Tutorial No 4, Semester 1, 2024/25

1. A closed pipe labelled K has a fundamental frequency p Hz and is sliced into eight pieces of equal length. This creates seven short open pipes labelled K1 to K7, and a short closed pipe K8. Two of the short open pipes K6 and K7 are joined up with K8 to make a closed pipe labelled L, and the remaining short open pipes K1 to K5 are joined up to make an open pipe labelled M. Calculate the fundamental frequencies of the pipes K8, L and M. What is the ratio of the interval between the frequency of L when it vibrates with 5 nodes between its two ends (not counting the node at one end), and the frequency of M when it vibrates with 10 nodes between its two ends?

2. An open pipe which is vibrating with 7 nodes between its two ends has a fundamental frequency of 180 Hz. When the note from the open pipe combines with the note from a closed pipe which is vibrating with 4 nodes between its two ends (not counting the node at one end), beats of 27 Hz are produced. What are the possible values of the fundamental frequency of the closed pipe? The closed pipe is then slightly shortened and the beat frequency is heard to decrease. Explain how the fundamental frequency of the closed pipe can be determined by the change in the beat frequency. Calculate the length of the open

pipe if the length of the closed pipe before it was shortened was g cm.

3. One theory of consonance or dissonance says that the degree of consonance between any two notes is dependent on the number of harmonics of one note which coincide with the harmonics of the other note. With this theory of consonance and dissonance, compare the consonance of a 120 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 120 Hz note for the comparison.)

   (a) A Just third.

   (b) A Just fifth.

   (c) A Just sixth.

   (d) A Just seventh.

4. The action of a Cristofori piano has 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 equal to the movement of the downwards key multiplied by the first, second and third levers by factors of 1, 1.8 and 4.2 times respectively. What is the upwards velocity of the hammer when the downwards velocity of the corresponding key is 2.4 cm per second? The second lever of the action is then replaced with a new lever which has a multiplication factor different from 1.8 times, and after the new lever has been installed, a downwards velocity of the key of 2.5 cm per second

is required to give the same upwards velocity of the hammer as before. Calculate the multiplication factor of the new second lever.

5. The soft (left) pedal, the sostenuto (middle) pedal and the sustain (right) pedal on a particular grand piano are functioning normally. A pianist plays on this piano, and each of the following four different situations regarding the pedals may occur. In situation 1, the sostenuto pedal is depressed, then the notes C2 and E2 are depressed, and then these keys are released. If she keeps pressing the sostenuto pedal will the notes C2 and E2 be sustained? In situation 2, the notes C2 and E2 are depressed, then the sostenuto pedal is depressed, and then the C2 and E2 keys are released while the sostenuto pedal remains depressed. Will the notes C2 and E2 be sustained? In situation 3, the sustain pedal is depressed, then the keys C2 and E2 are depressed and then released, keeping the sustain pedal depressed. Will the C2 and E2 notes be kept sustained? In situation 4, the the keys C2 and E2 are depressed, then the sustain pedal is depressed and then the keys C2 and E2 are released, and then the sustain pedal is kept depressed. Will the C2 and E2 notes be sustained in this case?

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?