Physics 121 – December 5, 2017

Announcements:

- Final exam on Thursday, Dec 14 at 9:00 AM in Workman 101
- Review on Dec 7 (last class meeting)
- Practice text available online. Note that it is about 50% *longer* than the length of the true final exam.

Assignments:

- Today, we will spend some time completing the FCI post-test.

- Last week of recitations. We will have a quiz on waves and do some practice problems from chapters 4, 5, and 8 (reviewing for final).

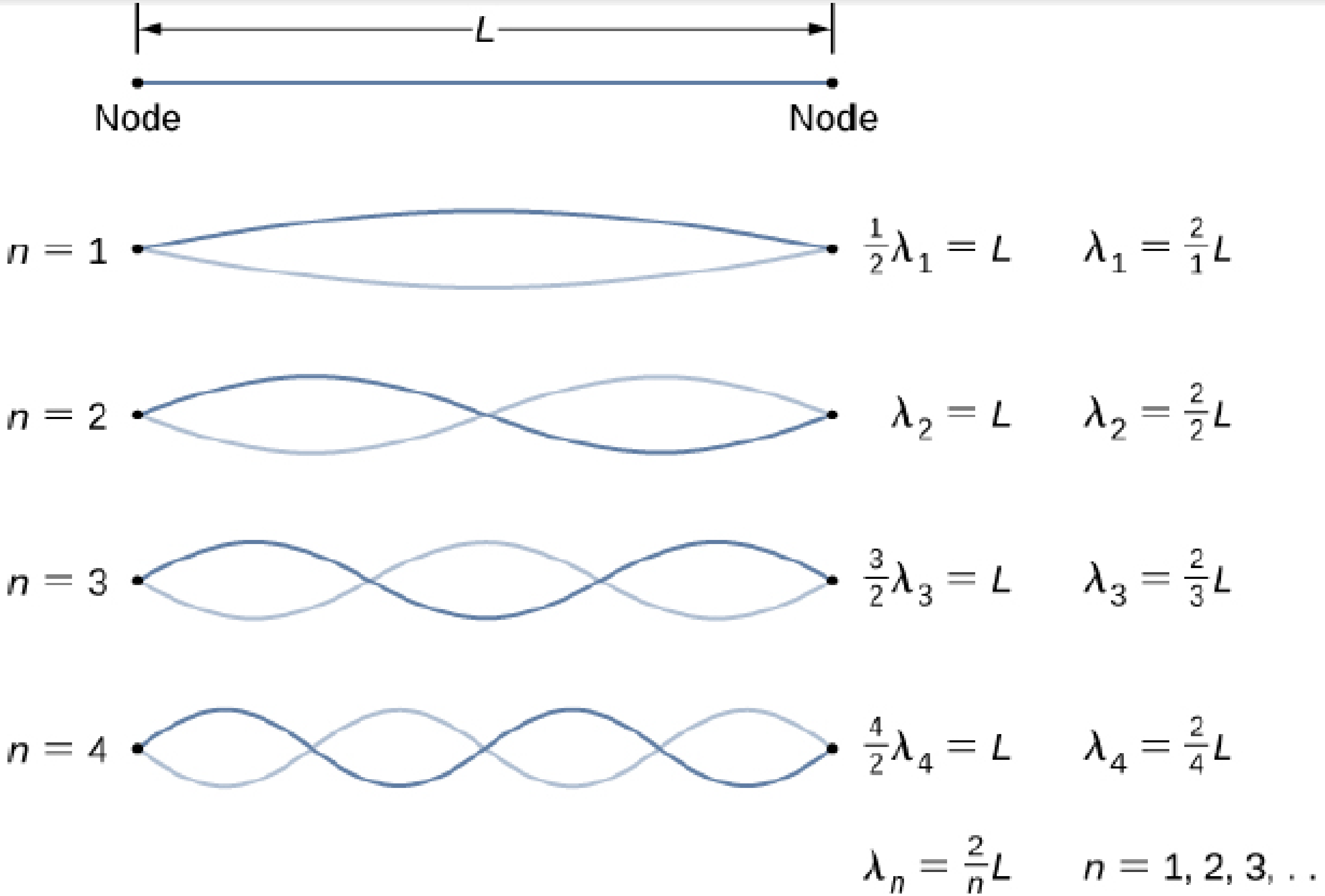

Figure 16.29 Standing waves created on a string of length L. A node occurs at each end of the string. The nodes are boundary conditions that limit the possible frequencies that excite standing waves. (Note that the amplitudes of the oscillations have been kept constant for