PHYS-1200 PHYSICS II NAME___MR KEY_____
EXAM 3-B Dec. 5, 2007

__d___A1) A sound wave propagates in material A with the following characteristics: wavelength, $\lambda_A = 2m$; frequency, $f_A = 400Hz$. It crosses a boundary into material B. The speed of sound in material B is twice that in material A. What are the characteristics of the wave in material B?

a) $\lambda_B = 2m$, $f_B = 800Hz$

b) $\lambda_B = 4m$; $f_B = 200Hz$

c) $\lambda_B = 2.82m$; $f_B = 282Hz$

d) $\lambda_B = 4m$; $f_B = 400Hz$

e) $\lambda_B = 1m$; $f_B = 400Hz$

__d___A2) Suppose that a Young's double slit experiment is performed with light of wavelength λ_1 nm. The slits are b_1 mm apart. The viewing screen is a distance L_1 from the slits. The distance between bright fringes on the screen is y_1. What is the distance between bright fringes when the distance between the slits is reduced to $b_1/2$ and the wavelength is doubled to $2\lambda_1$?

a) y_1, b) $y_1/2$ c) $2y_1$ d) $4y_1$ e) $y_1/4$

__a___A3) Light of intensity I_0 is received at a distance R from a isotropically emitting source. What is the intensity at distance 2R from the source?

a) $I_0/4$ b) $I_0/2$ c) $I_0/\sqrt{2}$ d) $\sqrt{2}\, I_0$ e) $2I_0$

__a___A4) Electron *A* has twice the momentum of electron *B*. The ratio of the wavelengths of the two electrons, $\frac{\lambda_A}{\lambda_B}$ is:

a. ½ b. ¼ c. 1 d. 2 e. 4

__d___A5) A free electron and a free proton have the same momentum. When the wavelengths and the kinetic energies of the two particles are compared, the electron has:

a. a shorter wavelength and a greater kinetic energy
b. a longer wavelength and a greater kinetic energy
c. the same wavelength and the same kinetic energy
d. the same wavelength and a greater kinetic energy
e. the same wavelength and a smaller kinetic energy

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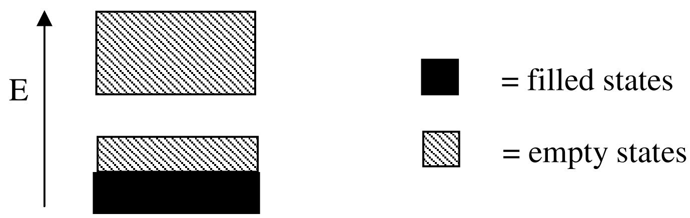
__c___A6) The Fermi level of a metal (measured with respect to the bottom of the conduction band) depends primarily on (pick the best answer)

a) the color of the metal (gold, silver, copper...)
b) the density of the metal
c) the density of electrons in the conduction band of the metal
d) the volume of the sample
e) the temperature

__a___A7) The energy level diagram shown below applies to



a) a metal
b) a semiconductor
c) an isolated atom
d) a free electron gas
e) none of the above

__a__A8) A particle of mass *m* is confined in an one dimensional box with infinitely high potential walls a distance of L_0 apart. The energy of the ground state is E_0. What would be the ground state energy of a particle of mass $2m$ in a box with side $2L_0$?

a) $E_0/8$
b) $E_0/2$
c) E_0
d) $2E_0$
e) $8E_0$

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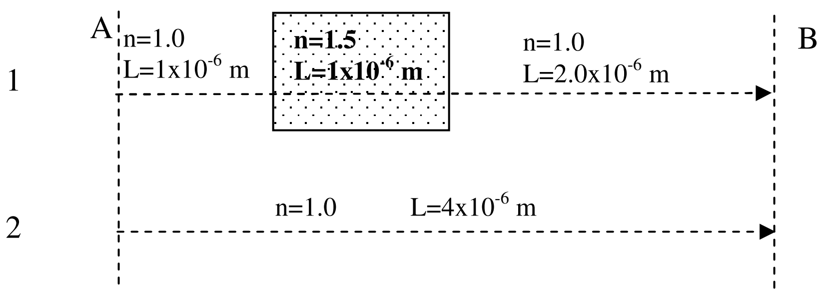
PART B.

