MATLAB INTRO: PREPARATION FOR ME323

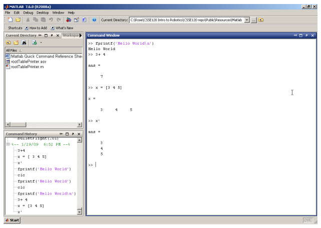
CSSE 120—Rose Hulman Institute of Technology

How is MATLAB different from Python?

- MATLAB = "**mat**rix **lab**oratory“
  - MATLAB defaults to use a 2D matrix of numbers (of type double) for as many things as possible
  - **Many** built-in functions without loading libraries
  - Array indices start at 1, not 0
  - MATLAB actually has good help docs ☺
  - MATLAB is pricey! Ballpark $5000 the day you stop going to Rose to have a personal copy of MATLAB.
  - Used heavily in industry. Very common.

What is MATLAB?

- Programming Language and
- Integrated Development Environment (IDE)
- Made by The MathWorks Inc.


MATLAB 7.6.0 (R2008a)
File Edit Debug Desktop Window Help
Current Directory: C:\Rose\CSSE120 Intro to Robotics\CSSE120 repo\Public\Resources\Matlab
Shortcuts How to Add What's New
Current Directory
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Matlab Quick Command Reference She
rootTablePrinter.asv
rootTablePrinter.m
Command History
Command Window
Start
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```
bulletFlight(.01)
%-- 1/29/09  6:52 PM --%
3+4
x = [ 3 4 5]
x'
fprintf('Hello World')
clc
fprintf('Hello World')
clc
fprintf('Hello World\n')
3+ 4
x = [3 4 5]
x'
```

```
>> fprintf('Hello World\n')
Hello World
>> 3+ 4

ans =

     7

>> x = [3 4 5]

x =

     3     4     5

>> x'

ans =

     3
     4
     5

>> 
```

Sample comparison code

- The first program we looked at in C was a print root table function. Let’s see the syntax in Matlab.
  - Review code in C and Python first
  - See how MATLAB would code the root table problem

How is MATLAB similar to Python?

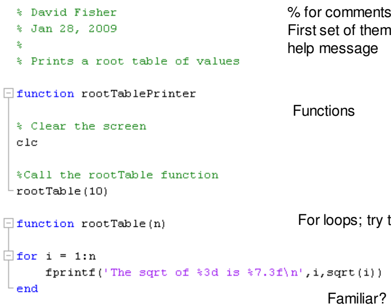
- Similar to IDLE:
  - Interactive mode for quick tests
  - Programming mode for writing code
    - Python has .py files for code
    - MATLAB uses .m files for code
- Similar programming concepts as Python…
  - Variables, functions, if, for, while, etc.

Parallel examples in Python and C.

```
from math import *

def printRootTable(n):
    for i in range(1,n):
      print " %2d   %7.3f" % (i, sqrt(i))

def main():
    printRootTable(10)

main()
```

```
#include <stdio.h>
#include <math.h>

void printRootTable(int n) {
   int i;
   for (i=1; i<=n; i++) {
      printf(" %2d   %7.3f\n", i, sqrt(i));
   }
}

int main() {
  printRootTable(10);
  return 0;
}
```

rootTable in MATLAB



```
% David Fisher
% Jan 28, 2009
%
% Prints a root table of values

function rootTablePrinter

% Clear the screen
clc

%Call the rootTable function
rootTable(10)

function rootTable(n)

for i = 1:n
    fprintf('The sqrt of %3d is %7.3f\n',i,sqrt(i))
end
```

% for comments
First set of them used as the
help message

Functions

For loops; try typing **1:10**

Familiar?

while loops

k = 10

while (k>0)

  k=k-1

end

Similar to the if statement

Can still use the “break” statement to exit early if needed

if statement

if-Statement Structure:

if (a<0)

  x = 1

end

Must have an “end” statement

tabbing is for looks only

() around condition

for loops

for i=1 : 0.001 : 10

   % do stuff

end

Compare to range in Python:

for i in range(1,10,0.001): (which doesn't work)

  #do stuff

MATLAB for loop, k = first : increment : last

(could omit increment to default to 1, like Python)

Your turn:
Program now: code to print multiples of 5 up to 50.
Then print only those not divisible by 3.

elif statement

if (a<0)

  x=1

elseif(a>0)

  x=2

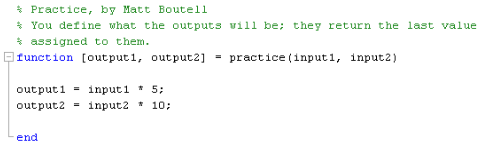
else

  x=3

end

elif is done as elseif (one word)

Functions in MATLAB



