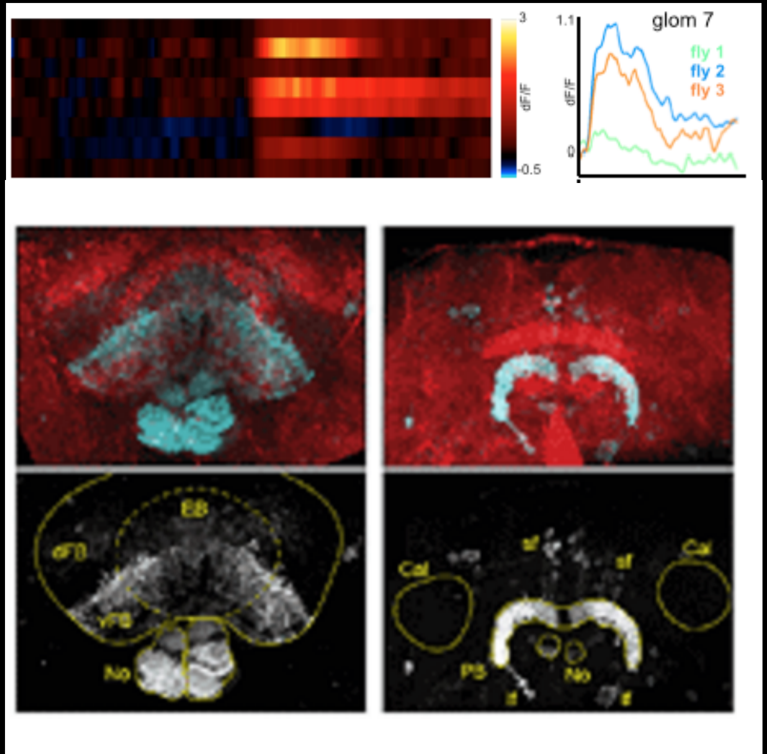
Introduction to Programming for Biology Research

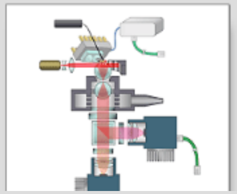
the de Bivort lab

Department of Organismic and Evolutionary Biology

Center for Brain Science

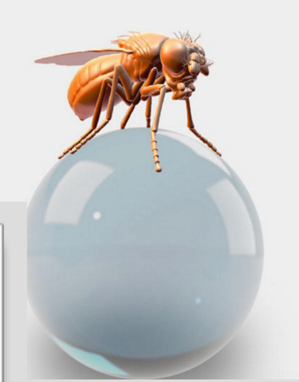
Harvard University





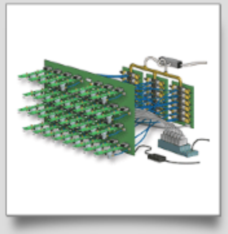
LegTracker

an instrument for recording the position of all 6 of a fly's legs, in real time, at 80Hz



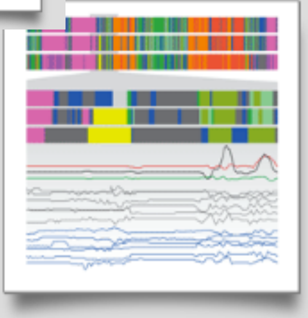
FlyVac

coordinates 32 modules to autonomously measure the light preference of individual flies, many times each



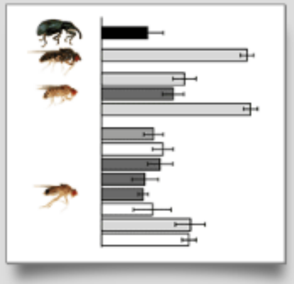
automated behavioral classification

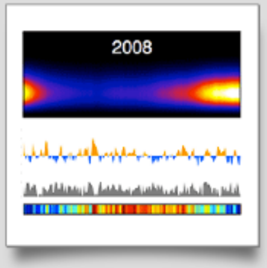
classifications of spontaneous behavior, assigned by human investigators and machine learning algorithms



variation across species

the white clover weevil and three *Drosophila* species vary across strain and species in how much phototactic personality they have





effect of weather on behavior

predicted fly population dynamics and phototactic behavior dynamics as influenced by real world weather conditions from 2008

Introduction to MATLAB: part I

MATLAB Basics

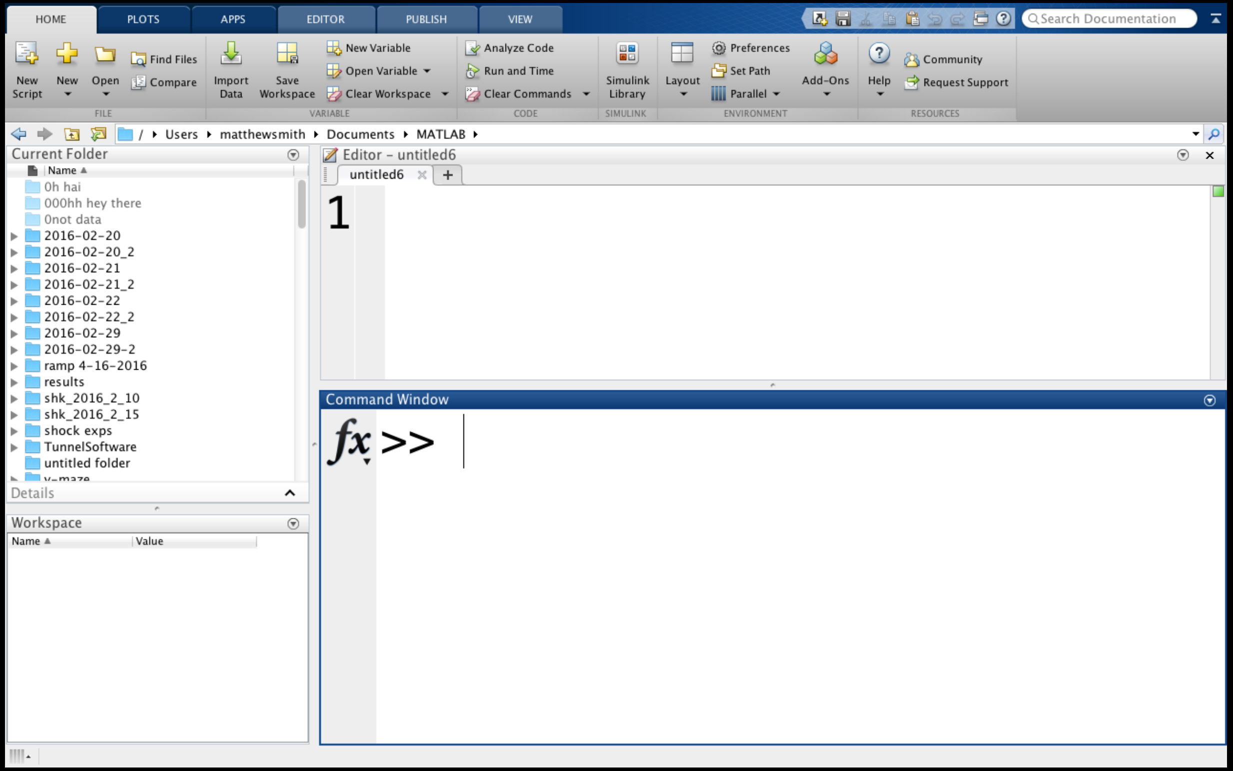
- The interface
- Variables/arrays/matrices
- Conditional statements
- Loops (for and while)

MATLAB®
MathWorks®
R2015a

MATLAB: The interface

4 Default windows:

1) Current folder
2) Workspace
3) Editor
4) Command window



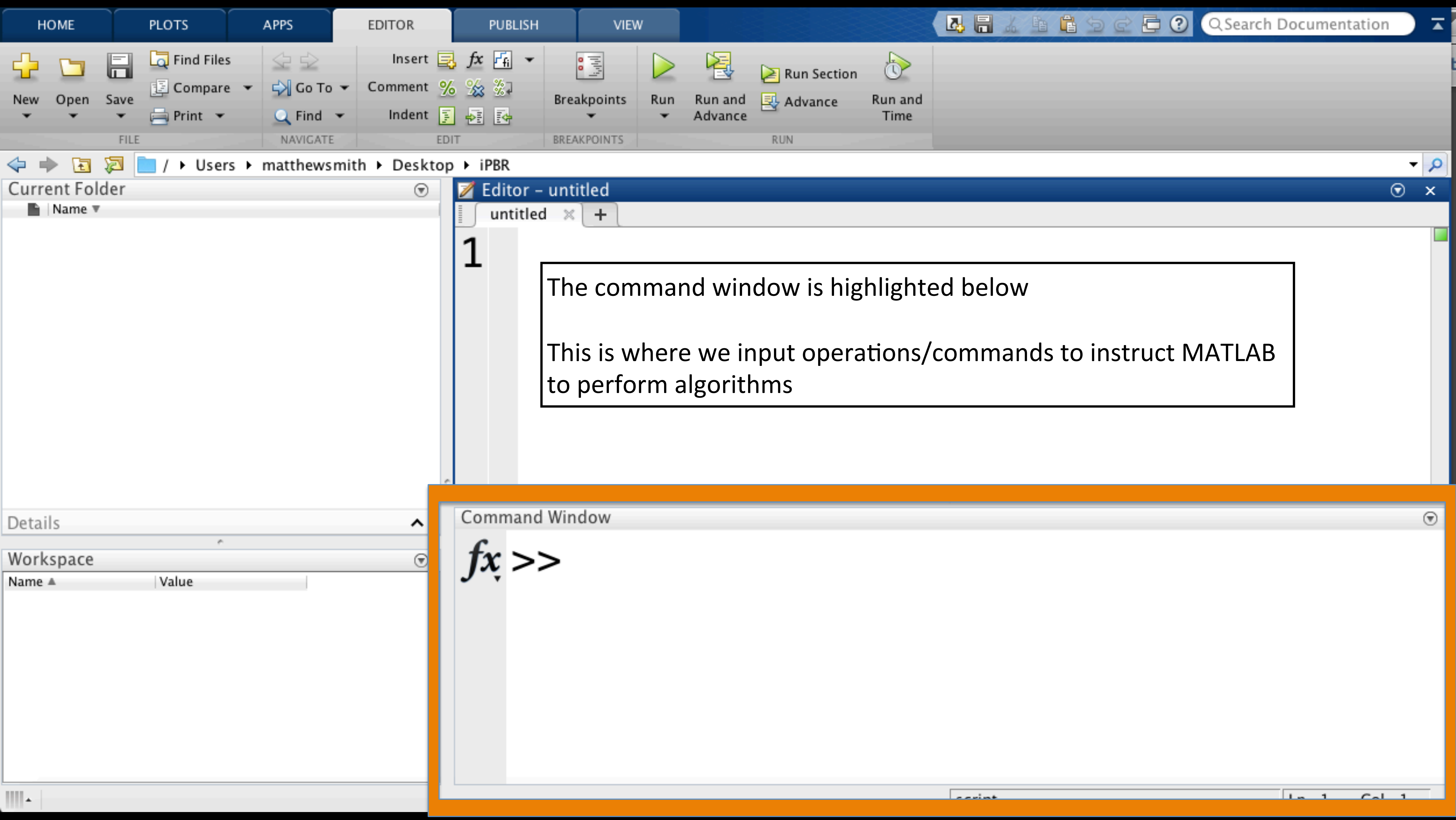
Command window

The command window is where one can type commands to MATLAB

Algorithms

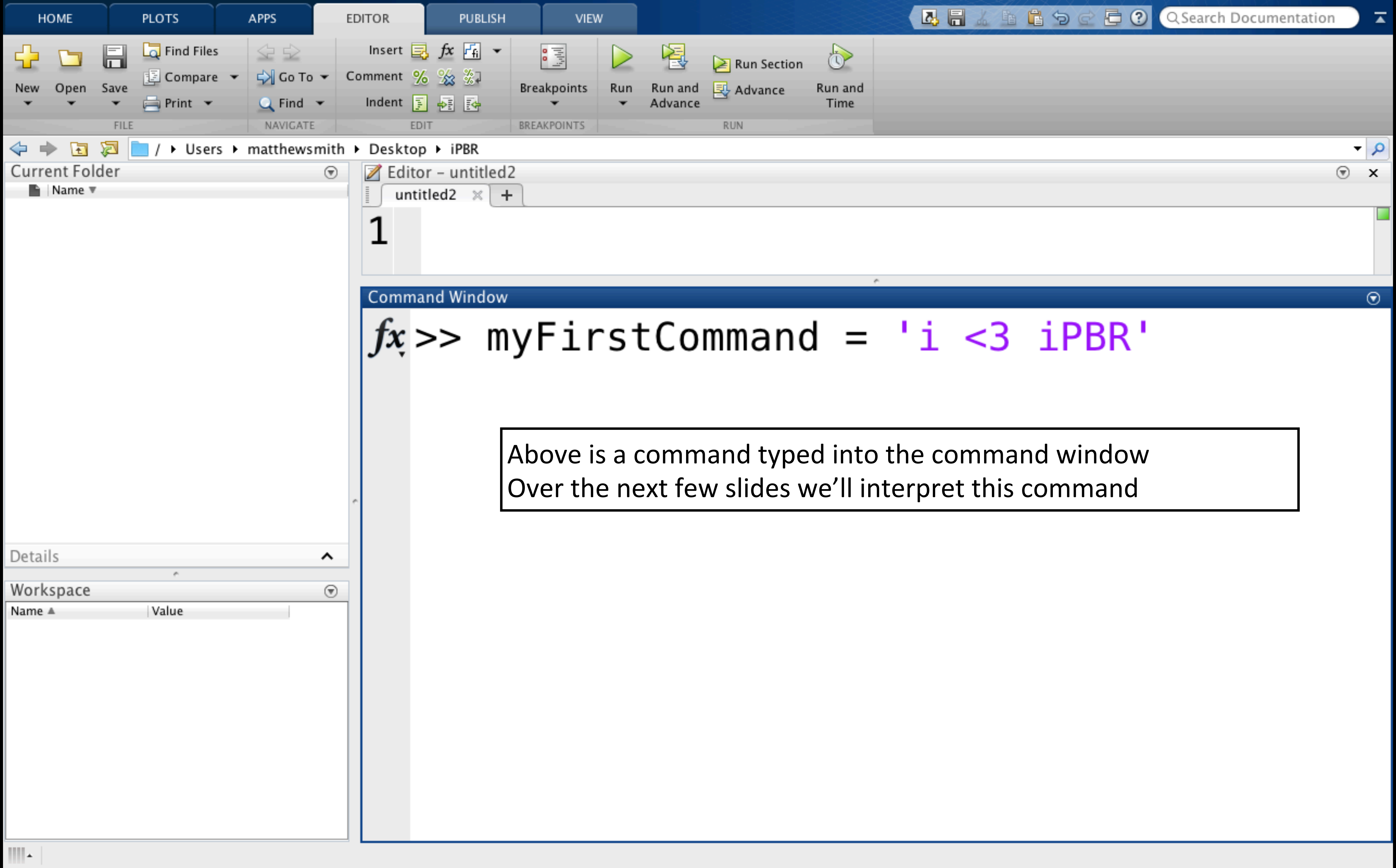
Algorithms

- Algorithms are a sequence of step-by-step instructions for accomplishing a task
- These instructions must be:
  - Effectively computable (doable)
  - Unambiguous
- When it is finished, the algorithm must end, and must produce some kind of result



The command window is highlighted below

This is where we input operations/commands to instruct MATLAB to perform algorithms



```
>> myFirstCommand = 'i <3 iPBR'
```

Above is a command typed into the command window
Over the next few slides we'll interpret this command

Variables. The Most Important Slides.

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In MATLAB, data is stored in ***Variables***

Variables are essentially named storage locations that correspond to a location in your computers RAM where MATLAB can find your data

Variables. The Most Important Slides.

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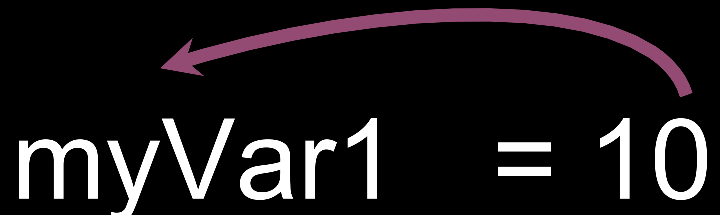
```
myVar1   = 10
```

Variables. The Most Important Slides.

In MATLAB, data is stored in ***Variables***

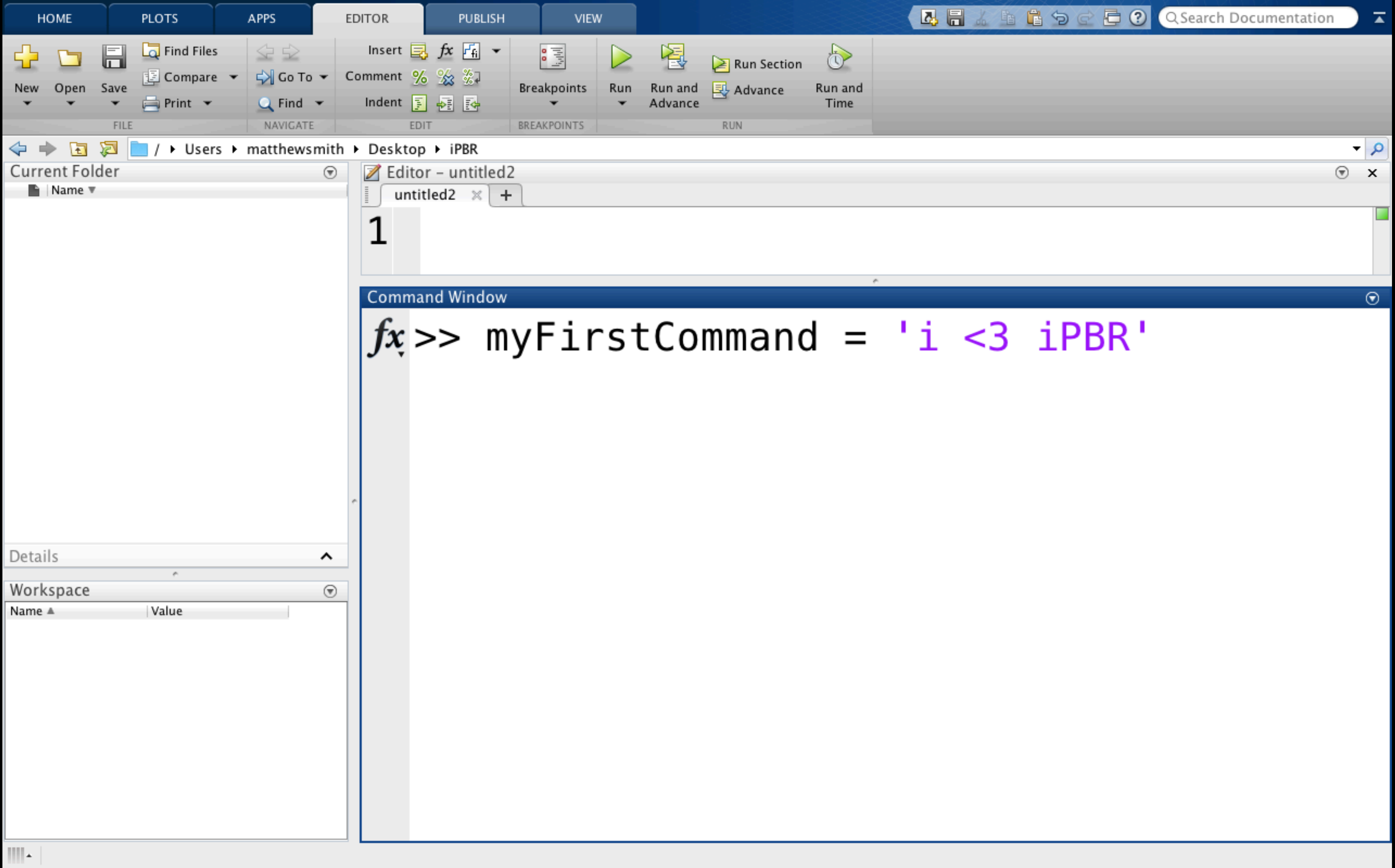
Variables are essentially named storage locations that correspond to a location in your computers RAM where MATLAB can find your data

Data is assigned to variables through the ‘equals sign’

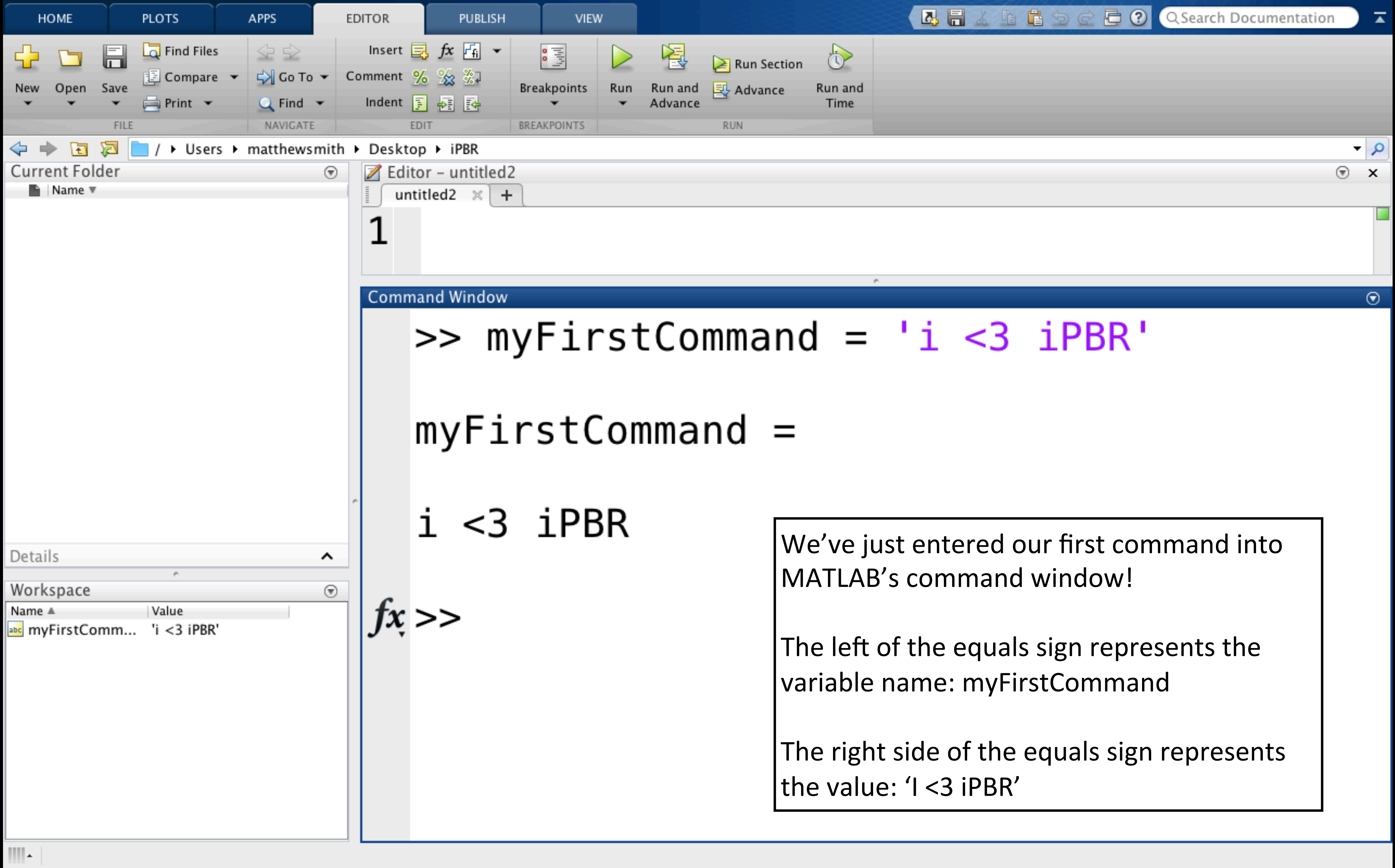


myVar1 = 10

Data is ***READ*** from the ***RIGHT*** and ***assigned*** to the ***left***



```
>> myFirstCommand = 'i <3 iPBR'
```



```
>> myFirstCommand = 'i <3 iPBR'

myFirstCommand =

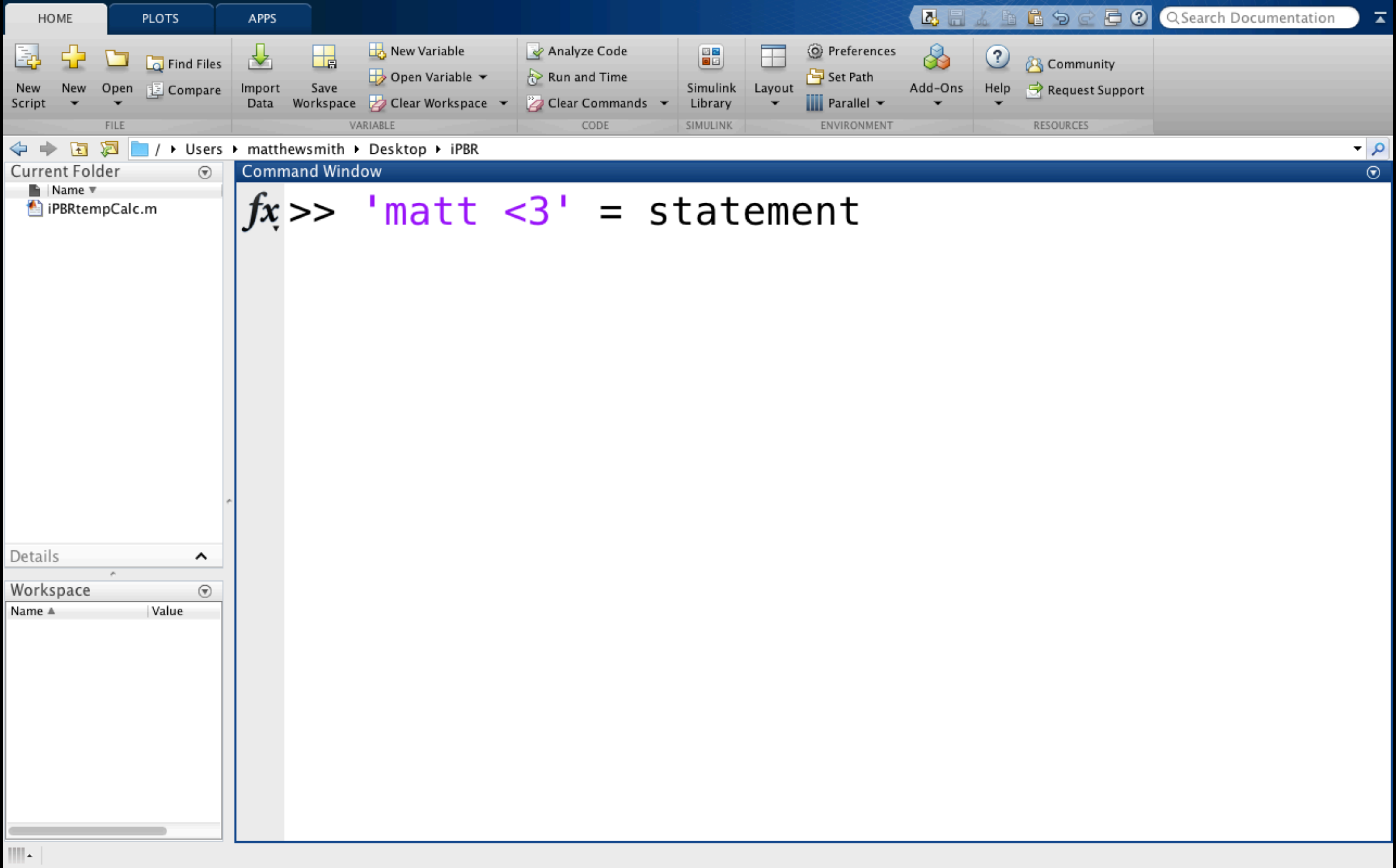
i <3 iPBR

>>
```

