Tutorial No 3, Semester 2, 2025/26

1. A string is vibrating with 7 antinodes between its two ends with a frequency of 1,400 Hz. A second string 40 cm long which has 5 nodes between its two ends (not counting the nodes at either end) is vibrating at a frequency of 1,440 Hz. What is the length of the first string which is vibrating with 7 antinodes? A third string which is 64 cm long is vibrating at a frequency of 900 Hz. How many nodes would this third string have between its two ends (not counting the nodes at either end)? (Assume that the three strings are similar in all respects except length.)

2. A sailing boat is travelling in the same direction and speed as the water waves on the surface of a lake, and the length of the boat happens to be exactly equal to 6 complete wavelengths of the waves. Calculate the length of the boat if the waves are moving with a speed of 1.4 m/s with a frequency of 1 Hz. The speed of the waves then increases to 1.8 m/s and the frequency increases to 1.2 Hz. How many wavelengths would now equal the length of the boat?.

3. A string has a fundamental frequency of 126 Hz. Its frequency when vibrating with 8 antinodes between its two ends is the same as that of a closed pipe of length p cm. If the closed pipe is vibrating with 4 nodes between its two ends (not counting the node at one end), what is its fundamental frequency? When

the closed pipe vibrates with 6 nodes between its two ends (not counting the node at one end), its frequency is the same as that of an open pipe vibrating with 6 antinodes between its two ends (not counting the antinodes at both ends). Calculate the length of the open pipe.

4. A 42 cm long string vibrating with 3 nodes between its two ends (not counting the nodes at both ends) produces a musical note which combines with the note from a closed pipe. When the closed pipe which has a fundamental frequency of 66 Hz vibrates with 2 nodes between its two ends (not counting the node at one end), beats of 10 Hz are produced. When the string is shortened slightly, the beat frequency decreases (without passing through 0 Hz). Calculate the fundamental frequency of the string. The string is then shortened from 42 cm to 40 cm, and assuming that the beats are still produced by the same harmonics of the string and the closed pipe as before, calculate the new beat frequency. If the closed pipe's length is decreased to 75% of its original length, what would the beat frequency then be, assuming that the string is still 40 cm long?

5. The A string of a violin is being tuned by a violinist with the help of an electronic tuner which is producing a musical note with a frequency of 440 Hz. When the note from the tuner combines with the note from the A string, beats of 4 Hz can be heard. When the violinist gradually loosens the A string of the violin, the beat frequency gradually decreases (without

passing through 0 Hz) to 3 Hz. What was the frequency of the note produced by the violin's A string when the beat frequency was equal to 4 Hz? How can the violinist get the frequency of the A string to come as close as possible to 440 Hz? If the beat frequency had increased to 5 Hz instead on loosening the A string, determine the A string's frequency when the beat frequency was 4 Hz.

6. A closed pipe labelled E is sliced into eight pieces of equal length, creating seven short open pipes labelled E1 to E7, and a short closed pipe labelled E8. Five of the short open pipes E1, E2, E3, E4 and E5 are joined up to make an open pipe labelled F, while the remaining short open pipes E6 and E7 are joined up with E8 to make a closed pipe labelled G. If the fundamental frequency of E was f Hz, calculate the fundamental frequencies of the pipes E8, F and G. Determine the ratio of the interval between the frequency of F when it vibrates with 6 nodes between its two ends and G when it vibrates with 5 nodes between its two ends (not counting the node at one end).

Scientific Inquiry discussion points

The Equal-tempered scale is obtained by dividing an octave into twelve equal steps. This gives us a scale with twelve notes, which has become the basis of most of Western music, whether classical, popular, folk, rock or any other genre of music. The democratic equality of these twelve notes enables music to modulate into any of the twelve available keys with ease, using just twelve notes in one octave. This greatly simplifies the design of musical instruments and how they are played. But this is not a "perfect" system in mathematical terms, as the important interval of the fifth is not exactly 3/2 as in the Just and Pythagorean scales, but deviates by ever so slightly an amount which is not apparent to most listeners. Are there other examples in science and technology where imperfections are an important part of the basis of an actual working system?