California State University, Sacramento
The College of Engineering and Computer Science

EEE 180 Signals & Systems

Midterm 1

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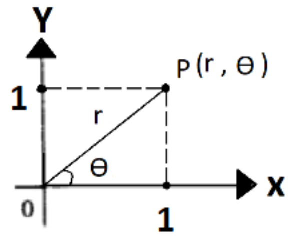
1. [30 points]. Select one correct answer for each of the following questions.

(1). The multiplication result of two complex numbers (3 + 4 j) x (3 – 4 j) is equal to

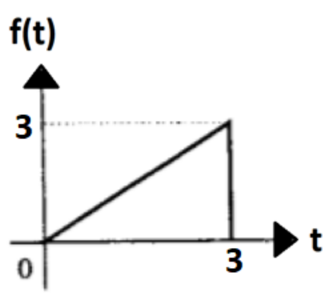
a. 6
b. 25
c. 6 + 8 j

(2). For the cartesian coordinates shown in the diagram below, find the polar coordinate (r, Θ) for the point p.



a. (r, Θ) = ($\sqrt{2}$, $\frac{\pi}{4}$).
b. (r, Θ) = (2, $\frac{\pi}{6}$) .
c. (r, Θ) = (2, $\frac{\pi}{4}$) .

(3). Find the energy of the following signal f(t) = t when t >=0, and t <=3, also f(t) =0 when t <0 or t >3.



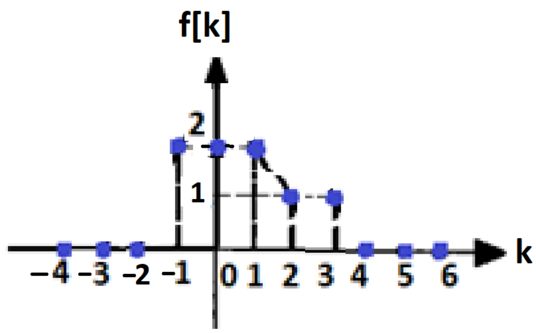
a. 9
b. 4.5
c. 1.5

(4). u(t) is a continuous time unit step function.
For the discrete time signal f[k] = (0.5^k) u[k], which statement below is correct?

a. When k=2 f[k]=f[2] = 0.5 + 0.5 = 1.
b. When k-> ∞, f[k] -> ∞.
c. When k-> ∞, f[k] -> 0.

-3

(5). Find the signal energy for the discrete time signal shown below.



a. 5
b. 8
c. 14

(6). A system is said to be linear if__________
a. It satisfies only the additivity property.
b. It satisfies only the scaling property.
c. It satisfies the superposition property.

(7). Is the system y[n] = 2x[n] linear?
a. Yes
b. No

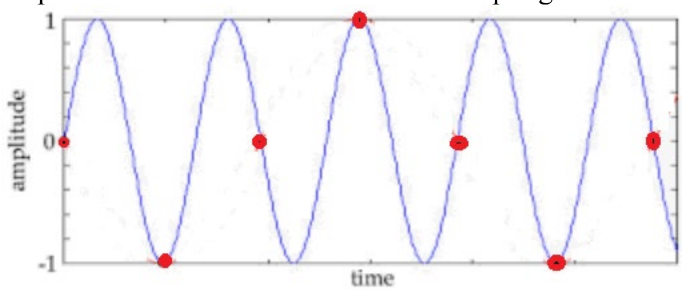
(8). When are LTI (linear time invariant) systems stable?
a. Only when a bounded input produces a bounded output
b. Only when a bounded input produces an unbounded output
c. Only when an unbounded input produces an unbounded output

(9). The discrete time cosine signal is always periodic.
a. True
b. False

(10) A time invariant signal must be linear. -6
a. True
b. False

2.[32 points].

(1). In the following figure, the continuous time signal is marked in blue and the discrete time samples are marked in red. Does this sampling cause aliasing?



Your Answer: Yes

(2). What is the requirement of the sampling period Ts for a continuous time signal with a maximum frequency of 1000 Hz?

$f = 2 f_{max} = 2(1\text{KHz}) = 2\text{KHz}$

$T = 1/f = 1/2\text{K} = \boxed{0.0005\ s}$

(3). f(t) = 20 cos (5 π t + 0.6 π) is sampled with a sampling interval of T= 0.2 second. Find the expression for the resulting discrete-time signal.