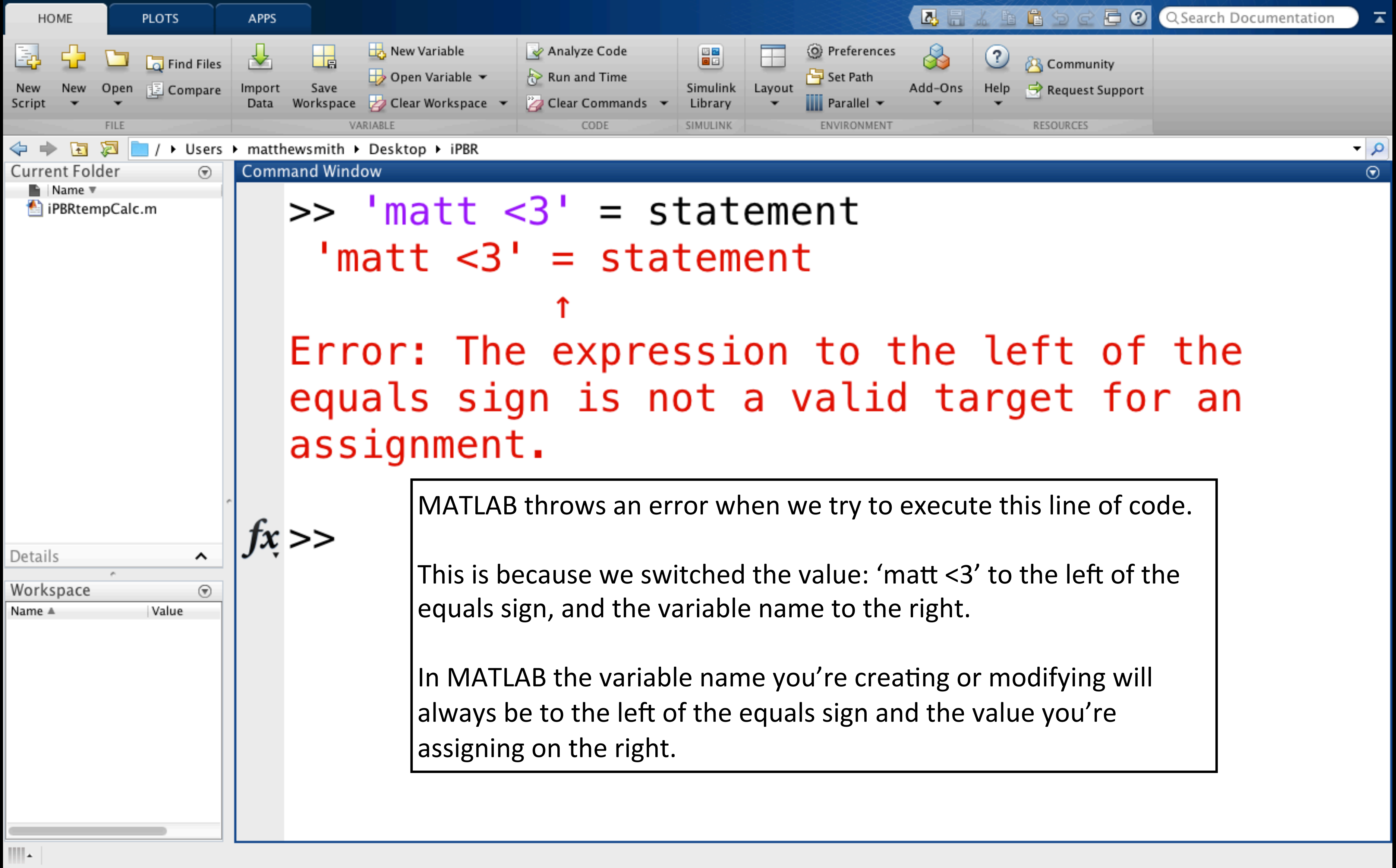
We've just entered our first command into MATLAB's command window!

The left of the equals sign represents the variable name: myFirstCommand

The right side of the equals sign represents the value: 'I <3 iPBR'



```
>> 'matt <3' = statement
```



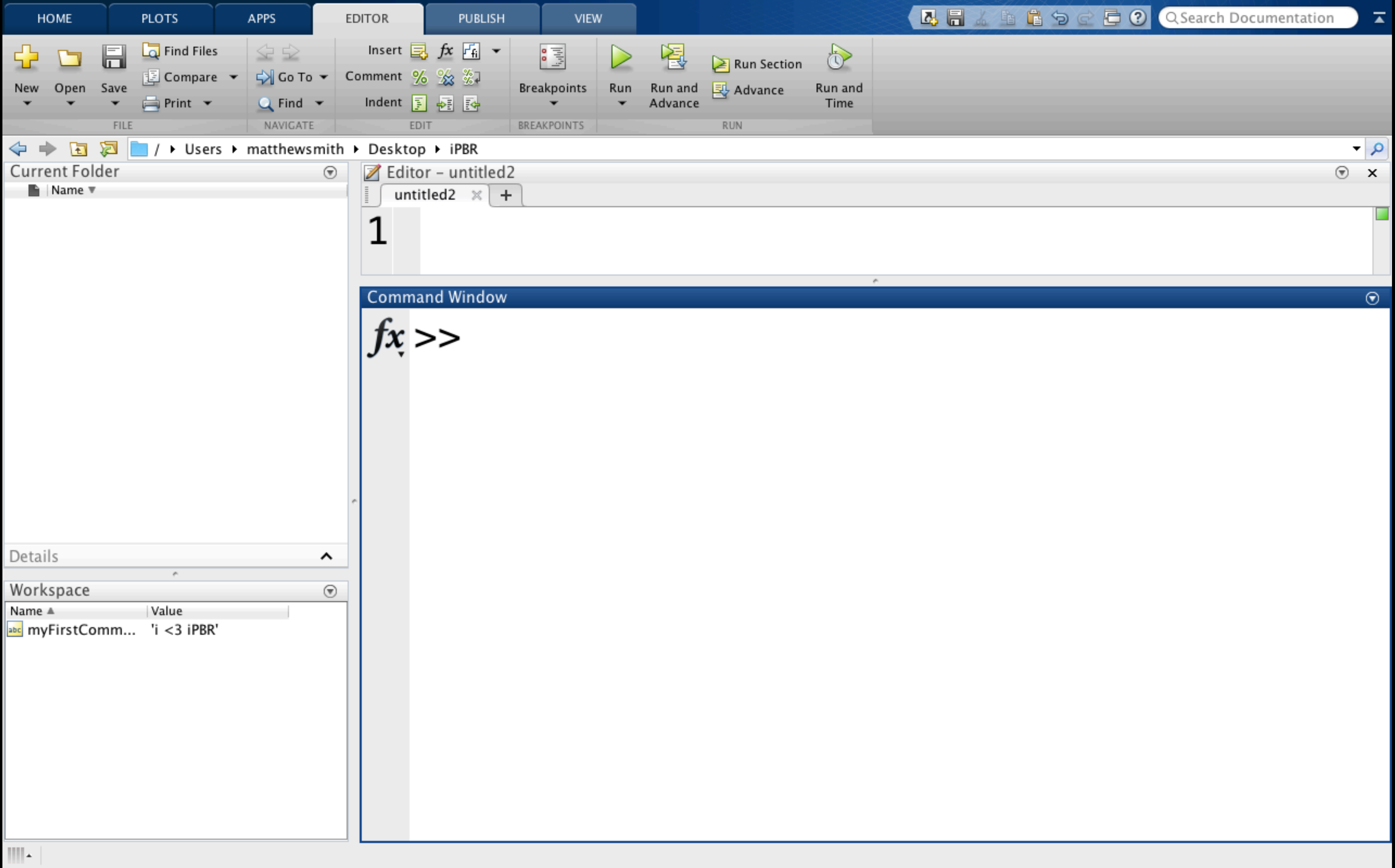
```
>> 'matt <3' = statement
 'matt <3' = statement
                ↑
Error: The expression to the left of the
equals sign is not a valid target for an
assignment.

fx >>
```

MATLAB throws an error when we try to execute this line of code.

This is because we switched the value: ‘matt <3’ to the left of the equals sign, and the variable name to the right.

In MATLAB the variable name you’re creating or modifying will always be to the left of the equals sign and the value you’re assigning on the right.



/ ▸ Users ▸ matthewsmith ▸ Desktop ▸ iPBR

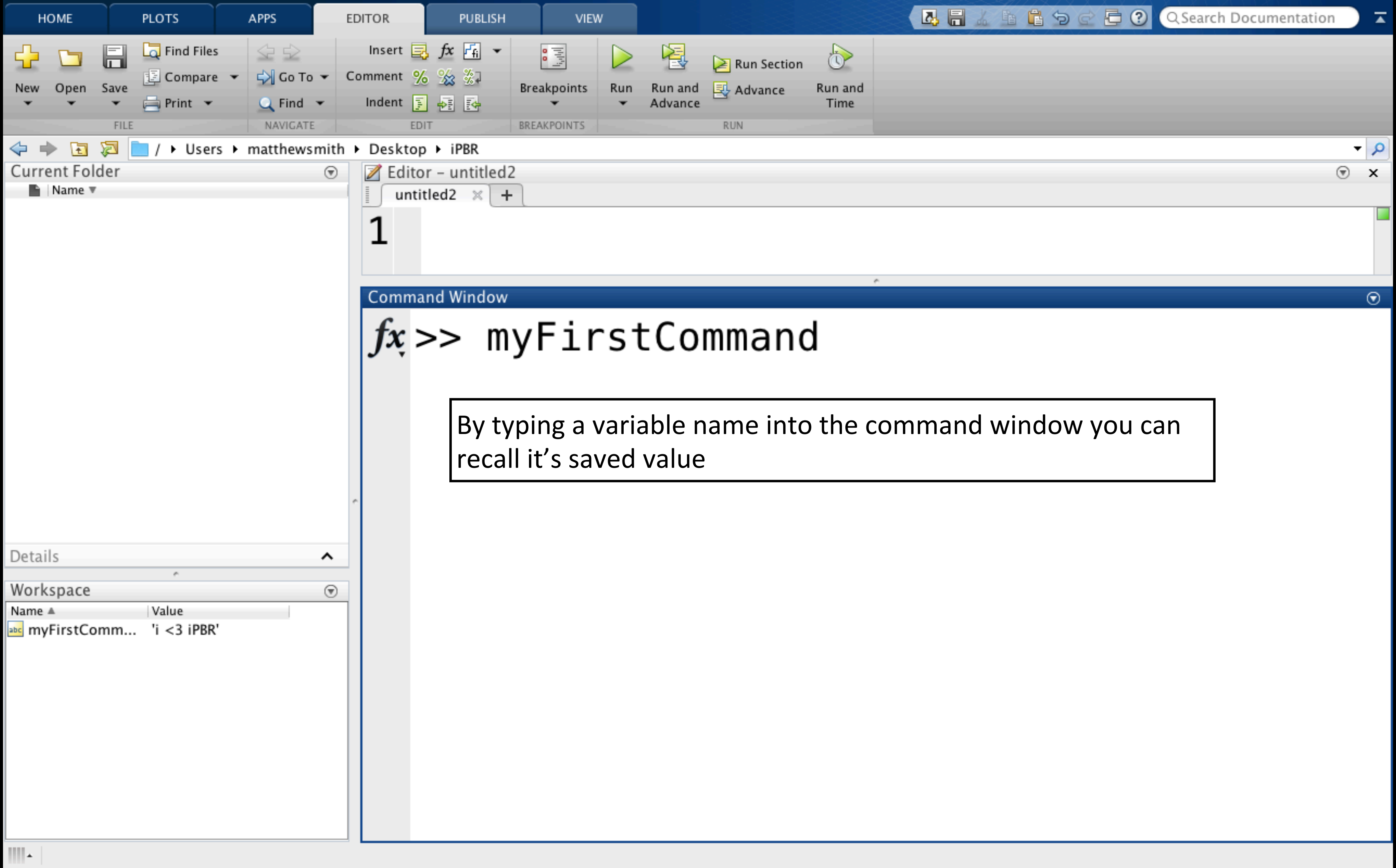
Editor – untitled2

untitled2

```
1
```

Name	Value
myFirstComm...	'i <3 iPBR'

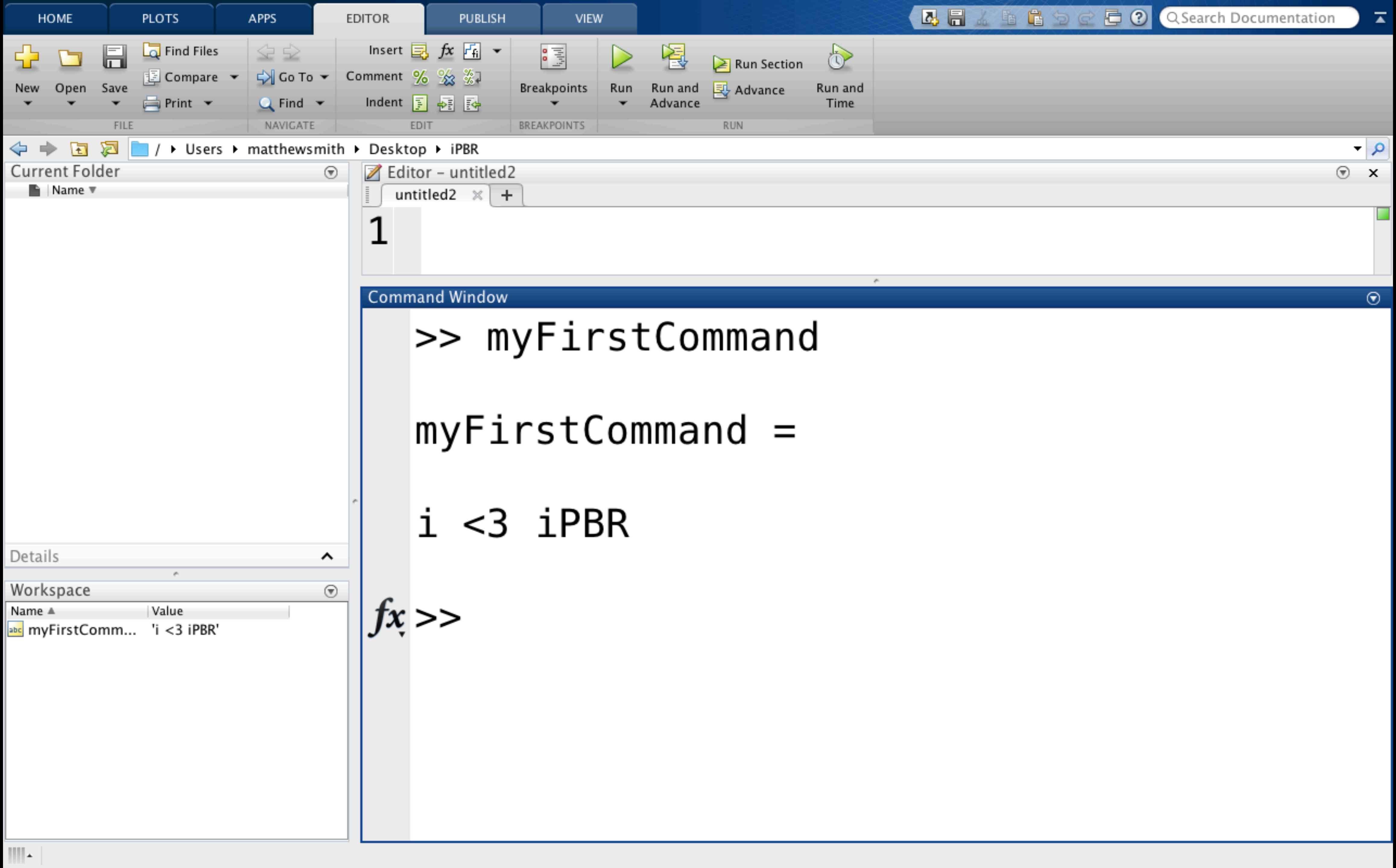
```
>>
```



```
>> myFirstCommand
```

By typing a variable name into the command window you can recall it’s saved value

Name	Value
myFirstComm...	'i <3 iPBR'



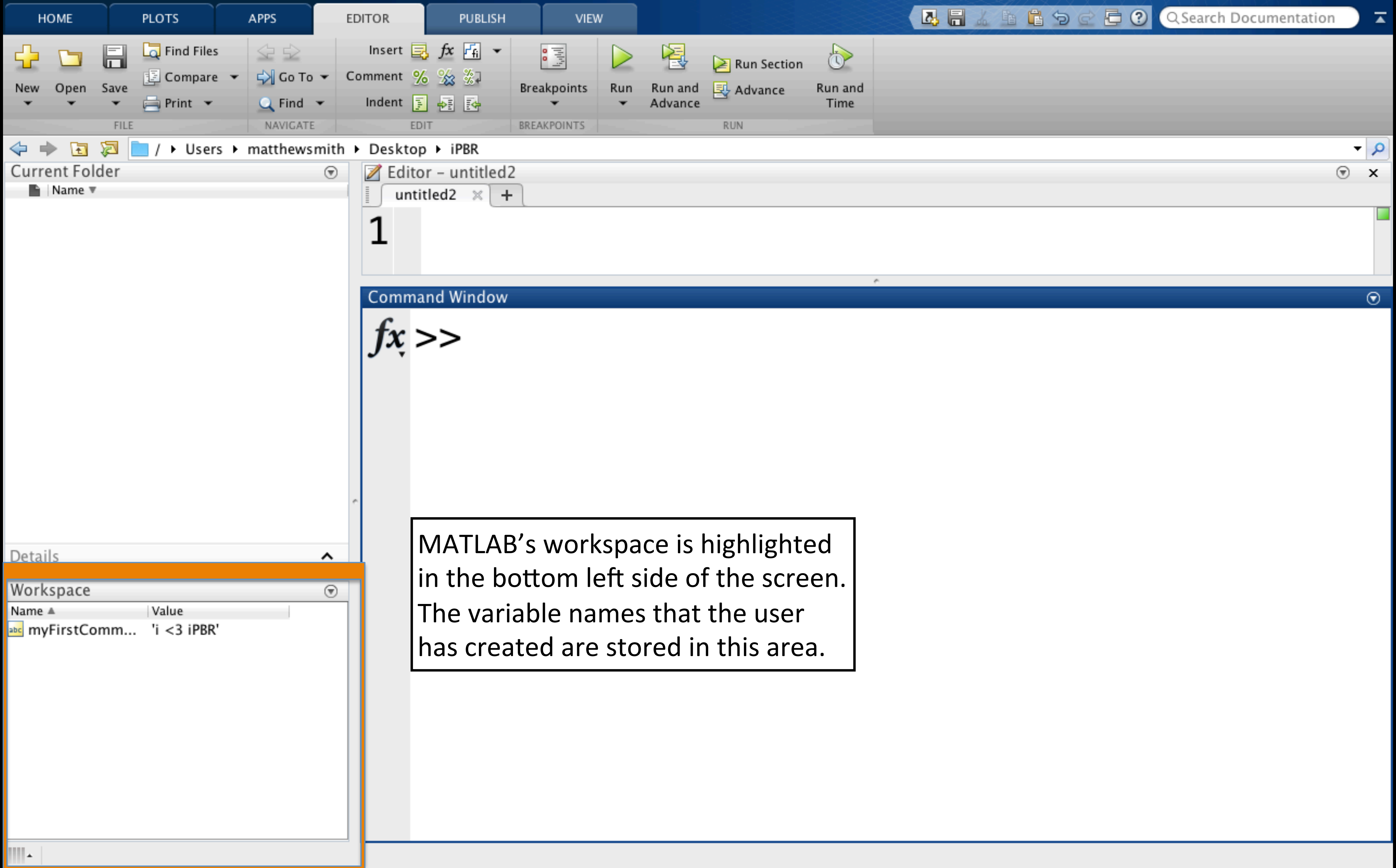
```
>> myFirstCommand

myFirstCommand =

i <3 iPBR

>>
```

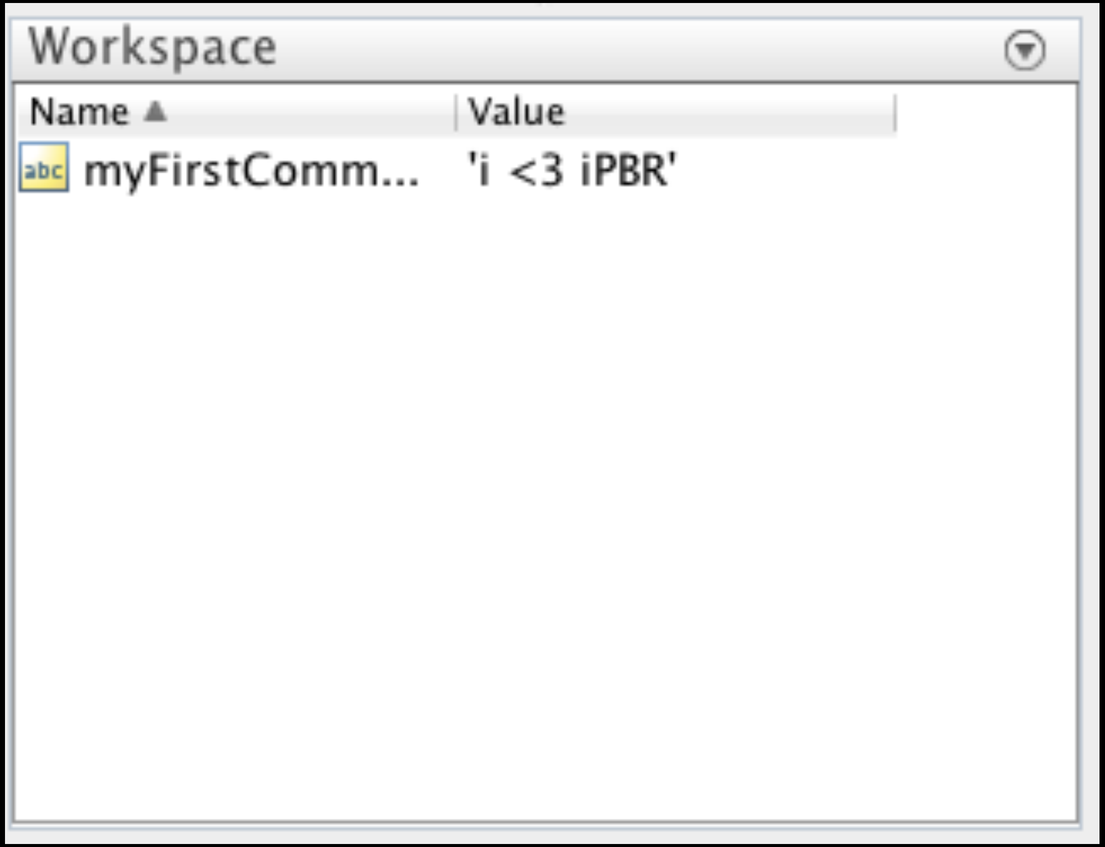
Name	Value
myFirstComm...	'i <3 iPBR'



```
fx >>
```

Name	Value
myFirstComm...	'i <3 iPBR'

MATLAB’s workspace is highlighted in the bottom left side of the screen. The variable names that the user has created are stored in this area.



