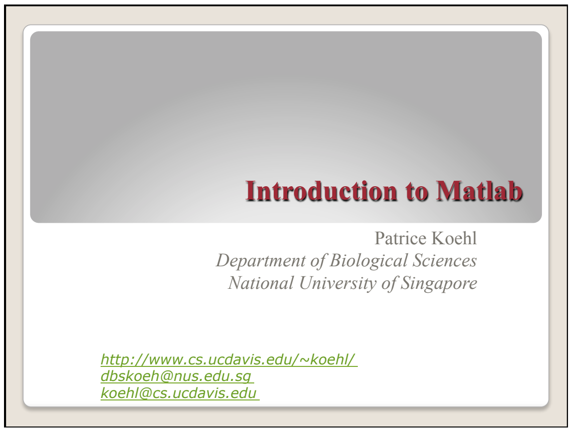

Introduction to Matlab

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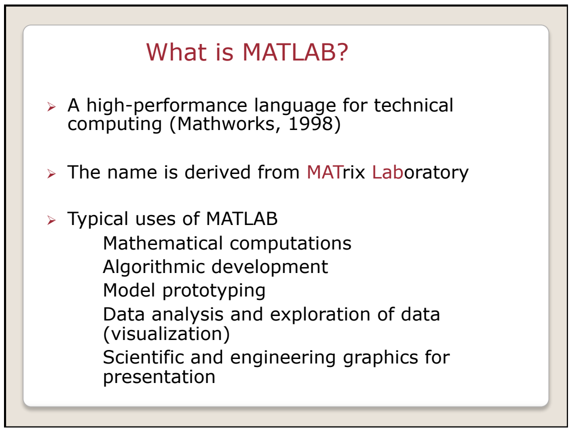
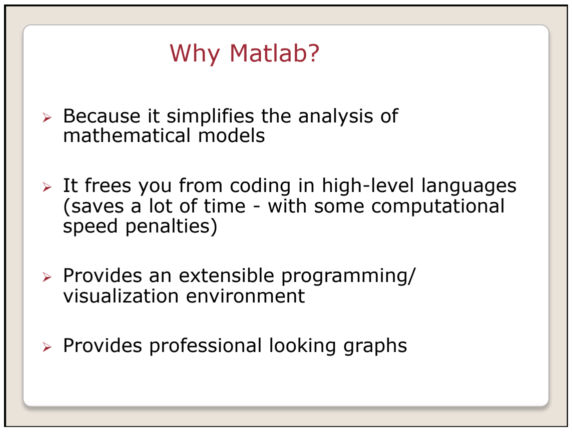


What is MATLAB?

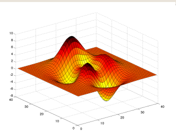
- A high-performance language for technical computing (Mathworks, 1998)
- The name is derived from MATrix Laboratory
- Typical uses of MATLAB
  - Mathematical computations
  - Algorithmic development
  - Model prototyping
  - Data analysis and exploration of data (visualization)
  - Scientific and engineering graphics for presentation



Why Matlab?

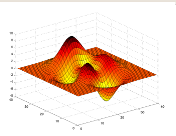
- Because it simplifies the analysis of mathematical models
- It frees you from coding in high-level languages (saves a lot of time - with some computational speed penalties)
- Provides an extensible programming/ visualization environment
- Provides professional looking graphs

Matlab



- ➢The Matlab Environment
- ➢Variables; operations on variables
- ➢Programming
- ➢Visualization

