Tutorial No 5, Semester 1, 2026/2027

1. The first 10 notes of a well-known Singapore song are: C4, F4, G4, A4, A4, A4, G4, F4, E4 and F4. Give the MIDI key numbers for these 10 notes. What are the paper roll track numbers for the first 10 notes of this song for it to be played by a player piano using a standard player piano paper roll? Show how the MIDI key numbers can be converted to paper roll track numbers in general. If we start on D4 instead of C4, what would be the MIDI key numbers and the paper roll track numbers for these 10 notes, assuming that the notes of the song will still have the same interval relationships from the first note?

2. A notebook computer can send and receive MIDI messages through MIDI in and MIDI out sockets through an interface box connected to the computer. The sockets of the box are labelled IB and OB respectively. An electronic piano which has only MIDI in and MIDI out sockets labelled IP and OP respectively is able to send MIDI messages to the computer for a song to be composed on the computer. An electronic organ has MIDI in, MIDI out and MIDI thru sockets labelled IR, OR and TR respectively, an electronic synthesiser has MIDI in, MIDI out and MIDI thru sockets labelled IS, OS and TS respectively, and an electronic tone generator has MIDI in, MIDI out and MIDI thru sockets labelled IG, OG

and TG respectively. When the song is completed, it is to be performed on the four electronic musical instruments (including the electronic piano). What are the connections which need to be made between the computer and the four electronic musical instruments (including the electronic piano) to enable the song to be composed and then performed as desired? If the electronic piano does have a MIDI thru socket, how would this affect the required connections?

3. The first 10 notes of the song in question 1 are to be sent to an electronic organ by a series of MIDI messages. The song is to be played on the clarinet MIDI instrument in the lowest MIDI channel by turning the notes on and off as fast as possible starting from the note D4. What are the MIDI messages which should be sent?

4. 12 electronic pianos are connected by MIDI cables to a desktop computer so that all the pianos can play a piece of music together. A certain chord in this piece is to be played simultaneously by all the 12 electronic pianos, and all the 12 pianos play the same number of notes of this chord. If all the notes of the chord have to be played within 0.11 seconds, calculate the maximum number of notes which this chord can have. If the time duration is 0.09 seconds instead of 0.11 seconds, what is the maximum number of notes which the chord can have? (Assume that it takes exactly one millisecond for a MIDI message to go through the MIDI sockets of all the 12 electronic pianos.)

5. According to the Nyquist theorem, the sampling rate of a digital recording or transmission should be double the highest frequency to be preserved in the recording or transmission. For example, if the highest frequency to be preserved is f Hz, the sampling rate should be $2f$ samples per second. The highest frequency to be preserved in the recording of a chamber music concert is 18,600 Hz. Calculate the bit rate of the recording if the bit length of the digital samples in the digital recording is 15 bits. If the highest frequency to be preserved is 21,300 Hz instead, what is the maximum possible bit length of the digital samples for the same bit rate? (Assume that the digital recording is in stereo, with two audio channels of equal bit rates to be digitally recorded.)

Scientific Inquiry discussion points

(a) The invention of sound recording by Edison and others, and of radio transmission later, made it possible for music to be recorded and heard by many more listeners than hitherto. This was multiplied greatly and the fidelity of the recordings vastly improved when digital transmission and recording, coupled with smartphones and the Internet, made both live and recorded music easily accessible to a large proportion of the world's population. Hence the societal impact of science and technology can indeed be immense. Can you cite other scientific and technological innovations which had a similar or greater impact on society?