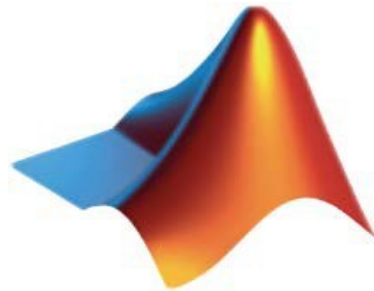


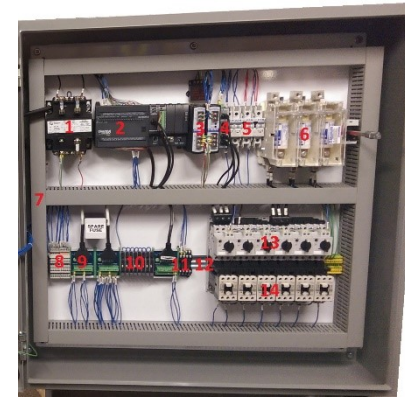


EEC380: Industrial Training (1)

Summer 2020



MATLAB



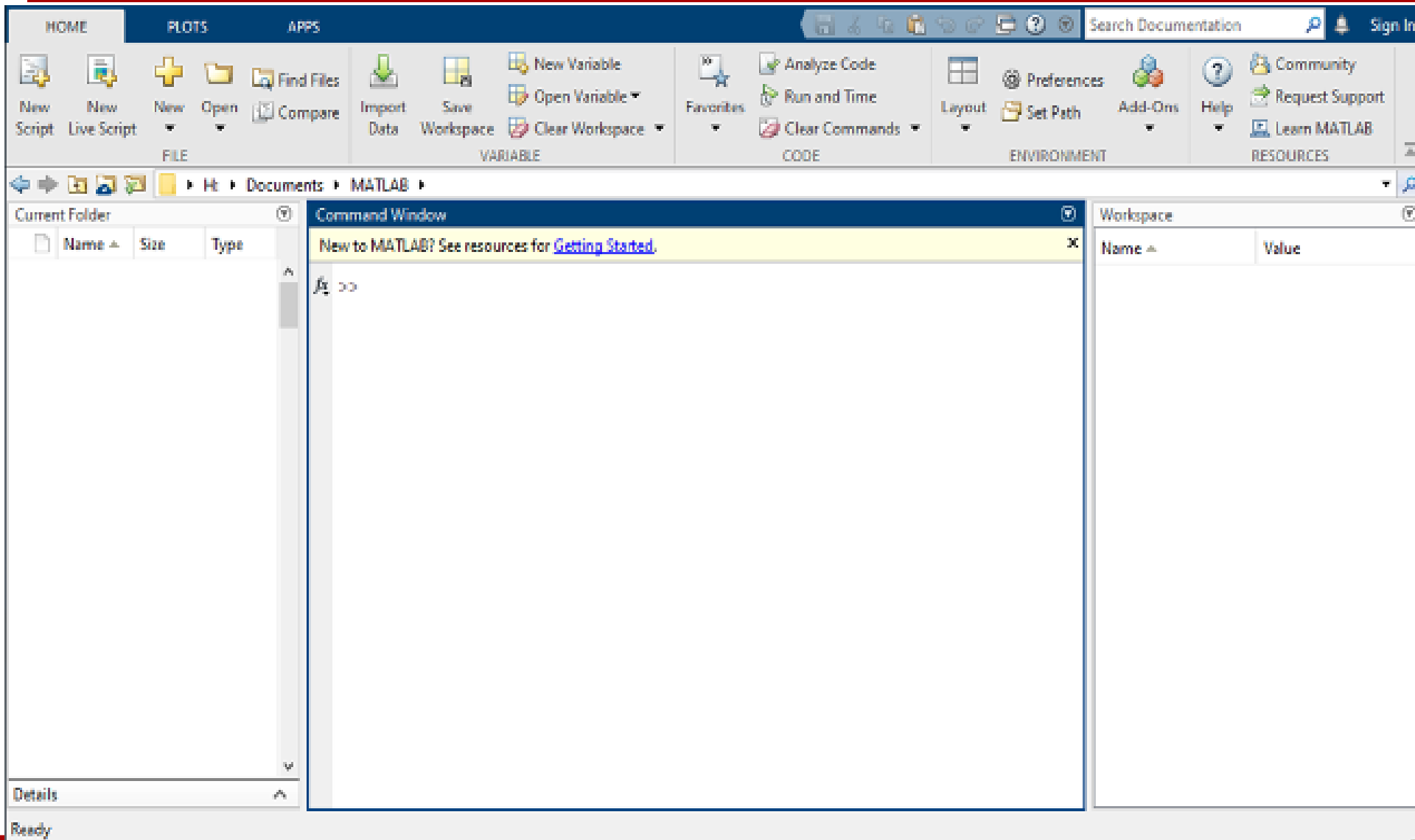
Industrial Control

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Outline

- Starting with MATLAB
- Operators and Math Functions
- MATLAB Commands
- Matrices and Selection Elements
- Matrix Operations
- Special Arrays
- Examples
- Assignment (1)

Starting with MATLAB



Operators and Math Functions

$$\square a1 = 3 + 5 + 2$$

$$\square a2 = 4 \times 22 + 6 \times 48 + 2 \times 82$$

$$\square a3 = 4^3$$

$$\square A = a1 + b2 \times c3$$

$$\square b1 = 2^2 + 3^2$$

$$\square b2 = (3 + 5)^2$$

$$\square b3 = 6/3 + 1/4$$

Operators and Math Functions

$$\square c1=6\sqrt[3]{+ 1\sqrt[4]}$$

$$\square c2=(4+3)^{1/5}$$

$$\square c3=(2+3)^{1\sqrt[5]}$$

$$\square d=6/3$$

$$\square d1=6\sqrt[3]$$

$$\square 3 e^d$$

$$\square 3 \ln(d)$$

$$\square 3 \sin(d1)$$

Operators and Math Functions

$$\square x = \sqrt{2}/2$$

$$\square y = (1/\sqrt{2\pi}) e^{-x/2}$$

$$\square z = 20 \log_{10} y$$

➤ Execute by yourself:

$$B2 = (3.5 (5-4)^3 / 6 - 4.2 \times 7 / (5+4)^{0.25}) / (3+2^4)^{0.5}$$

MATLAB Commands

- (a) `clc`, `clear`, `clf`, ...,
- (b) `help`, `doc`, `lookfor`
- (c) `abs(x)`, `sign(x)`,
- (d) `round`, `fix`, `ceil`, `floor`
- (e) `angle`, `real`, `imag`, `conj`
- (f) `date`, `clock`
- (g) `linspace`, `logspace`,

Matrices

- you create a matrix by entering elements in each row as comma or space delimited numbers and using semicolons to mark the end of each row.
 - ✓ For example, let us create a 4-by-5 matrix A


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

```
A =
```

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


Matrices

Referencing the Elements of a Matrix :

