Chapter 1: An Overview of MATLAB

MATLAB is:

A high-level language and interactive environment for numerical computation, visualization, and programming

MATLAB can:

Be used as a calculator, easily create scalars, vectors and arrays, be used as a programming environment, make sophisticated plots, be used to create models that describe experimental data, solve statistics and probability problems, solve systems of linear algebraic equations, solve differential equations

MATLAB is used for:

Finite element analysis, computational fluid dynamics, signal processing and communications, image and video processing, control systems, test and measurement, etc.

MATLAB is used by:

More than a million engineers and scientists in industry and academia

Chapter 1: An Overview of MATLAB

Chapter 1 Topics Covered:

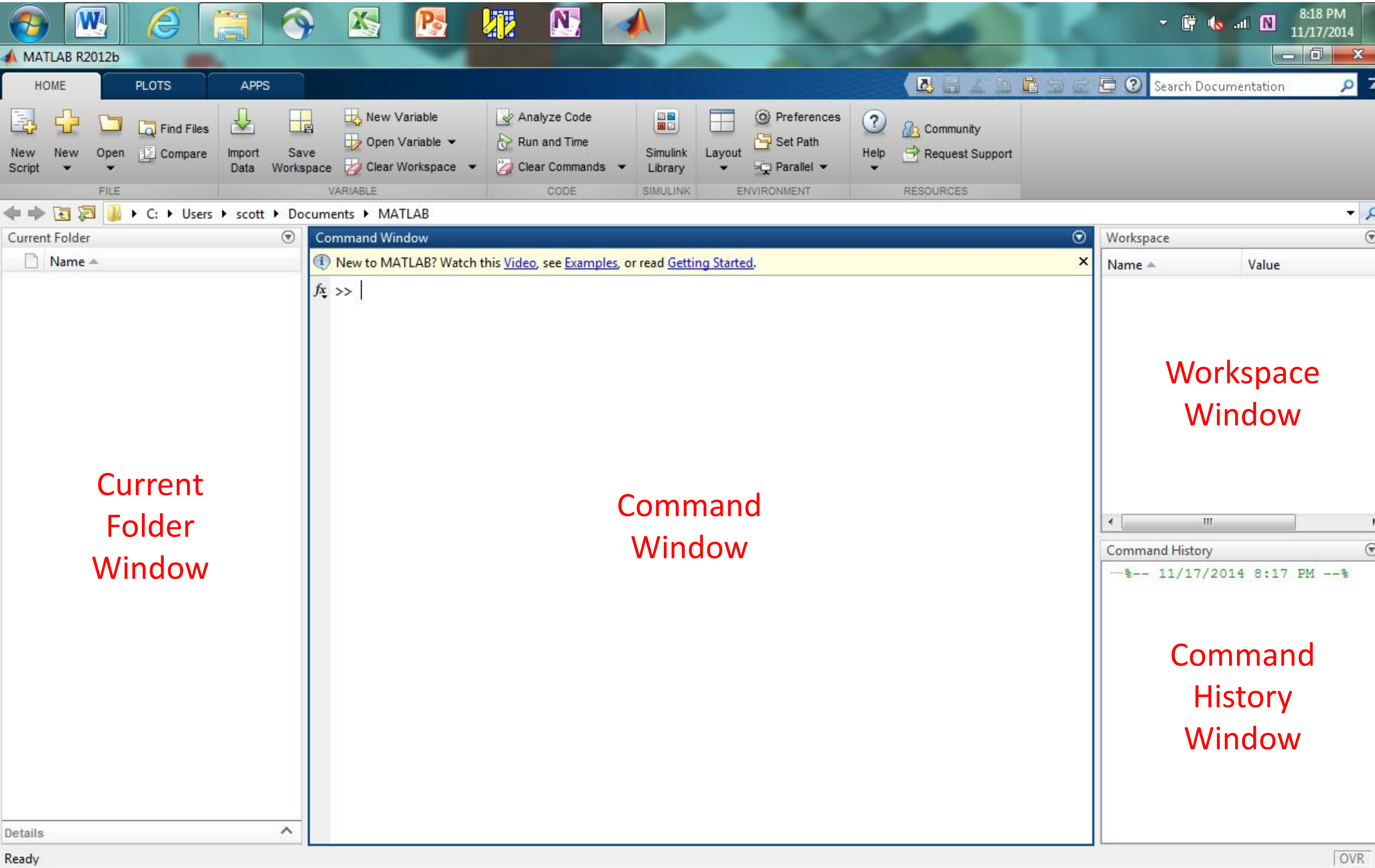
- MATLAB Windows: Current Folder, Command, Workspace, Command History

- Using MATLAB as a Calculator
  - Mathematical Operators
  - Clearing Windows
  - Assignment Operator

- Using MATLAB Script Files
  - Creating/Saving/Editing/Executing Script Files
  - Changing the Destination Folder
  - Using the Editor Window
  - Built-In Functions
  - Search Documentation
  - Order of Mathematical Precedence
  - Creating Arrays and using them in Calculations
  - Creating Plots with Arrays (Graphics Window)
  - Creating Arrays Automatically
  - Understanding Error Signals and Error Messages
  - Publishing MATLAB Files

Using MATLAB as a Calculator

Open MATLAB.



