**Instructions:**

1. There are four questions in part 1 and three questions in part 2. Answer all questions in part 1 and any one question in part 2.
2. Complete neatly with your name and student number on the first page.
3. Turnitin is enabled for this assessment. Please submit your answer file in word format. PDF format, JPEG images are not allowed.
4. Upload your answer file to
5. Submission Deadline: 23:59 12 Jun 2021 (Sat). (You are recommended to complete it as early as you can and reserve sufficient time to submit your work)
6. Question 2 and question 4 contain variables (W, X, Y and Z) whose values depend on your student number. W, X, Y and Z are the 5th, 6th, 7th and 8th digits of your student number. For example, student number “0281”, W = 0, X = 2, Y = 8 and Z = 1.
7. Marks will be deducted if you do not follow the instructions.

**Part 1 (70%): Answer all questions in this part.**

**[12 Marks] Question 1:** Determine the MIDI message (in hex) for each of the below actions.

1st Data Byte Description Meaning of 2nd Data Byte

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79 Reset all controllers None; set to 0

7A Local control 0 = off; 127 = on

7B All notes off None; set to 0

7C Omni mode off None; set to 0

7D Omni mode on None; set to 0

7E Mono mode on (Poly mode off) \*\*

7F Poly mode on (Mono mode off) None; set to 0

1. Pan the stereo of Channel 6 to absolute right

Because a single hex digit ranges from 0 to 15 (0-F hex), every four bit binary number can be represented by a single hex digit.

Decimal 6

Binary 0110

Hexadecimal 6

1. Change the instrument on Channel 6 to Rhodes Piano
2. Play the A4 note using ***mf*** loudness on Channel 6
3. Turn off the note played in action 3.
4. System reset

*Note: refer to the MIDI message format and GM instrument patch map in the lecture notes and tutorial notes*

**[24 Marks] Question 2:** Consider a completely new musical instrument Q. The lowest frequency played by Q is 32.703 Hz. The frequency range of Q is U octaves plus V semitones, where U = 8+1, V = 1+1.

*Note: Y = 8, Z = 1 and U = 9, V = 2.*

1. What is the highest frequency that Q can sound? Show your steps clearly. **(4 marks)**

2/1\*200 Hz=400 Hz (2nd ) harmonic

1. Given that the frequency of middle C (note name C4) is 261.63 Hz, find the name of the highest frequency note sounded by Q. Show your steps clearly. **(4 marks)**

3/2\*200 Hz=300 Hz (3rd harmonic)

1. You are going to record a 5 minutes solo performance of Q.
   1. Suggest a suitable sampling rate for the recording. **(2 marks)**
   2. Instead of mono, stereo is preferred for the recording. Suggest a reason to support the decision. **(2 marks)**

Yes, the number of shared harmonics is the total number of harmonics in a note (12) divided by the number in the numerator of the frequency ratio. For example, the shared harmonics for a note a fifth above is 12/(numerator in frequency ratio)=12/3=4. Likewise, the number of subharmonics shared is 5-(number in the denominator of the frequency ratio) as 5 may symbolize halfway point of the octave. total number thirds (the major unit, as it is the smallest harmonic in this example and the harmonic with the lowest number that is consonant, unlike the 2nd)?

* 1. Compute the raw data size (in bytes) for the recording if the sampling size is 24-bit.

Show your steps clearly. Equations:

A=B\*2(n/1200 for finer calculations) where A and B are frequencies of two different notes.

N=log2 (A/B) approximately equal to N=log10(A/B) where N is the number of cents

A semitone is a half step on the scale (100 cents), so the percent change in frequency is . A/B= 21/12= 1.047. 1.047-1=.047 or 4.7%.

Alternatively, 100/1200=1/12=.083 or 8.3%.

**(4 marks)**

1. You just learn how to play Q. Although your solo performance in (c) was bad, you would like to share your first solo to your friends. However, you find that the raw data size in (c)(iii) is too big for sharing. You consider to re-record it in MIDI format or compress it using MP3 technology.
   1. Describe two disadvantages for choosing MIDI format for (c). **(4 marks)**
   2. Describe two disadvantages for choosing MP3 format for (c). **(4 marks)**

**[16 Marks] Question 3:** Consider the following decoding order of a sequence of frames of a MPEG-1 Video:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Frame ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| Frame Type | I | P | B | B | B | P | B | B | B | I | B | B | B | I | P | B | P |

1. What is the display order of the frames? **(6 marks)**
2. Suppose there is an error in decoding frame ID R, which of the other frames may possibly suffer from error directly? **(6 marks)**
   1. R = 6
   2. R = 15
3. Compare the below two designs of frame structures:

Design U: I B B P B B I B B P B B I

Design V: I B B B B B B B B B B B I

* 1. Describe an advantage of choosing design U. **(2 marks)**
  2. Describe an advantage of choosing design V. **(2 marks)**

**[18 marks] Question 4:** Consider a video with frame size of 6 x 6 and macroblock size of 2 x 2. The luma values in the reference frame (left) and current frame (right) are given as follows:

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 7 | 1 | 7 | 9 | 6 | 0 |  | # | # | # | # | # | # |
| 7 | 4 | 1 | 4 | 2 | 4 | # | # | # | 0 | 2 | # |
| 8 | 0 | 6 | 0 | 8 | 5 | # | # | # | 8 | 1 | # |
| 8 | 5 | 7 | 5 | 3 | 1 | # | # | # | # | # | # |
| 3 | 0 | 3 | 1 | 2 | 7 | # | # | # | # | # | # |
| 7 | 6 | 5 | 9 | 4 | 3 | # | # | # | # | # | # |

