THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **CO2227 ZA**

BSc Examination

CREATIVE COMPUTING AND COMBINED DEGREE SCHEME

Creative Computing II: Interactive Multimedia

Date and Time: Monday 16 May 2016 : 10.00–13.00

Duration: 3 hours

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 hand held 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) CMYK

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

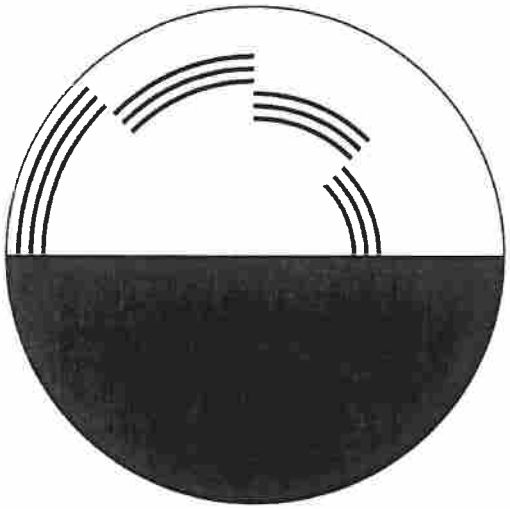
ii. Describe how CMYK inks are used to print the colour green. [2]

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

(b) Describe the purpose of the CIE 1931 colour space. [4]

(c) What is the fovea, and how does it relate to human vision? [4]

(d) The following figure shows a simplified version of Benham's Top. Why is this figure relevant to visual perception? [5]



(e) How do cone cells allow humans to perceive differences in different colours? [5]

Question 2 Animation

(a) Describe what interpolation is and how it is used in animation. Draw at least one figure and refer to it to support your answer. [8]

(b) The following sequence of keyframes specify the position of an object in an animation:

frame	x and y coordinates
1	(100, 50)
11	(200, 50)
16	(100, 75)

i. What will be the position of the object at frame 5, assuming linear interpolation? Show your work. [2]

ii. What will be the position of the object at frame 12, assuming linear interpolation? Show your work. [2]

iii. If an object is at horizontal position x_1 at time t_1, and horizontal position x_3 at time t_3, write an equation for employing linear interpolation to determine its position x_2 at time t_2, assuming time t_2 is in between time t_1 and time t_3. [3]

(c) Flip-book animation

i. What is a flip-book animation? [2]

ii. Approximately how fast would we have to move through a flip book in order to perceive motion? [2]

(d) Explain why we can perceive motion from a sequence of stills (such as a flip-book). [6]

Question 3 Audio and Music Perception

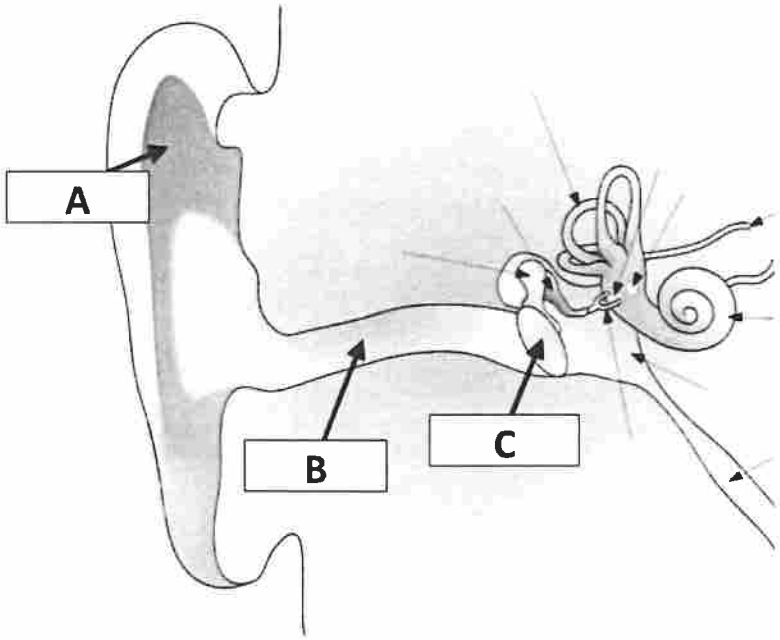
(a) What is melody? [3]

(b) Name the parts of the ear that correspond to the following labels: [3]

i. A

ii. B

iii. C



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

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

(e) A sine wave with amplitude 1.0 is generated by a computer and played out through its speakers. Describe what this sine wave will sound like to a human, in terms of pitch, volume, and timbre, as the frequency of the sine wave is gradually increased from 5 Hz to 22,000 Hz. [7]

