TT3010 - Audio technology and room acoustics.
Exercise 7 - Music instruments.

August 13, 2020

All tasks are based on chapters 10-12 in Rossings "Science of Sound" **?**. It is recommended that the student will try to do every task, but tasks marked *Mandatory* are to be handed in for approval (online). Deadline is November 23 at 16:00.

Tasks

String instruments

1. *Mandatory.* In fig. 10.3. and 10.5, note that plucking a string one-fifth the distance from one end suppresses the fifth harmonic, and plucking it at the midpoint (one-half the distance) suppresses the second harmonic. Also note that the phase of the harmonics (indicated by + and -) changes in going through a zero. Using this information, draw a similar diagram to show the addition of modes to obtain the shape of a string plucked at one-third its length.

2. Determine the musical intervals between the strings of the guitar (see section 10.9) and those of the electric bass (see section 10.15).

Wind instruments

3. *Mandatory.* Calculate the two lowest resonance frequencies of a pipe 46 cm long closed at both ends. Do the same for a pipe 33 cm long. Now compare these frequencies to those given for the resonances A_2 and A_4 (longer pipe) and A_3 and A_5 (shorter pipe) in fig. 10.27c. Discuss the significance of the similarity.

4. *Mandatory.* Assume that the length of a trombone is 275 cm in first ("open") position. How far should the slide have to be moved to lower the pitch one semitone? (Remember the length is increased by twice this amount.) If possible, compare this with the slide motion of an actual trombone.

5. *Mandatory.* A B$^\flat$ clarinet is about 67 cm long.

    a. What is the lowest resonance frequency of a closed pipe of that length?[1]

    b. The lowest note on a $B^\flat$ clarinet is D_3. Compare its frequency to your answer in a.

    c. Can you explain the difference between these two frequencies?

6. The length of an alto recorder (from the wind-way to the bell) is about 42 cm.

    a. What are the lowest resonance frequency of an open pipe of that length?

    b. The lowest note on the recorder is F_4. Compare its frequency to your answer in a.

    c. Explain the difference between these two frequencies.

FIGURE 10.3 Odd-numbered modes of vibration add up in appropriate amplitude and phase to the shape of a string plucked at its center.
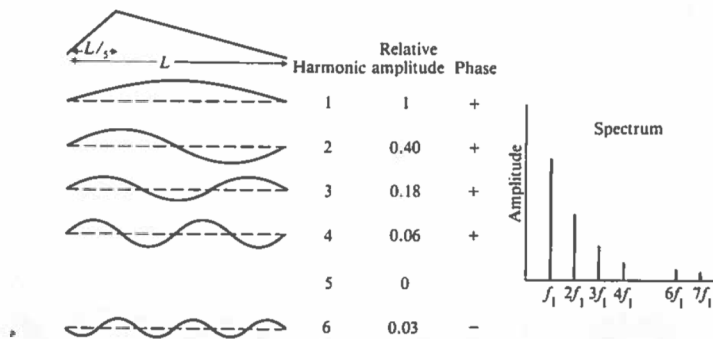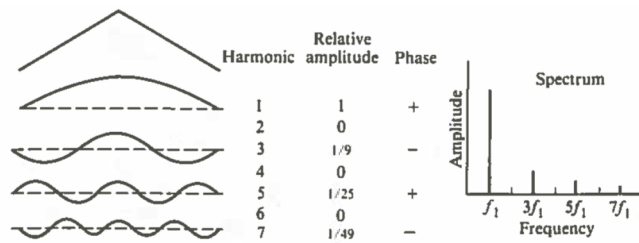

FIGURE 10.5 The addition of modes to obtain the shape of a string plucked at one-fifth its length. It should be noted that the spectra in Fig. 10.3 and the figure above show the relative amplitudes of the different modes of vibration. The spectra of the radiated sound will have the same frequencies but their relative amplitudes will be quite different due to the acoustical properties of the instrument.

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[1]In the book "Science of sound", the term "closed pipe" should be understood as a pipe which is closed at one end but open at the other end.

FIGURE 10.27
(a) Modes of a folk guitar top (Martin D-28) with the back and ribs in sand; (b) modes of the back with the top and ribs in sand; (c) modes of the air cavity with the guitar body in sand. Modal designations are given above the figures and modal frequencies below (Rossing, Popp, and Polstein 1985).

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