Matlab



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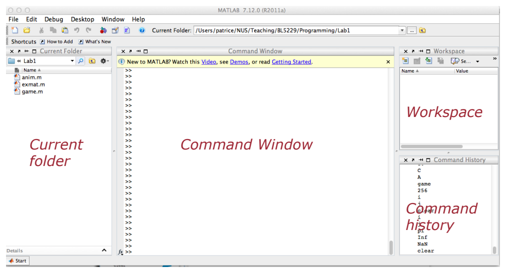
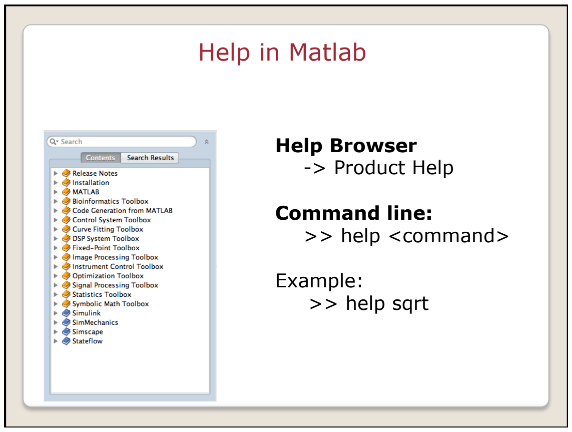
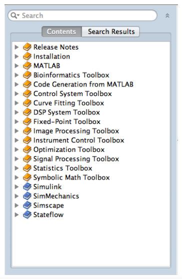
The Matlab Environment





Help in Matlab



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Help Browser
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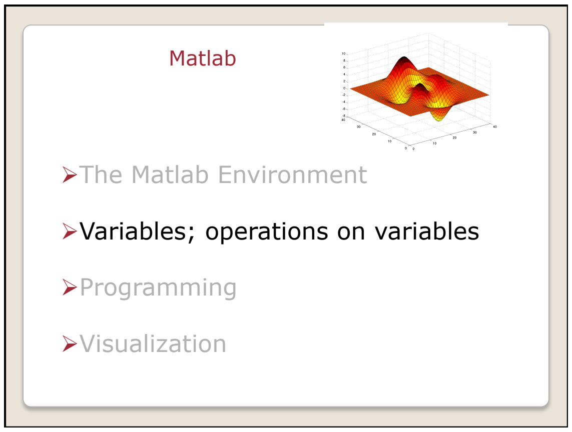
Command line:

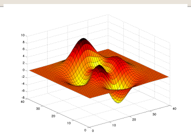
```
>> help <command>
```

Example:

```
>> help sqrt
```



Matlab



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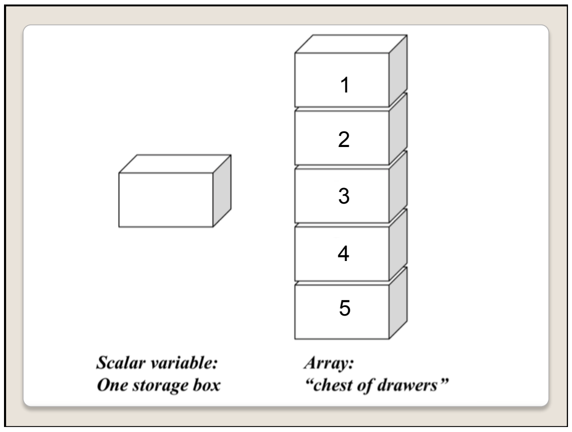
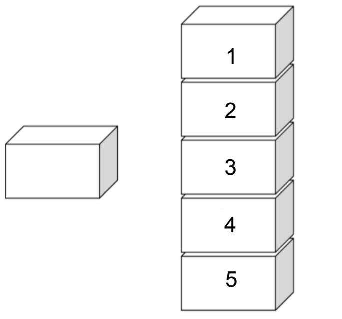
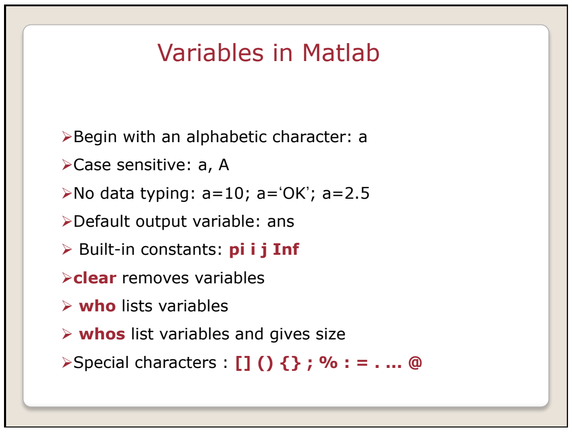