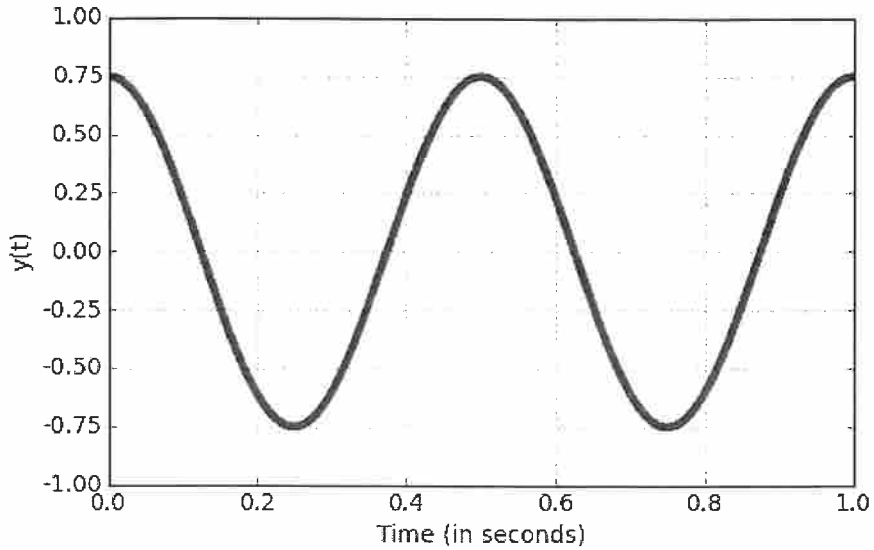
(f) A violin string is bowed, and its pitch is perceived to be the same as a computer-synthesised sine tone whose frequency is 400Hz. At what frequency/frequencies is the violin string vibrating? [3]

(g) A second violin is bowed, and its pitch is perceived to be the same as a computer-synthesized sine tone whose frequency is 401 Hz. What will you hear when this violin string is played at the same time as the first violin string from part (f)? [3]

Question 4 Digital Media Signals and Their Representations

(a) Sinusoids

i. What are the frequency, phase, and amplitude of the following sine wave? [3]



ii. Write an equation for the height of the wave, $y(t)$, as a function of time, t. [2]

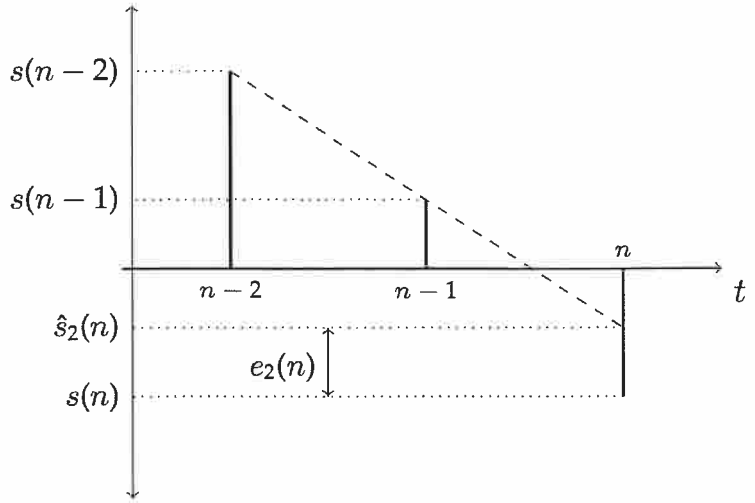
(b) Quantisation

i. What is quantisation (in digital audio)? [2]

ii. Under what circumstances might you choose to use more quantisation bits for an audio signal? Be specific. [2]

iii. Under what circumstances might you choose to use fewer quantisation bits for an audio signal? Be specific. [2]

(c) The following diagram is used in the Subject Guide description of FLAC compression.



