Tutorial No 4, Semester 2, 2025/26

1. A closed pipe labelled A is sliced into eight pieces of equal lengths, creating seven short open pipes labelled A1 to A7, and one short closed pipe labelled A8. Three of the short open pipes A1, A2 and A3 are joined up to make an open pipe labelled B. The three pipes A4, A5 and A6 are joined up and one end closed up to make a closed pipe labelled C. The remaining short open pipe A7 is joined up with A8 to make a closed pipe labelled D. Arrange the following frequencies in order of increasing frequency: the second harmonic of B, the fifth harmonic of C and the third harmonic of D.

2. A closed pipe vibrating with 5 nodes between its two ends (not counting the node at one end) has a fundamental frequency of 80 Hz. When the note from the closed pipe combines with the note from an open pipe which is vibrating with 4 nodes between its two ends, beats of 8 Hz are heard. Calculate the possible values of the fundamental frequency of the open pipe. If the beat frequency is heard to decrease when the open pipe is slightly shortened, how can we determine the fundamental frequency of the open pipe by the change in the beat frequency? Calculate the length of the closed pipe if the length of the open pipe before it was shortened was p cm.

3. One theory of consonance says that 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 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 second.

(b) A Just fourth.

(c) A Just fifth.

(d) A Just sixth

4. A Cristofori piano has an action with three levers for each of its keys which will 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, 2.4 and 4.8 times respectively. Calculate the upwards velocity of the hammer when the downwards velocity of the corresponding key is 3 cm per second. When the third lever of the action is replaced with a new lever with a multiplication factor different from 4.8 times, 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. What is the multiplication factor of the new third lever?

5. On a certain grand piano, the soft (left) pedal, the sostenuto (middle) pedal and the sustain (right) pedal

are functioning as normal. Each of the following four different situations regarding the use of the pedals may occur when a pianist plays on this piano. In situation 1, the sostenuto pedal is depressed then the keys A2 and E3 are depressed and the keys A2 and E3 are released with the sostenuto pedal kept depressed. Will the A2 and E3 notes be sustained? In situation 2, the notes A2 and E3 are depressed, then the sostenuto pedal is depressed, and then the A2 and E3 keys are released while the sostenuto pedal remains depressed. Will the notes A2 and E3 be sustained in this case? In situation 3, the sustain pedal is depressed, then the keys A2 and E3 are depressed and then released, keeping the sustain pedal depressed. Will the A2 and E3 notes be kept sustained? In situation 4, the notes A2 and E3 are depressed, then the soft pedal is depressed, and then these keys are released. If the pianist keeps depressing the soft pedal will the notes A2 and E3 be sustained?

Scientific Inquiry discussion points

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?