CH 21-4 – Standing Sound Waves

Important Ideas

- The pressure at an open end of a pipe is atmospheric air pressure, so it is constant and is a node. The displacement of the air at an open end of a pipe is an antinode.
- The pressure at a closed end of a pipe is an antinode, and the displacement is a node.
- For a pipe that is open at both ends or closed at both ends, the frequencies and wavelengths are given by the same equations as a string that is fixed at both ends.

$$\begin{aligned} \lambda &= \frac{2L}{n} \\ f_n &= \frac{n}{2L}v \\ f_n &= nf_1 \end{aligned}$$

- For a pipe that is open at one end and closed at the other, only the odd harmonics ($n = 1, 3, 5, ...$) exist. The fundamental has a wavelength that is 4 times the length of the pipe.

$$\begin{aligned} \lambda &= \frac{4L}{n} \\ f_n &= \frac{n}{4L}v \\ f_n &= nf_1 \end{aligned}$$

1. Sketch the pressure as a function of position for the first four harmonics for a standing longitudinal wave in a column that is open on both ends.

2. Sketch the pressure as a function of position for the first four harmonics for a standing longitudinal wave in a column that is closed on both ends.

3. Sketch the pressure as a function of position for the first four harmonics for a standing longitudinal wave in a column that is open on one end and closed on the other.

4. Which harmonic is the standing wave shown below?

Figure 1: Standing longitudinal wave in a cylinder.

5. If the length of the cylinder in the previous question is 0.5 m, what is the frequency of the sound?

6. Which harmonic is the standing wave shown below?

Figure 2: Standing longitudinal wave in a cylinder.

7. If the length of the cylinder in the previous question is 0.5 m, what is the frequency of the fundamental?