

Introduction to Scientific and Engineering Computing, BIL108E

#### INTRODUCTION TO SCIENTIFIC & ENGINEERING COMPUTING BIL 108E, CRN24023

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## ARRAYS

#### Introduction to Scientific and Engineering

Computing, BIL108E

#### ARRAYS

- Matlab stores all types of variables as in the form of an array.
- A single element array is called a scalar.
- An array with one column or row is called a vector.
- An array with m rows and n columns, where  $m, n \neq 1$  is called a matrix.

## ARRAYS

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ARRAYS

- x = start : increment : end
- $X = [a_{11}, a_{12}, a_{13}; a_{21}, a_{22}, a_{23}]$
- x = x' (transpose of x)



## ARRAYS

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Na	$lame \land$ Value >> x = 2 : 2 : 12	
H 1997	× [2,4,6,8,10	
	x =	
	2 4 6 8 10 12	
	y = Jinemaco(2, 12, 6)	
	>> x = 1  inspace(2, 12, 0)	
	X =	
4		
C	ommand History → □ <sup>2</sup> × 2 4 6 8 10 12	
	x = linspace(2, >>	
	clc	
	x = 2 : 2 : 12	
	x = linspace(2 = 1)	



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## VECTORS

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$$\mathbf{a} = (\begin{array}{cccc} a_1 & a_2 & \dots & a_n \end{array})$$

COLUMN VECTOR



## VECTORS

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#### VECTOR ADDITION AND SUBTRACTION

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Engineering Computing, BIL108E

Addition and subtraction are element-by element operations

• 
$$c = a + b, c_i = a_i + b_i, i = 1, 2, ..., n$$
  
•  $d = a - b, d_i = a_i - b_i, i = 1, 2, ..., n$   
•  $a = \begin{pmatrix} a_1 \\ a_2 \\ \vdots \\ a_m \end{pmatrix} \pm \begin{pmatrix} b_1 \\ b_2 \\ \vdots \\ b_m \end{pmatrix} = \begin{pmatrix} a_1 \pm b_1 \\ a_2 \pm b_2 \\ \vdots \\ a_m \pm b_m \end{pmatrix}$ 



#### VECTOR ADDITION AND SUBTRACTION

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ans X	[1,3;2,5;3,8 [1,2,3]	x =			
x_column	[2;4;6;8;10 [2,4,6,8,10	1	2	3	
∎y ∎z	[3,5,8] [4,7,11]	>> y =	[3, 5,	8]	
		y =			
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#### VECTOR ADDITION AND SUBTRACTION

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#### MULTIPLICATION BY SCALAR

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Multiplication by a scalar involves multiplying each element in the vector by the scalar:

• 
$$b = \alpha \times (a_i) = (\alpha \times a_i)$$
  
•  $b = \alpha \times \begin{pmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{pmatrix} = \begin{pmatrix} \alpha \times a_1 \\ \alpha \times a_2 \\ \vdots \\ \alpha \times a_n \end{pmatrix}$ 



#### MULTIPLICATION BY SCALAR

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Name ∠ Value	>> x = [3, 5, 8] x = 3 5 8 >> alpha = 3; >> y = alpha * x	
Command History H □ * x Z = y - x ← -ClC -x = [3, 5, 8] -alpha = 3; -y = alpha * x -y = alpha * x	y = 9 15 24 >> y = alpha .* x y =	



#### TRANSPOSE OF A VECTOR

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#### TRANSPOSE OF A VECTOR

$$\mathbf{a} = \begin{pmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{pmatrix}$$
$$\mathbf{a}^\mathsf{T} = \begin{pmatrix} a_1 & a_2 & \dots & a_n \end{pmatrix}$$



#### TRANSPOSE OF A VECTOR

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#### **OPERATIONS ON ARRAYS**

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Multiplication and Division

#### DOT PRODUCT

$$C = A \cdot * B = (a_1 \times b_1, a_2 \times b_2, \dots, a_n \times b_n)$$
  
 $C = A \cdot / B = (a_1/b_1, a_2/b_2, \dots, a_n/b_n)$ 



#### **OPERATIONS ON ARRAYS**

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Name ∠	Value		-
ΠX	[1,2,3;3,4] // a = [1, 2, 3]		
Ha	[1,2,3]		
Halpha	3 a =		
Hans	[9:15:24]		
Шb	[2,4,6] <b>1 2 3</b>		
Hc	[2.8.18]		
H ×	[3.5.8] <b>L FD A CT</b>		
x_column	[2:4:6:8:] >> <b>D</b> = [2, 4, 6]		
x_row	[2,4,6,8,]		
Ξv	[9,15,24] <b>b</b> =		
z	[2,3,5]		
•	2 4 6		
Command Hist	X S 🗆 🕶 yn		
c = a	*b the sh		
	· - >> C = a D		
CIC -			
a = [:	., 2, 3 c =		
b = [7	2, 4, 6]		
c = a	*h 2 8 18		
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#### **OPERATIONS ON ARRAYS**

