Tutorial No 4, Semester 2, 2024/25

1. An open pipe labelled P is sliced into seven pieces of equal lengths, creating seven short open pipes labelled P1 to P7. Two of the short open pipes P1 and P2 are joined up to make a pipe labelled Q. The three short open pipes P3, P4 and P5 are joined up to make another open pipe labelled R. The remaining two short open pipes are joined up and one end closed up to make a closed pipe labelled S. All three pipes are then made to vibrate at their fundamental frequencies. Arrange the following frequencies in order of increasing frequency: the second harmonic of Q, the fourth harmonic of R and the fifth harmonic of S.

2. An open pipe which has a fundamental frequency of 210 Hz is vibrating with 8 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. Calculate the possible values of the fundamental frequency of the closed pipe. When the closed pipe is slightly shortened, the beat frequency is heard to increase. Show how the fundamental frequency of the closed pipe can be determined 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 h cm?

3. 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, according to one theory of consonance. With this theory of consonance, compare the consonance of a 150 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 150 Hz note for the comparison.)

   (a) A Just second.

   (b) A Just third.

   (c) A Just fifth.

   (d) A Just sixth.

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 given by the movement of the downwards key multiplied by the first, second and third levers by factors of 1, 2 and 4.5 times respectively. Calculate the upwards velocity of the hammer when the downwards velocity of the corresponding key is 2.5 cm per second. After the second lever of the action is replaced with a new lever which has a multiplication factor different from 2 times, a downwards velocity of the key of 2 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 certain grand piano, the soft (left) pedal, the sostenuto (middle) pedal and the sustain (right) pedal are functioning normally. When a pianist plays on this piano, each of the following four different situations regarding the pedals may occur. In situation 1, the sustain pedal is depressed, then the keys A3 and E4 are depressed and then released, keeping the sustain pedal depressed. Will the A3 and E4 notes be kept sustained? In situation 2, the sostenuto pedal is depressed, then the notes A3 and E4 are depressed, and then these keys are released. If the pianist keeps pressing the sostenuto pedal will the notes A3 and E4 be sustained? In situation 3, the notes A3 and E4 are depressed, then the sostenuto pedal is depressed, and then the A3 and E4 keys are released while the sostenuto pedal remains depressed. Will the notes A3 and E4 be sustained? In situation 4, the keys A3 and E4 are depressed, then the soft pedal is depressed and then the keys A3 and E4 are released, with the soft pedal kept depressed. Will the A3 and E4 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?