THE PNG UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ELECTRICAL & COMMUNICATIONS ENGINEERING DEPARTMENT

SECOND (2ND) SEMESTER (2021)

EE494-Digital Signal Processing

TIME ALLOWED: 3 HOURS

INFORMATION FOR STUDENTS:

1. You have **TEN (10) MINUTES** to read this paper. Do not write during this allocated time

2.There are **Six (6) Questions** in this Exam Booklet. **Answer ALL Questions in Part A and ANY ONE (1) Questions in Part B**

3.All answers must be written in the **Answer Booklet**

4.**COMPLETE STUDENT DETAILS ARE TO BE FILLED ON THE ANSWER BOOKLET-DO THIS NOW**

5.Only drawing instruments and calculators are allowed on your desk. Textbooks and notebooks are **NOT** allowed

6.If you are found **Cheating** in this Exam, penalties specified by the **University** shall be applied.

7.TURN OFF all your mobile phones and place them on the floor under your seat before you start the examination

PART A. Answer

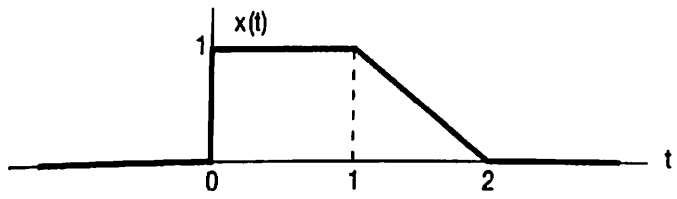
ALL THREE Questions from Part A

QUESTION 1

a) Define causality and give an example of a causal system

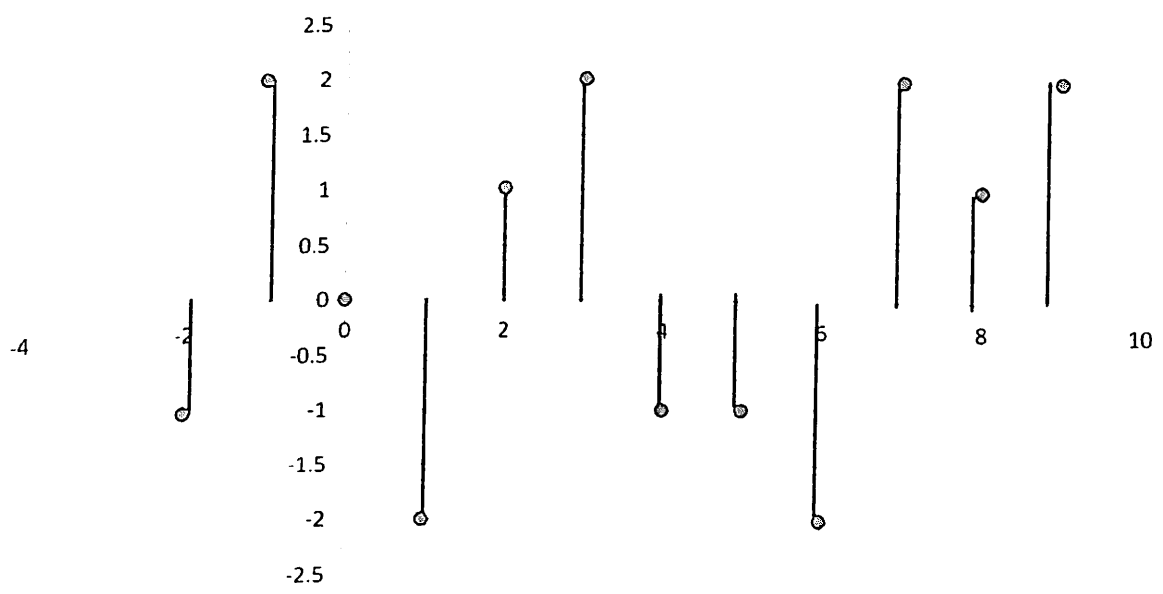
[3 marks]

b) Advance shift the given signal by one unit, reverse the signal and scale the signal by $X(\frac{3}{2}t)$



[7 Marks]

c) A signal is given as $x[4n+2]$



Perform the three basic operations to process an analogue signal to obtain the discrete signal shown.

