UNIVERSITY OF LONDON

GOLDSMITHS COLLEGE

Department of Computing

B. Sc. Examination 2015

IS52020B
Perception & Multimedia Computing

Duration: 3 hours

Date and time:

There are six questions in this paper. You should answer no more than four questions. Full marks will be awarded for complete answers to a total of four questions. Each question carries 25 marks. The marks for each part of a question are indicated at the end of the part in [.] *brackets.*

There are 100 marks available on this paper.

This is a practical examination; each answer requiring code or other computational material should be named according to question number, part and sub-part: for example, `Q5_b_2.pde` *for a Processing sketch in answer to part (b) sub-part (ii) of question 5. Save your answer to the exam submission folder. You are responsible for ensuring that your answers have been saved in the correct location.*

You are allowed to use the OpenGL Quick Reference Card, provided with this exam.

THIS PAPER MUST NOT BE REMOVED
FROM THE EXAMINATION ROOM

Question 1 Colour Spaces and Digital Displays

(a) Name **two** device-dependent colour spaces, and give examples of when those colour spaces might be used. [4]

(b) Sketch the xyY chromaticity diagram, using labelled axes and also labelling the spectral colours and the line of purples. [5]

(c) The sRGB primary colour coordinates are as follows:

R: { X: 0.4124 , Y: 0.2126 , Z: 0.0193 }

G: { X: 0.3576 , Y: 0.7152 , Z: 0.1192 }

B: { X: 0.1805 , Y: 0.0722 , Z: 0.9505 }

Using the conversion formula

$$x = \frac{X}{X+Y+Z}; y = \frac{Y}{X+Y+Z}$$

compute x and y coordinates for each of the sRGB primaries. [6]

(d) Using your answers from parts (b) and (c), describe one way in which standard digital displays are limited compared with the possibilities of human perception. [4]

(e) Describe another way in which standard digital displays are not able to keep up with human perception. [6]

Question 2 Gestalt and Perception

(a) Describe the perceptual effects known as *beta motion* and the *phi phenomenon*, including the typical response elicited, the characteristic timescales, and the relationship with the Gestalt school of perception. [9]

(b) Construct a *Processing* sketch illustrating at least one of beta motion or the phi phenomenon. Include, either in a written answer or in a comment section in your sketch the motion illustrated, and what you expect the viewer to experience. [8]

(c) Name and briefly describe **two** Gestalt principles of grouping visual stimuli. [4]

(d) Describe, with an explanation, aspects of grouping in a non-visual context which could be said to follow a Gestalt principle. [4]

Question 3 Essays on signal representation and perception

Respond to **both** of the following prompts, each in a separate short essay: [25]

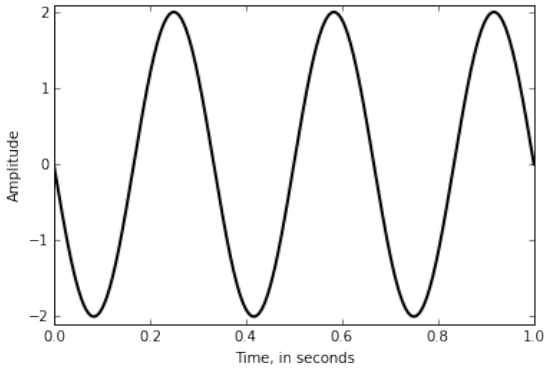
i. Critique the following statement: If you want to make a video file smaller, all you have to do is use a lower frame rate. For example, if your original video is 30 frames per second, delete every other frame and display only 15 frames per second.

ii. Critique the following statement: The phase of a waveform is not relevant to human sound perception.

Each essay is worth half the marks for this question.