To reference an element in the m^{th} row and n^{th} column, of a matrix A , we write  $A(m, n)$

For example, to refer to the element in the 2nd row and 5th column, of the matrix A

```
>> A(2,5)
```

```
ans =
```

```
6
```

```
A =
```

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

Matrices

Referencing the Elements of a Matrix :

To reference all the elements in the m^{th} column we type $A(:,m)$.

Let us create a column vector v , from the elements of the 4th row of the matrix A

```
>> v=A(:,4)
```

```
v =
```

```
4  
5  
6  
7
```

```
A =
```

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

Matrices

Referencing the Elements of a Matrix :

You can also select the elements in the m^{th} through n^{th} columns, for this we write $\rightarrow A(:, m:n)$

```
>> v=A(:,2:3)
```

```
v =
```

```
2 3
3 4
4 5
5 6
```

```
A =
```

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

In the same way, you can create a sub-matrix taking a sub-part of a matrix

```
>> V=A(2:3,2:4)
```

```
V =
```

```
3 4 5
4 5 6
```

Matrices

Deleting a Row or a Column in a Matrix:

You can delete an entire row or column of a matrix by assigning an empty set of square braces [] to that row or column.

Basically, [] denotes an empty array.

For example, let us delete the fourth row of A

```
>> A(:,4)=[]
```

A =	1	2	3	4	5
	2	3	4	5	6
	3	4	5	6	7
	4	5	6	7	8

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

Matrix Operations

Matrix Operations

Addition and Subtraction of Matrices

Division of Matrices

Scalar Operations of Matrices

Transpose of Matrix

Concatenating Matrices

Matrix Multiplication

Determinant of a Matrix

Inverse of a Matrix

Matrix Operations

1. Addition and Subtraction of Matrices :

You can add or subtract matrices. Both the operand matrices must have the same number of rows and columns.

