School of Engineering and Applied Science (SEAS)
Ahmedabad University

BTech(ICT) Digital Signal Processing (Section 1)

Laboratory Assignment-1

Enrollment No: AU1841145 **Name: Samarth Shah**

AIM : Revision of different concepts like signals and systems signal operations, sampling theorem etc. using MATLAB and creating various Functions.

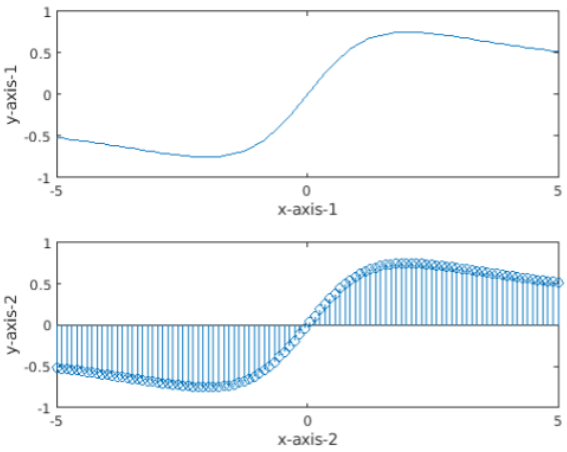
1. Solution Problem-1

   (a) Approach: In this question, plot function was used to plot continuous signal and stem function was used to plot Discrete signal.

   (b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_1) Generate deterministic continuous time signal having equation
% x(t)= 3t /(4+ t2) and discrete time signal having equation x(n)= 3n /(4+ n2).
% Use subplot command to display both figures .
subplot(2,1,1); %in order to have multiple graphs
x_axis_1=linspace(-5,5);
y_axis_1= 3*x_axis_1./(4+power(x_axis_1,2));
plot(x_axis_1,y_axis_1); %plotting the first function
xlabel ('x-axis-1');
ylabel ('y-axis-1');
subplot(2,1,2); %in order to have multiple graphs
x_axis_2=linspace(-5,5);%defining the range of the function
y_axis_2= 3*x_axis_2./(4+power(x_axis_2,2));
stem(x_axis_2,y_axis_2);%plotting discrete function using stem
xlabel ('x-axis-2');
ylabel ('y-axis-2');
```

   (c) Simulation Output:



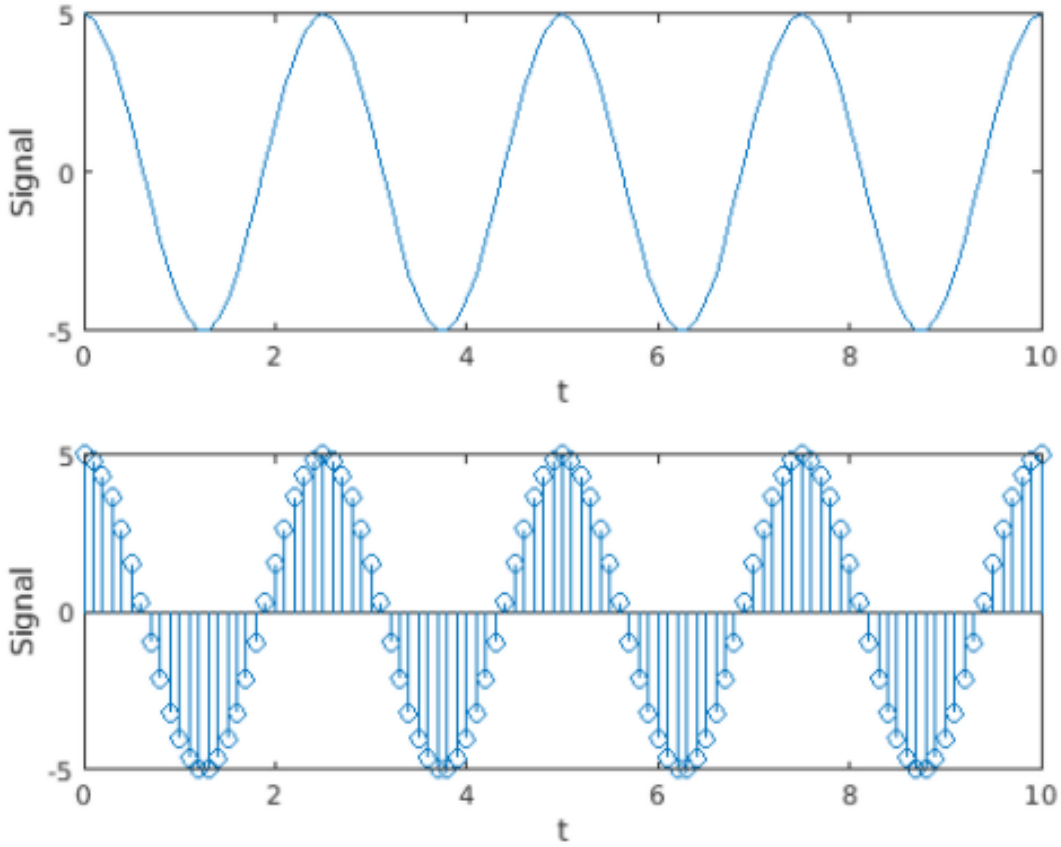
2. Solution Problem-2

(a) Approach: In this question, sampling frequency was considered as greater then 2 times of the main frequency. Using both frequencies continuous signal was plotted.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_2) Plot the continuous and discrete time sinusoidal wave for
    given amplitude, frequency,
%phase and sampling frequency.
frequency = 40; %defining frequency
sampling_freq =100; %defining sampling frequency
amplitude = 5; %defining amplitude
time = frequency / sampling_freq ; %defining time
samples = 0:0.1:10; %defining range
signal = amplitude * cos (2*pi*time* samples ); % output
subplot (2 ,1 ,1)%in order to have multiple graphs
plot ( samples , signal);
xlabel ('t');
ylabel ('Signal');
subplot (2 ,1 ,2)%in order to have multiple graphs
stem( samples , signal);
xlabel ('t');
ylabel ('Signal');
```

(c) Simulation Output:



3. Solution Problem-3

(a) Approach: In this question, first of all, the new length of array was create by getting minimum length and maximum length of 2 arrays. Then, both array were added after padding zero to those array elements who weren't there in the initial arrays.

