Ahsanullah University of Science and Technology

Department of Computer Science and Engineering

Course No: CSE 4228

Course Title: Digital Image Processing Lab

LAB MANUAL – 1

Objective:

The objective of this lab session is to getting familiar with MATLAB. This will cover the following topics –

1) MATLAB workspace, Command Window, Variable panel
2) Working with variables, vectors and function
3) Working with library functions.
4) Getting started with MATLAB plotting tools.

Software: MATLAB (any version higher than 2009a)

Pre-requisite: Vector, Matrix, Linear Algebra, Geometry, C, C++.

References:

[1] https://www.mathworks.com/help/matlab/learn_matlab/desktop.html
[2] https://www.mathworks.com/help/matlab/elementary-math.html
[3] https://www.mathworks.com/help/matlab/learn_matlab/matrices-and-arrays.html
[4] https://www.mathworks.com/help/matlab/functionlist.html?s_cid=doc_ftr
[5] https://www.mathworks.com/help/matlab/2-and-3d-plots.html

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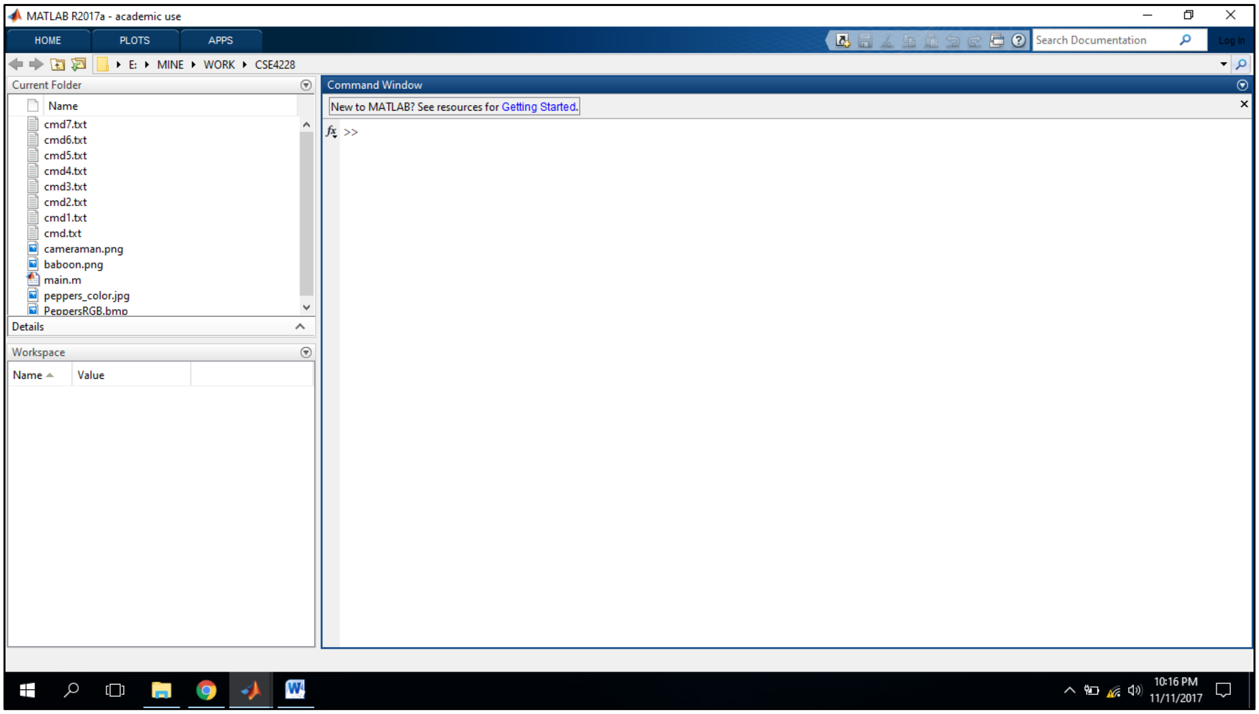


Figure 1

The desktop includes these panels (Figure 1): [1]

- Current Folder — Access your files.
- Command Window — Enter commands at the command line, indicated by the prompt (>>).
- Workspace — Explore data that you create or import from files.

Variables and the workspace:

Let's start with variable.