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

```
b = [ 7 5 6 ; 2 0 8; 5 7 1];
```

```
c = a + b
```

```
d = a - b
```

```
c =
```

```
      8      7      9
      6      5     14
     12     15     10
```

```
d =
```

```
     -6     -3     -3
      2      5     -2
      2      1      8
```

Matrix Operations

2. Division of Matrices:

You can divide two matrices using left (\) or right (/) division operators. Both the operand matrices must have the same number of rows and columns.

```
>> a = [ 1 2 ; 2 2 ];
```

```
b = [ 3 2 ; 1 1 ];
```

```
c = a / b
```

```
d = a \ b
```

```
d =
```

```
    -1     4  
     0     2
```

```
c =
```

```
   -2.0000   -1.0000  
    2.5000    1.5000
```

Matrix Operations

3. Scalar Operations of Matrices :

When you add, subtract, multiply or divide a matrix by a number, this is called the **scalar operation**.

Scalar operations produce a new matrix with same number of rows and columns with each element of the original matrix added to, subtracted from, multiplied by or divided by the number.

Matrix Operations

```
>> a = [ 10 12 23 ; 14 8 6; 27 8 9];
```

```
b = 2;
```

```
c = a + b
```

```
d = a - b
```

```
e = a * b
```

```
f = a / b
```

```
c =
```

12	14	25
16	10	8
29	10	11

```
d =
```

8	10	21
12	6	4
25	6	7

```
e =
```

20	24	46
28	16	12
54	16	18

```
f =
```

5.0000	6.0000	11.5000
7.0000	4.0000	3.0000
13.5000	4.0000	4.5000

Matrix Operations

4. Transpose of Matrix :

The transpose operation switches the rows and columns in a matrix. It is represented by a single quote(').

```
>> a = [ 10 12 23 ; 14 8 6 ; 27 8 9]
```

```
b = a'
```

```
a =
```

```
10    12    23
14     8     6
27     8     9
```

```
b =
```

```
10    14    27
12     8     8
23     6     9
```

Matrix Operations

5. Concatenating Matrices :

You can concatenate two matrices to create a larger matrix. The pair of square brackets '['']' is the concatenation operator.

MATLAB allows two types of concatenations :-

1. Horizontal concatenation
2. Vertical concatenation

When you concatenate two matrices by separating those using commas, they are just appended horizontally. It is called horizontal concatenation.

Alternatively, if you concatenate two matrices by separating those using semicolons, they are appended vertically. It is called vertical concatenation

Matrix Operations

```
>> a = [ 10 12 23 ; 14 8 6 ; 27 8 9]
```

```
b = [ 12 31 45 ; 8 0 -9 ; 45 2 11]
```

```
c = [a, b]
```

```
d = [a; b]
```

a =

10	12	23
14	8	6
27	8	9

b =

12	31	45
8	0	-9
45	2	11

c =

10	12	23	12	31	45
14	8	6	8	0	-9
27	8	9	45	2	11

d =

10	12	23
14	8	6
27	8	9
12	31	45
8	0	-9
45	2	11

Matrix Operations

6. Matrix Multiplication :

Consider two matrices A and B. If A is an $m \times n$ matrix and B is an $n \times p$ matrix, they could be multiplied together to produce an $m \times p$ matrix C. Matrix multiplication is possible only if the number of columns n in A is equal to the number of rows n in B.

```
>> a = [ 1 2 3 ; 2 3 4 ; 1 2 5] ;  
b = [ 2 1 3 ; 5 0 -2 ; 2 3 -1] ;  
prod = a * b
```

```
prod =
```

```
18    10    -4  
27    14    -4  
22    16    -6
```

Matrix Operations

7. Determinant of a Matrix :

Consider two matrices A and B. If A is an $m \times n$ matrix and B is an $n \times p$ matrix, they could be multiplied together to produce an $m \times p$ matrix C. Matrix multiplication is possible only if the number of columns n in A is equal to the number of rows n in B.

```
>> a = [ 1 2 3 ; 2 3 4 ; 1 2 5] ;  
b = [ 2 1 3 ; 5 0 -2 ; 2 3 -1] ;  
prod = a * b
```

```
prod =
```

```
    18    10    -4  
    27    14    -4  
    22    16    -6
```