visualization. The standing wave patterns possible on the string are known as the normal modes. Conducting this experiment in the lab would result in a decrease in amplitude as the frequency increases.)

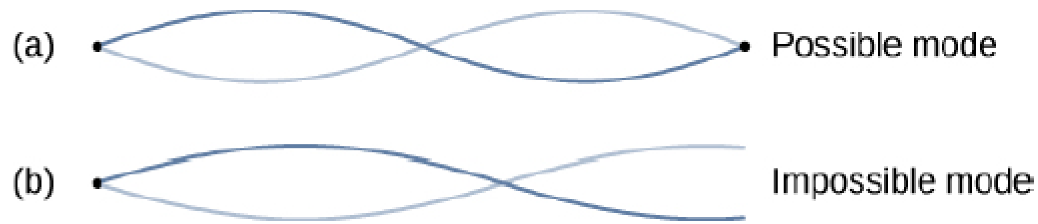

Figure 16.31 (a) The figure represents the second mode of the string that satisfies the boundary conditions of a node at each end of the string. (b)This figure could not possibly be a normal mode on the string because it does not satisfy the boundary conditions. There is a node on one end, but an antinode on the other.

But not impossible for a bar free to vibrate at one end, or at both ends.

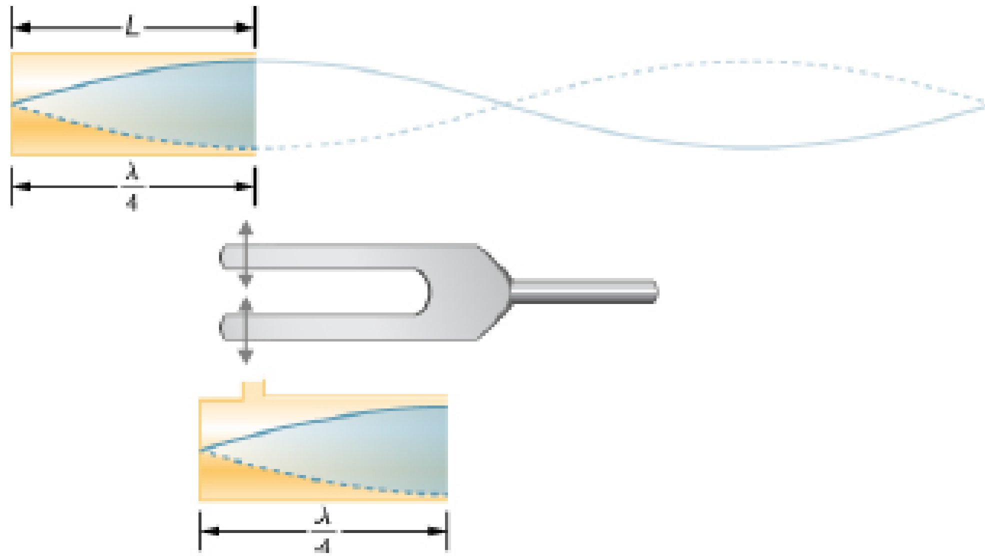

Figure 17.20 The same standing wave is created in the tube by a vibration introduced near its closed end.