```
% Practice, by Matt Boutell
% You define what the outputs will be; they return the last value
% assigned to them.
function [output1, output2] = practice(input1, input2)

output1 = input1 * 5;
output2 = input2 * 10;

end
```

Easy to return multiple values, no “return” statement needed

Autoruns first function, which should have same name as .m file

Inputs and outputs are optional

- function testFunction
  - No inputs or outputs
- function [x] = testFunction2
  - Only 1 output called x
- function testFunction3(n)
  - Only 1 input called n
- function [y] = testFunction4(a,b,c)
  - 3 inputs a, b, c and 1 output y

If the primary function has inputs, call from command line,

If no inputs needed, you can select Run (or F5)

factorialTable output

- Running factorialTable should product this output:

```
 1! = 1
 2! = 2
 3! = 6
 4! = 24
 5! = 120
 6! = 720
 7! = 5040
 8! = 40320
 9! = 362880
10! = 3628800
>>
```

MATLAB scripts vs MATLAB functions

- MATLAB scripts
  - No function signature line, just code
  - All variables visible in workspace
  - No subfunctions at all!
- MATLAB functions
  - First line of code is function [outputs] = name (inputs)
  - Subfunctions (helper functions) allowed in same .m file
  - Variable scope limited to function
- Revisit examples so far to see.

Debugger

- In this case, MATLAB is more like Eclipse than IDLE
- MATLAB has an easy to use debugger

- Add a breakpoint to the start of your factorialTable code (first line in the factorialTable function)
- Step into the code by running function in shell
- Open the Workspace window (upper left tab) to see values

Hands on MATLAB function .m files

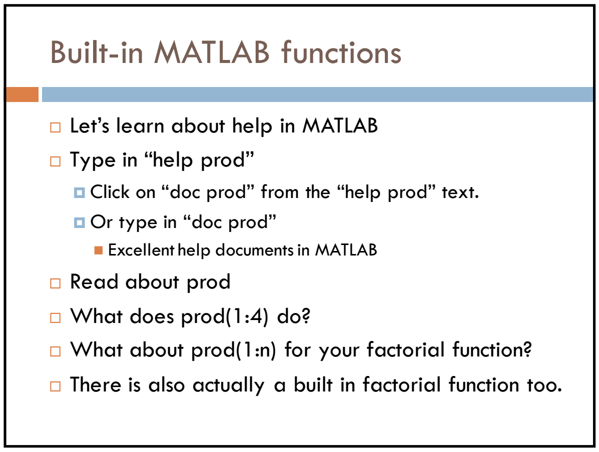
- One of the first functions we made in Python was a factorial function.
- Make a program that has an m file called "factorialTable.m"
- Make a subfunction called calculateFactorial(n) that returns the n! value to the factorialTable function
  - A little help on the subfunction:

```
function [result] = calculateFactorial(n)
result = 1
…
```

Example output on next slide:

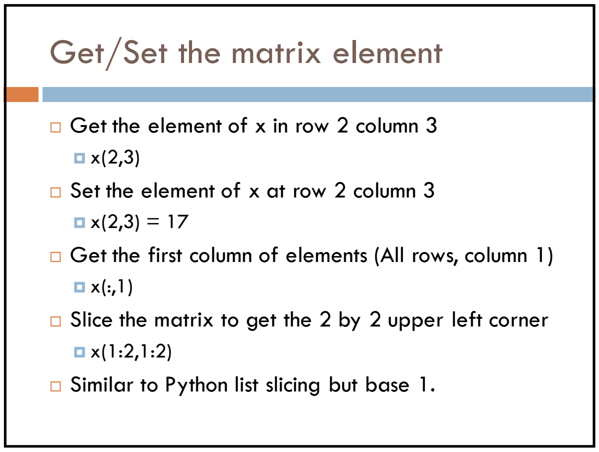
Fun quick keys/Shortcuts (on handout)

- Up Arrow - Interactive Mode Command History
- Comment line - Ctrl k
- Uncomment line - Ctrl t
- Select All/Auto Indent - Ctrl a Ctrl I
- Run .m file - F5
- Autocomplete - Tab
- Save - Ctrl s
- Standard copy, cut, paste



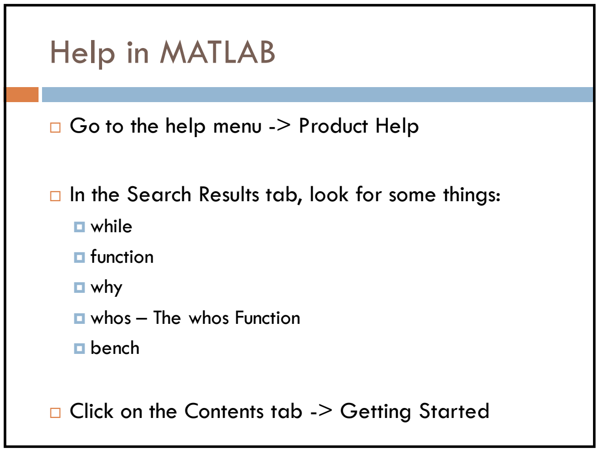
Built-in MATLAB functions

- Let's learn about help in MATLAB
- Type in "help prod"
  - Click on "doc prod" from the "help prod" text.
  - Or type in "doc prod"
    - Excellent help documents in MATLAB
- Read about prod
- What does prod(1:4) do?
- What about prod(1:n) for your factorial function?
- There is also actually a built in factorial function too.



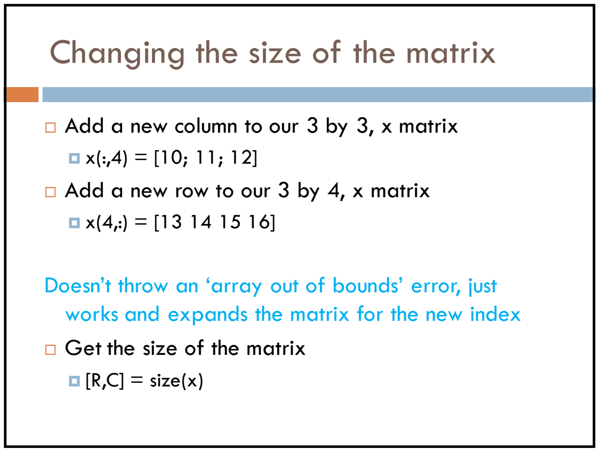
Get/Set the matrix element

- Get the element of x in row 2 column 3
  - x(2,3)
- Set the element of x at row 2 column 3
  - x(2,3) = 17
- Get the first column of elements (All rows, column 1)
  - x(:,1)
- Slice the matrix to get the 2 by 2 upper left corner
  - x(1:2,1:2)
- Similar to Python list slicing but base 1.



Help in MATLAB

- Go to the help menu -> Product Help
- In the Search Results tab, look for some things:
  - while
  - function
  - why
