# Recitation 1

Chapters 12 and 13

**Problem 12.1.**

**Problem 12.7.**

**Problem 12.20.**

**Problem 12.31.**

**Problem 12.33.**

**Problem 12.38.**

**Problem 13.16.**

**Problem 13.18.** A series of pulses, each of amplitude 0.150 m, are sent down a string that is attached to a post at one end. The pulses are reflected at the pulse and travel back along the string without loss of amplitude. When two waves are present on the same string, the net displacement of a particular element of the string is the sum of the displacements of the individual waves at that point. What is the net displacement of an element at a point on the string where two pulses are crossing (a) if the string is rigidly attached to the post and (b) if the end at which reflection occurs is free to slide up and down.

(a) With a rigid connection, the reflected pulses will be inverted. Therefor, overlapping pulses will cancel out (destructive interference) and the total amplitude will be 0 m.
(b) With a sliding connection, the reflected pulses will not be inverted. Therefor, overlapping pulses will add together (constructive interference) and the total amplitude will be 0.300 m.

**Problem 13.27.** An ultrasonic tape measure uses frequencies above 20 MHz to determine the dimensions of structures such as buildings. It does so by emitting a pulse of ultrasound into the air and then measuring the time interval for an echo to return from a reflecting surface whose distance away is to be measured. The distance is displayed as a digital readout. For a tape measure that emits a pulse of ultrasound with a frequency of 22 MHz, (a) what is the distance to an object from which the echo pulse returns after 24.0 ms when the air temperature is 26°? (b) What should be the duration of the emitted pulse if it is to include ten cycles of the ultrasonic wave? (c) What is the spatial length of such a pulse?

The speed of sound in dry air is approximately

$$v = 331 \text{ m/s} + 0.6 \text{ m/s}\cdot{}^\circ\text{C}\ , \tag{1}$$

so at 26°C, $v = 347$ m/s.
(a) The elapsed time is the time taken for the pulse to travel from the tape measure to the object and back, traveling the distance between the tape measure and the object twice.

$$2d = vt \qquad\qquad d = \frac{vt}{2} = 4.16 \text{ m} \tag{2}$$

(b) A pulse containing ten cycles is ten periods long

$$\Delta t = 10T = \frac{10}{f} = \frac{10}{22 \cdot 10^6 \text{ s}} = 0.455\ \mu\text{s} \tag{3}$$

(c)

$$L = v\Delta t = 347 \text{ m/s} \cdot 0.455\ \mu\text{s} = 0.158 \text{ mm} \tag{4}$$