$f[k] = 20\cos(5\pi k T + 0.6\pi) \qquad T = 0.2$

$\boxed{= 20\cos(\pi k + 0.6\pi)}$

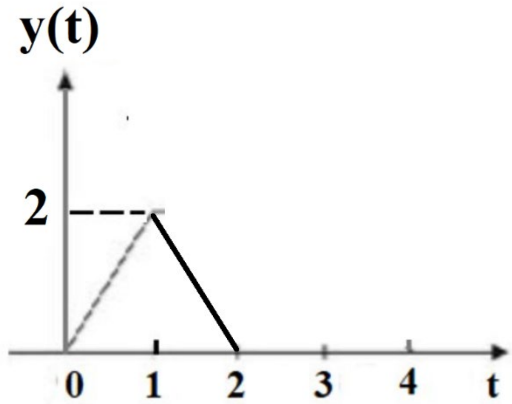
(4). The periodic discrete time signal cos(0.4 πk + 0.5) has a minimum period of N_0 samples. You must show your calculation procedure on how to find the value of N_0.

$N_0 = m\left(\frac{2\pi}{\Omega}\right) \qquad \Omega = 0.4\pi$

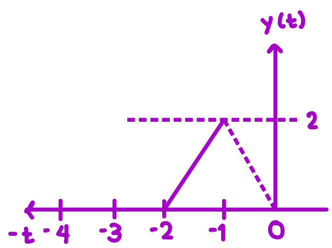
$N_0 = m\left(\frac{2\pi}{0.4\pi}\right) = m(5)$

$\boxed{\begin{array}{l} m = 1 \\ N_0 = 5 \end{array}}$

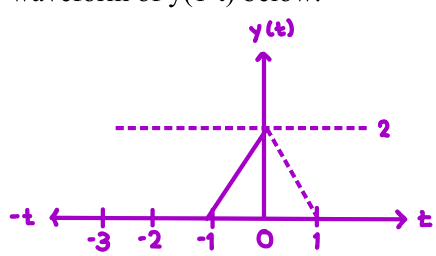
3. [38 points] (1). The waveform of the signal y(t) is given below:



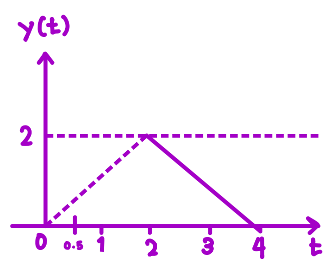
a. Draw the waveform of y(-t) below.



b. Draw the waveform of y(1-t) below.



c. Draw the waveform of y(t/2) below.



(2).

Suppose f(t) is the input signal, and h(t) is the system unit impulse response signal.

The continuous time domain convolution equation is defined below:

$$y(t) = f(t) * h(t) = \int_{-\infty}^{\infty} f(x)\, \boldsymbol{h}\, (t-x)\, dx$$

$$where\ f(t) = (6t^3 - 2)u(t),\ \ h(t) = tu(t),$$

and u(t) is the continuous time unit step function.

Please use the above integration formula to calculate the system response y(t) signal. You must show the detailed calculation procedure to get credit.

$f(t) = (6t^3 - 2)u(t)$

$h(t) = tu(t)$

$$\begin{aligned}
y(t) &= \int_{-\infty}^{\infty} f(x)h(t-x)dx \\
&= \int_{-\infty}^{\infty} (6x^3-2)u(x)(t-x)u(t-x)dx \\
&= \int_{0}^{t} (6x^3-2)(t-x)dx \\
&= \int_{0}^{t} (6tx^3 - 6x^4 - 2t + 2x)\, dx \\
&= \left[\frac{6t}{4}x^4 - \frac{6}{5}x^5 - 2tx + x^2 \right]_0^t = \frac{3}{2}t^5 - \frac{6}{5}t^5 - 2t^2 + t^2
\end{aligned}$$

$\boxed{y(t) = \left(\frac{3}{10}t^5 - t^2 \right)}$ u(t)

(3). Find $y_0(t)$, the zero-input component of the response for an LTI system described by the following differential equation: $(D^2 + 5D + 4)\, y(t) = D\, f(t)$, when the initial conditions are $y_0(0) = 0,\ \ \dot{y}_0(0) = -3.$

You must show the detailed calculation procedure to get credit.

$(D^2 + 5D + 4)\, y_0(t) = 0$

Characteristic polynomials:

$\lambda^2 + 5\lambda + 4 = 0$

$(\lambda + 4)(\lambda + 1) = 0$

roots: $\lambda = -4, -1$

zero-input system response:

$y_0(t) = c_1 e^{-4t} + c_2 e^{-t}$

$y_0'(t) = -4c_1 e^{-4t} - c_2 e^{-t}$

if $y_0(0) = 0$: $c_1 e^{-4(0)} + c_2 e^{-(0)} = 0 \longrightarrow c_1 + c_2 = 0$

$\dot{y}_0(0) = -3$: $-4c_1 e^{-4(0)} - c_2 e^{-(0)} = -3 \longrightarrow -4c_1 - c_2 = -3$

$c_1 = 1$, $c_2 = -1$

zero-input component of the response:

$\boxed{y_0 = e^{-4t} - e^{-t}}$