Tutorial No 4, Semester 1, 2025/26

1. An open pipe labelled E is sliced into nine pieces of equal lengths, creating nine short open pipes labelled E1 to E9, and five of the short open pipes E1, E2, E3, E4 and E5 are joined up to make a pipe labelled F. The three short open pipes E6, E7 and E8 are joined up to make another open pipe labelled G. The remaining short open pipe E9 is closed up at one end to make a closed pipe labelled H. All three pipes F, G and H are then made to vibrate at their fundamental frequencies. Arrange the following frequencies in order of increasing frequency: the fourth harmonic of F, the second harmonic of G and the third harmonic of H.

2. An open pipe 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 9 Hz are produced. What are the possible values of the fundamental frequency of the closed pipe? If the beat frequency is heard to decrease when the closed pipe is slightly shortened, show how we can find out the fundamental frequency of the closed pipe 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

k 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 200 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 200 Hz note for the comparison.)

   (a) A Just second.

   (b) A Just third.

   (c) A Just fifth.

   (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 given by the movement of the downwards key multiplied by the first, second and third levers by factors of 1, 2 and 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 has been 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. 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 as normal. When a pianist plays on this piano, each of the following four different situations regarding the pedals may occur. In situation 1, the notes G2 and D3 are depressed, then the sostenuto pedal is depressed, and then the G2 and D3 keys are released while the sostenuto pedal remains depressed. Will the notes G2 and D3 be sustained? In situation 2, the sostenuto pedal is depressed then the keys G2 and D3 are depressed and the keys G2 and D3 are released with the sostenuto pedal kept depressed. Will the G2 and D3 notes be sustained in this case? In situation 3, the sustain pedal is depressed, then the keys G2 and D3 are depressed and then released, keeping the sustain pedal depressed. Will the G2 and D3 notes be kept sustained? In situation 4, the notes G2 and D3 are depressed, then the sustain pedal is depressed, and then these keys are released. If the pianist keeps depressing the sustain pedal will the notes G2 and D3 be 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 down-

wards 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?