Matrix Operations

8. Inverse of a Matrix :

Inverse of a matrix in MATLAB is calculated using the **inv** function.
Inverse of a matrix A is given by $\text{inv}(A)$

```
>> a = [ 1 2 3 ; 2 3 4 ; 1 2 5]  
inv(a)
```

```
a =
```

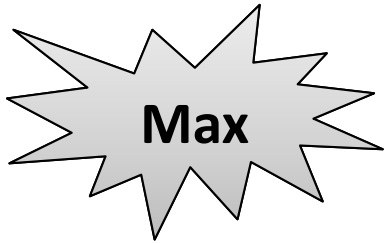
```
1     2     3  
2     3     4  
1     2     5
```

```
ans =
```

```
-3.5000    2.0000    0.5000  
 3.0000   -1.0000   -1.0000  
-0.5000         0    0.5000
```

Matrix Operations

OBTAINING INFORMATION ABOUT MATRIX PROPERTIES:



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

```
>> max(A)
```

```
A =
```

```
1     1     2
1     4     1
3     1     1
```

```
ans =
```

```
3     4     2
```

```
>> max(max(A))
```

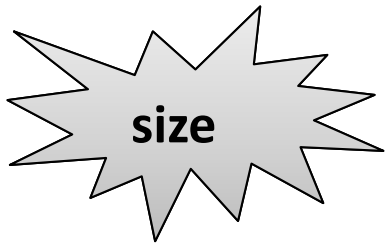
```
ans =
```

```
4
```



Matrix Operations

OBTAINING INFORMATION ABOUT MATRIX PROPERTIES:



```
>> A=[ 1 1 2 ; 1 4 1 ; 3 1 1 ];  
>> size(A)
```

```
ans =  
  
     3     3
```

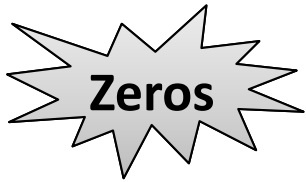


```
>> A=[ 1 1 2 ; 1 4 1 ; 3 1 1 ];  
>> whos A
```

Name	Size	Bytes	Class
A	3x3	72	double

Special Arrays

All variables of all data types in MATLAB are multidimensional arrays. A vector is a one-dimensional array and a matrix is a two-dimensional array.



```
>> zeros(3)
```

```
ans =
```

```
0     0     0
0     0     0
0     0     0
```

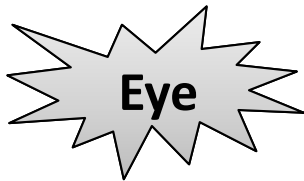


```
>> ones(3,2)
```

```
ans =
```

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

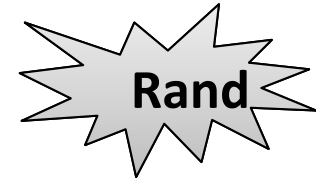
Special Arrays



```
>> eye(4)
```

```
ans =
```

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



```
>> rand(3,2)
```

```
ans =
```

```
    0.8147    0.9134
    0.9058    0.6324
    0.1270    0.0975
```

Special Arrays

Special Arrays in MATLAB



A **magic square** is a square that produces the same sum, when its elements are added row-wise, column-wise or diagonally.

```
ans =  
  
>> magic(3)      8      1      6  
                  3      5      7  
                  4      9      2
```

Examples

1. If $X=2$, $Y=5$, $a=1.12$, $b=2.34$, $c=0.72$, $d=0.81$, and $f=0.45$, write the following equations correctly using MATLAB:-

$$W1 = X + Y^3 ,$$

$$W2 = \frac{3X^2}{X+Y} ,$$

$$W3 = \frac{X^5}{X^5 - 1} ,$$

$$W4 = 1 + \frac{a}{b} + \frac{c}{f} ,$$

$$W5 = \frac{1}{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}} ,$$

$$W6 = ab \frac{1}{c} \frac{f^2}{2} ,$$

$$W7 = a(b + c(c + d))a ,$$

$$W8 = a + d \sin 60^\circ / b$$

Examples



Answer

```
>> X=2; Y=5; a=1.12; b=2.34; c=0.72; d=0.81; f=0.45;
```

```
>> W1=X+Y^3
```

