Physics 234-104 (Thursday Class) Final Exam, 5/5/03
**Due in Physics Office by 12 noon on May 12th**

Name:_____

1. (15 Pts) The end of one of the prongs of a tuning fork that executes simple harmonic motion of frequency 1000 Hz has an amplitude of 0.40 mm. Find (a) the magnitude of the maximum acceleration and (b) the maximum speed of the end of the prong. Find (c) the magnitude of the acceleration and (d) the speed of the end of the prong when the end has a displacement of 0.20 mm.

2. (10 Pts.) A string 4.0 m long has a mass of 3.0 g. One end is attached to a wall and the other hangs over a pulley and is attached to a 2 Kg mass.   What is the speed to the transverse wave in the horizontal section of the string?

3. (15 pts.) A girl is sitting near the open window of a train that is moving at a velocity of 10.00 m/s to the east. The girl's uncle stands near the tracks and watches the train move away. The locomotive whistle emits sound at frequency 500.0 Hz. The air is still. (a) What frequency does the uncle hear? (b) What frequency does the girl hear? A wind begins to blow from the east at 10.00 m/s. (c) What frequency does the uncle now hear? (d) What frequency does the girl now hear?

4. (15 pts.) An x-ray diffraction pattern in obtained by utilizing photons emitted when an electron in the 2p level of Cu moves to a 1s state. If the binding energy of the Cu 1s and Cu 2p levels are 8980 eV and 940 eV, respectively, estimate the d-spacings of the planes of KBr from the diffraction pattern shown below (plot of intensity vs. 2*θ).
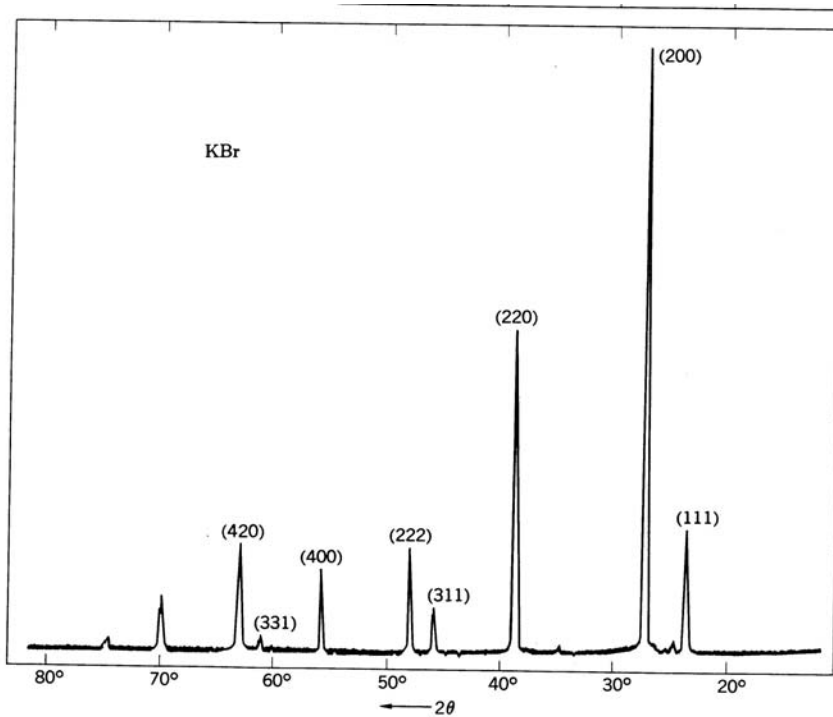
5. (15 pts.) Five waves (below) are sent along a string in the same direction. What is the resultant wave?

$y_1(x,t) = 4 \sin(kx - \omega t)$

$y_2(x,t) = 2 \sin(kx - \omega t + \pi)$

$y_3(x,t) = 7 \sin(kx - \omega t + \pi/3)$

$y_4(x,t) = 8 \sin(kx - \omega t + \pi/6)$

$y_5(x,t) = 3 \sin(kx - \omega t - \pi)$

6. (15 pts.) How many head-on Compton scattering events are necessary to double the wavelength of a photon having an initial wavelength of 200 pm?

7. (15 pts.) Suppose that a 100 W source radiate light of wavelength 600nm uniformly in all directions and the eye can detect this light if only 20 photons per second enter a dark adapted eye having a diameter of 7mm. How far from the source can the light be detected?

8. (20 pts.) Consider an electromagnetic wave in which the electric field oscillates in the y-direction and Poynting vector is given by

$$\mathbf{S}(x,t) = 100 \text{ w/m}^2 \cos^2 (10x - 3 \times 10^9 \, t) \, \mathbf{i}$$

(a) What is the direction of propagation of the wave. (b) Find the wavelength and frequency. (c) Find expressions for the electric and magnetic fields. (d) Find the average intensity. (d) Find the force exerted on a 1 m^2 sheet by absorption of this light.

9. (20 pts.). An electron is confined to a rectangular box defined by Lx= 200 pm Ly = 800 pm and Lz =400 with one corner at the origin. (a) Find the ground state energy (b) find the wavelength of the photon need to excite the electron the first excited state. (c) Show that the function

$$\psi_{nx \, ny \, nz} (x,y,z) = A \sin(n_x \pi x/L_x) \sin(n_y \pi y/L_y) \sin(n_y \pi z/L_z)$$

is the solution of Schrödinger's equation for this problem and find A. (d) Compute the average value of x, the average value of y and the average value of z in the ground state. (e) Plot the ground state probability density in the x-y plane at z equal to it's average value.

10. (10 pts. bonus) For hydrogen in the 2s (excited) state the radial probability density is

$$P(r) = r^2/ (8)(2 - r/a)^2 \, e^{-r/a}$$

What is the probability of finding the electron between 0 and 1.5a ? Compare the result to that for the ground state ($P(r) = 4/a^3 \, r^2 \, e^{-2r/a}$) and comment on the change in the electron distribution which occurs on going from the ground state to the first excited state.