Workspace

Name ▲	Value
myFirstComm...	'i <3 iPBR'

Workspace

The workspace consists of the variables you create and store in memory during a MATLAB session

Workspace

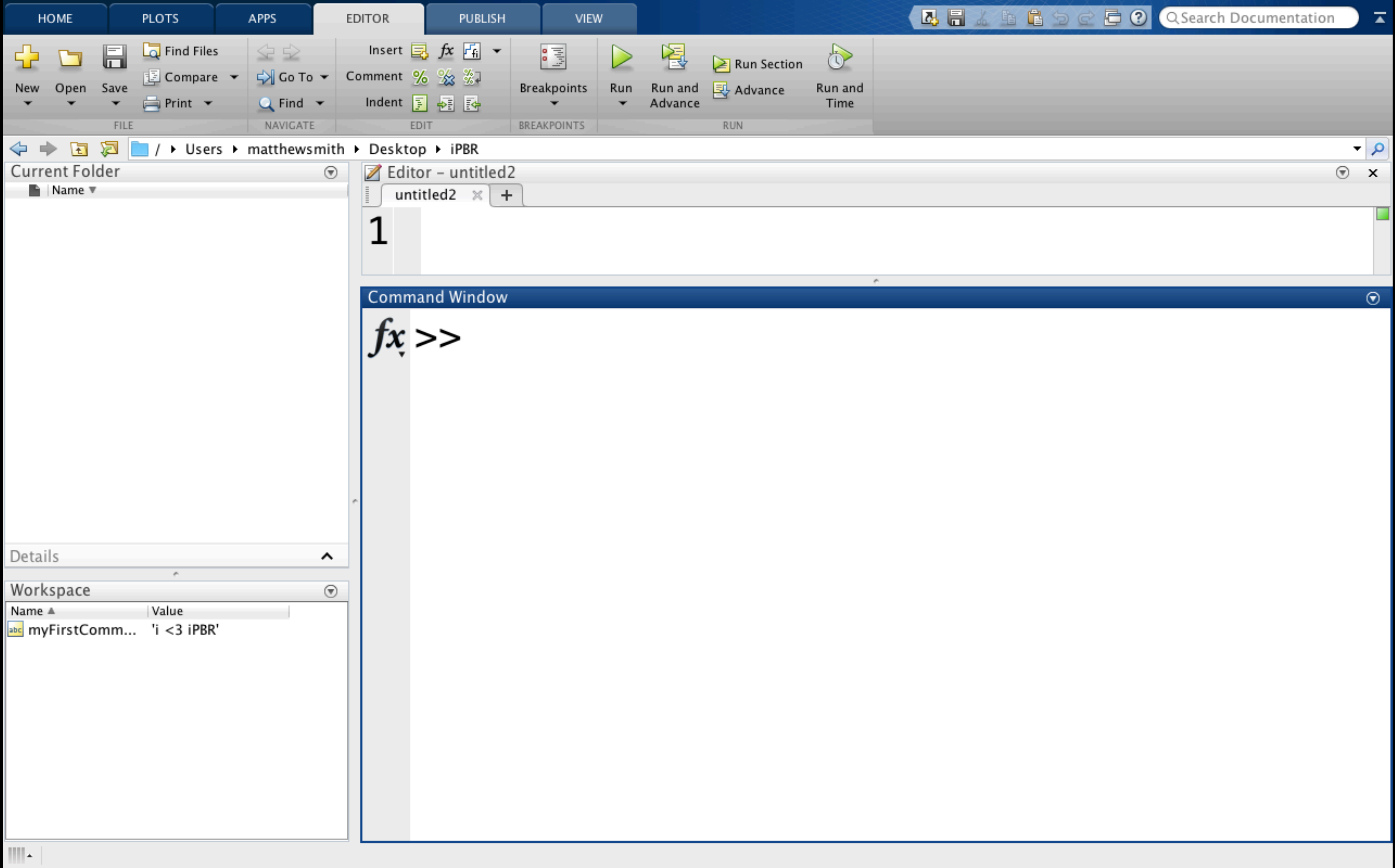
The workspace consists of the variables you create and store in memory during a MATLAB session

It’s like MATLAB’s short term memory!

Workspace

The workspace consists of the variables you create and store in memory during a MATLAB session

You add variables to the workspace by using functions, running MATLAB code, and loading saved workspaces.

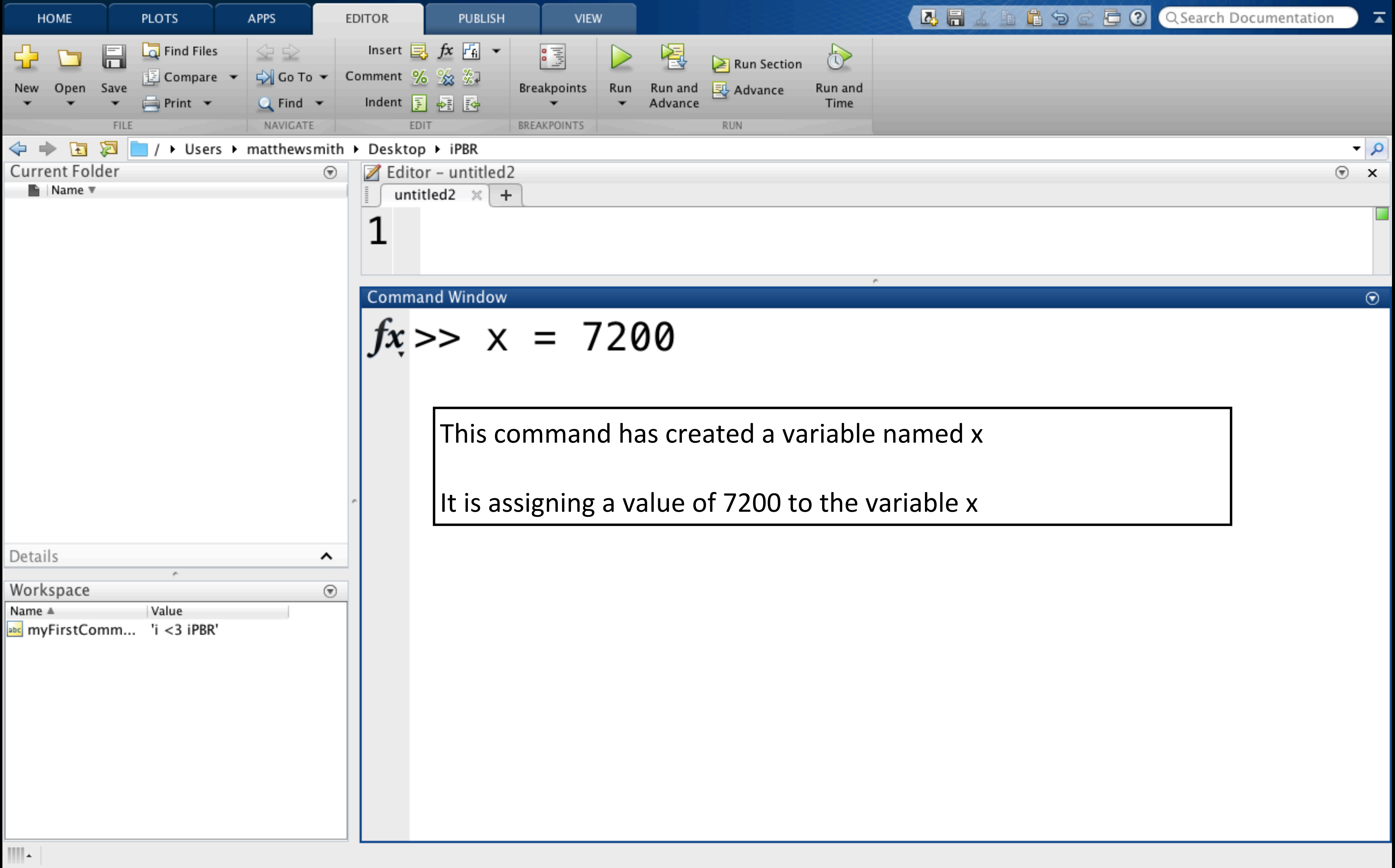


/ ▸ Users ▸ matthewsmith ▸ Desktop ▸ iPBR

```
1
```

```
>>
```

Name ▲	Value
myFirstComm...	'i <3 iPBR'

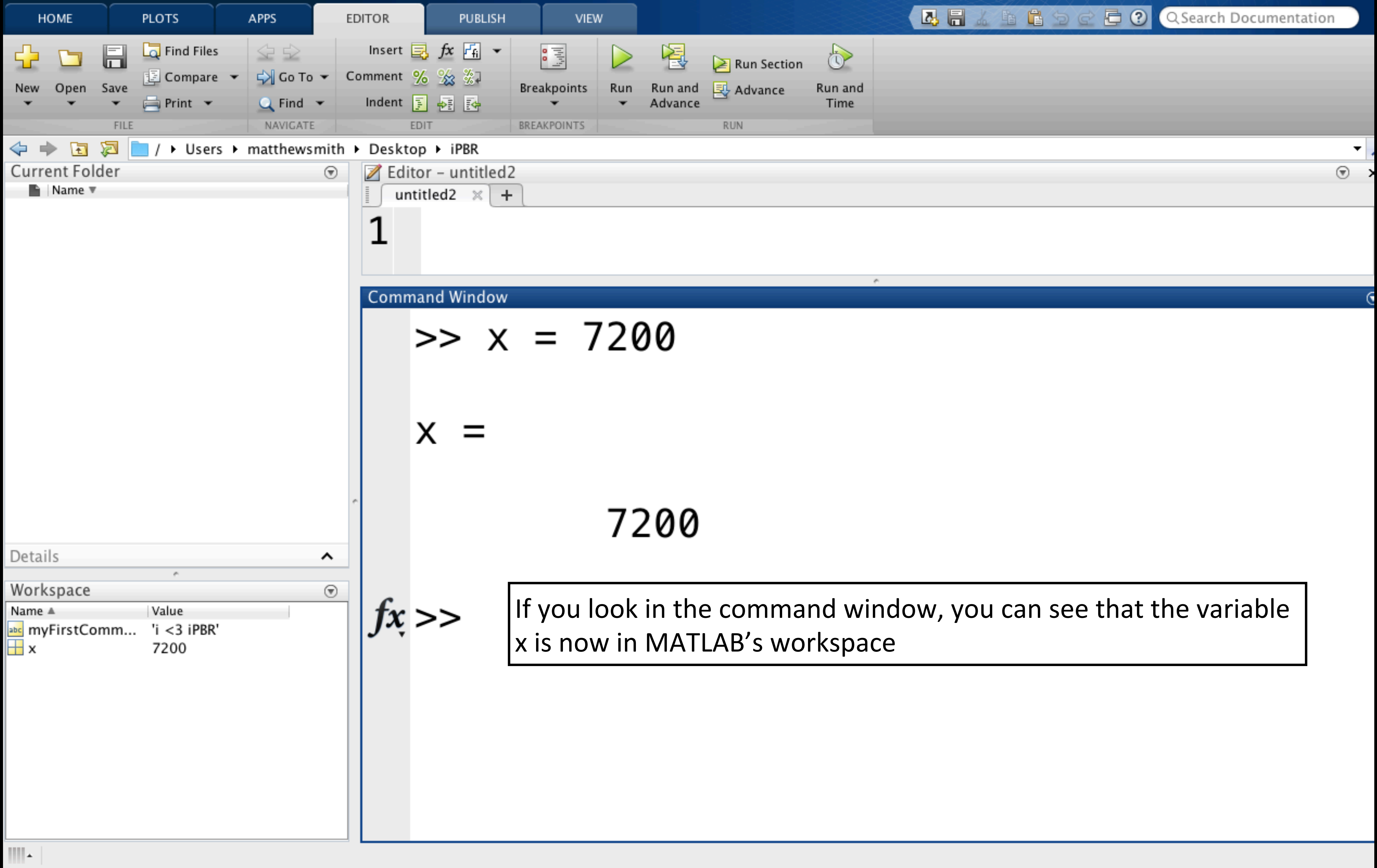


Name	Value
myFirstComm...	'i <3 iPBR'

```
>> x = 7200
```

This command has created a variable named x

It is assigning a value of 7200 to the variable x



```
1
```

```
>> x = 7200

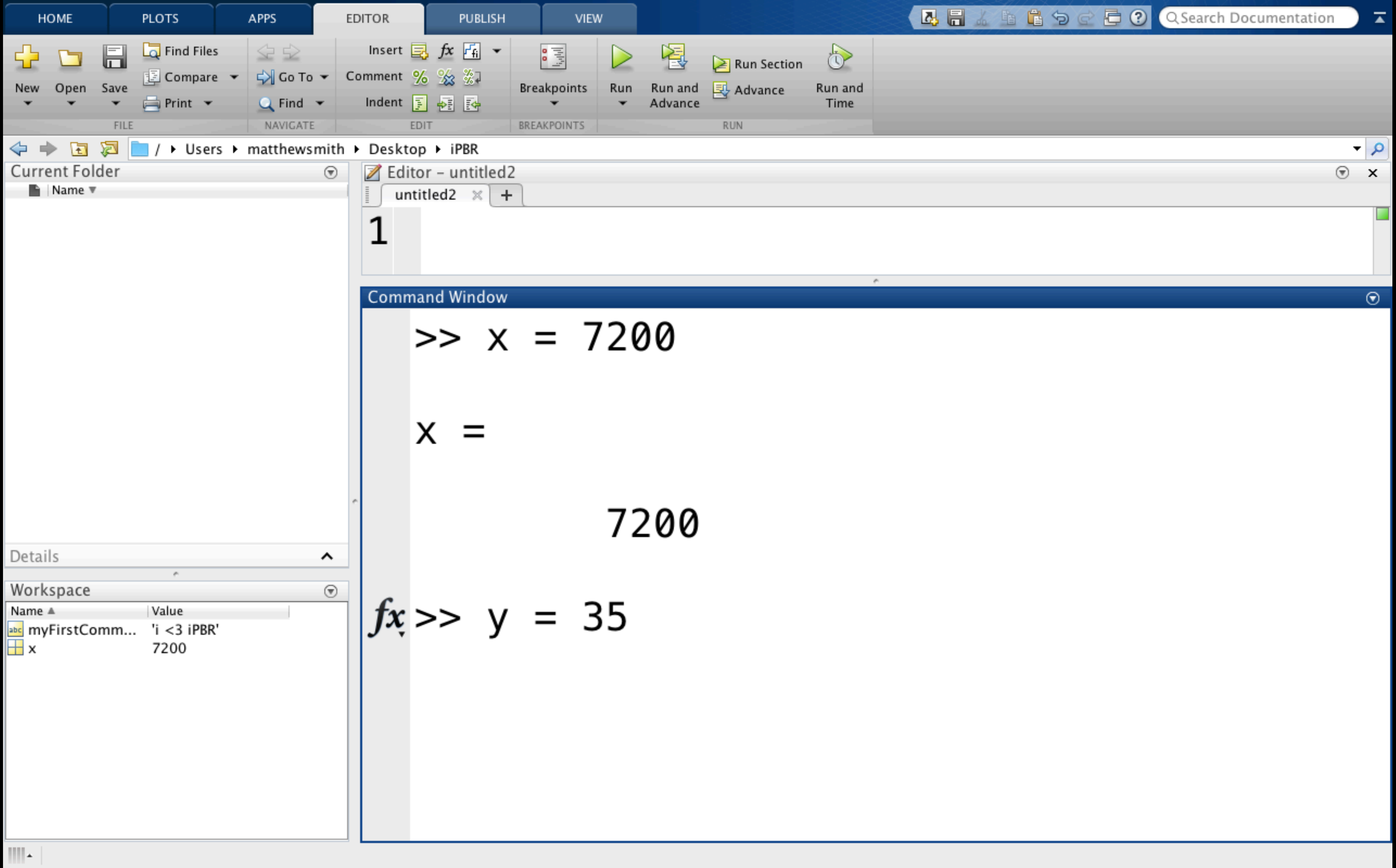
x =

        7200

fx >>
```

Name	Value
myFirstComm...	'i <3 iPBR'
x	7200

If you look in the command window, you can see that the variable x is now in MATLAB's workspace



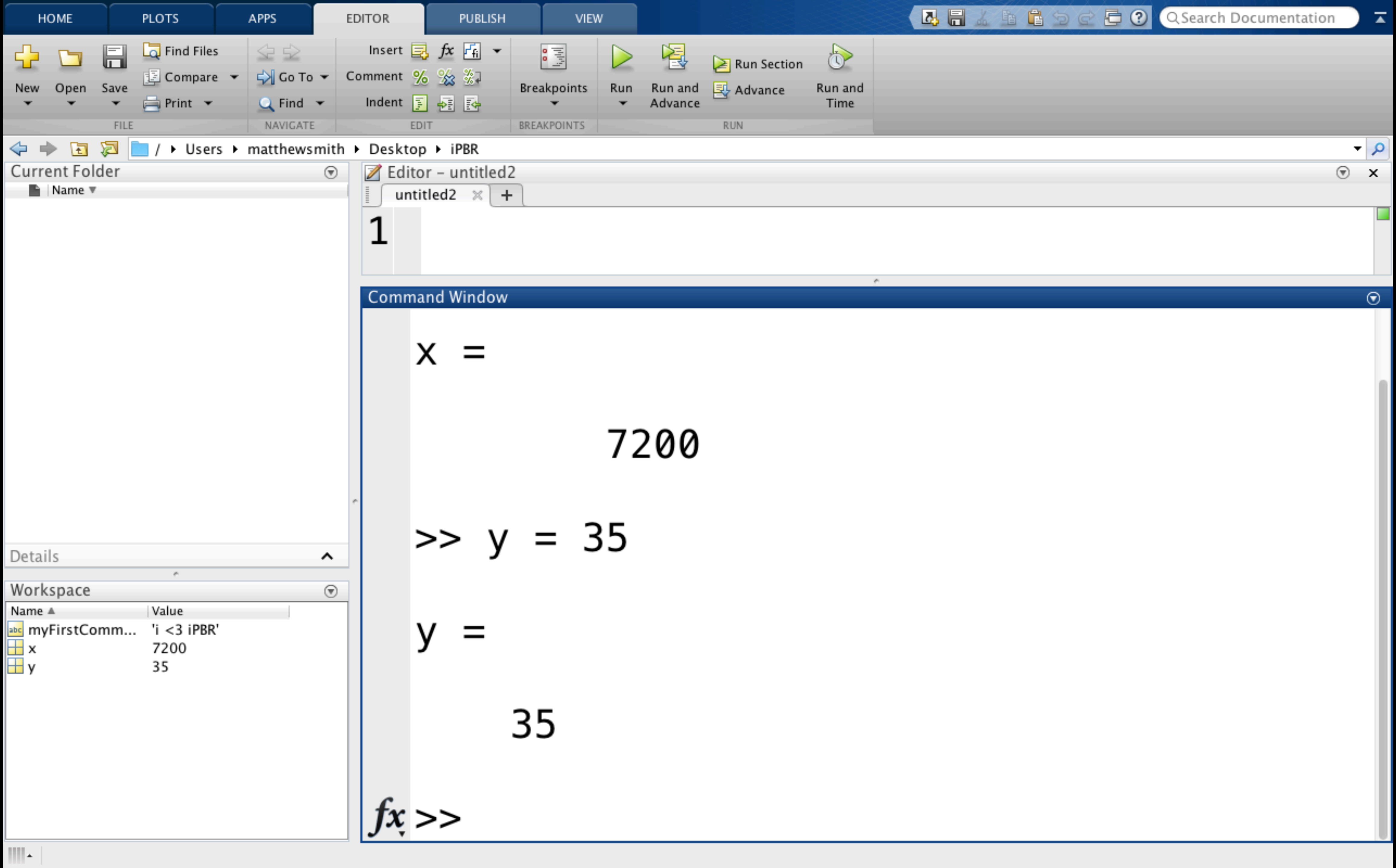
Name	Value
myFirstComm...	'i <3 iPBR'
x	7200

```
>> x = 7200

x =

        7200

>> y = 35
```



```
1
```

```
x =

        7200

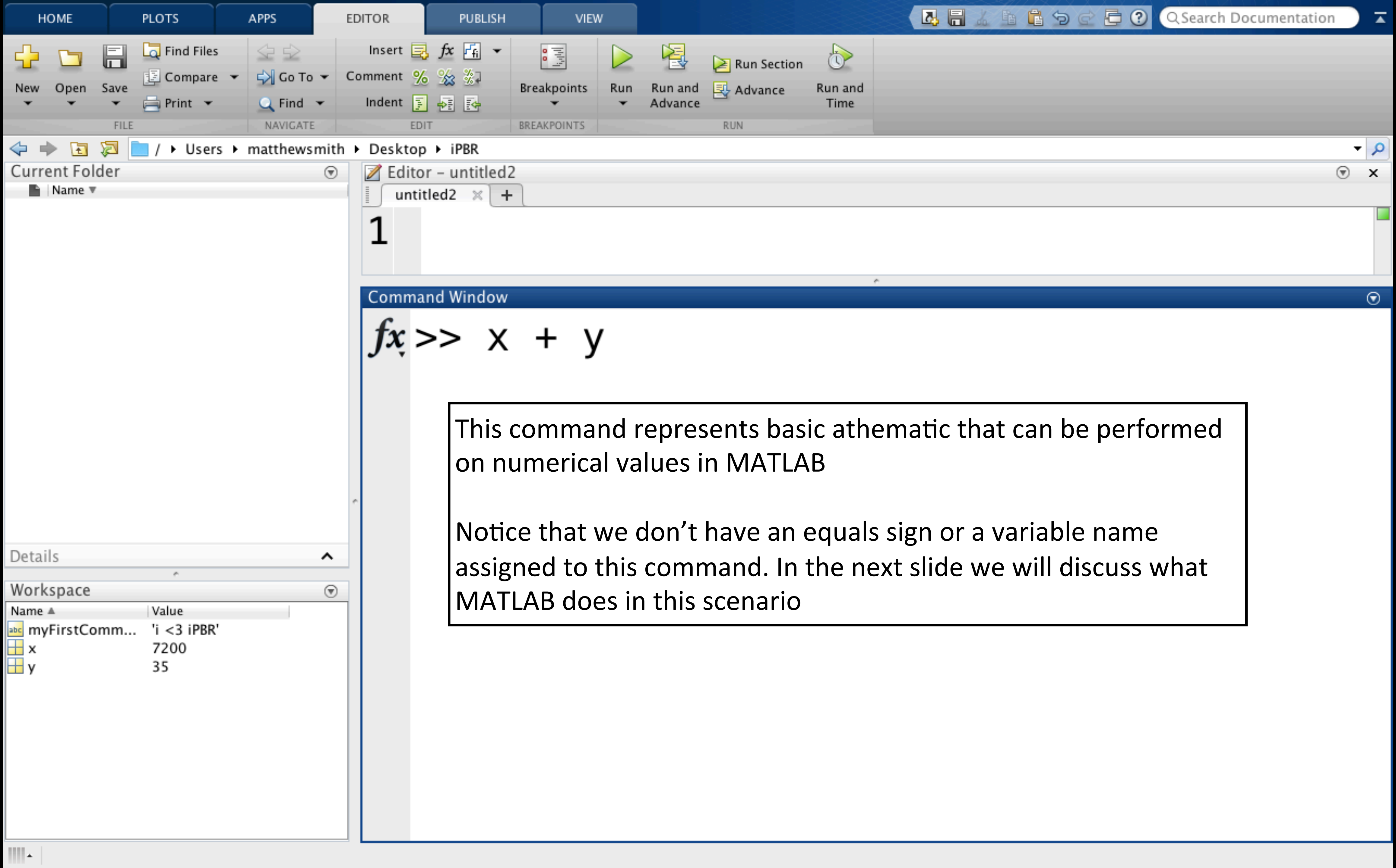
>> y = 35

y =

    35

fx >>
```

Name ▲	Value
myFirstComm...	'i <3 iPBR'
x	7200
y	35

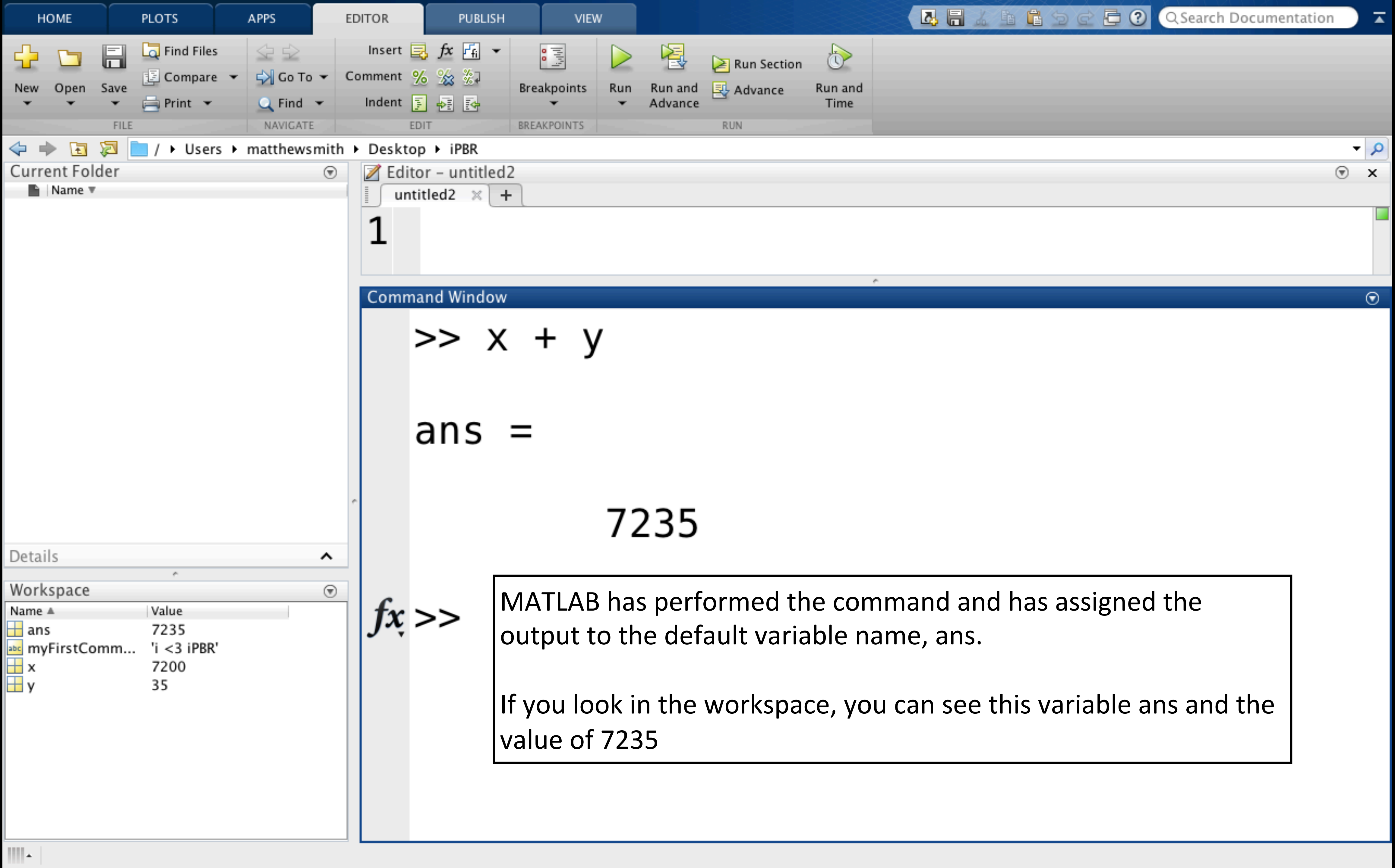


```
>> x + y
```

Name	Value
myFirstComm...	'i <3 iPBR'
x	7200
y	35

This command represents basic athematic that can be performed on numerical values in MATLAB

Notice that we don’t have an equals sign or a variable name assigned to this command. In the next slide we will discuss what MATLAB does in this scenario



```
>> x + y

ans =

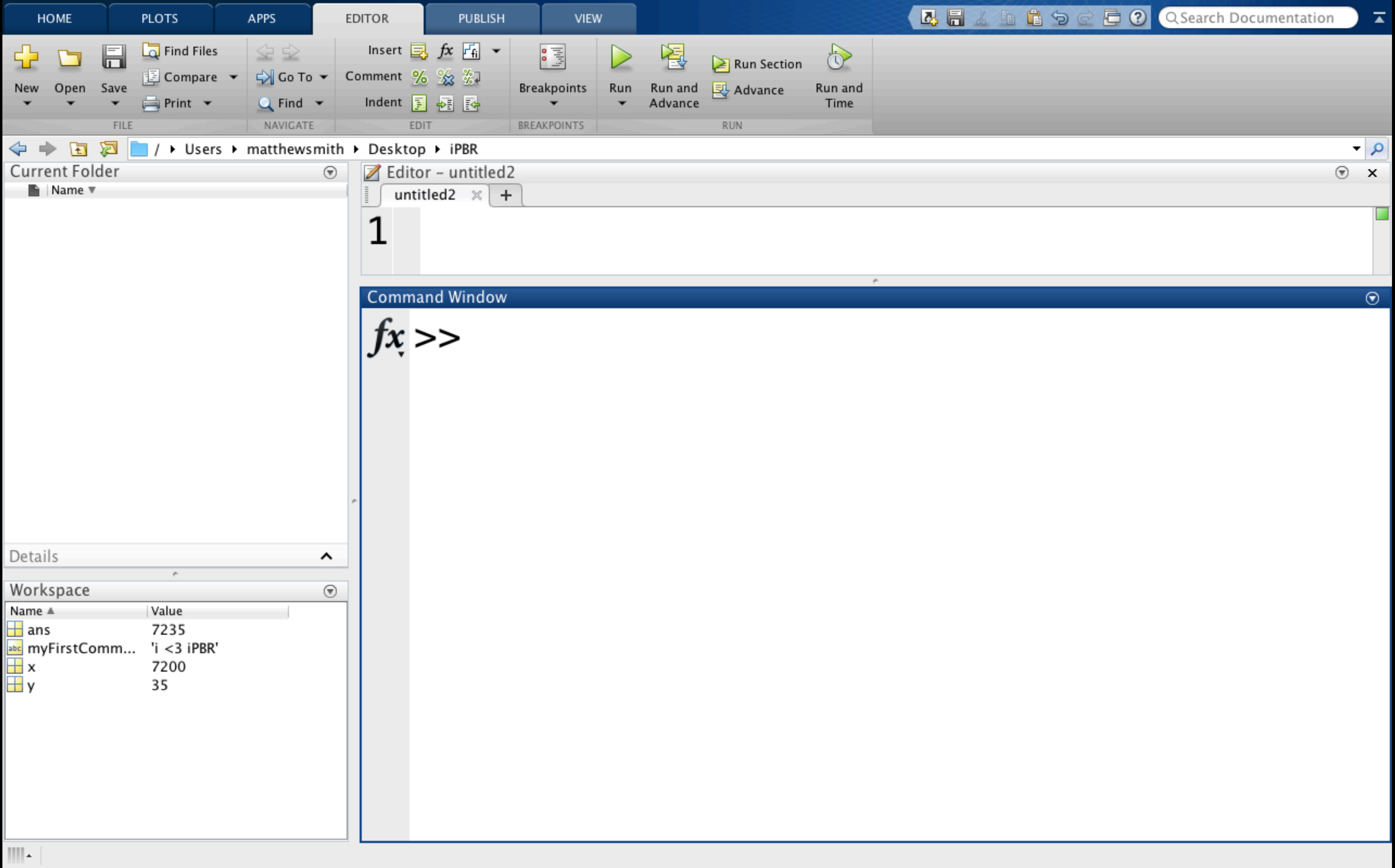
        7235

>>
```

Name ▲	Value
ans	7235
myFirstComm...	'i <3 iPBR'
x	7200
y	35

MATLAB has performed the command and has assigned the output to the default variable name, ans.