[10 marks]

[TOTAL 20 Marks]

QUESTION 2

(a) Define linearity and give an example of a linear system

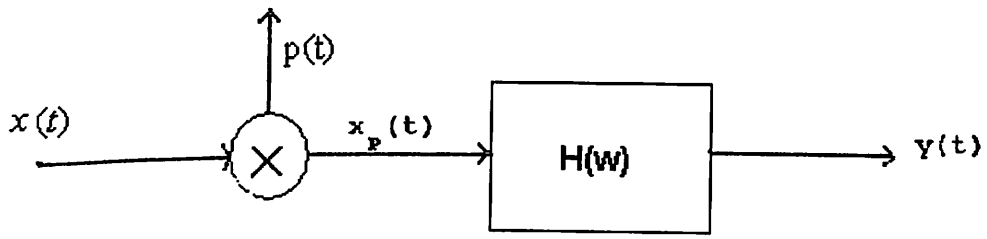
[3 marks]

(b) Determine whether the following signal x(t) is periodic or non periodic

$$x(t) = \begin{cases} \cos(t) & \text{if } t < 0 \\ \sin(t) & \text{if } t \geq 0 \end{cases}.$$

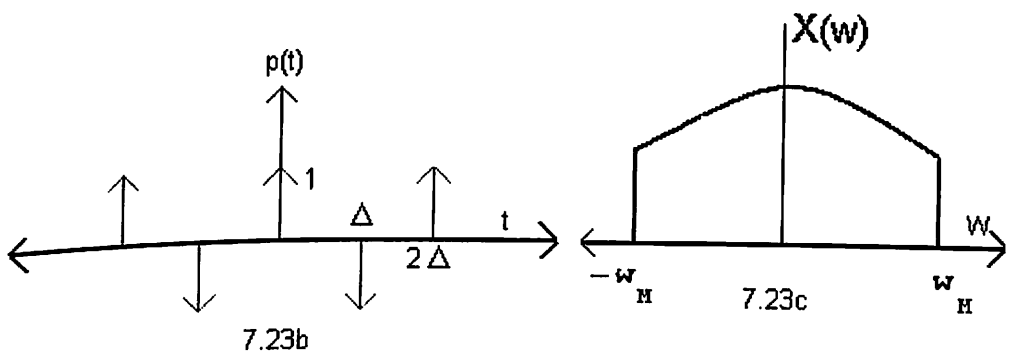
[5 marks]

(c) Shown in figure below is a system in which the sampling signal is an impulse train with alternating sign.



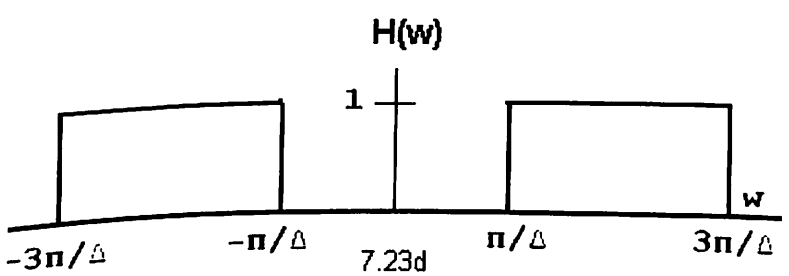
7.23a

The sampling signal p(t), the Fourier Transform of the input signal x(t) and the frequency response of the filter H(ω) are shown below:



7.23b

7.23c



7.23d

(a) Sketch the Fourier transform of $x_p(t)$ and y(t) .

(b) Determine a system that will recover x(t) from x_p (t) and another that will recover x(t) from y(t).

(c)What is the maximum value of in relation to wM for which x(t) can be recovered from either x_p(t) or y(t)?

[12 Marks]

[TOTAL 20 Marks]

QUESTION 3

a) What is the difference between a microcontroller and a microprocessor?

