THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALL

UNIVERSITY OF LONDON

CO2227 ZB

BSc EXAMINATION

CREATIVE COMPUTING and COMBINED DEGREE SCHEME

Creative Computing II: Interactive Multimedia

Monday 13 May 2019: 10.00 – 13.00

Time allowed: 3 hours

DO NOT TURN OVER UNTIL TOLD TO BEGIN

There are **SIX** questions in this paper. Candidates should answer **FOUR** questions. All questions carry equal marks, and full marks can be obtained for complete answers to a total of **FOUR** questions. The marks for each part of a question are indicated at the end of the part in [.] brackets.

Only your first **FOUR** answers, in the order that they appear in your answer book, will be marked.

There are 100 marks available on this paper.

A handheld calculator may be used when answering questions on this paper but it must not be pre-programmed or able to display graphics text or algebraic equations. The make and type of machine must be stated clearly on the front cover of the answer book.

Question 1 Colour and Light

(a) Hue, saturation, and brightness

i. What are hue, saturation, and brightness? [3]

ii. Using the equations below, convert the RGB value (r=0.0, g=0.8, b=0.5) into HSB values, where R, G and B are expressed in the range [0,1]. Show your work. [6]
H = ?
S = ?
B = ?

$$max = max(r, g, b);$$
$$min = min(r, g, b);$$
$$h = \begin{cases} 0 & max = min; \\ \frac{\pi}{3} \times \frac{g-b}{max-min} \mod 2\pi & max = r; \\ \frac{2\pi}{3} + \frac{\pi}{3} \times \frac{b-r}{max-min} & max = g; \\ \frac{4\pi}{3} + \frac{\pi}{3} \times \frac{r-g}{max-min} & max = b; \end{cases}$$
$$s = \begin{cases} 0 & max = 0; \\ 1 - \frac{min}{max} & otherwise \end{cases}$$
$$\beta = max$$

(b) Describe the function of the following parts of the human vision system:

i. Pupil [3]

ii. Rod cells [3]

(c) CMYK

i. Describe how subtractive mixing is used in the CMYK model of colour printing. [3]

ii. Describe how CMYK inks are used to print the colour green. [2]

iii. Describe how CMYK inks are used to print the colour black. [2]

(d) What is *deuteranomaly*? How does this affect design of multimedia systems? [3]

Question 2 Animation

(a) A two-dimensional animation of a circle is being drawn using cubic Hermite interpolation. The keyframes for the circle are given in the following table:

time (seconds)	coordinates (pixels)	tangent
0	(100, 500)	(200, 400)
1	(350, 400)	(100, 250)
2	(100, 250)	(-50, -50)

On a single unit interval ($0 \leq t \leq 1$), cubic Hermite interpolation can be defined as:

$$p(t) = (2t^3 - 3t^2 + 1)p_k + (t^3 - 2t^2 + t)m_k + (-2t^3 + 3t^2)p_{k+1} + (t^3 - t^2)m_{k+1}$$

where p_k at $t = 0$ is the starting point, p_{k+1} at $t = 1$ is the ending point, m_k is the tangent at $t = 0$ and m_{k+1} is the tangent at $t = 1$. Calculate the position of the circle at the following timepoints. Show your work. [6]

i. 0.5 seconds

ii. 1.8 seconds

(b) Describe why we are able to perceive motion from a sequence of still images when we are watching a film. Include a discussion of frame rate and flicker rate in your answer. [4]

(c) Animation techniques

i. Describe the process of stop-motion animation. [3]

ii. Describe how you would choose whether to use stop-motion or flat animation for a particular project. [3]

(d) This is the pseudo code of a lerp function:

```
vector lerp(vector p0, vector p1, float t)
{
     return p1 * t + p0 * (1 - t);
}
```

i. What does the lerp function do? [2]

ii. What is the range of t? [2]

iii. Suppose we set two keyframes of an object: it is at height 20 at frame 3, and at height 40 at frame 8. How would you use the lerp function to calculate the height of the object at frame 4 (*i.e.*, write down p0, p1, and t). What will be the return value? [3]

iv. What is the problem of keyframe animation generated with the lerp function? Discuss in terms of the trajectory and velocity. [2]

Question 3 Audio and Music Perception

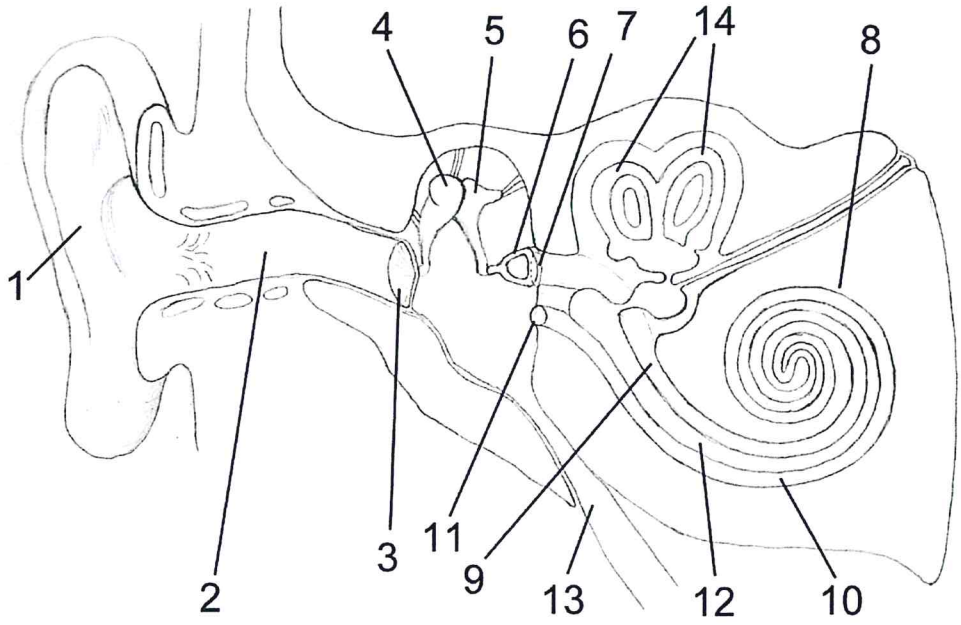
(a) Draw a diagram of a periodic waveform (a sine wave, for example) and label the amplitude, frequency, and phase. Describe each term in your own words. [6]

(b) Name the parts of the ear corresponding with the following numbers: [3]

i. 2

ii. 4

iii. 8



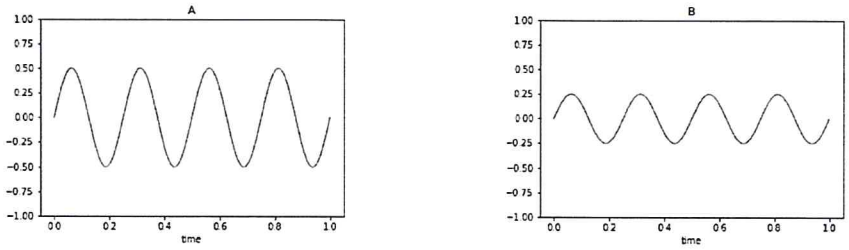
(c) Describe the role of the basilar membrane in hearing. [3]

(d) Briefly describe (simultaneous) auditory masking. [3]

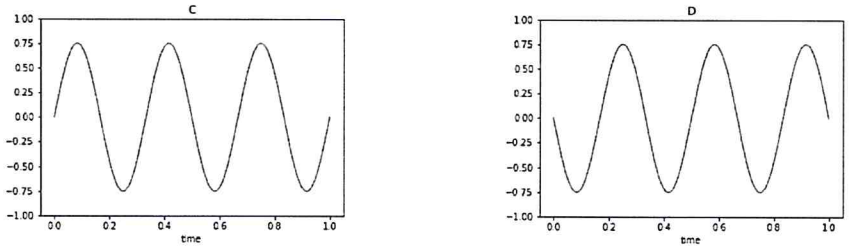
(e) What is rhythm? [3]

(f) For each row of waveforms below, describe as precisely as you can the difference in how the left waveform will sound from the right one. Assume that all sinusoids are at suitable amplitudes, frequencies, and phases to be audible. [3]

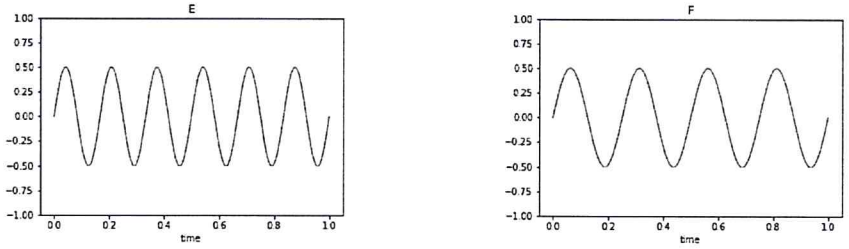
i. A vs B:



ii. C vs D:



iii. E vs F:



(g) A guitar plays a note whose pitch is perceived to be the same as a 86 Hz sine wave.

i. List 3 frequencies that are likely to be present in the guitar sound. [1]

ii. Explain your answer to (i) above. [3]

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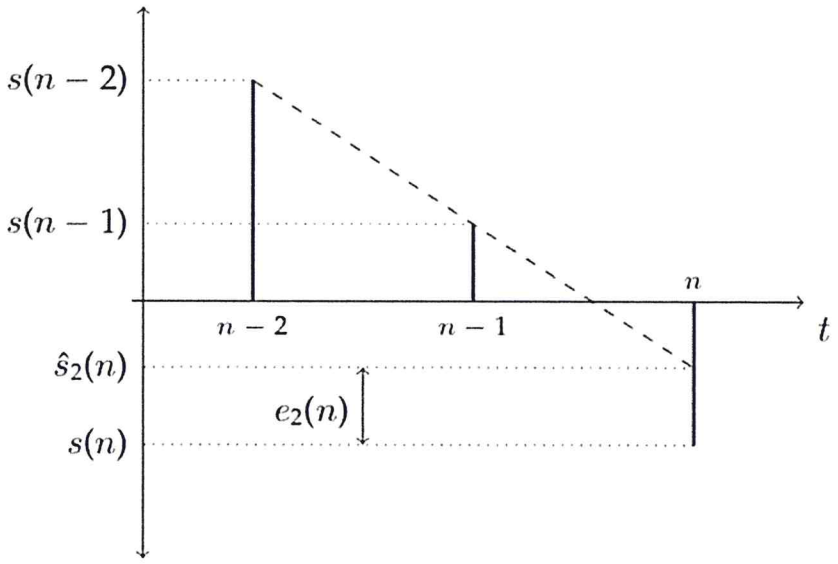
Question 4 Digital Media Signals and their representations

