A QUICK INTRODUCTION TO MATLAB

- Very brief intro to matlab -
- Basic operations and a few illustrations
- This set is independent from rest of the class notes.
- Matlab will be covered in recitations and occasionally in class

Intro to matlab – getting started



To start type 'matlab' under a unix terminal (or click icon under windows). You will get a matlab GUI with a command window that has the prompt: >>.

► I prefer to use matlab without the GUI [especially for the demos given in class]. In linux or mac OS this is done by typing into a terminal the command

% matlab -nodesktop

instead of

% matlab

To exit matlab use exit or quit

>> quit

Getting Help

➤ Most of the help for matlab is online. In the GUI you can click on the '?' icon.

Often it is faster to get help by typing into the matlab window

>> help topic

Examples > help | or >> help rref or >> help punct Alternatively you can get the same info in a pop-out window by typing:

>> doc topic

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'>> help' or '>> doc' by itself will list the help topics
 Same thing as clicking the '?' icon in the GUI.

Example:

```
>> help mod
mod modulus (signed remainder after division).
... followed by a few lines of explanation...
...
... then: shows related function (s):
See also REM.
```

Basic Operations in Matlab

► The following is on the basics of matlab. It starts with some basic operations and the help command.

> A useful command I used to generate some of these examples is

>>diary filename.

This is equivalent to a typescript. Everything displayed on screen is saved in a file. [useful for homeworks]

In what follows: Everything that starts with >> is what I typed into the matlab prompt.

Simple operations

>> 4+6+3	This is what I typed in
ans =	These lines are matlab's
13	answer
>> $4*20+ 3*57 + \exp(-0.1)$	This is what I typed in
ans =	These lines are matlab's
251.9048	answer

Note: ending versus not ending command with semi-colon.

>> a + 2	< do command + display result
ans =	< results of operation shown
25	
>> a+2;	<pre>< do command - do not display result</pre>
>>	< result not displayed

Squaring and powers:	Right/Left divide (/ and `
>> a = 12; >> a^2	>> a = 12; b = 3; >> a/b
ans = 144	ans = 4
>> a^4	>> a\b
ans = 20736	ans = 0.2500
	>> b/a
	ans = 0.2500

Important because these have their equivalent versions for matrices

more, disp, format

>> more on

> more on allows you to scroll page by page > disp(x) simply displays x without fillers > format selects format for displaying results : Options: format short, long, rat, ... >> format short >> pi ans = 3.1416 >> format long
>> pi
ans =
 3.141592653589793
>> format rat
>> pi
ans =
 355/113

Also useful: format compact [avoids empty line feeds.. useful for homeworks] The command '>> who' lists the variable currently stored
 >> who
 your variables are:
 a ans b
 >>
 See also: '>> whos' which has more detail

> Earlier we invoked exp which is the exponential function.

Get info by typing

>> help exp exp exponential. | answer:

exp(x) is the exponential of the elements of x, e to the x. for complex z=x+i*y, $exp(z) = \ldots$. + a few more lines of explanation ending with

see also log, log10, expm, expint.
overloaded methods
 help sym/exp.m

Explore the other elementary functions:

```
>> help elfun
```

will list all the elementary functions used by matlab - A long list that starts like this :

```
elementary math functions.
trigonometric.
sin - sine.
sinh - hyperbolic sine.
asin - inverse sine.
asinh - inverse hyperbolic sine.
cos - cosine.
```

Complex Numbers

```
>> c = 1 - 2i
с =
   1.0000 - 2.0000i
>> conj(c)
ans =
   1.0000 + 2.0000i
>> c*conj(c)
ans =
     5
>> abs(c)
ans
    =
    2.2361
```

Note: abs(c) is the modulus of c

Matrices

To define a matrix enter entries row by row, separated by a ";"

>> $A = [1 \ 1 \ 1 \ ; \ 2 \ 2 \ 2 \ ; \ 3 \ 3 \ 3 \]$

A =

Could use commas for separating columns (not required):

>> A = [1, 1, 1; 2, 2, 2; 3, 3, 3];

► So: ',' separates columns and ';' separates rows. The above matrix can also be defined as

>> A = [[1;2;3],[1;2;3], [1;2;3]]

Can use matrices as blocks [very convenient!]

>> B = [A, A]

B =

1	1	1	1	1	1
2	2	2	2	2	2
3	3	3	3	3	3

Show the result of the command: $>> C = [A, -A; A^*A, 2^*A]$

Two important special matrix functions								
	eye(n)		and		zero(r	1)		
>> A = A =	eye(5)		Iċ	lentity	matrix	of	size	5
1	0	0	0	0				
0	1	0	0	0				
0	0	1	0	0				
0	0	0	1	0				
0	0	0	0	1				

> It is enough to say eye(5) in this example but ...