If you look in the workspace, you can see this variable ans and the value of 7235



/ ▸ Users ▸ matthewsmith ▸ Desktop ▸ iPBR

Editor – untitled2

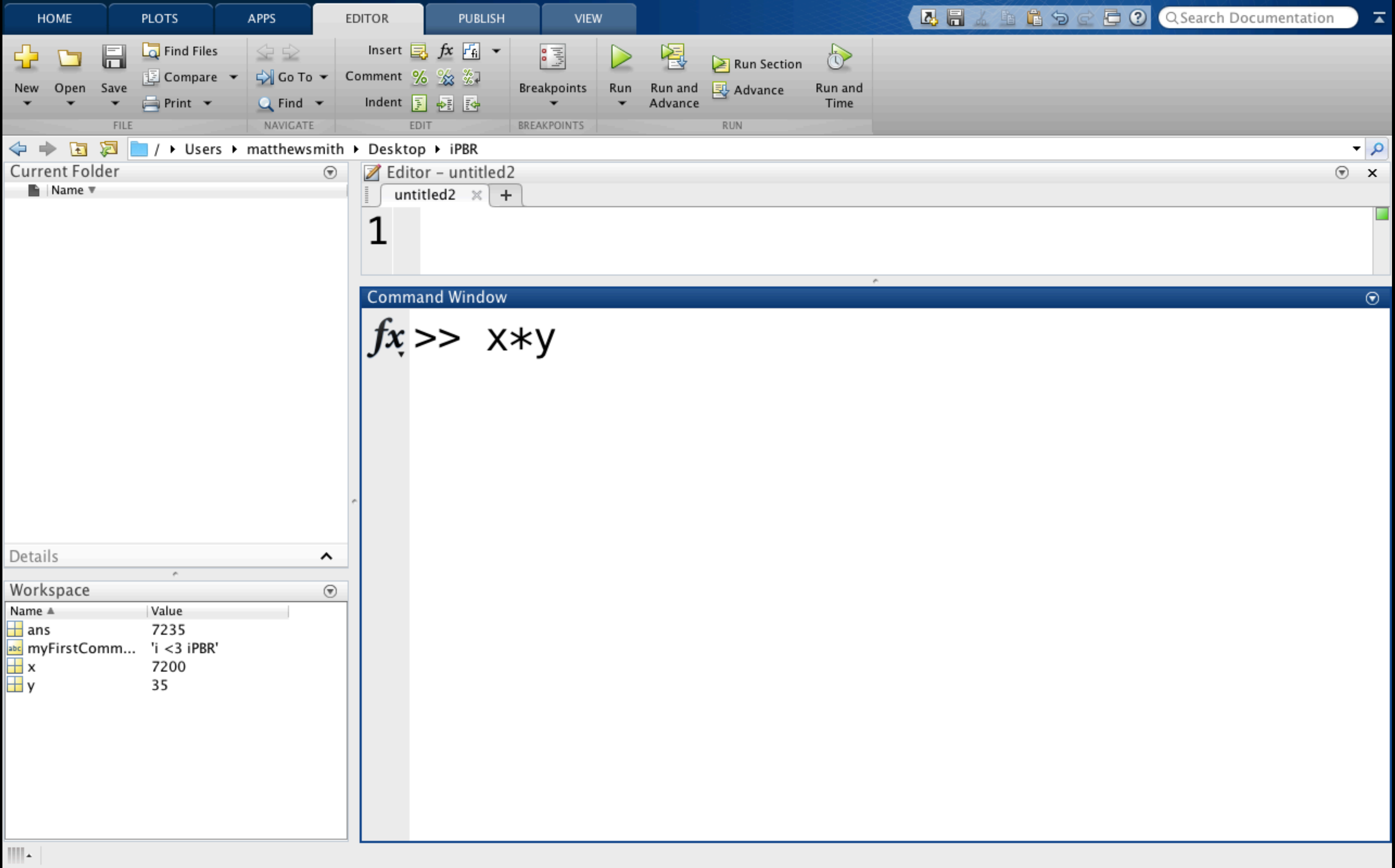
```
1
```

Command Window

```
fx >>
```

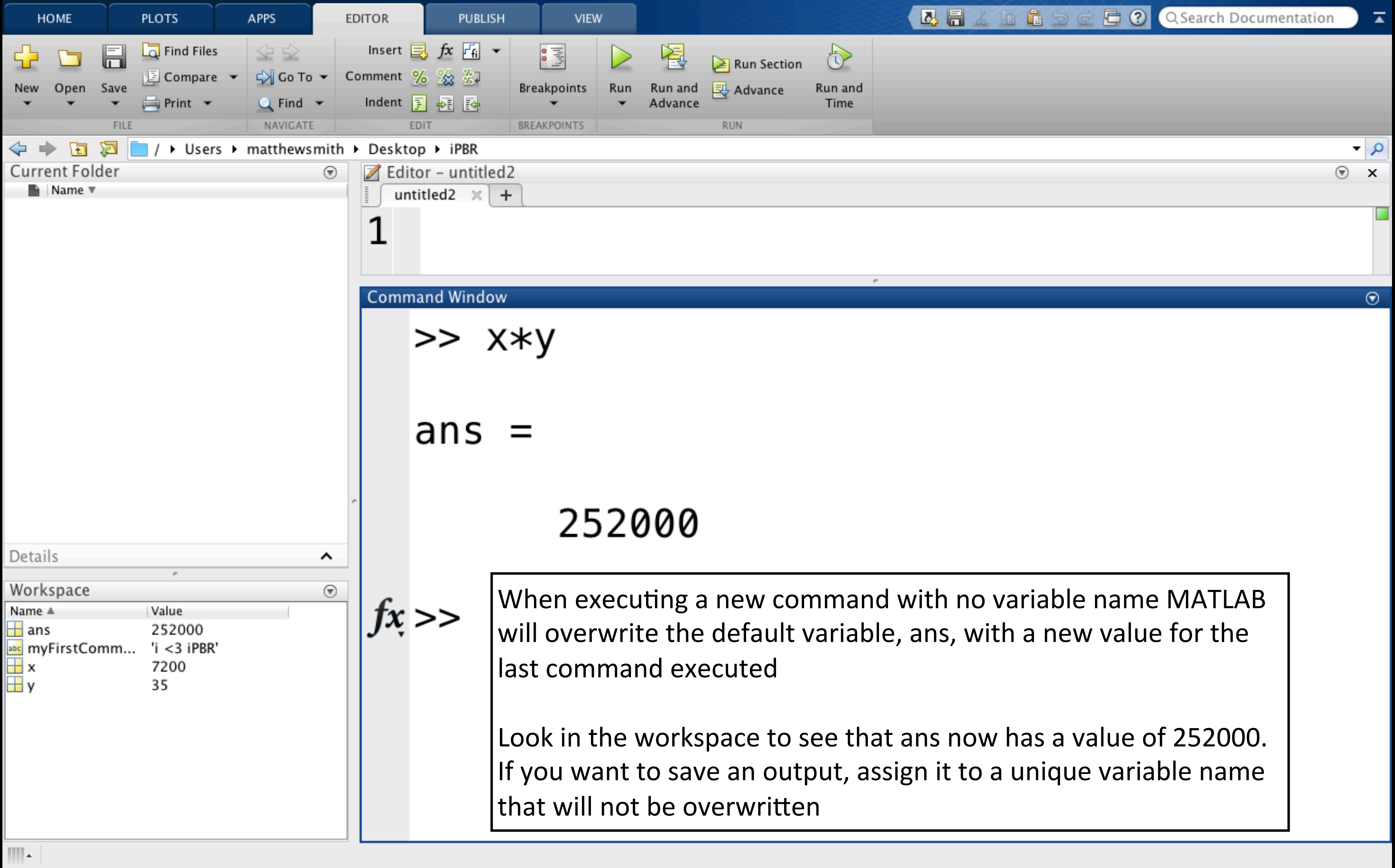
Workspace

Name ▲	Value
ans	7235
myFirstComm...	'i <3 iPBR'
x	7200
y	35



```
>>  x*y
```

Name	Value
ans	7235
myFirstComm...	'i <3 iPBR'
x	7200
y	35



```
1
```

```
>> x*y

ans =

      252000

fx >>
```

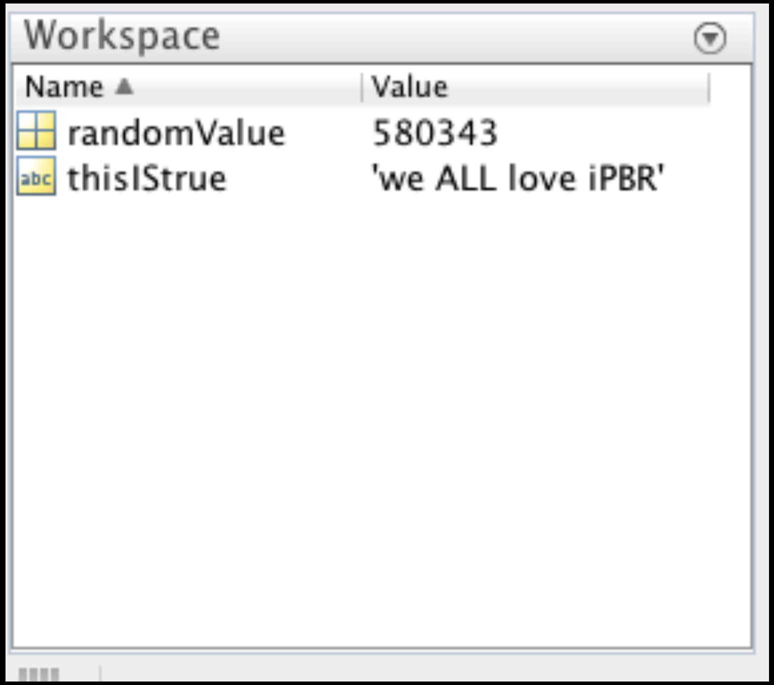
Workspace

Name ▲	Value
ans	252000
myFirstComm...	'i <3 iPBR'
x	7200
y	35

When executing a new command with no variable name MATLAB will overwrite the default variable, ans, with a new value for the last command executed

Look in the workspace to see that ans now has a value of 252000. If you want to save an output, assign it to a unique variable name that will not be overwritten

Variable Types

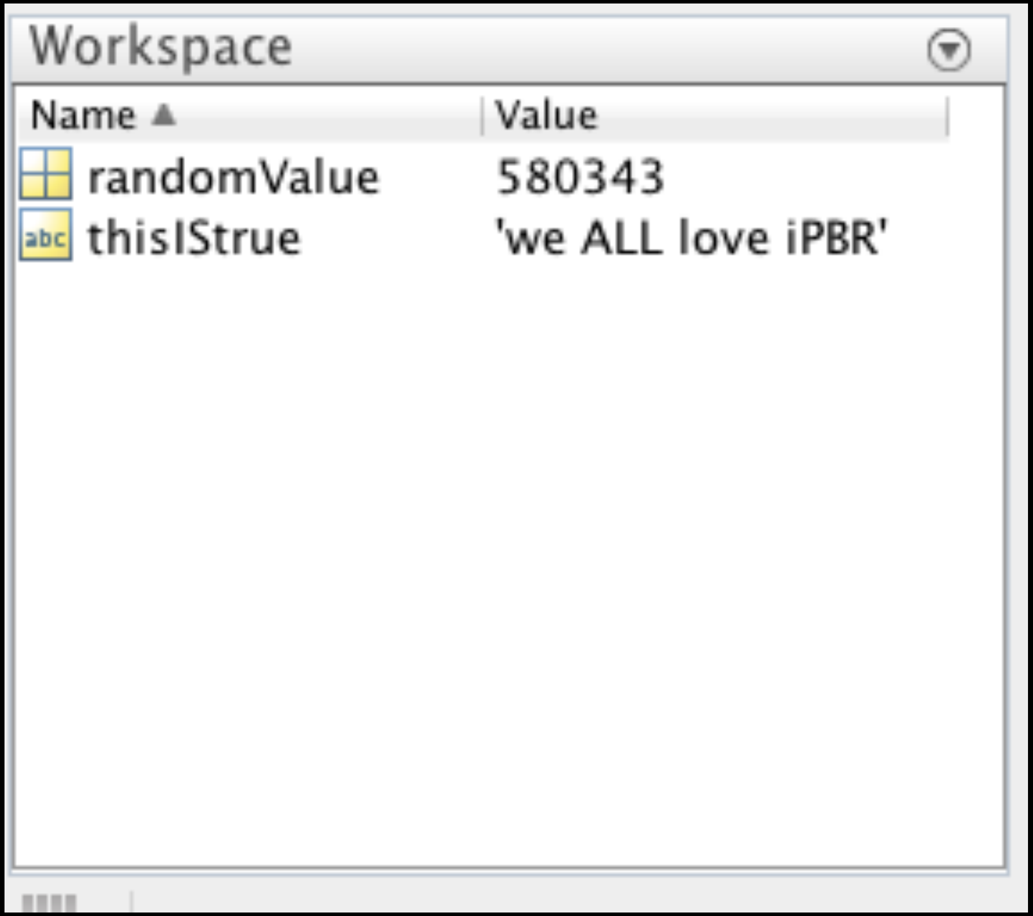


Workspace

Name ▲	Value
randomValue	580343
thisIStrue	'we ALL love iPBR'

Variable Types

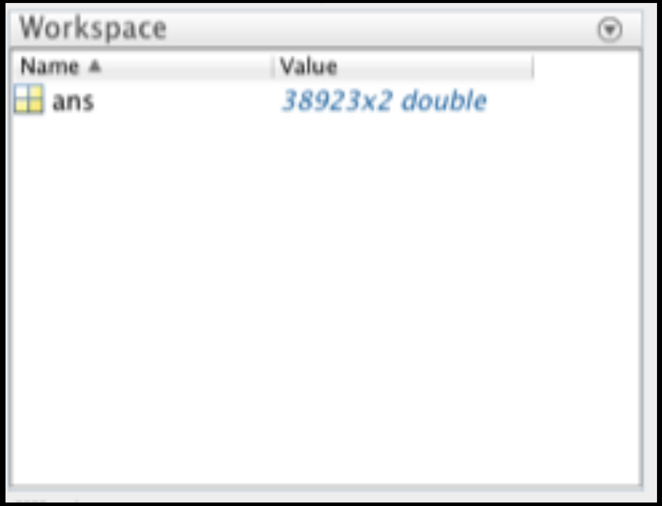
Numeric data: integer, double, float



Name ▲	Value
randomValue	580343
thisIStrue	'we ALL love iPBR'

Variable Types

Numeric data: integer, double, float

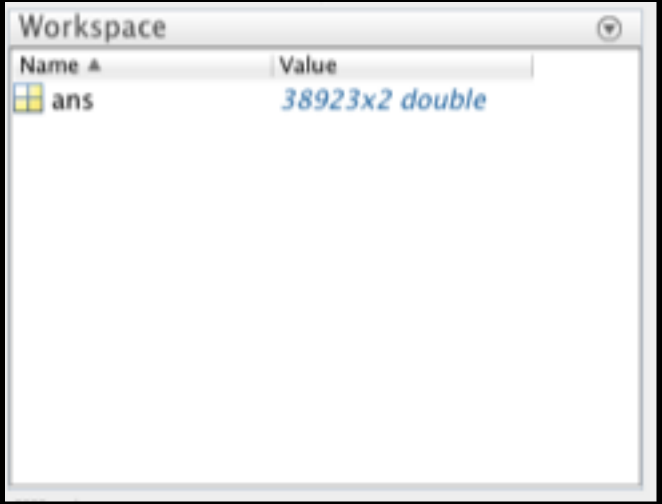


Name	Value
ans	38923x2 double

Basic mathematical operators:
addition, subtraction, multiplication, etc.

Variable Types

Numeric data: integer, double, float



Name	Value
ans	*38923x2 double*

Basic mathematical operators: addition, subtraction, multiplication, etc.

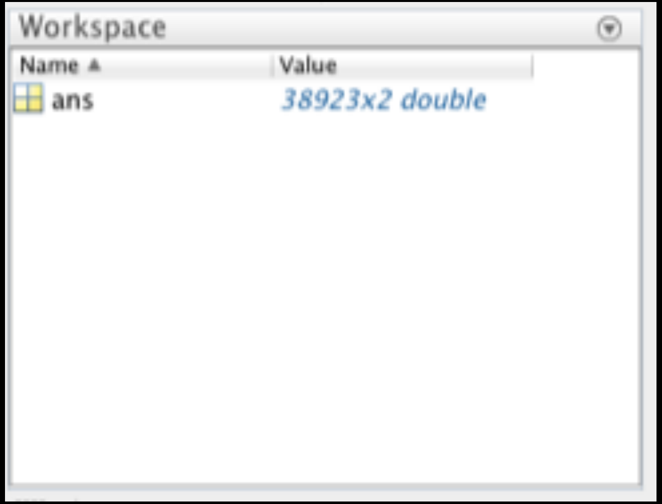
Text data: Sequence of characters, normally called a string. Strings are treated as arrays that contain characters.

Create a string in MATLAB by using single quotations:

‘This is a string’

Variable Types

Numeric data: integer, double, float

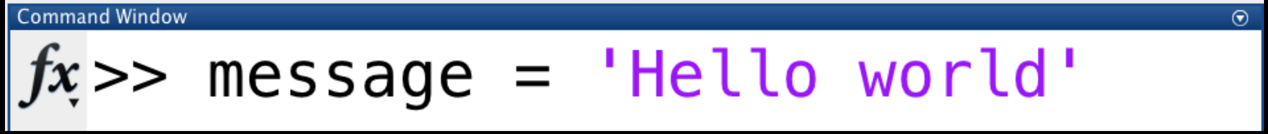


Name	Value
ans	*38923x2 double*

Basic mathematical operators: addition, subtraction, multiplication, etc.

Text data: Sequence of characters, normally called a string. Strings are treated as arrays that contain characters.

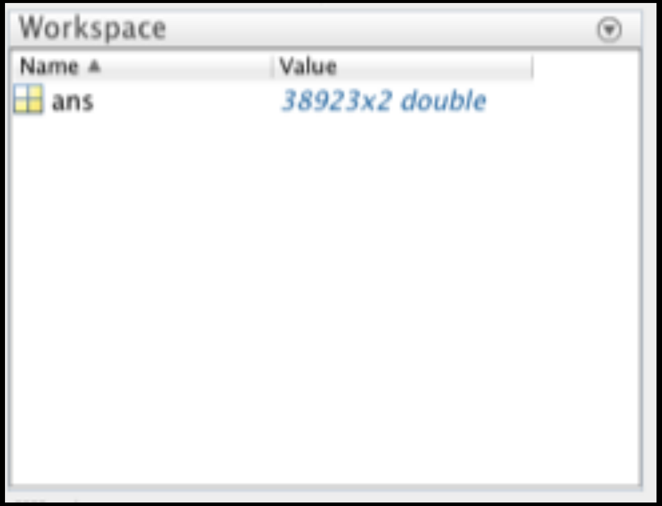
Create a string in MATLAB by using single quotations:



```
>> message = 'Hello world'
```

Variable Types

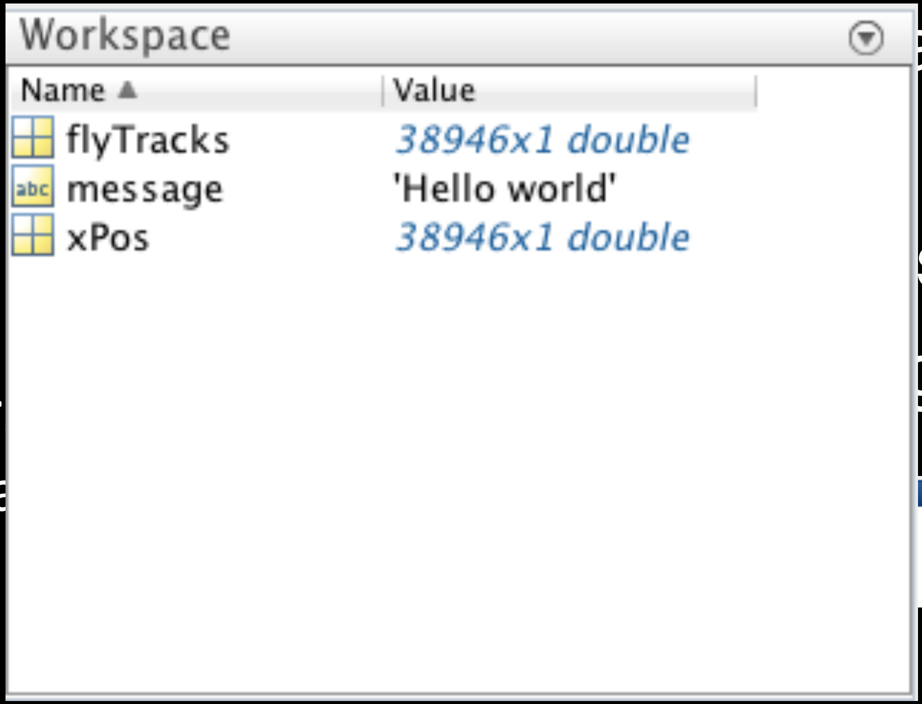
Numeric data: integer, double, float


Workspace

Name	Value
ans	38923x2 double

Basic mathematical operator

addition, subtraction, multiplica


Workspace

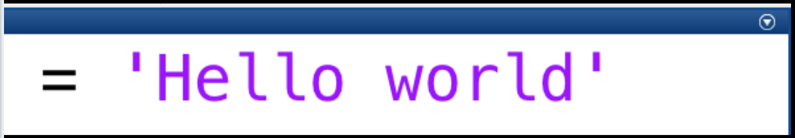
Name	Value
flyTracks	38946x1 double
message	'Hello world'
xPos	38946x1 double

Text data: Sequence of characters, normally called a string. Strings are treated as

at contain characters

string in MATLAB by

gle quotations:


```
= 'Hello world'
```

In-class exercise 1:

In-class exercise 1:

Discuss with your neighbor(s) an algorithm for converting degrees Fahrenheit to degrees Celsius

In-class exercise 1:

Write an algorithm to convert Fahrenheit to Celsius

In-class exercise 1:

Write an algorithm to convert Fahrenheit to Celsius

Execute this algorithm in MATLAB’s command window to convert 45.6F into degrees Celsius

Temperature conversion algorithm:

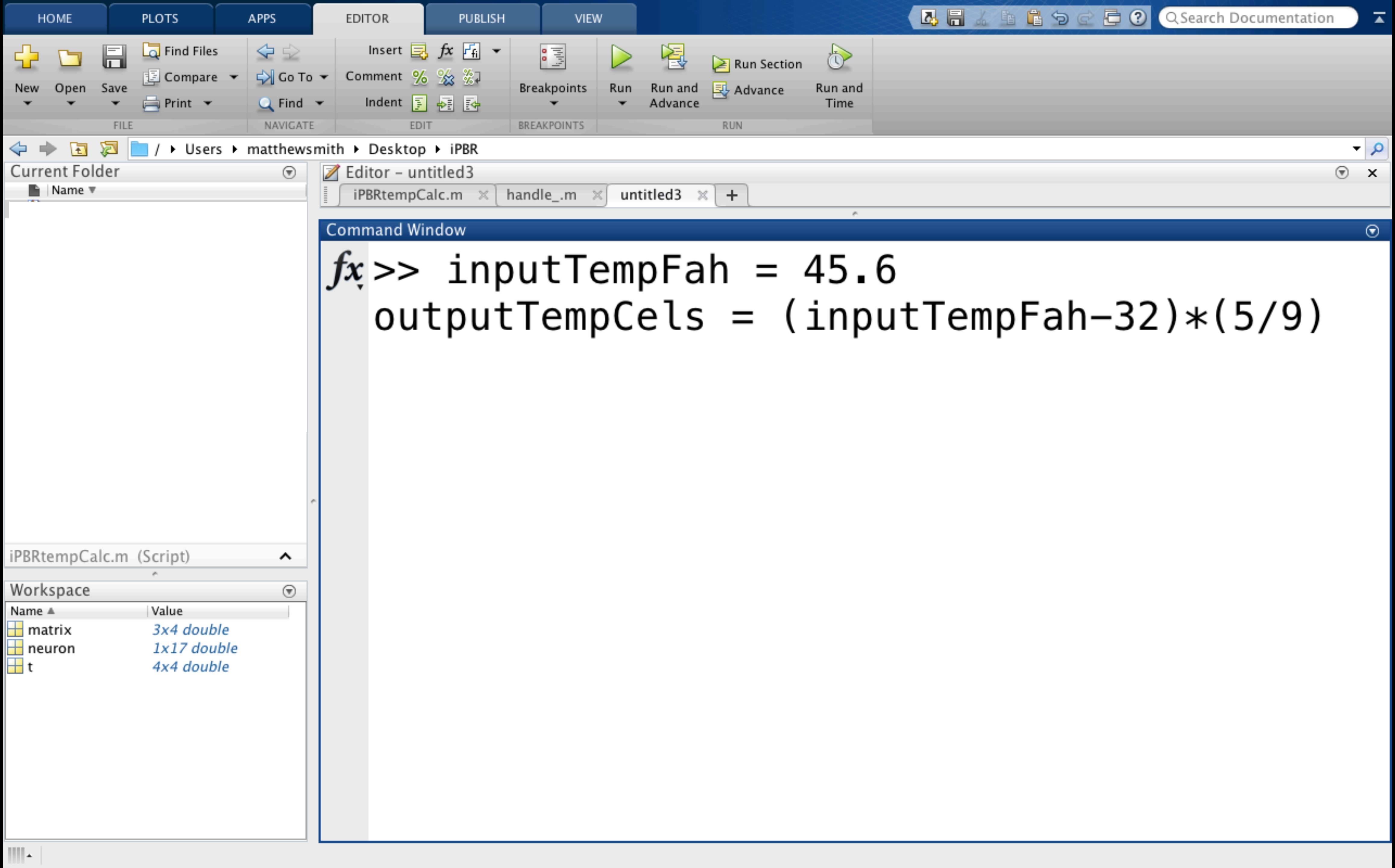
1) Select an input temperature in Fahrenheit to convert to Celsius
2) Perform the operation:
   celsius = input temperature – 32 * (5/9)

Temperature conversion algorithm:

1) Select an input temperature in Fahrenheit to convert to Celsius
2) Perform the operation:
   celsius = input temperature – 32 * (5/9)

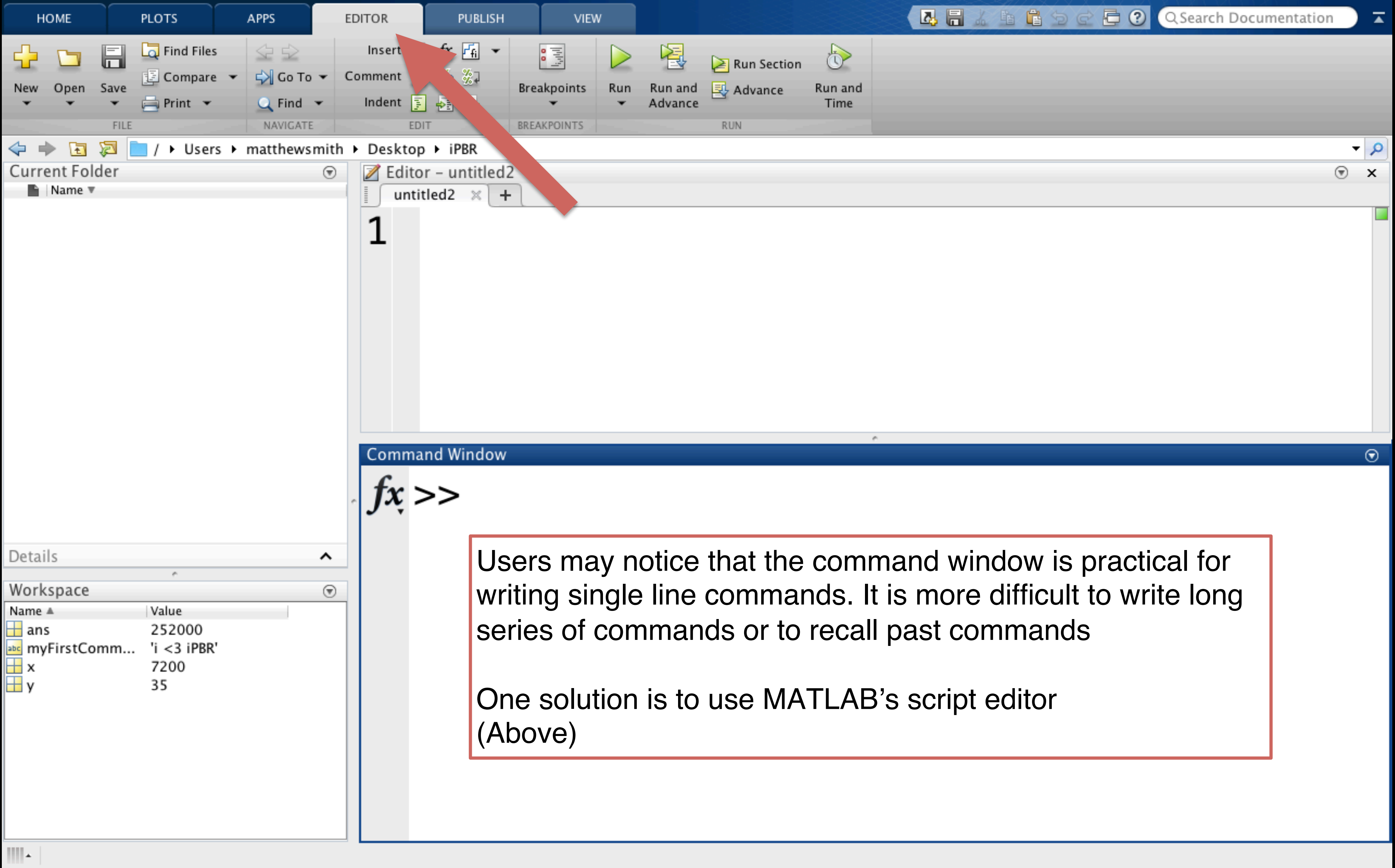
Temperature conversion algorithm: in MATLAB

1) inputTempFah = 45.6
2) outputTempCels = inputTempFah – 32 * (5/9)



```
>> inputTempFah = 45.6
outputTempCels = (inputTempFah–32)*(5/9)
```

Name	Value
matrix	3x4 double
neuron	1x17 double
t	4x4 double



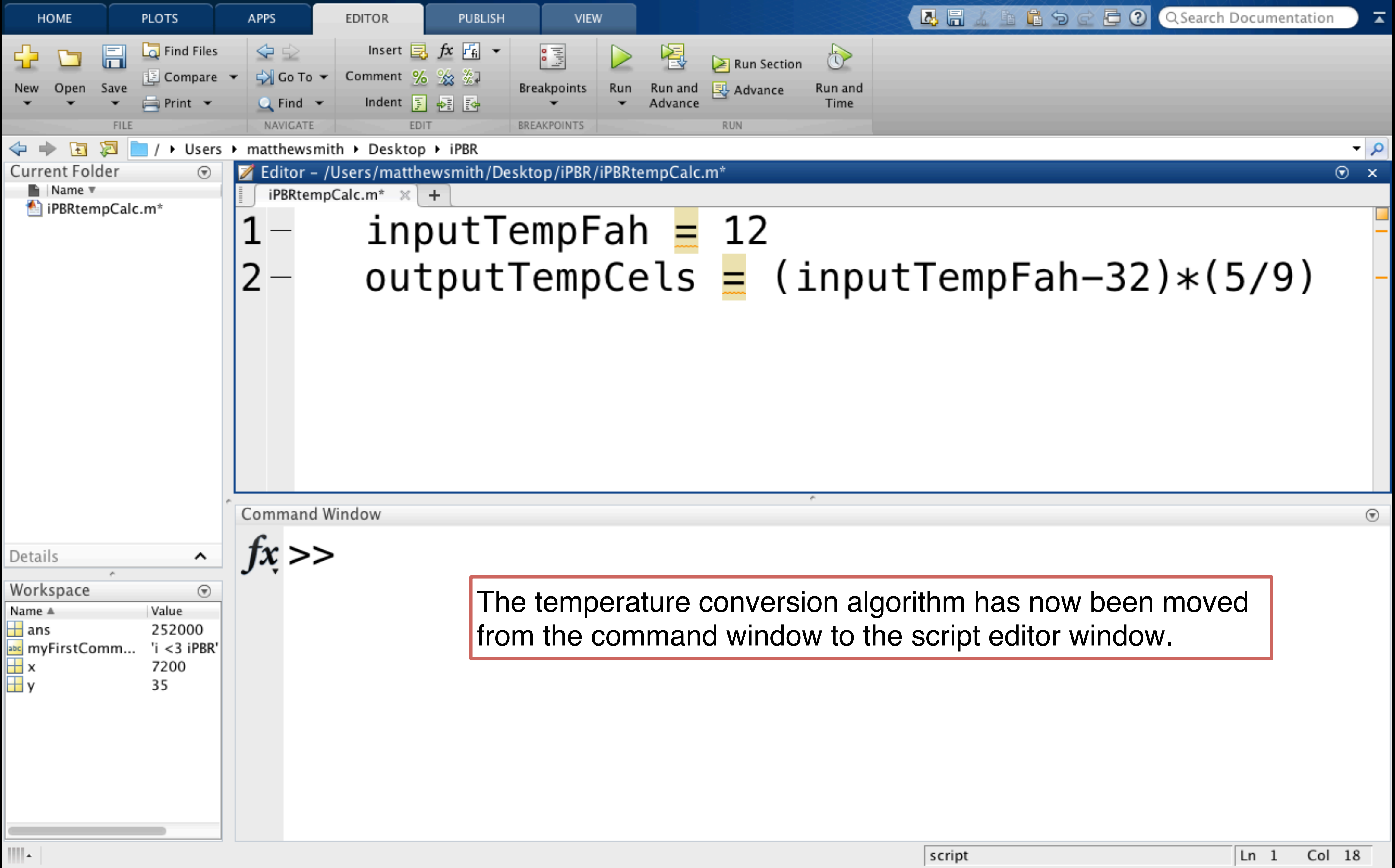
Name	Value
ans	252000
myFirstComm...	'i <3 iPBR'
x	7200
y	35

Users may notice that the command window is practical for writing single line commands. It is more difficult to write long series of commands or to recall past commands

One solution is to use MATLAB's script editor
(Above)

Writing scripts

Scripts are multiple lines of MATLAB commands and function that can be saved. You can execute a script by typing its saved name.

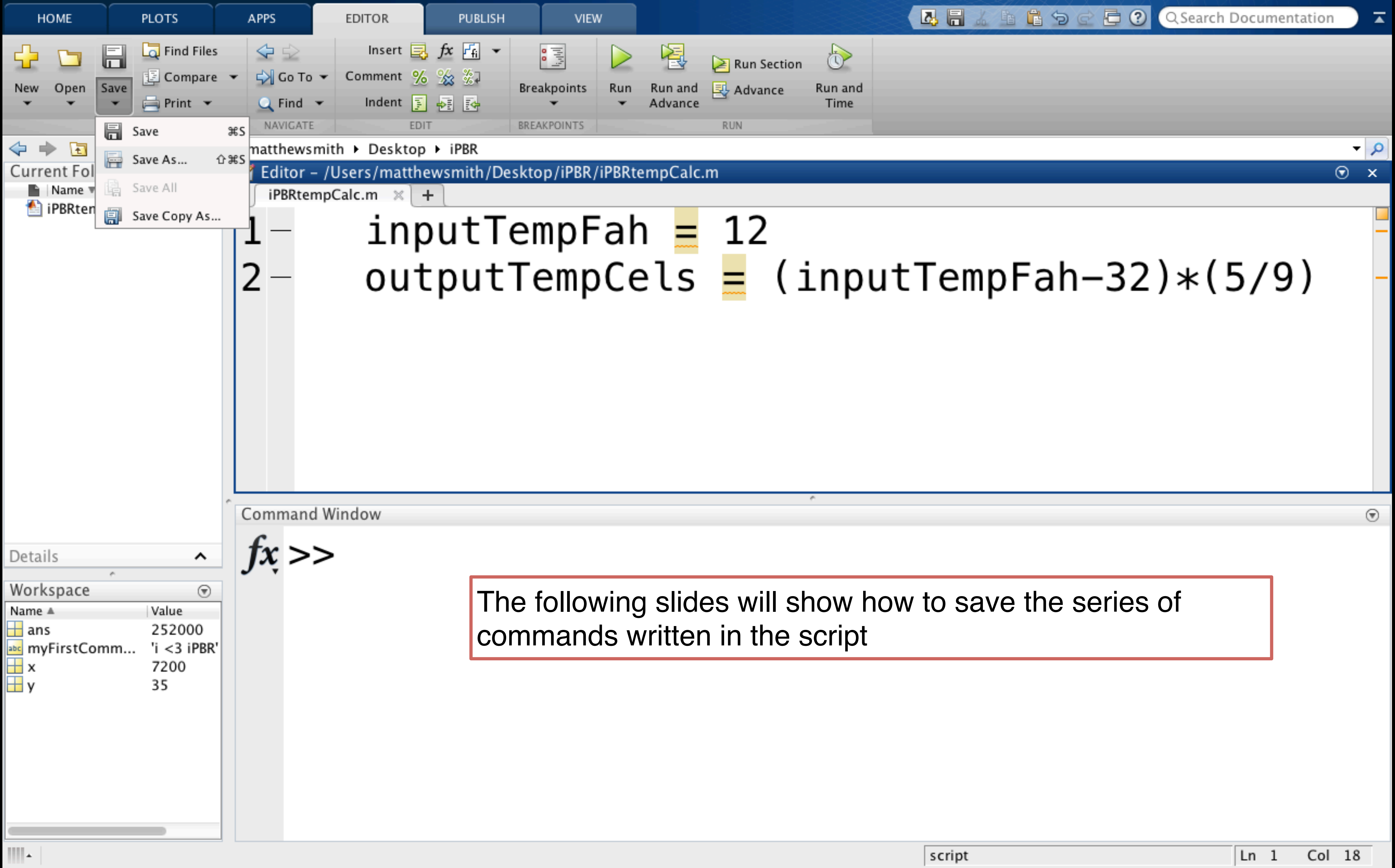


```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

```
fx >>
```

Name	Value
ans	252000
myFirstComm...	'i <3 iPBR'
x	7200
y	35

The temperature conversion algorithm has now been moved from the command window to the script editor window.

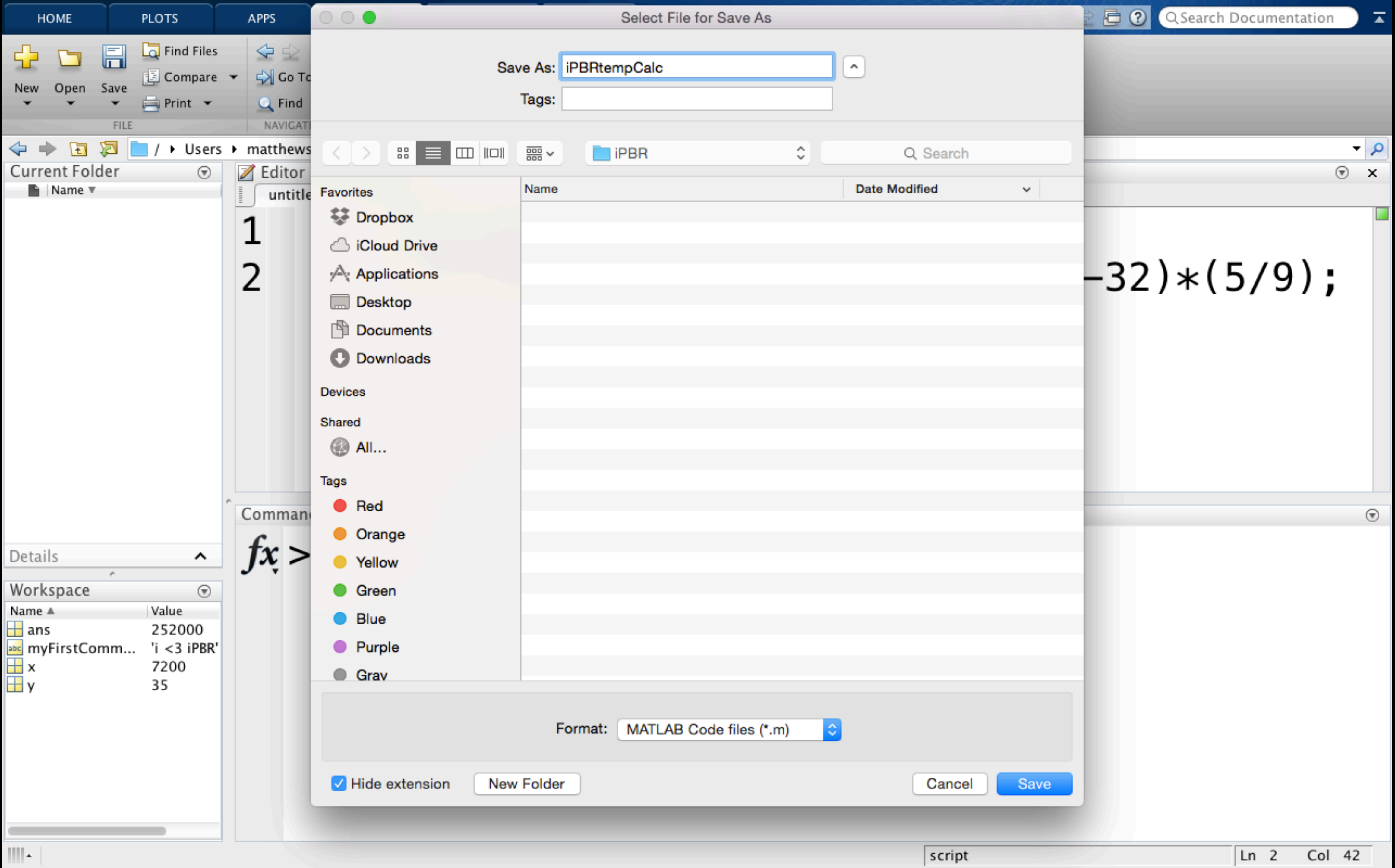


```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

```
>>
```

Name ▲	Value
ans	252000
myFirstComm...	'i <3 iPBR'
x	7200
y	35

The following slides will show how to save the series of commands written in the script



Save As: iPBRtempCalc

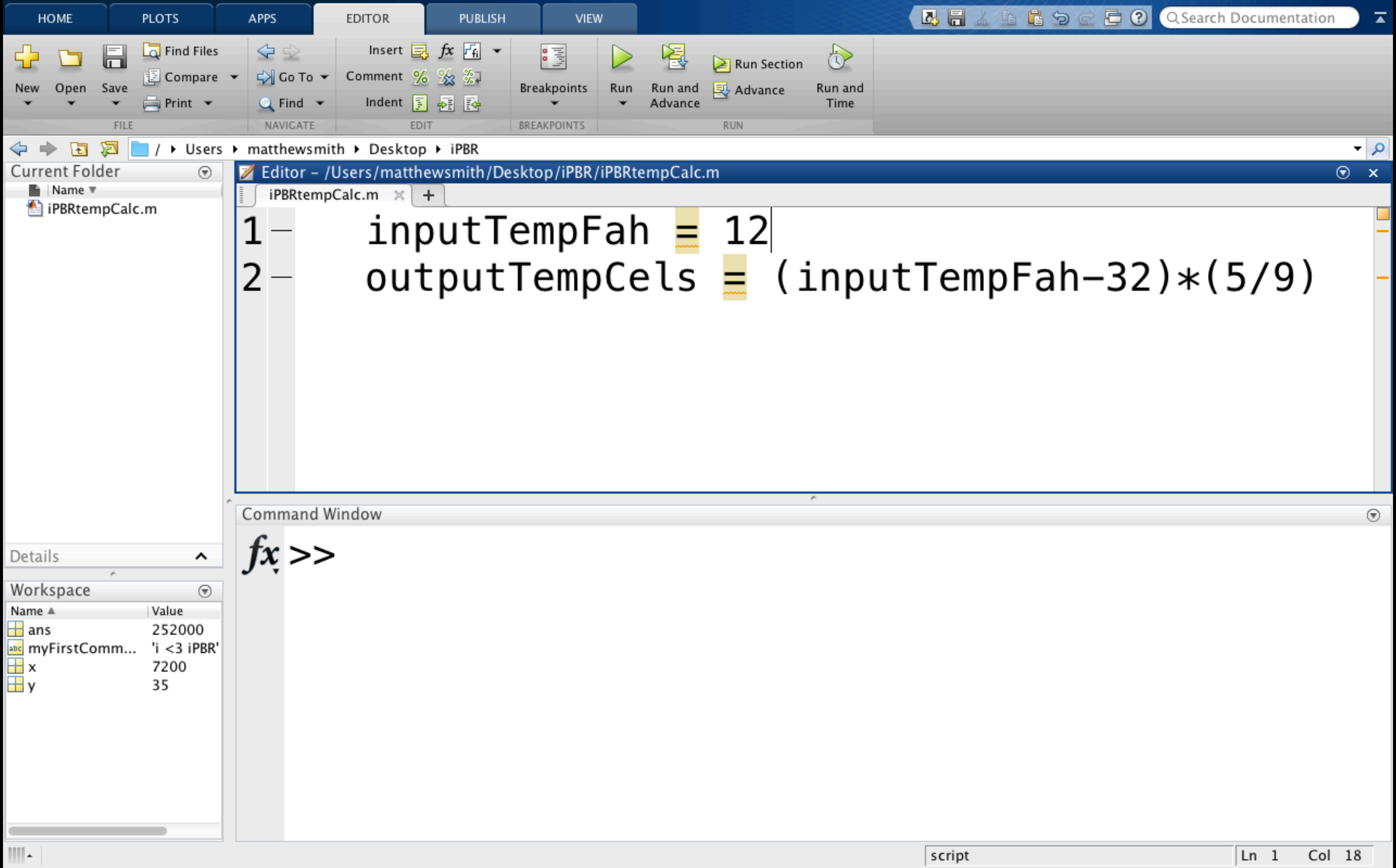
Format: MATLAB Code files (*.m)

☑ Hide extension

```
1
2                                    −32)∗(5/9);
```

Name ▲	Value
ans	252000
myFirstComm…	'i <3 iPBR'
x	7200
y	35

script   Ln 2   Col 42



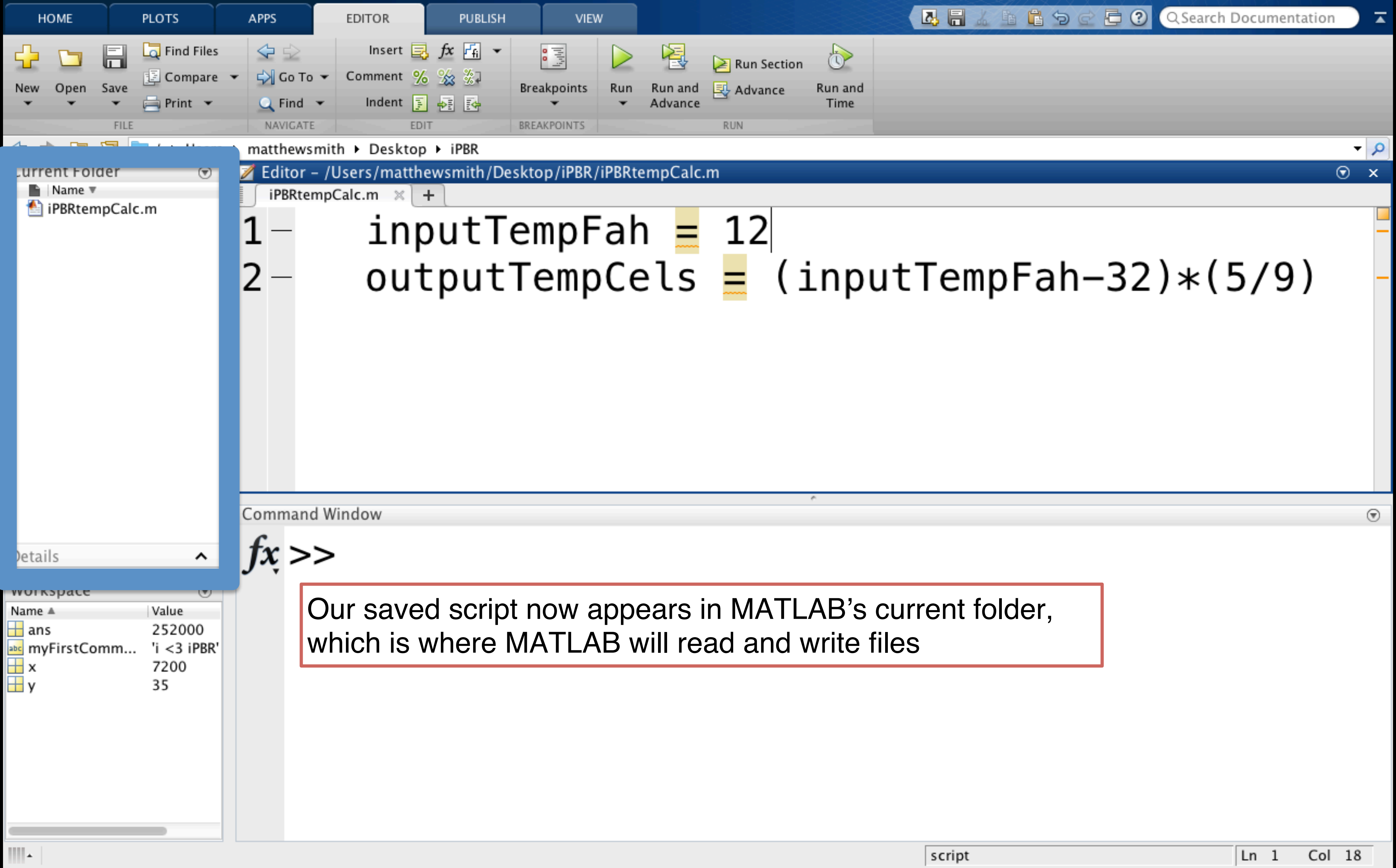
iPBRtempCalc.m

Editor - /Users/matthewsmith/Desktop/iPBR/iPBRtempCalc.m

```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

```
>>
```

Name	Value
ans	252000
myFirstComm...	'i <3 iPBR'
x	7200
y	35



```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

```
>>
```

Name	Value
ans	252000
myFirstComm...	'i <3 iPBR'
x	7200
y	35

Our saved script now appears in MATLAB’s current folder, which is where MATLAB will read and write files

Current folder (directory):

The current folder shows where MATLAB will read and write files to.