(b) Matlab Script:

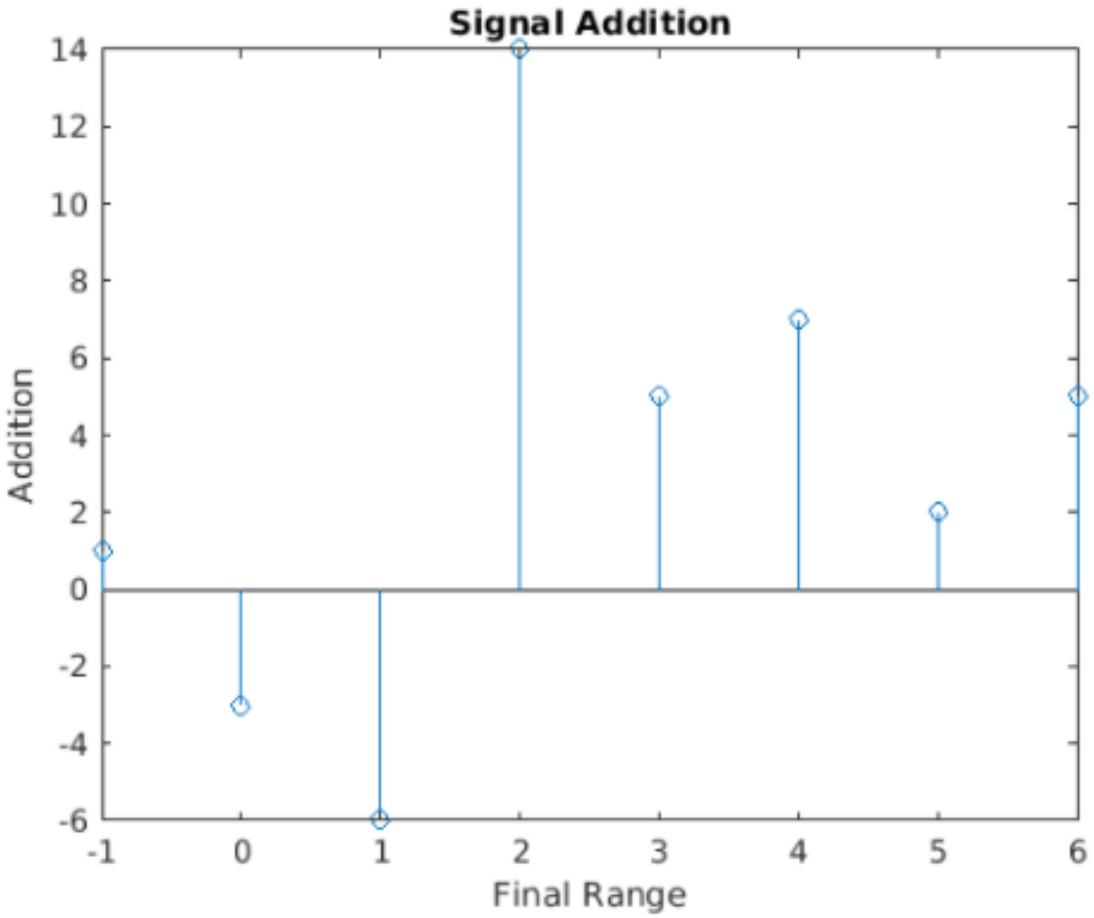
```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_3) Generate the function for signal addition. Add two sequences
    x1(n) ={1,-1,2,5,1,5,-1} and x2(n) ={-2,-8,9,4,2,3,5}.
clear;
clc ;
close all ;
input_series1 = [1,-1,2,5,1,5,-1] ; % input series1
range_series1 = [-1:5] ; % range of series1
input_series2 = [-2,-8,9,4,2,3,5] ; % input series2
range_series2 = [0:6] ; % range series2
output = additionOfSignals ( input_series1 , range_series1 , input_series2 ,
    range_series2 ); % calling function
min1 = min ( range_series1 ); % minimum of range of series1
min2 = min( range_series2 ); % min of range of series2
minOfmin = min ( min1 , min2 ); %min of mins
max1 = max( range_series1 ); % max of range of series1
max2 = max ( range_series2 ); %max of range of series2
maxOfmax = max ( max1 , max2 ); % max of maxs
axis = minOfmin : maxOfmax ; % axis
stem (axis , output ); % discrete
xlabel (" Final Range ") ;
ylabel (" Addition ") ;
title (" Signal Addition ") ;
```

(c) Function:

```
function func_output = additionOfSignals ( in_series1 , range_series1 , in_series2
     , range_series2 )
min1 = min ( range_series1 ); % minimum of range of Series 1
min2 = min( range_series2 ); % min of range of Series 2
max1 = max( range_series1 ); % max of range of Series 1
max2 = max ( range_series2 ); %max of range of Series 2
minimum = min ( min1 , min2 ); %min of min range
maximum = max ( max1 , max2 ); % max of max range

if( minimum < min1 ) % making least index same
series1= [ zeros(1 , min1 - minimum ) , in_series1 ];
end
if( minimum < min2 ) % making least index same
series2= [ zeros(1 , min2 - minimum ) , in_series2 ];
end
if( maximum > max1 ) % making higher index same
series1= [ in_series1 , zeros(1 , maximum - max1 ) ];
end
if( maximum > max2 ) % making higer index same
series2=[ in_series2 , zeros(1,maximum - max2)];
end
func_output = series1 + series2 ; % addition
end
```

(d) Simulation Output:



4. Solution Problem-4

(a) Approach: In this question, first of all, the new length of array was create by getting minimum length and maximum length of 2 arrays. Then, both array were multiplied after padding zero to those array elements who weren't there in the initial arrays.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_4) Generate the function for signal multiplication. For Two
    sequences x1(n) ={1,-1,2,5,1,5,-1} and x2(n) ={-2,-8,9,4,2,3,5}.
clear all;
clc ;
close all ;
input_series1 = [1,-1,2,5,1,5,-1] ; % input series1
range_series1 = [-1:5] ; % range of series1
input_series2 = [-2,-8,9,4,2,3,5] ; % input series2
range_series2 = [0:6] ; % range series2
output = multiplicationOfSignals( input_series1 , range_series1 , input_series2 ,
    range_series2 ); % calling function
min1 = min ( range_series1 ); % minimum of range of series1
min2 = min( range_series2 ); % min of range of series2
minOfmin = min ( min1 , min2 ); %min of mins
max1 = max( range_series1 ); % max of range of series1
```

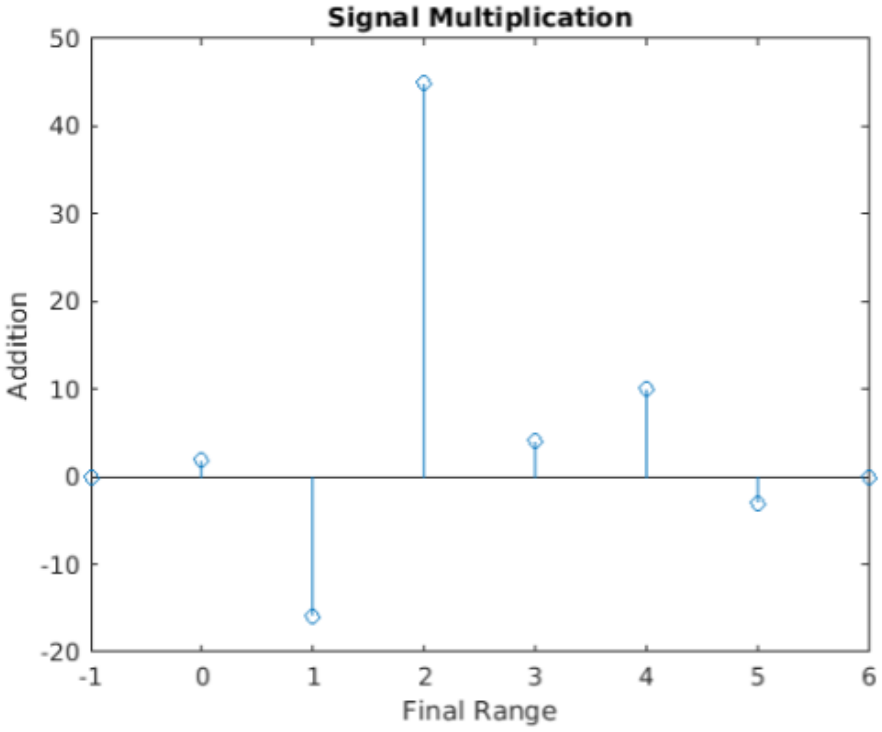
```
max2 = max ( range_series2 ); %max of range of series2
maxOfmax = max ( max1 , max2 ); % max of maxs
axis = minOfmin : maxOfmax ; % axis
stem (axis , output ); % discrete
xlabel (" Final Range ") ;
ylabel (" Addition ") ;
title (" Signal Multiplication ") ;
```

(c) Function:

```
function func_output = multiplicationOfSignals ( in_series1 , range_series1 ,
    in_series2 , range_series2 )
min1 = min ( range_series1 ); % minimum of range of Series 1
min2 = min( range_series2 ); % min of range of Series 2
max1 = max( range_series1 ); % max of range of Series 1
max2 = max ( range_series2 ); %max of range of Series 2
miniOfmin = min ( min1 , min2 ); %min of min range
maxiofmax = max ( max1 , max2 ); % max of max range