> 'eye' is defined for rectangular matrices too

>> A	_ =	eye(6,3)	
A =			
	1	0	0
	0	1	0
	0	0	1
	0	0	0
	0	0	0
	0	0	0

> zeros(m) or zeros(m,n) is defined similarly:

Defining a vector through loop constructs

>> start=0; inc=2; last=12; >> start:inc:last ans = 4 6 8 10 2 12 ()>> 0:2:12 ans = 2 4 6 8 10 12 ()Can also use real numbers start = 0.0; inc = 0.15; last = 1.0; >> start:inc:last ans = 0.1500 0.3000 0.4500 0.6000 0.7500 0.9000 () Text: matlab – MLintro 2-20

>> x = 0:0.15:1

x = 0.1500 0.3000 0.4500 0.6000 0.7500 0.9000 0 Quite convenient for doing simple plots (see later) Can use loop constructs in matrices as well: >> A = [1:4; 4:7]1st row = 1:4 = 1 2 3 4 2nd row = 4:7 = 4 5 6 7 A =2 3 5 6 1 1 47 >> A = [0.0:0.1:0.5; 2.1:0.2:3.1] | Must have same number of entries in the 2 rows A =0.1000 0.2000 0.3000 0.4000 0.5000 2.1000 2.3000 2.5000 2.7000 2.9000 3.1000

The function 'size'

Everything in matlab is considered a matrix. size(x) gives the dimensions of the object x

>> x = x = 0.0:0.1:0.8; |0.0 0.1 ... 0.8 (9 entries) >> size(x) ans = 1 9 <---- 1 row, 9 columns</pre> >> A = [1:4; 4:7];>> size(A) ans = 2 4 <---- 2 rows 4 columns</pre> >> >> size(pi) | number pi = a scalar ans = 1 <---- 1 row 1 column</pre> 1 Text: matlab – MLintro

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Vector operations

```
| adding 2 vectors of same shape
>> x+y;
>> 0.15*x - .0*y; | linear comb. of x and y
>> y = exp(-x) | point-wise exponential of -x
y
  1.0000 0.8607 0.7408 0.6376 0.5488 0.4724 0.4066
cannot square a vector:
>>
>> [1 2 3]^2
Error using
Inputs must be a scalar and a square matrix.
To compute elementwise POWER, use POWER (.^) instead.
```

Pointwise (array) product: >> a = [2, 3 4] ; b = [0 5 6] ; >> c = a .* b C = 15 24 0 Let us go back to $z = x^2$. To square the components of x, do: >> $y = x .^{2}$ y = 0 0.0225 0.0900 0.2025 0.3600 0.5625 0.8100 or $>> y = x \cdot x$ y = 0 0.0225 0.0900 0.2025 0.3600 0.5625 0.8100 Text: matlab - MLintro 2-24

Simple plotting

Matlab provides powerful graphics capabilities – 2D plots, 3D surfaces.

> The simplest command: >> plot(x,y) causes matlab to popout a window which has the following plot



Try the following commands and explain what they do

```
x = [0:0.01:2*pi];
y = x .* cos (x);
plot(x,y);
hold on
z = 1 ./ ( 1/6 + y.^2);
plot(x,z,'r--');
plot([0, 2*pi],[0 0]);
plot([0, 0],[0, 7]);
axis([-1 7 -4 8])
```

Basic operators

Standard arithmetic operators:

$$+, -, *, /$$

- > Unary operations (for example -A).
- Back-slash operator:

$$x = A ackslash b$$

where A is a matrix and b a vector (or matrix) then $x = A^{-1}b$. [to be seen later in the class.]

		- Equal	==
		- Not equal	~ =
	Polational operators	- Less than	<
Relational operators	Relational Operators.	- Greater than	>
	- Less than or equal	<=	
		- Greater than or equal	>=

Example:

```
>> a = 1; b = 0; c = 2;
>> a+b+c == c+a+b
ans =
1
> Not to confuse with '=':
>> a+b+c = c+a+b
??? Error: Assignment statements cannot produce a result.
```

Comparisons can be done on vectors and matrices: >> a = 1:2:20 a = 7 9 11 13 15 17 19 3 5 1 >> b = 2:2:21 b = 6 8 10 12 14 16 18 20 2 4 >> a == b ans = 0 0 0 0 0 0 0 0 0 0 >> a+1 == b ans = 1 1 1 1 1 1 1 1 1 1 Note: 1 means "true", 0 means "false"

Conditionals



Simplest form:

If statement

More general form:

if (logical-expression)

÷ .

commands

- : nd
- end

if (logical-expression)
 commands
elseif (logical-expression)
 commands
else
 commands
end

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Text: matlab – MLintro



Examples of other constructs

for j=0:3:31 for j=100:-1:0 for j=0.1:0.1:2.4

Example:

Simple version of script to compute the square root of 5. [shown in class]

```
tol = 1.e-10;
a = 5;
x = a;
for i=1:100
        x = 0.5*(x+a/x);
        if abs(x^2-a) < tol
            break;
        end
end
```



For the square example you can achieve the same result with a while loop

```
tol = 1.e-10;
a = 5;
x = a;
while abs(x<sup>2</sup> - a) > tol
        x = 0.5*(x+a/x);
end
```

The above needs a fix [potential for infinite loop]