Preparation Notes for Chapter 17 (Sound; 2-3 classes)

Note: these notes are still rather rough, as I have often been away when this section of the course is taught

Introduction to Sound

Reading is 17.1-17.2; problems 17.7, 17.45

(1) Introduction: could start with discussion: what kinds of things produce sound? are there different kinds of sound (like there are different kinds of EM radiation)? three types of sound waves: audible, infrasonic (elephants, whales?), ultrasonic (dogs, medical imaging); sound waves are longitudinal waves; particles in medium vibrate to produce changes in density and pressure; high and low pressure regions

(2) Presentations on speed of sound in air; speed of sound in air and water

(3) (follow-up) Speed of sound waves: $v = \sqrt{B/\rho}$ where B is the bulk modulus of the medium ($B = -\Delta V/(V_i \Delta P)$); v = $\sqrt{(elastic\ property)/(inertial\ property)}$; depends on temperature of medium; in air v = 331 m/s $\sqrt{1 + T/273}$

(4) Periodic sound waves: piston oscillates sinusoidally; sets up high pressure regions (condensations) and low pressure regions (rarefactions); wavelength equals distance between two successive condensations; medium oscillates in SHM parallel to wave direction; $s(x,t) = s_{max}\cos(kx - \omega t)$ where s_{max} is the maximum displacement of the medium from equilibrium; $\Delta P = \Delta P_{max}\sin(kx - \omega t)$, and $\Delta P_{max} = \rho v \omega s_{max}$

Intensity of sound

Reading is 17.3-17.4; problems 17.25, 17.27

(1) Intensity of sound; average power depends on the area the power is being transmitted over i.e. a very big (5 m) wave only 10 m wide has same power as a 1 m wave that is much longer, but only the 5 m wave will knock you down! intensity is power per unit area; recall we worked out the power in a wave in a string to be $P = \frac{1}{2}\mu\omega^2 A^2 v$; for the sound wave, substitute ρA (where A is area) for μ and s_{max} for A, to get $I = P_{avg}/A = \rho v \omega^2 s_{max}^2/2 = \Delta P_{max}^2/(2\rho v)$

(2) Intensity of spherical waves; source has a certain power; $I = P/A = P/(4\pi r^2)$ i.e. wave front is getting larger in area as it moves outward

(3) discussion topic: how does a megaphone work? (if time)

(4) A good scale for sound intensity; 1 W/m^2 is pain threshold, while 10^{-12} W/m^2 is hearing threshold; logarithmic scale $\beta = 10 log(I/I_o)$ where $I_o = 10^{-12}$ W/m^2; human hearing 0-120 decibels (dB)

(5) Problem 17.25 (decibels and adding sound) (if time)

(6) Presentations involving intensity of sound

Doppler effect and Shock Waves

Reading is 17.5-17.4; problems 17.39, 17.55

(1) Has anyone ever heard the Doppler effect? Where?

(2) Doppler effect: first discuss when observer is moving towards source and source is stationary; draw a series of circular waves and then a moving observer; λ is unchanged; speed of crests seen by observer is larger, therefore $f = v/\lambda$ is larger; $v' = v + v_o$ so $f_o = v'/\lambda = (v/\lambda)(1 + v_o/v) = f(v + v_o)/v$

(3) Doppler continued: then discuss when source is moving towards a stationary observer; draw the waves from the moving source (bunched up in direction of motion); now wave speed is unchanged (a property of the medium i.e. air); so if λ goes down, f goes up; $\lambda_o = \lambda - v_s/f$ so $f_o = v/\lambda_o = v/(v/f - v_s/f) = fv/(v - v_s)$

(4) Full Doppler equation is $f_o = f(v \pm v_o)/(v \mp v_s)$; upper sign is associated with motion towards

(5) Presentation on Doppler effect

(6) Presentation on bow waves in water (if scheduled)

(7) Follow-up: $\sin\theta = v/v_s$ where v is the speed of waves in the medium and v_s is the speed of the source; sketch figure 17.12 from textbook.

(8) Problem 17.55 (Bat chasing an insect) (if time)

Suggested Presentation Topics

See master list