DEPARTMENT OF ROBOTICS & MECHATRONICS ENGINEERING

University of Dhaka

Course: Digital Signal Processing Lab

Course Code: 4113

Lab Task 2: Matlab code for Arithmatic operations, Matrix and Vector Operations and Excel Read-Write

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Introduction

Matlab is a computational environment that supports matrix computations and plotting (in both two and three dimensions). Its major feature is that it is very easy to use. Matlab allows commands to be executed in two ways.
Interactive You can type commands directly to MATLAB, allowing you to proceed through a computation step-by-step, inspecting variables, and plotting intermediate results.
Program By creating a file of commands, a sequence of commands can be stored and executed as if each were typed in interactive mode. The file, created in an ordinary editor or by Matlab, should be named with extension ".m". It is executed by typing its file name without the extension '.m'.
The following MATLAB tutorial is useful for reference purpose:
http://users.ece.gatech.edu/~bonnie/book/TUTORIAL/tutorial.html

MATLAB Basics

User can terminate the MATLAB application by simply typing the command "exit" in the command window or by clicking the appropriate toolbar menu. The toolbar menu is "File>>Exit MATLAB".
It should be noted that the execution of each MATLAB command must be followed by a "return" or "enter" key press.

Matlab Tutorial

Variable

Variables are assigned with values by typing the expression directly. For example, type the command in the command window as follows. The MATLAB instantly displays the value of variable in the window. Try the following command in the command window.

Type >> a = 5
Try the following command again. What is the difference if a semicolon is put at the end of an expression?

Without semicolon the command does print on the screen and also get stored in the memory, without semicolon the command only get stored in the memory but does not print on the screen

Type >>a = 5;

Q.1.Ans:

MATLAB utilizes the following arithmetic operators and precedence rules:

+	,--	Addition

-	,--	Subtraction
*	,--	Multiplication
/	,--	Division (right matrix divide)
^	,--	Power operator

Try the following command
Type

```
>>a = 5;
>>b = 3;
>>c = a+b
```

What is the value of c? Find (a) c1 = a-b, (b) c2 = a*b, (c) c3 = a/b, (d) c4 = a^b.

Q.2.Ans:

a. **2**
b. **15**
c. **1.6667**
d. **125**

Q.3. Case Sensitive

MATLAB is case sensitive. Therefore, "a" and "A" are two different names. For example, the following commands are valid.

```
>>a = 5;
>>A = 3;
>>c = a+A
```

What is the value of c?

Q.3.Ans: 8

Though both are A's, capital and small letter, but still shows the sum 8 because matlab variables are case sensitive

Q.4 Mathematical Expression using variables

A variable can be assigned using an expression in terms of real number. Type:

```
>>x = 3;
>>m = 2;
>>c = 2;
>>y = m*x+c
```

What is the result? Also try and find the results for: (a) y1 = x/m+c; (b) y2 = xm+c;

Q.4.Ans:

a. **3.5**
b. **8**

Complex number

Complex numbers are allowed in all operations and functions in MATLAB with i and j representing the root of unity. ‚ 1 ‚ 1
Try the following command in the command window and drop down the result of z
Type >>z= 2*(1+4*j)
There are a number of predefined functions can be used in the command expression. Two selected functions are quoted here:

abs	,magnitude of a number (absolute value for real numbers)
angle	,"angle of a complex number, in radians"

Q. 5 Try the following command in the command window and find the results

```
>>z= 2*(1+4*j);
>>y=2+8*j;
>> m=abs(z)
>>n=angle(y)
```

What are the values of (a) m and (b) n?

Q.5.Ans:

a. **m = 8.2462**
b. **n = 1.3258**

Vector

Vectors can be defined as follows.
Type >>u = [1 3 5 7];
A 1x4 matrixes (vectors) are defined with elements 1, 3, 5 and 7.
Try the following command.

```
>>u = [1 3 5 7];
>>v = [1;3;5 ;7];
```

What is the difference between vectors u and v? **Ans:**
Try the following command.

```
>>u = [1:7];
>>u1 = [1:1:7];
>>u2 = [1:2:7];
```

What is the difference between vectors u and u1? What happens while determining u2:

Ans:

Vector `u` is a row vector of 1×4 matrix with elements arranged horizontally

Vector `v` is a column vector of 4×1 matrix with elements arranged vertically

Matrix

Matrices can be defined in two ways and elements of the matrix are entered row by row as follows: To define matrices:
M = [1 2 4] [3 6 8]
N = [-4 -2 0 2 4] [-1 0 1 2 3]
Type

```
>>M =[1 2 4; 3 6 8]
>>N =[-4:2:4; -1:3]
```

Matrix element can be accessed by specifying row number and column number using the format: M(row,column)

Q.8 Matlab command can be used to accessed a particular element of a matrix. Try the following command and comment on the results
Type

```
>>M = [1 2 4; 3 6 8]
>>a= M(1,2)
```

What will be the value of a? Also try for (b) M (2,3) and (c) M(3,3) and comment on the results
Q.8.Ans:

a. **M(1, 2) = 8**
b. **M(2, 3) = list index out of range error as matlab start indexing from 0, 0 so there 2nd row index but now 3rd column index so gets error**
c. **M(3, 3) = list index out of range error as matlab start indexing from 0, 0 so there is no 3rd row index but now 3rd column index so gets error**

Q.9 Matlab command can be used to access the whole column or whole row of a matrix. Try the following command and comment on the results.

```
>>M = [1 2 4; 3 6 8]
>>a= M(:,2)
>>b= M(1,:)
```

What will be the values of a and b? comment on the results. **Ans:**

a. 2 6
b. 1 2 4

Matrix Basic matrix operations using Matlab.

Instruction: Use the concept on matrix operations in Matlab tutorial for this Lab.
Representation of Matrix in Matlab: Consider two matrices M and N given below
M =

```
[ 1  2 -2 ]
[ 3 -1  5 ]
[ 2  3  1 ]
```

N =

```
[ 3 -1  2 ]
[ 5  1 -2 ]
[-1  4  1 ]
```

In Matlab, we can represent matrix A in an m-file using the following command M=[1 2 -2;3 -1 5;2 3 1];
Similarly, we can represent matrix B as given below N=[3 -1 2;5 1 -2;-1 4 1]
Table-1: Matrix Operations on M and/or N

Operation	Description	How to apply
+	Addition	M+N
-	Subtraction	M-N
*	Matrix multiplication	M*N
.*	Element-by-Element multiplication	M.*N
/	Matrix division	M/N
./	Element-by-Element multiplication	M./N
det	Determination of a matrix	Det(M)
inv	Inverse of a matrix	inv(M)
‘	Transpose of a matrix	M’
diag	Gives the diagonal of a matrix	diag(M)
rank	Gives the rank of a matrix	Rank(M)

Observation-1 : Apply all the above operations listed in Table-1 for matrices M and N. For the operation on a single matrix, use matrix M. Just observe the results. You don’t need to show the results in your lab report.
Observation-2 : For the matrix M, find

- the first, middle and last elements of the 3rd column.
- the first, middle and last elements of the 2nd row.
- the whole of 3rd column and
- the whole of 2nd row Just observe the results. You don’t need to show the results in your lab report.