W1 =127

```
>> W2=3*X^2/(X+Y)
```

W2 =1.7143

```
>> W3=X^5/(X^5-1)
```

W3 =1.0323

```
>> W4=1+a/b+c/f
```

W4 =3.0786

```
>> W5=1/(1/a+1/b+1/c+1/d)
```

W5 =0.2536

```
>> W6=a*b*1/c*f^2/2
```

W6 =0.3686

```
>> W7=a*(b+c*(c+d))*a
```

W7 =4.3171

```
>> W8=a+d*sind(60)/b
```

W8 =1.4198

Examples

2. Use MATLAB to create a 3×3 identity matrix.
3. Use MATLAB to create a 4×4 matrix whose elements are all ones.
4. Use MATLAB to create 3×3 diagonal matrix whose diagonal elements are 3, 7, 13.
5. Use MATLAB to create a 5×5 matrix (X) whose elements are generated by a uniformly distributed pseudo-random number generator.
6. Use MATLAB to create a new matrix (Y) whose elements are the last two columns of the matrix obtained in Problem 5 (i.e. remove the first three columns).

Examples



Answer

2. Use MATLAB to create a 3×3 identity matrix.

```
>>eye(3,3)
```

3. Use MATLAB to create a 4×4 matrix whose elements are all ones.

```
>>ones(4,4)
```

4. Use MATLAB to create 3×3 diagonal matrix whose diagonal elements are 3, 7, 13.

```
>>diag([3,7,13])
```

5. Use MATLAB to create a 5×5 matrix (X) whose elements are generated by a uniformly distributed pseudo-random number generator.

```
>>X=rand(5,5)
```

6. Use MATLAB to create a new matrix (Y) whose elements are the last two columns of the matrix obtained in Problem 5 (i.e. remove the first three columns).

```
>>Y=X(:,[4,5])
```


Examples

7. From the given matrices **A**, **B**, and **C** find the following:-

$$A = \begin{bmatrix} 1 & 4 \\ 2 & 5 \\ 3 & 6 \end{bmatrix}, \quad B = \begin{bmatrix} 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix}, \quad C = [7 \ 8]$$

- I. Extract the second, third and fourth elements of the **B** vector and store them in a new vector (say **D**)
- ii. Create a new row vector (say **E**) from vector **B** and the number 3 such that $E = [3 \ 9 \ 7 \ 5 \ 3 \ 1]$

- iii. Create a new matrix (say **F**) from matrix **A**, vector **C** and the number 9 such that

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

Examples



$$A = \begin{bmatrix} 1 & 4 \\ 2 & 5 \\ 3 & 6 \end{bmatrix}, \quad B = \begin{bmatrix} 9 \\ 7 \\ 5 \\ 3 \\ 1 \end{bmatrix}, \quad C = [7 \ 8]$$

- I. Extract the second, third and fourth elements of the **B** vector and store them in a new vector (say **D**)

```
>> D=B(2:4)
```

- ii. Create a new row vector (say **E**) from vector **B** and the number 3 such that $E = [3 \ 9 \ 7 \ 5 \ 3 \ 1]$

```
>> E=[3 B']
```

- iii. Create a new matrix (say **F**) from matrix **A**, vector **C** and the number 9 such that

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

```
>> F=[A';c 9]
```

Examples

8. From the matrix F in problem (7-iii), find the following:-

- a) Extract the third column of the matrix F
- b) Extract the last two elements of the matrix F
- c) Convert the F matrix into a long column vector whose elements are the columns of the matrix F stacked one by one under each other.
- d) Extract the lower triangular part of the matrix F .

Examples

8. From the matrix **F** in problem (7-iii), find the following:-

a) Extract the third column of the matrix **F**

```
>>F(:,3)
```

b) Extract the last two elements of the matrix **F**

```
>>F([8,9])
```

c) Convert the **F** matrix into a long column vector whose elements are the columns of the matrix **F** stacked one by one under each other.

```
>>F(:)
```

d) Extract the lower triangular part of the matrix **F**.

```
>> tril(F)
```

Assignment (1)

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End of Lecture

Thank you for attention!
Any questions?

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