Philadelphia University
Faculty of Engineering

Marking Scheme

Examination Paper

BSc CEE

Signals and Systems *(*650320+640543*)*

First Exam First semester Date: 17/11/2019

Section 1

Weighting 20% of the module total

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Marking Scheme

Signals and Systems (650320+640543)

The presented exam questions are organized to overcome course material through 5 questions.
The *all questions* are compulsory requested to be answered.

Question 1 This question is attributed with 5 marks if answered properly; the answers are as following:

1) The **unit step** function is related to the **unit impulse** function via which of the following relationships

a) $u(t)=\int_{-\infty}^{t}\delta(\tau)d\tau$

b) $u(t)=\int_{0}^{t}\delta(\tau)d\tau$

c) $u(t)=\int_{t}^{\infty}\delta(\tau)d\tau$

d) $u(t)=\sum_{0}^{\infty}\delta(t-n)$

2) If you evaluate $\int_{-\infty}^{\infty}(t-1)\delta(t-5)dt$ you get

a) 0
b) 5
c) 4
d) $t-5$

3) The system is **linear**, if it is both

a) **Additive and commutative**
b) **Additive and associative**
c) **Additive and distributive**
d) **Additive and homogeneous**

4) The system $y(t)=x(t)cosh(t)$ is

a) **BIBO stable**
b) **Only memoryless**
c) **Memoryless and causal**
d) **Causal and BIBO stable**

5) Which of the following systems is **time invariant**?

a) $y(t) = x(t) + x(t-1)$
b) $y(t) = x(t) + x(1-t)$
c) $y(t) = -x(t) + x(1-t)$
d) $y(t) = x(2t) + x(t)$

Question 2: This question is attributed with 4 marks if answered properly,

Solution

Time shifting

Given a D-T signal $x[n]$ and a positive integer p, then

- $y[n]=x[n-p]$ is the p-step right shift of $x[n]$ that results in a **delay** of the signal by p units of time (replacing n by $n-p$).
- $y[n]=x[n+p]$ is the p-step left shift of $x[n]$ that results in an **advance** of the signal by p units of time (replacing n by $n+p$).

Time reversal or Folding

Let $x[n]$ be the original sequence, and $y[n]$ be reflected sequence, then $y[n]$ is defined by $y[n]=x[-n]$,

Time scaling

Let $x[n]$ denote a D-T signal, then the signal $y[n]$ obtained by scaling the independent variable, time n, by a factor a is defined by

$$y[n]=x[an], a>0.$$

✓ If $a>1$, the signal is a compressed version of $x[n]$ and some values of the discrete time signal

$y[n]$ are lost.

✓ if $0 < a < 1$, then the signal $y[n]$ is an expanded version of $x[n]$.

Manipulation involving the signal amplitude (dependent variable):

Transformations performed on amplitude (dependent variable) are shown in table 2-2.

Table 2-2: Transformation performed on amplitude

Operation	D-T signals	C-T signals	Physical device
1. Amplitude scaling	$y[n] = cx[n]$	$y(t) = cx(t)$	Electronic amplifier
	c - scaling factor		
2. Addition	$y[n] = x_1[n] + x_2[n]$	$y(t) = x_1(t) + x_2(t)$	Audio mixer
3. Multiplication	$y[n] = x_1[n] \cdot x_2[n]$	$y(t) = x_1(t) \cdot x_2(t)$	Modulator
4. Differentiation	Difference equation	$y(t) = d\dfrac{x(t)}{dt}$	Inductor
5. Integration	Summation	$y(t) = \int_{-\infty}^{t} x(\tau)d\tau$	Capacitor

<u>Question 3:</u> This question is attributed with 5 marks if answered properly,

a) *(1 mark)*

Solution

$$i(t) = Au_0\left(t + \frac{T}{2}\right) - Au_0\left(t - \frac{T}{2}\right) = A\left[u_0\left(t + \frac{T}{2}\right) - u_0\left(t - \frac{T}{2}\right)\right]$$

b) *(2 marks)*

Solution

The N -point non-causal MA average filter can be expressed by the following equation:

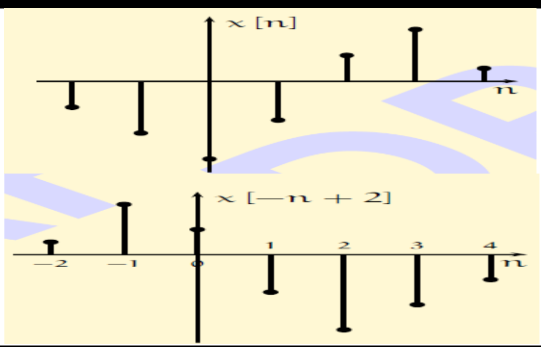
$$y[n] = \frac{1}{N}\sum_{k=\frac{-(N-1)}{2}}^{\frac{N-1}{2}} x[n-k],$$ where N is an odd and positive integer.

The N -point non-causal Exponentially Weighted Moving (EWMA) Filter defined by

$$y[n] = \sum_{i=\frac{-(N-1)}{2}}^{\frac{N-1}{2}} a \cdot b^i \cdot x[n-i],\ b - \text{real number},\ 0 < b < 1,\ a - \text{positive number},\ a = \frac{1-b}{1-b^N}.$$

c) *(2 marks)*

Solution



<u>Question 4:</u> This question is attributed with 2 marks if answered properly,

Solution

- This system has memory, because it depends on future values of the input.
- This system is not stable, because if $x[n]$ is bounded, $y[n]$ is still grows without bound because of the presence of the $-\infty$ term in the summation limits.
- This system is non-causal, because it depends on the input at future times.
- This system is linear. Consider

$$\hat{T}\{ax_1[n]\} = a\sum_{k=-\infty}^{n} x_1[k+2] = ay_1[n]$$

$$\hat{T}\{bx_2[n]\} = b\sum_{k=-\infty}^{n} x_2[k+2] = by_2[n]$$

$$ay_1[n] + by_2[n] = a\sum_{k=-\infty}^{n} x_1[k+2] + b\sum_{k=-\infty}^{n} x_2[k+2]$$

$$\hat{T}\{ax_1[n] + bx_2[n]\} = \sum_{k=-\infty}^{n} (ax_1[k+2] + bx_2[k+2]) = a\sum_{k=-\infty}^{n} x_1[k+2] + b\sum_{k=-\infty}^{n} x_2[k+2]$$

<u>Question 5:</u> This question is attributed with 4 marks if answered properly,

Solution

```
% Part(a) %
t = -5:0.001:5; % Set the time from -5 to 5 with a sampling rate of 0.001s.
x1 = 5*sin(2*pi*t).*cos(pi*t-8);    % compute function x1
% plot x1(t)
subplot (2,1,1); % select the 1st out of 2 subplots
plot (t,x1); % plot a CT signal
grid on; % turn on the grid
xlabel ('time (t)'); % Label the x-axis as time
ylabel ('5sin(2\pi t)cos(\pi t - 8)');% Label the y-axis
title ('Part (a)'); % Insert the title
```

(2 marks)

```
% Part(b) %
n = -5:25;
x2 = 2 * 1.1.^(1.8*n) - 2.1 * 0.9.^(0.7*n);
% plot x2(n)
subplot(2,1,2), % select the 2nd out of 2 subplots
stem(n, x2, 'filled'); % plot a DT signal
grid
xlabel('n')
ylabel('2(1.1)^{1.8n} - 2.1(0.9)^0.7n')
title('Part (b)')
```

(2 marks)