THE SCIENCE OF MUSIC

EXERCISES FOR CHAPTER 13

13.1   What are the frequencies of the first three modes of vibration of a rectangular wooden bar 25 cm long and 1.5 cm thick?

13.2   A rectangular wooden bar plays the note C5 when struck. What note would be played by a bar of the exact same dimensions made of (a) fiberglass and (b) steel?

13.3   What approximately is the musical interval between the fundamental and the second mode of a vibrating rectangular bar? What is the interval between the fundamental and the third mode?

13.4   Two xylophone bars play the notes A4 and A5. Assuming the thickness of the bars is the same and they are made of the same type of wood, what is the ratio of their lengths?

13.5   At the end of Section 13.1.2 we showed that Eq. (13.1) for the frequency of a vibrating bar is in error by 12.9 musical cents for the fundamental mode. By how many cents is the formula in error for the second mode?

13.6   A standard vibraphone spans the range from F3 to F6. What are the lengths of the longest and shortest resonator tubes?

13.7   A standard set of tubular bells spans the range from C4 to F5. The shortest bell has length 50 cm. How long is the longest one, assuming all the bells are made of piping with the same diameter and thickness?

13.8   An orchestral triangle is 20 cm along each edge of the triangle, cylindrical in shape with a 10 mm diameter, and made of solid steel. Approximately what is it's fundamental frequency of vibration?

13.9   A church has six bells that play the first six notes of a major scale. The lowest pitched bell is 1 meter in diameter. What is the diameter of the highest pitched, if the bells scale according to Eq. (13.48)?

13.10   Six and eight bells are the most common numbers found in churches and cathedrals, but sometimes one of the bells may not be working, and one can still ring changes on the remaining bells. How long would it take to ring a full extent of changes on seven bells, if you can ring one change every two seconds?

13.11   A mylar drum head with diameter 40 cm and weight $250\,\text{g/m}^2$ has tension 600 N/m.

a) What are the frequencies of the first three modes of vibration of the drum head, ignoring any effects of air loading or the drum body?
b) When we account for air loading, will the frequencies be higher or lower?

13.12   A timpani has a mylar drum head with weight $250\,\text{g/m}^2$, diameter 70 cm, and tension 2000 N/m.

a) What will be the frequency of the lowest vibration mode, ignoring air loading and any effects of the drum body?
b) When air loading and body effects are taken into account what will be the frequency of the lowest vibration mode?
c) What is the frequency of the note the ear will actually hear when the timpani is played?

13.13   The largest bass drums used in a marching bands have a diameter of 28 inches and a drum head that vibrates back and forth about a millimeter when struck firmly. If the fundamental frequency of such a drum is 100 Hz, about how loud will the sound be in decibels to a listener 5 meters away?