THIS PAPER IS NOT TO BE REMOVED FROM THE EXAMINATION HALLS

UNIVERSITY OF LONDON **CO2227 ZB**

BSc Examination

CREATIVE COMPUTING AND COMBINED DEGREE SCHEME

Creative Computing II: Interactive Multimedia

Date and Time: Monday 15 May 2017: 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.

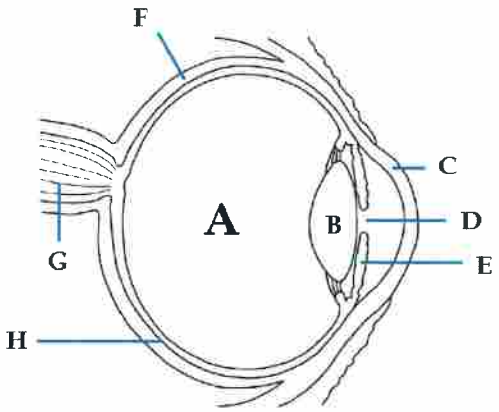
Question 1 Colour and Light

(a) Name the parts of the eye that correspond to the following labels: [3]

i. A

ii. B

iii. D



(b) Describe the role of the cornea in human sight [2]

(c) Describe the role of the retina in human sight [2]

(d) Describe as precisely as possible Grassman's axioms of colour perception for each of the following properties: [3]

- additivity
- proportionality
- transitivity

(e) When do Grassman's axioms hold? [2]

(f) Why do Grassman's laws matter for digital colour production? [2]

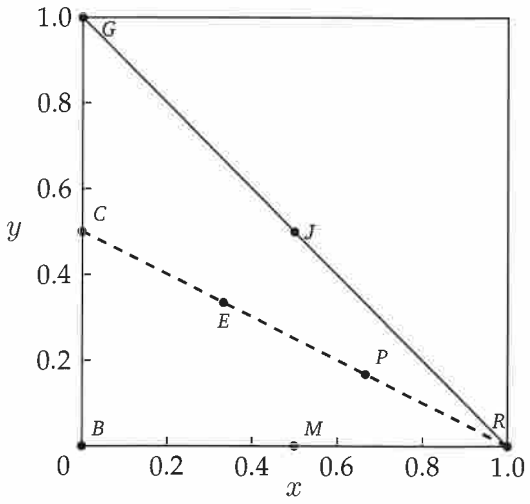
(g) The figure below shows a Maxwell triangle representing the colour space of red, green, and blue primaries.

i. What is point G? [1]

ii. What is the dashed line? [1]

iii. What is the name for the set of points that lie within or on the edge of this triangle? [1]

iv. What is so special about this set of points? [2]



(h) For each of the following descriptions, indicate whether it describes a rod cell or a cone cell: [6]

i. This cell cannot distinguish between wavelengths of light

ii. This cell has a relatively fast response time

iii. This cell is important for sharp central vision

iv. This cell is sensitive to motion but has poor spatial discrimination

v. This cell is extremely sensitive to light and functions well in dark conditions

vi. This cell is absent from the centre of the retina

Question 2 Animation

(a) Explain what is meant by *keyframing* in the context of animation. [3]

(b) Describe how you would choose whether to use stop-motion or computer animation for a particular project. [3]

(c) Let Point A have the coordinates $(50, 0)$ and Point B have the coordinates $(130, 100)$. An animation shows a car stopped at Point A from frame 0 until frame 20. Frame 20 is the last frame at which the car is at Point A; from frame 21 to frame 100, the car moves from Point A to Point B. It then stays at Point B.

