} = I_{max} (1 - e^{-t/T}) \]

\[ t = -T \ln (0.99) \]

\[ t = -5 \times 10^{-4} \ln (0.99) => L = 5.03 \times 10^{-6} \text{s} \]

2) A coil of resistance 17 ohms and inductance 10 H is in series with a capacitor and a 120 volt (rms) 60 Hz source. The rms current in the circuit is 3.0 A. a) Calculate the capacitance in the circuit. b) Calculate the rms voltage across the coil. [12 pts]

a) \[ X_L = 2\pi fL = 2\pi \times 60 \times 10 = 377 \Omega \]

\[ X_C = \frac{1}{2\pi fC} \]

\[ I_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{\sqrt{R^2 + (X_C - X_L)^2}} \]

\[ \Rightarrow 3 = \frac{120}{\sqrt{17^2 + (377 - 377)^2}} \Rightarrow X_C = 373 \text{ } \Rightarrow C = 7.1 \times 10^{-7} \text{ } \]

b) \[ V_{rms} = I_{rms} \times \sqrt{L^2 + R^2} \]

\[ = 3 \times \sqrt{377^2 + 17^2} \]

\[ = 11.313 \text{ V} \Rightarrow V_{rms} = 11.313 \text{ V} \]

3) Digital cameras use a charge-coupled device (CCD) to record an image instead of film. Many CCD's have a peak sensitivity to light with a wavelength of approximately 650 nm. a) Is this blue or red light? b) What is the frequency of this light? [12 pts]

a) \[ \lambda = 650 \text{ nm} \Rightarrow \text{Red Light} \]

b) \[ f = \frac{c}{\lambda} = \frac{3 \times 10^8}{650 \times 10^{-9}} \Rightarrow f = 4.62 \times 10^{14} \text{ Hz} \]
4) A square conducting loop has sides of length 1 m. It is at an angle of 5 degrees with respect to a constant magnetic field of 10 T. The magnetic field is changed at constant rate to 1 T going in the opposite direction. What is the induced emf in the loop? [12 pts]

\[ E = -\frac{d\Phi}{dt} = -\frac{\Delta\Phi}{\Delta t} = -\frac{\Delta B \cdot A}{\Delta t} = -\left( B_0 \cos \theta \cdot \frac{B_0}{10} \sin \theta \right) \cdot A \]

\[ = \frac{(1 \cdot \cos 50 - 10 \cos 0)}{10} \cdot 1^2 \]

\[ = 1.096 \text{ V} \]

5) Sunlight has an intensity of 1 kW/m². What maximum electric field does that correspond to? b) Calculate the maximum magnetic field also. c) How much pressure does that light exert on a 10m x 10m square sheet of material which absorbs 100% of the light? [12 pts]

\[ S = I = 10^3 \text{ W/m}^2 \]

a) \[ S = \frac{E_{\text{max}}}{\epsilon_0} \Rightarrow E_{\text{max}} = \sqrt{\frac{2 \mu_0 c S}{\epsilon_0}} = \sqrt{2 \times \left(\frac{1}{2 \times 10^{-7}}\right) \times \left(3 \times 10^8\right)^2 \times 10^4} \]

\[ E_{\text{max}} = 868 \text{ V/m} \]

b) \[ S = \frac{c B_{\text{max}}}{\mu_0} \Rightarrow B_{\text{max}} = \frac{S}{\epsilon_0} \cdot \frac{\mu_0}{c} = \sqrt{\frac{10^3 \times 2 \times \left(\frac{1}{2 \times 10^{-7}}\right)}{3 \times 10^8}} \]

\[ B_{\text{max}} = 2.89 \times 10^{-6} \text{ T} \]

c) \[ P = \frac{S}{c} = \frac{10^3}{3 \times 10^8} \Rightarrow P = 3.33 \times 10^{-6} \text{ Pa} \]