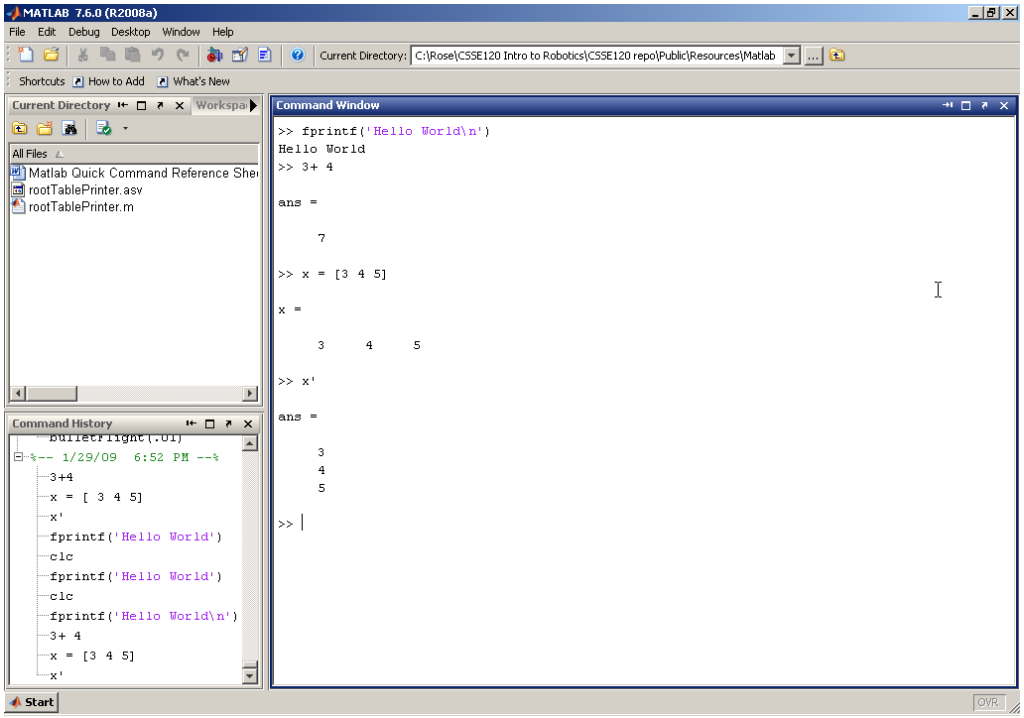
MATLAB INTRO: PREPARATION FOR ME323

CSSE 120—Rose Hulman Institute of Technology

What is MATLAB?

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



How is MATLAB similar to Python?

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

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.

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

```python
from math import *

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

def main():
    printRootTable(10)

main()
```

Parallel examples in Python and C.

```c
#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

Indenting is for readability, but not required

Familiar?

if statement

if-Statement Structure:

```
if (a<0)
    x = 1
End
```

Must have an “end” statement

no :

tabbing is for looks only

() around condition

elif statement

```
if (a<0)
    x=1
elseif(a>0)
    x=2
else
    x=3
end
```

elif is done as elseif (one word)

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

for loops

```
for i=1 : 0.001 : 10
    x=x+5
end
```

Program now: code to print multiples of 5 up to 50.
Then print only those not divisible by 3.
Try to add a ; to the end of the loop body line
After running the code, type *i* in the shell

Compare to range in Python:

```
for i in range(1,10,0.001): (which doesn't work)
    x = x+5
```

MATLAB for loop, k = first : increment : last

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

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)

MATLAB scripts vs MATLAB functions

- MATLAB scripts
  - No code word function, 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.

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 factorial(n) that returns the n! value
  - A little help on the subfunction:

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

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

Fun quick keys/Shortcuts

- 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"

- Read about prod
- What does prod(1:4) do?
- What about prod(1:n) for your factorial function?
- Click on "doc prod" from the "help prod" text.
  - Excellent help documents in MATLAB

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

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]

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.

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)

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.')

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

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 and the time 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

I was kind enough to start you off

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

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]

Information about ME123

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