



北京邮电大学



# EBU6018

Alternative Assessment (Odd Semester - Paper A)

## Joint Programme Assessments 2022/23

### EBU6018 Advanced Transform Methods

Answering this paper requires **2 hours**; Answers to be submitted within the allocated **3 hours window**.

**Answer ALL questions**

#### **INSTRUCTIONS**

1. **You must NOT share any content from this document during the assessment period.**
2. Your answers must be typed, and diagrams or equations must be written clearly and legibly with black or blue colour **and in English**.
3. You need to submit your answers BEFORE the allocated deadline.
4. **Read the instructions on the inside cover of the questions sheet.**

#### **Examiners**

Mr Andy Watson, Dr Yixuan ZOU

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Filename: EBU6018\_ALT-2022-23\_S1A

## Instructions

This is an open-book assessment, which should be completed **within 2 hours**. You **MUST** submit your answers within the allocated time in the timetable.

You **MUST** complete the assessment on your own, without consulting any other person. You **MAY NOT** check your answers with any other person.

You can refer to textbooks, notes and online materials to facilitate your working, if you provide a direct quote, or copy a diagram or chart, you must cite the source.

### **Before you start the assessment**

- 1) Read the questions thoroughly and understand them.
- 2) Ensure you have all the resources you require to complete and upload the final assessment.
- 3) If you require any assistance, **raise the issue via the messaging section of this assessment on QMPlus**, immediately.

### **During the assessment session**

- 1) Use the supplied answer sheet document to enter your answers. Start on a new page for each question. Make sure it is clear which question number you are answering.
- 2) **Type your answers** in the supplied answer sheet; hand-written equations or sketches can be incorporated into the answer sheet. Please save your work at least every 15 minutes so that you do not risk losing it.
- 3) When completed answering all questions, perform a word count and list the number of words on the answer sheet, then save the file as pdf before uploading, **only pdf will be accepted**, any other file format will not be accepted.
- 4) Your submission must be your own work, and you must ensure that you do not break any of the rules in the Academic Misconduct Policy.

### **Submitting the Assessment**

- 1) You must submit your answers within the scheduled assessment time – do not leave submissions too close to the deadline. **NO late submission will be accepted, no exceptions.**
- 2) Make sure you upload and submit the final version before the deadline.
- 3) Please be aware that submissions will be subject to review, including but not limited to plagiarism detection software.

If you have any problems relating to access or submitting during the assessment period, please contact the email ([it-issues@qmbupt.org](mailto:it-issues@qmbupt.org)), state the module code in the subject, and clearly state your name and student ID and any issues you are experiencing. You must use either @qmul.ac.uk or @bupt.edu.cn email address. Requests from external email addresses will not be processed.

**Question 1**

a) For matrix A, find x, y and z so that the columns of A form an orthogonal basis for  $R^3$ .

**[10 marks]**

IF YOUR BUPT ID IS ODD,  $A = \begin{bmatrix} -1 & x & 2 \\ 2 & y & 3 \\ 2 & z & -2 \end{bmatrix}$

IF YOUR BUPT ID IS EVEN,  $A = \begin{bmatrix} 2 & x & -2 \\ -1 & y & 4 \\ 2 & z & 4 \end{bmatrix}$

**(10 marks)**

b) This question is about the Short-Time Fourier Transform.

**[15 marks]**

The Short Time Fourier Transform is used to localise the frequency content of a signal in time in addition to the signal's frequency content.

i) List the steps involved in performing a STFT.

**(4 marks)**

ii) Two factors influence the choice of window, namely shape and width.

IN YOUR OWN WORDS, briefly discuss these.

**(11 marks)**

**Question 2**

a) This question is about the Discrete Cosine Transform (DCT).

[19 marks]

i) The Discrete Cosine Transform (DCT) is related to the Fourier Transform, and has several advantages. **IN YOUR OWN WORDS**, state and briefly explain THREE advantages of the DCT.  
(6 marks)

ii) The DCT is a separable transform.

