Physics Problems (show explicitly all your work for full credit):

1. Bloomfield: Exercise 41, page 314
2. Bloomfield: Problem 1, page 314

4. Some organ pipes are open at one end and closed at the other. The length of such a pipe is the distance from a node to the first antinode of a wave having the proper frequency and traveling at the velocity of sound in air.

Given: A certain organ pipe is 11 inches long. The velocity of sound in air is 1100 ft/sec at a certain temperature.

Find: (a) What is the wavelength, in feet, of the note produced by this organ pipe? 
(Note: 12 inches = 1 foot).

(b) What frequency does this note correspond to?
5. The transverse flute is a hollow tube closed at one end and open at the other, but the placement of the mouthpiece makes it act as if it were open at both ends.

*Given:* The room temperature is 20°C. The lowest note that can be played on a flute is C, at 261.6 Hz, and the highest note is C three octaves higher, at 2093 Hz.

*Find:* (a) What is the wavelength of the lowest C that can be played on a flute?  
(b) What is the wavelength of the highest C that can be played on the flute?  
(c) Draw the first three harmonics for the flute.  
(d) What is the distance from a node to an antinode for the lowest C on this instrument?

6. The transmitting antenna for a radio station is 7.00 km from your house. The frequency of the electromagnetic wave broadcast by this station is 536 kHz. The station builds a second transmitting antenna that broadcasts an identical electromagnetic wave in phase with the original one. The new antenna is 8.12 km from your house. Does constructive or destructive interference occur at the receiving antenna of your radio? Show your calculations.
7. Light waves bend when they pass from one medium into another having a larger index of refraction, because the wavelength for the same frequency of light must be smaller when the light travels slower in the second medium.

*Given:* Light travels at $3.00 \times 10^8 \text{ m/sec}$ in air but only $2.25 \times 10^8 \text{ m/sec}$ in water. The wavelength of the yellow light from a sodium arc lamp is $5.89 \times 10^{-7} \text{ m}$ in air.

*Find:* (a) What is the frequency of this light? (b) What is the wavelength of this same frequency of light as it travels at a slower velocity in water?

8. The figure above shows three situations in which light reflects almost perpendicularly from the top and bottom surfaces of a thin film, with the indices of refraction as shown. *For a film to appear dark, the waves represented by rays 1 and 2 must be out of phase.* This can arise from phase shifts associated with the reflection at the top and bottom surfaces of the film and the extra distance traveled by ray 2 as it moves through the film.

(a) For all 3 situations, write the relation between thickness and wavelength for constructive and destructive interference.

(b) For which situation(s) is there a net phase shift (due to reflection) between waves 1 and 2 that is equivalent to either zero wavelengths or one wavelength $\lambda$, where $\lambda$ is the wavelength of the light in the film?

(c) For which situation(s) will the film appear dark when the thickness of the film is equal to $\frac{1}{2} \lambda$?
9. A soap film \((n = 1.33)\) is 375 nm thick and coats a flat piece of glass \((n = 1.52)\). Thus, air is on one side of the film and glass is on the other side, as shown to the left. Sunlight, whose wavelengths (in vacuum) extend from 380 to 750 nm, travels through the air and strikes the film nearly perpendicularly. For which wavelength(s) in this range does constructive interference cause the film to look bright in reflected light?

10. Young’s double slit diffraction pattern: Carefully count the number of wavelengths (same as the number of wave crests) along the following paths between the slits and the screen.

- a. Number of wavelengths between slit A and point a is _____
- b. Number of wavelengths between slit B and point a is _____
- c. Number of wavelengths between slit A and point b is _____
- d. Number of wavelengths between slit B and point b is _____
- e. Number of wavelengths between slit A and point c is _____
- f. Number of wave crests between slit B and point c is _____

When the number of wavelengths along each path is the same or differs by one or more whole wavelengths, interference is

- [constructive] [destructive]

And when the number of wavelengths differ by a half-wavelength (or odd multiples of a half-wavelength), interference is

- [constructive] [destructive].