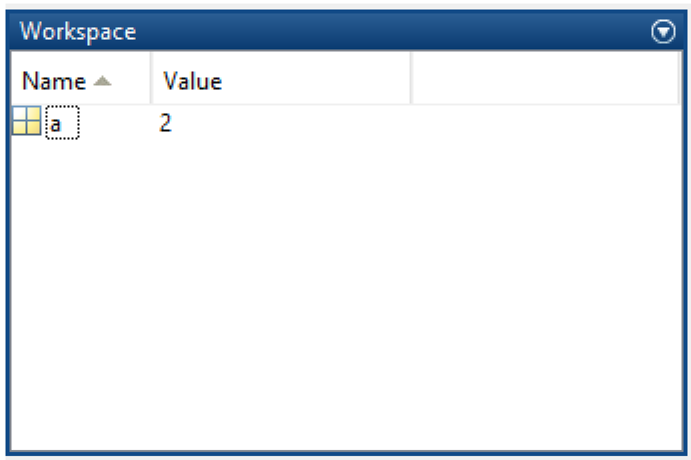
```
a = 2
```

After entering, the immediate next line will display the variable with the assigned value.

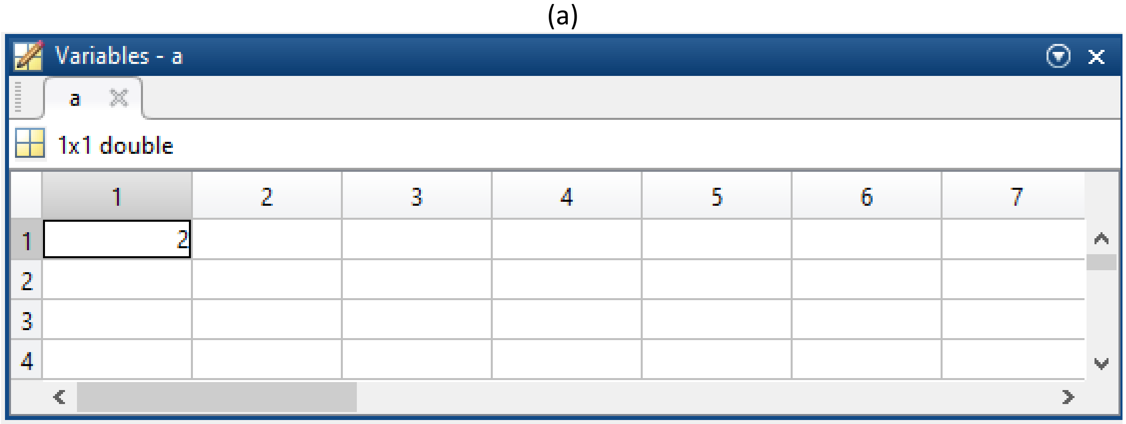
```
a =

     2
```

And you can see that, the variable is appeared in the workplace (Figure 2 a). If you double click on that variable icon, a panel named 'Variables' will popup (Figure 2 b).

MATLAB stores everything as matrix. You can note the indication of `1 x 1 double` in the variable panel. It mean `a` is a 1 by 1 matrix (eventually a matrix with only one element), which is `double` type. By default any numerical data is double type. There are other data types as well such as `uint8` (unsigned integer 8 bit), `char` (character), `logical` (boolean).



(a)



(b)

Figure 2

Note that, throughout this manual, to make it more readable, we will highlight the commands, and the prompted output will not be highlighted. For example, the following is a command.

```
b = 3
```

And the following is the immediate prompt.

```
b =

     3
```

Let's start with type casting.

```
a = 1

a =

      1

d = logical(a)

d =

   1
```

You can see that, `d` will be stored as `1 x 1 logical` variable in the workspace.

Now, Let's work more with variables and arithmetic operations. Let's play with some simple arithmetic operations. Assume that we have already have `a` and `b` in our workspace.

```
a + b

ans =

      5
```

Observe that, `ans` is a default variable that stores the result of `a + b`, and it is stored in workspace. If you simply use `ans` as a command, the value inside `ans` will be prompted.

```
ans

ans =

      5
```

But, we can store the result in a different variable as well.

```
c = a + b

c =

      5

c = a * b

c =

      6

c = b^3 % power of 3
```

```
c =

    27
```

You can observe that, % is used for commenting in MATLAB.
There are some special variables.

```
pi

ans =

    3.1416

c = a*pi

c =

    6.2832
```

Some library functions:

Some useful library functions for trigonometric operations are shown below.

```
c = cos(30) % take radian as  input

c =

    0.1543

c = cos(2*pi)

c =

     1

c = cosd(30) % take degree as input

c =

    0.8660

acosd(c) % inverse cosine (in degree)

ans =

   30.0000
```

You can also try `sin()`, `tan()` etc.

