Physics 273, Fall 2005
Exam # 1

Closed-book examination. One pre-prepared 8 ½" x 11" sheet of notes may be used. Calculator may be used. Show work for partial credit. Include UNITS on all answers.

EXAM ADVICE: If you don't immediately see what to do on one problem, go on to the next problem and come back to the unfinished problems later.

(10 pts) 1. Write the complex number z = 7 + 4i in the polar representation form.

(10 pts) 2. A sinusoidal wave of form Asin ($3m^{-1}x - 1000s^{-1}t$) is combined with a second sinusoidal wave of the same amplitude, and of angular frequency $1050s^{-1}$. The resulting waveform travels with no change in shape. What is the wavenumber, k, of the second sine wave?

(15 pts) 3. A series of equal masses are joined by springs, with equilibrium spacing $\Delta x = 100$ μm. Under the action of a longitudinal wave, the displacements of three neighboring masses are: $\xi 1 = 0.0987$ μm, $\xi 2 = 0.1069$ μm and $\xi 3 = 0.0796$ μm. Find the approximate value of the displacement curvature ($\partial^2 \xi / \partial x^2$) at the position of the second mass. (Give units on curvature.)

4. The charge on the capacitor of a series LC circuit is given by

$$Q = (15\mu C)\cos\left(1250 s^{-1} t + \pi/4\right).$$

(5 pts) a) What is the current in the circuit?

(10 pts) b) If the inductance L = 28 mH, what is the capacitance?

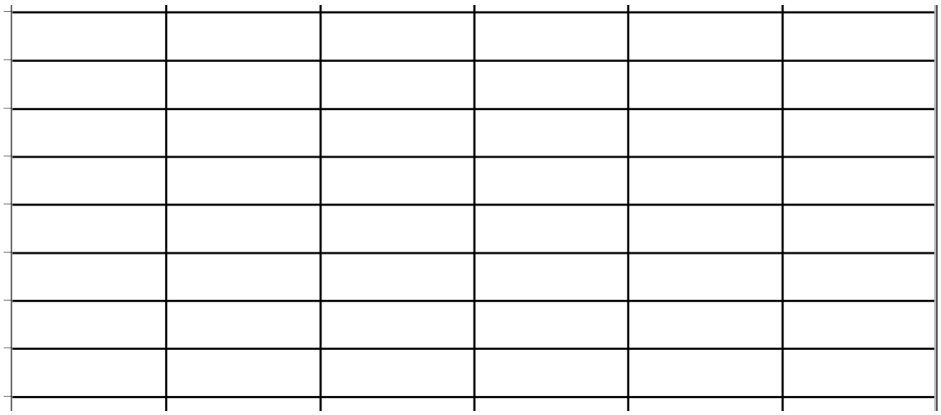
(5 pts). Extra credit (DO THIS PROBLEM LAST!!)

A garbage recycling plant spreads incoming refuse on a conveyor belt. The belt passes slowly under a strong permanent magnet that extracts iron-containing material. Then the belt passes over a strong, rotating magnet. What is the purpose of the second magnet? Describe the physical principal that makes it effective.

5. A waveform generator is set to mimic speech by creating a signal A(t) that contains a sum of sine waves of different frequencies.

(5 pts) a) In measuring the signal from this generator, how long would the measurement need to be to extract most of the information content if the frequencies range continuously from ν = 200 Hz to 1000 Hz.? How long would the measurement need to be if only two frequencies, 400 Hz and 600 Hz are included?

(20 pts) b) Derive an expression for the sum of the 400 Hz and 600 Hz waves (assume equal amplitude) and draw the waveform carefully over one full period of the sum waveform. Identify the times at which maxima in amplitude occur, and the times at which a discontinuity in slope occur. Shade in the area corresponding to the time interval calculated in part a.



6. Water has a mass density of 10^3 kg/m^2 and a bulk modulus of 2.1×10^9 N/m^2.

(15 pts) **a)** A very long pipe of diameter 1 cm is filled with water. A mechanical piston in contact with the water at one end of the pipe creates an oscillatory displacement of amplitude 0.1mm and frequency 1200 Hz. Write the differential equation and the corresponding waveform for the resulting longitudinal wave in the water. (assume there is no friction, no heating, no energy losses of any kind).

(10 pts) **C)** Assuming 100% efficiency, what power must the piston generate to maintain the wave in the water?