i. Sketch the keyframes that could be used for this animation. [3]

ii. If linear interpolation is used, what will be the x coordinate of the car in frame 40? Show your work. [2]

iii. If linear interpolation is used, what will be the y coordinate of the car in frame 40? Show your work. [2]

iv. Write an equation that can be used to compute $x(f)$, the x coordinate of the car for any frame f between 20 and 100: [2]

$$x(f) = ?$$

(d) Splines

i. What are cubic Hermite splines (csplines), and why are they used in animation? [3]

ii. Describe the specific perceptual effect of using a spline instead of linear interpolation to animate the car in part (c) above. [1]

iii. The equation below is used to compute a Catmull-Rom spline. What is $P(t_{k+1})$? [2]

$$m(t_k) = \frac{P(t_{k+1}) - P(t_{k-1})}{2}$$

(e) Persistence of Vision

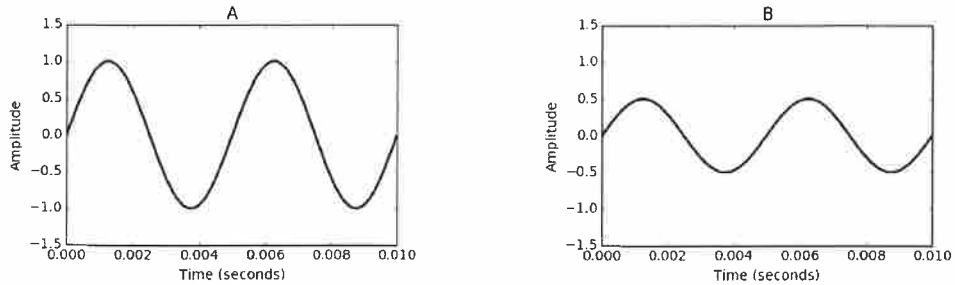
i. What is "persistence of vision" ? [2]

ii. Describe a human perceptual experience that can be explained by this phenomenon. [2]

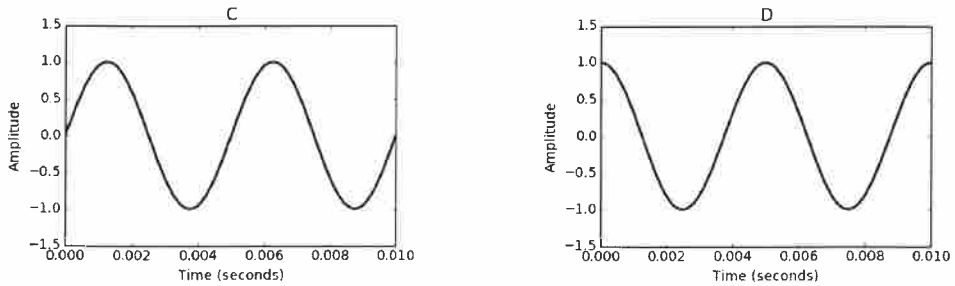
Question 3 Audio and Music Perception

(a) 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]

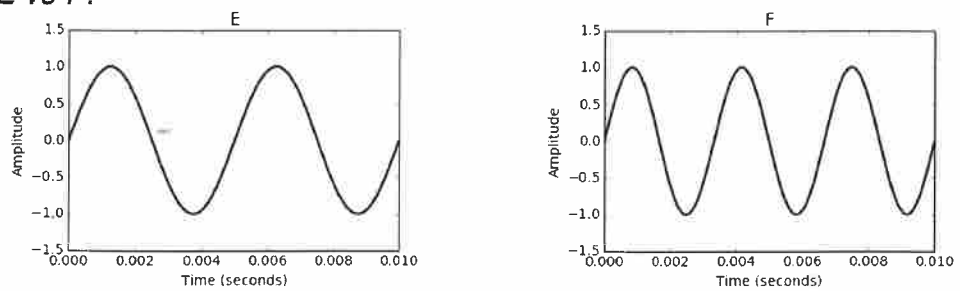
i. A vs B:



ii. C vs D:

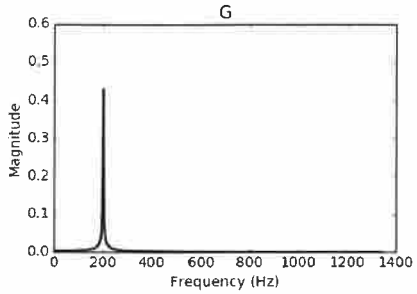


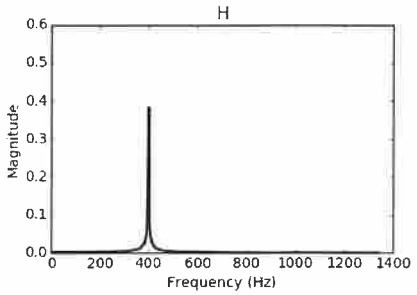
iii. E vs F:



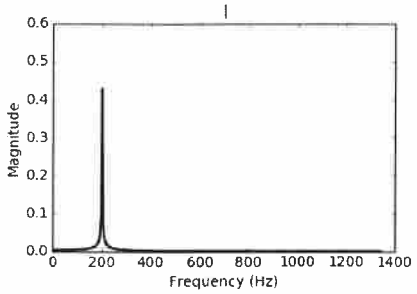
(b) Each row below shows FFTs for two example sounds. Describe as precisely as you can the difference between how the left and right examples will sound. (You can assume that the sounds don't change in volume or frequency content over time.) [3]

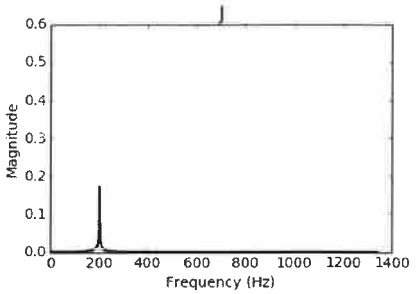
i. G vs H:



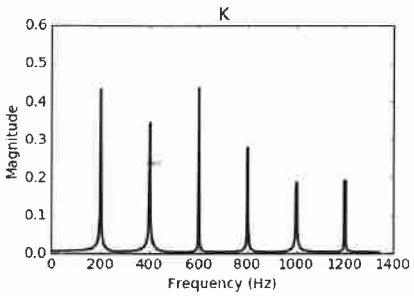


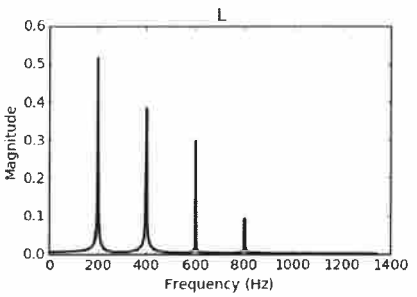
ii. I vs J:





iii. K vs L:





(c) How do we perceive the direction from which a sound is coming? Provide at least one figure, and be sure to make reference to the relevant part(s) of the ear. [6]

(d) Critique the following statement: "Human volume perception is very straightforward. The higher the amplitude of a sound, the louder it is." [6]

(e) A violinist plays a note whose pitch is perceived to be the same as a 600Hz sine wave.

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

ii. Explain your answer above. [1]

(f) What is melody? [3]

Question 4 Digital Media Signals and Their Representations

(a) Audio representations

i. A song is 4 minutes 10 seconds in length. How big will a PCM representation of this song be, assuming stereo, 16-bit quantisation, and a 44.1kHz sample rate? [3]

ii. An MP3 file of this song is 8.6 megabytes. What is the compression ratio achieved over the PCM representation? [1]

iii. Describe how MP3 is able to achieve such a compression ratio. [3]

iv. Rank the following file representations for this song in likely order of size, from smallest to largest: ZIP, WAV, MP3, FLAC [3]

(b) 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 lossless representation instead of a lossy one. [2]

(c) Mice can hear frequencies up to 70 kHz. What is the lowest sample rate you could use for analog-to-digital conversion of audio without removing frequencies noticeable to a mouse? [2]

(d) Aliasing

i. What is aliasing, in the context of digital audio? Include a diagram illustrating the phenomenon of aliasing. [3]

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

(e) What is quantisation (in the context of digital audio)? Include a diagram illustrating the quantisation process. [4]

Question 5 Signals and Systems

(a) Unit impulses

i. Draw a unit impulse on a plot. Provide labels on the x- and y-axis so it is clear what the value of this signal is at each point in time. [2]

ii. What is an impulse response? [2]

iii. Why is knowing the impulse response of a linear time-invariant system useful? [2]

(b) s is a signal whose values over time are given below:

Time index t	$s[t]$
0	1
1	2
2	3

r is the impulse response of a linear, time-invariant system; its values are given below:

Time index t	$r[t]$
0	0
0	1

You can assume that s and r are zero at all other times.

i. What is the output of the given system when s is input? Show values for $t = 0, 1, 2, 3$. Justify your answer by showing your work or providing a written explanation. [4]

ii. What type of system is this? Be as specific as you can, and defend your answer. [2]

(c) You are given the task of designing a filter to remove a low-frequency hum sound from a recording of a music concert.

i. What sort of filter might you use for this task? [2]

ii. What steps will you take to figure out how to build a good filter for this task? For example, what will you do to determine good cutoff frequency/frequencies, and to determine a good filter order? Be as specific as you can. [4]

iii. Sketch a realistic frequency response for a filter that you might build for this task. [3]

(d) 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]

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

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

Question 6 Information Retrieval

(a) What is a "feature," in the context of media information retrieval? [3]

(b) Specific features

i. CIE L*a*b*

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. cepstrum

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]

(c) Two media documents have the following feature values:

Document	Feature 1	Feature 2
A	104	150
B	80	160

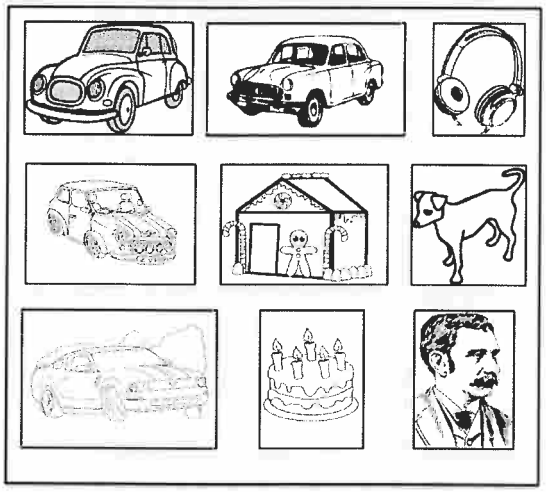
i. Compute the distance between documents A and B using Euclidean distance. Show your work. [2]

ii. A third document, C, has a Euclidean distance of 50 to document A. Which document—B or C—will be judged as more similar to A in this feature space? Why? [2]

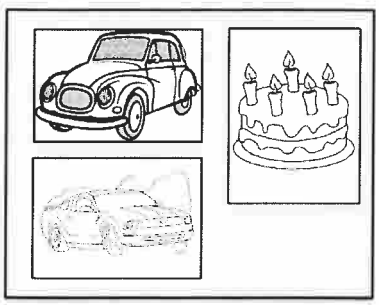
iii. Name two other distance metrics that could be used instead of Euclidean distance for these features. [2]

(d) Precision and Recall

The left side of the figure below shows the contents of a small image database of stock art. A journalist who is looking for a photo to accompany a news story about gardening searches this database using the query "car." The right side of the figure below shows the results returned to her query.



The full image database



Database images returned in response to query "car"

i. What is the precision for this query? [2]

ii. What is the recall for this query? [2]

iii. Do you think it is more important to a journalist to have high precision or high recall for this type of query? Or are these equally important? Defend your answer. [3]

END OF PAPER