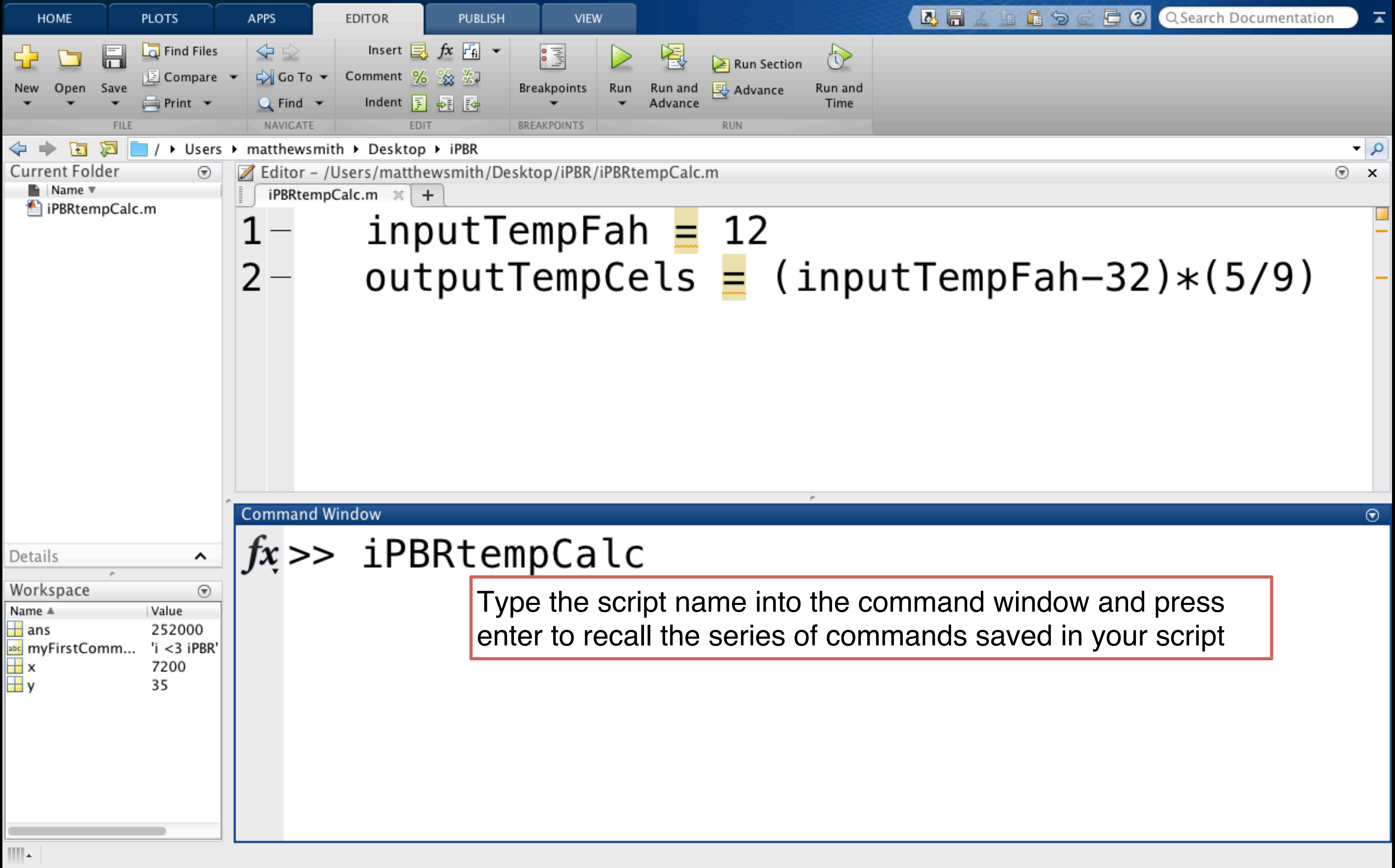
MATLAB default pathway:
/Users/host/Documents/MATLAB

Current folder (directory):

The current folder shows where MATLAB will read and write files to.

MATLAB default pathway:
/Users/Host/Documents/MATLAB

You can tell MATLAB to include folders that aren’t in your current directory by clicking “set path”.

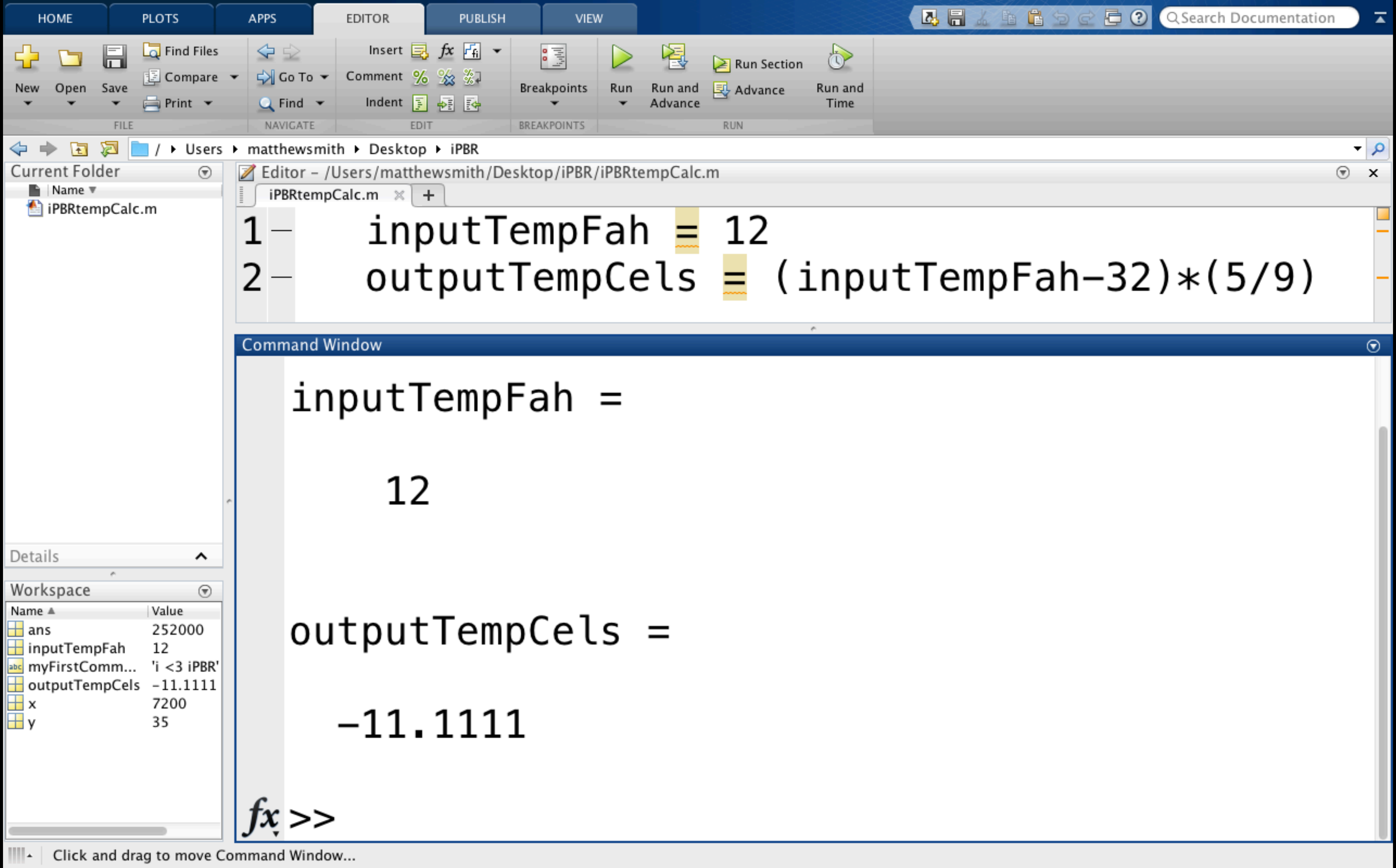


```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

```
>> iPBRtempCalc
```

Name	Value
ans	252000
myFirstComm...	'i <3 iPBR'
x	7200
y	35

Type the script name into the command window and press enter to recall the series of commands saved in your script



Editor – /Users/matthewsmith/Desktop/iPBR/iPBRtempCalc.m

```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

Command Window

```
inputTempFah =

    12


outputTempCels =

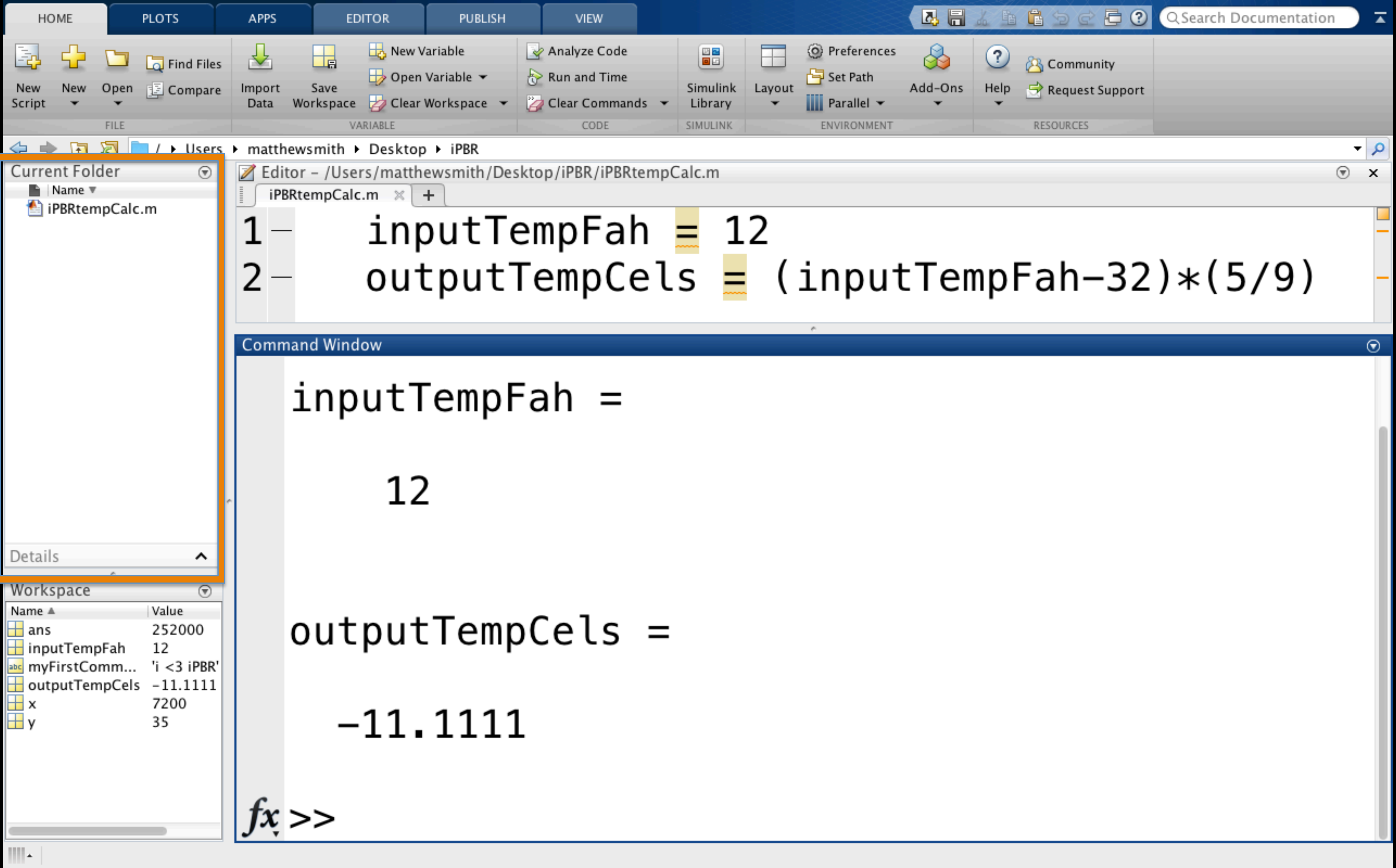
  -11.1111

>>
```

Workspace

Name	Value
ans	252000
inputTempFah	12
myFirstComm...	'i <3 iPBR'
outputTempCels	-11.1111
x	7200
y	35

Click and drag to move Command Window...



```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

```
inputTempFah =

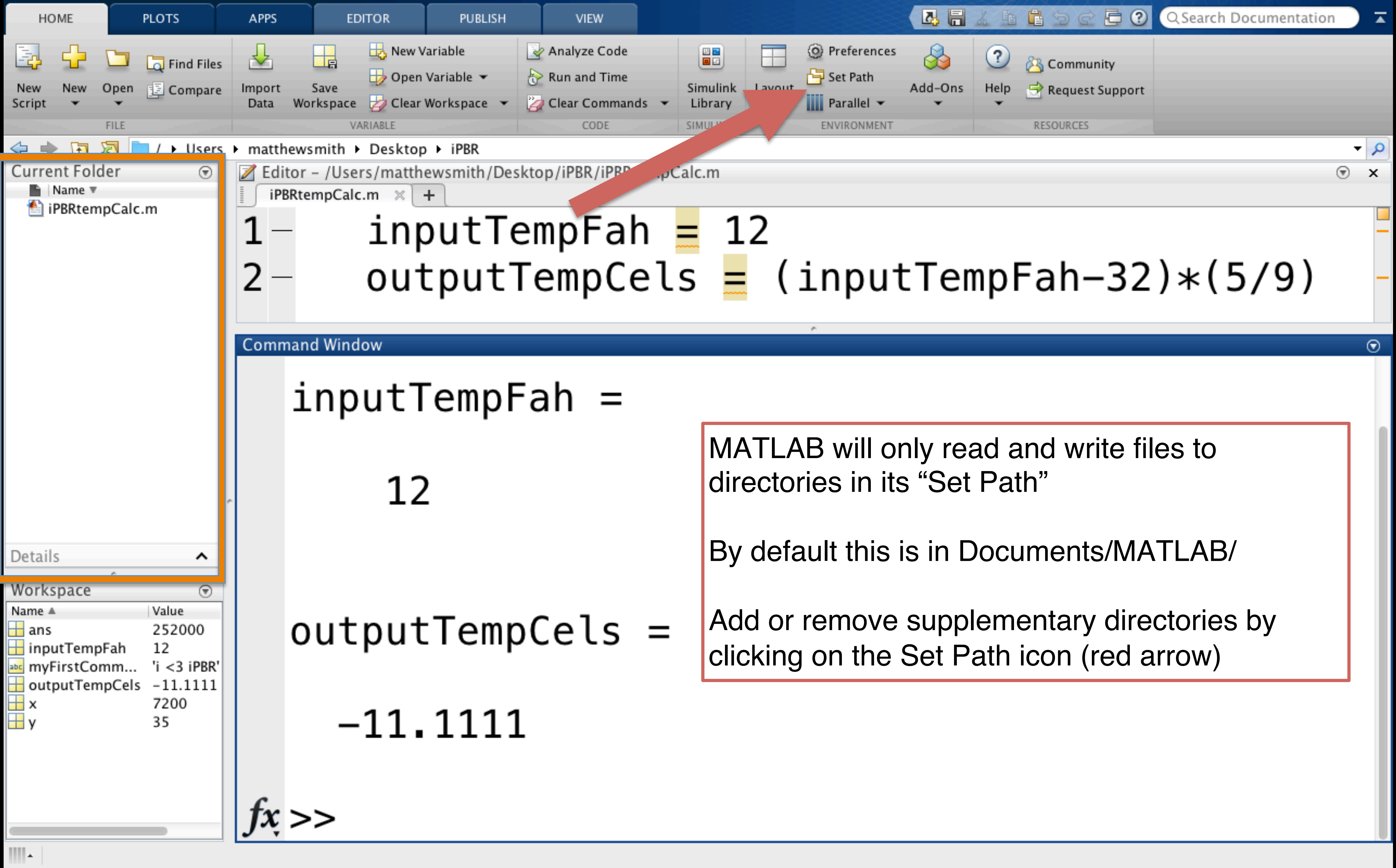
    12


outputTempCels =

  -11.1111

fx >>
```

Name ▲	Value
ans	252000
inputTempFah	12
myFirstComm...	'i <3 iPBR'
outputTempCels	-11.1111
x	7200
y	35



```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

```
inputTempFah =

    12


outputTempCels =

  -11.1111

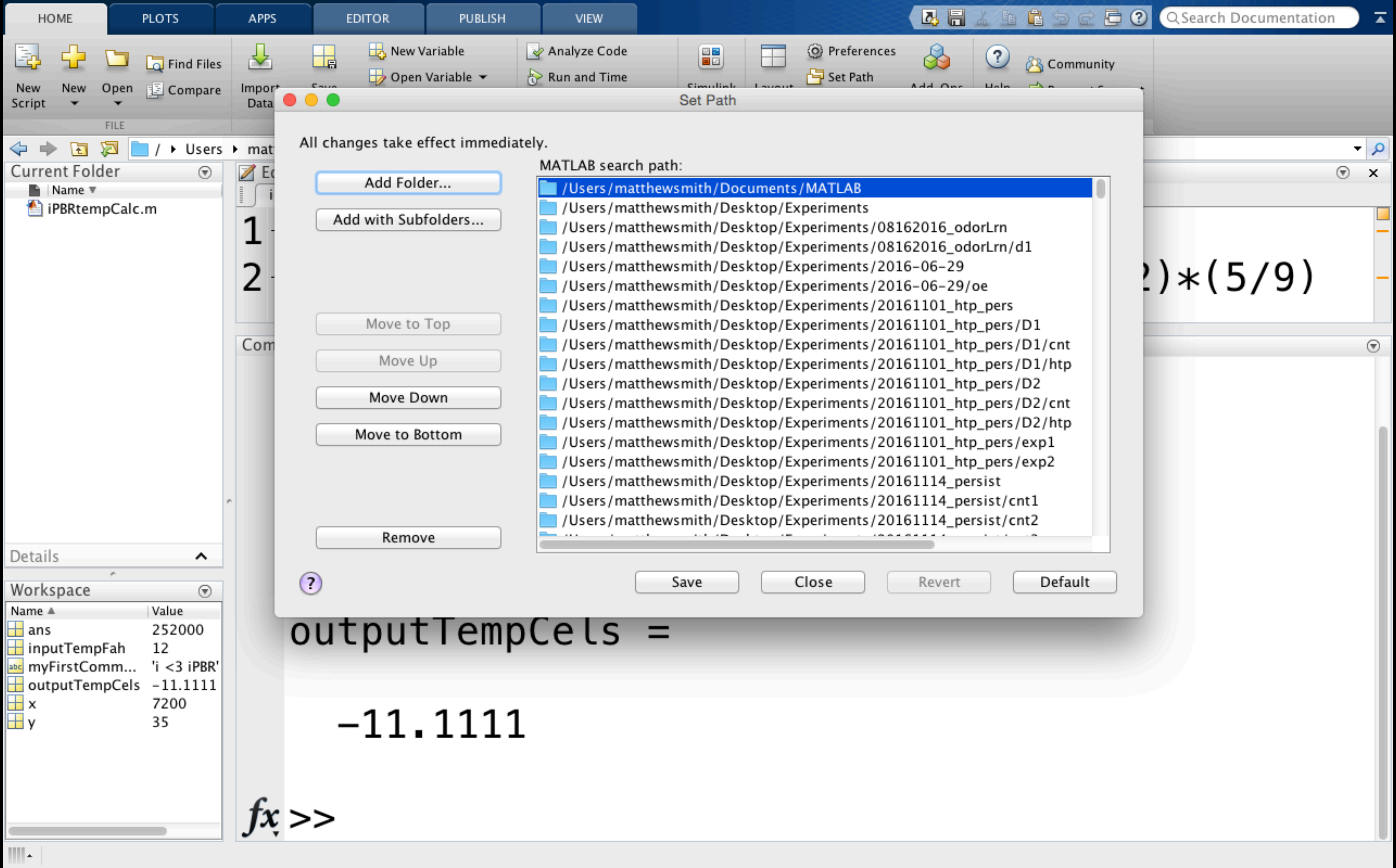
fx >>
```

Name ▲	Value
ans	252000
inputTempFah	12
myFirstComm...	'i <3 iPBR'
outputTempCels	-11.1111
x	7200
y	35

MATLAB will only read and write files to directories in its “Set Path”

By default this is in Documents/MATLAB/

Add or remove supplementary directories by clicking on the Set Path icon (red arrow)



All changes take effect immediately.

MATLAB search path:

```
/Users/matthewsmith/Documents/MATLAB
/Users/matthewsmith/Desktop/Experiments
/Users/matthewsmith/Desktop/Experiments/08162016_odorLrn
/Users/matthewsmith/Desktop/Experiments/08162016_odorLrn/d1
/Users/matthewsmith/Desktop/Experiments/2016-06-29
/Users/matthewsmith/Desktop/Experiments/2016-06-29/oe
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/D1
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/D1/cnt
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/D1/htp
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/D2
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/D2/cnt
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/D2/htp
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/exp1
/Users/matthewsmith/Desktop/Experiments/20161101_htp_pers/exp2
/Users/matthewsmith/Desktop/Experiments/20161114_persist
/Users/matthewsmith/Desktop/Experiments/20161114_persist/cnt1
/Users/matthewsmith/Desktop/Experiments/20161114_persist/cnt2
```

Name	Value
ans	252000
inputTempFah	12
myFirstComm...	'i <3 iPBR'
outputTempCels	-11.1111
x	7200
y	35

```
2)*(5/9)
```

```
outputTempCels =

  -11.1111

>>
```

Summary

MATLAB Layout:

- Command line
- Workspace
- Script editor
- Directory

Data storage in MATLAB

Arrays

Arrays

- When programmers (that’s you!) are dealing with large amounts of data, you can use *data structures* to store and access data
- MATLAB (and many other languages) often use arrays (a.k.a. matrices) to store data
    - MATLAB = MATrix LABoratory

Data storage in MATLAB

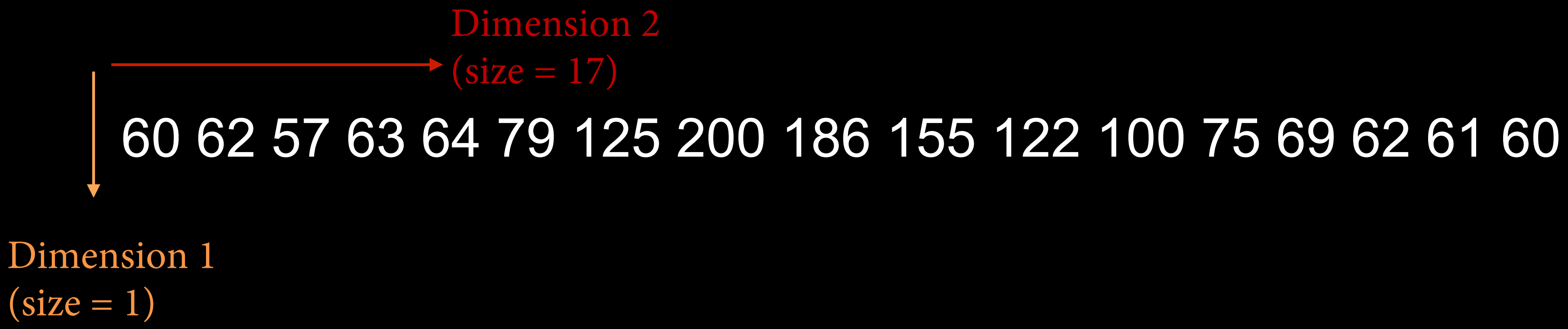
The basic unit for representing information and data is the **array**

Arrays are a useful organizational tool for storing arbitrary amounts of numbers inside of a ***single, structured*** unit

Data storage in MATLAB

60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60

Data storage in MATLAB



Dimension 2
(size = 17)

60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60

Dimension 1
(size = 1)

How to create arrays in MATLAB

How to create arrays in MATLAB

Arrays are created in MATLAB by using double brackets:

myFirstArray = [1,2,3,4,5,6]

How to create arrays in MATLAB

Arrays are created in MATLAB by using double brackets:

myFirstArray = [1,2,3,4,5,6]

brackets -> [ ]