Table-2: Additional command to generate typical matrices

Command	Description
A = randn(n)	A is an n×n random matrix having elements with random number.
A = ones(n)	A is an n×n one-matrix having all elements equal to 1.
A = zeros(n)	A is an n×n zero-matrix having all elements equal to 0.
A= eye(n)	"A is an n×n diagonal matrix whose diagonal elements are 1, all other elements are 0."
A = magic(n)	A is an n×n magic matrix whose sum from any angle is the same.

Observation-3 : Implement all of the typical matrices of size 5×5. Just observe the results. You don't need to show the results in your lab report.

Exercise

E1 : Implement the following two matrices A and B in Matlab

A =

```
[ 2   3   5 -1 ]
[-5   2 -1   2 ]
[ 1 -4   7   6 ]
[ 5   2   1 -4 ]
```

B =

```
[ 3   1   2 -1 ]
[-4 -5   5   2 ]
[ 1 -2 -3   3 ]
[ 6   3   1 -4 ]
```

1. Find the 3rd row named r3 of M1 where M1 is obtained by adding A and B. Put r3 below.

   r3 = 2 -6 4 9

2. Find the 5th column named c5 of M2 where M2 is obtained by element-by-element multiplication between A and B. Put c5 below.
   M2 is 4×4, there is no 5th column, getting index error.
3. Find the 4th element in the 2nd column named e42 of M3 where M3 is obtained by matrix multiplication between A and B. Put e42 below.
   e42 = 11
4. Determine the inverse of matrix A and put it below
   invA =

   -0.5208 0.5417 0.3229 0.8854
   -0.3542 0.7083 0.2396 0.8021
   0.4792 -0.4583 -0.1771 -0.6146

-0.7083 0.9167 0.4792 1.104

5. Determine the transpose of matrix B and put it below

B_trans =

```
 3   -4    1    6
 1   -5   -2    3
 2    5   -3    1
-1    2    3   -4
```

6. Determine the rank of the matrix A and put it below

rankA = 4

7. Find the diagonal of matrix B and put it below

diagB =

```
 3
-5
-3
-4
```

E2 : Generate a 5×5 one-matrix named N1, a magic matrix N2, and a diagonal matrix N3. Find a matrix E after dividing N1 by N2, Use element-by element division for this purpose. Now, find a matrix F after performing matrix multiplication between N2 and N3. Now find a matrix G by adding matrices E and F. You don't need to put these results in your report . Now find

1. the determinant d of matrix G and put the result below
2. Find the 2nd element in the 4th row r24 of G and put the result below

d = 4.7375e+06

r24 = 12.0833

E3 : (a) write matlab code to generate a 3×3 random matrix and RUN it. RUN the code again. Are the results obtained from these two run same? Justify your answer

ans =

```
0.0326   1.5442  -0.7423

0.5525   0.0859  -1.0616

1.1006  -1.4916   2.3505
```

ans =

```
-0.6156   0.8886  -1.4224

 0.7481  -0.7648   0.4882
```

-0.1924 -1.4023 -0.1774

No, becuase we created the matrix randomly so we will get difffrent matrix each time.

Matrix in linear algebra

MATLAB offers numerous matrix functions that are used for solving numerical linear algebra problems. Some commonly used functions are quoted here. There are a number of methods to find the solution of a linear set of equations. Gaussian elimination, LU factorization and direct use of A-1 are some common methods. The following example shows how to find the A-1 and solve the equations.

Example:

[1 2 3] [x1] [366] [4 5 6] . [x2] = [804] [7 8 0] [x3] [351]

Q.11 The solution of this set of equation can be found by the matrix left division operator (\ ),

```
>>A=[1 2 3; 4 5 6; 7 8 0];
>>b=[366; 804; 351];
>>x=A\b % The operator ( \ ) means the left division of A into b.
```

What will be the value of x?

Q.11.Ans:

25.0000

22.0000

99.0000

Matlab functions (Scripts)

(G1) if/else

```
if expression
statement(s) to be executed (known as the body of the loop)
end
```

Type the following codes and observe the result.

```
x=2;
if x>0 a=10 else a=15 end
```

Now change the values of x (= -1, 0, 1 etc) and observe the results.

Q.12 Let in digital communication system, a pulse of 10 V is sent for a binary “1” and no pulse (a pulse of 0 V) is sent for binary “0”. The signal is contaminated by noise. The receiver receives a signal as “1” when its input is greater than /equal to a threshold value (say 5) and receives a signal as “0” when its input is less than the threshold value. Write

a matlab code for the operation.

Type the following codes and observe the result.

```
x=7;
if x<0 a=10;
elseif x== 0 a=11;
elseif x>0 & x<5 a=12;
else a=13;
end
a
```

Now change the values of x (= -5, 0, 3, 7 etc) and observe the results.

Q.13: Let in digital communication system, a pulse of 0-5 V is sent for a binary "00"; a pulse of 5- 10 V is sent for a binary "01", a pulse of 10-15 V is sent for a binary "10" and a pulse of 15-20 V is sent for a binary "11" . The receiver receives the signal according to following table.

Received voltage (x)	symbol
x ≤ 5	00
5<x≤ 10	01
10<x≤ 15	10
x>15	11

Write a Matlab code to represent the system.

Code :

```
x = 7;
if x <= 5
   symbol = '00';
elseif x > 5 & x <= 10
   symbol = '01';
elseif x > 10 & x <= 15
   symbol = '10';
else
   symbol = '11';
end
symbol
```

(G2) while & break

Type the following code and observe the result.

```
a = 2;
while (a < 10 )
   a = a + 1
end
```

Type the following code and observe the result

```
b=2
while (b < 10 )
   b = b + 1
   if( b > 6)
      break;
   end
end
```

Q.14: (i) Let x=1. Determine x= x+1 while x≤ 5. (ii) Let x=10. Determine x= x-3 while x>0. (G3) for

Type the following code and observe the result

```
y(1)=3;
y(2)=2*y(1);
y(3)=2*y(2);
y(4)=2*y(3);
y(5)=2*y(4);
y
```

Now, the try the following code

```
y(1)=3;
for i=2:5;
   y(i)=2*y(i-1);
end
Y
```

Observe the result and compare it with the result obtained just now.

****Q.15: Let a =0.1, f(1) =1. Find, f(i)=(1-a)f(i-1) for i = 2 to 5.***

1.0000 0.9000 0.8100 0.7290 0.6561

Matlab Plotting

MATLAB has a powerful set of graphing functions for both 2D and 3D plots. In this section, you will learn how to create a simple 2D graph of two variables.