  - whos – The whos Function
  - bench
- Click on the Contents tab -> Getting Started

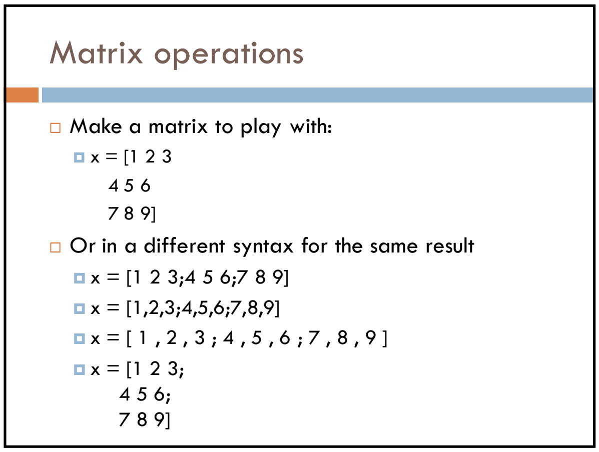


Changing the size of the matrix

- Add a new column to our 3 by 3, x matrix
  - x(:,4) = [10; 11; 12]
- Add a new row to our 3 by 4, x matrix
  - x(4,:) = [13 14 15 16]

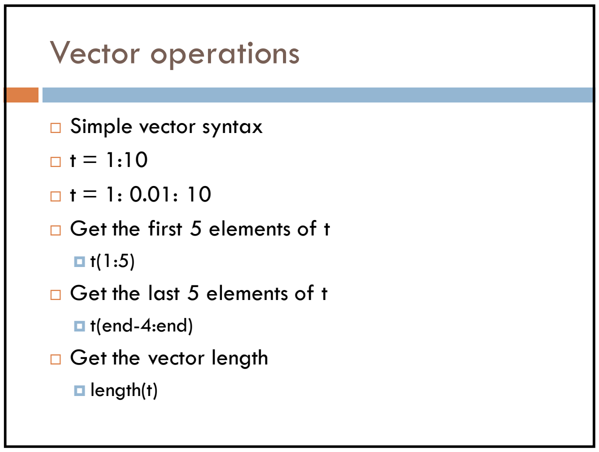
Doesn't throw an 'array out of bounds' error, just works and expands the matrix for the new index

- Get the size of the matrix
  - [R,C] = size(x)



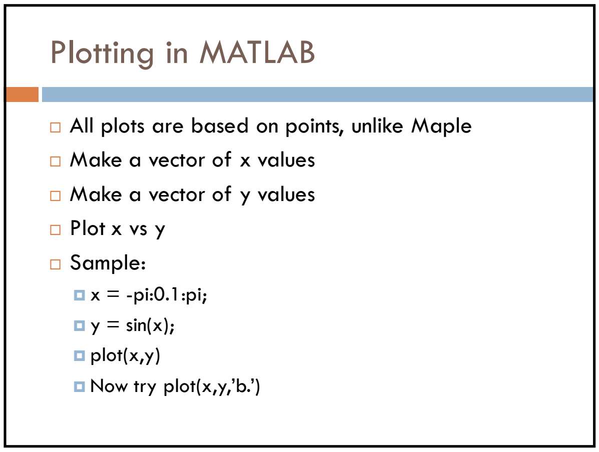
Matrix operations

- Make a matrix to play with:
  - x = [1 2 3
    4 5 6
    7 8 9]
- Or in a different syntax for the same result
  - x = [1 2 3;4 5 6;7 8 9]
  - x = [1,2,3;4,5,6;7,8,9]
  - x = [1 , 2 , 3 ; 4 , 5 , 6 ; 7 , 8 , 9]
  - x = [1 2 3;
    4 5 6;
    7 8 9]



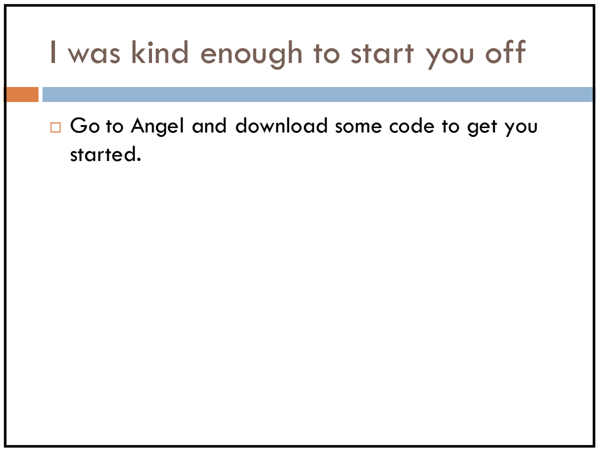
Vector operations

- Simple vector syntax
- t = 1:10
- t = 1: 0.01: 10
- Get the first 5 elements of t
  - t(1:5)
- Get the last 5 elements of t
  - t(end-4:end)
- Get the vector length
  - length(t)



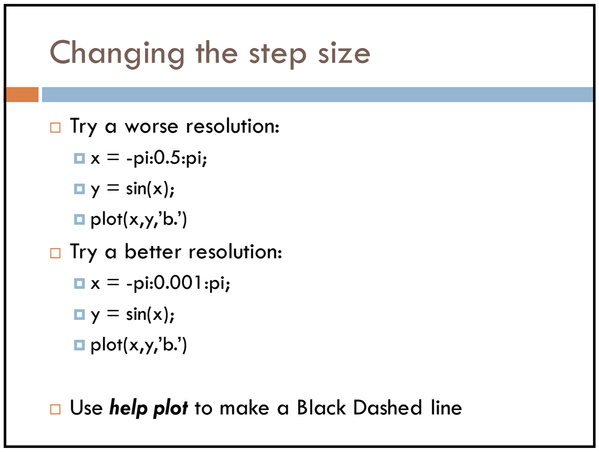
Plotting in MATLAB

- All plots are based on points, unlike Maple
- Make a vector of x values
- Make a vector of y values
- Plot x vs y
- Sample:
  - x = -pi:0.1:pi;
  - y = sin(x);
  - plot(x,y)
  - Now try plot(x,y,'b.')