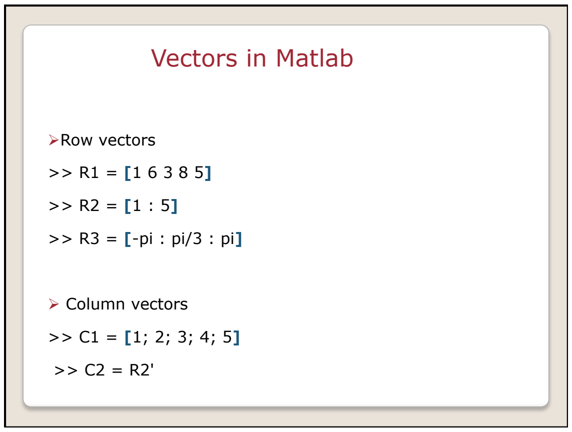
Scalar variable:
One storage box

Array:
"chest of drawers"



Variables in Matlab

- Begin with an alphabetic character: a
- Case sensitive: a, A
- No data typing: a=10; a='OK'; a=2.5
- Default output variable: ans
- Built-in constants: **pi i j Inf**
- **clear** removes variables
- **who** lists variables
- **whos** list variables and gives size
- Special characters : **[] () {} ; % : = ... @**



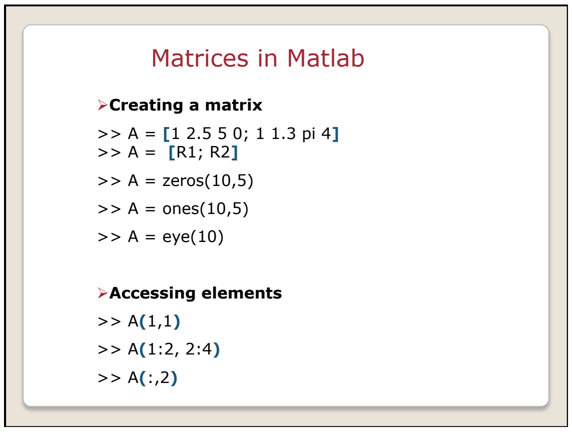
Vectors in Matlab

- Row vectors

```
>> R1 = [1 6 3 8 5]
>> R2 = [1 : 5]
>> R3 = [-pi : pi/3 : pi]
```

- Column vectors

```
>> C1 = [1; 2; 3; 4; 5]
>> C2 = R2'
```



Matrices in Matlab

- **Creating a matrix**

```
>> A = [1 2.5 5 0; 1 1.3 pi 4]
>> A =  [R1; R2]
>> A = zeros(10,5)
>> A = ones(10,5)
>> A = eye(10)
```

- **Accessing elements**

```
>> A(1,1)
>> A(1:2, 2:4)
>> A(:,2)
```

Matrix Operations

- **Operators + and –**

```
>> X = [1 2 3]
>> Y = [4 5 6]
>> A = X + Y
   A=   5  7   9
```

- **Operators *, /, and ^**

```
>> Ainv = A^-1 Matrix math is default!
```

Element wise operations

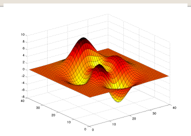
Operators .*, ./, and .^

```
>> Z = [2 3 4]'

>> B = [Z.^2 Z Z.^0]

B=    4   2    1
      9   3    1
     16   4    1
```

Matlab



- The Matlab Environment
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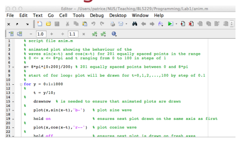
M-file programming


Editor - /Users/patrice/NUS/Teaching/BL5229/Programming/Lab1/anim.m
File Edit Text Go Cell Tools Debug Desktop Window Help

```
% script file anim.m
%
% animated plot showing the behaviour of the
% waves sin(x-t) and cos(x-t) for 201 equally spaced points in the range
% 0 <= x <= 8*pi and t ranging from 0 to 100 in steps of 1
%
x= 8*pi*[0:200]/200; % 201 equally spaced points between 0 and 8*pi
%
% start of for loop: plot will be drawn for t=0,1,2,...,100 by step of 0.1
%
for y = 0:1:1000
%
    t = y/10;
%
    drawnow  % is needed to ensure that animated plots are drawn
%
    plot(x,sin(x-t),'b-')   % plot sine wave
%
    hold on                 % ensures next plot drawn on the same axis as first
%
    plot(x,cos(x-t),'r--')  % plot cosine wave
%
    hold off                % ensures next plot is drawn on fresh axes
```

➢**Script M-Files**

▪Automate a series of steps.
▪Share workspace with other scripts and the command line interface.

