Workshop on MATLAB Programming

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INTRODUCTION

- MATLAB is widely used in all areas of applied mathematics, in education and research at universities, and in the industry.
- MATLAB stands for MATrix LABoratory and the software is built up around vectors and matrices.
- This makes the software particularly useful for linear algebra but MATLAB is also a great tool for solving algebraic and differential equations and for numerical integration.
- MATLAB has powerful graphic tools and can produce nice pictures in both 2D and 3D.
- It is also a programming language, and is one of the easiest programming languages for writing mathematical programs.
- MATLAB also has some tool boxes useful for signal processing, image processing, optimization, etc.

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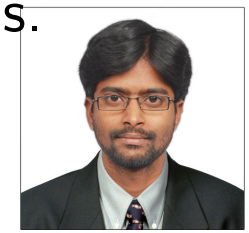
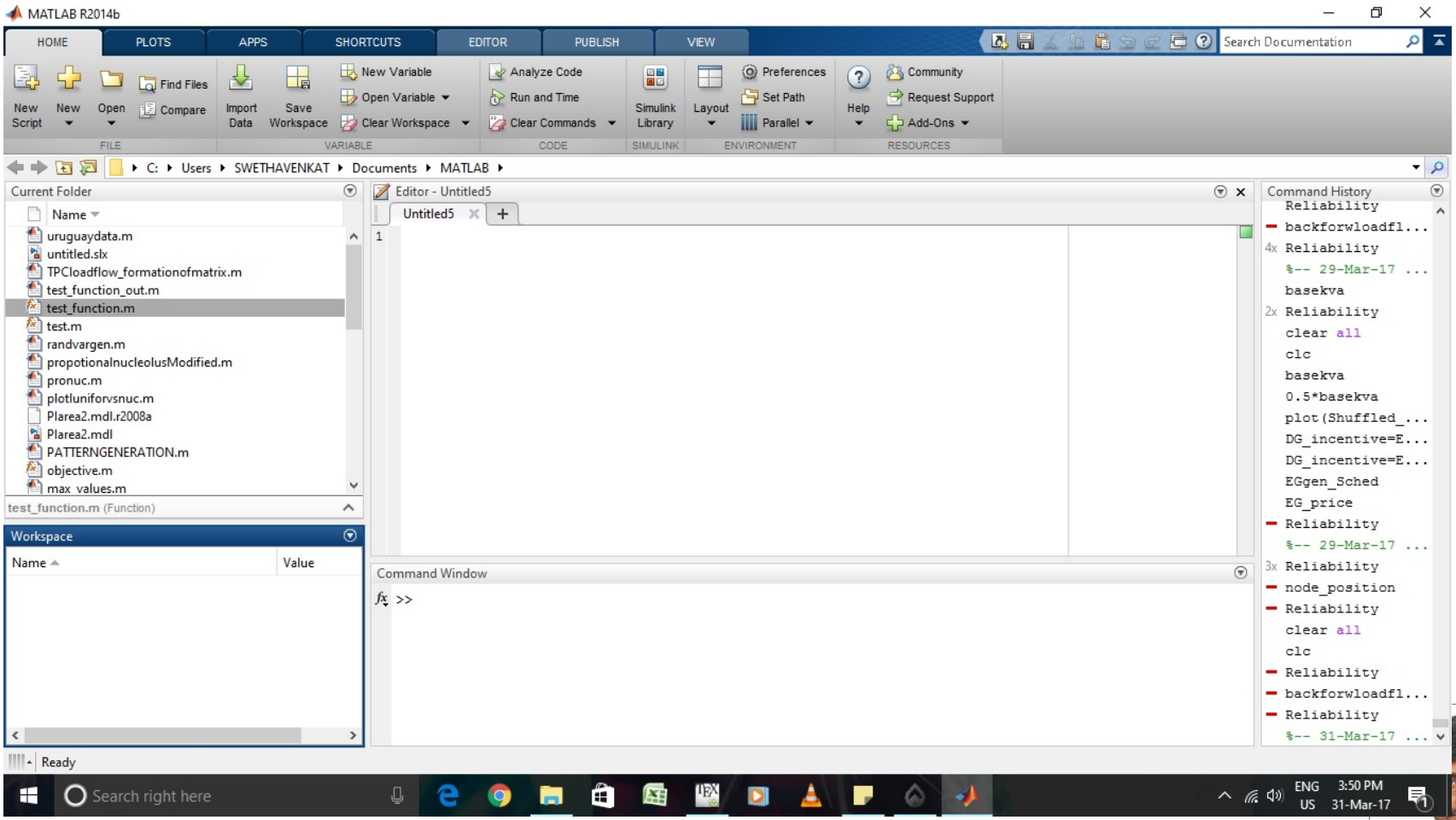
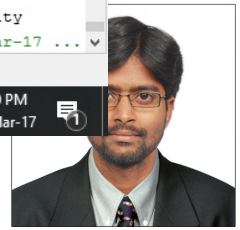


Windows on MATLAB SCREEN





Clear Commands

- clc -used to clear command window screen
- clear all -used to clear variables in workspace window

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Assignment

- Direct Assignment
  - a=2; Variable not displayed on command window
  - b=2 Variable displayed on command window
  - disp(a) -To print variable in command window without removing semi colon(;)
- Assignment from command window
  - a=input('enter value of a');

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sscanf command

- Read formatted data from string
- a='23 52 62'
  - b=sscanf(a,'%d');
  - c=sscanf(a,'%d', [2,2]);
  - d=sscanf(a,'%d', [1,3]);
  - $[f, n]$=sscanf(a,'%d');
- a='32.5 25.6 59.6'
  - b=sscanf(a,'%f');
  - c=sscanf(a,'%f', [2,2]);
  - d=sscanf(a,'%f', [1,3]);
  - $[f, n]$=sscanf(a,'%f');

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Mathematical Operations

- a=input('enter value of a');
- b=input('enter value of b');
  - Addition: a+b
  - Subtraction: a-b
  - Multiplication: a*b
  - Division: a/b
  - Remainder: rem(a,b)

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fprintf command

- a=30;
- b=2.6;

- fprintf('output a = %d',a) $\Longrightarrow$30
- fprintf('output a = %0.2d',a) $\Longrightarrow$30
- fprintf('output a = %0.3d',a) $\Longrightarrow$030
- fprintf('output a = %f',a) $\Longrightarrow$30.0000
- fprintf('output a = %0.2f',a) $\Longrightarrow$30.00
- fprintf('output b = %d',b) $\Longrightarrow$2.600000e+00
- fprintf('output b = %0.1d',b) $\Longrightarrow$2.6e+00
- fprintf('output b = %0.2d',b) $\Longrightarrow$2.60e+00
- fprintf('output b = %f',b) $\Longrightarrow$2.600000
- fprintf('output b = %0.1f',b) $\Longrightarrow$2.6
- fprintf('output b = %0.2f',b) $\Longrightarrow$2.60

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floor,ceil and round

- value=0.6;
  - floor(value)=0;
  - ceil(value)=1;
  - round(value)=1;

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Complex Numbers

- real=input('enter real part of complex numbers')
- imag=input('enter imaginary part of complex numbers')
  - X=complex(real,imag): X=real+imagi
  - Y=complex(2,3): Y=2+3i
  - real part of complex number=real(Y)=2
  - imaginary part of complex number=imag(Y)=3
  - Magnitude=abs(Y) $\Longrightarrow$ Magnitude=3.6056;
  - theta=angle(Y) $\Longrightarrow$ theta=0.9828;%Radians%
  - Z=conj(Y)$\Longrightarrow$ Z=2-3i
  - Perform arithmetic operations on complex numbers as on real numbers

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rand function

- 'rand' is a function which generated random value between 0 and 1
- rand $\Longrightarrow$0.9058

A= rand(2,2)

B= rand(1,3)

C= rand(2,1)

$$A = \begin{bmatrix} 0.2341 & 0.5622 \\ 0.2693 & 0.8424 \end{bmatrix}$$

$$B = \begin{bmatrix} 0.3413 & 0.5822 & 0.5692 \end{bmatrix}$$

$$C = \begin{bmatrix} 0.3413 \\ 0.5822 \end{bmatrix}$$

Random Numbers generation between two numbers

- LowerLimit=input('enter lower limit')
- UpperLimit=input('enter upper limit')

A= LowerLimit+rand(UpperLimit-LowerLimit)

B= LowerLimit+rand(2,2)(UpperLimit-LowerLimit)

C= LowerLimit+rand(1,2)(UpperLimit-LowerLimit)

D= LowerLimit+rand(2,1)(UpperLimit-LowerLimit)

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Matrix Representation

- Each row in a matrix separated by semicolon(;)
- Each column in a matrix separated by either space( ) or comma(,)
- All elements must be placed within square bracket

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

B= [8 5 6;7 5 6;1 3 7]

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$B = \begin{bmatrix} 8 & 5 & 6 \\ 7 & 5 & 6 \\ 1 & 3 & 7 \end{bmatrix}$$

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Accessing Elements of Matrix

