

Tutorial No 4, Semester 1, 2026/27

1. An open pipe labelled K is sliced into eight pieces of equal lengths to create eight short open pipes labelled K1 to K8. Two of the short open pipes K1 and K2 are joined up to make an open pipe labelled L. The pipes K3, K4 and K5 are joined up to make another open pipe labelled M. The remaining pipes K6, K7 and K8 are joined up and closed up at one end to make a closed pipe labelled N. All three pipes L, M and N are then made to vibrate at their fundamental frequencies. Arrange the following frequencies in order of increasing frequency: the third harmonic of L, the fifth harmonic of M and the seventh harmonic of N.
2. An open pipe which has a fundamental frequency of 140 Hz is vibrating with 6 nodes between its two ends, and when the note from the open pipe combines with the note from a closed pipe which is vibrating with 3 nodes between its two ends (not counting the node at one end), beats of 14 Hz are produced. What are the possible values of the fundamental frequency of the closed pipe? The beat frequency is then heard to increase when the closed pipe is slightly shortened. Explain how we can find out the fundamental frequency of the closed pipe by the change in the beat frequency. What is the length of

the open pipe if the length of the closed pipe before it was shortened was p cm?

3. According to one theory of consonance, the degree of consonance between any two notes depends on the number of harmonics of one note which coincide with the harmonics of the other note. Using this theory of consonance, compare the consonance of a 60 Hz note with a second note which is higher by each of the following intervals. (You need only consider the first 18 harmonics of the 60 Hz note for the comparison.)
 - (a) A Just third.
 - (b) A Just fourth.
 - (c) A Just fifth.
 - (d) A Just seventh.
4. A Cristofori piano has an action with three levers for each of its keys which cause the corresponding hammer to move upwards to strike the corresponding string when the key is struck downwards. The upwards velocity of the hammer is due to the movement of the downwards key multiplied by the first, second and third levers by factors of 1, 2.4 and 6 times respectively. Calculate the upwards velocity of the hammer when the downwards velocity of the corresponding key is 3 cm per second. After the second lever of the action has been replaced with a new lever which has a multiplication factor different from 2.4 times, a downwards velocity of the key of

3.6 cm per second is required to give the same upwards velocity of the hammer as before. What is the multiplication factor of the new second lever?

5. On a particular grand piano, the soft (left) pedal, the sostenuto (middle) pedal and the sustain (right) pedal on a particular grand piano are functioning as normal. When a pianist plays on this piano, each of the following four different situations regarding the pedals may occur. In situation 1, after the sostenuto pedal is depressed, the keys D3 and A3 are depressed. The keys D3 and A3 are then released and the sostenuto pedal kept depressed. Will the D3 and A3 notes be sustained in this case? In situation 2, the notes D3 and A3 are depressed, then the sostenuto pedal is depressed. The D3 and A3 keys are then released while the sostenuto pedal remains depressed. Will the notes D3 and A3 be sustained? In situation 3, after the notes D3 and A3 are depressed, the soft pedal is depressed, and then these keys are released. If the pianist keeps depressing the soft pedal will the notes D3 and A3 be sustained? In situation 4, the sustain pedal is depressed, then the keys D3 and A3 are depressed and then released. If the sustain pedal remains depressed, will the D3 and A3 notes remain sustained?

Scientific Inquiry discussion points

- (a) It has now been ascertained, by making scientific observations and from the technical knowledge of

how the piano action works, that a pianist playing a grand piano has only one possible effect on the sound produced when he or she strikes a piano key. All the pianist can do is to impart a certain downwards velocity to a piano key, which the mechanical leverage of the piano action converts to a faster upwards velocity of the corresponding hammer to strike the corresponding string. Hence the pianist can only affect the loudness of the sound produced. However, many pianists use their arms, hands and fingers in ways which they believe can also affect other aspects of the sound produced, such as tone quality, even though this is not the case. This is thus an example of public understanding and perception which does not correspond to the actual scientific facts. Can you think of other similar examples in everyday life?