

**CARDIFF UNIVERSITY
EXAMINATION PAPER**

Academic Year: 2010/2011

Examination Period: Autumn

Examination Paper Number: CM0340

Examination Paper Title: Multimedia

Duration: 2 hours

Do not turn this page over until instructed to do so by the Senior Invigilator.

Structure of Examination Paper:

There are 4 pages.

There are 4 questions in total.

There are no appendices.

The maximum mark for the examination paper is 81 and the mark obtainable for a question or part of a question is shown in brackets alongside the question.

Students to be provided with:

The following items of stationery are to be provided:

ONE answer book.

Instructions to Students:

Answer 3 questions.

The use of calculators is permitted in this examination.

The use of translation dictionaries between English or Welsh and a foreign language bearing an appropriate departmental stamp is permitted in this examination.

Q1. (a) What are the differences between analog signals and digital signals? [2]

A computer is to be used to add effects to analog audio signals. What *two* types of devices in general are needed? Describe their functionalities in the processing pipeline. [2]

(b) Audio signals are often sampled at different rates. CD quality audio is sampled at 44.1kHz rate while telephone quality audio sampled at 8kHz. What are the maximum frequencies in the input signal that can be fully recovered for these two sampling rates? Briefly describe the theory you use to obtain the results. [3]
If an arbitrary input signal is directly sampled, what artefact may result and how to solve this? [2]

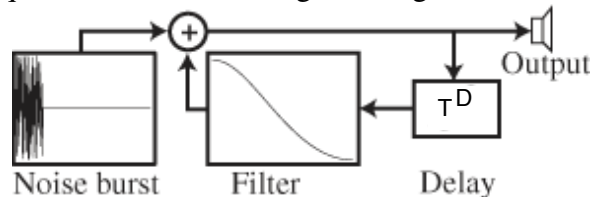
(c) A wavetable is used for digital audio synthesis. For two audio samples as follows (simplified for ease of calculation)

$S_1 : 0, 1, 0, -1, 0, 1, 0, S_2 : -1, -0.6, -0.4, 0, 0.4, 0.6, 1,$

each with 7 samples (1–7). What is the output of linear crossfading from S_1 to S_2 , assuming samples 3–5 are transitional samples with mixed information from both sources? [4]

For a wavetable entry S_3 representing a short audio sample with fundamental frequency of 600Hz. From this, a reshaped wave S_4 is derived satisfying $S_4(t) = S_3(0.75t)$. What is the fundamental frequency of S_4 assuming the same sampling rate is used for playback? [2]

(d) Answer the following questions based on the given diagram:



i. What is the audio synthesis algorithm described in the diagram? [1]

ii. Which general approach of digital audio synthesis most accurately does this algorithm belong to? [1]

iii. If the audio is sampled at 44.1kHz, and $D = 100$ (see the figure), what is the fundamental frequency of the synthesised audio? [2]

iv. To halve the fundamental frequency of the synthesised audio, what *two* possible changes can you make? [2]

(e) Describe what ADSR envelope means (with an illustration) and how this is applied in digital audio synthesis. [6]

Q2. (a) Dithering is often used when converting greyscale images to monochrome.

i. What is the basic idea of dithering? [1]

ii. For the given 2×2 dither matrix, briefly describe the *ordered dithering* algorithm. [2]

$$\begin{pmatrix} 0 & 2 \\ 3 & 1 \end{pmatrix}$$

- iii. Use the same dither matrix, what is the result for the following input? Assume that the input is greyscale intensities normalised to **0 to 1**. [4]

0.66	0.18	0.03	0.19
0.54	0.13	0.56	0.37
0.70	0.99	0.88	0.46
0.67	0.17	0.67	0.98

- (b) Different colour models are often used in different applications. What is the CMYK colour model? Give an application in which this colour model is mostly used and explain the reason. [3]

Given a colour represented in RGB colour space as $R = 0.2$, $G = 0.6$, $B = 0.3$, what is its representation in the CMYK colour model? [2]

- (c) Give *three* colour models other than RGB/CMYK and give a practical application in which that model is used. [6]

- (d) What is chroma subsampling? Why is chroma subsampling meaningful? What is the benefit of doing chroma subsampling? [3]

For the following array of colour values, give chroma subsampling results with 4:2:2, 4:1:1 and 4:2:0 schemes. [6]

80	88	96	12
60	8	72	68
24	52	52	8
28	20	48	12

- Q3. (a) GIF and JPEG are two commonly used image representations. What images are suitable to be represented as GIF and JPEG? Do they usually use lossless or lossy compression? Explain the reason by showing the major compression algorithm (for lossless) or the lossy steps of the algorithm (for lossy). [6]

- (b) In the following situations, which (mostly) *lossless* compression algorithm is most suitable? Briefly describe the basic idea of each algorithm *in one sentence*.

- Compression of a sequence of tokens with known, uneven probability distribution. [2]
- Compression of a sequence of tokens with unknown probability but with reoccurrence of patterns. [2]
- Compression of a sequence of gradually changing numbers. [2]
- Compression of a sequence of tokens with same tokens often appearing consecutively. [2]

- (c) What is the improvement of the LZW algorithm over the LZ algorithm? [2]

Given the following string as input (excluding the quotes), '/THIS/IS/HIS/IS/' with the initial dictionary below, **encode** the sequence with the LZW algorithm, showing the intermediate steps. [11]

Index	Entry
1	/
2	H
3	I
4	S
5	T

- Q4. (a) List *two* psychological phenomena that have been exploited in MEPEG audio compression. [2]

Briefly explain their meanings. [2]

- (b) What is the key difference between I-frames, P-frames and B-frames in MPEG-2 video compression? [3]

Give the advantages and disadvantages of using B-frames. [2]

- (c) Assume 2×2 macroblock is used. For the following macroblock

#	#	#	#
#	6	4	#
#	2	2	#
#	#	#	#

the corresponding intensities in the reference frame are given as follows:

5	3	6	2
1	4	7	3
4	5	3	3
3	2	3	3

Calculate the motion vector, with complete search within ± 1 pixel search window. List the steps to obtain the result. [5]

Should the intra-frame or inter-frame coding scheme be used for this macroblock? Why? [5]

What is the macroblock being coded after motion compensation? [2]

- (d) Given the following coding schemes for a group of sequential frames in MPEG-2:

I	B	B	P	B	B	B	P	I	B	B	B	P	B	P	P
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

What is the coding order of the frames? [6]