北京郵電大學

Queen Mary University of London

For examiners' use only

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Total	

BBU4374 A

Joint Programme Examinations 2022/23

BBU4374 Signals and Systems Theory

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										

NOT allowed: electronic calculators and electronic dictionaries.

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 Changchuan Yin, Dr Feng Zheng, Dr Dong Liang, Dr Yang Yang, Dr Shaoshi Yang, Dr Li Li

Filename: 2223_BBU4374_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 [18 marks]

i) Suppose a discrete-time sinusoidal signal is defined as $x[n] = A\sin(\frac{3}{8}\pi n + \frac{\pi}{4})$. Determine whether $x[n]$ is periodic; if yes, find its fundamental period.

(4 marks)

ii) The sequence $x[n]$ is shown in **Figure 1.1.** Please plot the sequence $y[n] = x[n]x[1-n]$.

(4 marks)

iii) The waveform of $f(-2t+1)$ is shown in **Figure 1.2**. Please draw the waveform of $f(t)$.

(4 marks)

iv) A discrete-time sequence is defined as $x[n] = \delta[n] + 2\delta[n-1] + 3\delta[n-2]$, where $\delta[n]$ is the unit-impulse sequence. Please plot sequence $x[n]$ and calculate its energy.

(6 marks)

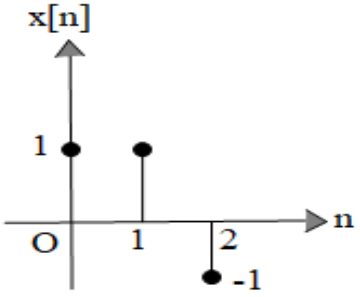

Figure 1.1

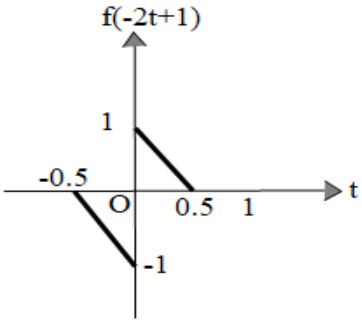

Figure 1.2

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		18 marks

Question marking: $\overline{18}$

Question 2

a) Determine and sketch the convolution of the following two signals:

$$x[n]=\begin{cases} n+1, 0 \le n \le 1, \\ 2-n, 1 < n \le 2, \\ 0, \text{其他}, \end{cases}$$

$h[n]=\delta[n+2]+2\delta[n+1]$

[10 marks]

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		10 marks

b) Consider a causal LTI system whose input x[n] and output y[n] are related by the difference equation: y[n]=1/4y[n-1]+x[n]. Determine y[n] if x[n]=δ[n-1].

[10 marks]

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		10 marks

Question marking: $\overline{10} + \overline{10} = \overline{20}$

Question 3

Consider a continuous-time LTI system with the impulse response $h(t) \xleftrightarrow{FT} H(jw)$. If the system with impulse response $h(t)$ is composed of the parallel connection of $h_1(t)$ and $h_2(t)$, as shown in **Figure 2**:

[15 marks]

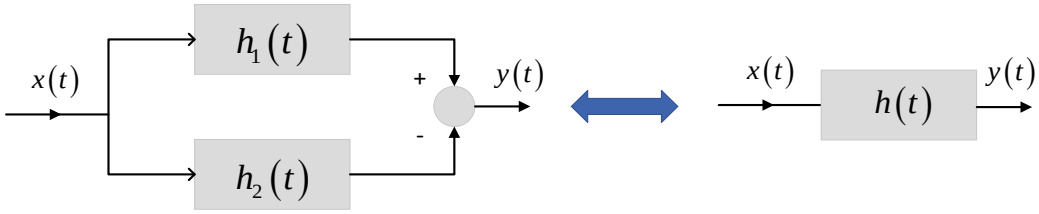

Figure 2: Block diagram of $h(t)$, which is equivalent to the parallel connection of $h_1(t)$ and $h_2(t)$.

i) Find the Fourier transform (FT) of the signals $x_1(t) = \text{sgn}'(t)$, $x_2(t) = e^{-3t}u(t-3)$ and $x_3(t) = \delta(t-1)$;