(a) A particular DVD format uses an audio sampling rate of 192kHz and a quantization level of 24-bits.

i. What is the highest frequency that can be accurately reproduced on DVD audio? [2]

ii. Assuming there are two channels, how much storage space is required for 5 minutes of DVD audio, without using compression? Show your work and express your answer in MB. [3]

(b) FLAC
The following diagram is used in the subject guide description of FLAC compression:



i. What are $n-1$, $n-2$, and n? [2]

ii. What is $e_2(n)$? [1]

iii. How does using *linear predication* achieve signal compression? [2]

(c) Compression

i. What is the difference between lossy and lossless compression? [2]

ii. Give an example of a circumstance in which you would prefer to use a lossy representation instead of a lossless one. [2]

(d) Describe how MP3 is able to achieve a higher compression ratio than FLAC. [4]

(e) Aliasing

i. What is aliasing in the context of digital audio? Include a diagram illustrating the phenomenon of aliasing. [2]

ii. How can aliasing be avoided in the analog-to-digital conversion process? [2]

(f) Rank the following audio file formats in likely order of size, from smallest to largest: ZIP, WAV, MP3, FLAC. [3]

Question 5 Signals and Systems

(a) A linear, shift-invariant system for images uses the following kernel. Name and describe as precisely as possible the image effect this kernel implements. [2]

$$\begin{bmatrix} 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \\ 1/9 & 1/9 & 1/9 \end{bmatrix}$$

(b) Name two other image effects that can be achieved using an image kernel. [2]

(c) Fill in the blanks:

i. If we convolve some signal, A, with another signal, B, in the time domain, this is equivalent to _____ the spectrum of signal A with the spectrum of signal B in the frequency domain. [2]

ii. The property of _____ means that a system responds in the same manner to its inputs at all instants in time. [2]

iii. A system T for which the following statement is true exhibits the property of _____. [2]

$$aTx[n] + bTy[n] = Tax[n] + by[n]$$

iv. A system which demonstrates both of the properties from ii. and iii. above is called a _____ system. [2]

v. The output of such a system for a given input signal is calculated by convolving the input signal with _____. [2]

vi. Convolving any signal with the unit impulse will produce _____. [2]

(d) You have been asked to create a new music visualiser program, in which the colour of the visualisation changes according to the current musical chord, and the size of the visualisation changes according to the volume. The input to this visualiser will be audio only – that is, you won't have access to MIDI or other data about the music; you must compute chord and loudness information directly from the audio samples.

i. Describe how you would compute information about the current musical chord. For instance, what musical feature(s) would you use, and why? [3]

ii. How well would you expect your computational approach described above to work? For instance, are there circumstances in which it is likely to fail? [3]

iii. What feature(s) would you compute from the audio in order to capture information about the current volume? Why? [3]

Question 6 Information Retrieval

(a) A collection of image files is stored on a disk. A CIE *L*a*b** representation of the predominant colour of each image has been pre-calculated and stored along with the files.

i. Describe a data structure and an algorithm that will allow retrieval of an image file whose predominant colour is perceptually closest to a query colour. [4]

ii. Comment on the efficiency of your solution. [2]

iii. The collection contains four image files with the following CIE *L*a*b** colours: [[67.3, 39.8, 72.1], [60.2, 98.1, -61.8], [47.2, 14.7, 55.9], [60.6, -87.3, 84.0]] with the corresponding file names [file01.png, file02.png, file03.png, file04.png]. Which filename should be returned for a query of [36.7, -15.2, 40.7]? Show your work. [4]

(b) You are designing a system to recommend books to a user based on books that they have already read and rated.

i. What would it mean for this particular system to have high precision? [2]

ii. What would it mean for this particular system to have high recall? [2]

iii. Do you think it is more important for this kind of system to have high precision or high recall? Justify your answer. [2]

(c) Specific Features

i. Levenshtein distance
For what specific type(s) of media might you use this feature? [1]
Describe in your own words what it would mean for two pieces of media to have similar values for this feature. [2]

ii. RMS amplitude
For what specific type(s) of media might you use this feature? [1]
Describe in your own words what it would mean for two pieces of media to have similar values for this feature. [2]

iii. term-frequency
For what specific type(s) of media might you use this feature? [1]
Describe in your own words what it would mean for two pieces of media to have similar values for this feature. [2]

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