COMPUTER APPLICATIONS

Mathematical Operations with Array

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ADDITION AND SUBTRACTION

- The operations + (addition) and – (subtraction) can be used to add and subtract arrays of identical size.
- They can also be used to add and subtract a scalar to an array.
- The matrix dimension MUST AGREE in addition and subtraction.

$$A = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \end{bmatrix} \text{ and } B = \begin{bmatrix} B_{11} & B_{12} & B_{13} \\ B_{21} & B_{22} & B_{23} \end{bmatrix}$$

$$\begin{bmatrix} (A_{11}+B_{11}) & (A_{12}+B_{12}) & (A_{13}+B_{13}) \\ (A_{21}+B_{21}) & (A_{22}+B_{22}) & (A_{23}+B_{23}) \end{bmatrix}$$

EXAMPL

>> A = [3 4 4; 2 6 3];   B = [2 -1 -8; -1 0 12];

>> C = A + B

C=

5	3	-4
1	6	15

>> A = [3 4 4; 2 6 3];   B = [2 -1 -8; -1 0 12];

>> D = A – B

D =

1	5	12
3	6	-9

ARRAY MULTIPLICATION

- The multiplication operation * is executed by MATLAB according to the rules of linear algebra.
- Suppose two matrices:

$$A = \begin{bmatrix} A_{11} & A_{12} & A_{13} \\ A_{21} & A_{22} & A_{23} \\ A_{31} & A_{32} & A_{33} \\ A_{41} & A_{42} & A_{43} \end{bmatrix} \text{ and } B = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \\ B_{31} & B_{32} \end{bmatrix}$$

- The Multiplication process is:

$$\begin{bmatrix} (A_{11}B_{11} + A_{12}B_{21} + A_{13}B_{31}) & (A_{11}B_{12} + A_{12}B_{22} + A_{13}B_{32}) \\ (A_{21}B_{11} + A_{22}B_{21} + A_{23}B_{31}) & (A_{21}B_{12} + A_{22}B_{22} + A_{23}B_{32}) \\ (A_{31}B_{11} + A_{32}B_{21} + A_{33}B_{31}) & (A_{31}B_{12} + A_{32}B_{22} + A_{33}B_{32}) \\ (A_{41}B_{11} + A_{42}B_{21} + A_{43}B_{31}) & (A_{41}B_{12} + A_{42}B_{22} + A_{43}B_{32}) \end{bmatrix}$$

ARRAY MULTIPLICATION

- % Multiplication of TWO matrices

  A = [1 2 3 4];

  B = [2 4 6 8];

  C = A * B   % What will be the execution of this operation??

```
>> % Try the following multiplications of matrix A and B
>> A = [ 1 2 3 4];
>> B = [2 4 6 8];
>> C = A * B
Error using  *
Inner matrix dimensions must agree.
```

WHY?!!

- % Multiplication of TWO matrices

  A = [1 2 3 4];

  B = [2; 4; 6; 8];

  C = A * B   % What will be the (

```
>> % Try the following multiplications of matrix A and B
>> A = [ 1 2 3 4];
>> B = [2; 4; 6; 8];
>> C = A * B

C =

    60
```

EXAMPLES

>> A = [1 2 3; 5 3 5; 6 2 2]; B = [2 2 2; 1 2 1; 3 2 3];

>> C = A*B;   %WHAT WILL BE THE ANSWER??!

>> D = A.*B;   %WHAT IS THE DIFFERENCE FROM C=A*B??!

ANSWER:

C =

13	***12***	***13***
28	***26***	***28***
20	***20***	***20***

D =

2	***4***	***6***
5	***6***	***5***
18	***4***	***6***

INVERSE AND MATRIX DIVISION

- To understand the terms "INVERSE", "LEFT DIVISION", and "RIGHT DIVISION", lets work on the following example:

Solve the following three linear equation to perform array division given below

$4x + 2y + 6z = 8$

$2x + 8y + 2z = 4$

$6x + 10y + 3z = 0$

$$\begin{bmatrix} 4 & -2 & 6 \\ 2 & 8 & 2 \\ 6 & 10 & 3 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 8 \\ 4 \\ 0 \end{bmatrix} \quad \text{or} \quad \begin{bmatrix} x & y & z \end{bmatrix} \begin{bmatrix} 4 & 2 & 6 \\ -2 & 8 & 10 \\ 6 & 2 & 3 \end{bmatrix} = \begin{bmatrix} 8 & 4 & 0 \end{bmatrix}$$

EXAMPLE SOLUTION

```
A = [4 -2 6; 2 8 2; 6 10 3];        % Defineing the equation elements in Matrix A.
B = [8; 4; 0];                      % Defining the equalities in a column matrix B.
% To perform "LEFT" division:
X_left = A\B;                       % In this equation "X_left" and "B" must be column vectors.
% To work on "RIGHT" division, both "X_right" and "B" must be row vectors:
% To do so, we need to "TRANSPORT" both arrays "A" and "B":
C = A';                             % The Transport of "A"
D = B';                             % The Transport of "B"
% To perform "RIGHT" division:
X_right = D/C;
A_inverse = inv(A);                 % Inverse matrix of "A"
```