1. Find the motion vector of the highlighted macroblock using window search with search range

±1 pixel. Show your steps clearly. **(10 marks)**

1. Having computed the motion vector, determine the residual to be coded after motion compensation. **(4 marks)**
2. Having computed the residual, explain whether intra mode or inter mode coding should be used for this macroblock. **(4 marks) Part 2 (30%):** **Answer any one question in this part**

Start with the list of codewords {10, 00, 001, 101} 10 is a prefix to 101: dangling suffix = 1  00 is a prefix to 001: dangling suffix = 1  {10, 00, 001, 101, 1} 1 is a prefix to 10: dangling suffix of 0  1 is a prefix to 101: dangling suffix of 01  {10, 00, 001, 101, 1, 0, 01} 0 is a prefix to 00: dangling suffix of 0  0 is a prefix to 01: dangling suffix of 1  0 is a prefix to 001: dangling suffix of 01 

Iteration Found Dangling Suffix New Dangling Suffix Same as Codeword? 1 1 1 None 2 0, 01 0, 01 None 3 0, 1, 01 Nil N/A

At this point we get no new dangling suffixes therefore this code is uniquely decodable. It is non-instantaneous since not prefix-free (10 is a prefix to 101, 00 is a prefix to 001).

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0

10

110 111

10

101

00

001

A

B

C D

A B

D C

As seen from the tree diagram, no codeword is the prefix of other codewords. So this code is a prefix code. Thus it is instantaneous (and also uniquely decodable)

As seen from the tree diagram, codeword A is the prefix of D, B is the prefix of C. So this code is a non-prefix code. Thus, it is not instantaneous (but uniquely decodable as proved using the Sardinas-Patterson algorithm) (e.g. 0010.. may be decoded as 00-10.. or 001-00 .., depending on the remaining bit sequence of the encoded string, 101.. may be decoded as 10-1.. or 10-.. depending on the remaining bit sequence of the encoded string)

To answer the questions in this part, you may use the Internet as a source of information. However, you should digest the content and use your own words to write the reports. You are also required to indicate the total number of words and the sources of information in your reports. Marks will be deducted if you do not follow the instructions.

**[30 Marks] Question 5:** JPEGsnoop ([https://www.impulseadventure.com/photo/jpeg-snoop.html)](https://www.impulseadventure.com/photo/jpeg-snoop.html) is a digital forensics software that able to tell whether a JPEG image was likely an original photo taken by a camera or had been edited using photo-editing software (e.g. Photoshop). In your own words, write a report in 300 to 400 words with appropriate diagrams to explain its digital forensics mechanism, its technical weakness, and explain whether the digital forensics mechanism can apply to MPEG videos or not.

**[30 marks]** **Question 6:** Steganography refers to techniques which hide secret information in a way that nobody but the sender and the intended recipient knows about the existence of the message. It is different from watermarking, which is a kind of digital signature to protect information against removal or modification. In your own words, write a report in 300 to 400 words with appropriate diagrams to describe how to apply steganography in images, videos and audio data, respectively. (You need to describe one method for hiding information in images, one method for videos, and one method for audio data.)

There are many ways to conceal information using Steganography. The most common method is by embedding information into digital images. We all know that digital images say, a JPEG image, contains several megabytes of data in the form of pixels. This allows some room for someone to embed steganographic information within the digital file. With the use of steganographic applications, a hacker alters the [least significant bits](https://searchsecurity.techtarget.com/answer/How-does-Steganography-work-and-does-it-threaten-enterprise-data) of the data file and embeds a malicious code into the image. Once the targeted user downloads and opens the image file in their computer, the malware is activated. Depending on its programming, the malware can now open a leeway for the attacker to gain control over the user’s device or network. The danger of Steganography is that the difference between the original image and the steganographic image is subtle and the two cannot be distinguished by the naked eye.

**Is Steganography still used?**

Yes, Steganography is still popular among cyber criminals. Recent attacks show that security researchers found a [new malware campaign](https://www.cisomag.com/hackers-using-Steganography-in-wav-audio-files-to-hide-malware/https:/www.cisomag.com/hackers-using-Steganography-in-wav-audio-files-to-hide-malware/) that used WAV audio files to hide their malware. It is believed that the attackers used Steganography to embed the malicious code inside the WAV audio file.

**3 Techniques used in Steganography**

**1. Least Significant Bit**

In this Steganography method, the attacker identifies the least significant bits of information in the carrier image and substitutes it with their secret message, in this case, malicious code. When the target downloads the carrier file, they introduce the malware into their computer which allows the attacker access to this device and the hack begins. Cybersecurity professionals commonly use sandboxes to detect these corrupt files. However, black hat hackers have invented various methods of bypassing sandboxes like sleep patching. Sleep patched malware is not easily detected by the sandbox since it poses as benign and buys time while studying the timing artifacts of the sandbox and executes when the sandbox is vulnerable.

**2. Palette Based Technique**

This technique also uses digital images as malware carriers. Here, the attackers first encrypt the message and then hide it in a stretched palette of the cover image. Even though this technique can carry a limited amount of data, it frustrates threat hunters since the malware is encrypted and takes a lot of time to decrypt.

**3. Secure Cover Selection**

This is a very complex technique where the cyber criminals compare the blocks of the carrier image to the blocks of their specific malware.

**[30 marks]** **Question 7:** FLAC (Free Lossless Audio Codec) is a non-proprietary lossless compression format for audio. FLAC performs better than classical lossless compression schemes for audio data and is able to reduce the size up to 50%. In your own words, write a report in 300 to 400 words with appropriate diagrams to describe the target applications, technical standards of FLAC, and explain why FLAC can achieve high compression rate for audio data.

**[End of Final Project]**