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- a=A(r,c)
  r is row number and c is column number of the element need to access

  a=A(3,2)$\Longrightarrow$a=8

  b=A(2,1)$\Longrightarrow$b=4

  c=A(1,3)$\Longrightarrow$c=3

Accessing Complete Row or Column or part of matrix

- A(:,n) % To access all rows in n^{th} column
- A(n,:) % To access all columns in n^{th} row
- A(a:b,:) % To access all columns from row a to b
- A(:,a:b) % To access all rows from column a to b

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

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A1=A(:,2)

$$A1 = \begin{bmatrix} 2 \\ 5 \\ 8 \end{bmatrix}$$

A2=A(3,:)

$$A2 = \begin{bmatrix} 7 & 8 & 9 \end{bmatrix}$$

A3=A(1:2,:)

$$A3 = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

A4=A(:,2:3)

$$A4 = \begin{bmatrix} 2 & 3 \\ 5 & 6 \\ 8 & 9 \end{bmatrix}$$

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Size of a Matrix

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

- S=size(A)$\Longrightarrow$[3,3]
- Row=S(1,1)
- Col=S(1,2)

[Row,Col]=size(A)$\Longrightarrow$Row=3 Col=3

Row=size(A,1)$\Longrightarrow$Row=3

Col=size(A,2)$\Longrightarrow$Col=3

Total Number of elements=numel(A)$\Longrightarrow$9

Operations on Matrix

Let us consider two matrices A and B as shown below

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$B = \begin{bmatrix} 3 & 4 & 9 \\ 7 & 3 & 8 \\ 5 & 2 & 1 \end{bmatrix}$$

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Addition

C=A+5 % Addition of a value to each element in matrix

$$C = \begin{bmatrix} 6 & 7 & 8 \\ 9 & 10 & 11 \\ 12 & 13 & 14 \end{bmatrix}$$

D=A+B %Addition of two matrices

$$D = \begin{bmatrix} 4 & 6 & 12 \\ 11 & 8 & 14 \\ 12 & 10 & 10 \end{bmatrix}$$

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Subtraction

E=A-1 % Subtraction of a value to each element in matrix

$$E = \begin{bmatrix} 0 & 1 & 2 \\ 3 & 4 & 5 \\ 6 & 7 & 8 \end{bmatrix}$$

F=A-B %Subtraction of two matrices

$$F = \begin{bmatrix} -2 & -2 & -6 \\ -3 & 2 & -2 \\ 2 & 6 & 8 \end{bmatrix}$$

Multiplication

G=A*2 % Multiply each element in matrix by a value

$$G = \begin{bmatrix} 2 & 4 & 6 \\ 8 & 10 & 12 \\ 14 & 16 & 18 \end{bmatrix}$$

H=A*B %Multiplication of two matrices

$$H = \begin{bmatrix} 32 & 16 & 28 \\ 77 & 43 & 82 \\ 122 & 70 & 136 \end{bmatrix}$$

J=A.*B % Element by element multiplication of two matrices

$$J = \begin{bmatrix} 3 & 8 & 27 \\ 28 & 15 & 48 \\ 35 & 16 & 9 \end{bmatrix}$$

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Matrix Inversion

Let us consider matrix

$$K = \begin{bmatrix} 2 & 4 & 0 \\ 4 & 10 & -2 \\ 8 & 20 & -2 \end{bmatrix}$$

L=inv(K) % For matrix inversion

$$L = \begin{bmatrix} 2.5 & 1 & -1 \\ -1 & -0.5 & 0.5 \\ 0 & -1 & 0.5 \end{bmatrix}$$

Transpose of matrix

Let us consider matrix

$$K = \begin{bmatrix} 2 & 4 & 0 \\ 4 & 10 & -2 \\ 8 & 20 & -2 \end{bmatrix}$$

M=transpose(K) % For transposing the matrix K

$$M = \begin{bmatrix} 2 & 4 & 8 \\ 4 & 10 & 20 \\ 0 & -2 & -2 \end{bmatrix}$$

M=K'

$$M = \begin{bmatrix} 2 & 4 & 8 \\ 4 & 10 & 20 \\ 0 & -2 & -2 \end{bmatrix}$$

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Eigen Values of a matrix

Let us consider matrix

$$K = \begin{bmatrix} 2 & 4 & 0 \\ 4 & 10 & -2 \\ 8 & 20 & -2 \end{bmatrix}$$

N=eig(K) % For computing eigen values of matrix K

$$N = \begin{bmatrix} 7.4641 \\ 0.5359 \\ 2.0000 \end{bmatrix}$$

Determinant of a Matrix

Let us consider matrix

$$K = \begin{bmatrix} 2 & 4 & 0 \\ 4 & 10 & -2 \\ 8 & 20 & -2 \end{bmatrix}$$

D=det(K) % For computing determinant of a matrix K
D=8

Characteristic polynomial of a matrix

Let us consider matrix K from previous slide
Characteristic polynomial of matrix K is determinant of [λI-K]
coefficients characteristic polynomial of a matrix K is obtained as

coff=poly(K)

$$coff = \begin{bmatrix} 1 & -10 & 20 & -8 \end{bmatrix}$$

Roots of characteristic polynomial of a matrix K (or) eigen values of matrix are obtained as below

r=roots(coff)

$$r = \begin{bmatrix} 7.4641 \\ 0.5359 \\ 2.0000 \end{bmatrix}$$

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Concatenate Matrices

Let us consider two matrices A and B as shown below

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$B = \begin{bmatrix} 3 & 4 & 9 \\ 7 & 3 & 8 \\ 5 & 2 & 1 \end{bmatrix}$$

Horizontal Concatenate

For this operation rows in matrices must be same

C=[A,B]
(OR)
D=horzcat(A,B)

$$C = D = \begin{bmatrix} 1 & 2 & 3 & 3 & 4 & 9 \\ 4 & 5 & 6 & 7 & 3 & 8 \\ 7 & 8 & 9 & 5 & 2 & 1 \end{bmatrix}$$

Vertical Concatenate

For this operation columns in matrices must be same

E=[A;B]
(OR)
F=vertcat(A,B)

$$E = F = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \\ 3 & 4 & 9 \\ 7 & 3 & 8 \\ 5 & 2 & 1 \end{bmatrix}$$

Matrix with all elements are 0's

A=zeros(a,b)

a represents number of rows

b represents number columns

In case a=4 and b=3 then

$$A = \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

Matrix with all elements as 1's

B=ones(a,b)

a represents number of rows

b represents number columns

In case a=2 and b=3 then

$$A = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

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Identity matrix

I=eye(a,b)

a represents number of rows

b represents number of columns

In case a=3 and b=3 then

$$I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Multidimensional Matrix

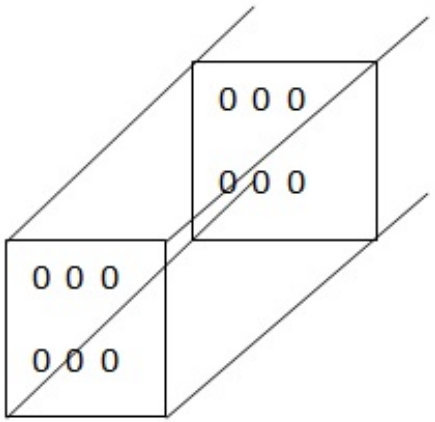
Let us consider two matrices A and B to form multidimensional matrix X

$$A = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{bmatrix}$$

$$B = \begin{bmatrix} 3 & 4 & 5 \\ 7 & 3 & 8 \end{bmatrix}$$

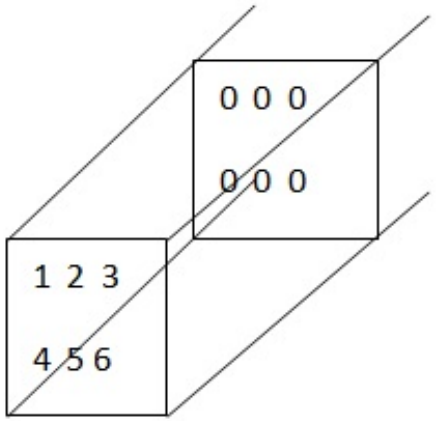
Now Initialize multidimensional matrix X with elements as 0's

X=zeros(2,3,2)