MATLAB CODE EXECUTION

```
>> A

A =

     4    -2     6
     2     8     2
     6    10     3

>> B

B =

     8
     4
     0
```

```
>> X_left

X_left =

   -1.8049
    0.2927
    2.6341

>> X_right

X_right =

   -1.8049    0.2927    2.6341
```

```
>> A_inverse

A_inverse =

   -0.0244   -0.4024    0.3171
   -0.0366    0.1463   -0.0244
    0.1707    0.3171   -0.2195
```

LEFT AND RIGHT DIVISION WITH "INV"

```
A = [4 -2 6; 2 8 2; 6 10 3];          % Defineing the equation elements in Matrix A.
B = [8; 4; 0];                        % Defining the equalities in a column matrix B.
% To perform "LEFT" division using "INVERSE" property:
A_inverse = inv(A);
X_left = A_inverse*B;                 % Same of ----->>  "X_left = A\B;"
% To work on "RIGHT" division, both "X_right" and "B" must be row vectors:
% To do so, we need to "TRANSPORT" both arrays "A" and "B":
C = A';                               % The Transport of "A"
D = B';                               % The Transport of "B"
% To perform "RIGHT" division using "INVERSE" property:
C_inverse = inv(C);
X_right = D*C_inverse;                % Same of ------>>  "X_right = D/C;"
```

```
>> X_left

X_left =

   -1.8049
    0.2927
    2.6341

>> X_right

X_right =

   -1.8049    0.2927    2.6341
```

SOME BUILT-IN FUNCTIONS

```
A = [ 13 22 76 44 90 12 16 13];          % A one-dimensional array
mean(A)                                  % Find the average value of vector A
        ans = 35.7000
max(A);                                  % Find the largest elements among all elements in vector A
        ans = 90
min(A);                                  % Find the smallest elements among all elements in vector A
        ans = 12
sum(A);                                  % Adds all elements of vector A
        ans = 286
sort(A);                                 % Ascending arrangement
        ans = 12   13   13   16   22   44   76   90
median(A);                               % Median value of vector A
        ans = 19
std(A);                                  % Standard deviation of vector A
        ans = 31.1895
```

BUILD-IN FUNCTION WITH MATRIX

```
A = [1 2 3; 4 5 6];
B = [3 4 2; 5 3 5];
        mean(A)
                ans = 2.5000   3.5000   4.5000
        median(A)
                ans = 2.5000   3.5000   4.5000
        sum(A)
                ans = 5    7    9
        sort(A)
                ans =

                   1   2   3
                   4   5   6
```

THE "rand" COMMAND

Command	Description	Example

`rand`	Generates a single random number between 0 and 1.	`>> rand`
		`ans =`
		`0.2311`

`rand(1,n)`	Generates an n-element row vector of random numbers between 0 and 1.	`>> a=rand(1,4)`
		`a =`
		`0.6068 0.4860 0.8913 0.7621`

`rand(n)`	Generates an $n \times n$ matrix with random numbers between 0 and 1.	`>> b=rand(3)`
		`b =`
		`0.4565 0.4447 0.9218`
		`0.0185 0.6154 0.7382`
		`0.8214 0.7919 0.1763`

`rand(m,n)`	Generates an $m \times n$ matrix with random numbers between 0 and 1.	`>> c=rand(2,4)`
		`c =`
		`0.4057 0.9169 0.8936 0.3529`
		`0.9355 0.4103 0.0579 0.8132`

`randperm(n)`	Generates a row vector with n elements that are random permutation of integers 1 through n.	`>> randperm(8)`
		`ans =`
		`8 2 7 4 3 6 5 1`

THE "randi" COMMAND

Command	Description	Example

`randi(imax)`
(imax is an integer)
	Generates a single random number between 1 and imax.	`>> a=randi(15)`
		`a =`
		`9`

`randi(imax,n)`	Generates an $n \times n$ matrix with random integers between 1 and imax.	`>> b=randi(15,3)`
		`b =`
		`4 8 11`
		`14 3 8`
		`1 15 8`

`randi(imax,m,n)`	Generates an $m \times n$ matrix with random integers between 1 and imax.	`>> c=randi(15,2,4)`
		`c =`
		`1 1 8 13`
		`11 2 2 13`

HOME WORK I

- Generate a random matrix of dimensions of (5x7) with elements confined between 20 and 60 and then find the following:
  - The inverse of the matrix,
  - The largest and the smallest elements in row 3,
  - Evaluate the following expression:

$$A = \cos(x) + x^2 \sqrt[5]{x}$$

HOME WORK II

Define p and w as scalars, $p = 2.3$ and define $w = 5.67$, and, t, x, and y as the vectors $t = [1, 2, 3, 4, 5]$, $x = [2.8, 2.5, 2.2, 1.9, 1.6]$, and $y = [4, 7, 10, 13, 17]$. Then use these variables to calculate the following expressions using element-by-element calculations for the vectors.

(a) $T = \frac{p(x+y)^2}{y}w$

(b) $S = \frac{p(x+y)^2}{yw} + \frac{wxt}{py}$