DUBLIN CITY UNIVERSITY

AUTUMN RESIT EXAMINATIONS 2009-2010

MODULE: (Title & Code)	EE554 Image and Video Compression
COURSE:	MEng in Electronic Systems (MEN) MEng in Telecommunications Engineering (MTC) Masters Engineering Qualifier Course (MEQ) Grad Cert. in Electronic Systems (GCES) Grad Cert. in Telecommunications Eng. (GCTC) Graduate Diploma in Electronic Systems (GDE) Grad Dip in Telecommunications Eng (GTC)
YEAR:	2010
EXAMINERS: (Including Telephone Nos.)	Prof Peter Ashburn Prof. Noel O'Connor, Ext no. 5078 Dr. David Sadlier, Ext no. 6830
TIME ALLOWED:	3 hours
INSTRUCTIONS:	Answer any FOUR questions

Please do not turn over this page until instructed to do so

The use of programmable or text storing calculators is expressly forbidden. Please note that where a candidate answers more than the required number of questions, the examiner will mark all questions attempted and then select the highest scoring ones

QUESTION 1 [TOTAL MARKS: 25]

1(a) [5 Marks]

What is meant by the term QUANTIZATION in a video encoding process? Is this a LOSSY or a LOSSLESS process? Give an example of an information source that undergoes quantization in an MPEG-1 video encoder.

1(b) [5 Marks]

Describe the key features of the CIF (Common Intermediate Format) standard for uncompressed video sequences. Calculate the storage required for a 2 min CIF video sequence assuming 4:2:0 format i.e. assume that the colour components are sub-sampled by a factor of 2 in each of the X (horizontal) and Y (vertical) directions.

1(c) [5 Marks]

Consider the following statement:

> "A compression scheme can be made arbitrarily efficient at the cost of encoding delay."

Is this statement TRUE or FALSE? Refer to Shannon's LOSSLESS CODING THEOREM to justify your answer.

1(d) [5 Marks]

Consider the following statement:

> "'If the information source is modeled correctly, Huffman coding is guaranteed to be 100% efficient."

Is this statement TRUE or FALSE? Give an example with a simple 3 symbol information source to justify your answer.

1(e) [5 Marks]

Briefly outline how pixels are encoded in either the Group 3 or Group 4 Fax coding standard.

[End of Question 1]

QUESTION 2 [TOTAL MARKS: 25]

2(a) [3 Marks]

Consider the following statement:

> "If two vectors are ORTHOGONAL, their DOT-PRODUCT equals 1.0."

Is this statement TRUE or FALSE? Provide a brief explanation to justify your answer.

2(b) [3 Marks]

Consider the following statement:

> "In Fourier analysis of signals, an amplitude shift in a waveform has NO effect on ANY of its corresponding Fourier coefficients."

Is this statement TRUE or FALSE? Provide a brief explanation to justify your answer.

2(c) [10 Marks]

Given below are the standard mathematical expressions for Fourier's Theorem, and for calculating the coefficients a_n and b_n. By examining these formulae, explain how the construction of evenly/oddly symmetric periodic functions, $f(x)$, allows us to dictate the properties of Fourier series expansions.

> Hint: exploit the interval of definition of the integrals $[-L/2, L/2]$, where L is the period.

$$f(x) = \frac{1}{2}a_0 + \sum_{n=1}^{\infty} a_n \cos(n\omega x) + \sum_{n=1}^{\infty} b_n \sin(n\omega x)$$

where:

$$a_0 = \frac{2}{L}\int_{-\frac{L}{2}}^{\frac{L}{2}} f(x)dx$$

$$a_n = \frac{2}{L}\int_{-\frac{L}{2}}^{\frac{L}{2}} f(x)cos(n\omega x)dx$$

$$b_n = \frac{2}{L}\int_{-\frac{L}{2}}^{\frac{L}{2}} f(x)sin(n\omega x)dx$$

2(d) [9 Marks]

