University of Maryland
Department of Physics

Physics 122 | **EXAM 3 - December 7, 2005** | **Dr. Kirkpatrick**

Name: ______________________________ (write in ink)

Section number: ________________________

TA: ________________________________

1) Try to answer as many questions as you can
2) To receive full credit, answers must be written on the exam in the spaces provided. You must show work leading to your answers. To be graded, the entire exam must be handed in.
3) On this cover sheet, fill in your name, etc., LEGIBLY in the space provided
4) Give units for all numerical answers
5) The exam has 4 problems; CHECK your copy to see that all pages are included!

----------Do not write below this line----------

Problem	Maximum Score	Score
1	25	
2	25	
3	25	
4	25	
Section No.		
TOTAL:		____________

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EXAM 3

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1. A 10-henry coil has a resistance of 180 ohms. (a) What size of capacitor must be put in series with it if the combination is to "resonate" when connected to a 60-cycle/sec outlet, (b) If the maximum input voltage is 150V, what is the maximum current in the circuit, and (c) Does the current lead or lag the input voltage at twice the resonance frequency, and by how much?

at resonance $\frac{1}{2\pi f C} = 2\pi f L$

$C = \frac{1}{(2\pi f)^2 L} = \frac{1}{(2\pi\, 60\,Hz)^2\, 10\,H}$

$= 7.04 \times 10^{-7}\ F$

b) maximum current at resonance

$I_{max} = \frac{V_{max}}{\sqrt{R^2 + \cancel{(X_L - X_C)^2}}}$ at resonance

$= \frac{150\,V}{180\,\Omega} = .833\ A$

c) $\tan\phi = \frac{X_L - X_C}{R}$

$X_L = 2\pi\,(2f_R)\,L$ ← twice resonance

$= 2\pi(2 \cdot 60\,Hz) \cdot 10\,H$

$= 7540\ \Omega$

$X_C = \frac{1}{2\pi(2f_R)C}$

$= \frac{1}{2\pi(2 \cdot 60\,Hz) \cdot 7.04\times10^{-7}\,F}$

$= 1885\ \Omega$

$\phi = \tan^{-1}\left(\frac{7540\,\Omega - 1885\,\Omega}{180\,\Omega}\right)$

$= 1.54$ rad voltage leads current

$= 88^\circ$

or current lags by 88°

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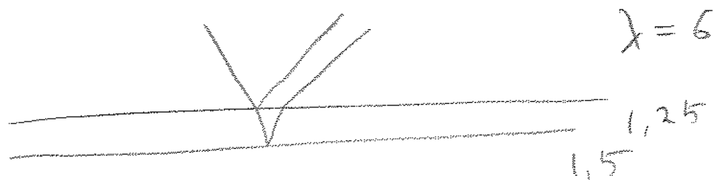
2. We wish to coat a flat piece of glass ($n = 1.50$) with a transparent material ($n = 1.25$) so that light of wavelength 6000 A (in vacuum) incident normally is not observed. How can this be done? How thick should the coat be?

$\lambda = 6000 \times 10^{-10}$ m



this may be done thru destructive interference.
Condition for destructive interference since we are sandwiched in between materials with 2 different refractive indexes is

$$2nt = \left(m + \tfrac{1}{2}\right)\lambda_n$$

lets coat with the thinnest film ($m=0$)

$$2(1.25)t = \tfrac{1}{2}\, 6000 \times 10^{-10}\text{ m}$$

$$t = 1200\,\text{Å} = .12\,\text{um}$$

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3. Light of a wavelength 2000 A falls on an aluminum surface. In aluminum 4.2 ev are required to remove an electron. What is the kinetic energy of (a) the fastest emitted photoelectrons? (b) What is the stopping potential? (c) What is the cutoff wavelength for aluminum?

$$f = \frac{c}{\lambda} = \frac{3\times10^{8}\frac{m}{s}}{2000\times10^{-10}m} = 1.5\times10^{15}Hz$$

a) $E = hf - \phi = 4.136\times10^{-15}eVs\,1.5\times10^{15}\frac{1}{s} - 4.2eV$

$= 2.004eV = 3.2\times10^{-19}J$

$=$ KE fastest emitted photoelectron

b) $E = eV_s \rightarrow V_s = \frac{2.004eV}{e} = 2.004V$

c) at cutoff $E = 0$

$hf_c = \phi$

$$f_c = \frac{\phi}{h} = \frac{4.2eV}{4.136\times10^{-15}eVs} = 1.017\times10^{15}Hz$$

$$\lambda_c = \frac{c}{f_c} = \frac{3\times10^{8}\frac{m}{s}}{1.017\times10^{15}Hz} = 2950\,\mathring{A}$$

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4. (a) A bullet of mass 40 gm travels at 1000 m/s.

   (i) What wavelength can we associate with it?
   (ii) Why does the wave nature of the bullet not reveal itself through diffraction effects?

   (b) The uncertainty in the position of an electron is given as about 0.5 A, which is the radius of the first Bohr orbit in hydrogen. What is the uncertainty in the linear momentum of the electron?

   (c) A microscope using photons is employed to locate an electron in an atom to within a distance of 0.1 A. What is the uncertainty in the momentum of the electron located in this way?

4 i]

$p = mv = 40\times10^{-3}\,kg \cdot 1000\,\frac{m}{s} = 40\,kg\,\frac{m}{s}$

$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}\,J\cdot s}{40\,kg\,\frac{m}{s}} = 1.66\times10^{-35}\,m$

ii] does not reveal itself is way smaller than the bullet or anything it could pass thru

b] $\Delta x\,\Delta p_x \geq \hbar \rightarrow \Delta p \geq \frac{1.05\times10^{-34}\,J\cdot s}{.5\times10^{-10}\,m}$

$\geq 2.1\times10^{-24}\,kg\,\frac{m}{s}$

c] $\Delta x = .1A$

$\Delta p \geq \frac{1.05\times10^{-34}\,J\cdot s}{.1\times10^{-10}\,m} = 1.05\times10^{-23}\,kg\,\frac{m}{s}$