Commands covered: plot xlabel ylabel title grid axis stem subplot

The most common command for plotting graph is “plot”, which creates linear plots of vectors and matrices. Command “plot(y,x)” plots the vector x on the x-axis and vector y on the y-axis. There are a number of options controlling the style and color of the line. The command specifying the option of the plot is of the form “plot(x,y,'option')”. The „option‟ string can be a combination of the symbols as described in the following table.

TABLE: OPTION

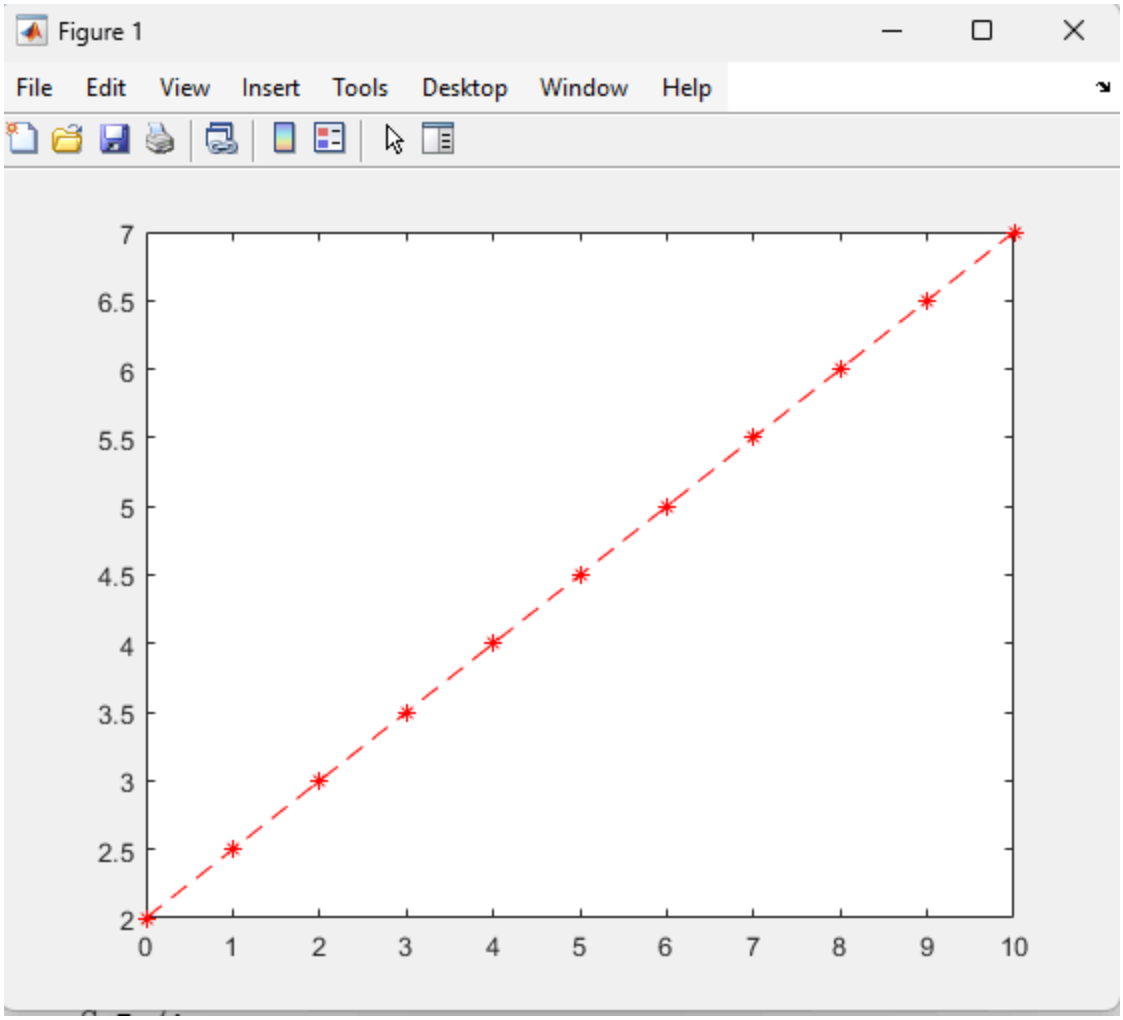
Symbol(L) –LineStyle	Colour	Symbol(C)	Marker	Symbol(M)
-	Solid	Black	k	Circle

Symbol(L) –LineStyle	Colour	Symbol(C)	Marker	Symbol(M)
--	Dashed	Blue	b	Square
-.	Dashdot	Cyan	c	Cross-mark
:	Dotted	Green	g	Plus
		Magenta	m	Star
		Red	r	Dimond
		Yellow	y	

For example, command " plot(x,y,'--') " uses a dashed line to connect points in graph. " plot(x,y,'*') " uses * at all the points defined in x and y without connecting the points while " plot(x,y,'g') " uses a solid green line. A combination of different styles can be used together. For example, " plot(t,y,'g:s')" plots a dotted green line with square-shaped marker. If the "option" string is not specified, the default value is "-". Therefore, the following two commands are equivalent. plot(x , y) = plot(x , y , "-")

Create an m file.Type the following command into the m file and RUN. Observe the plot.

