Signals & Systems Laboratory

CSE- 301L

Lab # 04

OBJECTIVES OF THE LAB

This lab will help you grasp the following concepts:

- *Discrete Signal representation in Matlab*
- *Matlab Graphics*
- *Two Dimensional Plots*
- *Plot and subplot*
- *Different Plotting Functions Used in Matla*b

4.1 DISCRETE-TIME SIGNAL REPRESENTATION IN MATLAB

In MATLAB, finite-duration sequence (or discrete time signal) is represented by row matrix/vector of appropriate values. Such representation does not have any information about sample position n. Therefore, for correct representation, two vectors are required, one for x and other for n. Consider the following finite duration sequence & its implementation:

$$x(n) = \{ 1\ -1\ 0\ \underset{\uparrow}{2}\ 1\ 4\ 6 \}$$

```
          >> n = [-3:1:3]
n =
        -3  -2  -1    0    1    2   3
          >> x = [1 -1 0 2 1 4 6]
x =
             1   -1    0    2  1  4   6
```

NOTE # 01: When the sequence begins at n=0, x-vector representation alone is enough.

NOTE # 02: An arbitrary infinite-sequence can’t be represented in MATLAB due to limited memory.

4.2 GRAPHICS

Two- and three-dimensional MATLAB graphs can be given titles, have their axes labeled, and have text placed within the graph. The basic functions are:

Function	Description
`plot(x,y)`	plots y vs x
`plot(x,y1,x,y2,x,y3)`	plots y1, y2 and y3 vs x on the same graph
`stem(x)`	plots x and draws a vertical line at each datapoint to the horizontal axis
`xlabel('x axis label')`	labels x axis
`ylabel('y axis label')`	labels y axis
`title ('title of plot')`	puts a title on the plot
`gtext('text')`	activates the use of the mouse to position a crosshair on the graph, at which point the 'text' will be placed when any key is pressed.
`zoom`	allows zoom IN/OUT using the mouse cursor
`grid`	draws a grid on the graph area
`print filename.ps`	saves the plot as a black and white postscript file
`Shg`	brings the current figure window forward.
`CLF`	clears current figure.

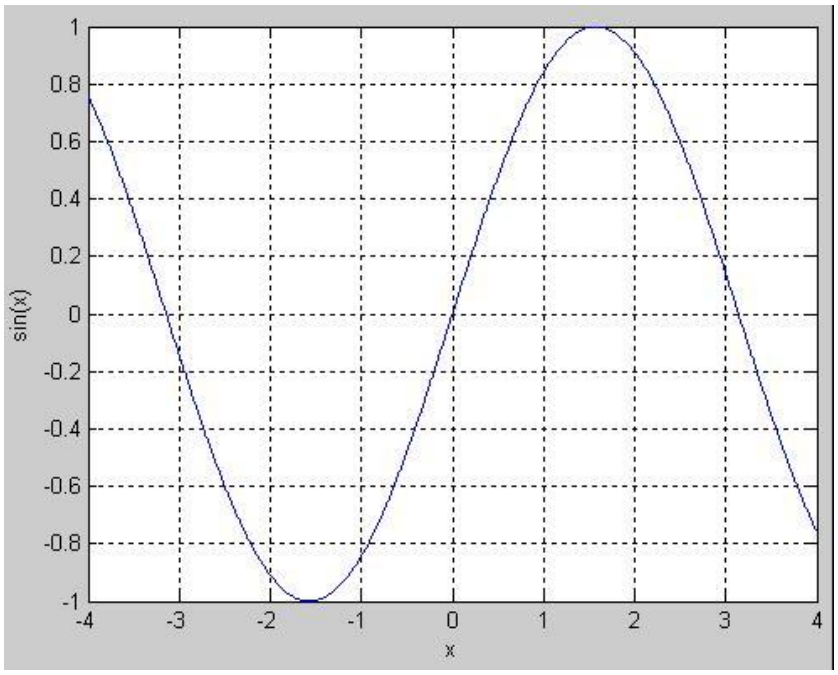
4.2.1 Two-dimensional plots

The plot command creates linear x-y plots; if x and y are vectors of the same length, the command plot(x,y) opens a graphics window and draws an x-y plot of the elements of x versus the elements of y.

Example: Let's draw the graph of the sine function over the interval -4 to 4 with the following commands:

```
>> x = -4:.01:4; y = sin(x); plot(x,y)
>> grid
>> xlabel('x')
>> ylabel('sin(x)')
```

The vector x is a partition of the domain with mesh size 0.01 while y is a vector giving the values of sine at the nodes of this partition (recall that sin operates entry wise). Following figure shows the result.



4.2.1.1 MULTIPLE PLOTS ON SAME FIGURE WINDOW

Two ways to make multiple plots on a single graph are:

i. **Single plot command**

```
x = 0:.01:2*pi;
y1= sin(x);
y2= sin(2*x);
y3 = sin(4*x);
```

```
plot(x,y1,x,y2,x,y3)
```

ii. Multiple plot commands

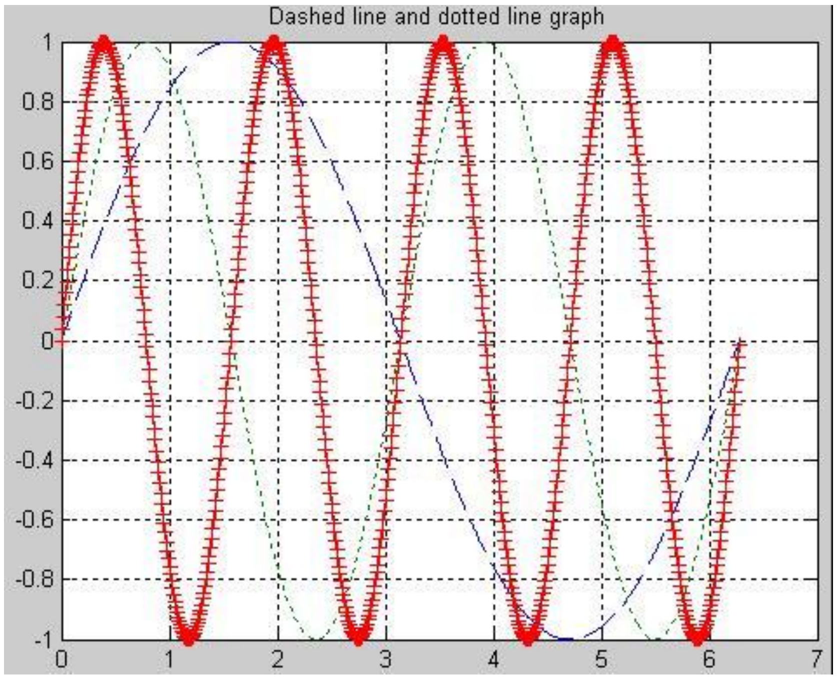
Another way is with **hold**. The command hold freezes the current graphics screen so that subsequent plots are superimposed on it. Entering hold again releases the ``hold.''

```
x = 0:.01:2*pi;
y1=sin(x);
y2=sin(2*x);
y3 = sin(4*x);
plot(x,y1);
hold on;
plot(x, y2);
plot(x,y3);
```

4.2.1.2 OVERRIDING THE DEFAULT PLOT SETTINGS

One can override the default linetypes and pointtypes. For example, the command sequence

```
x = 0:.01:2*pi;
y1=sin(x);
y2=sin(2*x);
y3=sin(4*x);
plot(x,y1,'--',x,y2,':',x,y3,'+')
grid
title ('Dashed line and dotted line graph')
```



The line-types, mark-types and colors are:

```
=============================================================
Linetypes : solid (-), dashed (--), dotted (:), dash-dot (-.)
Marktypes : point (.), plus (+), asterisk (*), circle (o),
x-mark (x), horizontal line (-), vertical line (|), square
(s), diamond (d), up-triangle (^), down-triangle (v),
left-triangle (<), right-triangle(>), pentagram (p),
hexagram (h)
Colortypes: yellow (y), magenta (m), cyan (c), red (r),
green (g), blue (b), white (w), black (k)
=============================================================
```

------------------------TASK 01------------------------

Given the signals:

$x_1[n]$ = [2 5 8 4 3]

$x_2[n]$ = [4 3 2]

a) Write a MatLab program that adds these two signals. Use vector addition and multiplication.

b) Instead of using vector addition and multiplication, use for loop to add and multiply the signals.

c) Design a function **SigPlot** that takes the original signals and their sum and product as input and plots them as:

i) Separate Figures,

ii) Single Figure overlapping all the signals, and

iiI) Single Figure with separate signal plots using subplots.

------------------------TASK 02------------------------

Amplitude scaling by a factor β causes each sample to get multiplied by β. Write a user-defined function **ScaleSig** that has two input arguments: (i) a signal to be scaled and (ii) scaling factor β. The function should return the scaled output to the calling program. In the calling program, get the discrete time signal as well as the scaling factor from user and then call the above-mentioned function.

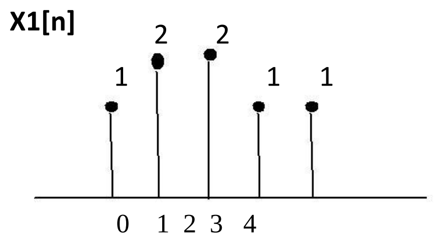
Design a function **SigPlot** that takes the original signals and their scaled versions as input from the main calling program and plots them as:

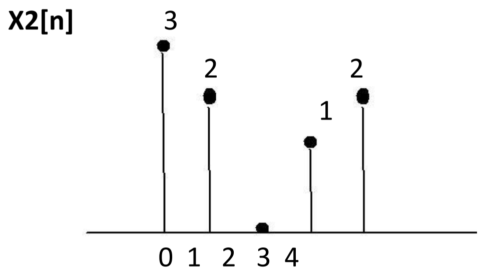
i) Separate Figures,

ii) Single Figure overlapping all the signals, and

iiI) Single Figure with separate signal plots using subplot.

------------------------TASK 03------------------------





Write a Matlab program to compare the signals $x_1[n]$ and $x_2[n]$. Determine the index where a sample of $x_1[n]$ has smaller amplitude as compared to the corresponding sample of $x_2[n]$. Use for loop.

Design a function **SigPlot** that takes the original signals as input from the main calling program and plots them as:

i) Separate Figures using **stem** command,

ii) Single Figure overlapping both the signals using multiple **stem** commands with **hold on**,

iii) Single Figure with separate signal plots using subplots and stem commands.

------------------------TASK 04------------------------

Plot the two curves **y1 = 2x .^2** and **y2 = 4x .^3** on the same graph using different plot styles.

a) Use x as a 31 entries sequence from -15:15.

b) Use x as a 101 entries sequence from -50:50.

(Hint: use plot(x,y1,'b--o',x,y2,'c*') or same with subplots or same with multiple stems) .

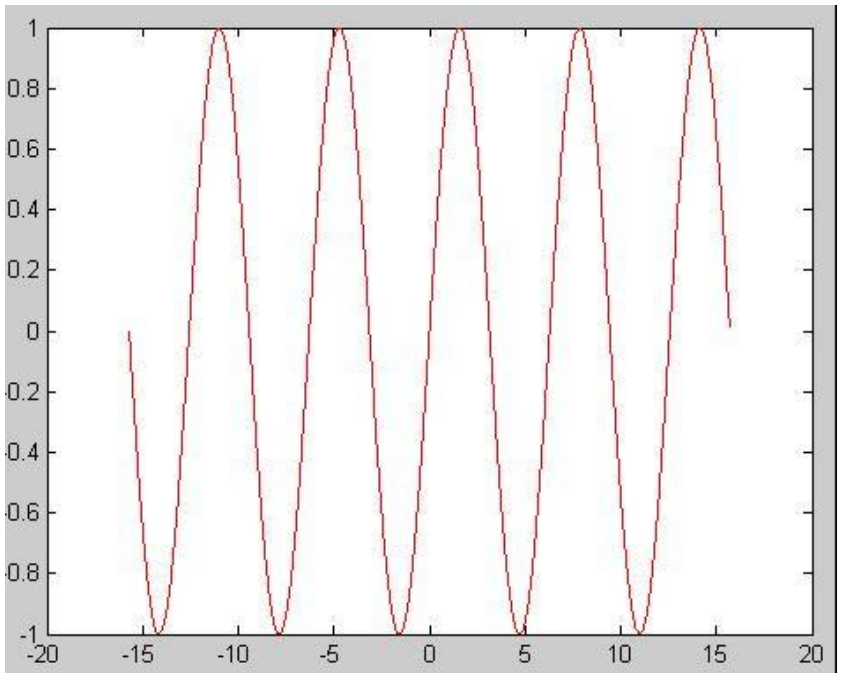
4.2.1.3 AXES COMMANDS (MANUAL ZOOMING)

MATLAB automatically adjusts the scale on a graph to accommodate the coordinates of the points being plotted. The axis scaling can be manually enforced by using the command **axis([xmin xmax ymin ymax])**. A signal can be zoomed out by specifying the axis coordinates by user himself.

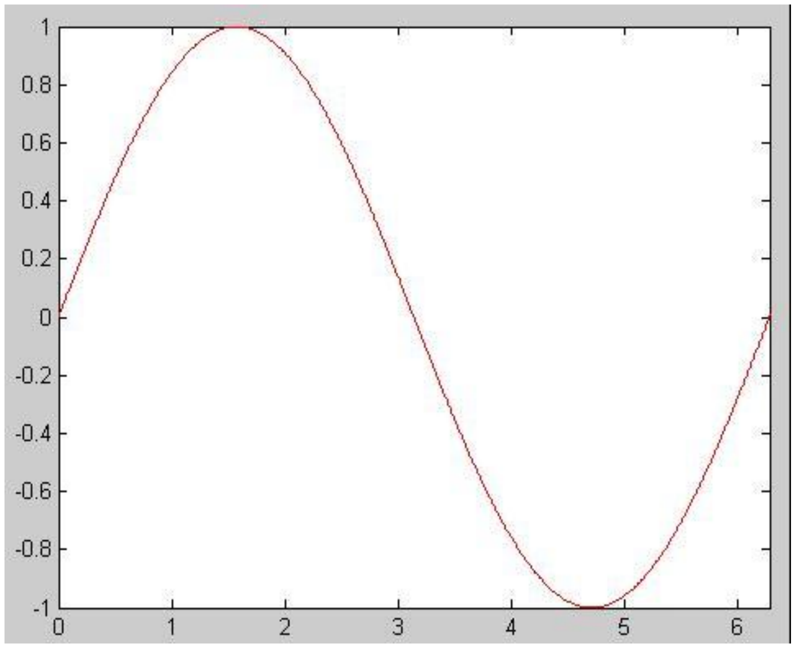
Example:

```
x = -5*pi:.01:5*pi;
y1=sin(x);
plot(x,y1, 'r')
```

The plot is shown in the figure below.

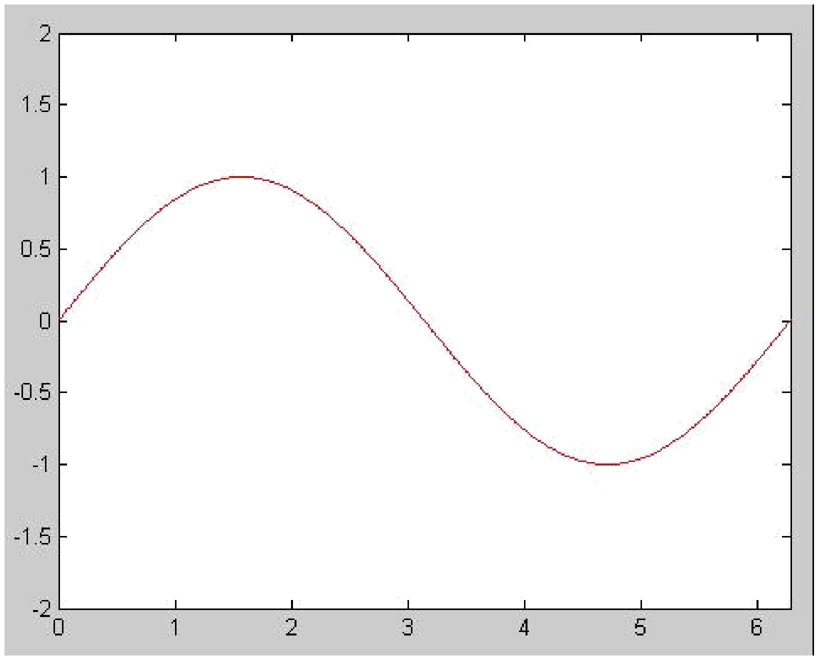


In order to see only one cycle of this signal from 0 to 2π, the signal is zoomed using axis command. Here we have specified xmin and xmax as 0 and 2π respectively. The magnified plot is shown in the figure below.



Similarly the y-axis can be adjusted according to requirements.

```
x = -5*pi:0.01:5*pi;
y1=sin(x);
plot(x,y1, 'r')
axis([0 2*pi -2 2])
```



4.2.1.4 LABELING A GRAPH

To add labels to your graph, the functions xlabel, ylabel, and title can be used as

follows: xlabel('x-axis')

ylabel('y-axis')

title('points in a plane')

4.2.1.5 SUBPLOT

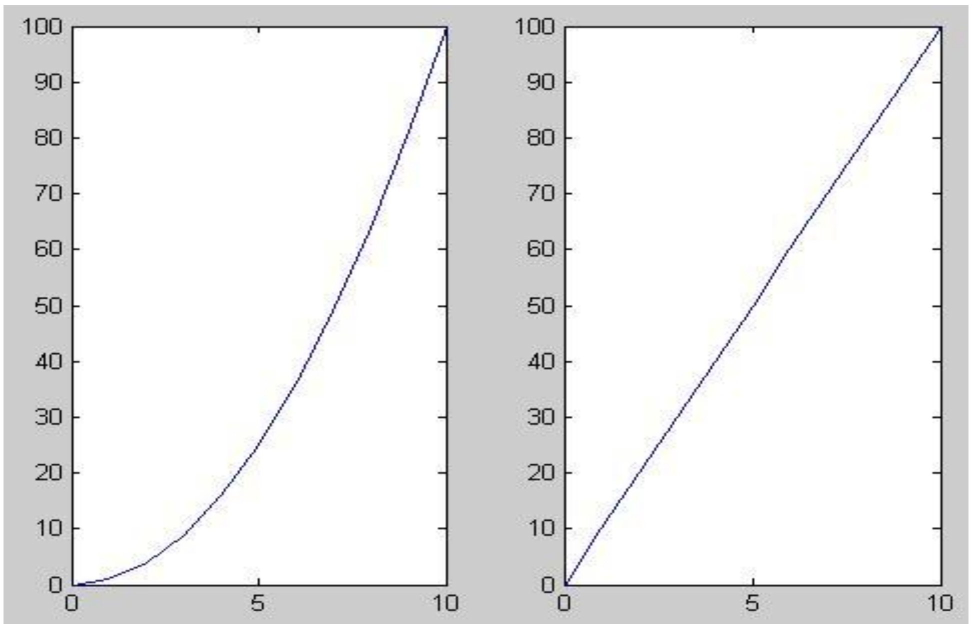
SUBPLOT Create axes in tiled positions.

MATLAB graphics windows will contain one plot by default. The command subplot can be used to partition the screen so that up to four plots can be viewed simultaneously. A single figure can be divided into a number of plotting areas where different graphs can be plotted. This can be accomplished by using the command subplot(m, n, p) where m, n specifies the total number of rows and columns respectively in the figure window and p specifies the specific cell to plot into.

```
 x=0:1:10;
 y=x.^2;
 z=10*x;
```

Now type the following code

```
figure
subplot (1,2,1)
plot(x,y)
subplot (1,2,2)
plot(x,z)
```



In the above case subplot(m,n,p) command was used, in our case subplot (1,2,1) and subplot (1,2,2). Here m=1 means that divide the figure into 1 row, n=2 means to divide the figure into 2 columns. This gives us a total of 2 subplots in one figure. Where p=1 means the window on the left (starting from row 1 and counting p=1 subplots to the right) and p=2 means the subplot on the right (starting from row 1 and counting p=2 subplots to the right).