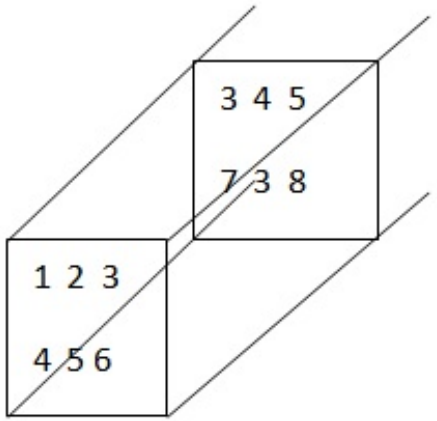


Updating multidimensional matrix X

X(:,:,1)=A



X(:,:,2)=B



Maximum and Minimum value in a matrix

Let us consider matrix A as below

$$A = \begin{bmatrix} 1 & 2 & 9 \\ 7 & 5 & 6 \\ 4 & 8 & 3 \end{bmatrix}$$

$$\max(A) \Longrightarrow [7\ 8\ 9]$$
$$\min(A) \Longrightarrow [1\ 2\ 3]$$

$$\max(\max(A)) \Longrightarrow 9$$
$$\min(\min(A)) \Longrightarrow 1$$

Sorting in Ascending Order

Let us consider matrix A as below

$$A = \begin{bmatrix} 1 & 2 & 9 \\ 7 & 5 & 6 \\ 4 & 8 & 3 \end{bmatrix}$$

C=sort(A)
(OR) [C,e]=sort(A)

$$C = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

$$e = \begin{bmatrix} 1 & 1 & 3 \\ 3 & 2 & 2 \\ 2 & 3 & 1 \end{bmatrix}$$

Sorting in descending Order

Let us consider matrix A as below

$$A = \begin{bmatrix} 1 & 2 & 9 \\ 7 & 5 & 6 \\ 4 & 8 & 3 \end{bmatrix}$$

D=sort(A,'descend')
(OR) [D,e]=sort(A,'descend')

$$D = \begin{bmatrix} 7 & 8 & 9 \\ 4 & 5 & 6 \\ 1 & 2 & 3 \end{bmatrix}$$

$$e = \begin{bmatrix} 2 & 3 & 1 \\ 3 & 2 & 2 \\ 1 & 1 & 3 \end{bmatrix}$$

Finding Required Solution using 'sort' function

Cost(INR)	Gen1(MW)	Gen2(MW)
150000	40	60
135000	70	30
140000	50	50

```
Cost=[150000;135000;140000];
Gen=[40 60;70 30;50 50];

[Cost,comb]=sort(Cost,'Ascend');
```

```
Solution=Gen(comb(1),:);
```

$\Longrightarrow$ [70 30]

'sum' function

This function has been used to compute sum of all elements in a complete row or column matrix

Let us consider a matrix 'A' as below

$$A = \begin{bmatrix} 7 & 8 & 9 \end{bmatrix}$$

value=sum(A);

value=24

Solving Linear equations

Let us consider below two equations to solve

$$\begin{aligned} 2x + y &= 12 \\ -3x + y &= 2 \end{aligned} \tag{1}$$

Form above equation in matrix form AX=B

$$A = \begin{bmatrix} 2 & 1 \\ -3 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 12 \\ 2 \end{bmatrix}$$

Method 1: X=inv(A)*B
Method 2: X=A \ B

$$X = \begin{bmatrix} 2 \\ 8 \end{bmatrix}$$

Solving Linear equations-Method 3 (linsolve function)

$$
\begin{aligned}
&syms \;\; x \;\; y; \\
&eq1 = 2 * x + y == 12; \\
&eq2 = -3 * x + y == 2; \\
&[A, B] = equationsToMatrix([eq1, eq2], [x, y]);
\end{aligned}
\tag{2}
$$

$$A = \begin{bmatrix} 2 & 1 \\ -3 & 1 \end{bmatrix}$$

$$B = \begin{bmatrix} 12 \\ 2 \end{bmatrix}$$

$$\mathrm{X} = \mathrm{linsolve(A,B)}$$

$$X = \begin{bmatrix} 2 \\ 8 \end{bmatrix}$$

Solving Linear equations-Method 4 (solve function)

$$
\begin{aligned}
&syms \quad x \quad y \\
&eq1 = 2 * x + y == 12; \\
&eq2 = -3 * x + y == 2;
\end{aligned}
\tag{3}
$$

```
Z=solve([eq1,eq2],[x,y]);
x=Z.x
y=Z.y
```

Output:

```
x=
   2
y=
   8
```

Roots of non linear equation: solve function

$$\begin{aligned} &syms \quad x \\ &eq1 = (x^2) + (4 * x) + 4 == 0; \\ &X = solve([eq1], [x]); \end{aligned} \tag{4}$$

$$X = \begin{bmatrix} -2 \\ -2 \end{bmatrix}$$

Roots of non linear equation: roots function

$$\begin{aligned} (4x^3) + (5x) + 15 = 0; \\ coeff = [4 \quad 0 \quad 5 \quad 15 \quad]; \\ X = roots(coeff) \end{aligned} \tag{5}$$

$$X = \begin{bmatrix} 0.6443 + 1.5796i \\ 0.6443 - 1.5796i \\ -1.2885 + 0.0000i \end{bmatrix}$$

Logical and Relational Operators

Symbol	Operator
==	equal to
~=	Not equal to
<	Strictly smaller
>	Strictly greater
<=	Smaller than or equal to
>=	Greater than or equal to
&&	AND operator
||	OR operator

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Trigonometric Functions

Command	Operation
sin(Θ)	sine of Θ, Θ in radians
cos(Θ)	cosine of Θ, Θ in radians
tan(Θ)	tangent of Θ, Θ in radians
asin(x)	Inverse sine of x
acos(x)	Inverse sine of x
atan(x)	Inverse sine of x
sinh(Θ)	Hyperbolic sine of Θ, Θ in radians
cosh(Θ)	Hyperbolic cosine of Θ, Θ in radians
tanh(Θ)	Hyperbolic tangent of Θ, Θ in radians
sind(Θ)	sine of Θ, Θ in degrees
cosd(Θ)	cosine of Θ, Θ in degrees
tand(Θ)	tangent of Θ, Θ in degrees
deg2rad	Convert angle from degrees to radians
rad2deg	Convert angle from radians to degrees

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Common Math Functions

Command	Operation
abs(x)	Provide absolute value of x
sqrt(x)	Provides square root of x
nthroot(x,n)	Provides nth root of x
x^ n	Provides nth power of x
log(x)	Provides log base e of x
log10(x)	Provides log base 10 of x
exp(x)	Provides exponential of x
mean(A)	Provides mean value of matrix A
median(A)	Provides median value of matrix A
std(A)	Provides standard deviation value of matrix A

'for' Loop

```
for variable=start:stop
% perform required operation %
end
```

Example:

```
for i=1:3
fprintf('value=%d\n',i)
end
```

Output:

```
value=1
value=2
value=3
```

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'while' Loop

```
while(condition)
% perform required operation %
end
```

Example:

```
i=1;
while(i<3)
fprintf('value=%d\n',i);
i=i+1;
end
```

Output:

```
value=1
value=2
```


if functioning

```
if(condition)
% perform required operation %
end
```

Example: Print even numbers in matrix A

$$A = \begin{bmatrix} 2 & 3 & 13 & 21 & 10 \end{bmatrix}$$

```
for i=1:5
if(rem(A(i),2)==0)
fprintf('even number=%d\n',A(i));
end
```

Output:

```
even number=2
even number=10
```

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if - else functioning

```
if(condition)
% perform required operation %
else
% perform required operation %
end
```

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Example

Example: Print even and odd numbers in matrix A

$$A = \begin{bmatrix} 2 & 3 & 13 & 21 & 10 \end{bmatrix}$$

```
for i=1:5
if(rem(A(i),2)==0)
fprintf('even number=%d\t',A(i));
else
fprintf('odd number=%d\t',A(i));
end
```

Output:even number=2 odd number=3 odd number=13 odd number=21 even number=10

Nested if - else

```
if(condition 1)
% perform required operation %
else
    if(condition 2)
    % perform required operation %
    else
    % perform required operation %
    end
end
```

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Example

Score	Grade
≥ 9	Ex
$8 \leq$ Marks < 9	A
$7 \leq$ Marks < 8	B
< 7	F

Assign grade to obtain marks shown in matrix

$$Marks = \begin{bmatrix} 9 & 8 & 7 & 10 & 6 \end{bmatrix}$$

$$GRADE = \begin{bmatrix} E & A & B & E & F \end{bmatrix}$$

Example Contd.

```
for i=1:5
if(Marks(i)≥9)
GRADE(i)='E'
else
  if(Marks(i)≥ 8 && Marks(i)< 9 )
  GRADE(i)='A'
  else
      if(Marks(i)≥ 7 && Marks(i)< 8 )
      GRADE(i)='B'
      else
      GRADE(i)='C'
      end
  end
end
```

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switch statement

```
switch expression
  case expression1
  % perform required operation %
  case expression2
  % perform required operation %
  otherwise % Optional %
  % perform required operation %
end
```

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Example

```
a=input('enter value of a');
b=input('enter value of b');
operation=input('enter value 0:ADD 1:SUB 2:MUL 3:DIV
4:REM');
```

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Example Contd.

```
switch operation
  case 0
    ADDITION=a+b
  case 1
    SUBTRACTION=a-b
  case 2
    MULTIPLICATION=a*b
  case 3
    DIVISION=a/b
  case 4
    REMAINDER=rem(a,b)
  otherwise
    fprintf('Invalid operation\n' );
end
```

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Example Contd.

```
Input 1
enter value of a20
enter value of b30
enter value 0:ADD 1:SUB 2:MUL 3:DIV 4:REM5
Output 1
Invalid operation

Input 2
enter value of a30
enter value of b10
enter value 0:ADD 1:SUB 2:MUL 3:DIV 4:REM4
Output 2
REMAINDER =
0
```

