

## Problem set # 1

Generation of Signals: continuous time

1. Plot the following continuous time signal for  $t = -2\pi$  to  $2\pi$

(a)  $Y_1(t) = 5 \sin(t)$

(b)  $Y_2(t) = \sqrt{3} \sin(t - 0.25)$

(c)  $Y_3(t) = (1.7)^2 \cos(t/4)$

(d)  $Y_4(t) = \tan^2(t)$

(a)	(c)
(d)	(b)

2. Plot the following continuous time signal for  $t = -L$  to  $L+5$

(a)  $Y_1(t) = u(t)$

(d)  $Y_2(t) = 3u(t-a)$

(b)  $Y_3(t) = -\delta(t)$

(e)  $Y_4(t) = \delta(t+a)$

(c)  $Y_5(t) = \sin(t)/t$

3. Plot the following continuous time signal for  $t = -7$  to  $7$

(a) 
$$Y_1(t) = \begin{cases} 15t^2 + 7 & \text{for } t \geq 4 \\ 30t & \text{for } t < -4 \\ 5 & \text{elsewhere} \end{cases}$$

(b) 
$$Y_2(t) = \begin{cases} 10 \sin(2\pi t) & \text{for } t > -3 \\ 3t - 2 & \text{elsewhere} \end{cases}$$

(c) 
$$Y_3(t) = \begin{cases} t & \text{for } t > 0 \\ 0 & \text{elsewhere} \end{cases}$$

4. Plot the following continuous time signal for  $t = -4\pi$  to  $4\pi$

(a)  $X_1(t) = e^{j2t} + e^{j3t}$

(b)  $X_2(t) = 5e^{0.2t}$

(c)  $X_3(t) = 3e^{j2t}$

(d)  $X_4(t) = a^t$  for  $|a| > 1, a = 1$  and  $|a| < 1$

(e)  $X_5(t) = a^t e^{jat}$  for  $|a| > 1, a = 1$  and  $|a| < 1$

(f)  $X_6(t) = 3^{-bt} e^{jbt}$  for  $|b| > 1, b = 1$  and  $|b| < 1$

## Problem set # 2

Generation of Signals: discrete time

1. Plot the following discrete time signal for  $n=-10$  to  $12$

(a)  $Y1[n]=5n^2 + 3n$

(b)  $Y2[n]=\sin(\pi n/2) + \cos(\pi n/4)$

(c)  $Y3[n]=a^n$  for  $|a|>1, a=1$  and  $|a|<1$

(b)

(a)

(c)

2. Plot the following discrete time signal for  $n=-L-3$  to  $L-2$

(a)  $Y1[n]=2u[n]$

(d)  $Y2[n]=u[n-b]$

(b)  $Y3[n]=3\delta[n]$

(e)  $Y4[n]=-\delta[n+b]$

(c)  $Y5[n]=3\sin(n)/n$

3. Plot the following discrete time signal for  $n=-5$  to  $5$

(a)	$Y1[n]=$	2	for $n \geq 3$
		-1	for $n < -3$
		$n$	elsewhere

(b)	$Y2[n]=$	$\sin(0.2\pi n)$	for $n > -2$
		1	elsewhere

(c)	$Y3[n]=$	$n$	for $n > 1$
		2	elsewhere

4. Plot the following discrete time signal for  $n=-3$  to  $6$

(a)  $X1[n]=e^{j2n} + e^{j3n}$

(b)  $X2[n]=5e^{2n}$

(c)  $X3[n]=3e^{j2n}$

(d)  $X4[n]=a^n e^{jan}$  for  $|a|>1, a=1$  and  $|a|<1$

(e)  $X5[n]=3^{-bn} e^{jbn}$  for  $|b|>1, b=1$  and  $|b|<1$

## **Problem set # 3**

Time shifting and time scaling of signals

1. Plot the following continuous time signal for  $t=-7$  to  $8$ 
  - (a)  $Y1(t) = 2u(t) - 3u(t-2.5) + u(2t+5)$  (using user defined function)
  - (b)  $Y2(t) = \sin(3\pi t - 2)$
  - (c)  $Y3(t) = e^{(0.9t-0.1)}$
  
2. Plot the following discrete time signal for  $n=-5$  to  $4$ 
  - (a)  $Y1[n] = e^{(-2n+3)}$
  - (b)  $Y2[n] = \sin(3n-1)$
  - (c)  $Y3[n] = 3u[3n+5] - u[n-3] + u[-n]$  (using user defined function)

## Problem set # 4

### Convolution of Signals

1. Consider an input  $x(t)$  and a unit impulse response  $h(t)$ , where

$$x(t) = e^{-at}u(t) \text{ and } h(t) = u(t)$$

Find the convolution of the signals. (with  $a > 0$ )