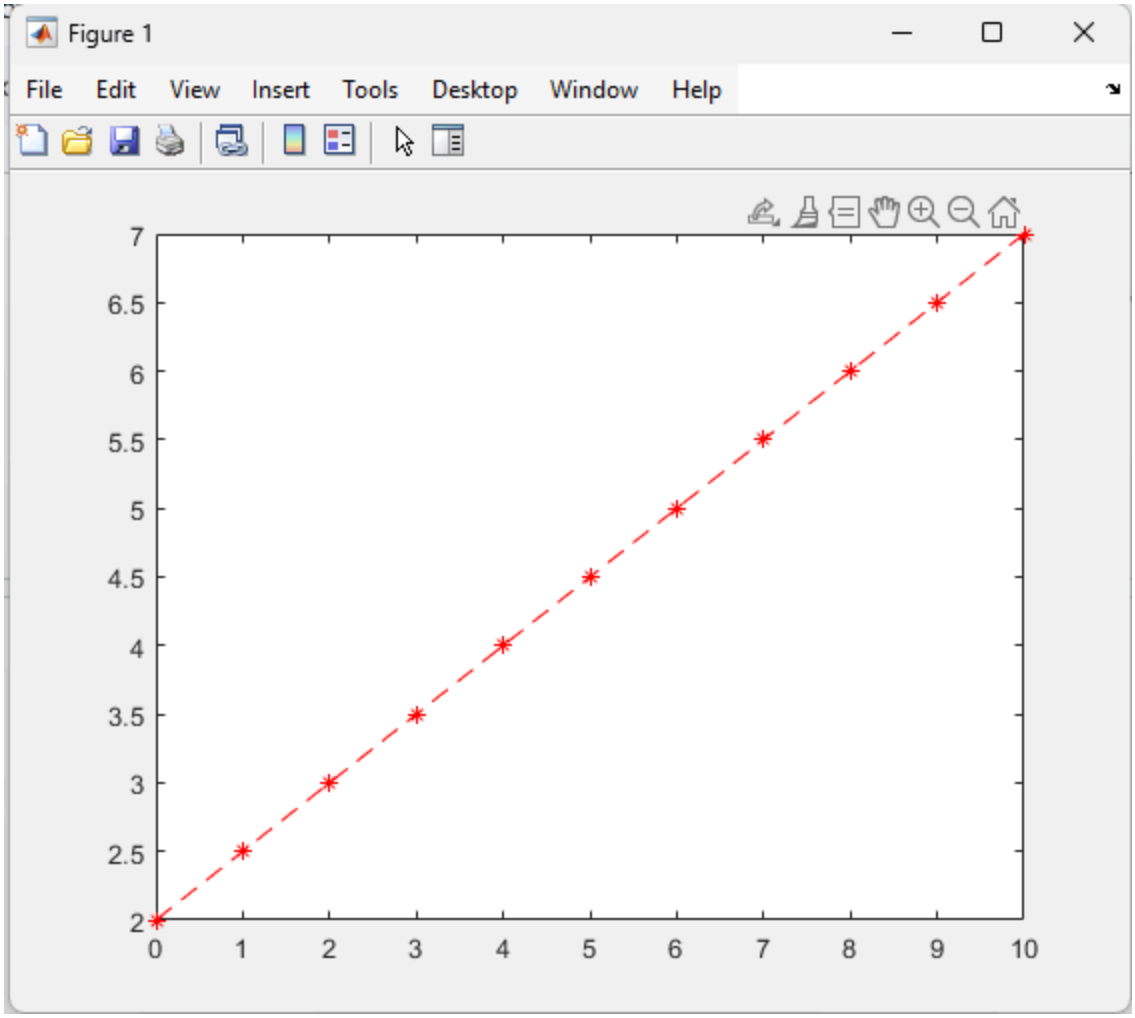
```
x = 0:1:10;
m = 0.5;
c = 2;
y = m*x+c;
figure;
plot(x,y)
```



6: Now modified the last line of the code as follows and RUN

```
x = 0:1:10;
m = 0.5;
c = 2;
y = m*x+c;
figure;
plot(x,y,'LCM')%% Select L, C and M symbol from above Table:OPTION
```

Choosen : plot(x,y,'-.r*')

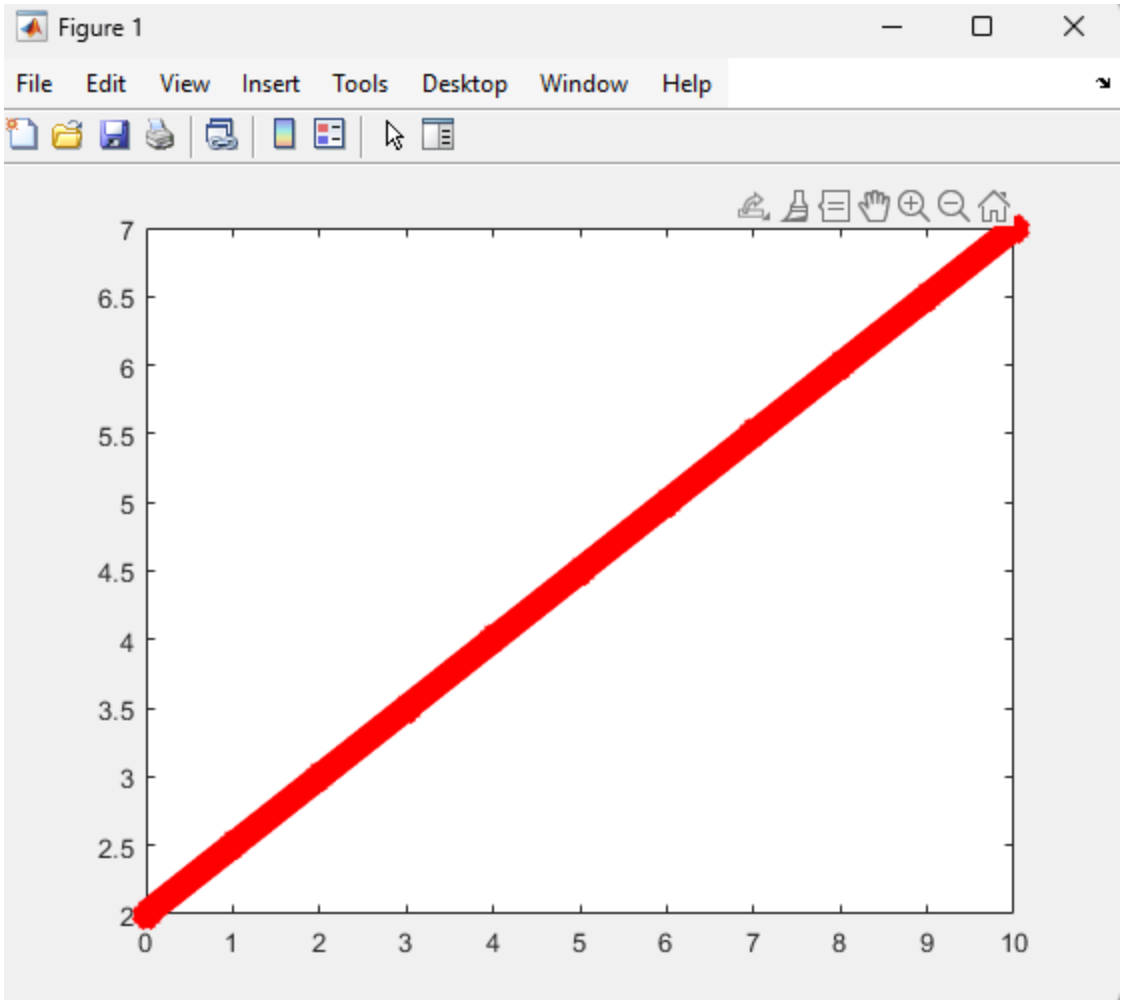


Sometimes we want to vary the linewidth of line. To do so, type the following command into the m file.

```
x = 0:1:10;
m = 0.5;
c = 2;
y = m*x+c;
figure;
plot(x,y,'LCM',’Linewidth’,2) %% Select L, C and M from above
Table:OPTION
```