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Extracting Data from Excel

create a excel sheet with data shown below and assign file name as test

Cost(INR)	Gen1(MW)	Gen2(MW)
150000	40	60
135000	70	30
140000	50	50

Now use 'xlsread' command as below to extract data from excel sheet and save as a matrix.

```
filename='test'
num=xlsread(filename)
```

output

$$num = \begin{bmatrix} 150000 & 40 & 60 \\ 135000 & 70 & 30 \\ 140000 & 50 & 50 \end{bmatrix}$$

Creation of function

Creation of function to return only one output

function $[Out_{var}]$=$functionname(ip_{var1}, ip_{var2}, ...)$
% write the code to compute Out_{var} %
end

Creation of function to return multiple outputs

function $[Out_{var1}, Out_{var1}, ...]$=$functionname(ip_{var1}, ip_{var2}, ...)$
% write the code to compute $Out_{var1}, Out_{var1}..$ %
end

Note:
The matlab file which has code to create a function must be save with *functionname*

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Example:Single Return Value

Creation of function to return only one output

```
function [output]=sumofinputs(a,b)
output=a+b;
end
```

Calling of a function

```
a=input('enter value of a')
b=input('enter value of b')
c=sumofinputs(a,b)
```

Example:output

==========

Output

==========

enter value of a2

enter value of b3

c=5

Example:Multiple Return Values

Creation of function to return two outputs

```
function [output1,output2]=sumandprod(a,b)
output1=a+b;
output2=a*b;
end
```

Calling of a function

```
a=input('enter value of a')
b=input('enter value of b')
[c,d]=sumandprod(a,b)
```

Example:output

```
==========================================================
Output
==========================================================

    enter value of a2

    enter value of b3

    c=5

    d=6
```


Figure: bar

To draw the bar graph use the following code

Step1 %Develop matrix containing x-axis elements(Xmatrix)%

Step2 %Develop matrix containing y-axis elements(Ymatrix)%

Step3 figure

Step4 bar(Xmatrix,Ymatrix,'colour','LineWidth',2);

Step5 title('% Note down title of figure %');

Step6 xlabel('% write x-axis label%')

Step7 ylabel('% write y-axis label%')

Example

- Draw bar graph between hour of the day (T) and load (P)

Step1 T=[1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24];

Step2 P=[10 13 5 25 65 52 42 58 65 22 32 35 65 21 45 28 56 26 45 47 25 29 37 51];

Step3 figure

Step4 bar(T,P,'g','LineWidth',2);

Step5 title('Hourly load on the system');

Step6 xlabel('Hour')

Step7 ylabel('Load (MW)')

Output(bar graph): Hour Vs Load

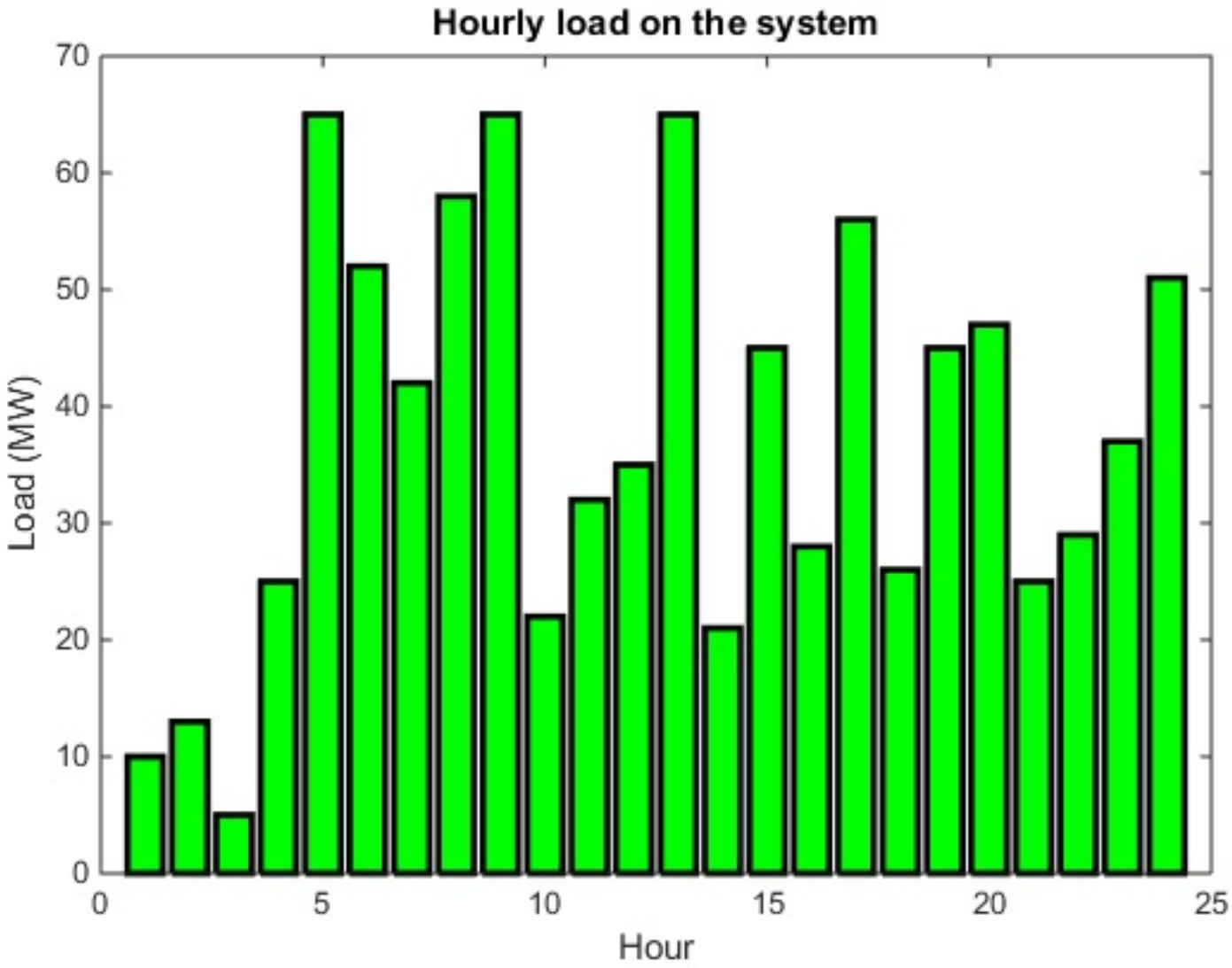

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Figure: plot

To draw the plot graph use the following code

Step1 %Develop matrix containing x-axis elements(Xmatrix)%

Step2 %Develop matrix containing y-axis elements(Ymatrix)%

Step3 figure

Step4 plot(Xmatrix,Ymatrix,'colour','LineWidth',2);

Step5 title('% Note down title of figure %');

Step6 xlabel('% write x-axis label%')

Step7 ylabel('% write y-axis label%')

Example

- Draw bar graph between hour of the day (T) and load (P)

Step1 T=[1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24];

Step2 P=[10 13 5 25 65 52 42 58 65 22 32 35 65 21 45 28 56 26 45 47 25 29 37 51];

Step3 figure

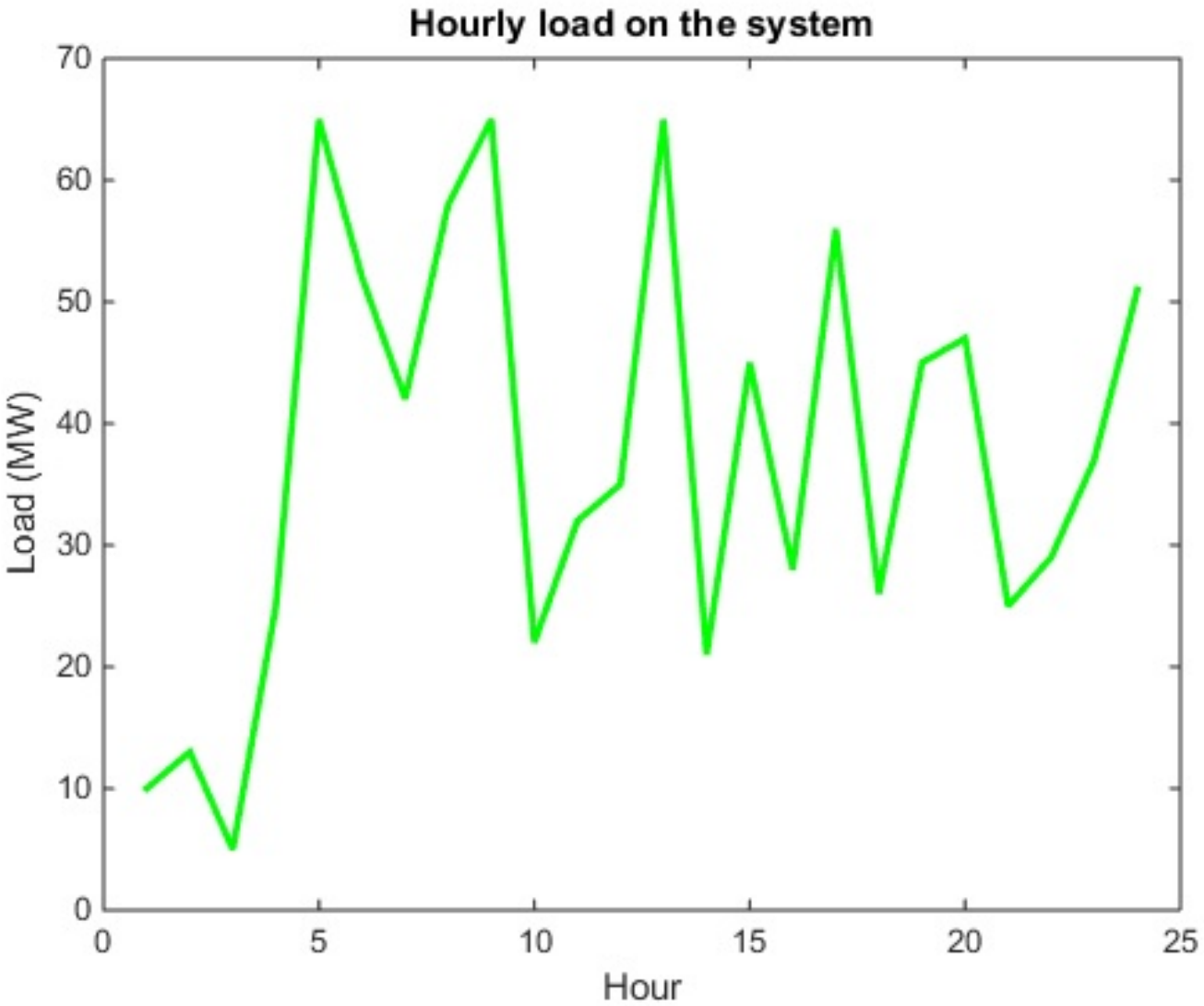
Step4 plot(T,P,'g','LineWidth',2);