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Name X alpha alpha b c x x_column x_cow y z	Value [1,2,3;3,5] [1,2,3] 3 [9;15;24] [2,4,6] [2,8,18] [3,5,8] [2;4;6;8; [2,4,6;8; [2,4,6;8; [2,4,6;8; [9,15,24] [2,3,5] ♥	>> a * b ??? Error using ==> mtimes Inner matrix dimensions must agree. >>	
Command Histo →CIC →a = [1 →b = [2 →c = a →clc	, 2, 3] , 4, 6] .* b		



#### MATRIX MULTIPLICATION

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#### MATRIX MULTIPLICATION



$$i = 1, 2, \dots, m, j = 1, 2, \dots, m$$

## MATRIX MULTIPLICATION

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•		MATLAB 7.6.0 (R2008a)	
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Name ∠	Value	$A = \begin{bmatrix} 1 & 2 & 2 & -1 \end{bmatrix}$	
A	[1,2;2,-1 *		
🖽 B	[3,2;2,-3	A =	
H×	[1,2,3;3,5		
🛨 a	[1,2,3]	1 2	
aipria ans	5		
H b	[2,4.6]	2 -1	
H c	[2,8,18]	л Гэ э э э <sup>1</sup>	
🖽 x	[3,5,8] -	>> B = [3, 2; 2, -3]	
🗄 x_column	[2;4;6;8;		
x_row	[2,4,6,8,	B .=.	
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-B = [	3, 2; 2, -		
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A = [:	1, 2; 2, -		
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## MATRIX MULTIPLICATION

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<b>H</b> A [1,2;2,-1 <b>2</b> -1	
⊞ B [3,2;2,-3	
$\mathbb{H}^{\mathbb{C}}$ [3,4;4,3] >> B = [3, 2; 2, -3]	
$\mathbf{H}$ alpha $\mathbf{B}$ =	
ans [9:15:24]	
🗄 b [2,4,6] <b>3 7</b>	
⊞c [2,8,18]	
⊞× [3,5,8]	
$\mathbf{x}$ column [2;4;6;8;]	
$\sum_{n=1}^{\infty} \sum_{n=1}^{\infty} \sum_{n$	
-B = [3, 2; 2, -1] C =	
clc	
A = [1, 2; 2, -] 3 4	
B = [3, 2; 2, -]  4 3	
$C = A \cdot B$	
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Vame / Value 3 2	
A [1,2;2,-1] 2 -3	
B [3,2;2,-3	
BC [7,-4;4,7	
■× [1,2,3;3,5] >> C = A . * D	
a [1,2,3]	
alpha 3 C =	
ans [9;15;24]	
<b>b</b> [2,4,6] <b>3 4</b>	
<b>4 3</b>	
X [3,5,6]	
(12,4,0,0,0,0) $(12,4,0,0,0,0)$	
Command History H T A X	
A = [1, 2; 2, -]	
B = [3, 2; 2, -] 7 -4	
C = A * B 4 7	
C = A * B	



## INPUT AND OUTPUT

Introduction	
to Scientific	
and	
Engineering	
Computing,	
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The input statement

variable = input(' prompt ')

inch = input('Enter length: '); centimeter = inch \* 2.54; disp([num2str(inch), ' inches = ']); disp(centimeter);

## INPUT AND OUTPUT

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Current Directory 🏎 🖬 🛪 🐄	Command Window	× × ⊡ * ×
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## INPUT AND OUTPUT

#### Introduction to Scientific

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#### input

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- The prompt message prompts for the value(s) to be entered. It must be enclosed in apostrophes (single quotes).
- A semicolon at the end of the input statement will prevent the value entered from being immediately echoed on the screen.
- You normally do not use input from the command line, since you shouldn't need to prompt yourself in command – line mode.
- Vectors and matrices may also be entered with input, as long as you remember to enclose the elements in square brackets.
- You can enter an expression in response to the prompt for example, a + b (as long as a and b have been defined) or rand(5). When entering an expression in this way, don't include a semicolon (it is not part of the expression).