How to create arrays in MATLAB

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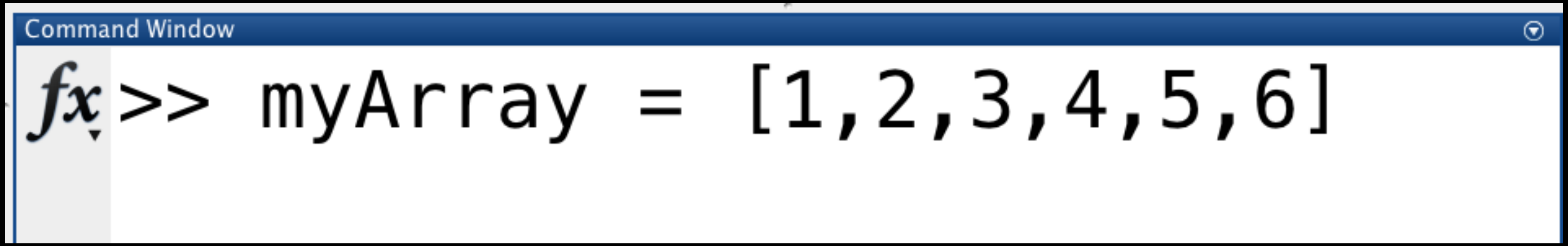
myFirstArray = [1,2,3,4,5,6]

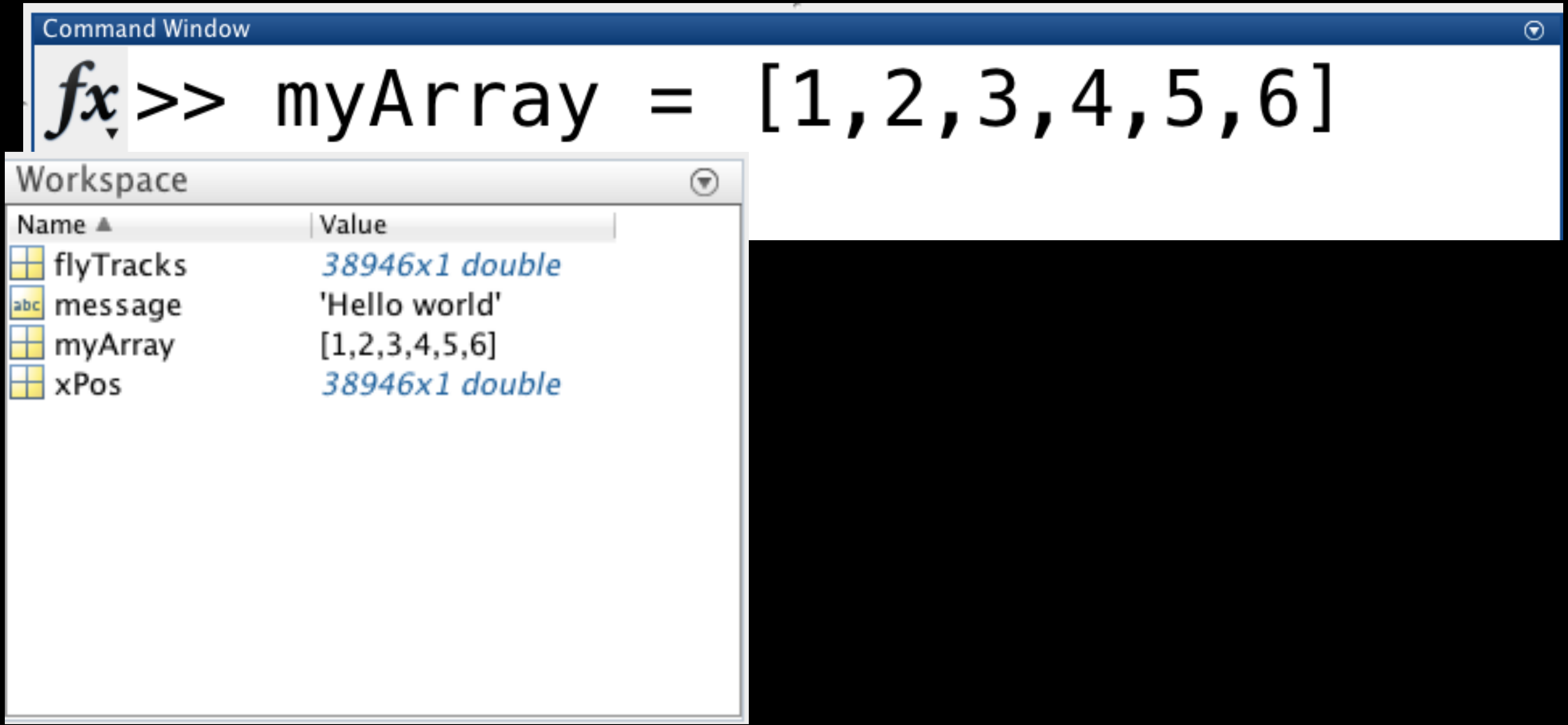


```
>> myArray = [1,2,3,4,5,6]
```

How to create arrays in MATLAB

Arrays are created in MATLAB by using double brackets:

myFirstArray = [1,2,3,4,5,6]



```
fx >> myArray = [1,2,3,4,5,6]
```

Name ▲	Value
flyTracks	38946x1 double
message	'Hello world'
myArray	[1,2,3,4,5,6]
xPos	38946x1 double

Data storage in MATLAB

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

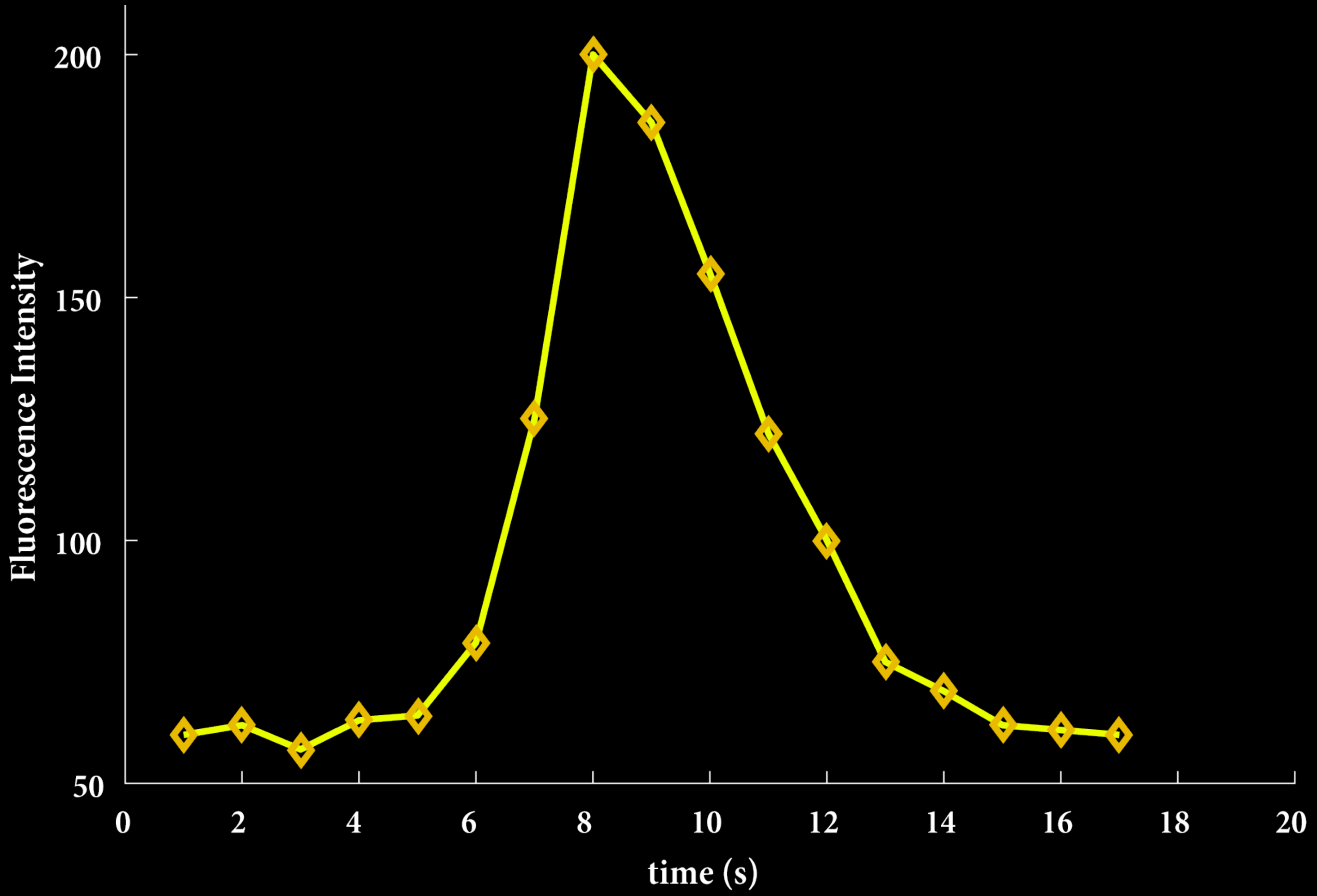
Data storage in MATLAB

```
myArray =  [ 60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60 ]
```

```
figure;plot(myArray)
```

Data storage in MATLAB

OMG!



But what good is storage, if you can’t get the data out?

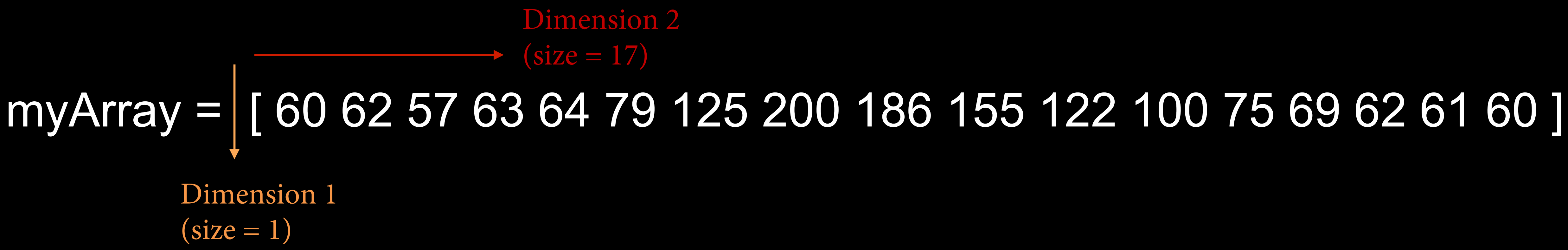
But what good is storage, if you can’t get the data out?

<3 INDEXING

<3 INDEXING

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

<3 INDEXING

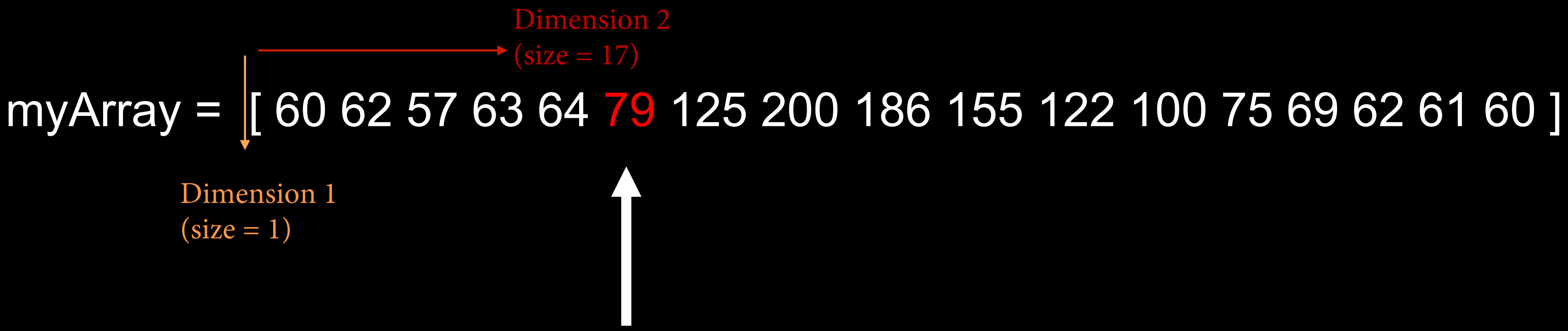


Dimension 2
(size = 17)

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

Dimension 1
(size = 1)

<3 INDEXING



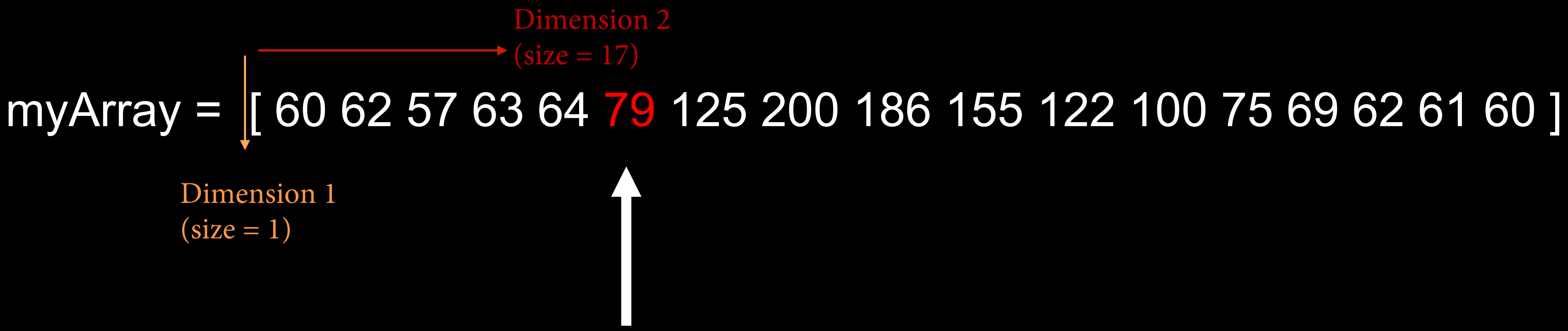
Dimension 2
(size = 17)

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

Dimension 1
(size = 1)

I want this value. What position is it in?

<3 INDEXING



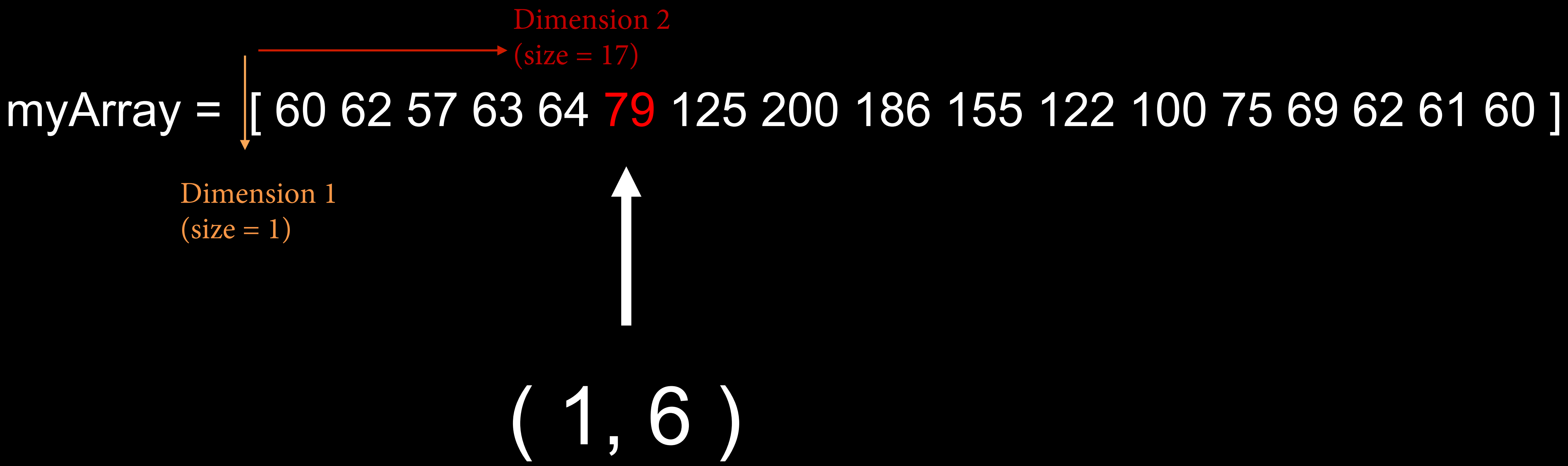
Dimension 2
(size = 17)

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

Dimension 1
(size = 1)

(row, column)

<3 INDEXING



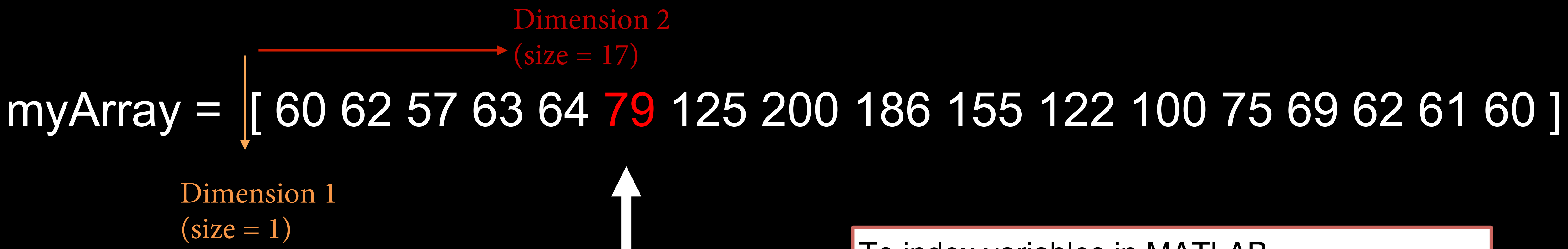
Dimension 2
(size = 17)

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

Dimension 1
(size = 1)

(1, 6)

<3 INDEXING



Dimension 2
(size = 17)

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

Dimension 1
(size = 1)

myArray(1, 6)

To index variables in MATLAB

Type the variable name, followed by parentheses with your index position inside those parentheses.

Enter the command:

```
myArray2 = myArray( 1, : )
```

This command will return every element in first row of myArray

Colon operator

:

The colon has multiple important functions in MATLAB

Colon operator

:

The colon has multiple important functions in MATLAB

1) Selecting all elements in a dimension of an array
myArray(1 , :)   select the first row and all columns

Enter the command:

```
myArray3 = 1 : 1 : 100
```

start

end

interval

This command will create a list starting at 1, counting by 1, and ending at 100

Enter the command:

```
myArray3 = 1 : 2 : 100
```

start

interval

end

This command will create a list starting at 1, counting by 2, and ending at 100

Colon operator

:

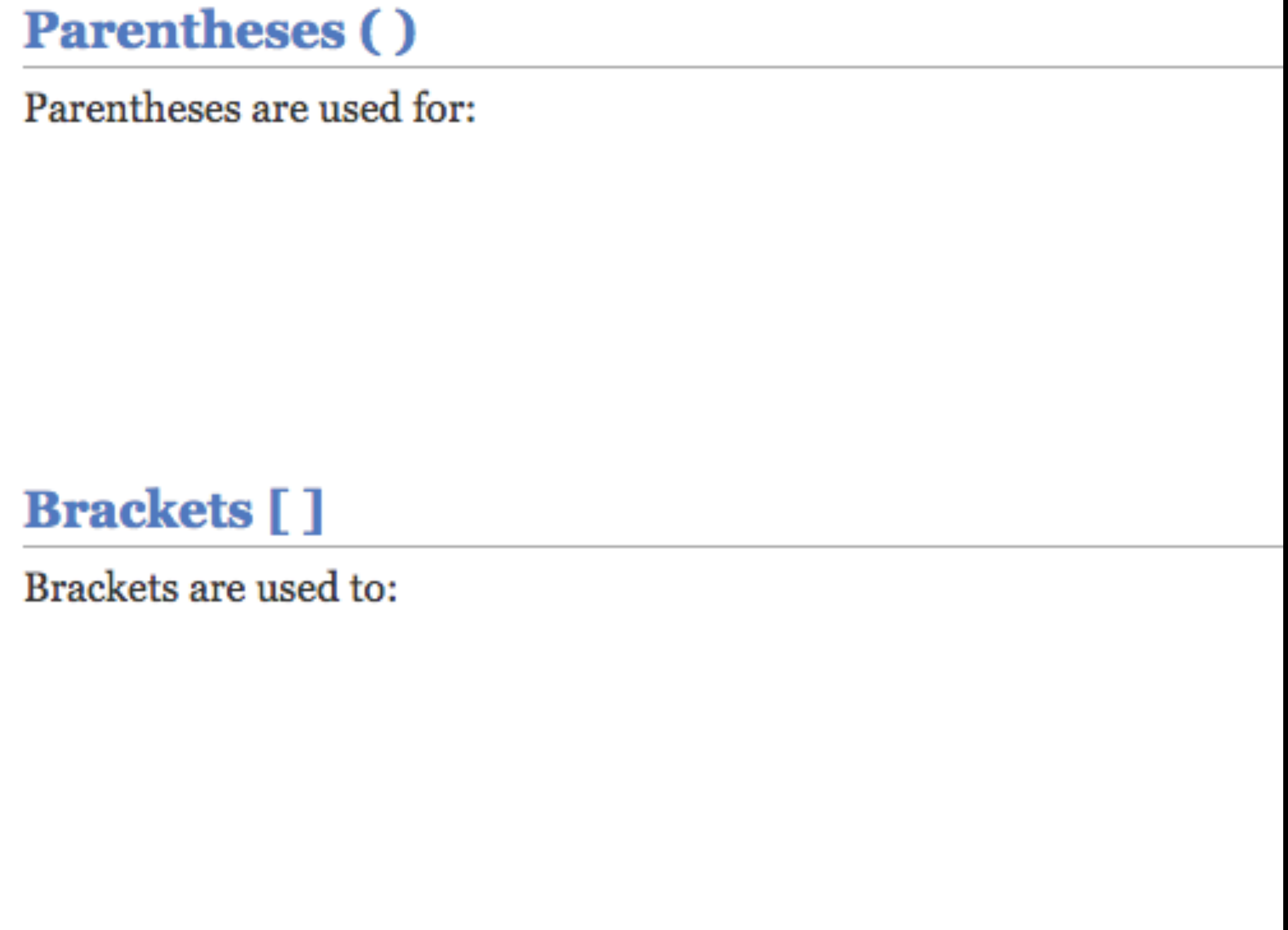
The colon has multiple important functions in MATLAB

1) Selecting all elements in a dimension of an array
myArray(1 , :)   go to the first row, select all rows

2) Creating lists of numbers
myArray2 = 1:1:100 make a list of numbers from 1 to 100 and count by 1s

Parentheses versus brackets in MATLAB

Parentheses versus brackets in MATLAB



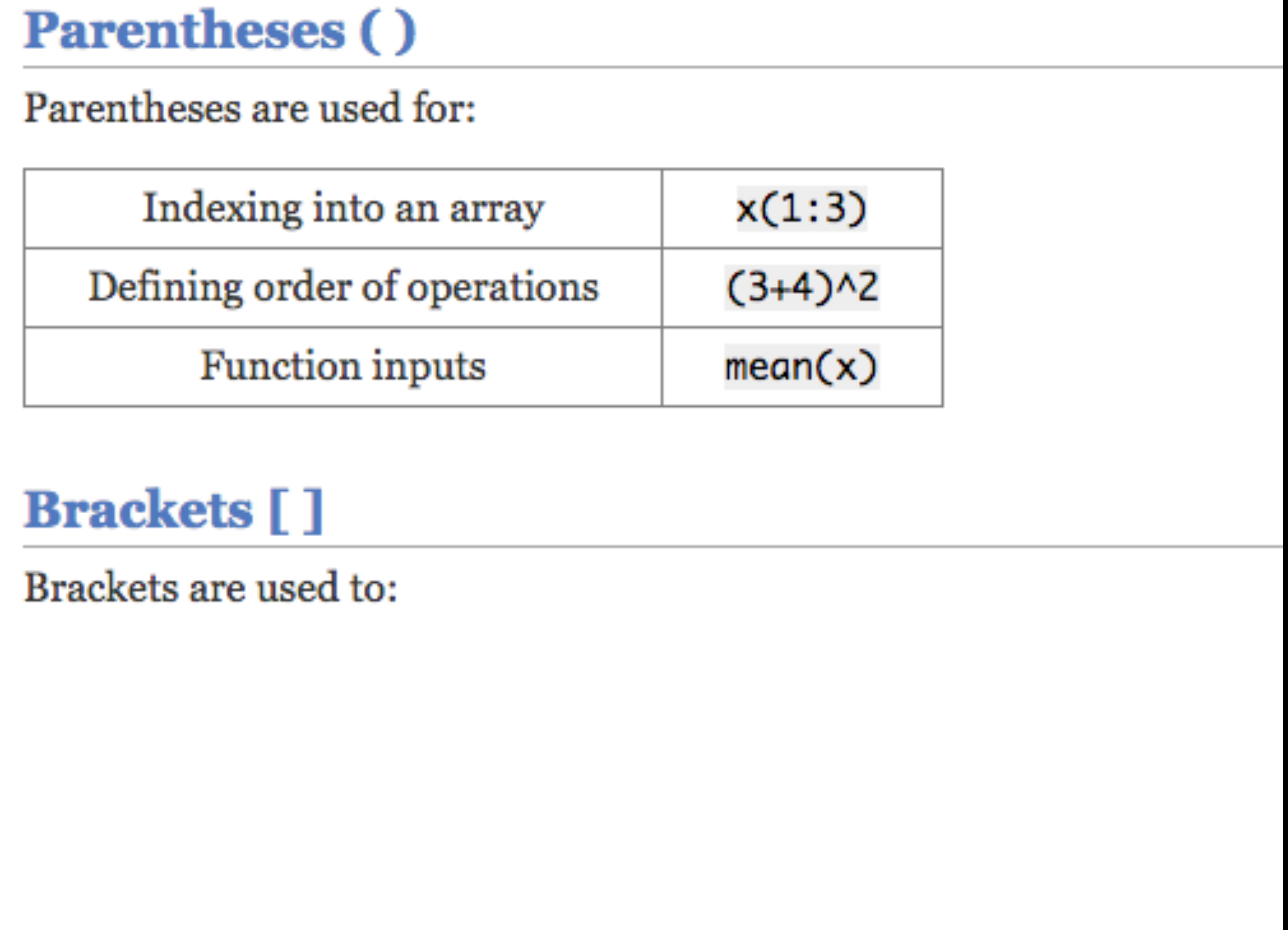
Parentheses ( )

Parentheses are used for:

Brackets [ ]

Brackets are used to:

Parentheses versus brackets in MATLAB



Parentheses ( )

