北京郵電大學

Queen Mary University of London

For examiners' use only

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Total	

EBU5303 A

Joint Programme Examinations 2019/20

EBU5303 Multimedia Fundamentals

Paper A

Time allowed 2 hours

Answer ALL questions

Complete the information below about yourself very carefully.

QM student number										
BUPT student number										
Class number										

Allowed: electronic calculators

INSTRUCTIONS

1. **You must NOT take answer books, used or unused, from the examination room.**
2. Write only with a black or blue pen **and in English**.
3. Do all rough work in the answer book – **do not tear out any pages**.
4. If you use Supplementary Answer Books, tie them to the end of this book.
5. Write clearly and legibly.
6. **Read the instructions on the inside cover.**

Examiners

Dr Marie-Luce Bourguet, Dr Atm Shafiul Alam

Filename: 1920_EBU5303_A No answer book required

Instructions

Before the start of the examination

1) Place your BUPT and QM student cards on the corner of your desk so that your picture is visible.

2) Put all bags, coats and other belongings at the back/front of the room. All small items in your pockets, including wallets, mobile phones and other electronic devices must be **placed in your bag in advance**. **Possession of mobile phones, electronic devices and unauthorised materials is an offence.**

3) Please ensure your mobile phone is switched off and that no alarm will sound during the exam. **A mobile phone causing a disruption is also an assessment offence.**

4) Do not turn over your question paper or begin writing until told to do.

During the examination

1) You must not communicate with or copy from another student.

2) If you require any assistance or wish to leave the examination room for any reason, please raise your hand to attract the attention of the invigilator.

3) If you finish the examination early you may leave, but not in the first 30 minutes or the last 10 minutes.

4) For 2 hour examinations you may **not** leave temporarily.

5) For examinations longer than 2 hours you **may** leave temporarily but not in the first 2 hours or the last 30 minutes.

At the end of the examination

1) You must stop writing immediately – **if you continue writing after being told to stop, that is an assessment offence.**

2) Remain in your seat until you are told you may leave

Question 1

a) This question is about digitisation. Consider a sound wave W with a frequency f = 440 Hz.

[8 marks]

i) What is the sine function representing W?

(1 mark)

ii) What kind of sound is represented by a completely regular sine wave such as W?

(1 mark)

iii) What does the amplitude of W tell us about the sound it represents?

(1 mark)

iv) What is the minimum sampling rate you should use to ensure that you can digitise W without audio aliasing? Justify your answer.

(2 marks)

v) You decide to use 5 bits per sample. How many different values can W take?

(1 mark)

vi) Calculate an approximation of the Signal-to-Quantisation Noise Ratio (SQNR) of W. Explain your calculation.

(2 marks)

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	8 marks

b) This question is about colour encoding.

[12 marks]

i) In a true colour image, what is the number of different colours that can be represented? Justify your answer.

(2 marks)

ii) Describe the properties of a fully saturated colour.

(2 marks)

iii) In the HSV colour model, how is the grayscale represented?

(2 marks)

iv) What (R, G, B) values would you use to encode an unsaturated dark blue colour?

(2 marks)

v) What (C, M, Y) values would you use to encode a fully saturated bright green colour?

(2 marks)

vi) Yellow ink is spread onto a white sheet of paper. What colour will you see if the paper is illuminated with a blue light? Justify your answer.

(2 marks)

	Do not write in this column	
		12 marks

c) Consider a video with the following properties: frame size is 1280-by-720-pixels; colour depth is 24-bits; frame rate is 30 fps; duration is 1 minute.

[5 marks]

i) How much data rate reduction can be achieved by reducing the width and height of this video to half? Prove your answer by calculating the data rates.

(3 marks)

ii) Give two possible strategies for reducing the colour depth of the video to just a third of its original depth.

(2 marks)

	Do not write in this column
	5 marks

Question marking: $\frac{}{8} + \frac{}{12} + \frac{}{5} = \frac{}{25}$

Question 2

a) This question is about audio.

[5 marks]

i) Briefly explain what is shown in an audio histogram such as the one in Figure 1. In particular, comment the units used on the X and Y axes.

(3 marks)

ii) Do audio histograms and audio spectrograms represent signals in the same domain? Justify your answer.

(2 marks)

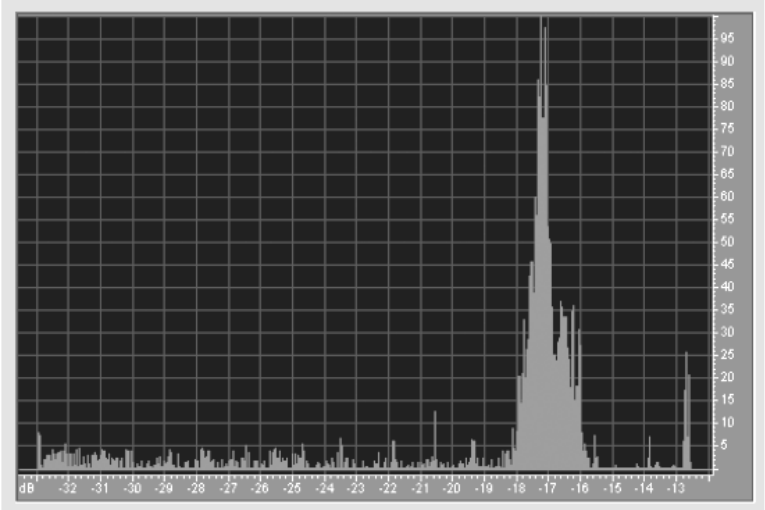

Figure 1: Audio histogram

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	5 marks

b) Image lossless compression.