Paste the figure below.

```
plot(x,y,'-r*','Linewidth',10)
```



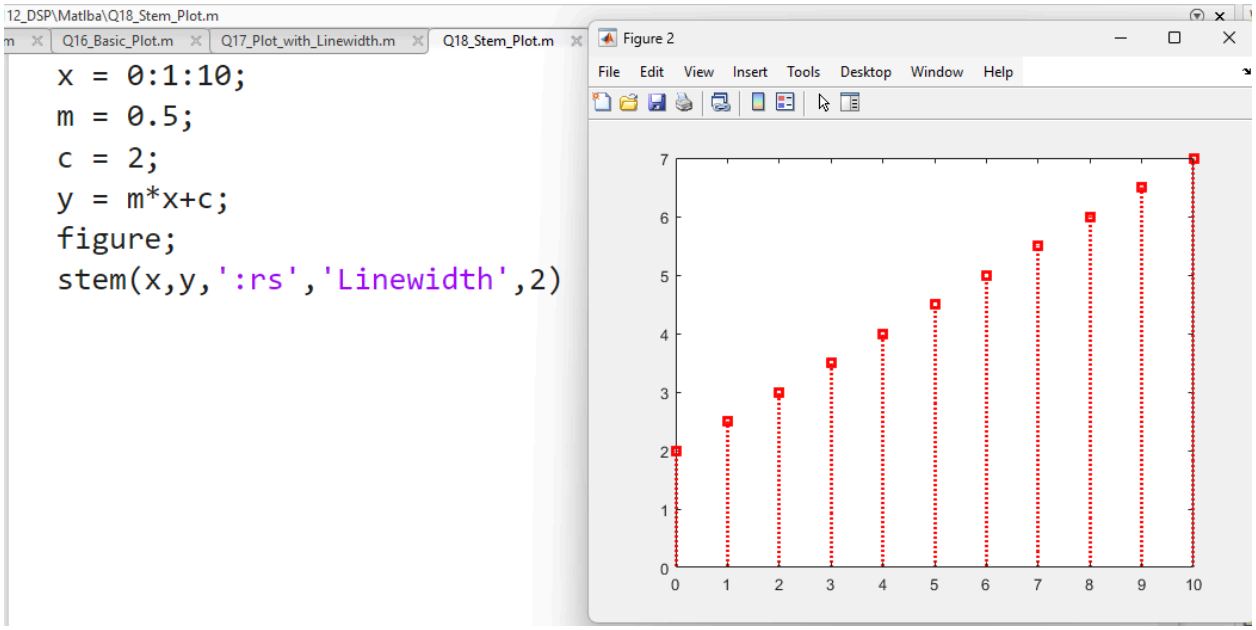
What is the different between this and the plot obtained in Q.16?

In Q16 we just provided **LCM** meaning **Line type, Color and Marker** but now we are also providing linewidth like in this case we provided it 10 and the line looks fat

Sometimes we want to draw discrete sequence data. To do so, type the following command into the m file. What is the different between this and the plot obtained in Q17?

```
x = 0:1:10;
m = 0.5;
c = 2;
y = m*x+c;
figure;
stem(x,y,':rs','Linewidth',2)
```

Paste the graph below and comment on the graph.



Q17 is like bar plot where we can see the line distance from x plane whereas we couldnt see that before

Customized Matlab plot. Add the following extra command into the m file and observe the plot.

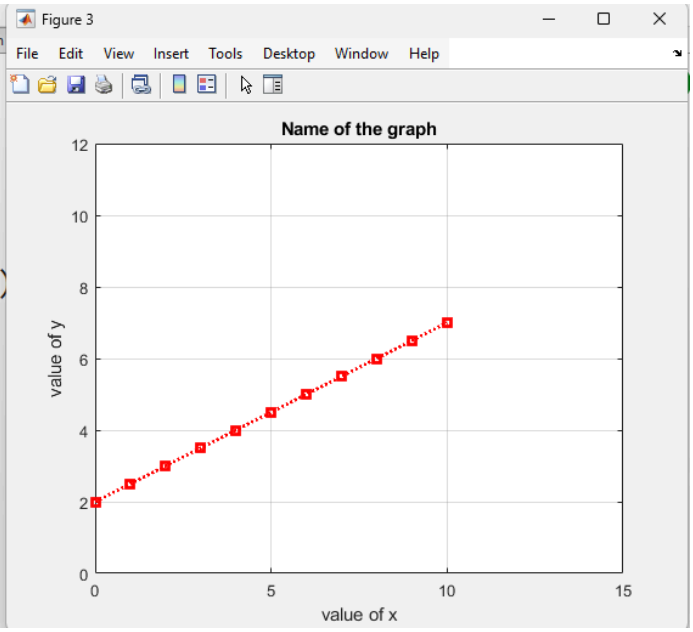
```
x = 0:1:10;
m = 0.5;
c = 2;
y = m*x+c;
figure;
plot(x,y,':RS','Linewidth',2)
title('Name of the graph')
xlabel('value of x')
ylabel('value of y')
xlim([0 15])
ylim([0 12])
grid on
```

Paste the graph below and comment on the graph.

I12_DSP\Matlba\Q19_Customized_Plot.m

m | Q16_Basic_Plot.m | Q17_Plot_with_Linewidth.m | Q18_Stem_Plot.m

```
x = 0:1:10;
m = 0.5;
c = 2;
y = m*x+c;
figure;
plot(x,y,':rs','Linewidth',2)
title('Name of the graph')
xlabel('value of x')
ylabel('value of y')
xlim([0 15])
ylim([0 12])
grid on
```



Plotting more than 1 Figure in 1 plot (hold on & subplot)

Try the following command and observe the figure

```
clc;closeall;clearall;
x1 = 0:1:10;
x2=2:1:12;
m1 = 0.5;
m2 = 0.6;
c1 = 2;
c2 = 3;
y1 = m1*x1+c1;
y2 = m2*x2+c2;
figure;
plot(x1,y1,':rs',x2,y2,':go','Linewidth',2)
title('Name of the graph')
xlabel('value of x')
ylabel('value of y')
xlim([0 15])
ylim([0 12])
grid on
legend('graph of x1','graph of x2')
```

HOLD ON : Try the following command and observe the figure

```
x1 = 0:1:10;
x2=2:1:12;
m1 = 0.5;
m2 = 0.6;
c1 = 2;
c2 = 3;
```

```
y1 = m1*x1+c1;
y2 = m2*x2+c2;
figure;
plot(x1,y1,'-bo','Linewidth',2)

hold on
stem(x2,y2,':rs','Linewidth',2)
title('Name of the graph')
xlabel('value of x')
ylabel('value of y')
xlim([0 15])
ylim([0 12])
grid on
legend('graph of x1','graph of x2')
```

Subplot: Try the following command and observe the plot

```
x1 = 0:1:10;
x2=2:1:12;
m1 = 0.5;
m2 = 0.6;
c1 = 2;
c2 = 3;
y1 = m1*x1+c1;
y2 = m2*x2+c2;
figure;
subplot(1,2,1)
plot(x1,y1,'-rs','Linewidth',2)
grid on
subplot(1,2,2)
stem(x2,y2,':go','Linewidth',2)
title('Name of the graph')
xlabel('value of x')
ylabel('value of y')
xlim([0 15])
ylim([0 12])
grid on
legend('graph of x1','graph of x2')
```

Some special functions in matlab: pi (π), exp (e)

Q 20 :You want to draw four sinewaves for time t = 1 to 0.5 second having same amplitude of 10 unit but different frequencies of F1 =10, F2 =20, F3=30 and F4=40 Hz.