Mathematical Operators

Symbol	Operation	MATLAB form
^	exponentiation: a^b	a^b
*	multiplication: ab	a*b
/	right division: $a/b = \frac{a}{b}$	a/b
\	left division: $a\backslash b = \frac{b}{a}$	a\ b
+	addition: $a + b$	a+b
-	subtraction: $a - b$	a-b

Type the following commands into the **Command Window** to solve Problem 1.1(a):

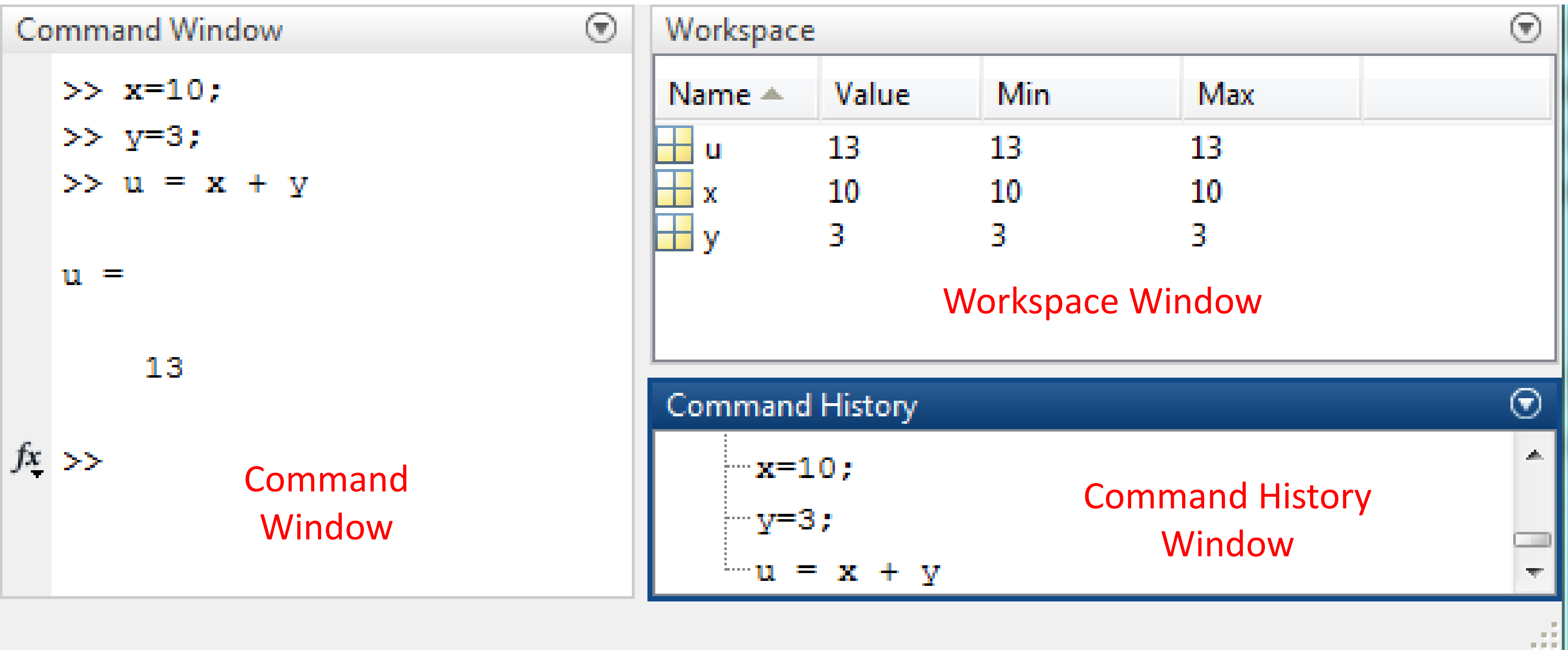
```
>> x=10;
>> y=3;
>> u=x+y
```

1. Make sure you know how to start and quit a MATLAB session. Use MATLAB to make the following calculations, using the values $x = 10$, $y = 3$. Check the results by using a calculator.