➢**Function M-Files**

▪Extend the MATLAB language.
▪Can accept input arguments and return output arguments.
▪Store variables in internal workspace.

M-file programming

➢**Always has one script M-File**

➢**Uses built-in and user-defined functions**

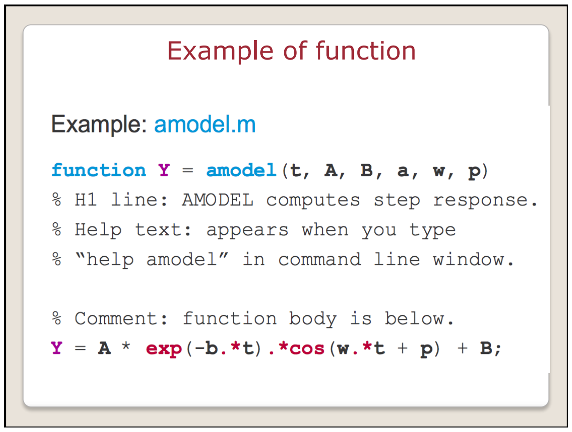
➢**Created in MATLAB Editor**
```
>> edit model.m
```

➢**Run from Command Line Window**
```
>> model
```

Example of script

Example: model.m

```
% Define input
T = [ 0 : 0.01 : 30]
% Compute model
Y = exp(-T);
% Plot model
plot (T, Y);
```

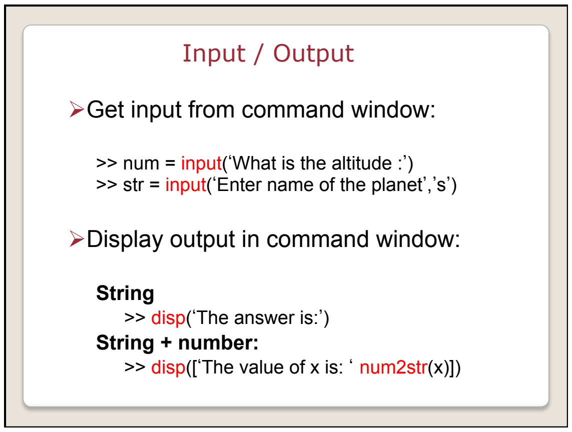


Example of function

Example: amodel.m

```
function Y = amodel(t, A, B, a, w, p)
% H1 line: AMODEL computes step response.
% Help text: appears when you type
% "help amodel" in command line window.

% Comment: function body is below.
Y = A * exp(-b.*t).*cos(w.*t + p) + B;
```



Input / Output

- Get input from command window:

```
>> num = input('What is the altitude :')
>> str = input('Enter name of the planet','s')
```

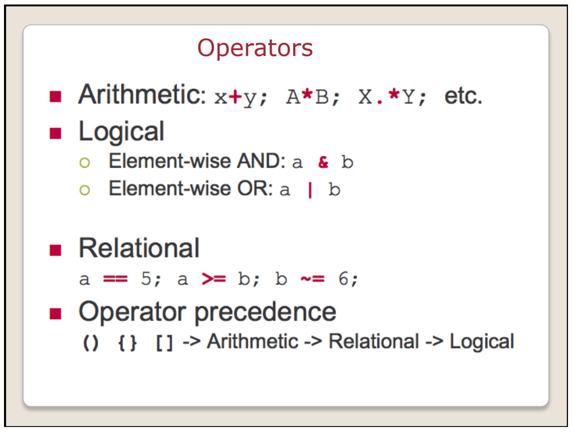
- Display output in command window:

String

```
>> disp('The answer is:')
```

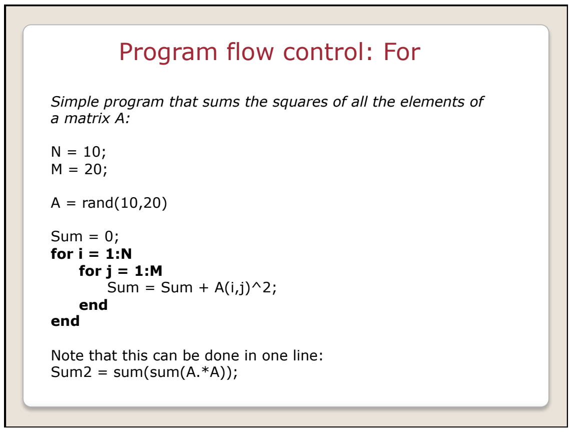
String + number:

```
>> disp(['The value of x is: ' num2str(x)])
```



Operators

- Arithmetic: `x+y; A*B; X.*Y;` etc.
- Logical
  - Element-wise AND: `a & b`
  - Element-wise OR: `a | b`
- Relational
  `a == 5; a >= b; b ~= 6;`
- Operator precedence
  `() {} []` -> Arithmetic -> Relational -> Logical



Program flow control: For

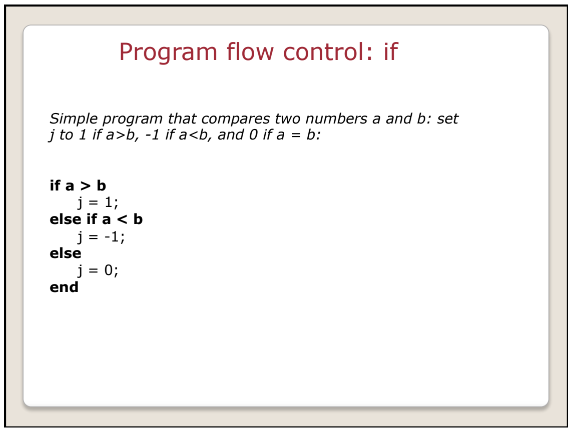
Simple program that sums the squares of all the elements of a matrix A:

```
N = 10;
M = 20;

A = rand(10,20)

Sum = 0;
for i = 1:N
    for j = 1:M
        Sum = Sum + A(i,j)^2;
    end
end
```

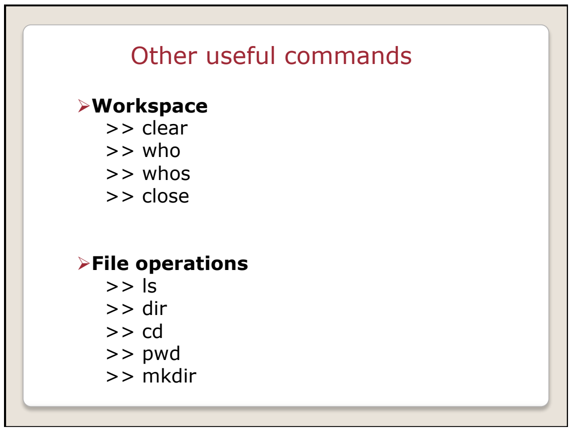
Note that this can be done in one line:
Sum2 = sum(sum(A.*A));



Program flow control: if

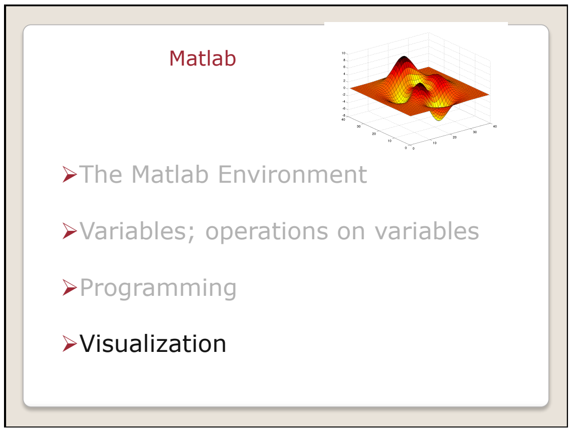
Simple program that compares two numbers a and b: set j to 1 if a>b, -1 if a<b, and 0 if a = b:

```
if a > b
    j = 1;
else if a < b
    j = -1;
else
    j = 0;
end
```

