Chapter 14

Terms

Be able to define or discuss the following terms and ideas, with their SI units if appropriate.

1. wavefunction
2. wavelength
3. frequency
4. period
5. speed (wave speed)
6. transverse wave
7. longitudinal wave
8. superposition
9. standing wave
10. node
11. antinode
12. harmonics for a standing wave on a string that is fixed at both ends
13. speed of a transverse wave on a string and how it relates to tension and linear density
14. displacement and pressure for a longitudinal wave
15. boundary conditions for a closed end of a pipe
16. boundary conditions for an open end of a pipe
17. harmonics for a standing longitudinal wave in a pipe that is open on both ends
18. harmonics for a standing longitudinal wave in a pipe that is open on one end and closed on other end
19. speed of a longitudinal wave in a medium and how it depends on the type of medium (such as whether it is a solid, liquid, or gas)
20. beats (or beating)
21. sound level
22. intensity
23. Doppler effect

Equations

Understand the meaning and know the SI units of all symbols in these equations; know how to perform each mathematical operation, such as trig functions; know how to solve for any unknown quantity; understand how changing one quantity affects another quantity (if all other quantities remain constant); be able to apply one or more equations to solve a problem.

- frequency
$$f = \frac{1}{T} \tag{1}$$
- wave speed
$$v = \lambda f \tag{2}$$
- wavelength of harmonics of a transverse standing wave on a string that is fixed on both ends
$$\lambda = \frac{2L}{n} \tag{3}$$
- speed of a wave on a string
$$v = \sqrt{\frac{T}{\mu}} \tag{4}$$
- frequencies of harmonics on a string fixed at both ends as a function of the properties of the string
$$f = \frac{n}{2L}\sqrt{\frac{T}{\mu}} \tag{5}$$
- wavelength of harmonics of a longitudinal standing wave in a pipe that is open at both ends
$$\lambda = \frac{2L}{n} \tag{6}$$
- wavelength of harmonics of a longitudinal standing wave in a pipe that is closed at one end and open at the other end
$$\lambda = \frac{4L}{n} \qquad n = 1, 3, 5... \text{ (odd harmonics)} \tag{7}$$
- beat frequency $= |f_1 - f_2|$
- sound level
$$\text{sound level} = 10 \text{ dB} \log_{10}\left(\frac{I}{I_0}\right) \tag{8}$$
- Doppler effect
$$f_d = \left(\frac{v \mp v_d}{v \pm v_s}\right) f_s \qquad \text{upper sign is for detector and source moving away from each other} \tag{9}$$

Skills

1. Sketch at least the first five harmonics for a transverse standing wave on a string.
2. Sketch at least the first five harmonics for a longitudinal standing wave in a pipe open at both ends.
3. Sketch at least the first five harmonics for a longitudinal standing wave in a pipe that is open on one end and closed on the other end.
4. Discuss how changing L, T, or μ affects the frequency of the fundamental standing wave for a stringed instrument.

5. View a picture of a standing transverse or longitudinal wave and identify the harmonic.
6. View a picture of a standing transverse or longitudinal wave and find the antinodes and nodes of a standing wave.
7. Know that an increase in the sound level by an additional 10 dB corresponds to the intensity increasing by a factor of 10.
8. Know that if the source and detector are moving toward each other, the wavelength of the detected sound waves is shorter (and thus frequency is higher).
9. Know that if the source and detector are moving away from each other, the wavelength of the detected sound waves is longer (and thus frequency is shorter).
10. View a picture of sound waves from a point source and identify the direction of motion of the source.

Lab Skills

1. Use a picture of a sinusoidal wave (y vs. x) to measure the amplitude and wavelength of the wave.
2. Use a graph of y vs. t for an oscillating point on a string to determine the amplitude and period of the wave.
3. Use a curve fit of the form $v = (\text{const})\sqrt{T}$ to determine the linear density of the string.
4. Use a picture of a standing transverse wave on a string fixed at both ends to determine the harmonic # and the wavelength of the wave.