Tutorial No 5, Semester 1, 2025/2026

1. The first 16 notes of a well-known Singapore National Day song are: F4, E4, D4, D4, C4, C4, D4, E4, F4, E4, D4, D4, C4, C4, E4 and G4. Give the MIDI key numbers for these 16 notes, as well as the paper roll track numbers for the first 16 notes of this song which is to be played by a player piano using a standard player piano paper roll. Show how in general, the MIDI key numbers can be converted to paper roll track numbers. If we start on A4 instead of F4, what would be the MIDI key numbers and the paper roll track numbers for these 16 notes, assuming that the notes of the song will still have the same interval relationships from the first note?

2. A notebook computer is enabled to send and receive MIDI messages through MIDI in and MIDI out sockets on an interface box connected to the computer, the sockets being labelled IB and OB respectively. MIDI messages are sent by an electronic piano, which has only MIDI in and MIDI out sockets labelled IP and OP respectively, to the computer enabling 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 keyboard has MIDI in, MIDI out and MIDI thru sockets labelled IK, OK and TK respectively, and an electronic tone generator has MIDI in, MIDI out

and MIDI thru sockets labelled IG, OG and TG respectively. If the completed song 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 does this affect the required connections?

3. An electronic keyboard is to receive MIDI messages to play the first 16 notes of the National Day song in question 1 on the flute MIDI instrument in the lowest MIDI channel, turning the notes on and off as fast as possible, and starting from the note G4. What are the MIDI messages which should be sent?

4. MIDI cables connect 14 electronic organs to a desktop computer to enable all the organs to play a piece of music together. A particular chord in this piece is to be played simultaneously by all the 14 electronic organs. If all the 14 organs play the same number of notes of this chord, and all the notes of the chord have to be played within 0.12 seconds, calculate the maximum number of notes which this chord can have. If the time duration is 0.15 seconds instead of 0.12 seconds, calculate 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 14 electronic organs.)

5. According to the Nyquist theorem, the sampling rate of a digital recording or transmission is 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 must be $2f$ samples per second. If a symphony orchestra concert is being digitally recorded with the highest frequency to be preserved being 19,800 Hz, calculate the bit rate of the recording if the bit length of the digital samples in the digital recording is 15 bits. If we change the highest frequency to be preserved to 17,200 Hz, what would be 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?