Tutorial No 4, Semester 2, 2023/24

1. A closed pipe which has a fundamental frequency k Hz is labelled P, and is sliced into seven pieces of equal length. This creates six short open pipes, labelled P1 to P6, and a short closed pipe P7. Three of the short open pipes P4, P5 and P6 are joined up with P7 to make a closed pipe labelled Q, and the remaining short open pipes P1 to P3 are joined up to make an open pipe labelled R. What are the fundamental frequencies of the pipes P1, P7, Q and R? Calculate the ratio of the interval between the frequency of Q when it vibrates with 4 nodes between its two ends (not counting the node at one end), and the frequency of R when it vibrates with 6 nodes between its two ends.

2. An open pipe which has a fundamental frequency of 80 Hz is vibrating with 7 nodes between its two ends. 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. Give the possible values of the fundamental frequency of the closed pipe. When the closed pipe is slightly shortened, the beat frequency increases. 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 d cm.

3. According to one theory of consonance or dissonance, 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. Use this theory of consonance and dissonance to 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 for each of its keys having three levers 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, 1.6 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. The third lever of the action is then replaced with a new lever which has a multiplication factor different from 4.5 times. After the new lever has been installed, a downwards velocity of the key of 2.4 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 particular grand piano, the soft (left) pedal, the sostenuto (middle) pedal and the sustain (right) pedal function normally. A pianist then performs on the piano, and each of the following four different situations regarding the pedals may occur. In situation 1, the notes D2 and A2 are depressed, then the sostenuto pedal is depressed, and then the D2 and A2 keys are released while the sostenuto pedal remains depressed. Will the notes D2 and A2 be sustained? In situation 2, the sostenuto pedal is depressed, then the notes D2 and A2 are depressed, and then these keys are released. If she keeps pressing the sostenuto pedal will the notes D2 and A2 be sustained? In situation 3, the the keys D2 and A2 are depressed, then the sostenuto pedal is depressed and then the keys D2 and A2 are released, and then the sostenuto pedal is released. Will the D2 and A2 notes be sustained in this case? In situation 4, the sustain pedal is depressed, then the keys D2 and A2 are depressed and then released, keeping the sustain pedal depressed. Will the D2 and A2 notes be kept 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?