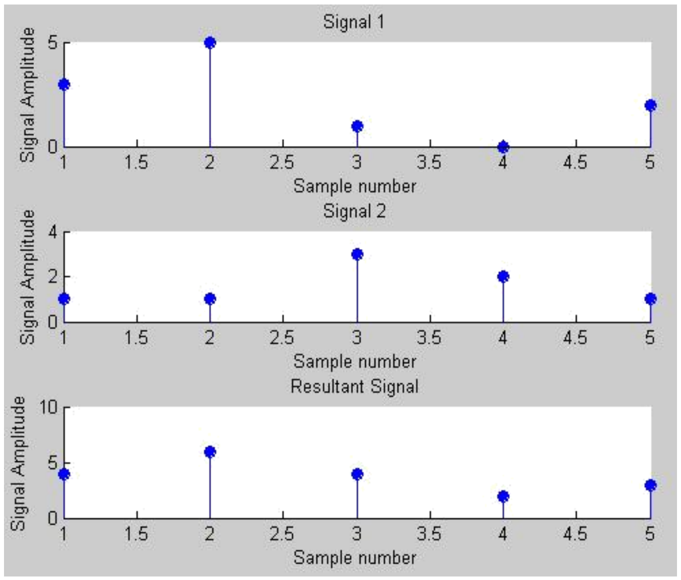
Example: Performing operations on signals entered by user

```
clear
x=input('Enter the first discrete time signal\n');
```

```
len_x=length(x);
y=input('Enter the second discrete time signal\n');
len_y=length(y);

while(len_y~=len_x)
    disp('Error: Length of signals must match. Enter the 2nd
    signal again')
    y=input('');
    len_y=length(y);
end

z=x+y;
subplot(3,1,1)
stem(x,'filled')
title('Signal 1')
xlabel('Sample number')
ylabel('Signal Amplitude')

subplot(3,1,2)
stem(y,'filled')
title('Signal 2')
xlabel('Sample number')
ylabel('Signal Amplitude')

subplot(3,1,3)
stem(z,'filled')
title('Resultant Signal')
xlabel('Sample number')
ylabel('Signal Amplitude')
```

output:

```
Enter the first discrete time signal
[3 5 1 0 2]
Enter the second discrete time signal
[1 1 3 2]
```



-------------------------TASK 05-------------------------

Create a function **PlotCircle** that takes points x, y and radius r from user as inputs and generates a graph of circle centered at point (x,y) with a radius equal to r. Use **axis equal** to use equal data units along each coordinate direction and use **axis square** to view square axis. (Hint: use circle equation: x-axis = r*cos(theta)+x; y-axis=r*sin(theta)+y; where theta=0:1/100:2*pi and plot x-axis versus y-axis)

-------------------------TASK 06-------------------------

Given the signals:

X1[n] = 2δ[n] + 5δ[n-1] + 8δ[n-2] + 4δ[n-3] + 3δ[n-4]
X2[n] = δ[n-4] + 4δ[n-5] +3δ[n-6] + 2δ[n-7]

Write a Matlab program that adds these two signals. Plot the original signals as well as the final results using different plotting designs.

-------------------------TASK 07-------------------------

Create a function **AmpScale** that takes a discrete-time signal **S** and a threshold **T** from user and scales the amplitude of the input signal. The function saves and counts the number of samples with amplitude greater than **T** and less than **-T** and plots the amplitude scaled signal and gives the number of sample within the thresholds as output.

-------------------------TASK 08-------------------------

Write your own function **downsamp** that takes a signal as input, retain odd numbered samples of the original signal and discard the even-numbered (down sampling by 2). The function must return the down sampled version of that signal as output. See Fig for example.