1. Draw the four sine waves separately in four different plots.
2. Draw the four sine waves in a single plot using hold on Matlab function.
3. Draw the four sine waves as subplots of a single plot subplot Matlab function.

Note: A sine wave “x” is given by: $x=2\pi Ft$

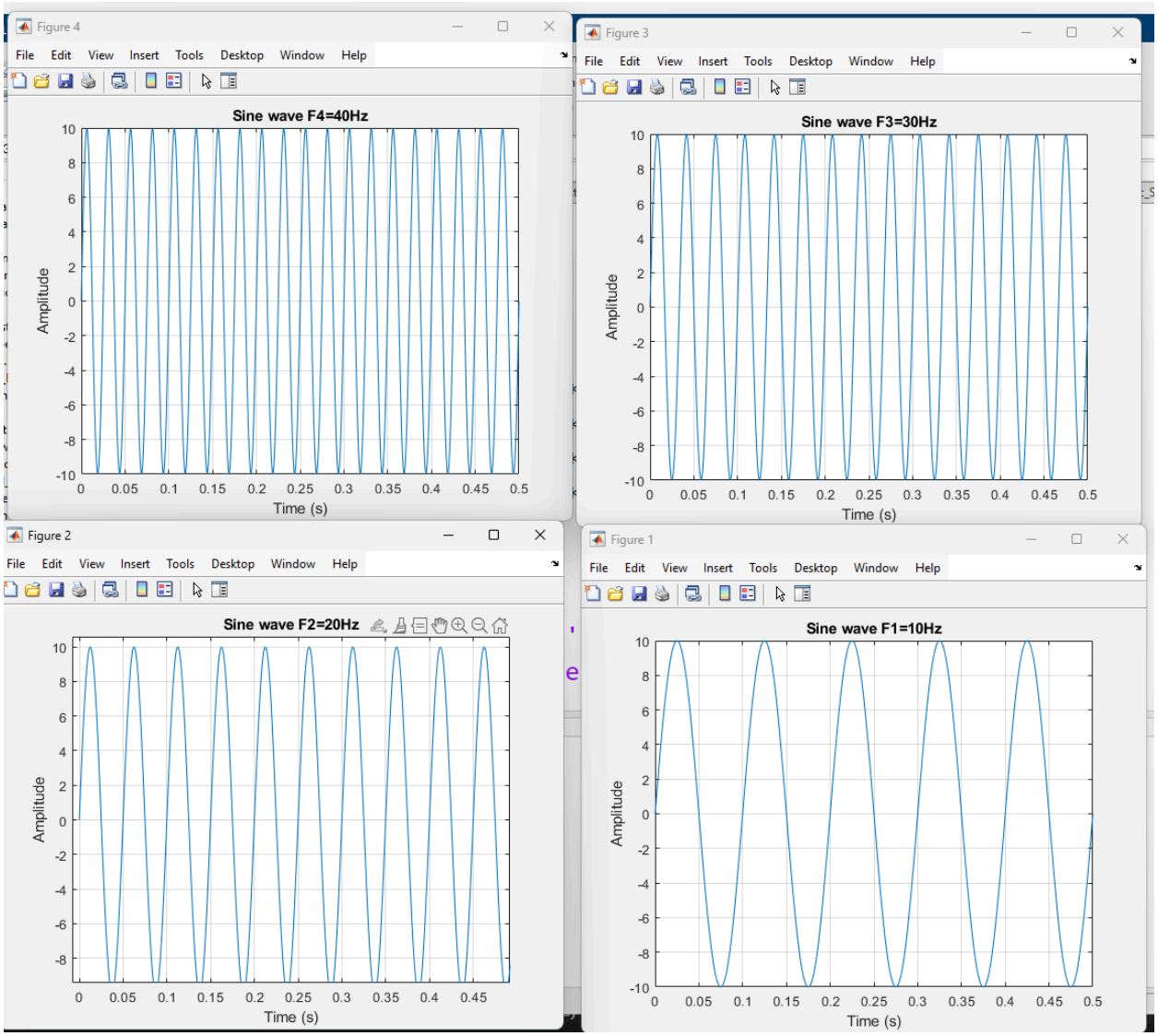
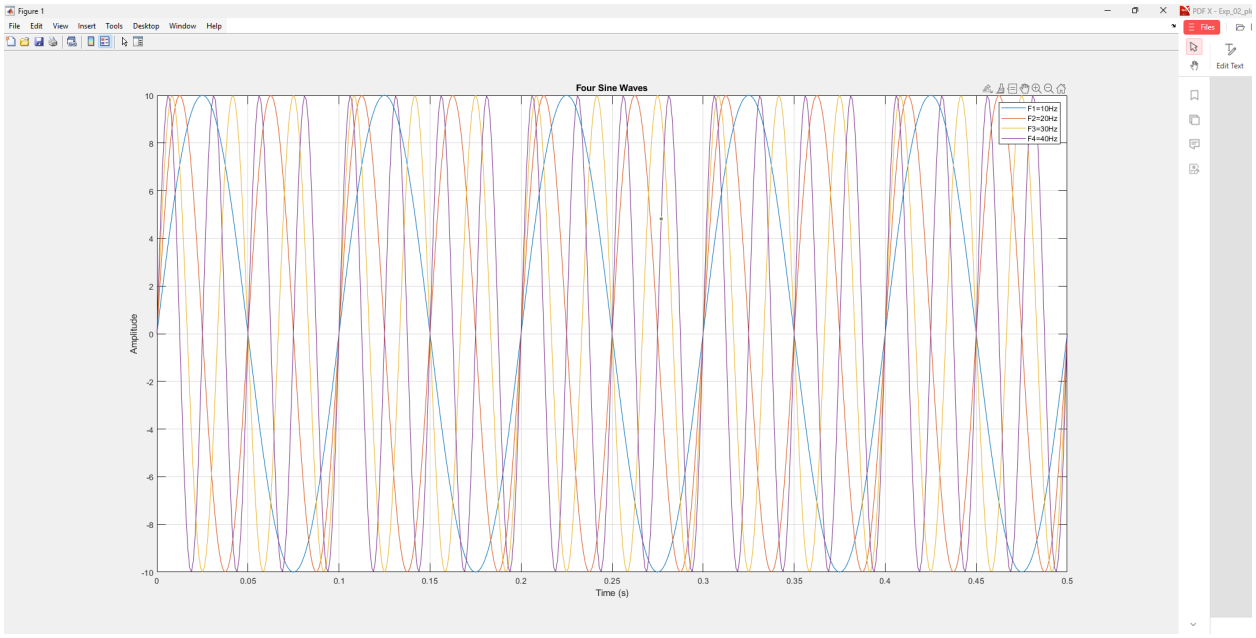
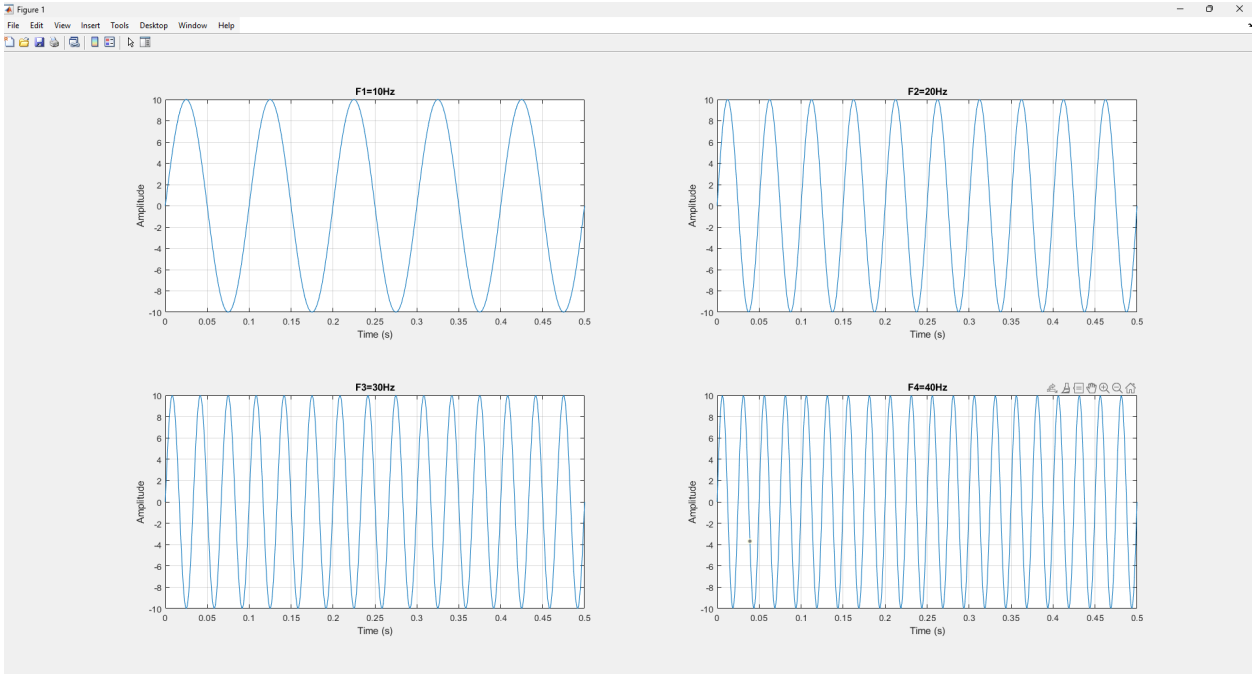