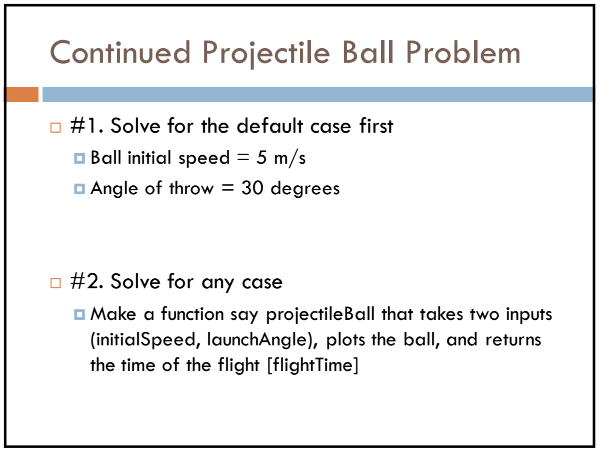
I was kind enough to start you off

- Go to Angel and download some code to get you started.



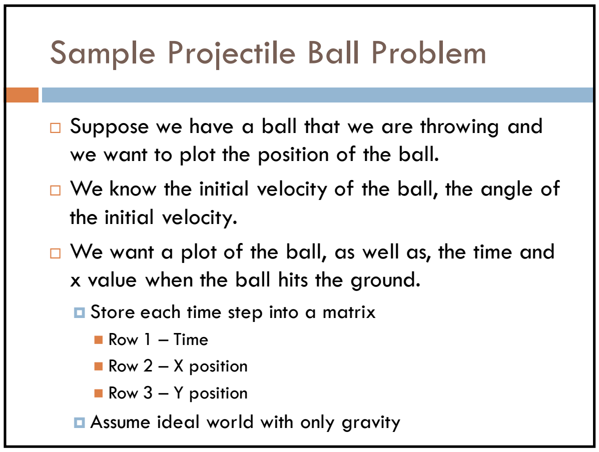
Changing the step size

- Try a worse resolution:
  - x = -pi:0.5:pi;
  - y = sin(x);
  - plot(x,y,'b.')
- Try a better resolution:
  - x = -pi:0.001:pi;
  - y = sin(x);
  - plot(x,y,'b.')
- Use ***help plot*** to make a Black Dashed line



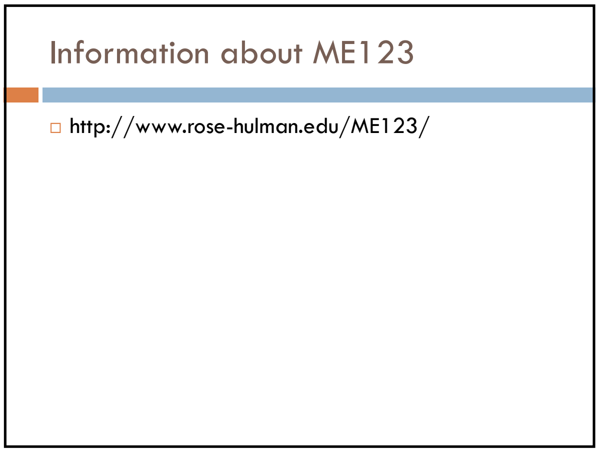
Continued Projectile Ball Problem

- #1. Solve for the default case first
  - Ball initial speed = 5 m/s
  - Angle of throw = 30 degrees
- #2. Solve for any case
  - Make a function say projectileBall that takes two inputs (initialSpeed, launchAngle), plots the ball, and returns the time of the flight [flightTime]



Sample Projectile Ball Problem

- Suppose we have a ball that we are throwing and we want to plot the position of the ball.
- We know the initial velocity of the ball, the angle of the initial velocity.
- We want a plot of the ball, as well as, the time and x value when the ball hits the ground.
  - Store each time step into a matrix
    - Row 1 – Time
    - Row 2 – X position
    - Row 3 – Y position
  - Assume ideal world with only gravity



Information about ME123

- http://www.rose-hulman.edu/ME123/