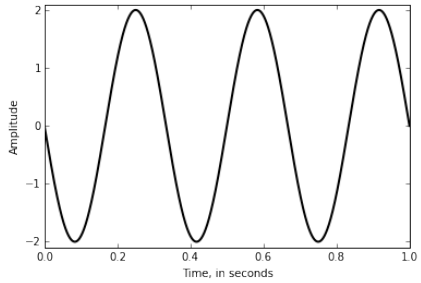
Question 4 Sound and Visual Perception and Representation

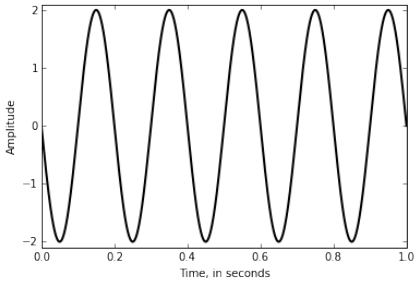
(a) What are the amplitude, frequency, and phase of the following sinusoid? That is, what are A, ϕ, and f in the equation $y = A\sin(2\pi ft + \phi)$? [3]



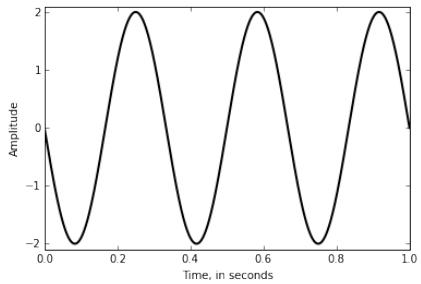
(b) For each row of waveforms below, describe as precisely as you can the difference in how the left waveform will sound from the right one. (Assume that all sinusoids are at suitable amplitudes, frequencies, and phases to be audible.) [4]

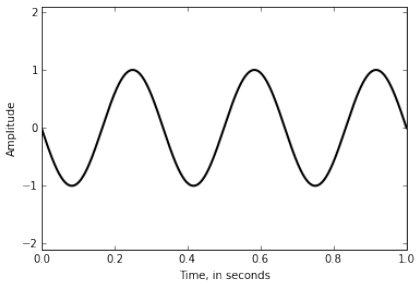
i. A vs B:



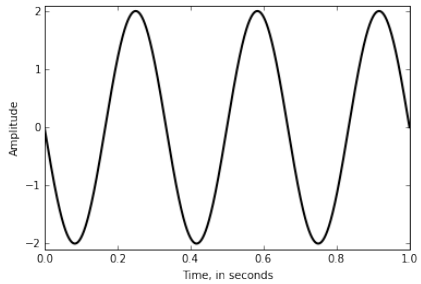


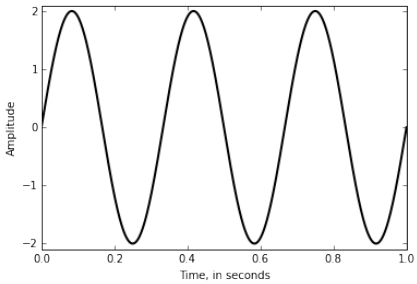
ii. C vs D:



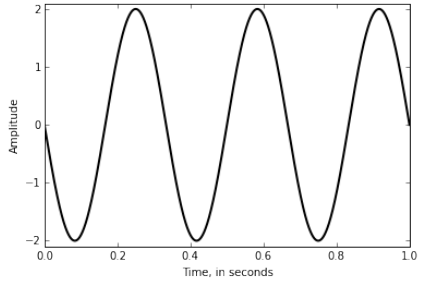


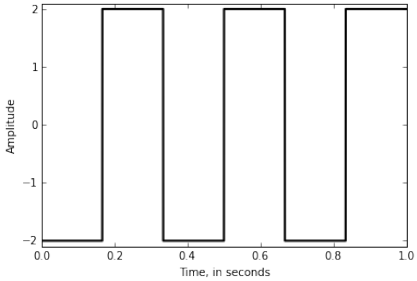
iii. E vs F:



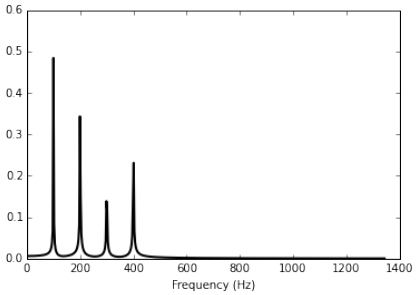


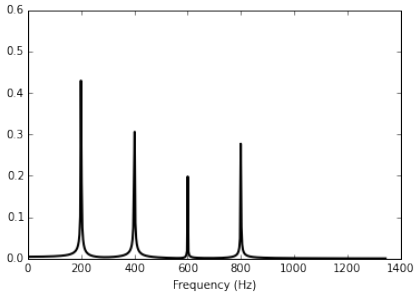
iv. G vs H:





(c) The figures below show the FFTs of two example sound files:





i. Describe as precisely as you can what you will hear if you listen to the example on the left. (You can assume that it doesn't change in volume or frequency content over time.) [2]

ii. Describe as precisely as possible how the second example will sound compared to the first. [2]

(d) Joe wants to write some music in which three sounds increase in volume, one after another. Specifically, he would like the difference between Sound 1 and Sound 2 to be **equal in decibels** to the difference between Sound 2 and Sound 3. Joe digitally synthesizes three waveforms, all pure sine waves with the same frequency. Sound 1 has an amplitude of 0.5. Sound 2 has an amplitude of 0.6. What should the amplitude of the third waveform be? Defend your answer. [4]

(e) The same song is encoded in the following four formats:

FLAC, MP3, WAV, and a zipped WAV file

Rank these formats in likely order of increasing size, justifying your answer. [5]

(f) What does it mean for a visual property to be "pre-attentive"? Name 3 examples of pre-attentive properties, and describe why knowledge of pre-attentive properties is useful in producing effective visualizations. [5]

Question 5 Information Retrieval

(a) You query an image database containing images of all the people living in Lewisham (284,000 people in total), using the search term "man with white hair." Of the 10,000 images that were returned, 9,000 are men with white hair. 2,000 other pictures of men with white hair exist in the database but were not returned to your query.

i. What is the number of true positives? true negatives? false positives? false negatives? [4]

ii. Describe one real-world use for this database in which you might prefer a high rate of precision, even at the cost of low recall. [2]

iii. Describe one real-world use for this database in which you might prefer a high rate of recall, even at the cost of high precision. [2]

(b) You are building a database of paint colours for a paint company. You are also building a user interface to the database that allows customers to query the database by choosing an example of a colour they like; the database will return the five closest colours in the database.

i. What colour space will you use, and why? [2]

ii. How will you choose which five colours to return in response to a query, and why? (e.g., what distance metric?) [3]

(c) Consider the two numeric sequences below:
135679
123578

i. What is the Hamming distance between these two numeric sequences? Show your work. (Hint: treat each number as a sequence of digits, not as an integer.) [2]

ii. What is the Levenshtein distance between them? Show your work. [2]

iii. Give an example of a circumstance in which Levenshtein distance might be preferable over Hamming distance for comparing numeric sequences like those above. [2]

(d) Define (in words) the following computational techniques, and describe how they might be used:

i. Multimedia fingerprinting [3]

ii. Stopword removal [3]

Question 6 OpenGL

For this question, you may find it helpful to refer to the OpenGL Quick Reference Card provided with this exam.

You may choose to test your code for this section by running it on a computer. However, please submit all answers for this question **on paper, written in your exam booklet**.

(a) OpenGLES 2.0 API

i. What is alpha blending? [2]

ii. Write a short segment of code to enable alpha blending, so that the source alpha controls the opacity. [3]

iii. What is depth testing? [2]

iv. Write a short segment of code to enable depth testing that passes if the incoming depth value is equal to the stored depth value. [3]

(b) GLSL shading language

i. In GLSL, how do we represent the colour red with 50% alpha? [2]

ii. Write code for a simple fragment shader that will draw a solid red fragment. [5]

iii. Write code for a vertex shader and fragment shader that renders an attribute "color" for type "vec4". [8]