Figure 4
File Edit View Insert Tools Desktop Window Help
Sine wave F4=40Hz
Amplitude
Time (s)
Figure 3
File Edit View Insert Tools Desktop Window Help
Sine wave F3=30Hz
Amplitude
Time (s)
Figure 2
File Edit View Insert Tools Desktop Window Help
Sine wave F2=20Hz
Amplitude
Time (s)
Figure 1
File Edit View Insert Tools Desktop Window Help
Sine wave F1=10Hz
Amplitude
Time (s)





Writing and Reading data from excel file

Writing data to excel file

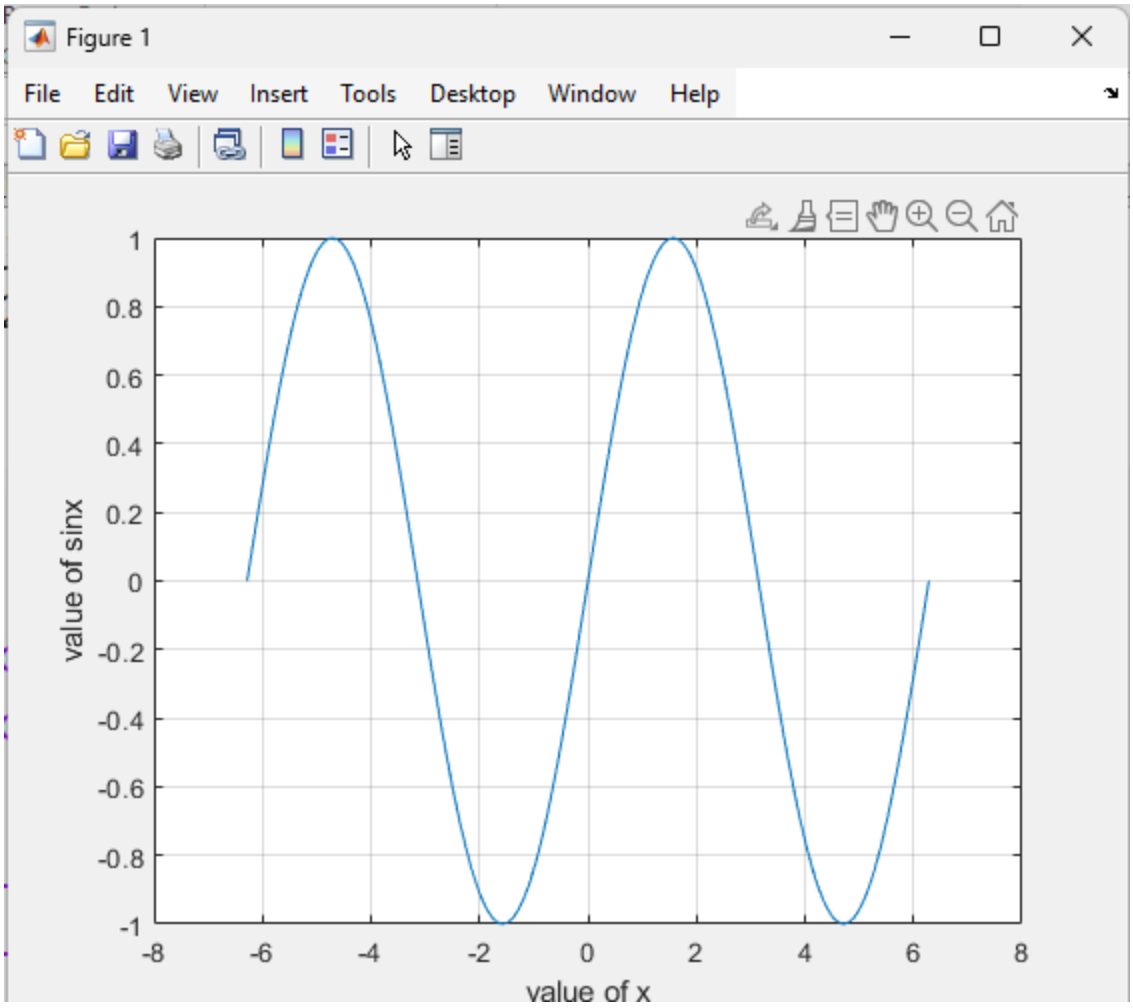
Sometimes we need to write (store) data in excel file. For this we can use " xlswrite" matlab command.

