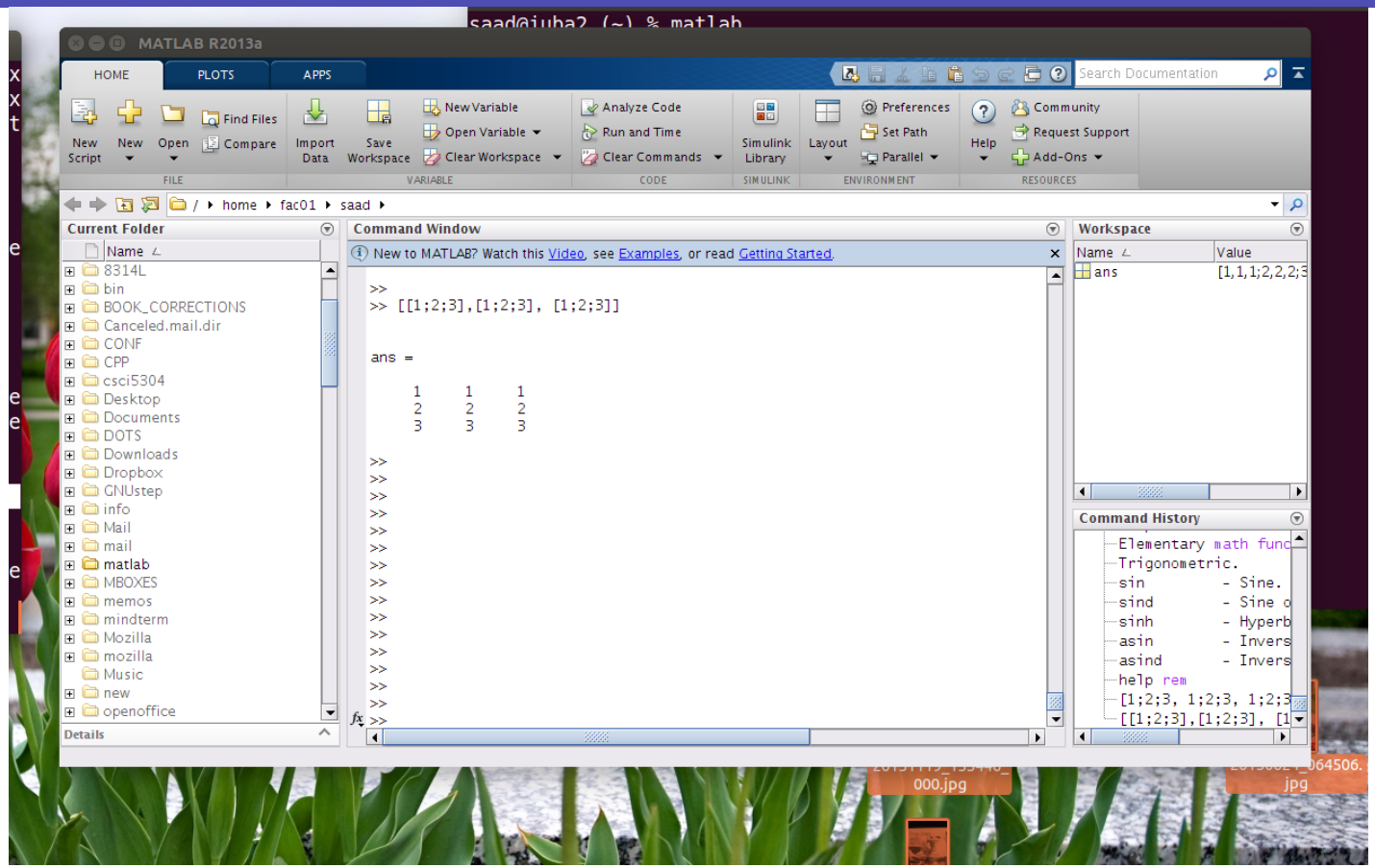
A QUICK INTRODUCTION TO MATLAB

- 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
```

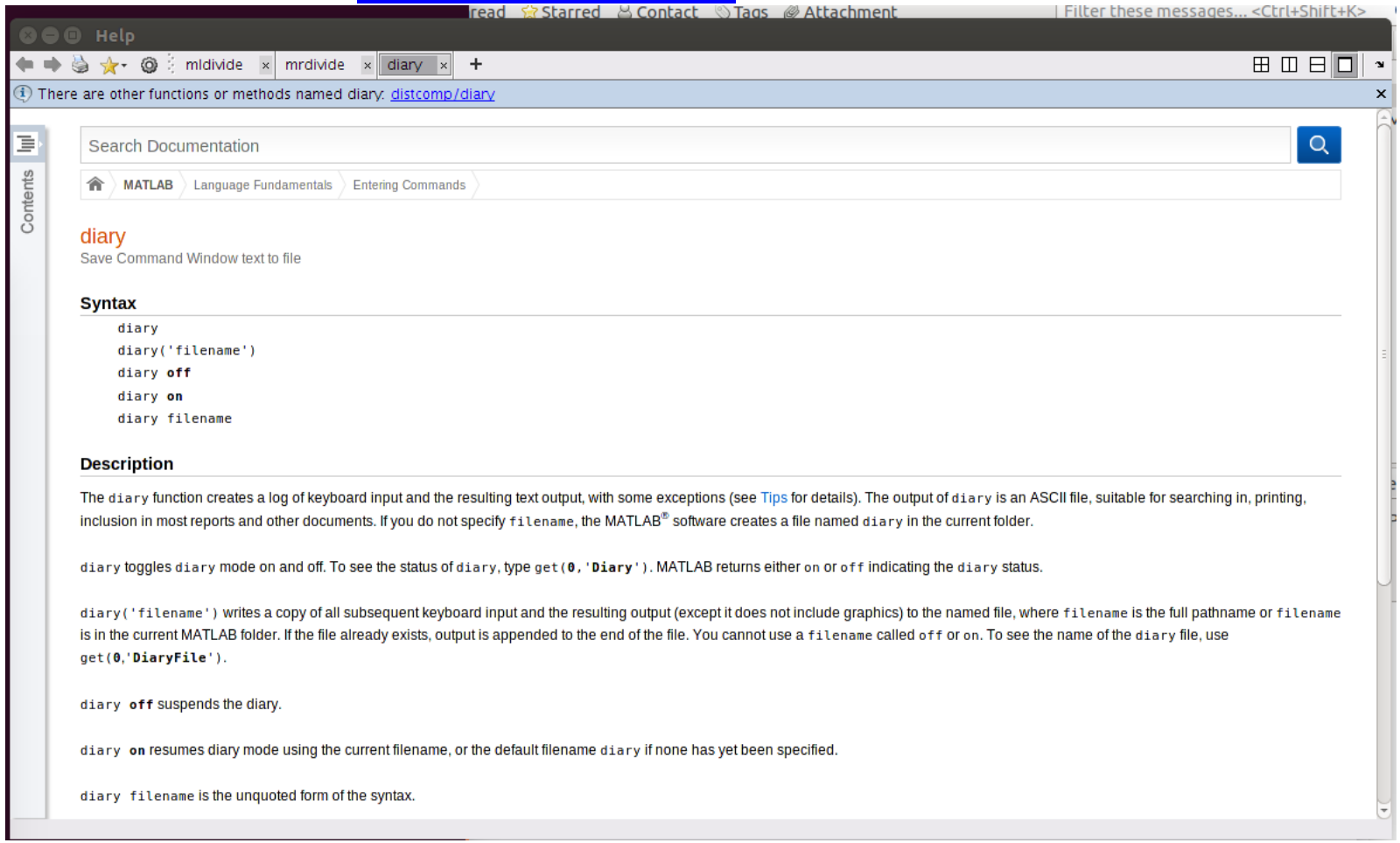
- Examples

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

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

```
>> doc topic
```

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



- '>> 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 =
   3.14159265358979 3

>> 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: `>> C = [ A, -A; A*A, 2*A]`