Step5 title('Hourly load on the system');

Step6 xlabel('Hour')

Step7 ylabel('Load (MW)')

Output(plot graph): Hour Vs Load



Multiple Plots in same figure window

To draw the multiple plots use the following code

Step1 %Develop matrix containing x-axis elements(Xmatrix)%

Step2 %Develop matrix containing y-axis elements(Ymatrix(1)) of first plot%

Step3 %Develop matrix containing y-axis elements(Ymatrix(2)) of second plot%

Step4 figure

Step5 plot(Xmatrix,Ymatrix(1),'colour','LineWidth',2);

Step6 hold on;

Step7 plot(Xmatrix,Ymatrix(2),'colour','LineWidth',2);

Step8 title('% Note down title of figure %');

Step9 xlabel('% write x-axis label%')

Step10 ylabel('% write y-axis label%')

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Multiple Plots in same figure window

- Draw bar graph between hour of the day (T) and load on first system (P1) and second system (P2)

Step1 T=[1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24];

Step2 P1=[10 13 5 25 65 52 42 58 65 22 32 35 65 21 45 28 56 26 45 47 25 29 37 51];

Step3 P2=[20 26 50 52 56 62 48 52 85 88 62 53 56 69 54 82 65 62 44 74 52 69 73 65];

Step4 figure

Step5 plot(T,P1,'g','LineWidth',2);

Step6 hold on;

Step7 plot(T,P2,'b','LineWidth',2);

Step8 title('Hourly load on the system');

Step9 xlabel('Hour')

Step10 ylabel('Load (MW)')

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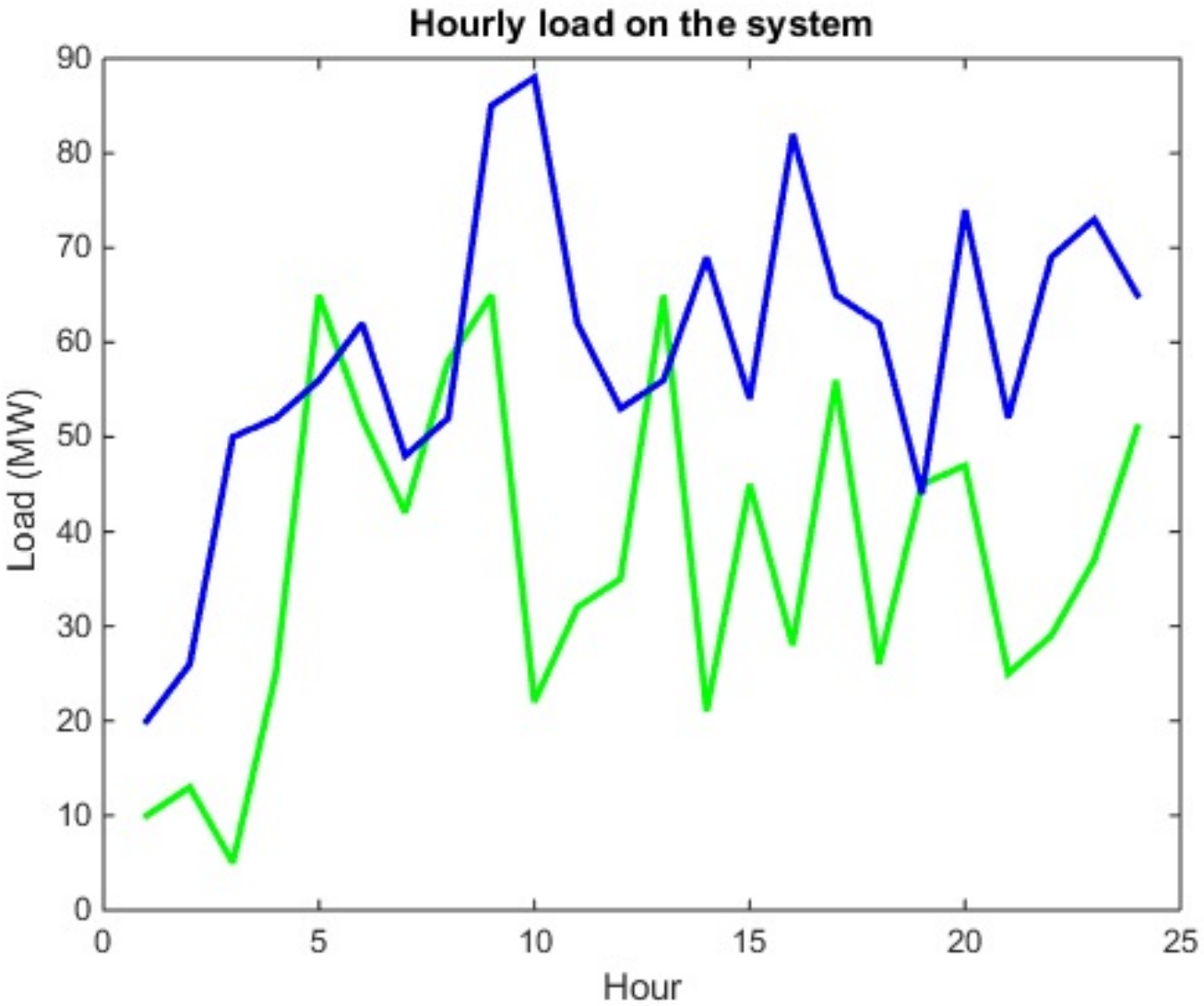
Output(Multiple plot graphs): Hour Vs Load



Simple plot and bar graphs code

Plot graph

plot(x,y)

bar graph

bar(x,y)