Example-1: Write the following code in a m file

```
clc; close all;clear all;
```

```
x=-2*pi:pi/32:2*pi;
y=sin(x);
x_y=[x;y];
figure;
plot(x,y)
xlabel('value of x')
ylabel('value of sinx')
grid on
xlswrite('x_vs_sinx_column.xlsx',x_y')
xlswrite('x_vs_sinx_row.xlsx',x_y)
```

Questions: What do you obtain after running the above code? Comments on the graph and the written excel files named x_vs_sinx_row and x_vs_sinx_row



- **A sine wave plot showing one complete cycle of sin(x) from -2π to 2π. The graph displays a smooth sinusoidal curve oscillating between -1 and +1, with proper axis labels and grid.**
- **x_vs_sinx_column.xlsx: Contains data in column format where the first column has x values and the second column has corresponding sin(x)**

values. Each row represents a data point.

- **x_vs_sinx_row.xlsx: Contains data in row format where the first row has all x values and the second row has all corresponding sin(x) values. Each column represents a data point.**

Reading data from excel file

We can also read data from an excel file. For this we can use „ xlsread‟matlab command.

Example-2 : Try the following matlab code:

```
clc;close all;clear all;
x_y=xlsread('x_vs_sinx_column.xlsx');
x=x_y(:,1);
y=x_y(:,2);
figure;
plot(x,y)
xlabel('value of x')
ylabel('value of y')
grid on
```

Questions:

1. From where the values of “x‟ are obtained?
2. From where the values of “y‟ are obtained?
3. Is the plot same to that obtained from example-1?

The values of "x" are obtained from the first column of the Excel file 'x_vs_sinx_column.xlsx' using the command x=x_y(:,1).

The values of "y" are obtained from the second column of the Excel file 'x_vs_sinx_column.xlsx' using the command y=x_y(:,2).

Yes, the plot is exactly the same as obtained from th previous one. It shows the same sine wave from -2π to 2π because the data read from the Excel file is identical to the data that was originally written to it in Example-1.

Example-3 : Again try the following matlab code:

```
clc;close all;clear all;
x_y=xlsread('x_vs_sinx_row.xlsx');
x=x_y(1,:);
y=x_y(2,:);
figure;
plot(x,y)
xlabel('value of x')
ylabel('value of y')
grid on
```

Exercise-J: Let x= [-3pi: pi/20:3pi] and y=sin(x)+sin(2x) +sin(3x) +sin(4x).

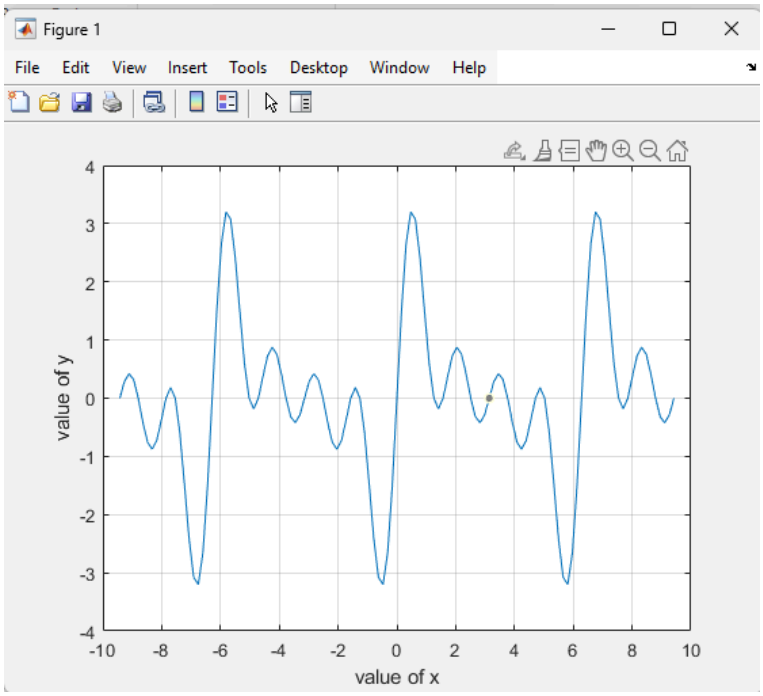
1. Write x and y values in an excel file where x values are in the 1st column and y values are in the 2nd column.
2. Write x and y values in an excel file where x values are in the 1st row and y values are in the 2nd row.
3. Read excel file written in (a), find x and y, and plot x versus y.
4. Read excel file written in (b), find x and y, and plot x versus y.

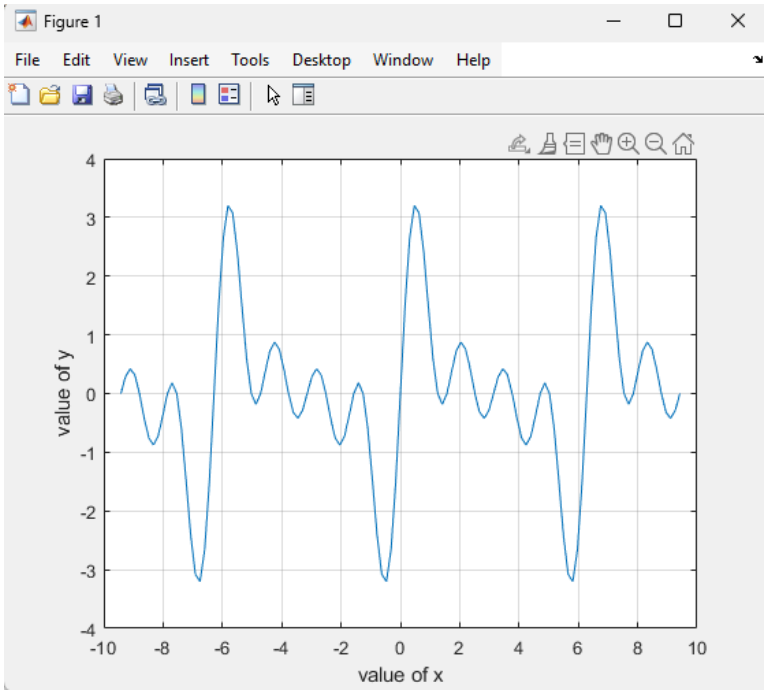
1.

```
clc; close all; clear all;

x = -3*pi:pi/20:3*pi;

y = sin(x)+sin(2*x)+sin(3*x)+sin(4*x);

x_y = [x;y];

xlswrite('exercise_j_column.xlsx',x_y')
```

2.

```
clc; close all; clear all;

x = -3*pi:pi/20:3*pi;

y = sin(x)+sin(2*x)+sin(3*x)+sin(4*x);

x_y = [x;y];

xlswrite('exercise_j_row.xlsx',x_y)
```





Best of Luck !!!!

References

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