PHY 1304 Test 3 Nov 11, 2008 Name: KEY

Note: Do 3 of the 4 problems. 12 pts.

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 $t=0 \Rightarrow I=0$

b) $I = I_{max}(1-e^{-t/\tau})$ $\qquad \tau = \frac{L}{R} = \frac{5\times10^{-3}}{10} = 5\times10^{-4}$

$0.01\, I_{max} = I_{max}(1-e^{-t/\tau})$

$t = -\tau \ln(0,99)$

$t = -5\times10^{-4}\ln(0,99) \Rightarrow \boxed{t = 5.03\times10^{-6}\,s}$

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) $X_L = 2\pi f L = 2\pi\times60\times10 = 3770\,\Omega$, $\quad X_C = \frac{1}{2\pi f C}$

$I_{rms} = \frac{V_{rms}}{Z} = \frac{V_{rms}}{\sqrt{R^2+(X_C-X_L)^2}} \Rightarrow 3 = \frac{120}{\sqrt{17^2+(3770-X_C)^2}} \Rightarrow X_C = 3734 \Rightarrow \boxed{C = 7.1\times10^{-7}\,F}$

b) $V_{rms} = I_{rms}\cdot\sqrt{X_L^2+R^2}$

$= 3\cdot\sqrt{3770^2+17^2}$

$= 11313\,V \Rightarrow \boxed{V_{rms} = 11.313\,kV}$

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? [8 pts]

a) $\lambda = 650\,nm \Rightarrow$ Red Light

b) $f = \frac{c}{\lambda} = \frac{3\times10^8}{650\times10^{-9}} \Rightarrow \boxed{f = 4.62\times10^{14}\,Hz}$

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]

$t = 1\,s$

$$\mathcal{E} = -\frac{d\Phi}{dt} = -\frac{\Delta\Phi}{\Delta t} = -\frac{\Delta B \cdot A}{\Delta t} = -\frac{(B_f \cos\theta_f - B_i \cos\theta_i)\cdot A}{\Delta t}$$

$$= -\frac{(1\cdot\cos 180 - 10\cos 0)\cdot 1^2}{10}$$

$$= \boxed{1.096\ V}$$

5) Sunlight has an intensity of 1 kW/m^2. a) 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]

$S = I = 10^3\ W/m^2$

a) $S = \frac{E_{max}^2}{2\mu_0 c} \Rightarrow E_{max} = \sqrt{2\mu_0 c S} = \sqrt{2\times(4\pi\times10^{-7})(3\times10^8)(10^3)}$

$$\boxed{E_{max} = 868\ V/m}$$

b) $S = \frac{c B_{max}^2}{2\mu_0} \Rightarrow B_{max} = \sqrt{S\cdot 2\mu_0/c} = \sqrt{10^3\cdot 2\cdot\frac{(4\pi\times10^{-7})}{3\times10^8}}$

$$\boxed{B_{max} = 2.89\times10^{-6}\ T}$$

c) $P = \frac{S}{c} = \frac{10^3}{3\times10^8} \Rightarrow \boxed{P = 3.33\times10^{-6}\ P}$