Introduction to MATLAB

MATLAB(Matrix Laboratory) is a proprietary multi paradigm programming language and numeric computing environment invented by Mathematician and computer programmer Cleve Moler in 1970 and developed by MathWorks Company.

MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.

Primarily MATLAB is a powerful and most popular mathematical software which takes ~18GB memory and this software runs on both Windows and Mac operating system. This software is useful in Signal processing, Deep Learning, Image Processing, Machine Learning, Structural Analysis, Electric Vehicles Design and so forth used by Electrical, Mechanical, Civil, Computer Engineers, other research and much more.

To be specific we are now going to use this sophisticated app for our upcoming laboratory assignments.

Matrix Introduction

Discovered by Arthur Cayley(1860) A 2D array of number(real and complex) arranged vertically(columns) and horizontally(rows) enclosed between round or square brackets is called matrix. A matrix is assigned to any alphabets for identification.

Matrix are identified by numbers of it's rows and columns (i.e (rows)*(columns)) example: 4 × 4 (pronounced as four by four matrix) matrix has 4 rows and 4 columns.

Example: $A = \begin{bmatrix} 4 & 1 & 2 & 4 \\ 2 & 4 & 4 & 1 \\ 1 & 4 & 4 & 2 \\ 4 & 2 & 1 & 4 \end{bmatrix}$, $B = \begin{bmatrix} 4 & 4 \\ 4 & 4 \end{bmatrix}$

Row Matrix: Matrix having only one row and single column is called row matrix Example: $A = \begin{bmatrix} 1 & 2 & 3 \end{bmatrix}$

Column Matrix: Matrix having one column and single rows is called column matrix Example: $A = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$

Applications: Primarily used in field of sociology, economics, engineering, physical sciences, statistics computer graphics and so on.

Lab-1 (Matrix Arithmetics)

Addition of Matrices: Two matrices only with same order can be added together. example: $\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ + $\begin{bmatrix} 3 & 2 \\ 1 & 0 \end{bmatrix}$ = $\begin{bmatrix} 4 & 4 \\ 4 & 4 \end{bmatrix}$

Subtraction of Matrices: Two matrices only with same order can be subtracted together. example: $\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$ - $\begin{bmatrix} 3 & 2 \\ 1 & 0 \end{bmatrix}$ = $\begin{bmatrix} -2 & 0 \\ 2 & 4 \end{bmatrix}$

Qn.1 If $A = \begin{bmatrix} 4 & 0 & 4 \\ 2 & 4 & 8 \\ 4 & 6 & 4 \end{bmatrix}$ and $B = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$ using matlab find

I) A+B ii) A-B

i) A+B

Solution: codes in MATLAB

```
>>A=[4,0,4;2,4,8;4,6,4]

A= 4   0   4
   2   4   8
   4   6   4

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

B= 1   2   3
   4   5   6
   7   8   9

>>A+B

 Ans= 5   2   7
      6   9   14
      11  14  13
```

ii) A-B

Solution: codes in MATLAB

```
>>A=[4,0,4;2,4,8;4,6,4]

A= 4   0   4
   2   4   8
   4   6   4

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

B= 1   2   3
   4   5   6
   7   8   9

>>A-B

Ans= 3  -2   1
    -2  -1   2
    -3  -2   5
```

Matrix Multiplication: Matrix multiplication is only possible if column of first matrix and row of second matrix are equal and performed as row of first matrix times column of second matrix. Example: $\begin{bmatrix}1 & 3 & 5\\5 & 3 & 1\\1 & 5 & 3\end{bmatrix}$ * $\begin{bmatrix}2 & 4 & 6\\4 & 2 & 6\\6 & 4 & 2\end{bmatrix}$ = $\begin{bmatrix}44 & 30 & 33\\28 & 30 & 50\\40 & 26 & 42\end{bmatrix}$

Qn.2 If $A = \begin{bmatrix}1 & 3 & 5\\5 & 3 & 1\\1 & 5 & 3\end{bmatrix}$and $B = \begin{bmatrix}2 & 4 & 6\\4 & 2 & 6\\6 & 4 & 2\end{bmatrix}$ using matlab find A*B

Solution: codes in MATLAB:

```
>>A=[1,3,5;5,3,1;1,5,3]

A= 1   3   5
```

5 3 1
1 5 3

```
>>B=[2,4,6;4,2,6;6,4,2]

B= 2   4   6
   4   2   6
   6   4   2

>>A*B

Ans= 44    30    33
     28    30    50
     40    26    42
```

Lab-2 (Determinants of matrices)

The determinant is a scalar value that is a function of the entries of a square matrix. It allows characterizing some properties of the matrix and the linear map represented by the matrix.