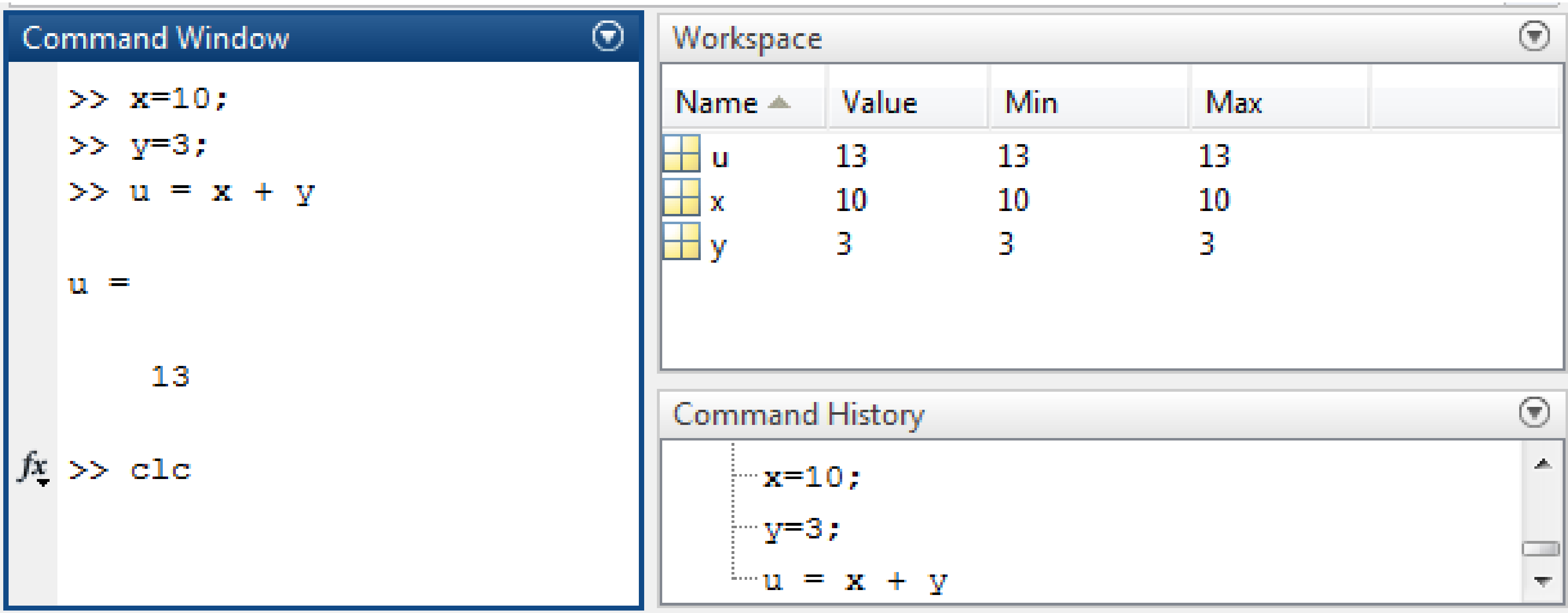
a. $u = x + y$ *b.* $v = xy$ *c.* $w = x / y$

