

Tutorial No 3, Semester 1, 2026/27

1. A string is vibrating at a frequency of 1,600 Hz with 4 antinodes between its two ends. A second string 40 cm long which has 7 nodes between its two ends (not counting the nodes at either end) is vibrating at a frequency of 2,000 Hz. Calculate the length of the first string which is vibrating with 4 antinodes. A third string which is 50 cm long is vibrating at a frequency of 1,400 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 yacht is travelling in the same direction and speed as the water waves on the surface of the sea. The length of the yacht is exactly equal to 8 complete wavelengths of the waves. What is the length of the yacht if the waves are moving with a speed of 1.8 m/s with a frequency of 1.2 Hz? If the speed of the waves then decreases to 1.2 m/s and the frequency decreases to 1.0 Hz, how many wavelengths would then equal the length of the yacht?
3. A string is vibrating with 6 antinodes between its two ends and has a fundamental frequency of 140 Hz. Its frequency of vibration is the same as that of a closed pipe of length k cm which is vibrating with 3 nodes between its two ends (not counting the node at one end). Calculate the fundamental frequency

of the closed pipe. When the closed pipe vibrates with 4 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 5 antinodes between its two ends (not counting the antinodes at both ends). What is the length of the open pipe?

4. A string which is vibrating with 4 nodes between its two ends (not counting the nodes at both ends) and is 54.5 cm long produces a musical note which combines with a note from a closed pipe. The closed pipe which has a fundamental frequency of 48 Hz vibrates with 5 nodes between its two ends (not counting the node at one end), producing beats of 11 Hz with the vibrating string. When the string is slightly shortened, the beat frequency increases (without passing through 0 Hz). What is the fundamental frequency of the string? If the string is shortened from 54.5 cm to 53.9 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 increased to 120% of its original length, calculate the beat frequency assuming that the string is still 53.9 cm long.
5. A 'cellist tunes the A string of a 'cello with the help of an electronic tuner which is producing a musical note with a frequency of 220 Hz. When the note from the A string combines with the note from the tuner, beats of 3 Hz can be heard. When the 'cellist gradually tightens the A string of the 'cello, the beat frequency gradually decreases (without passing

through 0 Hz) to 2 Hz. Calculate the frequency of the note produced by the 'cello's A string when the beat frequency was equal to 3 Hz. Explain how the 'cellist could get the frequency of the A string to come as close as possible to 220 Hz. If the beat frequency had increased to 4 Hz instead on tightening the A string, what would have been the A string's frequency when the beat frequency was 3 Hz?

6. A closed pipe labelled A is sliced into seven pieces of equal length. This creates six short open pipes labelled A1 to A6, and a short closed pipe labelled A7. Four of the short open pipes A1, A2, A3 and A4 are joined up to make an open pipe labelled B. The remaining short open pipes A5 and A6 are joined up with A7 to make a closed pipe labelled C. If the fundamental frequency of A was f Hz, what would be the fundamental frequencies of the pipes A1, B and C? Calculate the ratio of the interval between the frequency of B when it vibrates with 7 nodes between its two ends and C when it vibrates with 6 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?

While we may consider mathematical and physical perfection to be most desirable, in the real world most things and processes deviate from mathematical perfection. One crucial example is in the DNA of our genetic code. The reproduction of DNA as it replicates in the multiplication of living cells is not perfect, in that errors may occur in the replication due to natural events such as the alteration of the DNA code by natural radiation or cosmic rays. This may seem undesirable and it does lead to undesirable effects sometimes, but this same process makes evolution possible, as the errors in replication allow changes in the make-up of living things, which may then make an organism less or more suited to the changing environment. Hence the progress brought about by evolution depends on these imperfections in replication.