LAB 11
Standing Waves

OBJECTIVES

(1) Observe the behavior of transverse and longitudinal standing waves.
(2) Experimentally measure the wavelength, frequency, and speed of waves.
(3) Experimentally verify $v = \sqrt{\frac{F}{m/L}}$ for the speed of waves on a string.
(4) Calculate the speed of sound in air.
(5) Observe the **very cool** standing wave patterns in a vibrating metal plate (Chladni plate).

EQUIPMENT

Strings, elastic cords, masses, Mechanical Wave Driver, function generator, pulleys, clamps, support rods, Chladni plate, meter stick, water tubes, jugs, and tuning forks.

PROCEDURE

Part 1: Standing Waves on an Elastic Cord

(a) Attach one end of the cord to the Mechanical Wave Driver and pass the other end over a pulley attached to the end of the lab table. Attach 310 g (total) to the end of the cord.

(b) Attach the Mechanical Wave Driver to the function generator and drive the elastic cord using a sine wave.

(c) Vary of the frequency of the function generator until you produce a standing wave at the cord's fundamental frequency (or first harmonic).

(d) *Record the frequency of the function generator and hence the frequency of the wave. Measure the wavelength of the wave. From the frequency and wavelength, calculate the wave speed.*

(e) *Increase the frequency and produce standing waves at each of the higher harmonic frequencies (n = 2, 3, 4, …). Calculate the wave speed at each of these frequencies.* ***You should be able to get to at least the 10th harmonic.***

(f) How well do your wave speeds compare at the different frequencies? Calculate the average and the standard deviation of the wave speed from your values.

(g) Directly measure the wave speed of the elastic cord by timing how long it takes a pulse to go back and forth across the lab room. How does the measured wave speed compare with your group's experimental wave speed?

(h) *Calculate the theoretical wave speed ($v = \sqrt{\frac{F}{m/L}}$). The linear mass density of the elastic cord is m/L $\approx$ 0.0033 kg/m.*

(i) Is your group's experimental wave speed consistent with the theoretical value?

Part 2: Standing Sound Waves

(a) Listen for the fundamental standing sound wave in a tube driven with a small speaker. Start with the water level near the top of the tube and lower it until a resonance is heard. Then sweep up and down through the resonance level several times to locate it accurately. *(Warning; this is tricky!)*

(b) Mark the location of the resonance with a rubber band. Where are the waves reflected in this system, and are the reflection points nodes or antinodes?

(c) Continue lowering the water until you find the next resonance (third harmonic). Sketch the third harmonic standing wave in your notes.

(d) *From the frequency and wavelength of the standing wave (Hint: measure the distance between the rubber bands), calculate the speed of sound in the tube.*

(e) *The accepted value for the speed of sound is temperature dependent and given by*

$$v_{sound} = \sqrt{\frac{\gamma RT}{M}} = 20.1\sqrt{T} \text{ m/s}$$

where T is the temperature measured in Kelvin. Are your measurements consistent with the accepted value?

Part 3: Standing Waves on Chladni Plates

(a) For the Chladni plate, vary the frequency of the function generator until you produce a standing wave. You will be able to tell if you have produced a standing wave by sprinkling sand on the vibrating plate as demonstrated by your fearless instructor.

(b) *Produce **at least** 4 standing waves and sketch each wave in your lab notebook. Be sure and label the frequency of the standing wave for each sketch.*