if( miniOfmin < min1 ) % making lower index same
series1= [ zeros(1 , min1 - miniOfmin ) , in_series1 ];
end
if( miniOfmin < min2 ) % making lower index same
series2= [ zeros(1 , min2 - miniOfmin ) , in_series2 ];
end
if( maxiofmax > max1 ) % making higher index same
series1= [ in_series1 , zeros(1 , maxiofmax - max1 ) ];
end
if( maxiofmax > max2 ) % making higer index same
series2=[ in_series2 , zeros(1,maxiofmax - max2)];
end
func_output = series1.*series2 ; % multiplication
end
```

(d) Simulation Output:



5. Solution Problem-5

(a) Approach:In this question, the range is subtracted by 1 to forward the signal by 1 time unit and for delaying the signal by 1 time unit, 1 unit was added in the range.

(b) Matlab Script:

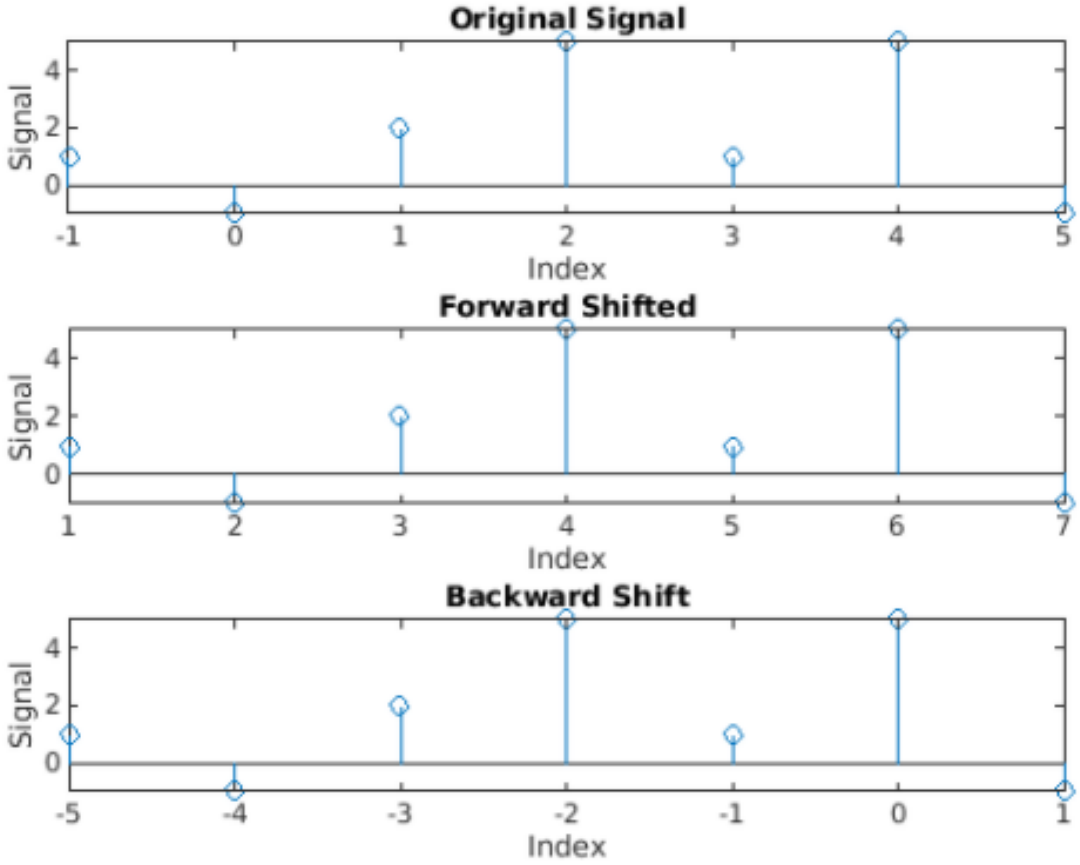
```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_5) Generate the function for timing shifting. For sequences x(n)
    ={1,-1,2,5,1,5,-1}.
clear ;
clc ;
close all ;
input_series = [1,-1,2,5,1,5,-1]; % input signal
range_series = [-1:5] ; % index
subplot (3 ,1 ,1) ;
stem ( range_series , input_series ) ;
xlabel ('Index');
ylabel ('Signal');
title ('Original Signal');
range1 = forward(2,range_series); %shifting forward by a particular unit
output_1 = input_series;
subplot (3 ,1 ,2) ;
stem( range1 , output_1 ) ; % plotting the discrete graph
xlabel ('Index') ;
ylabel ('Signal');
title ('Forward Shifted');
range2 = backward(4,range_series); % to shift backward by particular unit
output_2 = input_series;
subplot (3 ,1 ,3) ;
stem ( range2 , output_2 ) ; % plotting the discrete graph
xlabel ('Index') ;
ylabel ('Signal');
title ('Backward Shift');
```

(c) Function:

```
function func_output = forward( units,range_series )
func_output = range_series + units;   %for forward
end
```

```
function func_output = backward( units,range_series )
func_output = range_series - units;  %for backward
end
```

(d) Simulation Output:



6. Solution Problem-6

(a) Approach: In order to fold the signal, the whole signal is multiplied by -1. So that it will be a mirror image along the x-axis.

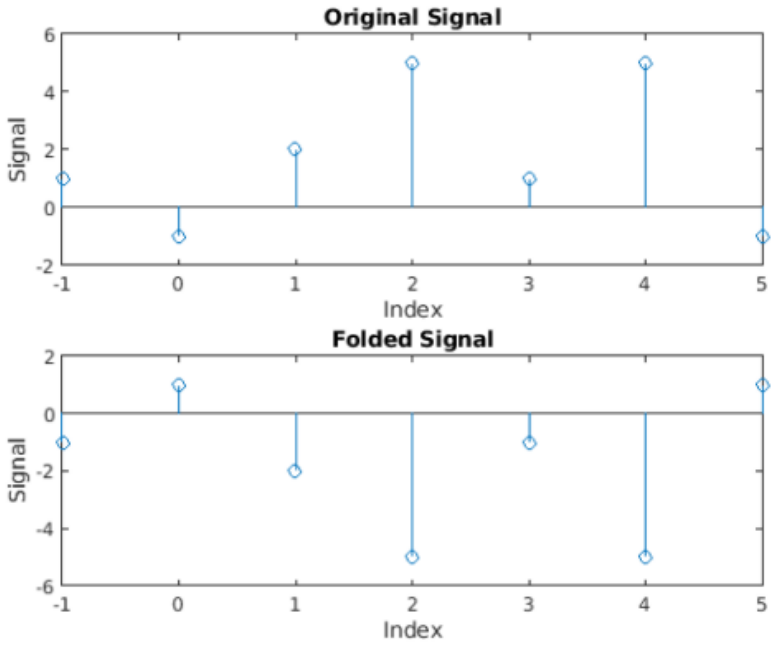
(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_6) Generate the function for signal folding. Fold the sequence x(
    n) ={1,-1,2,5,1,5,-1}.
clear ;
clc ;
close all ;
input_series = [1,-1,2,5,1,5,-1]; % defining input signal
range_series = [-1:5] ; % defining range
subplot (2 ,1 ,1) ;
stem ( range_series , input_series ) ;
xlabel ('Index');
ylabel ('Signal');
title ('Original Signal');
range1 = range_series;
out1 = fold(input_series) ;%using fold function to invert the graph or to take the
     mirror image along x axis
subplot (2 ,1 ,2) ;
stem( range1 , out1 ) ; % plotting the discrete graph
xlabel ('Index') ;
ylabel ('Signal');
title ('Folded Signal');
```

(c) Function:

```
function func_output = fold( input_series )
func_output = input_series.*(-1);   %taking mirror image along x axis
end
```

(d) Simulation Output:



7. Solution Problem-7

(a) Approach: In this question, multiplying range with k factor means, there will be a compression by the factor of k. So, the range will be divide by k and multiplication will be done.