For 2x2 matrix

$\begin{vmatrix} a11 & a12 \\ a21 & a22 \end{vmatrix}$ = $(a_{11}*a_{22})-(a_{21}*a_{12})$

For 3x3 matrix

$\begin{vmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{vmatrix} = a_{11}\begin{vmatrix} a22 & a23 \\ a32 & a33 \end{vmatrix} - a_{12}\begin{vmatrix} a21 & a23 \\ a31 & a33 \end{vmatrix} + a_{13}\begin{vmatrix} a21 & a22 \\ a31 & a32 \end{vmatrix}$

Example: $\begin{bmatrix} 4 & 0 & 4 \\ 2 & 4 & 8 \\ 4 & 6 & 4 \end{bmatrix} = 4\begin{vmatrix} 4 & 8 \\ 6 & 4 \end{vmatrix} - 0\begin{vmatrix} 2 & 8 \\ 4 & 4 \end{vmatrix} + 4\begin{vmatrix} 2 & 4 \\ 4 & 6 \end{vmatrix}$=-168-0+(-16)=-184

Qn.3 if A= $\begin{bmatrix} 4 & 0 & 4 \\ 2 & 4 & 8 \\ 4 & 6 & 4 \end{bmatrix}$ find the determinant using MATLAB

Solution: codes in MATLAB

```
>>A=[4,0,4;2,4,8;4,6,4]

A= 4    0    4
   2    4    8
   4    6    4

>>det(A)
Ans= -184
```

Qn.4 find determinant of matrix $A = \begin{bmatrix} 7 & 9 & 5 \\ 4 & 6 & 7 \\ 2 & 3 & 8 \end{bmatrix}$

Solution: in MATLAB

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

A =

     7     9     5
     4     6     7
     2     3     8

>> det(A)

ans =

   27.0000
```

Lab-3(Inverse of matrix)

Inverse of Matrix: Inverse of matrix is matrix which gives identity matrix when multiplied with it's original state to find inverse of matrix we need to know that matrix should be singular(determinant should not be equal to zero) and adjoint of matrix is also needed to find the inverse of matrix A is denoted by A^{-1} mathematically A^{-1} =adj(A)/|A|

Qn.5 find inverse of matrix $A = \begin{bmatrix} 7 & 9 & 5 \\ 4 & 6 & 7 \\ 2 & 3 & 8 \end{bmatrix}$

Solution: in MATLAB

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

A =

     7     9     5
     4     6     7
     2     3     8

>> inv(A)

ans =

    1.0000   -2.1111    1.2222
   -0.6667    1.7037   -1.0741
    0.0000   -0.1111    0.2222
```

Qn 6 Find the inverse of matrix $A = \begin{bmatrix} 1 & 4 & 6 \\ 2 & 3 & 9 \\ 5 & 7 & 8 \end{bmatrix}$

Solution: in MATLAB

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


A =


     1     4     6

     2     3     9

     5     7     8


>> inv(A)


ans =


   -0.5493    0.1408    0.2535

    0.4085   -0.3099    0.0423

   -0.0141    0.1831   -0.0704
```

Lab-4(Adjoint of matrix)

Adjoint of Matrix: The matrix obtained by interchanging the columns and rows of co-factor of matrix is called adjoint of matrix.

Example let A= $\begin{vmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{vmatrix}$ and let A_{ij} be the co-factor of a_{ij}

then matrix of co-factor will be $\begin{vmatrix} A11 & A12 & A13 \\ A21 & A22 & A23 \\ A31 & A32 & A33 \end{vmatrix}$ and adjoint will be transpose of the matrix of co-factor that is $\begin{vmatrix} A11 & A21 & A31 \\ A12 & A22 & A32 \\ A13 & A23 & A33 \end{vmatrix}$

Qn.7 If $A = \begin{bmatrix} 4 & 5 & 6 \\ 6 & 5 & 4 \\ 5 & 4 & 6 \end{bmatrix}$ find adjoint of A using MATLAB

Solution: in MATLAB

>>A=[4,5,6;6,5,4;5,4,6]

A= $\begin{matrix} 4 & 5 & 6 \\ 6 & 5 & 4 \\ 5 & 4 & 6 \end{matrix}$

>>det(A)*inverse(A)

Ans= $\begin{matrix} 14 & -6 & -10 \\ -16 & -6 & 20 \\ -1 & 9 & -10 \end{matrix}$

Qn.8 If $A = \begin{bmatrix} 1 & 2 & 7 \\ 8 & 4 & 4 \\ 9 & 1 & 4 \end{bmatrix}$ find adjoint of A using MATLAB

Solution: in MATLAB

>> A=[1,2,7;8,4,4;9,1,4]

A =