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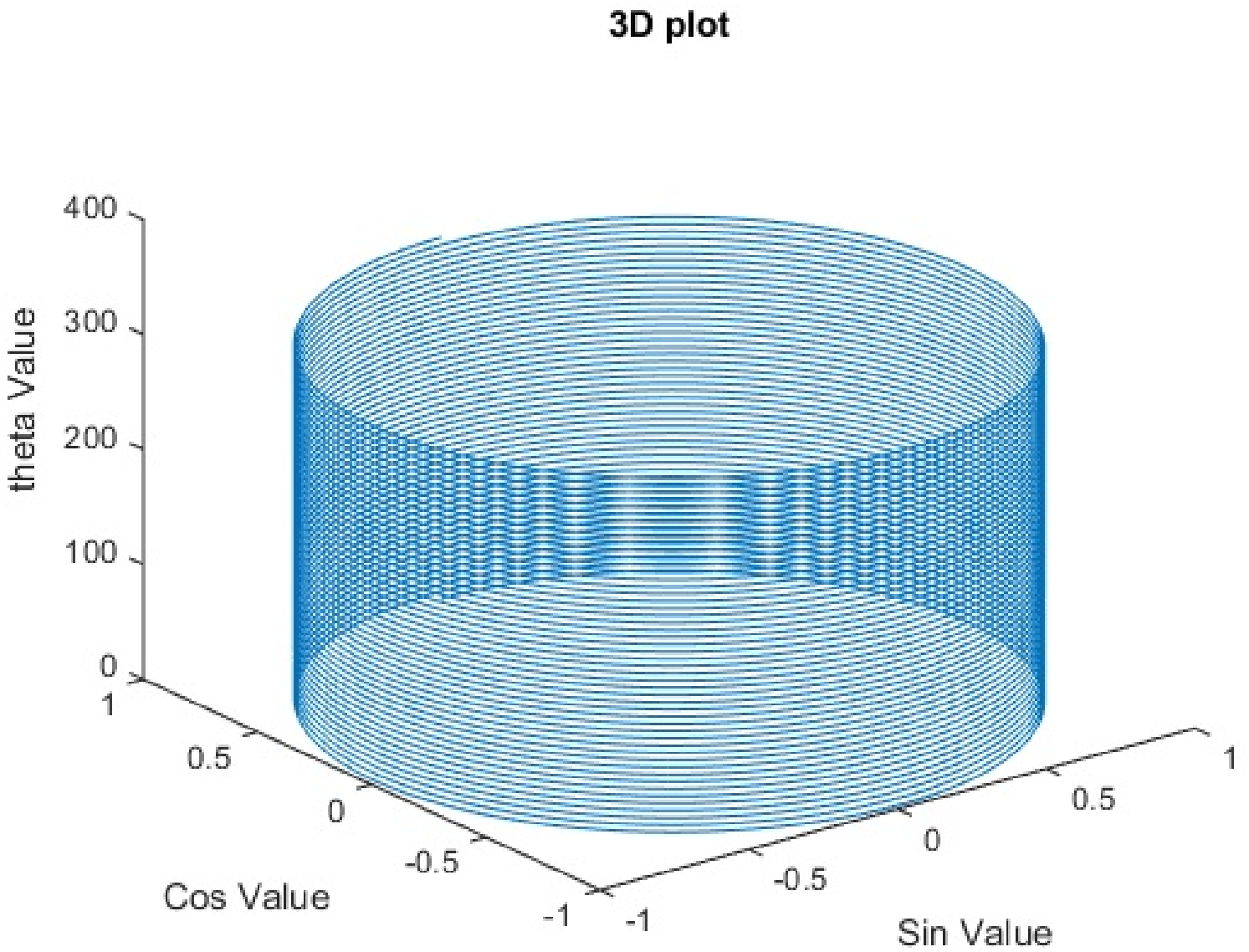
3D plot

- Plot the values of sin(x) and cos(x) as x varying from 0 to $\Pi * 100$

Use the below code

```
x=0:pi/100:pi*100;
val1=sin(x);
val2=cos(x);
figure
plot3(val1,val2,x)
title('3D plot')
xlabel('Sin Value')
ylabel('Cos Value')
zlabel('x Value')
```


Output



Split Figure

```
x=0:pi/10:pi;
val1=sin(x);
val2=cos(x);
val3=tanh(x);
val4=sinh(x);

figure
subplot(2,1,1);
plot(x,val1,'*');
title('sin value');
subplot(2,1,2);
plot(x,val2,'o');
title('cos value');
```

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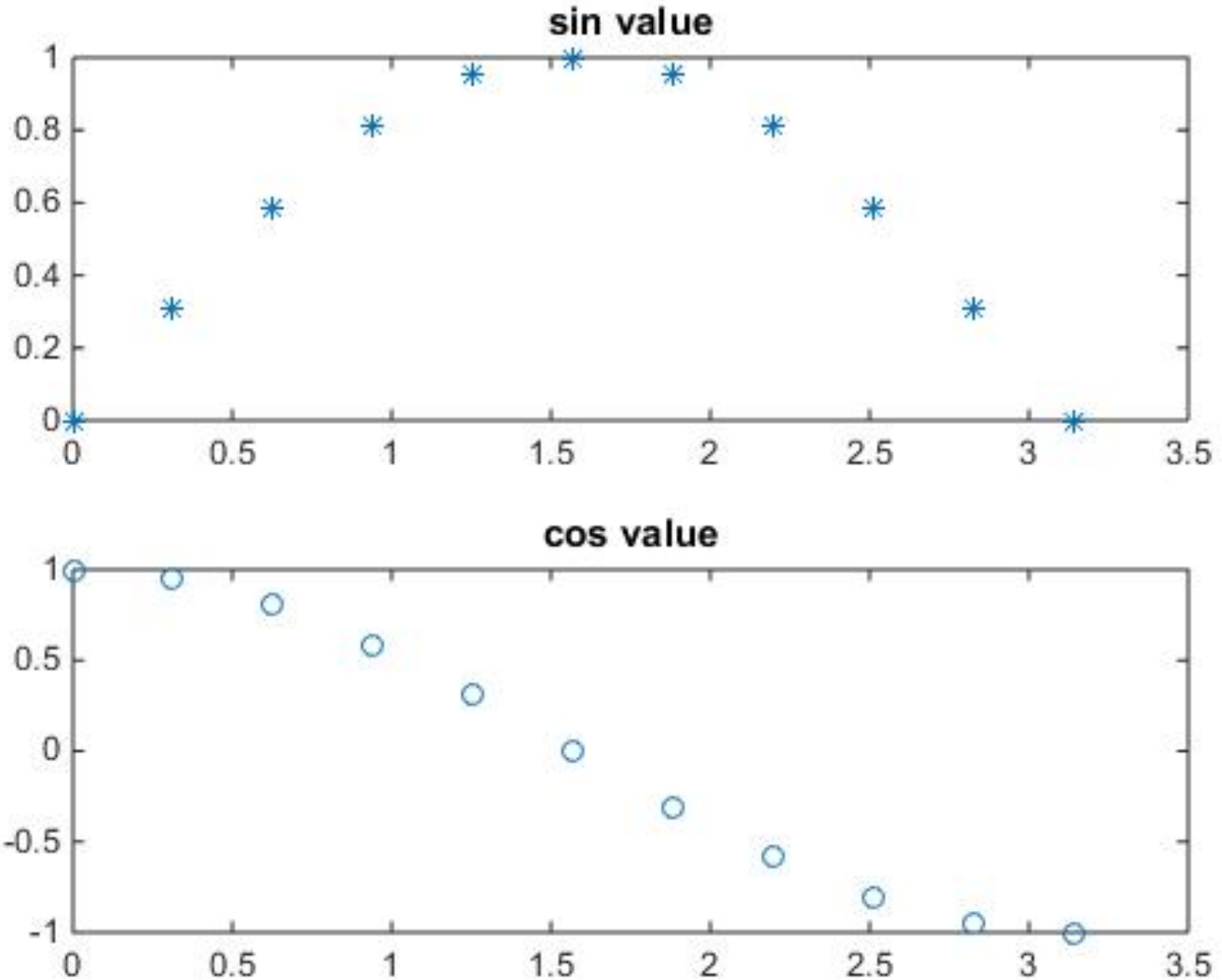
Output



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Split Figure contd.

```
figure
subplot(2,2,1);
plot(x,val1,'+');
title('sin');
subplot(2,2,2)
plot(x,val2,'-');
title('cos')
subplot(2,2,3);
plot(x,val3,'*');
title('tanh')
subplot(2,2,4);
plot(x,val4,'.')
title('sinh')
```

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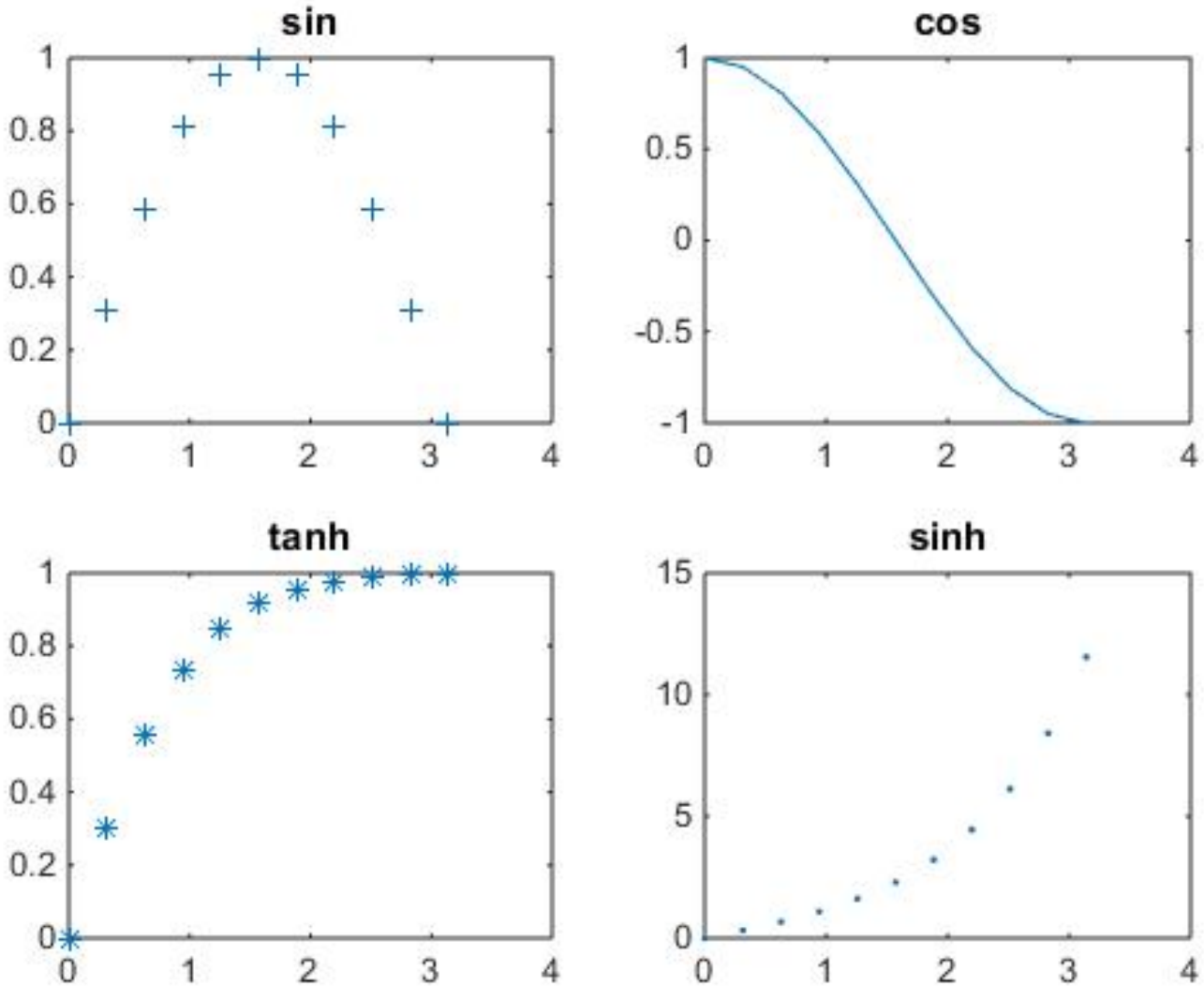
Output



