Standing Waves
• Formed through reflection + superposition of waves moving in opposite directions
• Contains ‘nodes’ (no displacement) and ‘anti-nodes’ (maximum displacement)
• “Normal Mode”: property of a system in which all particles move sinusoidally at same freq.
• Lowest freq. normal mode: ‘fundamental’
  Higher freq. normal modes: ‘harmonics’/‘overtones’

Longitudinal Waves
• Displacement is in direction of wave motion
• Need to distinguish particles from pressure

Sound as Pressure Wave
Three ways to describe sound waves
Pressure is 90° out of phase with displacement!

Standing waves and Normal modes
Pre-reading: §16.1

Three ways to describe sound waves
Pressure is 90° out of phase with displacement!

Sound as Pressure Wave

Longitudinal Standing Waves
• Waves reflect at open or closed end
• Need to distinguish displacement of particles from pressure
• Node: no displacement
• Anti-node: Time-averaged location where max displacement is reached
• Displ. node = Pressure anti-node
  Displ. anti-node = Pressure node

Open pipes
\[ f_n = \frac{n \nu}{2L}, \quad n = 1, 2, 3, \ldots \]

Closed pipes
\[ f_n = \frac{n \nu}{4L}, \quad n = 1, 3, 5, \ldots \]

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§15.8

§16.1

§16.1

§16.4
Next lecture

Sound waves
and
Perception of sound

Read §16.1–16.3