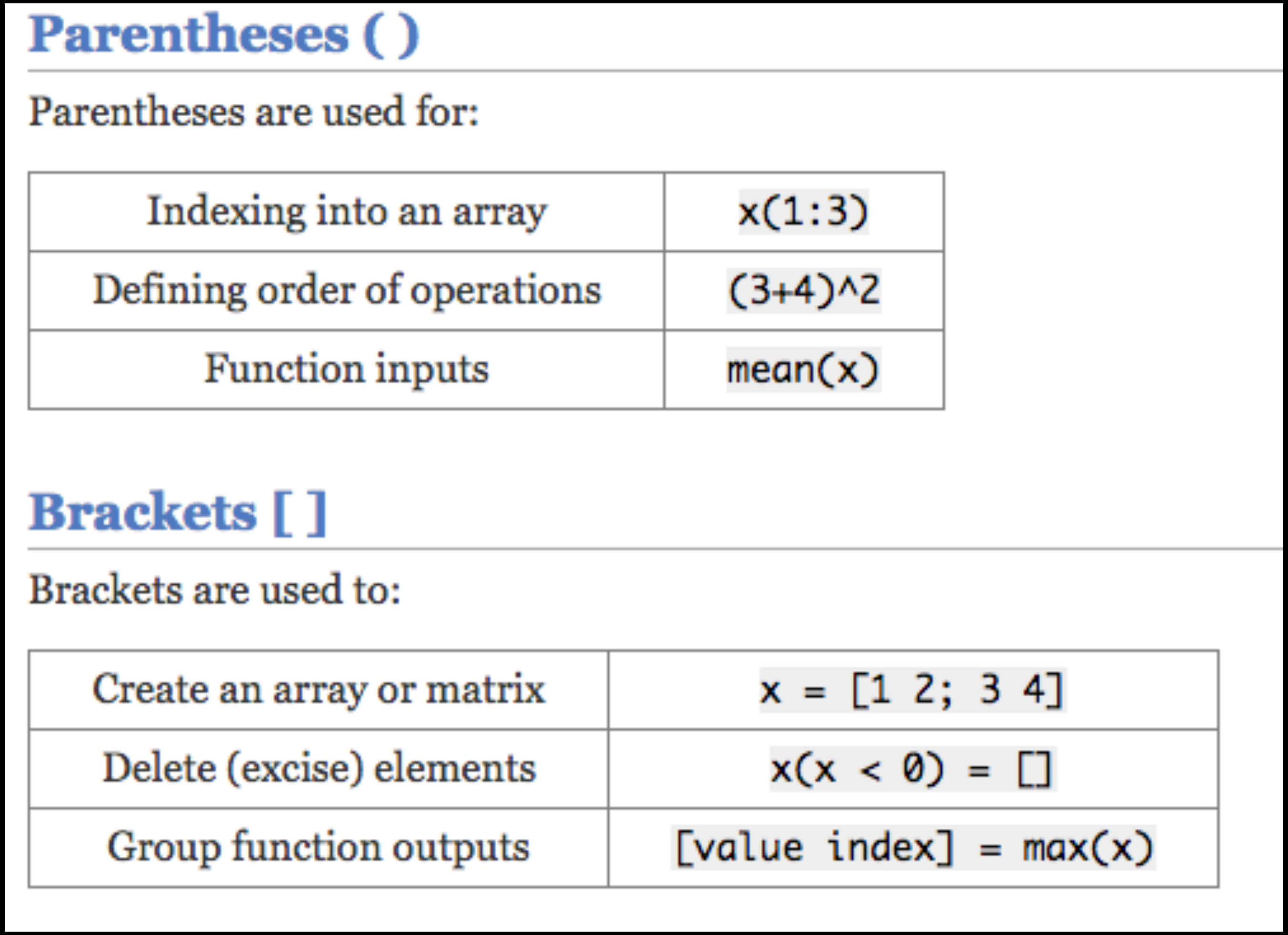
Parentheses are used for:

Indexing into an array	`x(1:3)`
Defining order of operations	`(3+4)^2`
Function inputs	`mean(x)`

Brackets [ ]

Brackets are used to:

Parentheses versus brackets in MATLAB



Parentheses ( )

Parentheses are used for:

Indexing into an array	`x(1:3)`
Defining order of operations	`(3+4)^2`
Function inputs	`mean(x)`

Brackets [ ]

Brackets are used to:

Create an array or matrix	`x = [1 2; 3 4]`
Delete (excise) elements	`x(x < 0) = []`
Group function outputs	`[value index] = max(x)`

Enter the command:

```
myArray4 = 1 : 2 : 100;
```

The semicolon **;**
at the end of a command will suppress the displayed output
MATLAB will still execute the command even though the output isn’t displayed

Semicolon operator

;

The semicolon has multiple important functions in MATLAB

1) Suppress a command’s displayed output

Semicolon operator
;

The semicolon has multiple important functions in MATLAB

1) Suppress a command’s displayed output

2) Creating matrices

How to create matrices in MATLAB

How to create matrices in MATLAB

In MATLAB you can create a new row inside an array using the semi-colon

;

How to create matrices in MATLAB

In MATLAB you can create a new row inside an array using the semi-colon

;

myMatrix =
[100,101,102,103;104,105,106,107;108,109,110,111]

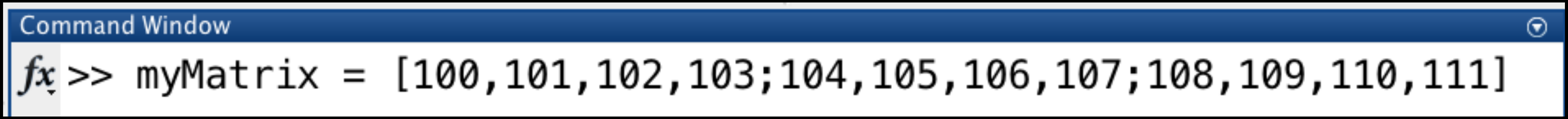
How to create matrices in MATLAB

In MATLAB you can create a new row inside an array using the semi-colon

;

myMatrix =

[100,101,102,103;104,105,106,107;108,109,110,111]



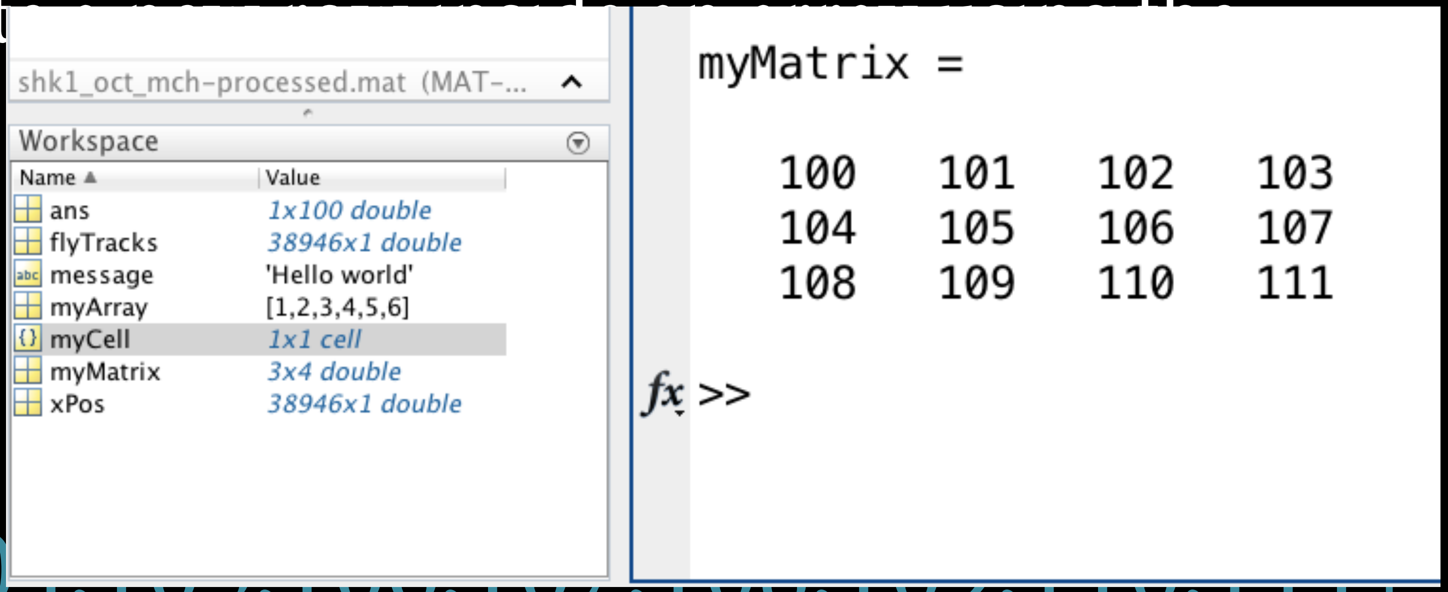
```
>> myMatrix = [100,101,102,103;104,105,106,107;108,109,110,111]
```

How to create matrices in MATLAB

In MATLAB you can create a new row inside an array using the semi-colon

myMatrix =

[100,101,102,103;104,105,106,107;108,109,110,111]



shk1_oct_mch-processed.mat (MAT-...

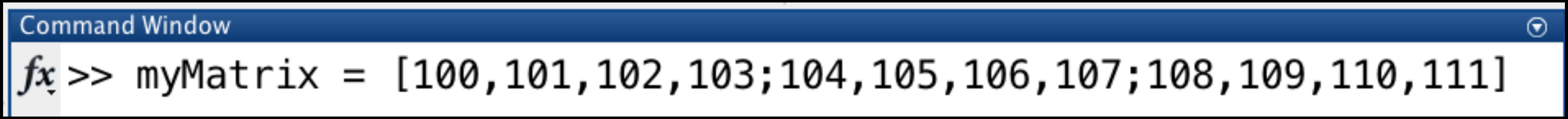
Workspace

Name ▲	Value
ans	1x100 double
flyTracks	38946x1 double
message	'Hello world'
myArray	[1,2,3,4,5,6]
myCell	1x1 cell
myMatrix	3x4 double
xPos	38946x1 double

```
myMatrix =

   100   101   102   103
   104   105   106   107
   108   109   110   111

fx >>
```



Command Window

```
fx >> myMatrix = [100,101,102,103;104,105,106,107;108,109,110,111]
```

Enter the command:

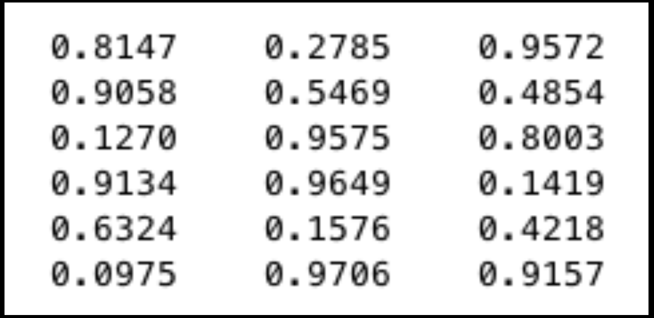
```
figure;surf(myMatrix)
```

Cell-Arrays

Cell-Arrays

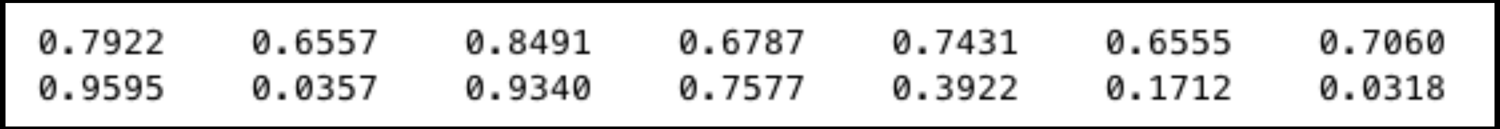
Two data sets of different sizes, but we’d like to store them in one variable

Tiny image



```
0.8147    0.2785    0.9572
0.9058    0.5469    0.4854
0.1270    0.9575    0.8003
0.9134    0.9649    0.1419
0.6324    0.1576    0.4218
0.0975    0.9706    0.9157
```

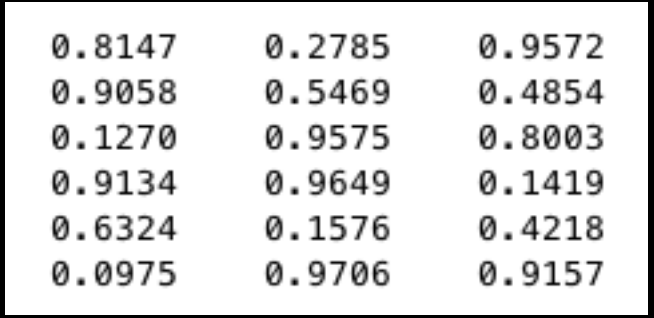
Metadata on tiny image



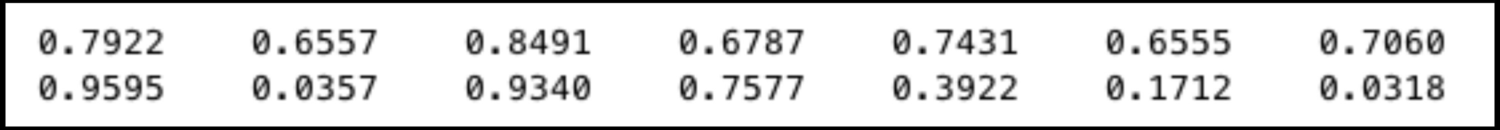
```
0.7922    0.6557    0.8491    0.6787    0.7431    0.6555    0.7060
0.9595    0.0357    0.9340    0.7577    0.3922    0.1712    0.0318
```

Cell-Arrays

Two data sets of different sizes, but we'd like to store them in one variable



```
0.8147    0.2785    0.9572
0.9058    0.5469    0.4854
0.1270    0.9575    0.8003
0.9134    0.9649    0.1419
0.6324    0.1576    0.4218
0.0975    0.9706    0.9157
```



```
0.7922    0.6557    0.8491    0.6787    0.7431    0.6555    0.7060
0.9595    0.0357    0.9340    0.7577    0.3922    0.1712    0.0318
```

BUT HOW?

Cell-Arrays

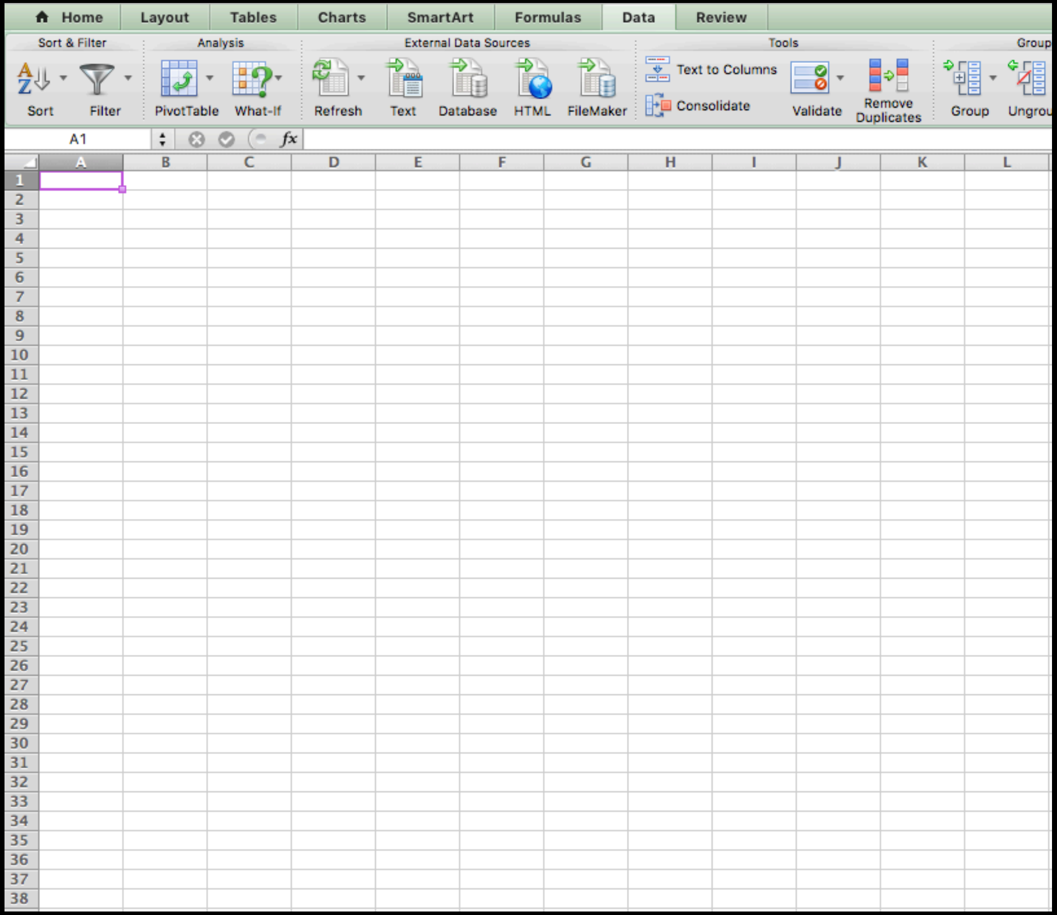
These are data types with indexed containers called “cells”. The user can instruct MATLAB to store large amounts of data in a specific cell.

Cell-Arrays

These are data types with indexed containers called “cells”. The user can instruct MATLAB to store large amounts of data in a specific cell.

Almost like an excel spreadsheet

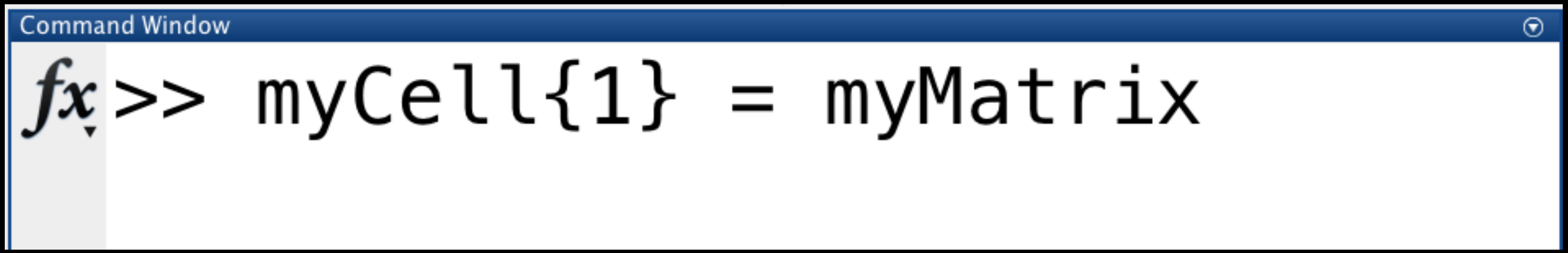
Within each cell you can store numerical or string data of any size



Cell-Arrays

These are data types with indexed containers called “cells”. The user can instruct MATLAB to store large amounts of data in a specific cell.

Curly braces

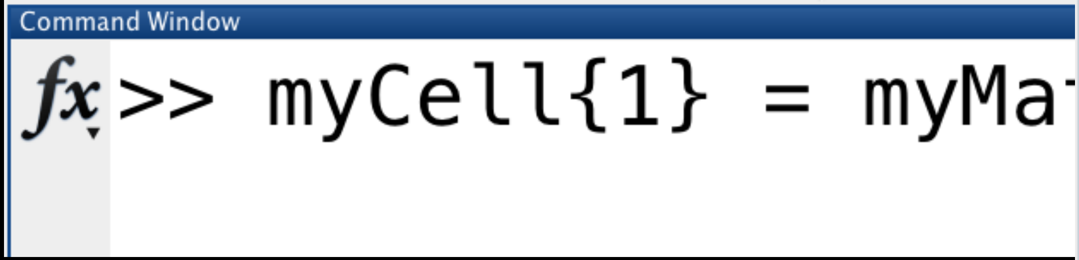


```
>> myCell{1} = myMatrix
```

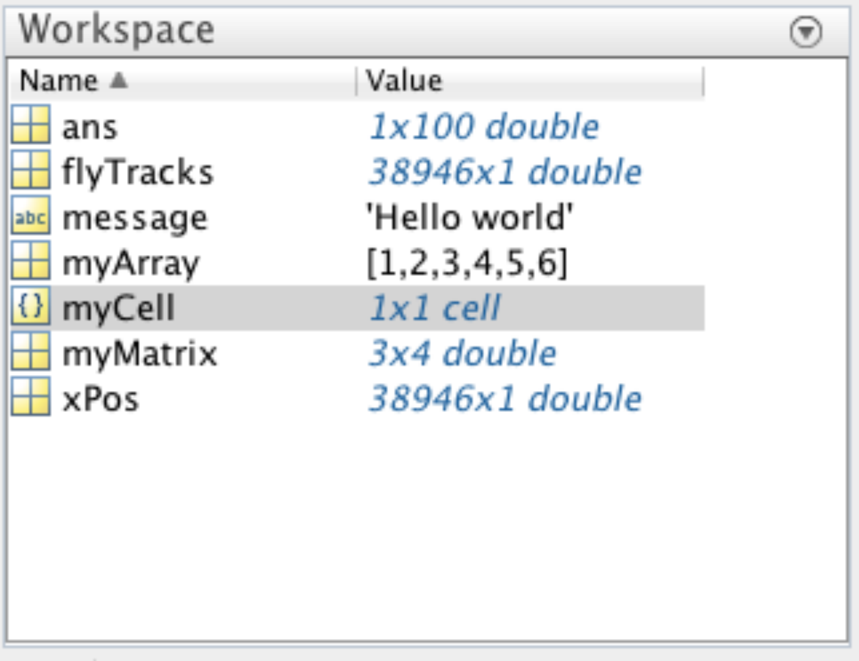
Cell-Arrays

These are data types with indexed containers called “cells”. The user can instruct MATLAB to store large amounts of data in a specific cell.

Curly braces



```
>> myCell{1} = myMa
```



Name ▲	Value
ans	1x100 double
flyTracks	38946x1 double
message	'Hello world'
myArray	[1,2,3,4,5,6]
myCell	1x1 cell
myMatrix	3x4 double
xPos	38946x1 double

Types of Operations

- Conditional operations: instructions are carried out only if certain conditions are met

Learning to Program:

```
1. Check your calendar
2. IF it is Monday or Wednesday,
   attend iPBR class
3. Tackle coding assignments
4. Become master programmer
```

Logical (boolean):

A variable that has two values:

true or false

Logical (boolean):

A variable that has two values:

true or false

MATLAB interprets this as either:

1 or 0

Logical (boolean):

Operators for logical comparison:

Logical operator:		Meaning:
<	------------------	is less than
>	------------------	is greater than
>=	------------------	is greater than or equal to
<=	------------------	is less than or equal to
==	------------------	is equal to
~=	------------------	not equal to
&	------------------	and
|	------------------	or

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

```
if freeFood == true
    MattAttend = true
```

This conditional statement starts with if, followed by a logical

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

```
if freeFood == true
    MattAttend = true
elseif interestingSpeaker == true | Georgia_Attend == true
    MattAttend = true
```

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

```
if freeFood == true
    MattAttend = true
elseif interestingSpeaker == true | Georgia_Attend == true
    MattAttend = true
```

The second conditional statement uses ELSEIF If the first logical evaluates false, then evaluate this ELSEIF statement. Perform the operation under the ELSEIFclause, if the logical evaluates true.

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

```
if freeFood == true
    MattAttend = true
elseif interestingSpeaker == true | Georgia_Attend == true
    MattAttend = true
else
    MattAttend = false
```

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

```
if freeFood == true
    MattAttend = true
elseif interestingSpeaker == true | Georgia_Attend == true
    MattAttend = true
else
    MattAttend = false
```

The last conditional statement uses else
If all ELSE fails (every other statement evaluates false), then perform the commands below else

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

```
if freeFood == true
    MattAttend = true
elseif interestingSpeaker == true | Georgia_Attend == true
    MattAttend = true
else
    MattAttend = false
end
```

Conditional statements:

Conditional statements enable you to select at run time which block of code to execute. The simplest conditional statement is an if statement.

Will I go to class today?

```
if freeFood == true
    MattAttend = true
elseif interestingSpeaker == true | Georgia_Attend == true
    MattAttend = true
else
    MattAttend = false
end
```

Tell MATLAB to end a conditional statement by typing end

Conditional statements:

myArray = [60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60]

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```
if     sum(myArray) > 1000
               print(‘The neuron has spiked.’)
elseif sum(myArray) < -500
       print(‘The neuron has been inhibited.’)
else
       print(‘There is no significant change.’)
end
```

Conditional statements:

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myArray =  [ 60 62 57 63 64 79 125 200 186 155 122 100 75 69 62 61 60 ]

if      sum(myArray) > 1000
                disp(‘The neuron has spiked.’)
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        disp(‘The neuron has been inhibited.’)
else
        disp(‘There is no significant change.’)
end
```

The output of this series of commands will be:
The neuron has spiked

MATLAB evaluates the first conditional statement and finds the statement to be true so it evaluates the command beneath it

Types of Operations

- Iterative operations: instructions are carried out repeatedly

Learning to Program:

```
1. Attend iPBR lectures and
   review sessions
2. Tackle coding assignments
3. REPEAT steps 1 and 2
   until August 2
4. Become master programmer
```

How can I repeat the same lines of code?

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Scenario: You're looking for warm places to travel. You look online at all the trendy and hip spots around the world, but all the recorded temperature data is in Celsius.

You have a friend that can do the temperature conversions in their head extremely quickly. You must instruct your friend to convert the temperatures listed below.

WHAT DO YOU SAY?

12, 6, 130, 273, -34

"Hello, friend. Could you use your conversion equation **FOR** the temperatures: 12, 6, 130, 273, and -34

Loop Control

Used to repeatedly execute a block of code

Two loop control operators:

Loop Control

Used to repeatedly execute a block of code

Two loop control operators:

For

While

Loop Control: **for**

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```

Write MATLAB code to iterate your temp conversion algorithm over the five numerical values:
12, 6, 130, 273, -34

My temp conversion algorithm:

```
inputTempFah = 12
outputTempCels = (inputTempFah-32)*(5/9)
```

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```

In the scenario (slide 143), I instruct my friend to convert a set of values by using the word for. “for the number 12, 6..etc”

To the left is represents the same idea in MATLAB code. MATLAB will execute the commands inside the for-loop with the value of the inputTempFah changing for each iteration of the loop.

Coming Up Next

- Congrats on finishing part 1 of intro to MATLAB
- Next week we will continue with part 2:
  - While loops
  - Executing/writing functions
  - Basic plotting
- Problem set 2 will be released tomorrow morning
- Review session on Monday at 7pm (243NW)