**IN YOUR OWN WORDS**, explain what is meant by a separable transform how this is implemented when a DCT is applied to a 2D image.

(6 marks)

iii) The definition of a 1D Discrete Cosine Transform (DCT) is:

$$DCT[k] = c(k) \sum_{n=0}^{N-1} s[n] \cos \frac{\pi(2n+1)k}{2N}$$

$$c(k) = \begin{cases} \sqrt{1/N} & k = 0 \\ \sqrt{2/N} & k \neq 0 \end{cases}$$

The basis functions of a [4x4] DCT are given by the matrix:

$$\Psi = \begin{bmatrix} 0.50 & 0.50 & 0.50 & 0.50 \\ 0.65 & 0.27 & -0.27 & -0.65 \\ 0.50 & -0.50 & -0.50 & 0.50 \\ 0.27 & -0.65 & 0.65 & -0.27 \end{bmatrix}$$

**IF YOUR BUPT ID IS ODD**, determine the output sequence  $y[n]$  if the input is the sequence

$$s[n] = [7, 3, -4, 2]$$

**IF YOUR BUPT ID IS EVEN**, determine the output sequence  $y[n]$  if the input is the sequence

$$s[n] = [3, 2, 7, -4]$$

(4 marks)

iv) The DCT is lossless, but is used to produce jpeg compressed images.

**IN YOUR OWN WORDS**, briefly explain the use of the DCT for this application.

(3 marks)

b) This question is about the analysis filterbank.

**[6 marks]**

In the wavelet transform, the scaling function coefficients  $c_{m,n}$  and wavelet series coefficients  $d_{m,n}$  can be calculated recursively according to the following equations:

$$c_{m-1,n} = \sqrt{2} \sum_i h_0[i - 2n] c_{m,i}$$
$$d_{m-1,n} = \sqrt{2} \sum_i h_1[i - 2n] c_{m,i}$$

**IN YOUR OWN WORDS**, explain how this can be interpreted in terms of filtering and downsampling, and hence leads to the concept of an *analysis filterbank*. Sketch a diagram to illustrate this filterbank. **(6 marks)**

**Question 3**

This question is about Haar Functions.

**[25 marks]**

i) Haar functions are a set of functions that can be used to perform Haar wavelet transforms.

1) With the help of diagrams, define the Haar scaling function and the Haar wavelet function  
**(2 marks)**

2) The Haar Function can be used as a simple wavelet. Briefly explain why this is possible.

**(5 marks)**

ii)

1) State the 8x8 unnormalized Haar transform matrix.

**(4 marks)**

2) **IN YOUR OWN WORDS**, explain what each row of the 8x8 unnormalized Haar matrix can be used to measure.  
**(8 marks)**

iii) Below is the transform coefficients of an 8-point Haar transform, **IN YOUR OWN WORDS**, explain what does the transform coefficients imply about the input sequence.  
**(6 marks)**

$$S[k] = [9.5, -10.21, 1.01, 14.2, 2.09, -0.08, 0.19, -2.89]$$

**Question 4**

a) This question is about the Karhunen-Loeve Transform (KLT)

**[20 marks]**

i) The Karhunen-Loeve Transform (KLT) is used for data compression, and maximises the quality of compression for any given level of compression. **IN YOUR OWN WORDS**, briefly explain how it achieves this.

**(10 marks)**

ii) **IN YOUR OWN WORDS**, briefly state and explain

1) The advantage(s) of KLT

**(5 marks)**

2) The disadvantage(s) of KLT

**(5 marks)**

b) This question is about the Uncertainty Principle.

**[5 marks]**

Time-frequency analysis is used to obtain both time and frequency information in non-stationary signals.

i) State and explain the UNCERTAINTY PRINCIPLE

**(2 marks)**

ii) **IN YOUR OWN WORDS**, explain how it affects the accuracy of the time and frequency information.

**(3 marks)**

END OF PAPER

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