## USING SYSTEM COMMANDS

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Executing operating system commands

Example;

!time

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🖞 ex_03_04.m	M-file	drwx 11 sept root 4096 1970-01-01 02:00						
🖞 ex_03_05.m	M-file	-rwx 1 sept root 46 2010-02-21 17:58 ex_03_01.m						
🖞 ex_03_06.m	M-file	-rwx 1 sept root 18 2010-02-21 18:01 ex 03 02.m						
🖞 ex_03_07.m	M-file	-rwy 1 sent root 16 2010-02-21 18:04 ex 03 03 m						
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USING SYSTEM COMMANDS





Introduction to Scientific and Engineering

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## GENERAL FILE I/O

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	fopen		
	∎ fclose		
	fread		
	fwrite		
	fseek		

GOOD PROGRAMMING STYLE

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#### GOOD PROGRAMMING STYLE

Here are some hints on how to improve your programming style:

- You should make liberal use of comments, both at the beginning of a script to describe briefly what it does and any special methods that may have been used, and throughout the coding to introduce different logical sections.
- The meaning of each variable should be described briefly in a comment when it is initialized. You should describe variables systematically, for example, in alphabetical order.
- Blank lines should be freely used to separate sections of coding (e.g., before and after loop structures).

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#### cont'd,

- Coding (i.e., statements) inside structures (fors, ifs, whiles) should be indented (tabulated) a few columns to make them stand out.
- Blank spaces should be used in expressions to make them more readable – for example, on either side of operators and equal signs. However, blanks may be omitted in places in complicated expressions where this may make the logic clearer.



## INTRODUCTION TO GRAPHICS

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PRESENTING AND VISUALIZING GRAPHICAL DATA

A picture is worth a thousand words.

- 2D plotting
- 3D plotting



### SIMPLE 2D GRAPHICS

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and	
Engineering	
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#### plot statement

In its sipmplest form plot takes a single vector argument.

Example;

plot(rand(1, 20))

Plots 20 random numbers against the integers 1-20.

## SIMPLE 2D GRAPHICS

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🖻 🗂 🖪 🗟 •	New to MATLAB? Watch this <u>Video</u> , see <u>Demos</u> , or read <u>Getting Started</u> .	×
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Command History ** 2 * x clc a = 1:7; fprintf('elemen clc plot(rand(1, 20; * start		

# SIMPLE 2D GRAPHICS

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#### SIMPLE 2D GRAPHICS

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- If the argument is a matrix , its columns are plotted against element indexes.
- Axes are automatically scaled and drawn to include the minimum and maximum data points.



#### SIMPLE 2D GRAPHICS

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	<pre>&gt;&gt; A = [rand(1,20); rand(1,20); rand(1,20)]; &gt;&gt; plot(A) &gt;&gt; plot(A) &gt;&gt; plot(A) </pre>	
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## SIMPLE 2D GRAPHICS

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#### SIMPLE 2D GRAPHICS

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plot(x, y)

x and y are vectors of the same length. Example;

x = 0 : pi/20 : 8\*pi; y = cos(x); plot(x, y)

*i* th point coordinates are  $x_i, y_i$ 



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#### SIMPLE 2D GRAPHICS

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#### DRAWING STRAIGHT LINES

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#### DRAWING STRAIGHT LINES

Straight-line graphs are drawn by giving the x and ycoordinates of the end points by two vectors.

plot([0 2], [2 2])

Matlab has a set of easy-to-use plotting commands.

ezplot('tan(x)')



## SIMPLE 2D GRAPHICS

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plot([0,2], [2,. **▲** Start 📢 😰 Comp.... 🧕 Micha... 🕘 berk s... 🔳 sept... 🔺 MATL... 🝙 sept -... 🔚 Deskt... 🍙 [Trans... 🕎 [Figur... 🔺 📷 🛜



#### SIMPLE 2D GRAPHICS





#### SIMPLE 2D GRAPHICS

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#### LABEL SETTINGS

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Computing, BIL108E Graphs may be labeled with the following statements:

- gtext('text') writes a string in the graph window. Text may be placed also with Tools-Edit Plot from the figure window.
- grid add/removes grid lines.
- text(x, y, 'text') writes text at the point specified by x and y.
- title('text') writes the text as a title at the top of the graph.
- xlabel('horizontal') labels the x-axis.
- ylabel('vertical') labels the y-axis.