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

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

iii. How is the process illustrated here useful in achieving signal compression? [3]

(d) File formats

i. A 15-second WAV file employs a 44,100Hz sample rate, 16-bit quantization, and 2 channels. What is the size of the file, in kilobytes? Show your work, and take care in converting between bits, bytes, and kilobytes! [2]

ii. Rank the following from smallest file size to largest file size: [3]
A: The WAV file above
B: The WAV file above, converted to MP3
C: A .zip file of the WAV file above
D: The WAV file above, converted to FLAC

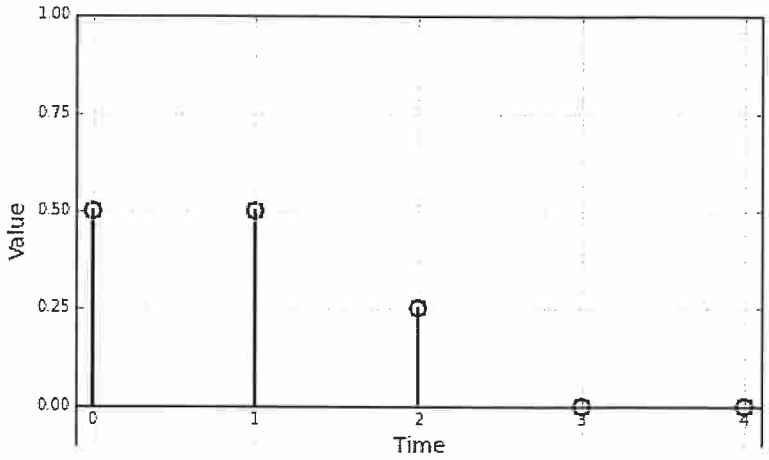
(e) Compression

i. Name one lossy compression format for audio or image. [1]

ii. Describe a specific situation in which you would probably prefer a lossy compression format to a lossless one. [2]

Question 5 Signals and Systems

(a) Draw the result of applying a unit delay to the following digital signal: [2]



(b) Fill in the blanks:

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

ii. The output of a LTI system for a given input signal is computed by convolving the input signal with _____ [2]

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

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

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

$$a\mathrm{T}\{\mathrm{x}[n]\} + b\mathrm{T}\{\mathrm{y}[n]\} = \mathrm{T}\{a\mathrm{x}[n] + b\mathrm{y}[n]\}$$

vi. A system that exhibits both of the properties from iv. and v. above is called a _____ system. [2]

(c) Sketch the magnitude spectrum of the following signal (assuming a sampling rate of 44,100Hz). On your x-axis, show frequency from 0 to 5000 Hz. On your y-axis, show magnitude, but don't worry about the units or about being exact in how you represent magnitude in your plot. [5]

$y(t) = 0.5 \times \sin(2\pi \times 1000t) + 0.25 \times \sin(2\pi \times 2000t) + 0.8 \times \sin(2\pi \times 4000t)$

(d) Describe as precisely as possible the image effect that will be produced by the following kernel: [3]

$$\begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0.5 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0.5 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

(e) Gaussian blur is one example of an image effect that can be achieved using an image kernel. Name three other image effects that can be achieved using an image kernel. [3]

Question 6 Information Retrieval

(a) A music database contains 5000 songs. A user queries the database by humming a melody, intending to find all songs in the database with that melody. 22 songs in the database actually contain this melody; of these, 20 are returned to the user. 5 other songs not containing that melody are also returned to the user.

i. What is the number of true positives for this query? [1]

ii. What is the number of false negatives for this query? [1]

(b) You are building a movie recommendation site that supplies a list of suggested movies which a user is (hopefully) likely to enjoy based on his or her prior ratings of movies.

i. Describe what it would mean for this system to have high precision. [2]

ii. Describe what it would mean for this system to have high recall. [2]

iii. Is it more important to you to make a recommendation system with higher precision, or higher recall? Or are these equally important? Defend your answer. [3]

(c) Distance Measures

i. What does Levenshtein distance measure? [2]

ii. Describe a specific information retrieval application in which this distance measure would be appropriate. [3]

(d) A collection of four images is stored on disk. A representation in CIE LAB space of each image's predominant colour has been precomputed.

A disk store contains three images whose predominant CIE LAB colour coordinates appear in the table below. Which filename should be retrieved for a query colour with CIE LAB coordinates $(50, 30, 35)$? Justify your choice. [7]

File	CIE LAB coordinates
first.png	(48, 80, -50)
second.png	(65, 8, 68)
third.png	(53, -56, 55)
fourth.png	(9, -8, -2)

(e) Describe a perceptual audio feature that you might use if you were implementing a similarity-based search engine for music. Make sure you are describing a specific feature that could be computed, not a general property of music such as "melody." Additionally, make sure you explain why this feature would be relevant for computing musical similarity. [4]

END OF PAPER