Split Figure contd.

```
figure
subplot(2,2,1)
plot(x,val1,'+');
title('sin');
subplot(2,2,2)
plot(x,val2,'-');
title('cos')
subplot(2,2,[3,4]);
plot(x,val3,'*');
title('tanh')
```

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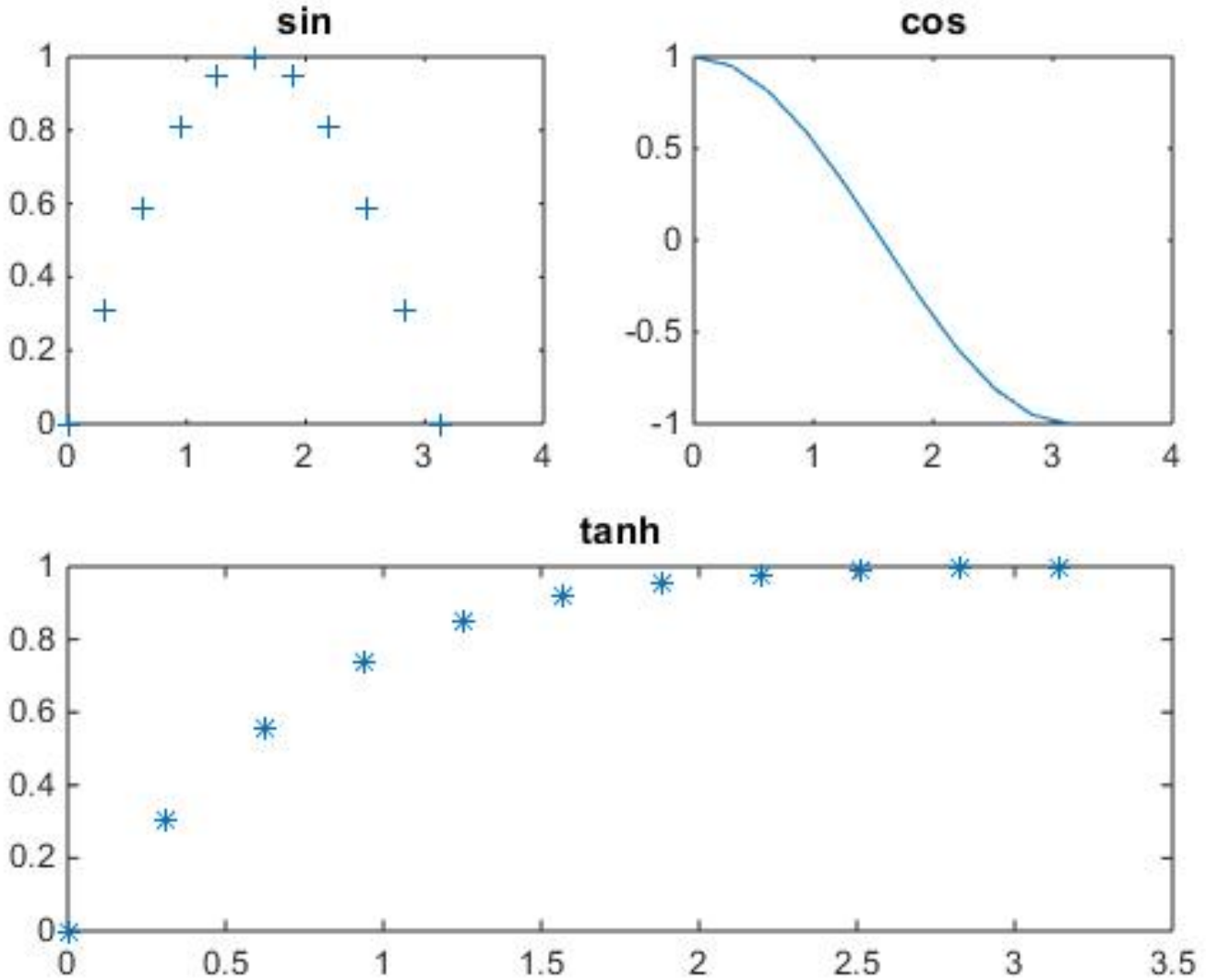
Output



Solving Differential equations

Solve the differential equation $\frac{dx}{dt} = xt$

Follow the below steps to solve equation in MATLAB

1. syms x(t) % Define variable x %
2. eq=diff(x,t)-x*t==0 % Define differential equation%
3. xsol(t)=dsolve(eq) % Solve differential equation%

Output
xsol(t) =
$C2 * exp(t^2/2)$

Solving Differential equations with initial conditions

Solve the differential equation $\frac{dx}{dt} = xt$ with initial condition x(0)=10

Follow the below steps to solve equation in MATLAB

1. syms x(t) % Define variable x %
2. eq=diff(x,t)-x*t==0 % Define differential equation%
3. cond=x(0)==10;% Define initial condition%
4. xsol(t)=dsolve(eq,cond) % Solve differential equation%

Output
xsol(t) =
$10 * exp(t^2/2)$

Solving higher order differential equations with initial conditions

Solve the differential equation $\frac{d^3x}{dt^3} = x$ with initial condition x(0)=10 x'(0)=-10 x''(0)=Π

Follow the below steps to solve equation in MATLAB

1. syms x(t) % Define variable x %
2. Dx=diff(x,t);
3. D2x=diff(x,t,2);
4. eq=diff(x,t,3)-x==0 % Define differential equation%
5. cond1=x(0)==10;
6. cond2=Dx(0)==-10;
7. cond3=D2x(0)==pi;
8. cond=[cond1 cond2 cond3];% Define initial condition%
9. xsol=dsolve(eq,cond) % Solve differential equation%

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Output

$$\text{xSol} =$$
$$(pi * exp(t))/3 - exp(-t/2) * cos((3^(1/2) * t)/2) * (pi/3 - 10) - (3^(1/2) * exp(-t/2) * sin((3^(1/2) * t)/2) * (pi + 10))/3$$

Numerical Integration - int command

syms Variable
Write Function
Output=int(Function,LowerLimit,UpperLimit)
Example:
syms t (Represent Variable)
i=0.1*(exp(0.2.*t)-1) (Function)
q=int(i,0,10); (Integration Format)

Numerical Integration - quad command

First create a MATLAB function which return a function which needs to be integrate

function output=functionname(variable)
output=Write function which needs to be integrate
end

For integration use the following code
q=quad('functionname',lowerlimit,upperlimit)

Example:
function i=current(t)
i=0.1*(exp(0.2.*t)-1)
end
q=quad('current',0,10)

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Numerical Integration - integral command

Define function as below

fun=@(variable)f(variable)
Calculate integral of function as below

sol=integral(fun,LowerLimit,UpperLimit)

Example:
fun=@(t)0.1*(exp(0.2.*t)-1)
q=integral(fun,0,10)

Numerical Integration - Example

Find $\int_0^{\Pi/2} sin(x)dx$

Use the following code in MATLAB

1. fun=@(x) sin(x) % Create function %
2. sol=integral(fun,0,pi/2) % for solving %

Output
sol =
1.0000

Solving linear programming problem

In linear programming problem both objective function and constraints are linear in control variables
Convert the linear programming problem in below format

$$\begin{aligned} min \quad & f^T V \\ CfM_{ieq} V &\leq CoM_{ieq} \\ CfM_{eq} V &= CoM_{eq} \\ lb &\leq V \leq ub \end{aligned} \tag{6}$$

linprog function

linprog function has been used to solve linear programming problem in MATLAB

Syntax [x,fval,exitflag] = linprog(f, CfM_{ieq}, CoM_{ieq}, CfM_{eq}, CoM_{eq},lb,ub,x0,options)

x:optimal solution

fval:objective function value at optimal solution

x0:Starting point

linprog function

options

'interior-point'

'dual-simplex'

'active-set'

'simplex'

exitflag

1 Function converged to a solution x.

0 Number of iterations exceeded options.MaxIter.

-2 No feasible point was found.