B1) (10%) Two waves of light of (vacuum) wavelength λ_0 =500 nm, are initially in phase at plane A and traveling to the right. They then travel through layers of material as shown below.



a) (7%) What is the phase difference (in multiples of wavelength λ_0) between these two beams when they pass through plane B?

$$N = \frac{1}{\lambda}\left(\sum_{path1} n_i L_i - \sum_{path2} n_i L_i \right) = \frac{0.5\times10^{-6}}{5\times10^{-7}} = 1$$

ANSWER:______1__________

b) (3%) At plane B, are these two beams completely in-phase, completely out of phase, or somewhere in between? Explain.

Completely in phase because the difference is an integer multiple of wavelength.

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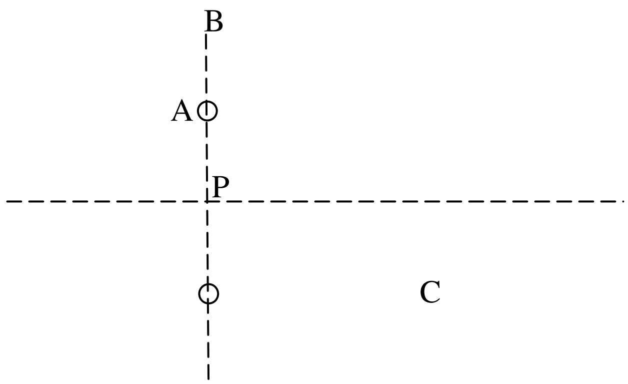
B2) (12%) Two isotropic point sources S_1 at (0,-0.5) and S_2 at (0,0.5) emit radio waves of wavelength 2 m. The wave from S_1 is in phase with the wave from S_2 at point P=(0,0) midway between the two sources. Give the phase difference (in wavelengths) between the two waves at points A=(0,0.5), B=(0,1), C=(1,-0.5). (All coordinates are in meters.)



A)______1/2 λ____________

Explain your answer:__***The two sources are ½ wavelength apart along the y axis.***___

B)______1/2 _λ______

Explain your answer:___***The difference in path length along the y axis is still ½ wavelength.***

C)____0.2 λ__________

Explain your answer:___

$$L_1 = 1m$$
$$L_2 = \sqrt{1+1} = \sqrt{2} \cong 1.41$$
$$\Delta L = 0.41m$$
$$N = \frac{\Delta Lm}{2m} \cong 0.2$$

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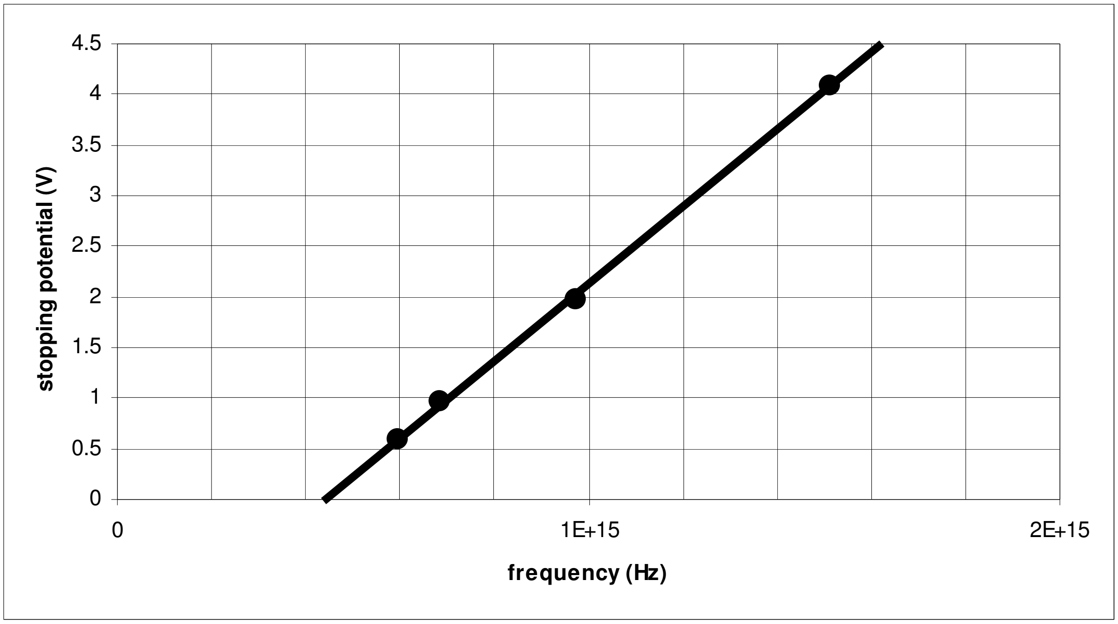
PART C.

C-1) A photoelectric effect measurement is carried out on an unknown metal with the following results.

wavelength (nm)	200	310	410	500
stopping potential (V)	4.1	2.0	0.95	0.55

a) (6%) Plot the stopping potential against frequency and estimate the cutoff frequency of the material in Hz.



$f = \frac{c}{\lambda} = \frac{3\times10^{17}}{\lambda(nm)}$ so we can easily find frequency.

200	1.5E+15
310	9.68E+14
410	7.32E+14
500	6E+14

f_{cutoff}~$0.45\text{x}10^{15}$ Hz.

b) (8%) Estimate Planck's constant from your plot. (Use c=$3\text{x}10^8$ m/s.) (Explain your logic.)

$$h = \frac{e\Delta V}{\Delta f} = \frac{1.6\times10^{-19}\times4.5}{(1.61-0.45)\times10^{15}} = 6.2\times10^{-34}\,Js$$

b) (4%) Find the work function of this unknown metal. (Use h=$6.6\text{x}10^{-34}$ J-s for this part.)

$$\phi = hf_{cutoff} \sim 6.6\times10^{-34}\,Js\times0.45\times10^{15}\,Hz \sim 3\times10^{-19}\,J \sim 2eV$$

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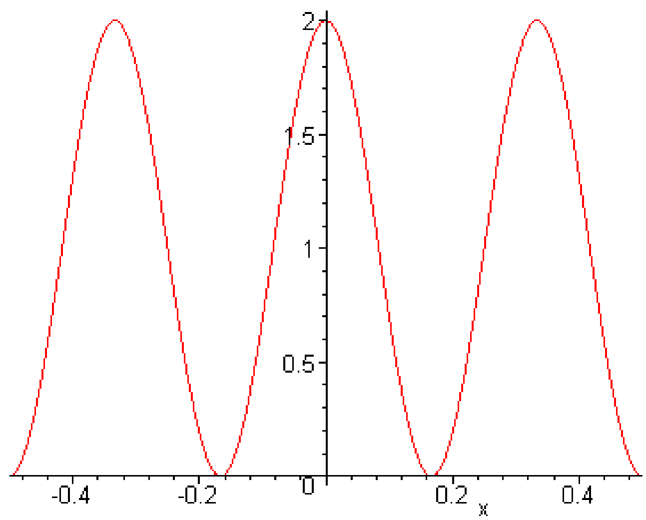
C-2) (20%) At a particular time, the wavefunction for an electron trapped in a box extending from x=-0.5 nm to x=+0.5 nm is given by $\psi = -\sqrt{\frac{2}{1nm}}\cos\left(\frac{3\pi x}{1nm}\right)$.

a) Sketch the probability distribution for finding the electron as a function of position.



b) Write the mathematical expression for finding the particle between x=-a and x=a. (You don't have to solve it, but you should have the correct functions and constants in the correct place.)

$$P = \int_{-a}^{a} \psi^2 dx = \frac{2}{1}\int_{-a}^{a} \cos^2(3\pi x)\, dx$$

c) What is the probability of finding the electron between x=-1/6 nm and x=+1/6 nm? If you don't do the integral, explain your answer.

You don't have to do the integral. The wavefunction has three equal lobes, each one has an area of 1/3. The region given includes just one lobe.

d) Estimate the probability of finding the particle between x=-0.001 and x=+0.001. (You don't necessarily have to do the integral, but you must explain your logic clearly.)

$$P = \int_{-a}^{a} \psi^2 dx = 2\int_{-0.001}^{0.001} \cos^2(3\pi x)\, dx \cong 2\int_{-0.001}^{0.001} dx = 0.004$$