Physics 2010 (Schroeder) Name ______________________________
spring 2004

Problem Set 11

(due Monday, April 5)

1. A periodic wave on a long, taut cord has a speed of 240 m/s and a wavelength of 3.2 m. What are the (a) frequency and (b) period of this wave?

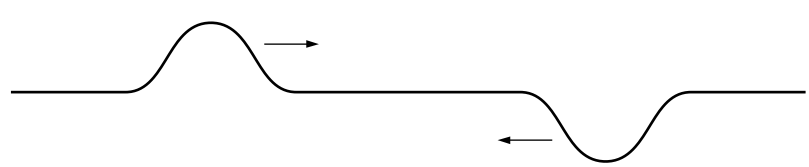
2. Ocean waves in a certain location have a wavelength of 40 meters, an amplitude of 1.5 meters, and a period of 5 seconds. (a) What is the (horizontal) speed of the waves? (b) A duck is floating on the water as these waves pass by. Very roughly, what is the average speed of the duck's motion?

3. The speed of electromagnetic waves in vacuum is 3.0×10^8 m/s. (a) Wavelengths of visible light waves range from about 400 nm (violet) to about 700 nm (red). What is the range of frequencies of visible light waves? (b) The range of frequencies for shortwave radio (including FM and VHF television) is 1.5 MHz to 300 MHz. What is the corresponding wavelength range? (c) X-rays are also electromagnetic waves. Their wavelength range extends from about 5.0 nm to about 0.01 nm. What is the corresponding frequency range?

4. Suppose you are wiggling the end of a long string, to produce a sinusoidal wave. After a while, you double the frequency of your wiggles, without changing the string tension. (a) What happens to the speed of the waves produced? (b) What happens to the wavelength of the waves produced?

5. The speed of a transverse wave on a string is 170 m/s when the string tension is 120 N. To what value must the tension be changed to raise the wave speed to 180 m/s?

6. Two pulses travel along a string in opposite directions, as shown below. (a) If the wave speed is 2.0 m/s and the peaks of the pulses are 6.0 cm apart at $t = 0$, sketch the patterns when $t = 5$, 10, 15, 20, and 25 milliseconds. (b) What has happened to the energy of the pulses at $t = 15$ ms?



7. Two identical sinusoidal traveling waves, moving in the same direction, are out of phase by $\pi/2$ radians. These waves combine to form a single resultant wave. How does the amplitude of the resultant wave compare to the amplitudes of the original waves? (Please answer this question by *carefully* plotting both waves, then adding the waves graphically and measuring the resulting amplitude with a ruler.)

8. A nylon guitar string has a length of 90 cm (between the fixed supports), a tension of 150 N, and a mass per unit length of 7.2 g/m. (a) What is the speed of traveling waves on this string? (b) Suppose that the string is oscillating in a standing wave pattern with two nodes (hence three "bumps"). What is the wavelength of this standing wave? (c) What is the frequency of the standing wave?

9. A 1.5 meter wire has a mass of 8.7 g and is held under a tension of 120 N. The wire is held from both ends and set into vibration. Calculate (a) the speed of waves on the wire; (b) the

wavelengths of the three longest-wavelength sinusoidal standing waves; and (c) the frequencies of these standing waves.

10. At high noon, the intensity of solar radiation reaching earth's surface is about 1000 watts per square meter. Solar photovoltaic panels can convert this radiant energy into electrical energy with an efficiency of about 15%. What size panels would you need, if you wished to power an electric hairdryer (requiring 1500 watts), assuming that it is high noon and the panels are directly facing the sun? Briefly discuss some of the issues that make it awkward to implement solar electrical systems in homes.

11. The intensity of sunlight striking earth's upper atmosphere is measured to be 1370 watts per square meter. Use this measurement to calculate the sun's *total* power output, assuming that the sun emits power equally in all directions.

Study Guide

You should understand the following terms as applied to waves: transverse; longitudinal; amplitude; frequency; period; wavelength; speed; superposition; interference; standing wave; fundamental frequency; intensity.

The speed of a wave is the speed at which any recognizable "feature" (such as a crest or trough) travels. This is *not* the same as the speed of the medium that carries the wave. For instance, the speed of a water wave is not the same as the same as the speed of the water molecules that carry the wave (or of a duck floating on the water). For a periodic wave, we can take Δt to be one full period of the wave, during which our "feature" will travel a distance of exactly one wavelength; therefore the wave's speed can be calculated as

$$v_x = \frac{\Delta x}{\Delta t} = \frac{\lambda}{T} = \lambda f.$$

You should either memorize these formulas or (better) be able to figure them out.

For transverse waves traveling along a taut string, Newton's laws of motion predict that the speed should be

$$\text{speed} = \sqrt{\frac{\text{tension}}{\text{mass/length}}}.$$

(This equation is not in your textbook and you needn't memorize it.) Thus the tighter the string, the faster the wave travels, while the heavier the string (per unit length), the slower the wave travels.

You should understand the principle of superposition as applied to waves and wave pulses. You should be able to determine when two waves will cancel completely ("destructive interference") and when they will add to a maximum resultant wave ("constructive interference").

You should be able to draw standing-wave patterns and determine the various standing-wave wavelengths and frequencies for a string (or rope or cord) that is fixed at both ends.