#### **MULTIPLE PLOTS**

#### Multiple plots on the same axis

- Use hold to keep the current plot on the axes. Released with either hold off or hold
- Use plot with multiple arguments.  $plot(x_1, y_1, x_2, y_2)$
- Use plotyy to have independent *y*-axis on the left and on the right
- $plotyy(x, y_1, x, y_2)$
- Use the form plot(x, y), where x and y may be both matrices or one may be a vector and one a matrix.



#### LINE STYLES, MARKERS AND COLOR

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Computing,

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Example:

x = 0 : pi/20 : 3\*pi; y = cos(x);plot(x, y, '--') hold plot(x, cos(2\*x), 'o')plot(x, cos(4\*x), 'om--')

Available color symbols c, m, y, k, r, g, b, w

## **MULTIPLE PLOTS**







#### **AXIS SETTINGS**

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Axis limits can be overriden with

axis([xmin, xmax, ymin, ymax])

- Sets the scaling on the current plot.
- Use Inf or -Inf for the autoscaled limit.
- Use axis auto to return to the automatic axis scaling.
- v = axis returns the current axis scaling in the vector v.
- Use axis manual to freeze current scaling, so subsequent plots use the same limits.
- Use axis equal to make equal unit length on both axis. The effect is undone with axis normal.
- Turn axis labeling and tick marks with axis off and axis on.



## MULTIPLE PLOTS - subplot

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To show a number of plots in the same figure window use subplot function.

subplot(m, n, p)

divides the figure window into  $m \times n$  small sets and selects the p th set for the current plot.

The command subplot(1,1,1) returns to a single set of axes.



#### MULTIPLE PLOTS - subplot

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Computing,

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```
[x, y] = meshgrid(-3:0.3:3);
z = x .* exp(x .^ 2 - y .^ 2);
subplot(2,2,1)
mesh(z),title('subplot(2,2,1)')
subplot(2,2,2)
mesh(z)
view(-37.5,70),title('subplot(2,2,2)')
subplot(2,2,3)
mesh(z)
view(37.5,-10),title('subplot(2,2,3)')
subplot(2,2,4)
mesh(z)
view(0,0),title('subplot(2,2,4)')
```

## MULTIPLE PLOTS - subplot

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#### figure



figure(h), creates a new figure window or make the h th figure window current.

*h* is called figure handle

clf clears current figure.

cla deletes all plots and text from the current axes.

#### LOGARITHMIC PLOT

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- loglog plots both axis in logarithmic scale
- semilogx plots only x axis in logarithmic scale
- semilogy plots only y axis in logarithmic scale



## LOGARITHMIC PLOT

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x = 0:0.01:4; semilogy(x, exp(x)), grid

LOGARITHMIC PLOT

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POLAR PLOT



The point (x, y) in cartesian coordinates represented by the

point  $(\theta, r)$  in *polar* coordinates

$$x = rcos(\theta)$$

$$y = rsin(\theta)$$

polar(theta, r)



## POLAR PLOT

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> x = 0 : pi/40 : 2 \* pi; polar(x, sin(2\*x)), grid



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fplot plots the function given with the string.

- Use fplot if the function changes rapidly.
- Reduce the increment when using the plot command.



## POLAR PLOT



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-1 -1 -08 -0.6 -0.4 -0.2 0 0.2 0.4 0.6 0.8 1

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x-axi

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v-axis

except it draws an animated graphic.



#### MESH SURFACES

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meshgrid

mesh(x, y, z)

surf(x, y, z)

contour

[x, y] = meshgrid(0:5)



## MESH SURFACES

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## MESH SURFACES

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#### MESH SURFACES

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## MESH SURFACES

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# MESH S

[x y] = meshgrid(-2:.2:2); z = x .\* exp(-x.^2 -y.^2); meshc(z)



#### MESH SURFACES

#### Introduction to Scientific





#### MATRIX VISUALIZATION

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mesh(A)
spy(A)
A complete list of graphics functions
MATLAB help

#### STANIN A STA

## MATRIX VISUALIZATION

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> a = zeros(30,30); a(:,15) = 0.2\*ones(30,1); a(7,:) = 0.1\*ones(1,30); a(15,15) = 1; mesh(a)

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#### MATRIX VISUALIZATION

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