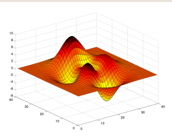


Other useful commands

- **Workspace**
  ```
  >> clear
  >> who
  >> whos
  >> close
  ```
- **File operations**
  ```
  >> ls
  >> dir
  >> cd
  >> pwd
  >> mkdir
  ```



Matlab



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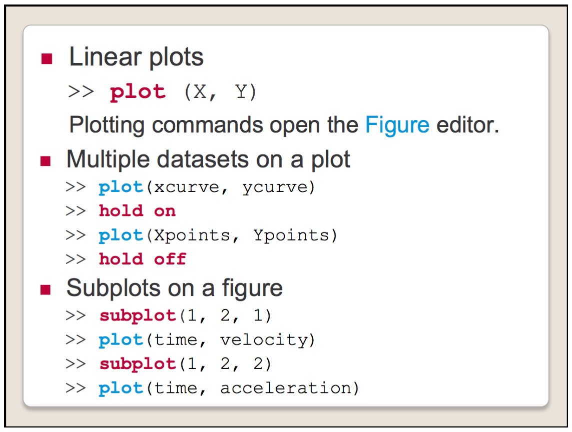


- Linear plots

```
>> plot (X, Y)
```

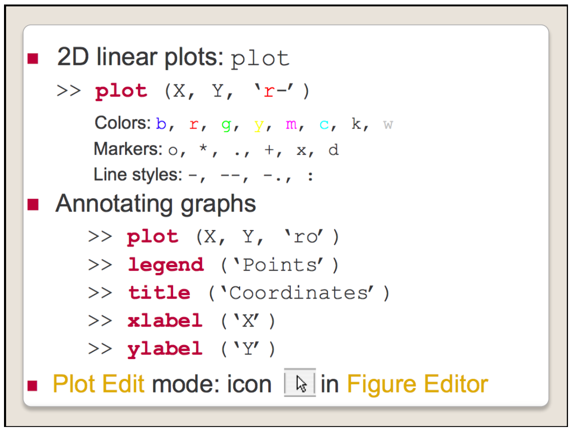
Plotting commands open the Figure editor.

- Multiple datasets on a plot

```
>> plot(xcurve, ycurve)
>> hold on
>> plot(Xpoints, Ypoints)
>> hold off
```

- Subplots on a figure

```
>> subplot(1, 2, 1)
>> plot(time, velocity)
>> subplot(1, 2, 2)
>> plot(time, acceleration)
```



- 2D linear plots: `plot`

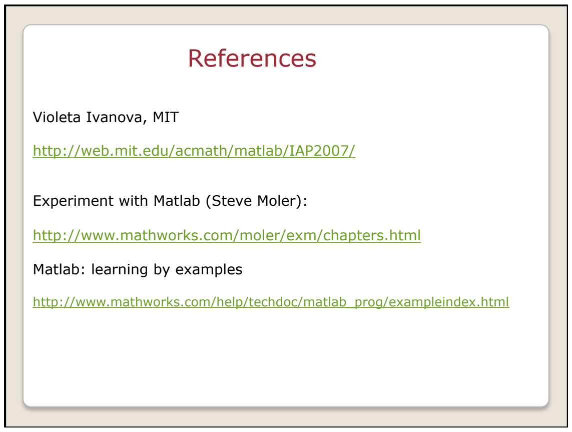
```
>> plot (X, Y, 'r-' )
```

Colors: `b, r, g, y, m, c, k, w`
Markers: `o, *, ., +, x, d`
Line styles: `-, --, -., :`

- Annotating graphs

```
>> plot (X, Y, 'ro' )
>> legend ('Points' )
>> title ('Coordinates' )
>> xlabel ('X' )
>> ylabel ('Y' )
```

- Plot Edit mode: icon ↖ in Figure Editor



References

Violeta Ivanova, MIT

http://web.mit.edu/acmath/matlab/IAP2007/

Experiment with Matlab (Steve Moler):

http://www.mathworks.com/moler/exm/chapters.html

Matlab: learning by examples

http://www.mathworks.com/help/techdoc/matlab_prog/exampleindex.html