[10 marks]

i) What image property is used in Huffman encoding to achieve compression? Justify your answer.

(3 marks)

ii) Decode the following binary message using the Huffman encoding table provided in Table 1.

Binary message: 1111101111010011011110101101100110111110101011001100100111111

(2 marks)

iii) Assuming that each symbol of Table 1 would normally be encoded using 3 bits (which is enough to encode 5 different symbols), how much compression is achieved in the binary message of question ii) above?

(3 marks)

iv) Consider the following statement: "For compression to remain lossless, an image should be encoded/decoded only once". Is it correct? Justify your answer.

(2 marks)

symbol	probability	code
A	0.40	00
B	0.20	01
C	0.20	10
D	0.10	110
E	0.10	111

Table 1: Huffman encoding table

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	10 marks

c) Consider the block diagram shown in Figure 2 and answer the questions below.

[10 marks]

i) Describe what is contained inside the block marked with the label "A".

(2 marks)

ii) What step of the JPEG compression process is marked with the label "B"? Explain this step.

(3 marks)

iii) Explain the use of quantisation tables in the JPEG compression process.

(3 marks)

iv) Which phenomenon of human vision is exploited in chroma sub-sampling?

(2 marks)

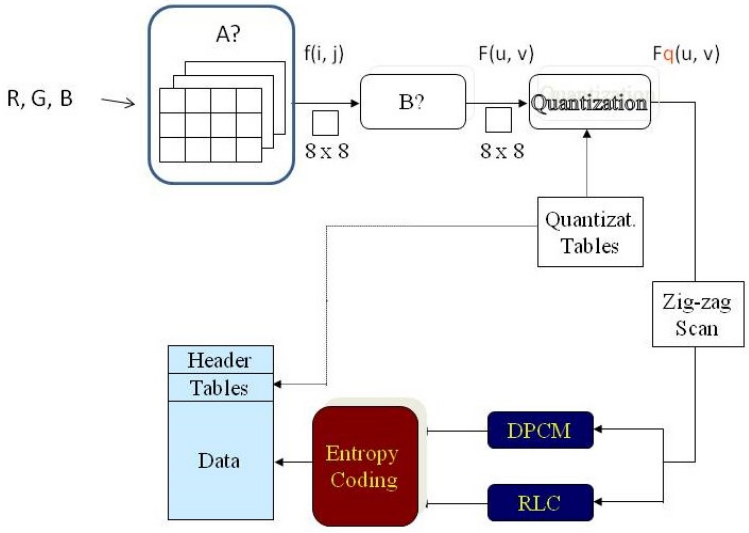

Figure 2: JPEG block diagram

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	10 marks

Question marking: $\frac{\quad}{5} + \frac{\quad}{10} + \frac{\quad}{10} = \frac{\quad}{25}$

Question 3

a) This question is about MPEG.

[14 marks]

i) What type of MPEG frame makes no prediction?

(1 mark)

ii) What type of MPEG frame is never used as a reference frame during decompression? Why?

(3 marks)

iii) Suppose an MPEG encoder uses the nine-frame sequence IBBPBBPBB. Draw a diagram showing the dependencies between the first 12 frames of a compressed clip produced by this encoder.

(3 marks)

iv) Briefly explain the Block Matching Algorithm (BMA) for motion estimation when a maximum motion displacement of x pixels is used.

(4 marks)

v) Given a maximum motion displacement of 8 pixels, how many evaluations of the matching criterion are required in the BMA?

(1 mark)

vi) Briefly explain the basic principle of fast motion estimation techniques.

(2 marks)

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		14 marks

b) This question is about perceptual encoding.

[11 marks]

i) With A-law coding, larger signals are represented with greater precision – more data bits – than smaller signals. Is this statement true or false? Justify your answer.

(4 marks)

ii) There are 24 critical bands in the human hearing range, but critical bands for low frequencies are narrower than those for high frequencies. What is this statement telling us about the human ability to distinguish between frequencies?

(3 marks)

iii) What is the threshold of hearing and how does frequency masking affect the threshold of hearing?

(4 marks)

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		11 marks

Question marking: $\frac{}{14} + \frac{}{11} = \frac{}{25}$

Question 4

a) This question is about MP3.

[15 marks]

i) In MP3, one way to reduce the amount of data in the compressed signal is to use scaling factors that increase the quantisation error where it doesn't matter. Briefly explain how the parts of the signal that will be multiplied by a large scaling factor can be found.

(5 marks)

ii) Say that an uncompressed band value is 10,000 and values from all bands are quantised by dividing by 128 and rounding down. What is the quantisation error? Show your calculations.

(3 marks)

iii) Now suppose that this band requires less precision because of a strong masking tone, and that it should be scaled by a factor of 0.1. Recalculate the quantisation error.

(3 marks)

iv) With an MP3 bitrate of 128 kbit/s, calculate the compression ratio that is achieved on a CD quality digital audio signal (CD quality = 44100 samples per second, stereo and 16 bits per channel).

(2 marks)

v) What is meant by "Average Bit Rate" (ABR)?

(2 marks)

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		15 marks

b) This question is about DVB-S.

[10 marks]

i) What compression standard is used for source coding in DVB-S?

(2 marks)

ii) What is the purpose of energy dispersal?

(2 marks)

iii) How does the Reed-Solomon Error Protection scheme work?

(2 marks)

iv) Assuming a symbol rate of 27.5 MS/s, QPSK modulation, Reed-Solomon code with rate (204, 188), and a code rate of ¾ are used, calculate the bit stream net data rate. Show your calculations.

(4 marks)

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	10 marks

Question marking: $\frac{}{15} + \frac{}{10} = \frac{}{25}$

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