Some other important functions are provided below.

```
c = mod(10,3) % remainder

c =

     1

c = exp(2) % exponential

c =

    7.3891

d = ceil(c) % ceiling (there is floor() and round() as well)

d =

     8

c = log(10) %natural logarithm

c =

    2.3026

c = log10(10) % 10 base logarithm

c =

     1
```

There is a huge collection of functions dedicated for elementary math. You can find them here [1].

Let's see some other useful command.

- `pwd` : to print the current directory
- `clc` : to clean command prompt history
- `clear` : to delete all the variables from the workspace. You can delete a particular variable from the workspace by the clear command followed by the variable name. For example,

  ```
  clear c
  ```

Using / not using semicolon:

Semicolons (`;`) can be used after each command. If used, the output prompt will be suppressed. For example, if you use the following command without a semicolon at the end, the output will be prompted.

```
d = cos(pi)

d =

    -1
```

But, if you use the following command with a semicolon at the end, the output will not be prompted.

```
d = cos(pi);
```

Working with vector and matrix:

Defining a row vector –

```
v = [1, 2, 3, 4]

v =

     1     2     3     4
```

You can also omit the commas (`,`) in between the elements. This will give you the same vector.

```
v = [1 2 3 4]

v =

     1     2     3     4
```

We are going to follow this approach throughout this manual.

Now, Defining a column vector –

```
v = [1; 2; 3; 4]

v =

     1
     2
     3
     4
```

Having the idea of row and column vector, now we can easily define a matrix –

```
M = [1 2 3 4; 5 6 7 8; 9 1 2 3]

M =

     1     2     3     4
     5     6     7     8
     9     1     2     3
```

In MATLAB, the matrix element indices start from the top left corner. As we traverse right, we go through each column. And as we traverse down, we go through each row.

```
                1st column         4th column
                    |                   |
                    v                   v
      1st row -> 1     2     3     4
                 5     6     7     8
      3rd row -> 9     1     2     3
```

Accessing elements of a matrix:

Now let's see how to access elements from a matrix. To access we use the following format of the command: `Matrix (which_row, which_column)`. For example, Let's assume that we have matrix M in our workspace.

```
m = M(1,1) % accessing 1st row, 1st column from M

m =

     1

m = M(2,3) % accessing 2nd row, 3rd column from M

m =

     7
```

You can use `end` to access the last element in a row or column.

```
M(1, end) % 1st row, last column

ans =

     4
```

```
M(end, end) % last row, last column

ans =

     3
```

Assigning elements of a matrix:

```
M(2,2) = 99

M =

     1     2     3     4
     5    99     7     8
     9     1     2     3
```

Some library functions to generate matrix:

`eye(m)` : Generating an identity matrix, For example, for m = 5

```
I = eye(5) % identity matrix of 5 x 5

I =

     1     0     0     0     0
     0     1     0     0     0
     0     0     1     0     0
     0     0     0     1     0
     0     0     0     0     1
```

`ones(m)` : Generating a matrix that contains only 1 (one). For example, m = 5

```
I = ones(5)

I =

     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
```

You can also generate matrix rather than square shape. You can use `ones(m,n)` to define rows and columns. For example,

```
I = ones(3,5) % 3 rows and 4 columns

I =

     1     1     1     1     1
     1     1     1     1     1
     1     1     1     1     1
```

Similarly,

```
I = zeros(3,5)

I =

     0     0     0     0     0
     0     0     0     0     0
     0     0     0     0     0


I = rand(3,5)

I =

    0.8147    0.9134    0.2785    0.9649    0.9572
    0.9058    0.6324    0.5469    0.1576    0.4854
    0.1270    0.0975    0.9575    0.9706    0.8003


I = ceil(rand(3,2))

I =

     1     1
     1     1
     1     1
```

Let's apply matrix operations of two matrices `A` and `B`.

```
A = [1 2 3; 4 5 6; 7 8 9]

A =

     1     2     3
     4     5     6
     7     8     9



B = [9 8 7; 6 5 4; 3 2 1]
```

```
B =

     9     8     7
     6     5     4
     3     2     1

C = A + B

C =

    10    10    10
    10    10    10
    10    10    10

C = A - B

C =

    -8    -6    -4
    -2     0     2
     4     6     8

C = A * B

C =

    30    24    18
    84    69    54
   138   114    90

C = 2*A

C =

     2     4     6
     8    10    12
    14    16    18

C = A^2

C =

    30    36    42
    66    81    96
   102   126   150
```

Q.1: Now, can you generate a matrix with random numbers greater than or equal to 1 using one single line of command?

