

**CARDIFF UNIVERSITY
EXAMINATION PAPER**

Academic Year: 2012/2013
Examination Period: Spring
Examination Paper Number: CM0340/CMT502
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) How does the *human eye* sense colour? What characteristics of the human visual system can be exploited for the compression of colour images and video? [5]
- (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) What is a *colour look-up table* and how is it used to represent colour? [5]
 Give an advantage and a disadvantage of this representation with respect to true colour (24-bit) colour. [2]
 How do you convert from 24-bit colour to an 8-bit colour look up table representation? [1]
- (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]

90	100	96	42
80	18	82	78
44	62	52	38
28	23	48	22

- Q2. (a) GIF and JPEG are two commonly used image representations. Do they usually use lossless or lossy compression? State the major compression algorithm (if lossless) or the lossy steps of the algorithm (if lossy) for each representation. [4]
- (b) Briefly describe the four basic types of data redundancy that data compression algorithms can apply to audio, image and video signals. [8]
- (c) Given the following string as input, /TAN/HAN/HAN/AN/, with the initial dictionary below, **encode** the sequence with the LZW algorithm, showing the intermediate steps. [10]

Index	Entry
1	/
2	H
3	A
4	N
5	T

- (d) Briefly describe the LZW *decoding process*, and illustrate your answer with the above string sequence [5]

- Q3. (a) Briefly, with the aid of suitable diagrams, outline the *JPEG/MPEG I-Frame compression pipeline* and list *the constituent compression algorithms* employed at each stage in the pipeline. [9]
 What are the *key differences* between the JPEG and MPEG I-Frame compression pipelines? [4]
- (b) *Motion JPEG (or M-JPEG)* is a video format that uses JPEG picture compression for *each frame* of the video. Why is M-JPEG *not widely used* as a video compression standard? [2]
 Briefly state what *additional approaches* are used by MPEG video compression algorithms to improve on M-JPEG. [2]
- (c) What processes, outlined in (a), give rise to the *lossy* nature of JPEG/MPEG video compression? [4]
- (d) Given the following portion from a *block* (assumed to be 4x4 pixels to simplify the problem) from an image after the Discrete Cosine Transform stage of the compression pipeline has been applied:

118	42	54	150
42	32	30	34
100	60	43	98
44	39	40	31

- i. What is the result of the *quantisation step* of the MPEG video compression method assuming that a constant quantisation value of 32 is used? [3]
- ii. What is the output of the following *zig-zag step* being applied to the resulting quantised block? [3]

Q4. (a) In MPEG audio compression, what is

i. *frequency masking*? [2]

ii. *temporal masking*? [2]

Briefly describe the *cause* of each kind of masking in the human auditory system?

[6]

(b) Briefly describe, using a suitable diagram if necessary, the *MPEG-1 audio compression algorithm*, outlining how frequency masking and temporal masking are encoded. [10]

(c) In MPEG-4 Audio an alternative *synthesis-based* approach may be adopted to achieve compression. Briefly discuss how the following may be compressed with MPEG-4 Audio:

- Musical Audio Signals
- Spoken Word Audio.

What are advantages and disadvantages of such approaches? [4]

(d) Assume that after analysis, the critical band filters of MPEG-1 Audio have output the levels of 3 consecutive critical bands as:

Band	1	2	3
Level (dB)	20	90	55

Assuming that *signal-to-mask ratios* for bands 1, 2 and 3 are for signals above 80 dB in band 2 a masking of 30 dB in band 1 and 40 dB in band 3:

Show how frequency masking is implemented in MPEG audio compression.

What is the saving in bits to transmit the masked value in each masked band?

[3]