2. Find the convolution of the following two signals:

$$\begin{aligned} x(t) &= \begin{cases} 1 & 0 < t < T \\ 0 & \text{otherwise} \end{cases} \\ h(t) &= \begin{cases} T & 0 < t < 2T \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

3. Find the convolution of the signals:

$$x(t) = e^{2t}u(-t) \text{ and } h(t) = u(t-3)$$

4. Consider an input  $x[n]$  and a unit impulse response  $h[n]$  given by

$$x[n] = a^n u[n] \text{ and } h[n] = u[n]$$

Find the convolution of the signals. (with  $0 < a < 1$ )

5. Consider two sequences

$$\begin{aligned} x[n] &= \begin{cases} 1 & 0 \leq n \leq 4 \\ 0 & \text{otherwise} \end{cases} \\ h[n] &= \begin{cases} a^n & 0 \leq n \leq 6 \\ 0 & \text{otherwise} \end{cases} \end{aligned}$$

Find the convolution of the signals. (with  $a > 1$ )

6. Consider an input  $x[n]$  and a unit impulse response  $h[n]$  specified as follows:

$$x[n] = 2^n u[-n] \text{ and } h[n] = u[n]$$

Find the convolution of the signals.

## **Problem set # 5**

Solution of Differential/ Difference equations

1. Solve the first order differential equation:

$$dy(t)/dt + 2y(t) = x(t)$$

when the input signal is  $x(t) = Ke^{3t}u(t)$ , where  $K$  is a real number. The system also satisfies the condition of initial rest.

Hint:  $y(t) = K/5[e^{3t} - e^{-2t}]u(t)$

2. Consider an LTI system whose input  $x(t)$  and output  $y(t)$  are related by the differential equation:

$$dy(t)/dt + 4y(t) = x(t)$$

The system also satisfies the condition of initial rest. If  $x(t) = e^{-t} \cos(3t)u(t)$ , what is  $y(t)$ ?

Hint:  $y(t) = 1/6[e^{-t}(\cos 3t + \sin 3t) - e^{-4t}]u(t)$

3. Consider an LTI system whose input  $x[n]$  and output  $y[n]$  are related by the difference equation:

$$y[n] - 0.5*y[n-1] = x[n]$$

The system also satisfies the condition of initial rest. If  $x[n] = K\delta[n]$ , where  $K$  is a real number. What is  $y[n]$ ?

Hint:  $y[n] = 0.5^n Ku[n]$

4. Solve the first order difference equation:

$$y[n] = 0.25*y[n-1] + x[n]$$

when the input signal is  $x[n] = \delta[n-1]$ . The system also satisfies the condition of initial rest.

Hint:  $y[n] = 0.25^{n-1} u[n-1]$

5. Solve the first order difference equation:

$$y[n] - 0.5*y[n-1] = x[n]$$

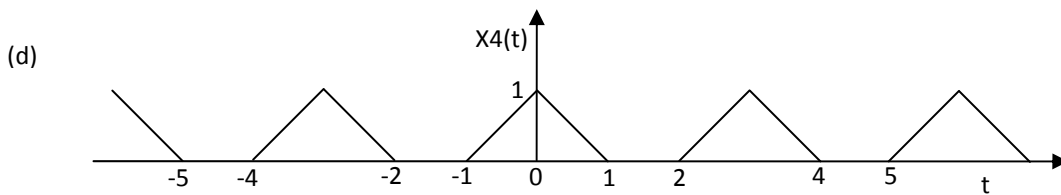
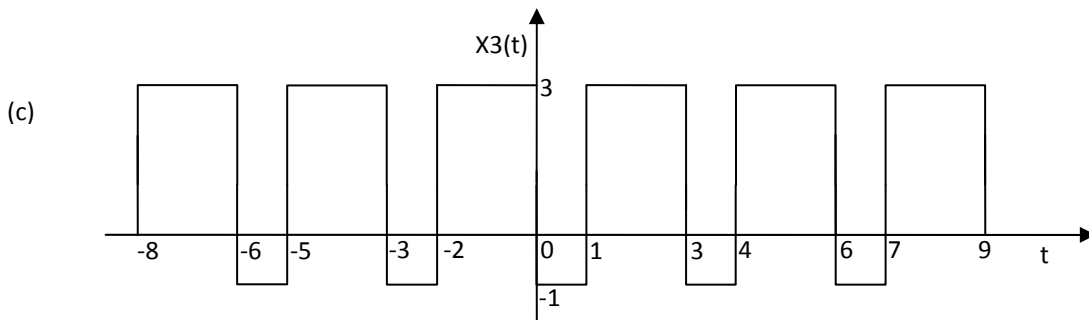
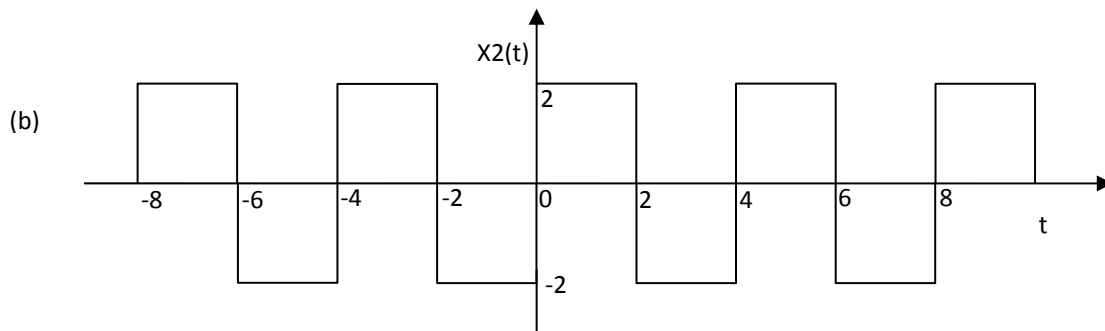
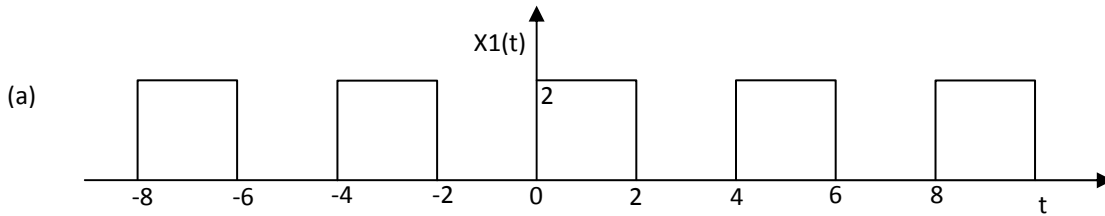
when the input signal is  $x[n] = (1/3)^n u[n]$ . The system also satisfies the condition of initial rest.