We can apply element wise operations. To perform that, we need to put a dot(.) in front of the operator. For example, the following command will do element wise multiplication, that means 1st element of A will be multiplied with the 1st element of B, 2nd of A will be multiplied with 2nd element of B, and so on.

```
C = A .* B

C =

     9    16    21
    24    25    24
    21    16     9
```

Q.2: Now, can you square every element of the matrix A using one single line of command?

Q.3: Also, can you square each elements of both A and B, add the squared elements of A with the squared elements B and store them in the matrix C? (Again, using one single line of command)

Using colon operator:

Let's take the matrix A in previous examples.

```
A = [1 2 3; 4 5 6; 7 8 9]

A =

     1     2     3
     4     5     6
     7     8     9
```

Say, we want to access all the columns at 1st row, that is `1, 2` and `3`

```
c1 = A(1,:)

c1 =

     1     2     3
```

Moreover,

```
c1 = A(2,:) % 2nd row, all columns

c1 =

     4     5     6
```

Similarly, to get all rows at 3rd columns -

```
r1 = A(:,3)

r1 =

     3
     6
     9
```

We can use colon operator to convert a matrix into a column vector.

```
v = A(:)

v =

     1
     4
     7
     2
     5
     8
     3
     6
     9
```

Colon operator is very useful to access a range of elements from a matrix. To give an example, let's take a bigger matrix.

```
R = floor(rand(7)*10)

R =

     1     5     0     4     1     0     0
     2     9     0     0     6     2     4
     6     2     5     3     2     9     1
     4     7     7     1     6     1     9
     3     7     9     7     6     8     0
     8     3     1     3     7     5     7
     5     5     5     5     4     9     8
```

Say, we want to access 2nd row to 5th row of 1st column.

```
s = R(2:5, 1)

s =

     2
     6
     4
     3
```

Similarly,

```
s = R(1, 2:5) % column 2 to 5 of row 1

s =

     5     0     4     1
```

We can crop a region using the same concept. For example, row 2 to 5 and column 3 to 6.

```
S = R(2:5, 3:6)

S =

     0     0     6     2
     5     3     2     9
     7     1     6     1
     9     7     6     8
```

For better understanding, the elements of `S` accessed from `R` are gray-shaded below.

```
     1     5     0     4     1     0     0
     2     9     0     0     6     2     4
     6     2     5     3     2     9     1
     4     7     7     1     6     1     9
     3     7     9     7     6     8     0
     8     3     1     3     7     5     7
     5     5     5     5     4     9     8
```

We can assign as well.

```
R(2:5, 3:6) = 99

R =

     1     5     0     4     1     0     0
     2     9    99    99    99    99     4
     6     2    99    99    99    99     1
     4     7    99    99    99    99     9
     3     7    99    99    99    99     0
     8     3     1     3     7     5     7
     5     5     5     5     4     9     8
```

The colon operator is useful to generate a range of values. Say, we want to create a vector named `data` with values from 1 to 10.

```
data = 1:10
```

```
data =

     1     2     3     4     5     6     7     8     9    10
```

```
data = 1:2:10 % increment by 2 steps

data =

     1     3     5     7     9
```

Q.4: Can you generate a vector containing 10 values stating from pi to 2*pi with equal steps in between?

Some library function for matrix/ vector:

Transpose of Vector:

```
t = transpose(data)

t =

     1
     3
     5
     7
     9
```

Same thing can be done using a single quote (‘) operator.

```
t = data'

t =

     1
     3
     5
     7
     9
```

Sorting a vector:

```
t = sort(data)
```

```
t =

     1     3     5     7     9
```

Many MATLAB functions can be overloaded.

```
t = sort(data, 'descend')
t =

     9     7     5     3     1
```

Sum of all the elements of a vector:

```
k = sum(data)

k =

    25
```

Mean, median:

```
k = mean(data)

k =

    4.1429

k = median(data)

k =

     4
```

Transpose of Matrixr:

```
R = floor(rand(5)*10)

R =

     2     2     3     5     7
     6     7     4     3     0
     6     2     6     4     6
     1     8     8     7     4
     4     8     6     8     4


r = R'
```

```
r =

     2     6     6     1     4
     2     7     2     8     8
     3     4     6     8     6
     5     3     4     7     8
     7     0     6     4     4
```

Sorting a Matrix:

```
R = floor(rand(5)*10)

R =

     8     4     1     8     0
     0     9     8     6     2
     3     1     5     3     1
     2     2     5     5     1
     8     1     1     4     2
```

By default, MATLAB sorts row-wise. That means it treats every column as an individual vector and sort them.

```
s = sort(R)

s =

     0     1     1     3     0
     2     1     1     4     1
     3     2     5     5     1
     8     4     5     6     2
     8     9     8     8     2
```

However, if you want to perform colum-wise, just pass 2 as parameter.

```
s = sort(R,2)

s =

     0     1     4     8     8
     0     2     6     8     9
     1     1     3     3     5
     1     2     2     5     5
     1     1     2     4     8
```

This concept works for other functions as well.

Sum of Matrix:

```
k = sum(R) % row-wise

k =

    21    17    20    26     6

k = sum(R,2) % column-wise

k =

    21
    25
    13
    15
    16


k = sum(R(:)) %sum of all the values.

k =

    90
```

Mean of Matrix:

```
k = mean(R) % row-wise

k =

    4.2000    3.4000    4.0000    5.2000    1.2000

k = mean(R,2) % column-wise

k =

    4.2000
    5.0000
    2.6000
    3.0000
    3.2000

k = mean(R(:))% mean of all

k =

    3.6000
```

More functions can be found here [4].

Plotting:

Assume that, we want to plot five 2-D points. The `(x, y)` coordinates are `(-5, -2)`, `(6, 4)`, `(8, -3)`, `(9, 5)` and `(-1, 1)`. Now, let's store this coordinate data in two vectors X and Y, where X contains all x-coordinates and Y contains all the y-coordinates.

```
X = [-5 6 8 9 -1];

Y = [-2 4 -3 5 1];
```

To plot them, we can simply call the `plot()` function.

```
Plot(X,Y,'*')
```

A window will pop up (Figure 3) showing the axis and the plotted points. Points will be plotted with `(*)` as we pass this as the third parameter. These are called markers. You can use `'.'`, `'O'`, `'o'`, `'X'`, `'x'` etc. as markers.

Note that, MATLAB plotting axis system follows the conventional Cartesian coordinates (Figure 4).

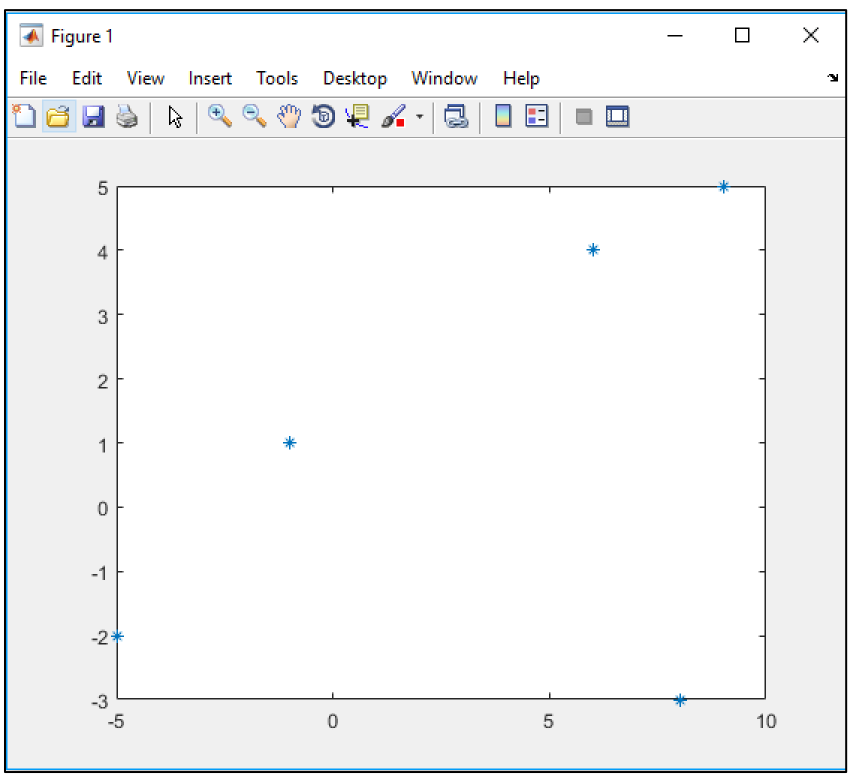


Figure 3

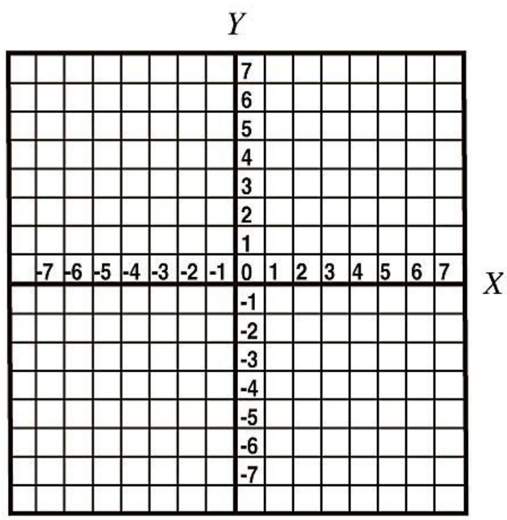


Figure 4

Let's plot $y = x^3$ equation. We define 50 points for x. Then obtain the y from $y = x^3$ equation (Figure 5).

```
x = 1:50;
y = x.^3;
plot(x,y,'.')
```

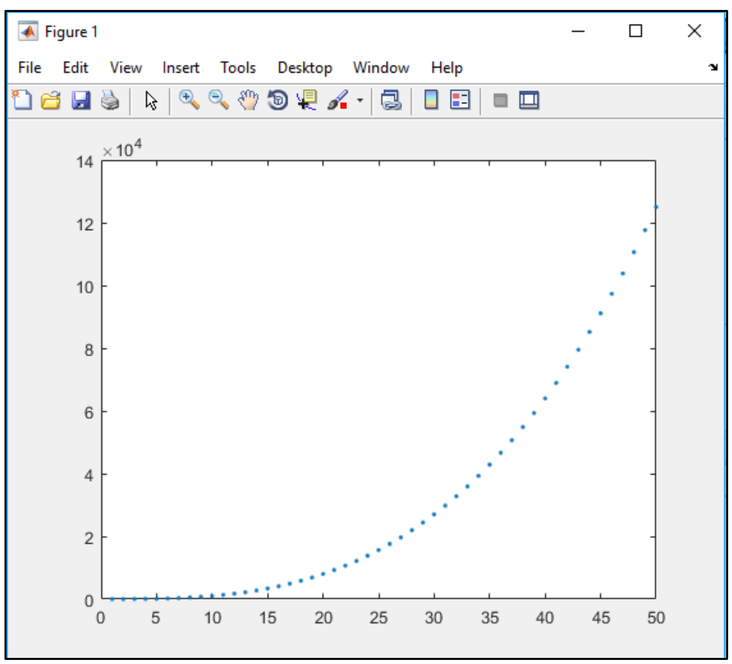


Figure 5

We can connect the points by passing different parameter.

```
plot(x,y,'.-')
```

A hyphen after the dot means to connect the dots with a continuous line (Figure 6).

You can also change the colors of the markers.

```
plot(x,y,'.-r') % r stands for red.
```

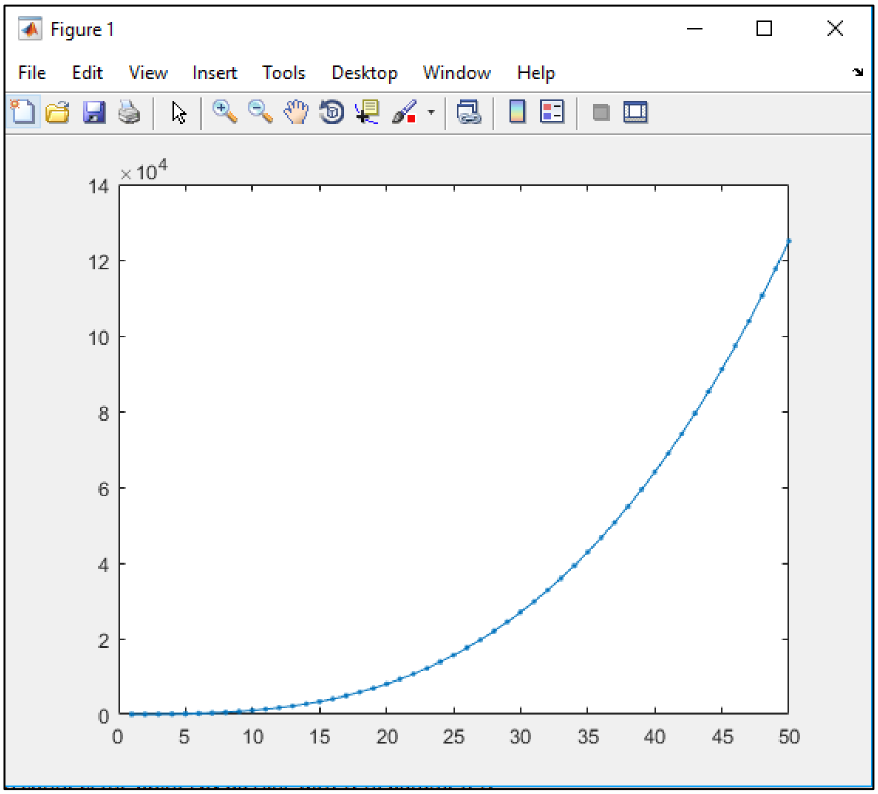


Figure 6

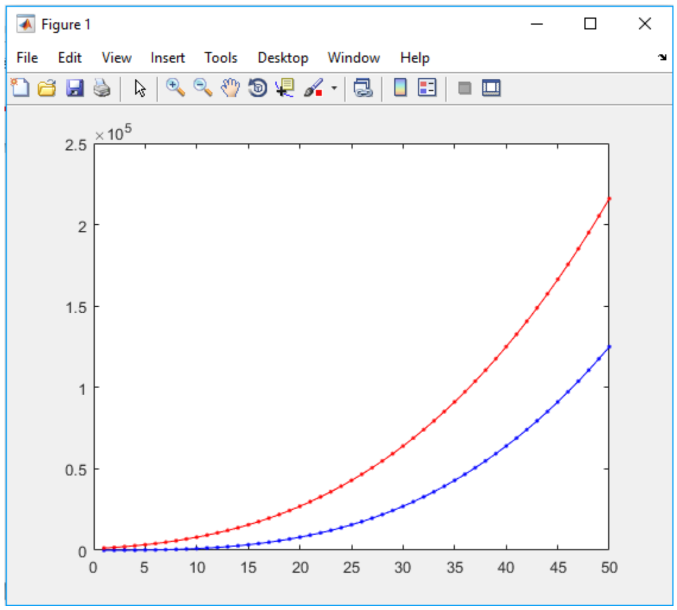
MATLAB allows you to redraw on a current figure. Say, we want to plot `y = (x+10)`^{3} along with the `y = x`^{3}. That means you want to plot on top each other. In that case, we use `hold on` command to let the figure window wait for next plotting.

```
x = 1:50;

y = x.^3;

plot(x,y,'.-b');  % plotting the first equation

hold on; % holding the figure to wait.
```

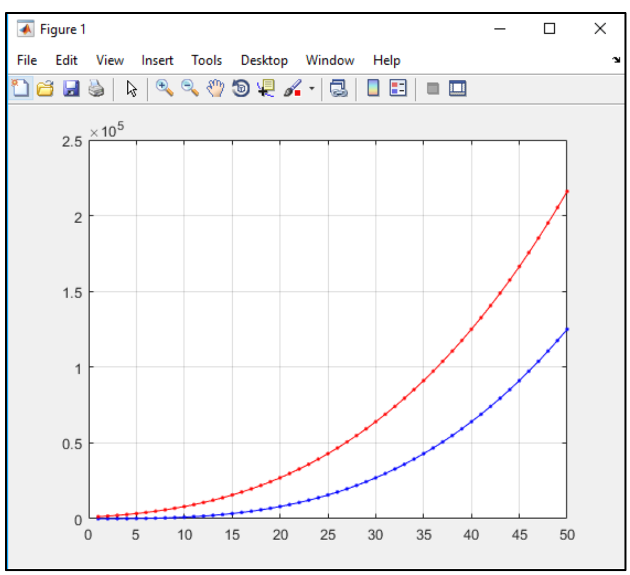
```
y = (x+10).^3; % deriving the y for the second equation

plot(x,y,'.-r'); % plotting the first equation

hold off; % do not wait any more
```

See output in figure 7a. You can introduce grid lines on the current figure (Figure 7b). To do this, keep the current figure opened and enter the command –

```
grid on;
```



(a)



(b)

Figure 7

Also, you can have multiple figures for multiple plotting. Say, we want the previous two equations to be plotted in two different figure windows. In that case, enter `figure` command to open a new figure (Figure 8).

```
x = 1:50;
y = x.^3;
figure; % new window
plot(x,y,'.-b');
y = (x+10).^3;
figure; % new window
plot(x,y,'.-r');
```