(3 marks)

ii) If the impulse response $h_1(t) = e^{-2t}u(t)$ and $h_2(t) = e^{-3t}u(t)$, find the frequency response $H(j\omega)$, magnitude spectrum $|H(j\omega)|$ and phase spectrum $\arg\{H(j\omega)\}$;

(4 marks)

iii) Find the output signal $y(t)$ and its FT $Y(j\omega)$ with input $x_4(t) = \delta(t-1) + \delta(t+1)$;

(4 marks)

iv) If the output is $y(t) = e^{-2t}u(t)$, find its corresponding input $x_5(t)$ and its FT $X_5(j\omega)$.

(4 marks)

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		15 marks

Question marking: $\overline{15}$

Question 4

a) Consider a discrete-time LTI system, $h[n]=\delta[n]-2\delta[n-1]+3\delta[n-2]$

[8 marks]

i) Determine the frequency response $H(e^{j\Omega})$;

(2 marks)

ii) Find the Discrete-time Fourier series (DTFS) coefficients of the signal $x_1[n]=\cos\left(\frac{\pi}{8}n+\frac{\pi}{3}\right)$;

(3 marks)

iii) Calculate the output of the system $y_1[n]$ with the input signal $x_1[n]$.

(3 marks)

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	8 marks

b) The input to a discrete-time system is given by $x[n] = \sin\left(\frac{\pi}{5}n\right) + \cos\left(\frac{\pi}{3}n\right)$, use the DTFT to find the output of the system, $y[n]$, if the impulse response is given by $h[\mathrm{n}] = \frac{2\sin\left(\frac{\pi}{4}n\right)}{\pi n}$.

[7 marks]

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	7 marks

Question marking: $\frac{\quad}{8} + \frac{\quad}{7} = \frac{\quad}{15}$

Question 5

a) Find the FT representation of $w(t)$ as depicted in **Figure. 3**.

[5 marks]

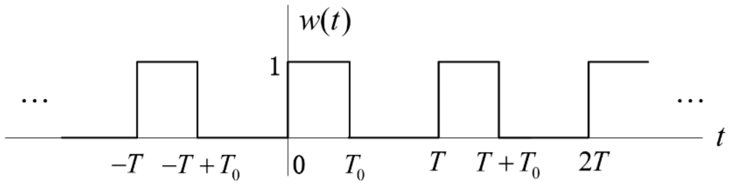

Figure. 3

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	5 marks

b) Use $w(t)$ in a) as depicted in **Figure. 3** as the input to an LTI system with the frequency response

$$H(j\omega)=\begin{cases}1, & |\omega-8\pi|<2\pi \\ 1, & |\omega+8\pi|<2\pi \\ 0, & \text{otherwise}\end{cases}.$$

If we have $T_0=0.125$, $T=0.5$, determine the system output $y(t)$.

[4 marks]

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		4 marks

c) Consider sampling the signal $x(t)=\sum_{k=1}^{7}\frac{1}{k^2}\cos\left(k3\pi t\right)$ with sampling interval T_s, determine the bound on T_s, which guarantee that there will be no aliasing.

[3 marks]

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	3 marks

Question marking: $\frac{}{5}+\frac{}{4}+\frac{}{3}=\frac{}{12}$

Question 6

a) A differential equation of a linear time-invariant causal continuous time system can be described as

$$y''(t) + 5y'(t) + 6y(t) = x''(t) + 3x'(t) + 2x(t).$$

When the input signal is $x(t) = (1 + e^{-t})u(t)$, the output signal is

$$y(t) = (4e^{-2t} - \frac{4}{3}e^{-3t} + \frac{1}{3})u(t).$$

Find the zero-input response $y_{zi}(t)$, and the zero-state response $y_{zs}(t)$.

[10 marks]

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		10 marks

b) Find the inverse transform x[n] of $X(z) = \frac{-11z}{4z^2 - 13z + 3}$ under the following three conditions:

(1) $|z| > 3$

(2) $\frac{1}{4} < |z| < 3$

(3) $|z| < \frac{1}{4}$

[10 marks]

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		10 marks

Question marking: $\frac{}{10} + \frac{}{10} = \frac{}{20}$

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Rough Working

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