[4 marks]

b) Write a simple Arduino Code for a light controlled LED

[8 marks]

c) Change the code below so that the relay switches "ON" when movement is detected by the PIR sensor. On your answer booklet only write down the part of the code that you change.

[8 marks]

```
const int MOTION_SENSOR_PIN = 7;   // Arduino pin connected to the OUTPUT
pin of motion sensor
const int RELAY_PIN        = 3;   // Arduino pin connected to the IN pin of relay
int motionStateCurrent     = LOW; // current  state of motion sensor's pin
int motionStatePrevious    = LOW; // previous state of motion sensor's pin

void setup() {
  Serial.begin(9600);              // initialize serial
  pinMode(MOTION_SENSOR_PIN, INPUT); // set arduino pin to input mode
  pinMode(RELAY_PIN, OUTPUT);      // set arduino pin to output mode
}

void loop() {
  motionStatePrevious = motionStateCurrent;          // store old state
  motionStateCurrent  = digitalRead(MOTION_SENSOR_PIN); // read new state

  if (motionStatePrevious == LOW && motionStateCurrent == HIGH) { // pin state
change: LOW -> HIGH
    Serial.println("Motion detected!");
    digitalWrite(RELAY_PIN, HIGH); // turn on
```

```
  }
  else
  if (motionStatePrevious == HIGH && motionStateCurrent == LOW) { // pin state
change: HIGH -> LOW
    Serial.println("Motion stopped!");
    digitalWrite(RELAY_PIN, LOW);  // turn off
  }
}
```

[TOTAL 20 Marks]

PART B.
Answer ANY TWO (2) Questions from Part B

Question 4

Write MATLAB™ codes for FIVE the following two dimensional digital signal processing operations on an image:

1. Image segmentation
2. Feature extraction
3. Edge detection
4. Classification
5. Threshold and merging of images
6. 3D mesh generation
7. Waypoint generation.

[4 MARKS EACH]
[TOTAL 20 MARKS]

Question 5

(a) Given the following MATLAB™ code, sketch and sketch the expected results are expected and what processes are being carried out:

```
t = 0:0.0005:6;
subplot(3,2,1)
y1 = sin(2*pi*t);
plot(t,y1)
title('frequency = 1')
subplot(3,2,2)
y2 = sin(6*pi*t);
plot(t,y2)
title('frequency = 2')
subplot(3,2,3)
y3 = sin(10*pi*t);
plot(t,y3)
title('frequency = 5')
subplot(3,2,4)
y4 = sin(20*pi*t);
```

```
plot(t,y4)
title('frequency = 10')
subplot(3,2,5)
y5 = sin(40*pi*t);
plot(t,y5)
title('frequency = 20')
subplot(3,2,6)
y_sum = y1 + y2 + y3+y4 + y5;
plot(t,y_sum)
title('sum of signals')
```

[6MARKS]

(b) For the six waveforms sketched in part (a), sketch the frequency spectrum of each waveforms. Discuss the frequency spectrum, including the appearance of negative frequency spectral lines.

[6 Marks]

(c) Explain HOW the following steps will result in linear convolutions:

convolution?

1. Folding. Fold h(n) about n = 0 to obtain h(−n);

2. Shifting. Shift h(−n) by k to the right (left) if k is positive (negative), to obtain h(k − n);

3. Multiplication. Multiply x(n) by h(k − n) to obtain the product sequence x(n)h(k − n);

4. Summation. Sum all the values of the product sequence to obtain the value of the output at time n = k. Here k is an integer.

[8 MARKS]

[TOTAL 20 MARKS]

Question 6

(a) Write down the advantages and disadvantages of the IIR and FIR filters. Explain why FIR filters are the most commonly used digital filters and when are IIR filters used?

[5 Marks]

(b) Write an essay on ONE of the following areas of digital signal processing application. The essay should have a MINIMUM of 500 words. Where

possible, signal or image processing algorithms or MATLAB™ codes should be given.

(i) Digital single processing in music recording, filtering, voice smoothing and signal mixing.

(ii) Digital signal and image processing for both drone (a) navigation and (b) imaging and image recognition.

[15 Marks]

[Total 20 MARKS]