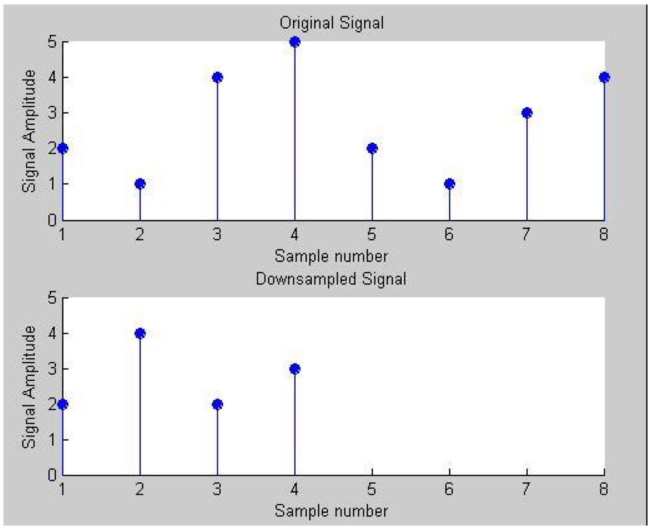


Fig. Down Sampling

a) Call this function from a matlab file. Verify your result by using the built-in command "**downsample**". Plot the original signal, downsampled signal determined by your program, and downsampled signal obtained by the command **downsample**.
b) Modify your function to work as generic down sampling function that takes both the **input signal** and the **sampling factor** from the user. Your function must also check the possibility of down sampling by comparing the sampling rate with the number of samples in the input signal.

------------------------TASK 09-------------------------

Write your own function to **upsamp** a signal i.e. copy the 1st sample of original signal in the new signal and then place an extra sample of 0, copy the 2nd sample of original signal and then place a 0, and so on. See Fig for example.

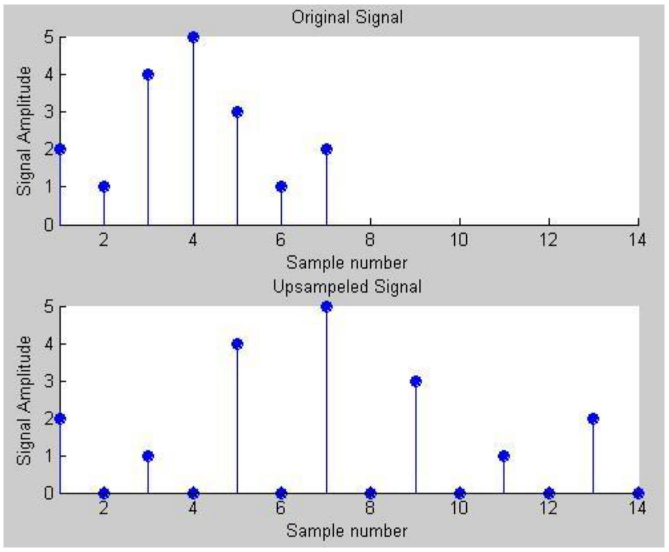


Fig. Up Sample

a) Call this function from a matlab file. Verify your result by using the built-in command "**upsample**". Plot the original signal, upsampled signal determined by your function **upsamp**, and upsampled signal obtained by the command **upsample**.
b) Modify your function to work as generic up sampling function that takes both the **input signal** and the **sampling factor** from the user.
c) Your function must also perform other up sampling methods such as instead of **0**, the new sample is the **copy** of preceding or succeeding sample of the original signal or the new sample is the **average** of both. Check for possibility new up sampling methods by comparing the samples in the input signal.

-------------------------TASK 10-------------------------

Plotting **3-D graphics** with MatLab. This is a complementary task for practicing 3d graphs in MatLab. **Surf** command is used in Matlab for plotting 3D graphs, the **meshgrid** command is used for setting up 2D plane

```
clear all
close all

% set up 2-D plane by creating a -2:.2:2 sequence and copying it
to all rows of x size(-2:.2:2) times and vice versa
[x,y] = meshgrid([-2:.2:2]);

% plot 3D on plane
Z = x.*exp(-x.^2-y.^2);

figure

% surface plot, with gradient(Z) determining color distribution
surf(x,y,Z,gradient(Z))

% display color scale, can adjust location similarly to legend
colorbar
```