(b) Matlab Script:

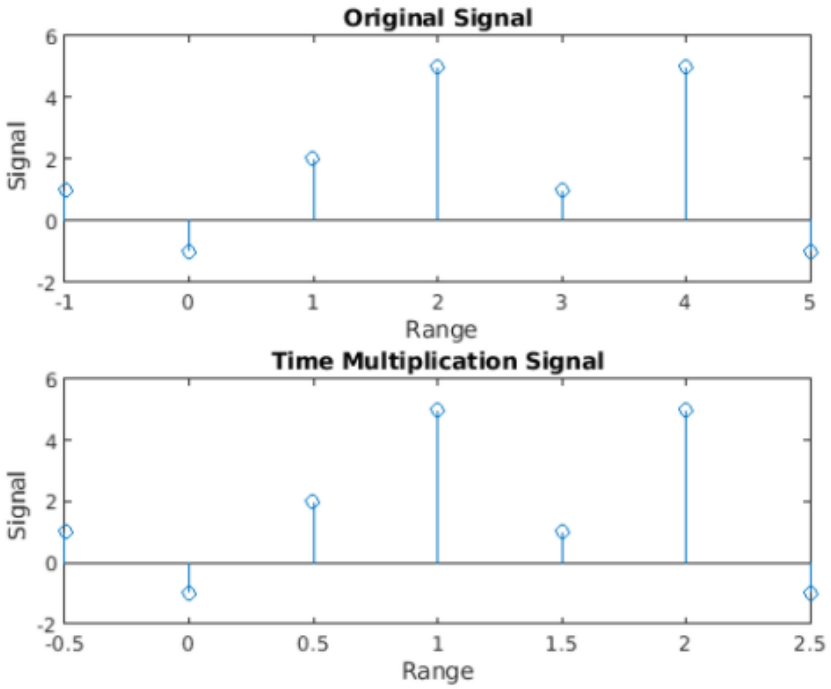
```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_7) Generate the function for time multiplication. Use it for
    sequence x1(n) ={1,-1,2,5,1,5,-1}.
clc ;
clear all ;
close all ;

input_series = [1,-1,2,5,1,5,-1]; % defining input signal
range_series = [-1:5] ; % index
subplot (211) ;
stem ( range_series , input_series ) ;
xlabel (" Range") ;
ylabel (" Signal") ;
title (" Original Signal ")
output_range = t_multiply ( range_series); %updated Range
subplot (212)
stem ( output_range , input_series ); %plotting the discrete plot
xlabel (" Range ") ;
ylabel ("Signal ") ;
title (" Time Multiplication Signal ")
```

(c) Function:

```
function output = t_multiply ( range_x)
output = range_x .* (1/2) ;
end
```

(d) Simulation Output:



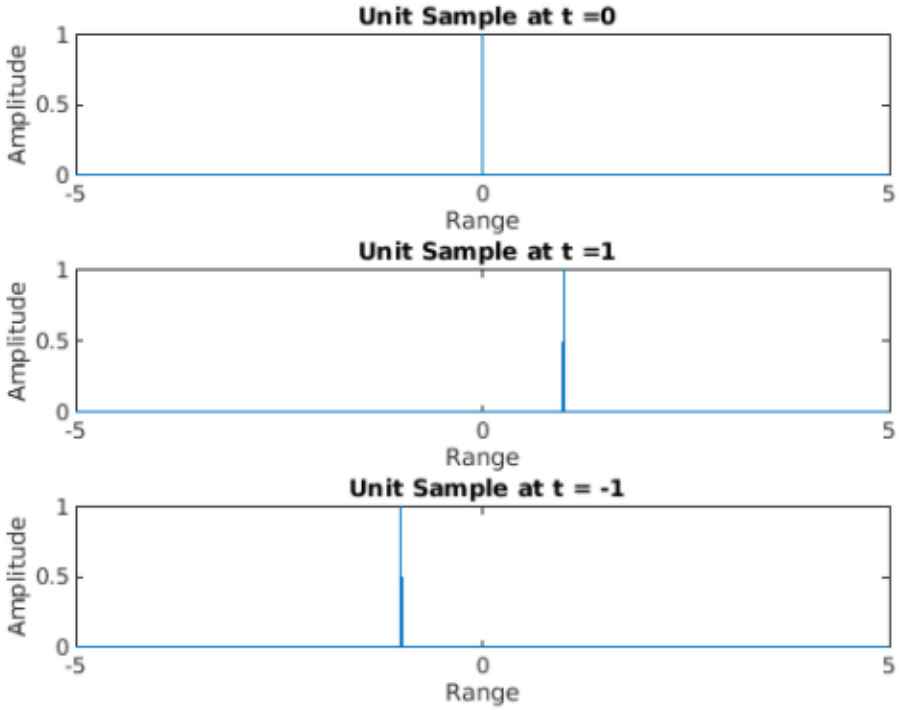
8. Solution Problem-8

(a) Approach:In order to generate sample function, at t=0, the value of the function will be 1 otherwise it will be 0. δ(t-1) function, means at t=1 the value of the function will be 1 otherwise it will be 0.δ(t+1) function, means at t=-1 the value of the function will be 1 otherwise it will be 0.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_8) Generate function for unit sample signal.
clc ;
clear all ;
close all ;
range_signal = ( -5:0.01:5) ; % time range for the unit sample signal
signal_1 = (range_signal ==0) ; % generating the unit sample signal
subplot (3 ,1 ,1) ; % generating the 1st graph
plot (range_signal , signal_1 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit Sample at t =0") ;
signal_2 = ((range_signal -1) ==0) ; % generating the unit sample for t -1
subplot (3 ,1 ,2) ; % generating the 2nd graph
plot (range_signal , signal_2 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit Sample at t =1") ;
signal_3= (( range_signal +1) ==0) ; % generating the unit sample for t+1
subplot (3 ,1 ,3) ; % generating the 3rd graph
plot (range_signal , signal_3 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit Sample at t = -1") ;
```

(c) Simulation Output:



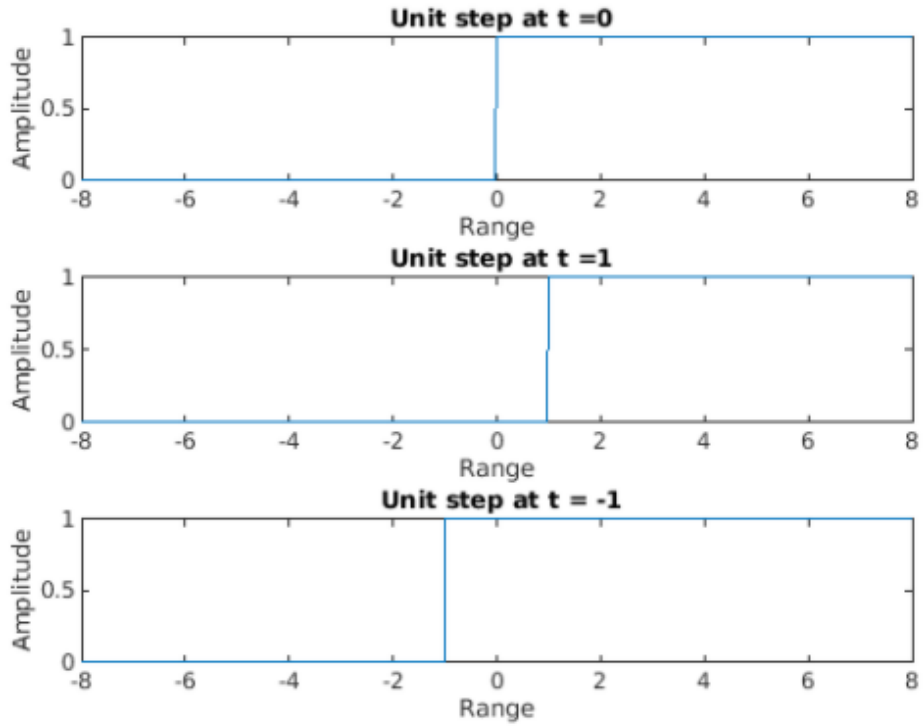
9. Solution Problem-9

(a) Approach: In order to generate step function, from t¿=0, the value of the function will be 1 otherwise it will be 0. δ(t-1) function, means from t¿=1 the value of the function will be 1 otherwise it will be 0.δ(t+1) function, means from t¿=-1 the value of the function will be 1 otherwise it will be 0.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_9)Generate function for unit step signal..
clc ;
clear all ;
close all ;
range_signal = ( -8:0.02:8) ; % time range for the unit step signal
signal_1 = (range_signal>=0) ; % generating the unit step signal
subplot (3 ,1 ,1) ; % generating the 1st graph
plot (range_signal , signal_1 );%plotting the range vs step graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit step at t =0") ;
signal_2 = ((range_signal -1)>=0) ; % generating the unit step for t -1
subplot (3 ,1 ,2) ; % generating the 2nd graph
plot (range_signal , signal_2 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit step at t =1") ;
signal_3= (( range_signal +1)>=0) ; % generating the unit step for t+1
subplot (3 ,1 ,3) ; % generating the 3rd graph
plot (range_signal , signal_3 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit step at t = -1") ;
```

(c) Simulation Output:



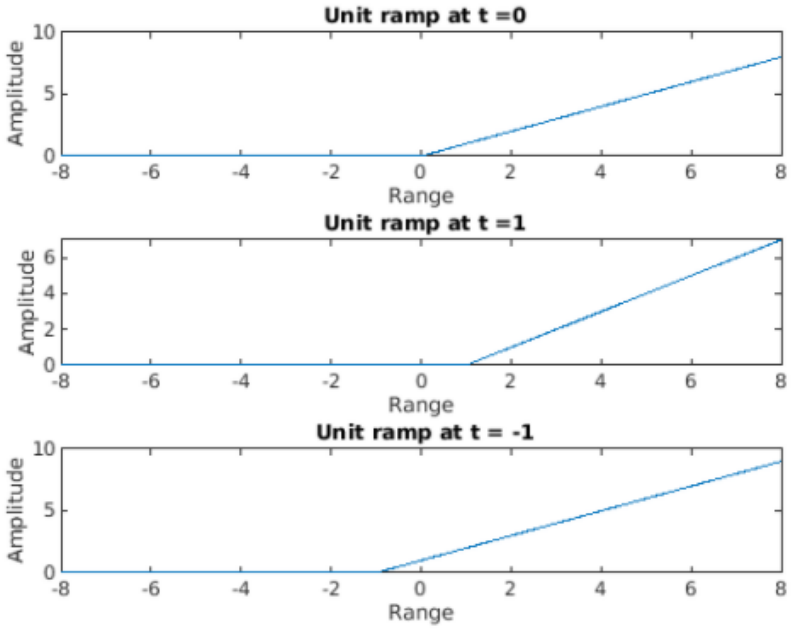
10. Solution Problem-10

(a) Approach: In order to generate remp function, from t¿=0, the value of the function will be 1*range otherwise it will be 0. u(t-1) function, means from t¿=1 the value of the function will be 1*range otherwise it will be 0. u(t+1) function, means from t¿=-1 the value of the function will be 1*range otherwise it will be 0.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_10)Generate function for  unit ramp signal..
clc ;
clear all ;
close all ;
range_signal = ( -8:0.02:8) ; % time range for the unit ramp signal
signal_1 = range_signal.*(range_signal>=0) ; % generating the unit ramp signal
subplot (3 ,1 ,1) ; % generating the 1st graph
plot (range_signal , signal_1 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit ramp at t =0") ;
signal_2 = (range_signal -1).*((range_signal -1)>=0) ; % generating the unit ramp
    for t -1
subplot (3 ,1 ,2) ; % generating the 2nd graph
plot (range_signal , signal_2 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit ramp at t =1") ;
signal_3= ( range_signal +1).*(( range_signal +1)>=0) ; % generating the unit ramp
     for t+1
subplot (3 ,1 ,3) ; % generating the 3rd graph
plot (range_signal , signal_3 );%plotting the range vs signal graph
xlabel (" Range ") ;
ylabel (" Amplitude ") ;
title (" Unit ramp at t = -1") ;
```

(c) Simulation Output:



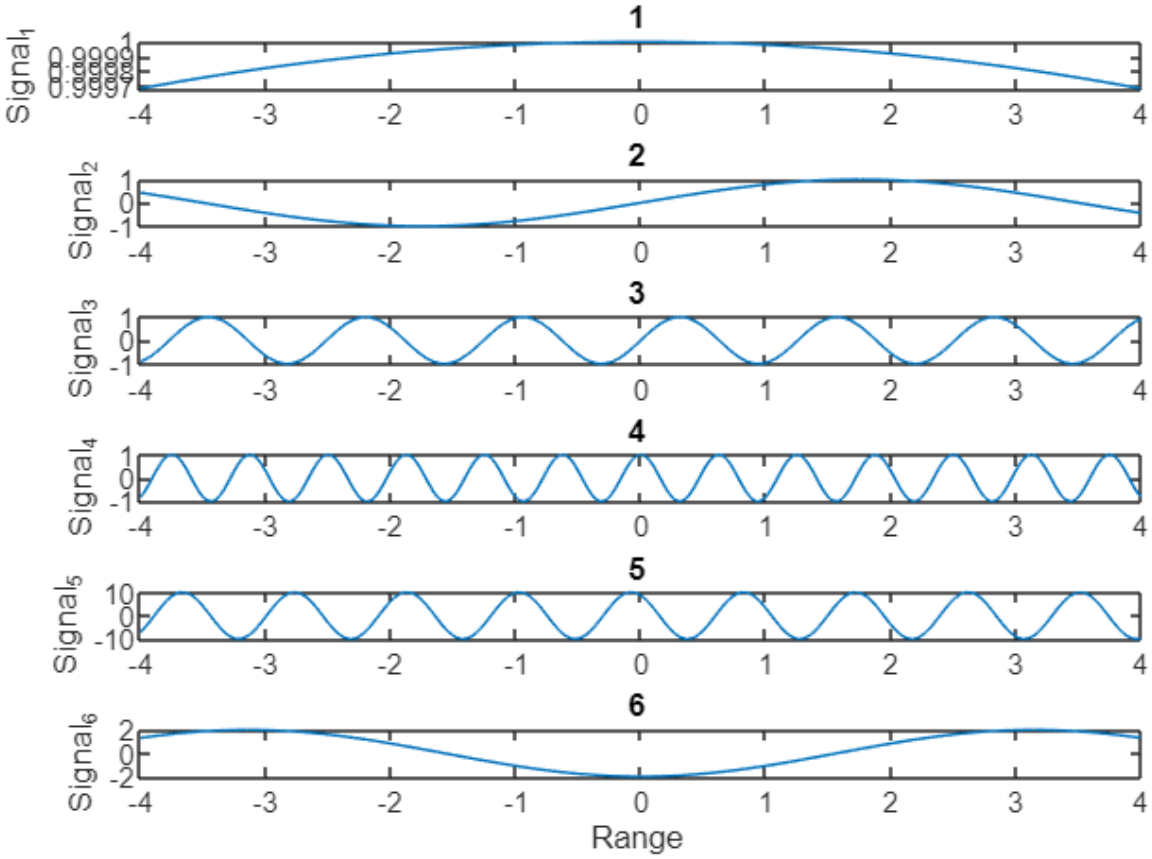
11. Solution Problem-11

(a) Approach: In this question, signals were plotted using sin and cos functions. The periodicity was found using $\omega = 2^{*}\pi/T$.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_11) Plot all the given signals and comment on their output for
    periodicity writing common
% MATLAB code.
%1 x(n) = cos(0.002*pi*n)
%2 x(n) = sin(30*pi*n/105)
%3 x(n) = sin(n*5)
%4 x(n) = cos(32n*pi*/10)
%5 x(n) = 10*cos(7n+pi/6)
%6 x(n) = 2*exp j(n-pi)
clc ;
clear;
close all ;
n = -4:0.01:4; %Defining the range
signal1 = cos (0.002*pi*n); %Equation of Function 1
subplot(611);
plot (n,signal1 );%Plotting Signal 1
ylabel ('Signal_1 ');
title ("1 ");
signal2 = sin (30*n*pi/105); %Equation of Function 2
subplot (612);
plot (n,signal2 );%Plotting Signal 2
ylabel ('Signal_2 ');
title ("2 ");
signal3 = sin(5*n); %Equation of Function 3
subplot (613);
plot (n,signal3 );%Plotting Signal 3
ylabel ('Signal_3 ');
title ("3 ");
signal4 = cos(32*pi*n/10) ;%Equation of Function 4
subplot (614);
plot (n,signal4 );%Plotting Signal 4
ylabel ('Signal_4 ');
title ("4 ");
signal5 = 10*cos((7*n)+(pi/6) ); %Equation of Function 5
subplot (615);
plot (n,signal5 );%Plotting Signal 5
ylabel ('Signal_5 ');
title ("5 ");
signal6 = 2*exp(1i*(n-pi)); %Equation of Function 6
subplot (616);
plot (n,signal6 );%Plotting Signal 6
xlabel ('Range ');
ylabel ('Signal_6 ');
title ("6 ");
%Periodicity
% Answer of 1st Graph: Period 1000
% Answer of 2nd Graph: 7
% Answer of 3rd Graph: Period 2*pi/5
% Answer of 4th Graph: Period 5/8
% Answer of 5th Graph: Period 2* pi /7
% Answer of 6th Graph: Period 2*pi
```

(c) Simulation Output:



12. Solution Problem-12

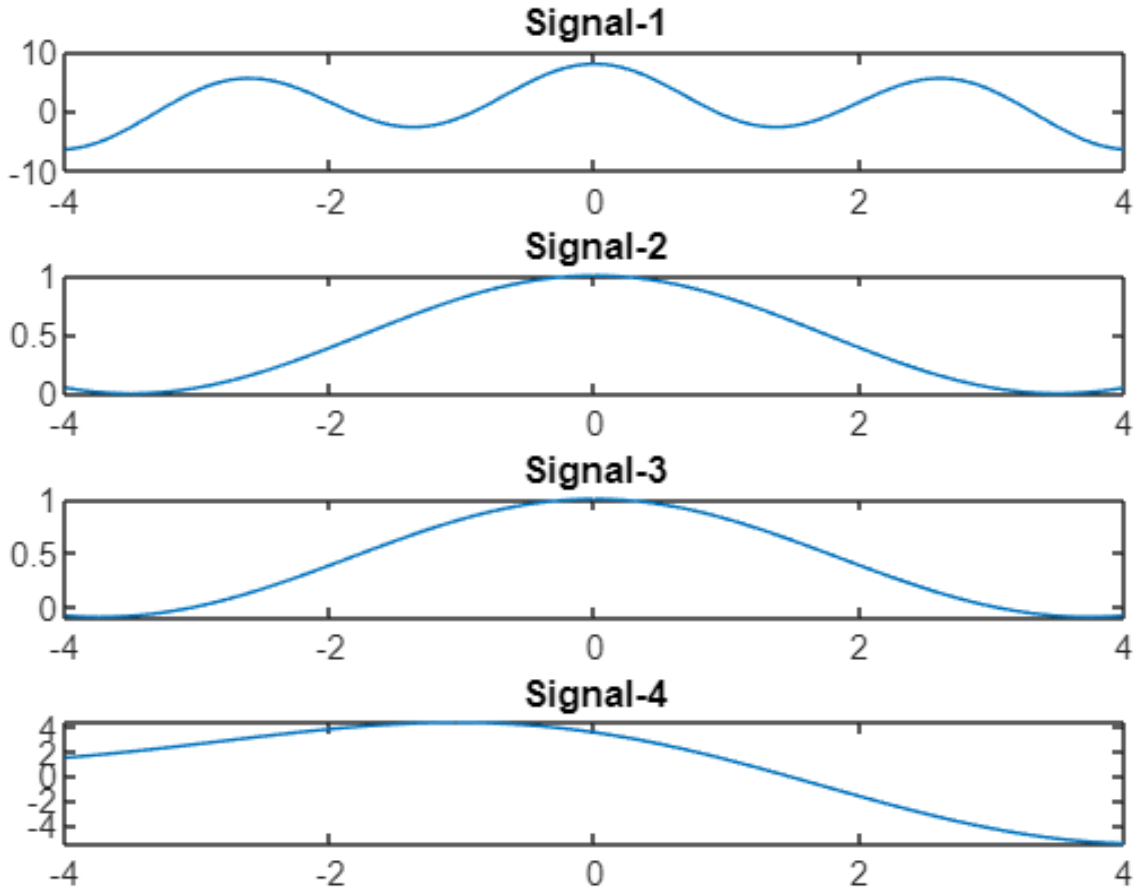
(a) Approach: Here, additions of the signals are there. To find the period out of this addition, we need to find the common factor of both signals' periods.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_12) Plot all the given signals and comment on their output for
    periodicity writing common
% MATLAB code.
%1 x(n) = 3cos(pi*n/6)+ 5cos(3*pi*n/4)
%2 x(n) = cos(n/7)*cos(n*pi/7)
%3 x(n) = cos(n*pi/6)*cos(n*pi/9)
%4 x(n) = 2*cos(n*pi/4)-sin(n*pi/6)+3*cos((n*pi/8)+pi/3)
clc ;
clear;
close all ;
n = -4:0.01:4; %Defining the range
signal1 = 3*cos ((1/6)*pi*n) + 5*cos ((3/4)*pi*n); %Equation of Function 1
subplot(411);
plot (n,signal1 );%Plotting Signal 1
title ("Signal-1");
signal2 = cos((1/7)*pi*n).*cos ((1/7)*pi*n); %Equation of Function 2
subplot (412);
plot (n,signal2 ); %Plotting Signal 2
title ("Signal-2");
signal3 = cos((1/6)*pi*n).*cos ((1/9)*pi*n); %Equation of Function 3
subplot (413);
plot (n,signal3 ); %Plotting Signal 3
title ("Signal-3");
signal4 = 2*cos((1/4)*pi*n)-sin((1/6)*pi*n)+ 3*cos((1/8)*pi*n + (1/3)*pi);%
    Equation of Function 4
subplot (414);
plot (n,signal4 );
title ("Signal-4"); %Plotting Signal 4

%Periodicity
% Answer of 1st Graph: Period 24
% Answer of 2nd Graph: Aperiodic
% Answer of 3rd Graph: Period 36
% Answer of 4th Graph: Period 48
```

(c) Simulation Output:



13. Solution Problem-13

(a) Approach: : In the question, it was given that the main freq=2khz is sampled with 10khz and 3khz. Out of which Nyquist rate criteria is not satisfied by 10khz. sampling frequency = 3khz satisfies the criteria successfully. Thus, it provides a clear wave.

(b) Matlab Script:

```
% Name : Samarth Shah
% Roll No: AU1841145
% Lab1 (Question_13) Sample the sinusoid x = sin(2 pi f t), where f = 2 kHz, and
    plot the sampled signals over the
%continuous-time signal.
%- Let x1 be the signal sampled at 10 kHz.
%- Let x2 be the signal sampled at 3 kHz.
%Plot required waveforms and comment on the same by writing common MATLAB code.
clc;
close all ;
clear all ;
freq = 2000; %declaring frequency
sampling_freq1 =10000;%declaring the sampling frequency
sampling_freq2 = 3000;%declaring the sampling frequency
time1 = freq/sampling_freq1; %calculating time=1/sampling freq.
time2 = freq/ sampling_freq2;%calculating time=1/sampling freq.
range = 0:0.1:10; %defining the range
x = sin (2* pi*time1* range );  %calculating function 1
y = sin (2* pi*time2* range );  %calculating function 2
subplot (211)
plot (range ,x) %Plotting Function 1
xlabel ('X Axis ');
ylabel ('Y Axis ');
title ('Signal sampled at sampling freq. = 100000 ')
subplot (212)
plot (range ,y) %Plotting Function 2
xlabel ('X Axis ');
ylabel ('Y Axis ');
title ('Signal sampled at sampling freq. = 3000 ')
```

(c) Simulation Output: