

# Computing with MATLAB™

## Part 1



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## Outline

### The very basics of using MATLAB

Defining vectors and arrays to hold data

Basic calculations: addition, subtraction, etc.

Array computations versus matrix computations

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# Basic MATLAB operations

## Defining variables and simple arithmetic

MATLAB commands in black Courier. Comments in red Arial

```
>> format compact
>> a = 4
a =
    4
>> b = 3
b =
    3
>> c = a + b
c =
    7
>> d = a*b
d =
   12
>> d = a/b ;
>> d
d =
   1.3333
```

This helps so that MATLAB does not add so many spaces.

Commands to add, multiply etc. are intuitive

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# Basic MATLAB operations

## Defining one-dimensional vectors

```
>> a = [1,2,3,4,5,6,7,8,9,10]
a =
    1    2    3    4    5    6    7    8    9   10
>> a = 1:10
a =
    1    2    3    4    5    6    7    8    9   10
[evenly spaced integers]
>> a = 2:2:20
a =
    2    4    6    8   10   12   14   16   18   20
[middle 2 defines spacing]
>> a = 20:-2:2
a =
   20   18   16   14   12   10    8    6    4    2
[descending because spacing = -2]
>> a = ones(1,10)
a =
    1    1    1    1    1    1    1    1    1    1
>> a = zeros(1,10)
a =
    0    0    0    0    0    0    0    0    0    0
>> a = rand(1,10)
a =
    0.9501    0.2311    0.6068    0.4860    0.8913    0.7621    0.4565    0.0185
    0.8214    0.4447
[uniformly distributed random numbers]
```

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# Basic MATLAB operations

## Creating arrays/matrices

```
>> A = [1,2,3;4,5,6]
A =
     1     2     3
     4     5     6
>> B = [(1:3);(4:6);(7:9)]
B =
     1     2     3
     4     5     6
     7     8     9
>> C = [A;B]
C =
     1     2     3
     4     5     6
     1     2     3
     4     5     6
     7     8     9
>> C=[A,B]
??? Error using ==> horzcat
CAT arguments dimensions are not consistent.
```

[comma for horizontal concatenation  
semicolon for vertical concatenation]

[can use colon to create evenly spaced rows  
semicolons to separate rows]

[can concatenate two matrices together]

A is 2 x 3. B is 3 x 3. They cannot be combined horizontally

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# Basic MATLAB operations

## More examples of concatenation

```
>> a = 1:3
a =
     1     2     3
>> a = [a,a]
a =
     1     2     3     1     2     3
>> a = [a,9]
a =
     1     2     3     1     2     3     9
>> a = [a;a]
a =
     1     2     3     1     2     3     9
     1     2     3     1     2     3     9
Note: After these commands, previous versions of 'a' are lost
If both are to be kept, use a new variable name, i.e.:
>> a = 1:3
a =
     1     2     3
>> b = [a,a]
b =
     1     2     3     1     2     3
[variable "a" can appear on both the left and the right hand side
define the new "a" based on the old "a"]
[now the original definition of a is maintained]
```

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## Basic MATLAB operations

### Matrix versus array arithmetic

```
>> A = [1,2,3;4,5,6]
A =
     1     2     3
     4     5     6
>> B = [4,1,7;9,2,3]
B =
     4     1     7
     9     2     3
>> C = 2*A
C =
     2     4     6
     8    10    12
>> D = A + 3
D =
     4     5     6
     7     8     9
>> E = 2*A + B
E =
     6     5    13
    17    12    15
```

```
>> F = A*B
??? Error using ==> mtimes
Inner matrix dimensions must agree.
[A and B are each 2 x 3
They cannot be multiplied]
>> G = A.*B
G =
     4     2    21
    36    10    18
[dot * multiplies element
by element]
>> H = (A > B)
H =
     0     1     0
     0     1     1
[compares corresponding elements
of the two matrices]
```

[adds 3 to each element in A]

[multiplies each element in A by 2  
then adds matrices, element by element]

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## Basic MATLAB operations

### The "whos" command

Lists all the currently-defined variables

Useful for understanding when incompatibility errors occur

```
>> whos
```

Name	Size	Bytes	Class
A	2x3	48	double array
B	3x3	96	double array
C	5x3	144	double array
a	2x7	112	double array
b	1x1	8	double array
c	1x1	8	double array
d	1x1	8	double array

Grand total is 53 elements using 424 bytes

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# Basic MATLAB operations

## Accessing sections of arrays

MATLAB commands in black Courier. Comments in red Arial

```
C =
     1     2     3
     4     5     6
     1     2     3
     4     5     6
     7     8     9

>> e = C(1,1)
e =
     1

>> f = C(5,3)
f =
     9 [access a single element]

>> D = C(:,1)
D =
     1
     4
     1
     4
     7 [access an entire column]

>> E = C(:,[1,3])
E =
     1     3
     4     6
     1     3
     4     6
     7     9

>> F = C(end,:)
F =
     7     8     9 ["end" = last row]

>> G = C([2,5],1:2)
G =
     4     5
     7     8

>> H = C(1:5,1:5)
??? Index exceeds matrix dimensions. [error because C is only 5 x 3
4th and 5th columns undefined]
```

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# Basic MATLAB operations

## Matrix and array operations

```
>> clear B C D E F G
```

```
>> A
A =
     1     2     3
     4     5     6

>> B = [4,1,7;9,2,3]
B =
     4     1     7
     9     2     3
```

```
>> C = 2*A
```

```
C =
     2     4     6
     8    10    12
```

```
>> D = A + 3
```

```
D =
     4     5     6
     7     8     9
```

```
>> E = 2*A + B
```

```
E =
     6     5    13
    17    12    15
```

```
>> F = A*B
```

```
??? Error using ==> mtimes
Inner matrix dimensions must agree.
```

```
>> G = A.*B
```

```
G =
     4     2    21
    36    10    18
```

```
>> H = (A > B)
```

```
H =
     0     1     0
     0     1     1
```

```
>> whos H
```

```

Name Size Bytes Class
H      2x3      6 logical array
```

Grand total is 6 elements using 6 bytes

Let's understand the basis for this error

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# Basic MATLAB operations

## Matrix multiplication

```
>> A
A =
     1     2     3
     4     5     6

>> B
B =
     4     1     7
     9     2     3

>> B'
ans =
     4     9
     1     2
     7     3

>> F = A*B'
F =
    27    22
    63    64
```

[A and B are both 2 x 3  
A\*B is undefined]

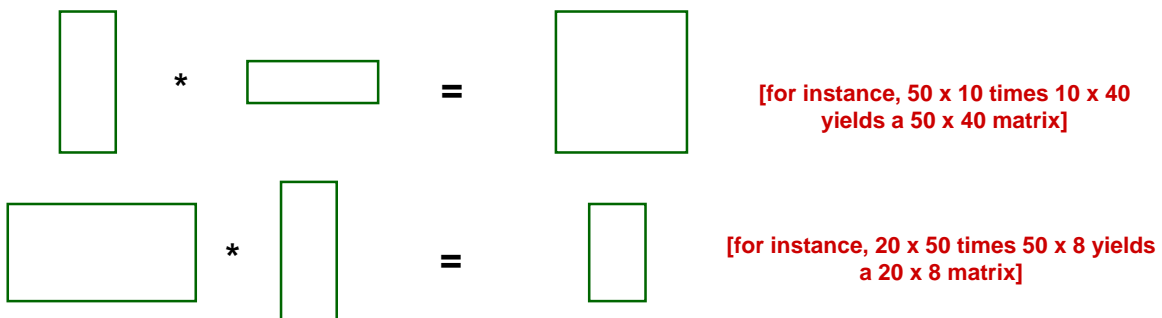
[apostrophe = transpose the matrix  
B' is 3 x 2  
A\*B' can be computed]

[27 = 1\*4 + 2\*1 + 3\*7  
other elements computed similarly]

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## Matrix multiplication

- 1) Multiplication can only occur if the inner dimensions agree
- 2) If A is  $n \times m$  and B is  $m \times p$ , product  $A*B$  will have dimensions  $n \times p$



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## Summary

Variables in MATLAB are either scalars, vectors, or arrays

Array dimensions influence the operations that are allowed

Arrays can only be added, multiplied, concatenated if dimensions “match”

Symbols, e.g. colon, semicolon, period, have special meaning

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## Self-assessment question 1

In analyzing data, you have defined an array **A**. This array has 32 rows and 15 columns. To access a subset of **A**, you type:

```
>> B = A(20:end,[1,3,6,11]) ;
```

What are the dimensions of **B**?

- (A) 32 x 15
- (B) 15 x 32
- (C) 13 x 4
- (D) 13 x 11
- (E) 20 x 4

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## Self-assessment question 2

You have defined the following two arrays:

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

Then you attempt to type:

```
>> C = [A;B] ;
```

What type of error do you receive, and why?

- (A) Error using `horzcat` because A and B have different numbers of rows
- (B) Error using `horzcat` because A and B have different numbers of columns
- (C) Error using `mtimes` because you cannot multiply A and B
- (D) Error using `vertcat` because A and B have different numbers of rows
- (E) Error using `vertcat` because A and B have different numbers of columns