- Two important special matrix functions

`eye(n)` and `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

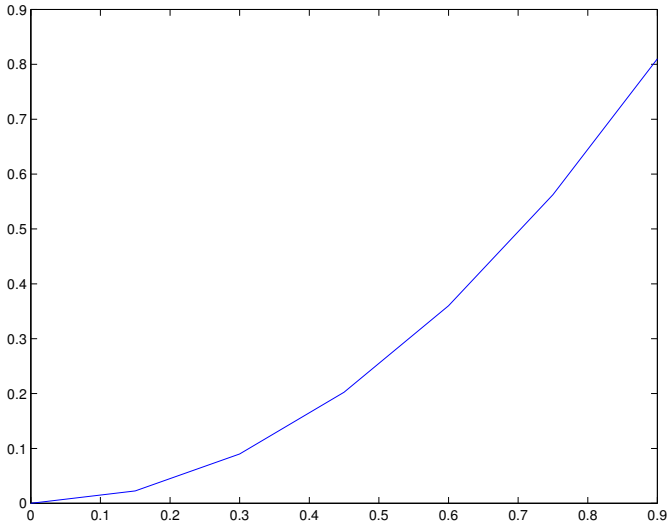
```
>> y = x .* x

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

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 $-\boldsymbol{A}$).
- Back-slash operator:

$$\boldsymbol{x} = \boldsymbol{A}\backslash\boldsymbol{b}$$

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

- Relational operators.

- Equal	==
- Not equal	~=
- 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]