-3 Problem is unbounded.

-4 NaN value was encountered during execution of the algorithm

-5 Both primal and dual problems are infeasible.

-7 Search direction became too small. No further progress could be made.

Example

Let us consider following linear programming problem

$$
\begin{aligned}
min \quad & 2v_1 + 3v_2 + 4v_3 \\
st. \quad & \\
& 3v_1 + 2v_2 - 1v_3 \leq 20 \\
& -1v_1 - 3v_2 - 5v_3 \leq -40 \\
& v_1 + v_2 + v_3 = 18 \\
& v_1 \geq 0 \quad v_2 \geq 0 \quad v_3 \geq 0
\end{aligned} \tag{7}
$$

Develop matrices based on objective and constraints

$$f = \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix}$$

$$CfM_{ieq} = \begin{bmatrix} 3 & 2 & -1 \\ -1 & -3 & -5 \end{bmatrix}$$

$$CoM_{ieq} = \begin{bmatrix} 20 \\ -40 \end{bmatrix}$$

$$CfM_{eq} = \begin{bmatrix} 1 & 1 & 1 \end{bmatrix}$$

$$CoM_{eq} = \begin{bmatrix} 18 \end{bmatrix}$$

$$lb = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

Find solution using linprog

use the below code to find optimal solution of a given problem

[x,fval,exitflag] =
linprog(f, CfM_{ieq}, CoM_{ieq}, CfM_{eq}, CoM_{eq},lb,[],[],'simplex')

Output

Optimization terminated.
x =
9.5000
0.0000
8.5000
fval =
53.0000
exitflag =
1

Read the data from matlab file

Open a new MATLAB editor file

Write the data a below

Item	Price
1	20
2	25
3	30

Save the MATLAB file as readfile.m

To call the data available in readfile.m use below code

```
ip=fopen('readfile.m','r++');
itemprice=fscanf(ip,'%d',[2,3]);
```

$$itemprice = \begin{bmatrix} 1 & 2 & 3 \\ 20 & 25 & 30 \end{bmatrix}$$

Write the data in to a matlab file

Open a new MATLAB editor file

save that file as writefile.m

```
% Read the input %
ip=fopen('readfile.m','r++');
itemprice=fscanf(ip,'%d',[2,3]);
n=size(itemprice,2);
item=input('enter item code');
quantity=input('enter quantity');
for i=1:n
if(i==item)
Amount=itemprice(2,i)*quantity;
break;
end
end
```


Contd.

```
% print bill into writefile %
bill=fopen('writefile.m','w++');
fprintf(bill,'==========================\n');
fprintf(bill,'HOTEL MEGHALAYA\n');
fprintf(bill,'==========================\n');
fprintf(bill,'Amount=% d INR\n',Amount);
fprintf(bill,'==========================\n');
```

Now open writefile, we can see output as below

```
==========================
HOTEL MEGHALAYA
==========================
Amount=75 INR
==========================
```

TUTORIALS

Tutorial-1

Write MATLAB code for the requirements of a person who sitting at the cash counter as shown below

- Read itemcode and corresponding price from a Mfile
- Read total number of items required
- Read item code and quantity
- Generate bill as shown below in a new Mfile

itemcode	price
1	20
2	25
3	30
4	40

AIM: To understand Assignment, Reading data from Mfile, Writing data in to a Mfile, functioning of for and while loops, usage of 'fprintf' and Matrix operation

Tutorial-1:Output

==========

HOTEL VAISHNAVI

==========

itemcode qunatity price amount

==========

1 2 20 40
2 2 25 50
3 2 30 60

==========

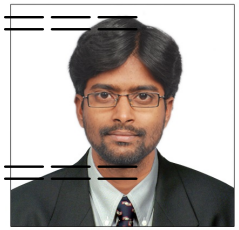
Total Amount=150

==========

==========

THANK YOU & VISIT AGAIN

==========



Tutorial-2

Write the matlab code for following requirements

1. To generate 10 combinations of x,y and z values
2. To compute the value of $obj = \frac{2x+3y}{4z}$ for each combination
3. To identify combination of (x,y,z) which gave minimum value of obj and what is the value of minimum obj
4. To identify combination of (x,y,z) which gave maximum value of obj and what is the value of maximum obj

variable	Lower limit	Upper limit
x	10	30
y	15	25
z	20	40

AIM: To understand generation of random values, sorting operation

Tutorial-3

- Solve the below linear equations using methods 1, 2, 3, and 4

$$\begin{aligned} 3x - y &= 7 \\ 23 + 3y &= 1 \end{aligned} \tag{8}$$

Solution x=2 and y=-1

AIM: To understand matrix inversion operation, linsolve and solve functions

Tutorial-4

Solve the differential equation shown below

$$\frac{d^2y}{dx^2} = cos(2x) - y \tag{9}$$

Initial Conditions
y(0)=1;
y'(0)=0;

Solution
$1 - (8 * (sin(x/2))^4)/3$

Tutorial 5

Find the integral of below equation

$$f(x) = \frac{1}{x^3 - 2x - 5} \tag{10}$$

$$\int_0^2 f(x)dx$$

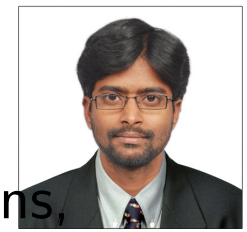
Solution
-0.4605

Tutorial 6

1. Write a function which take angle(in radians) as input and returns sin,cos,tan,sinh and cosh of angle
2. Write a function which take angle(in degrees) as input and returns sin,cos,tan,sinh and cosh of angle
3. Write a function which take matrices A and B as input and returns inverse, transpose, determinant and eigen values of those matrices and test all above functions

$$A = \begin{matrix} 4 & 7 \\ 2 & 6 \end{matrix}$$

$$B = \begin{matrix} 1 & 2 & 3 \\ 0 & 4 & 5 \\ 1 & 0 & 6 \end{matrix}$$



AIM: To understand creation of functions and testing of functions, Trigonometric functions and operations on matrices

Tutorial-7

A	B	C	D
1	18358	14960	
2	18012	14476	
3	17795	13979	
4	17559	13670	
5	17402	13567	
6	17520	13787	
7	17698	13944	
8	18103	14244	
9	18119	14363	
10	18827	14846	
11	18968	15331	
12	18813	15637	
13	19194	15840	
14	19344	15977	
15	19156	16030	
16	19182	16139	
17	19663	16682	
18	20678	18002	
19	20522	17664	
20	20237	17337	
21	19967	16961	
22	19343	16317	
23	18699	15504	
24	17941	14682	

Tutorial-7 contd.

Enter the data in excel as shown in previous slide and assign name as 'Tutorial7'

Extract the data from excel to a variable 'plottut' in matlab

Draw the plot between A and B

Draw the bar between A and C

Draw the 3D plot between A, B and c

AIM: To understand extract data from excel, drawing the plot graph, bar graph and 3D graph

Tutorial-8

Solve below linear programming problem using MATLAB

$$\begin{aligned} \textit{Maximize} \quad Z = f(x,y) &= 3x + 2y \\ 2x + y &\leq 18 \\ -2x - 3y &\geq -42 \\ -3x - y &\geq -24 \\ x \geq 0, y &\geq 0 \end{aligned} \tag{11}$$

Solution

x =

4.2857

11.1429

Tutorial-9

Develop simulink model to estimate the energy price due to any household appliance by considering follwing inputs

- household appliance code
- household appliance manufacturer code
- Number of items having that code
- Usage hours per day
- Number of days

Consider price per unit 1.50 INR if number of units less than 50 otherwise 2.50 INR

Tutorial-9 contd.

1 *tube* 2 *cfl* 3 *fan* 4 *cooler* (Appliance)

10 *W* 20 *X* 30 *Y* 40 *Z* (Manufacturer)

Table : Power Rating in Watts

	Manufacturer			
Appliance	10	20	30	40
1	40	35	30	45
2	25	20	35	30
3	50	65	75	70
4	100	90	95	80

AIM: Usage of lookup table

References:

MathWorks, I. (2005).

MATLAB: the language of technical computing. Desktop tools and development environment, version 7, volume 9.

MathWorks.

Patnaik, P. (2013).

Load frequency control in a single area power system.

PhD thesis.

Sandberg, K. (2000).

Introduction to image processing in matlab.

Department of Applied Mathematics, University of Colorado at Boulder, http://amath. colorado. edu/courses/4720/2000Spr/Labs/Worksheets/Matlab_tutorial/matlabimpr. html.


Thank you!