```
     1     2     7
     8     4     4
     9     1     4
```

```
>> det(A)*inv(A)
```

ans =

```
   12.0000   -1.0000  -20.0000
    4.0000  -59.0000   52.0000
  -28.0000   17.0000  -12.0000
```

Lab-5(Rank of Matrices)

The rank of a matrix is the maximum number of its linearly independent column vectors (or row vectors). It is blatant that the rank of a matrix cannot exceed the number of its rows or columns.

Example: $\begin{bmatrix} 4 & 0 & 4 \\ 2 & 4 & 8 \\ 4 & 6 & 4 \end{bmatrix} = 4\begin{vmatrix} 4 & 8 \\ 6 & 4 \end{vmatrix} - 0\begin{vmatrix} 2 & 8 \\ 4 & 4 \end{vmatrix} + 4\begin{vmatrix} 2 & 4 \\ 4 & 6 \end{vmatrix}$=-168-0+(-16)=-184

- Therefore determinant is not equal to zero so as a result this given matrix has rank of it’s order that is 3

Qn. 9 If $A = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 2 & 4 & 1 & 3 \\ 2 & 1 & 3 & 4 \\ 1 & 3 & 2 & 4 \end{bmatrix}$ find the rank of the matrix using MATLAB.

Solution: In MATLAB

>>A=[1,2,3,4;2,4,1,3;2,1,3,4;1,3,2,4]

A= $\begin{matrix} 1 & 2 & 3 & 4 \\ 2 & 4 & 1 & 3 \\ 2 & 1 & 3 & 4 \\ 1 & 3 & 2 & 4 \end{matrix}$

>>rank(A)

Ans= 4

Lab-6(Solve by matrix method)

Qn.10 Find the value of x and y using MATLAB

x+3y=12

4x+2y=13

Solution: in MATLAB

```
>> A=[1 3; 4 2];

>> b=[12;13];

>> X=A\b


X =

    1.5000

    3.5000
```

Qn.11 Find value of x,y,z from given equation using MATLAB
$x+y+z=9$, $2x+5y+7z=52$ & $2x+y-z=0$

Solution:

```
>> A=[1 1 1; 2 5 7; 2 1 -1];

>> b=[9; 52; 0];

>> X=A\b


X =

     1

     3

     5
```

Lab-7 (Equation operations)

An equation is a formula that expresses the equality of two expressions, by connecting them with the equals sign "="

Types of equation:

1. Linear Equation
2. Quadratic Equation
3. Polynomial Equation
4. Radical Equation

1. **Linear Equation:**

Equations with 1 as the degree are known as linear equations in math. In such equations, 1 is the highest exponent of terms. These can be further classified into linear equations in one variable, two-variable linear equations, with three variables, etc. The standard form of a linear equation with variables X and Y are aX + bY - c = 0, where a, and b are the coefficients of X and Y respectively and c is the constant.

2. **Quadratic Equation:**

Equations with degree 2 are known as quadratic equations. The standard form of a quadratic equation with variable x is ax2 + bx + c = 0, where a ≠ 0. These equations can be solved by splitting the middle term, completing the square, or by the discriminant method.

3. **Polynomial Equations:**

Equations with degree 3 are known as cubic equations. Here, 3 is the highest exponent of at least one of the terms. The standard form of a cubic equation with variable x is ax3 + bx2 + cx + d = 0, where a ≠ 0.

4. **Radical Equations:**

In a radical equation, a variable is lying inside a square root symbol or you can say that the maximum exponent on a variable is ½

Example : $\sqrt{3x^2+10x}=5$

Qn.12 solve $4x^2+14x+10=0$ manually and by using matlab

Solution:

$=>4x^2+14x+10=0$

$=>4x^2+10x+4x+10=0$

$=>2x(2x+5)+2(2x+5)=0$

$=>(2x+2)(2x+5)=0$

Either $2x+2=0=>x=-1$

Or $2x+5=0=>x=-5/2$

In MATLAB

```
>> syms x
>> solve(4*x^2+14*x+10==0,x)

ans =

 -5/2
   -1
```

Qn.13 solve $x^2+5x+6=0$ manually and by using matlab

Solution:

$=>x^2+5x+6=0$

$=>x^2+2x+3x+6=0$

$=>x(x+2)+3(x+2)=0$

$=>(x+3)(x+2)=0$

Either $x+3=0=>x=-3$

Or $x+2=0=>x=-2$

In MATLAB

```
>> syms x
>> solve(x^2+5*x+6==0,x)

ans =

 -3
 -2
```

Qn.14 solve $x^{-2}-5x^{-1}-6=0$ manually and by using matlab

Solution:

$=> x^{-2}-5x^{-1}-6=0$

Let $u= x^{-1}$ so that $u^2=x^{-2}$

$=> u^2-5u-6=0$

$=>u^2-6u+u-6=0$

$=>u(u-6)+1(u-6)=0$

$=>(u+1)(u-6)=0$

Either $u+1=0=>u=-1$

Or $u-6=0=>u=6$

Now

$x^{-1}=-1$	$x^{-1}=6$
$x=-1$	$x=1/6$

In MATLAB

```
>> syms x

>> solve(x^-2-5*x^-1-6==0,x)


ans =


  -1

 1/6
```

Qn.15 Solve the equation $x^3-2x^2-5x+6=0$ manually and using MATLAB

Solution:

$f(x)= x^3-2x^2-5x+6=0$

Values that might make equation possible are ±1, ±2, ±3 and ±6

$f(1)=(1)^3-2(1)^2-5(1)+6= 1-2-5+6= 0$

one value is 1 which is (x-1)

1	1	-2	-5	6
		1	-1	-6
	1	-1	-6	0

Equation obtained= x^2-x-6

$=>x^2-3x+2x-6=0$

$=>x(x-3)+2(x-3)=0$

$=>(x-3)(x+2)(x-1)=0$ [above equation: (x-1)]

Either $x-3=0=>x=3$

Or $x+2=0=>x=-2$

Or $x-1=0=>x=1$

In MATLAB

```
>>syms x
>> solve(x^3-2*x^2-5*x+6==0,x)

ans =

 -2
  1
  3
```

Lab-8(Vector)

Vector: Vector is an object that has both a magnitude and a direction. Geometrically, we can picture a vector as a directed line segment, whose length is the magnitude of the vector and with an arrow indicating the direction. The direction of the vector is from its tail to its head.

Some types of vector:

1. **Unit vectors:** Vectors that have magnitude equals to 1 are called unit vectors, denoted by a^. It is also called the multiplicative identity of vectors. The length of unit vectors is 1. It is generally used to denote the direction of a vector.

2. **Parallel vectors:** Two or more vectors are said to be parallel vectors if they have the same direction but not necessarily the same magnitude. Vectors are said to be parallel if their cross product is 0(a×b=0).

3. **Orthogonal vectors:** Two or more vectors in space are said to be orthogonal if the angle between them is 90 degrees. Vectors are said to be Orthogonal vectors if their dot product is 0(a.b=0)

4. **Zero or null vectors:** The vector having magnitude 0 is called zero vector. Ex: $\underset{a}{\rightarrow}$=(0,0)

Magnitude/Length/modulus of vector: Magnitude of vector is aggregate root of sum of individual square of each direction denoted by|$\underset{a}{\rightarrow}$|.

Dot product: dot product is sum of product of direction of each axis. This returns magnitude and also termed as 'scalar product' mathematically: $\underset{a}{\rightarrow}$= a1b1+a2b2+a3b3

Cross product: In mathematics, the cross product or vector product is a binary operation on two vectors in a three-dimensional oriented Euclidean vector space, and is denoted by the symbol times. This returns magnitude and direction of vector and also termed as vector product.

Mathematically : $A = \begin{vmatrix} i & j & k \\ a1 & a2 & a3 \\ b1 & b2 & b3 \end{vmatrix}$

Qn.16 find Magnitude of 4i+2j-k

Solution: in MATLAB

>> a1=4;

>> a2=2;

>> a3=-1;

>> Magnitude=sqrt(a1^2+a2^2+a3^2)

Magnitude =

    4.5826

Qn.17 find a.(bxc) and ax(bxc) using MATLAB if $\underset{\boldsymbol{a}}{\rightarrow}$=4i+7j+10k and $\underset{\boldsymbol{b}}{\rightarrow}$=9i-40j+k and $\underset{\boldsymbol{c}}{\rightarrow}$=i-j-4k

Solution

I. **For a.(bxc) using MATLAB**

>> a=[4 7 10]

a =

     4   7   10

```
>> b=[9 -40 1]

b =

     9   -40     1

>> c=[1 -1 -4]

c =

     1    -1    -4

>> dot(a, cross(b,c))

ans =

        1213
```

ii. For ax(bxc) In MATLAB

```
>> a=[4 7 10]

a =

     4     7    10
```

```
>> b=[9 -40 1]

b =

     9   -40     1

>> c=[1 -1 -4]

c =

     1    -1    -4

>> cross(a, cross(b,c))

ans =

        -153        1486        -979
```

Qn.18 find a.(bxc) using MATLAB if $\vec{a}$=1i+4k and $\vec{b}$=i-11j-k and $\vec{c}$=7j-4k

Solution using MATLAB

```
>> a=[1 0 4]
```

```
a =

     1  0  4

>> b=[2, 12, 99]

b =

     2  12 99

>> c=[1 -1 -4]

c =

     1    -1    -4

>> dot(a, cross(b,c))

ans =

        -153        1486        -979
```

Lab-9(Plotting in graphs)

Types of graphs:

1. **Linear graphs:** These types of graphs have no power raised and has equation of $y=mx+c$ where positivity or negativity of m decides the upward and downward sloping of line.
2. **Power graphs:** These type of graphs are produced by raising power ex: $y=ax^2$. When power is even the graph line goes same direction as edge if power is odd edges goes down and up.
3. **Quadratic graphs:** This type of graphs use quadratic equations ($ax^2+bx+c=0$) and returns parabola. Here a,b,c determines location of graphs and where a is positive parabola is U-shaped and when a is negative parabola is umbrella shaped.
4. **Polynomial graphs:** This type of graphs use polynomial equation($a_nx^n+a_{n-1}x^{n-1}+\ldots+a_2x^2+a_1x^1+a_0=0$). Higher power the polynomial has more curves are encountered
5. **Rational graphs:** This type of graphs use rational function which don't give irrational numbers and imaginary numbers example x+1 and 1/x.
6. **Exponential graphs:** These type of graphs are graphs where power is raised to any constant ex: 2^x these functions increases relatively faster after crossing the axis.
7. **Logarithmic graphs:** These type of graphs are inverse of exponential graphs uses equation $y=\log_b x$. Domain of $\log_b x$ is always positive and real numbers and if no base indicated base 10 is used.
8. **Sine graph:** these graphs use trigonometric function sin $y=\sin(x)$ and x is measured in degree or radian.

Qn.19: plot the following linear graph y=2x+10 within the range of [-8,10]

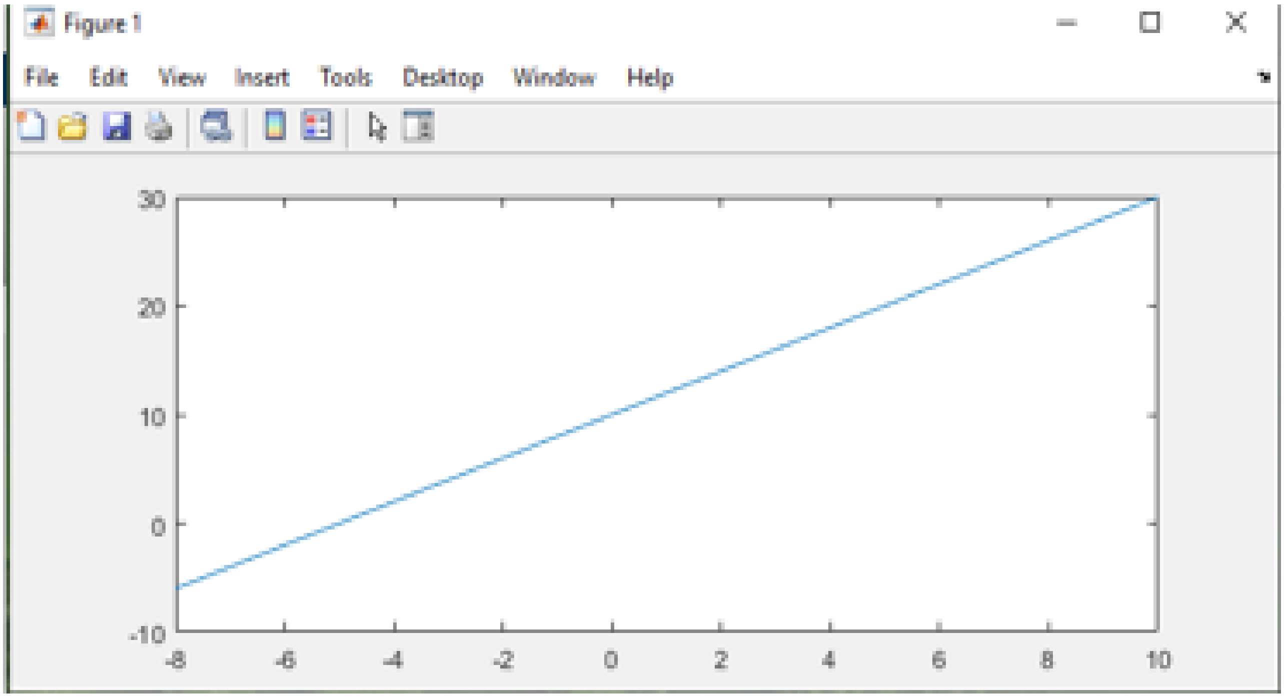
Solution:

>>x=[-8:10];

>>y=2*x=10;

>>plot(x,y)

Graph output:



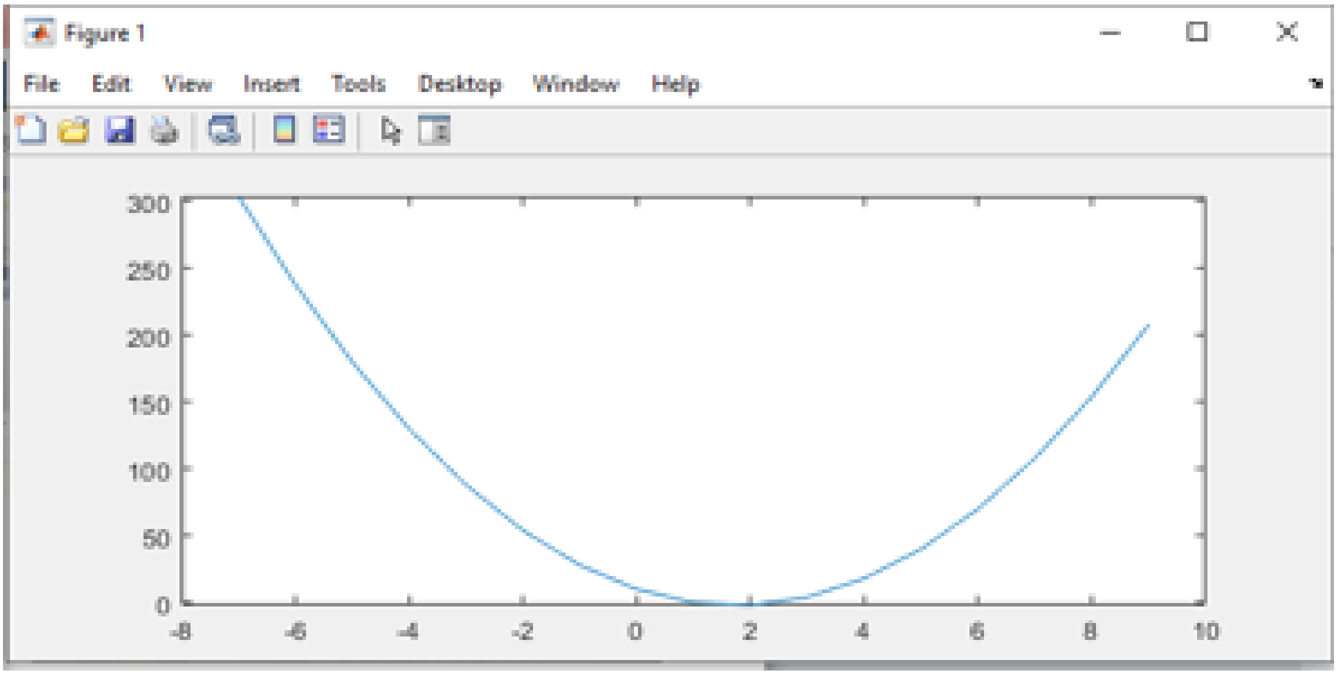
Qn.20: plot the following quadratic graph y=4x^2-14x+10=0 within the range of [-7,9]

Solution:

>>x=[-7:9]; %this creates range for graph

>>y=4*x.^2-14*x+10; %this assigns quadratic equation to y

>>plot(x,y); plots quadratic graph



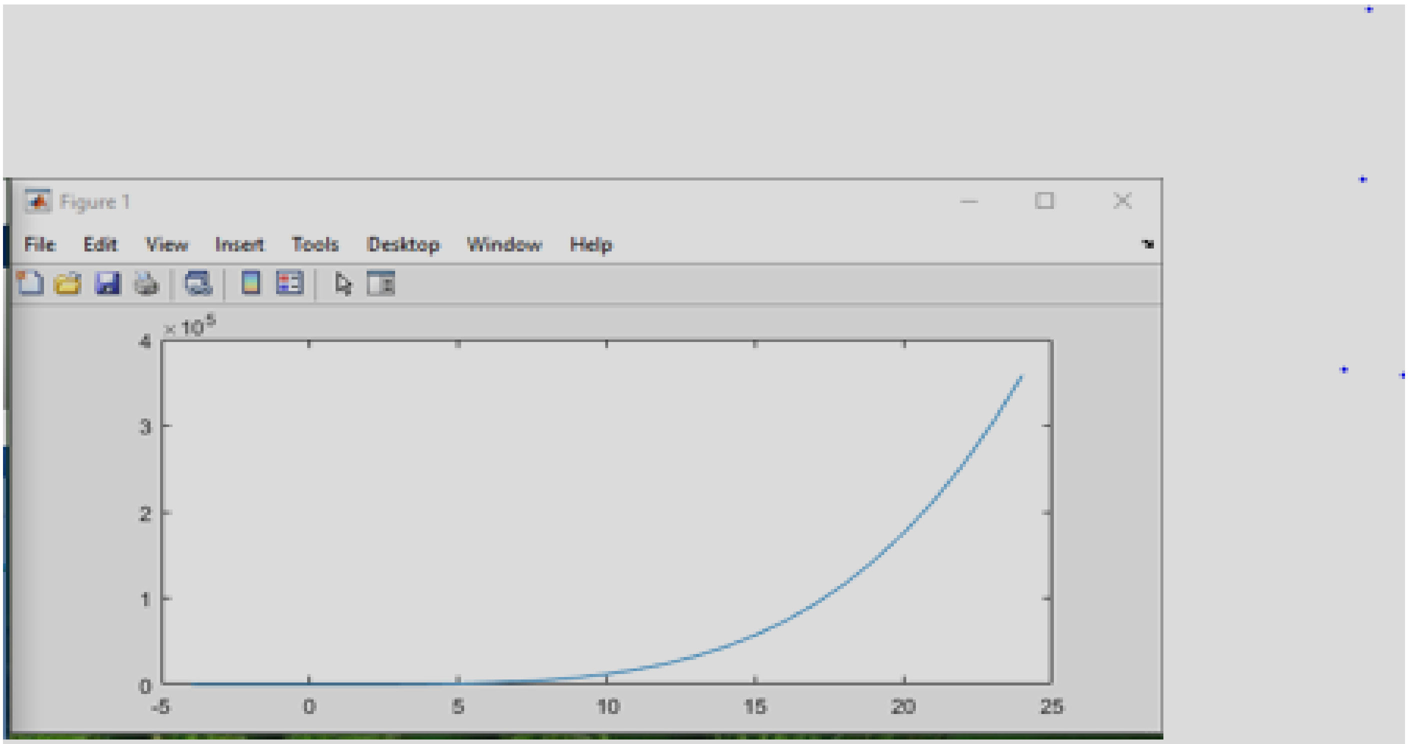
Qn. 20: plot the following polynomial graph $y= x^4+2x^3-2x^2-5x+6=0$ within the range of [-4,24]

Solution:

>>x=[-4,24]; %sets the range of graph from -4 to 24

>>y=x.^4+2*X.^3-2*x.^2-5*x+6; %sets y as polynomial equation

>>plot(x,y) %plots polynomial graph



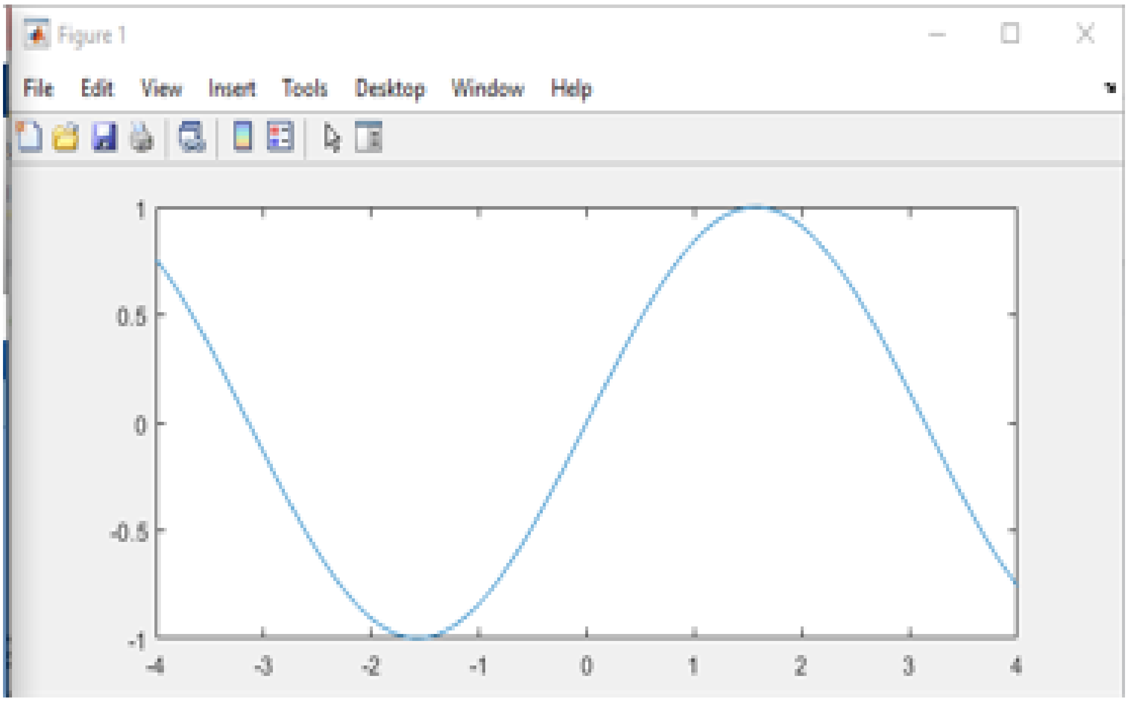
Qn. 21: plot the following sine graph y=sin(x) which ranges from -4 to 4 with increment of 0.1

Solution:

>>x=-4:0.1;4; %ranges from -4 to 4 increasing by 0.1

>>y=sin(x); %assigns y to a trigonometric value

>>plot(x,y) %plots sine gaph



Qn. 22: Plot a parabola ranging from -4 to 4 where y=1/4x^2

Solution:

>> x=[-4:4];

>> y=1/4*x.^2;

>> plot(x,y)

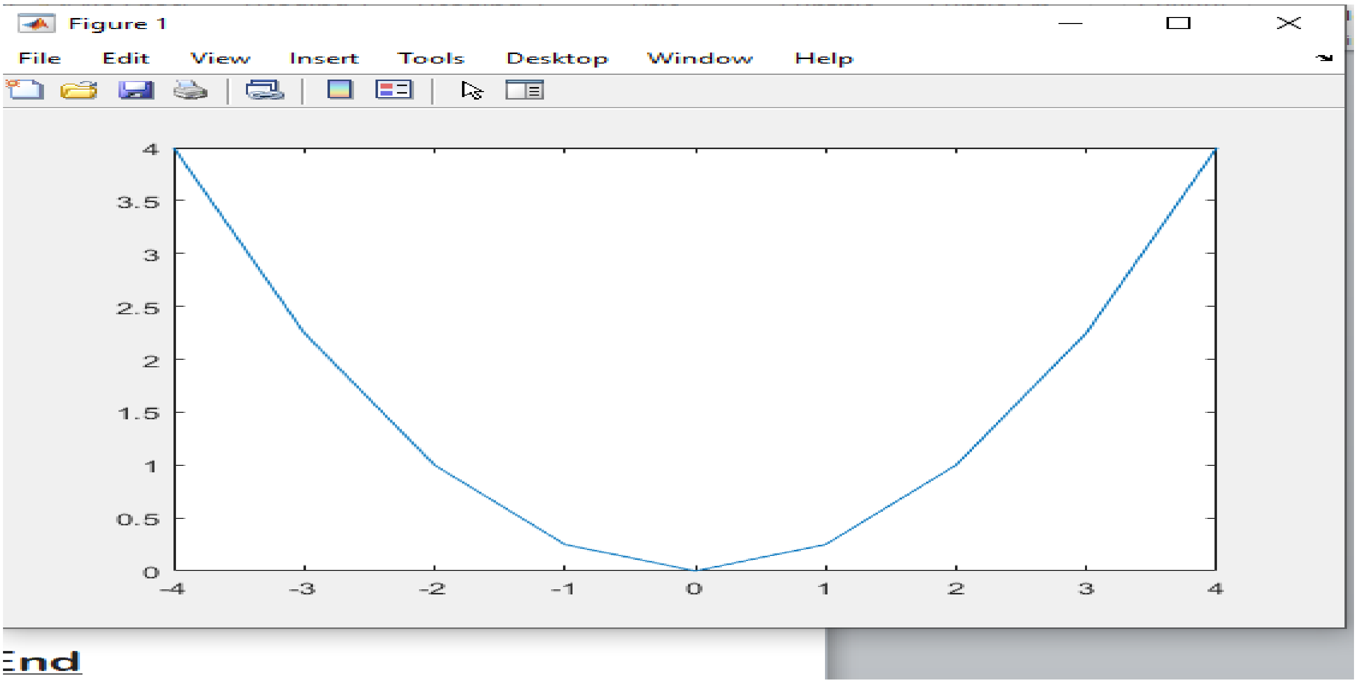


Figure 1
File Edit View Insert Tools Desktop Window Help
4
3.5
3
2.5
2
1.5
1
0.5
0
-4 -3 -2 -1 0 1 2 3 4

The End