Explain why HALF-RANGE Fourier series with SINE-ONLY terms tend to exhibit slower convergence than half-range series with cosine-only terms. Explain why convergence of the Fourier series of the following function is UNLIKELY to be faster than $\frac{1}{n^3}$, where n is the number of terms.

$$f(x) = \begin{cases} 2x^2 & 0 \leq x < 0.25 \\ -2x^2 + 2x - 0.25 & 0.25 \leq x < 0.75 \\ 2x^2 - 4x + 2 & 0.75 \leq x < 1 \end{cases}$$

[End of Question 2]

QUESTION 3 [TOTAL MARKS: 25]

3(a) [3 Marks]

Outline how the one-dimensional Discrete Cosine Transform (DCT) can be extended to handle TWO-DIMENSIONAL input data.

3(b) [3 Marks]

Consider the following statement:

> "In image processing, the transformation of pixel values via the DCT is a LOSSY process, resulting in the input image being represented by a smaller number of data values."

Is this statement TRUE or FALSE? Provide a brief explanation to justify your answer.

3(c) [3 Marks]

Consider the following statement:

> " In the context of bit-allocation/quantization, the OPTIMAL division of an average bitrate across multiple coefficients corresponds to the uniform quantizer of each individual expression having the SAME STEP-SIZE."

Is this statement TRUE or FALSE? Provide a brief explanation to justify your answer.

3(d) [3 Marks]

Explain how JPEG exploits the INTER-COMPONENT REDUNDANCY of tri-channel (e.g. RGB) input images.

3(e) [3 Marks]

Briefly outline the structure of the informal 'standard' Motion JPEG (M-JPEG). [3 marks]

3(f) [10 Marks]

Outline the STRUCTURE of the video compression layer of the ISO MPEG-1 digital audio/video coding standard, explaining the ROLE PLAYED by each component process.

[End of Question 3]

QUESTION 4 [TOTAL MARKS: 25]

4(a) [4 Marks]

Briefly describe why a MATCHING CRITERION is required in a motion estimation search process. Give a mathematical formulation for the MEAN ABSOLUTE DIFFERENCE (MAD) criterion.

4(b) [8 Marks]

Estimate the computational cost (i.e. the total NUMBER OF COMPUTATIONS required), for generating a motion vector for ALL 16×16 blocks in a CIF video frame. You should assume:

- motion estimation is carried out on the luminance (Y) component only;
- a FULL SEARCH motion estimation algorithm is used with a search window size of ± 8 pixels;
- there are THREE computations required for each pixel location accessed, corresponding to a subtraction, absolute value and an accumulation.

4(c) [9 Marks]

Sketch the high level structure of a H.261 VIDEO ENCODER and briefly describe its operation. In your diagram, indicate the DECODING components that are implicit components of the encoder.

4(d) [4 Marks]

Consider the following statement:

> "The H.263 standard for video compression is effectively a description of a video decoder and a specification of a bitstream syntax."

Is this statement TRUE or FALSE. Provide a brief explanation to justify your answer.

[End of Question 4]

QUESTION 5 [TOTAL MARKS: 25]

5(a) [12 Marks]

Sketch the BITSTREAM DIAGRAMS as specified for a H.261 video codec. You should provide separate sketches for:

- Picture layer
- Group of Blocks (GOB) layer
- Macroblock layer
- Block layer

In each case, explain what each bitstream component/acronym refers to and specify whether it is encoded as a fixed length code or a variable length code. (NOTE: You DO NOT need to specify how many bits are used for each bitstream component.)

5(b) [9 Marks]

What is meant by SPATIAL SCALABILITY in the context of an MPEG-4 video encoding process? Explain the relationship between the different kinds of VOPS present in the BASE LAYER and ENHANCEMENT LAYER – provide a diagram to illustrate your answer.

5(c) [4 Marks]

Describe the relationship between FEATURE EXTRACTION from source audio-visual content and the MPEG-7 standard. What is the TERM USED to identify and describe such aspects of any standard?

[End of Question 5]

[END OF EXAM]