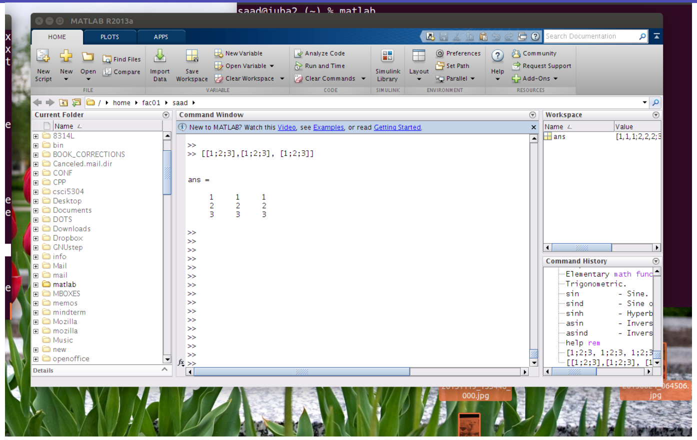
A QUICK INTRODUCTION TO MATLAB

- **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



New to MATLAB? Watch this Video, see Examples, or read Getting Started.

```
>>
>> [[1;2;3],[1;2;3], [1;2;3]]


ans =

     1     1     1
     2     2     2
     3     3     3

>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
>>
```

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

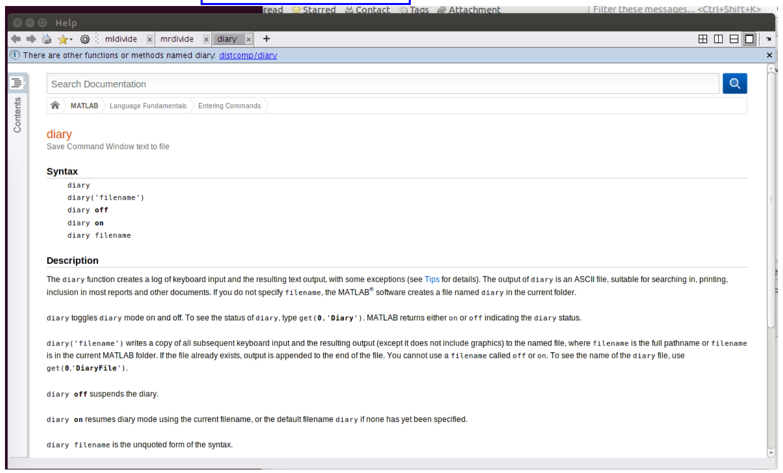
➤ Examples

>> help | or >> help rref or >> help punct

➤ Alternatively you can get the same info in a pop-out window by typing:

```
>> doc topic
```

➤ For example: `>> doc diary` gave this:



There are other functions or methods named diary: distcomp/diary

diary
Save Command Window text to file

Syntax

```
diary
diary('filename')
diary off
diary on
diary filename
```

Description

The `diary` function creates a log of keyboard input and the resulting text output, with some exceptions (see Tips for details). The output of `diary` is an ASCII file, suitable for searching in, printing, inclusion in most reports and other documents. If you do not specify `filename`, the MATLAB® software creates a file named `diary` in the current folder.

`diary` toggles `diary` mode on and off. To see the status of `diary`, type `get(0,'Diary')`. MATLAB returns either `on` or `off` indicating the `diary` status.

`diary('filename')` writes a copy of all subsequent keyboard input and the resulting output (except it does not include graphics) to the named file, where `filename` is the full pathname or `filename` is in the current MATLAB folder. If the file already exists, output is appended to the end of the file. You cannot use a `filename` called `off` or `on`. To see the name of the `diary` file, use `get(0,'DiaryFile')`.

`diary off` suspends the diary.

`diary on` resumes diary mode using the current filename, or the default filename `diary` if none has yet been specified.

`diary filename` is the unquoted form of the syntax.

➤ '>> 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.

>> a = 25; b = 3;
>> mod(a,b)
ans =
      1
>> mod(a,5)
ans =
      0
>> mod(25.2,2)

ans =
    1.2000
```

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;        <----- do command - do not display result
>>             <----- result not displayed
```

Squaring and powers:

```
>> a = 12;
>> a^2

ans =
   144

>> a^4

ans =
       20736
```

Right/Left divide (/ and \)

```
>> a = 12; b = 3;
>> a/b

ans =
     4

>> a\b

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) =  ....
   + 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
c =
   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 =
     1     1     1
     2     2     2
     3     3     3
```

- 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: $\boxed{\texttt{>> C = [A, -A; A*A, 2*A]}}$

➤ Two important special matrix functions

$\boxed{\texttt{eye(n)}}$ and $\boxed{\texttt{zero(n)}}$

```
>> A = eye(5)             |Identity matrix of size 5
A =
        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:

```
>> A = zeros(3,4)
A =
        0        0        0        0
        0        0        0        0
        0        0        0        0
```

Defining a vector through loop constructs

```
>> start=0; inc=2; last=12;

>> start:inc:last

ans =
        0        2        4        6        8       10       12

>> 0:2:12

ans =
        0        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   0.1500   0.3000   0.4500   0.6000   0.7500   0.9000
```

```
>> x = 0:0.15:1

x =
     0   0.1500   0.3000   0.4500   0.6000   0.7500   0.9000
```

➤ 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 =
     1     2     3     4
     4     5     6     7

>> 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   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

>> A = [1:4; 4:7];
>> size(A)

ans =
     2     4                     <---- 2 rows 4 columns

>>
>> size(pi)                      | number pi = a scalar

ans =
      1      1                   <---- 1 row 1 column
```

Vector operations

```
>> x+y;              | adding 2 vectors of same shape
>> 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 =
    0   15   24
```

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 .* x

y =
     0   0.0225   0.0900   0.2025   0.3600   0.5625   0.8100
```

Colum/row access; submatrices [Try these!]

```
>> A = randn(5,10);       | generate 5x10 random matrix
>> B = A(2:5,5:10);       | subarray of rows 2 to 5
                          | and columns 5 to 10
>> B = A(1:2:5,2:2:10);   | extract odd rows and even
                          | columns of A
>> r = A(1,:)             | 1st row of A
>> c = A(:,3:5)           | column 3 to 5 of A
>> A(:,3) = A(:,3)+0.5*A(:,1)
                          | Add 1/2 of col. 1 to col. 3
```

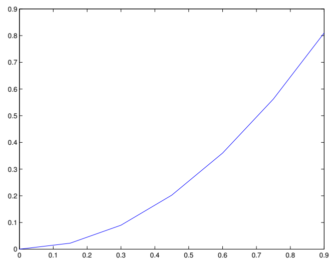
➤ Very useful:

```
r = r(:)                  | forces r to be  a column
                          | vector
```

Simple plotting

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

➤ The simplest command: `>> plot(x,y)` causes matlab to pop-out 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:

$$x = A \backslash b$$

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

➤ Relational operators.

- Equal	$==$
- Not equal	$\tilde{}=$
- Less than	$<$
- 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 =
     1     3     5     7     9    11    13    15    17    19

>> b = 2:2:21

b =
     2     4     6     8    10    12    14    16    18    20

>> 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

If statement

➤ Simplest form:

```
if (logical-expression)
    :
    commands
    :
end
```

If statement

More general form:

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

Loops

For loop

➤ Simplest form:

```
for j=1:m
    :
    commands
    :
end
```

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
```

While loop

➤ Generic form:

```
while (logical)
    :
    commands
    :
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^2 - a) > tol
   x = 0.5*(x+a/x);
end
```

The above needs a fix [potential for infinite loop]