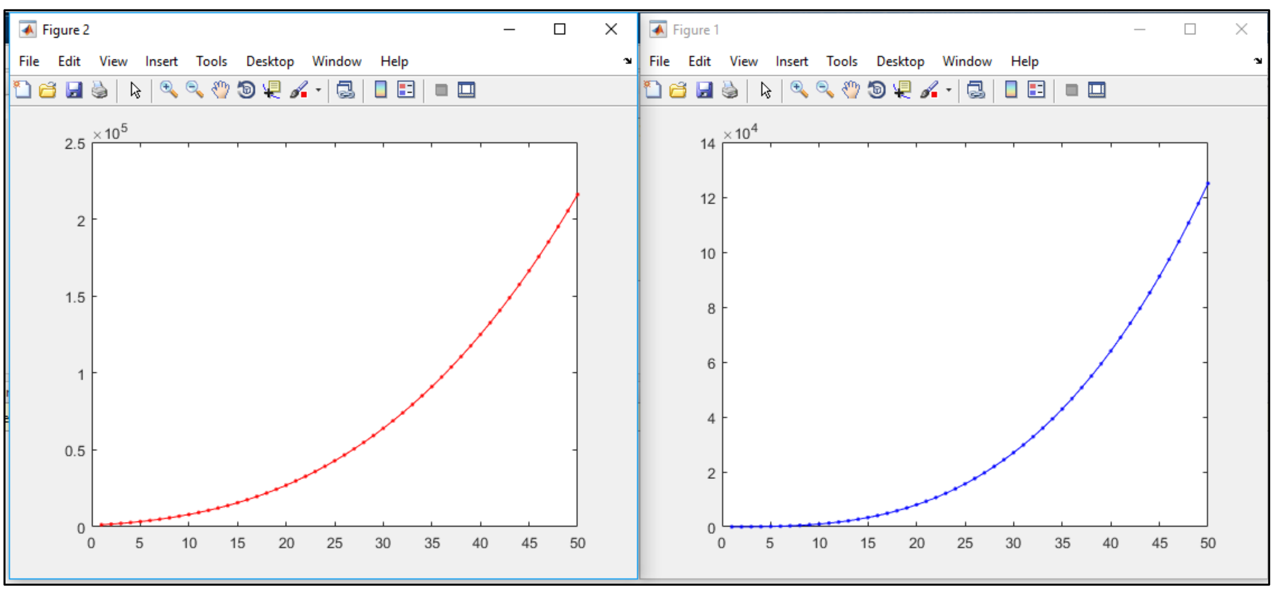


Figure 8

Another useful plotting function is `bar()`. For example,

```
bar(x, y)
```

Figure 9 shows the output.

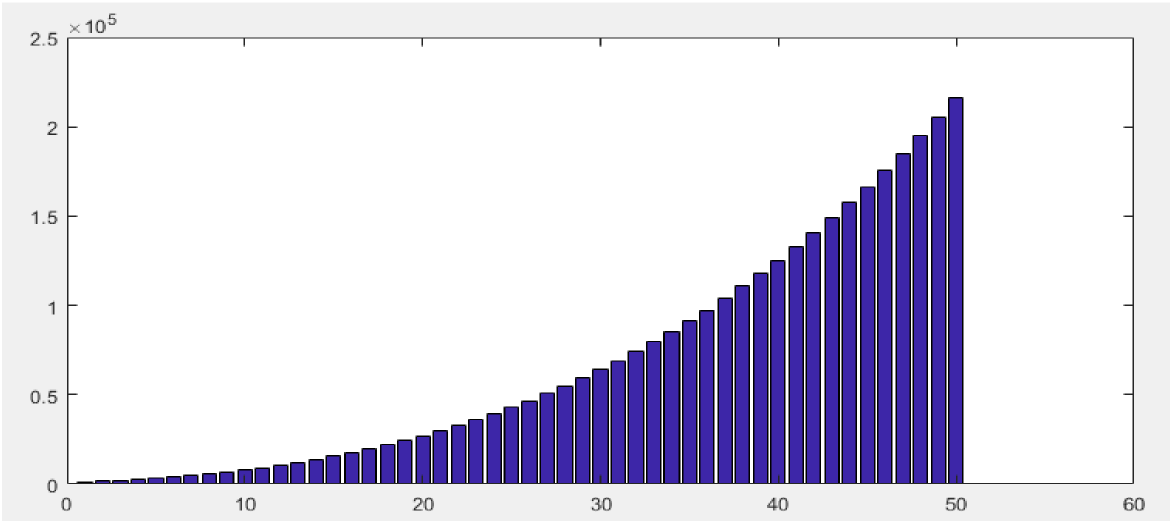


Figure 9

More about MATLAB plotting is available here [5].

[END]

Prepared by-

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