Hint:  $y[n] = [3(1/2)^n - 2(1/3)^n] u[n]$

## Problem set # 6

Fourier series representation of continuous time signals

1. Find Fourier series coefficients for following continuous time signals:



## **Problem set # 7**

Fourier transform of continuous time signals

1. Find the fourier transform of following continuous time signals:
  - (a)  $\cos(30\pi t)$
  - (b)  $e^{-at} u(t)$  for  $a > 0$
  - (c)  $e^{-a|t|} u(t)$  for  $a > 0$
  - (d)  $\delta(t)$
  - (e)  $e^{-\pi(t)^2}$
  - (f)  $A \text{ rect}(t/2T_0)$

## **Problem set # 8**

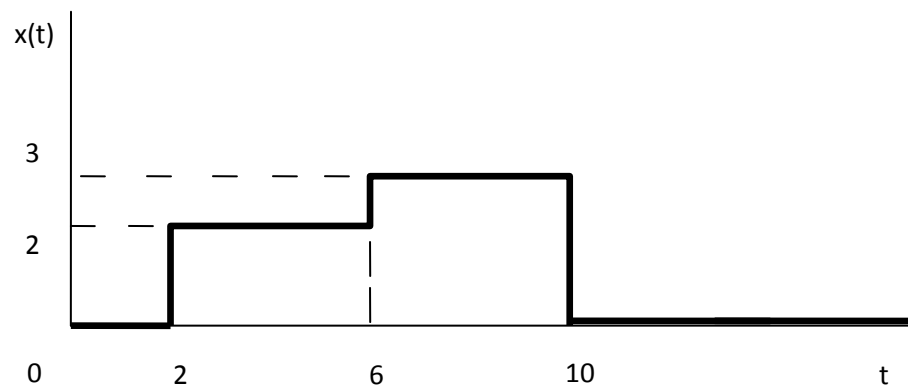
Laplace transform of continuous time signals

1. Find the laplace transform of following continuous time signals
  - (a)  $1/x^{0.5}$
  - (b)  $e^{-at}$
  - (c)  $\delta(t-3)$
  - (d)  $\text{heaviside}(t-\pi)$

## **Problem set # 9**

Introduction to XCOS and calculation of output of systems represented by block diagrams

1. Find the output of a low pass filter for unit step input and explain the results.
2. Find the output of a high pass filter for unit step input and explain the results.
3. Find the output of a low pass filter for sinusoidal input and comment on the results.
4. Find the output of a high pass filter for sinusoidal input and comment on the results.
5. Design a system to generate the following output signal  $x(t)$



6. Design a system to generate the following output signals:  $x(t-5)$ ,  $dx(t)/dt$  from the  $x(t)$  as given in problem 5.
7. Design a system to generate the following output signal  $y(t)=\sin^2(t) +5$