Introduction to Engineering
MATLAB – 4
Array Operations

Agenda

- Array Operations

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ARITHMETIC OPERATIONS WITH ARRAYS

Addition and subtraction

The operations + (addition) and - (subtraction) can be used with scalars or arrays. HOWEVER, only arrays with identical size can be added or subtracted.

The sum, or difference, of two arrays is obtained by adding, or subtracting, their corresponding elements.

```
>> A=[5 -3; 9 2]
A =
    5   -3
    9    2

>> B=[10 9; -11 15]
B =
   10    9
  -11   15
```

```
>> C=A+B
C =
   15    6
   -2   17

>> A-B
ans =
   -5  -12
   20  -13
```

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ARITHMETIC OPERATIONS WITH ARRAYS

Matrix multiplication and division * / and \

A*B follows the multiplication rules of matrices. It is defined only if the number of columns in A is equal to the number of rows in B.

/ is the left division.

A/B = A*B^{-1} It can be applied to square matrices A and B of the same size (B^{-1} is the inverse of B).

\ is the right division. It is used to solve a matrix equation.

If: A*x = b (A, x, and b are matrices)

Then: x = A\b

(The operations presented in this slide will not be used in the IE-182 course)

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ARITHMETIC OPERATIONS WITH ARRAYS

Element-by-element multiplication, division, and exponentiation .* ./ and .^

Element-by-element operations between two vectors or matrices is done by typing a period (.) in front of the arithmetic operator. Both must be of the same size.

Definition of element-by-element operations for vectors:

If: $a = [a_1\ a_2\ a_3\ a_4]$ and $b = [b_1\ b_2\ b_3\ b_4]$

Then: $a .* b = [a_1b_1\ a_2b_2\ a_3b_3\ a_4b_4]$

$a ./ b = [a_1/b_1\ a_2/b_2\ a_3/b_3\ a_4/b_4]$

$a .\hat{} b = [a_1\hat{}b_1\ a_2\hat{}b_2\ a_3\hat{}b_3\ a_4\hat{}b_4]$

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ARITHMETIC OPERATIONS WITH ARRAYS

Definition of element-by-element operations for matrices:

If: $d = \begin{bmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{bmatrix}$ and $e = \begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ e_{31} & e_{32} & e_{33} \end{bmatrix}$

Then:

$$d .* e = \begin{bmatrix} d_{11}e_{11} & d_{12}e_{12} & d_{13}e_{13} \\ d_{21}e_{21} & d_{22}e_{22} & d_{23}e_{23} \\ d_{31}e_{31} & d_{32}e_{32} & d_{33}e_{33} \end{bmatrix} \qquad d ./ e = \begin{bmatrix} d_{11}/e_{11} & d_{12}/e_{12} & d_{13}/e_{13} \\ d_{21}/e_{21} & d_{22}/e_{22} & d_{23}/e_{23} \\ d_{31}/e_{31} & d_{32}/e_{32} & d_{33}/e_{33} \end{bmatrix}$$

$$d .\hat{} 2 = \begin{bmatrix} (d_{11})^2 & (d_{12})^2 & (d_{13})^2 \\ (d_{21})^2 & (d_{22})^2 & (d_{23})^2 \\ (d_{31})^2 & (d_{32})^2 & (d_{33})^2 \end{bmatrix}$$

Also:

$$6*e = 6 .* e = \begin{bmatrix} 6e_{11} & 6e_{12} & 6e_{13} \\ 6e_{21} & 6e_{22} & 6e_{23} \\ 6e_{31} & 6e_{32} & 6e_{33} \end{bmatrix}$$

Any number

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EXAMPLES

```
a =
    2    6    3
    5    8    4

>> b=[1, 4, 10; 3, 2, 7]
b =
    1    4   10
    3    2    7

>> a .* b
ans =
    2   24   30
   15   16   28
```

```
>> a ./ b
ans =
    2.0000    1.5000    0.3000
    1.6667    4.0000    0.5714

>> b .^ 3
ans =
     1    64  1000
    27     8   343
```

If you try a * b the response is an error since a and b can not be multiplied as matrices (the number of columns in a is not equal to the number of rows in b).

```
>> a * b
??? Error using ==> *
Inner matrix dimensions must agree.
```

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SOME USEFUL BUILT-IN ARRAY FUNCTIONS

MATLAB has many built-in functions that can be used with arrays. Some of them are:

max(A)	Returns the largest element in A, when A is a vector.
min(A)	Returns the smallest element in A, when A is a vector.
mean(A)	Returns the average value of the elements in A.
sum(A)	Returns the sum of the elements of A, when A is a vector.
length(A)	Returns the number of elements in A, when A is a vector.
sort(A)	Sorts the elements of A, when A is a vector.

The help menu gives information about many other functions.

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EXAMPLE

```
>> A = [8 2 9 5 14 10]
A =
    8    2    9    5   14   10

>> max(A)
ans =
   14

>> min(A)
ans =
    2
```

```
>> mean(A)
ans =
    8

>> sum(A)
ans =
   48

>> length(A)
ans =
    6
```

```
>> sort(A)
ans =
    2    5    8    9   10   14
```

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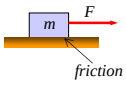
APPLICATIONS OF ELEMENT-BY-ELEMENT CALCULATIONS

Element-by-element calculations are useful in processing data and in calculating the value of a mathematical function at many points.

EXAMPLE OF PROCESSING DATA

The coefficient of friction μ is determined by measuring the force F required to move a mass m by $\mu = F / (mg)$ (g = 9.8 m/s^2).
Results from measuring F in five tests are given in the table.
Determine the coefficient of friction in each test, and the average from all tests.



Mass m (kg)	2	4	5	10	20	50
Force F (N)	12	23.5	30	60	117	294

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SOLUTION USING MATLAB:

```
>> % Enter m in a vector.
>> m = [2 4 5 10 20 50];
>> % Enter F in a vector.
>> F = [12.5 23.2 30 61 116 294];
>> % calculate the coefficient of friction.
>> meu = F./(9.8*m)
meu =
    0.6378    0.5918    0.6122    0.6224    0.5918    0.6000
>> % calculate the average of meu using the function mean.
>> meu_ave = mean(meu)
meu_ave =
    0.6094
```

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EXAMPLE OF CALCULATING THE VALUE OF A FUNCTION AT MANY POINTS.

For the function: $$y = \frac{x^2 - x}{x^2 + x + 1}$$

calculate y for x = -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, and 5.

SOLUTION USING MATLAB:

```
>> x = [-5:5]
x =
    -5    -4    -3    -2    -1     0     1     2     3     4     5
>> y = (x.^2-x)./(x.^2+x+1)
y =
    1.4286    1.5385    1.7143    2.0000    2.0000         0         0    0.2857
0.4615    0.5714    0.6452
```

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Assignment #4

- Do the problems below in the command window. Start each problem in a new (clear) window. The first two lines in each problem should be:
  - % First Last, CID
  - % MATLAB 4, Problem Number Page Number
- Submit the printout of the command window. Print each problem separately.
  - Problem 12 page 107 in the textbook.
  - Problem 16 page 108 in the textbook.
  - Problem 18 page 109 in the textbook.
  - 4. Use element-by-element calculations to calculate y for x = 0.6, 0.65, 0.7, 0.75, 0.8, and 0.85.

$$y = \frac{\pi x \sqrt{\pi^2 \left(1 - x^2\right) + 16x^2}}{\left(1 - x^2\right)^2}$$

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