Given that maximum air displacements are possible at the open end and none at the closed end, other shorter wavelengths can resonate in the tube, such as the one shown in Figure 17.21. Here the standing wave has three-fourths of its wavelength in the tube, or $\frac{3}{4}\lambda_3 = L$, so that $\lambda_3 = \frac{4}{3}L$. Continuing this process reveals a whole series of shorter-wavelength and higher-frequency sounds that resonate in the tube. We use specific terms for the resonances in any system. The lowest resonant frequency is called the **fundamental**, while all higher resonant frequencies are called **overtones**. All resonant frequencies are integral multiples of the fundamental, and they are collectively called **harmonics**. The fundamental is the first harmonic, the first overtone is the second harmonic, and so on. Figure 17.22 shows the fundamental and the first three overtones (the first four harmonics) in a tube closed at one end.

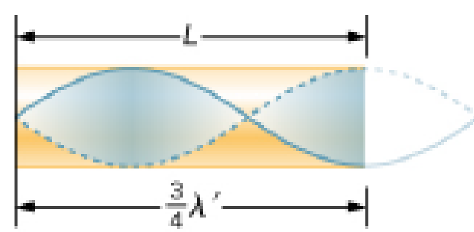

Figure 17.21 Another resonance for a tube closed at one end. This standing wave has maximum air displacement at the open end and none at the closed end. The wavelength is shorter, with three-fourths λ' equaling the length of the tube, so that $\lambda' = 4L/3$. This higher-frequency vibration is the first overtone.

Resonance in a Tube Open at Both Ends

Another source of standing waves is a tube that is open at both ends. In this case, the boundary conditions are symmetrical: an antinode at each end. The resonances of tubes open at both ends can be analyzed in a very similar fashion to those for tubes closed at one end. The air columns in tubes open at both ends have maximum air displacements at both ends (Figure 17.23). Standing waves form as shown.

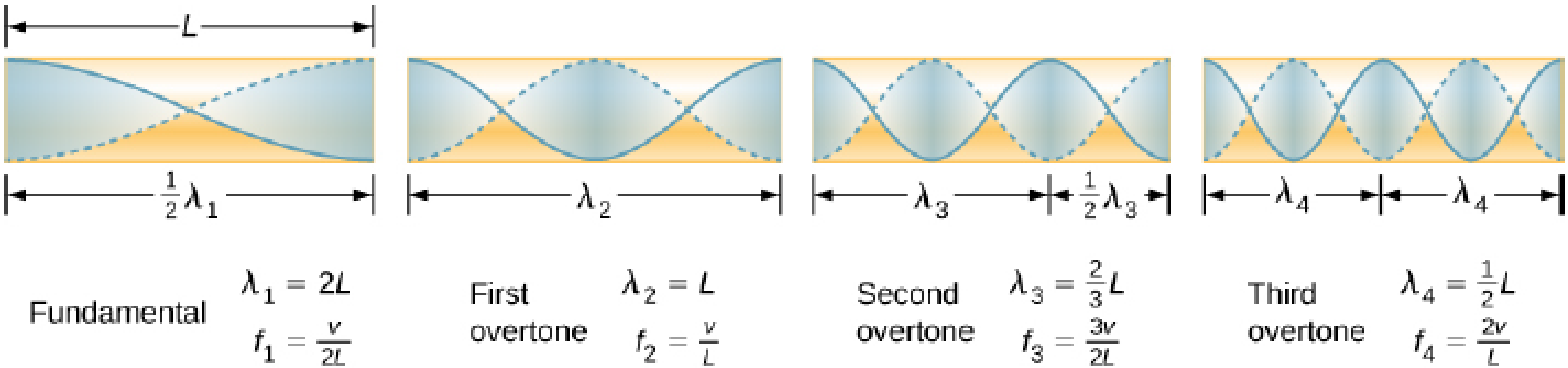

Figure 17.23 The resonant frequencies of a tube open at both ends, including the fundamental and the first three overtones. In all cases, the maximum air displacements occur at both ends of the tube, giving it different natural frequencies than a tube closed at one end.

The relationship for the resonant wavelengths of a tube open at both ends is

$$\lambda_n = \frac{2}{n}L, \quad n = 1, 2, 3, \ldots \tag{17.15}$$