d. $z = \sin x$ *e.* $r = 8 \sin y$ *f.* $s = 5 \sin (2y)$

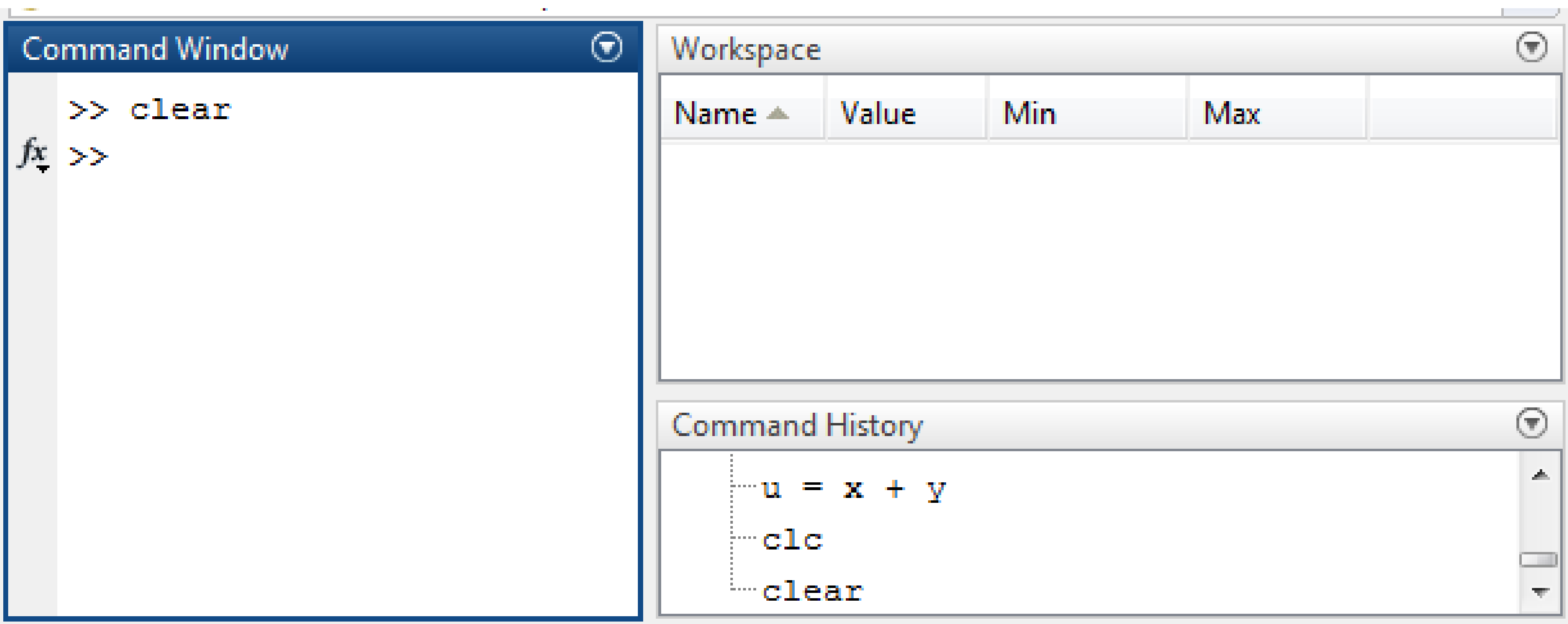
The output of the calculation appears in the **Command Window**.
The semi-colon **(;)** suppresses output to the **Command Window**.
The **Workspace Window** shows the names and values of the **Variables**.
The **Command History Window** shows the entered commands.
Previous commands can be accessed quickly by using the **Up Arrow** and **Down Arrow**. Try this!



Clear the **Command Window** by typing **clc** (and hit enter) into the **Command Window.**



Remove all of the variables from the **Workspace** by typing the command **clear** in the **Command Window**.



In the previous example, the equals sign **(=)** is called the **Assignment or Replacement Operator**. Type in the following session to demonstrate that the **Assignment Operator** is different than the **equals** sign in mathematics.

Command Window

New to MATLAB? Watch this Video, see Examples, or read Getting Started.

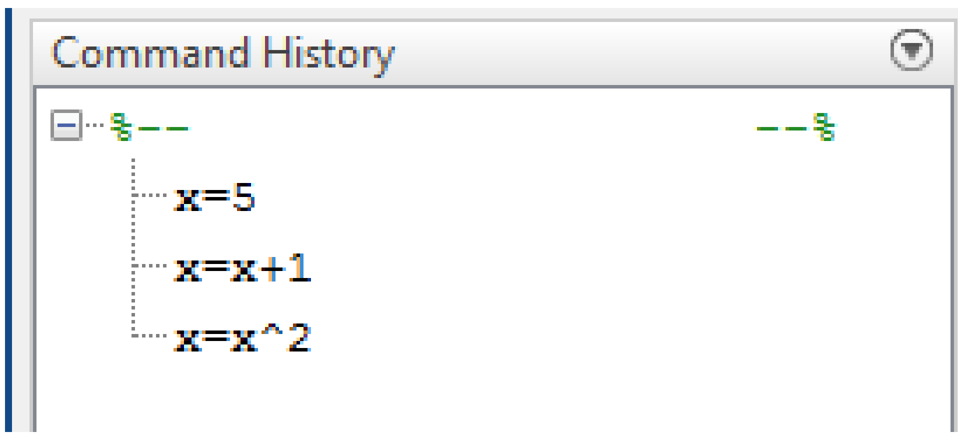
```
>> clear
>> x=5

x =

     5

>> x=x+1

x =

     6

>> x=x^2

x =

    36

>>
```

The second command line that was typed in is shown in the **Command History Window** below. It states the following:

"Replace variable **x** with the current contents of variable **x** plus 1."

In the third command line, the caret symbol **(^)** denotes exponentiation.

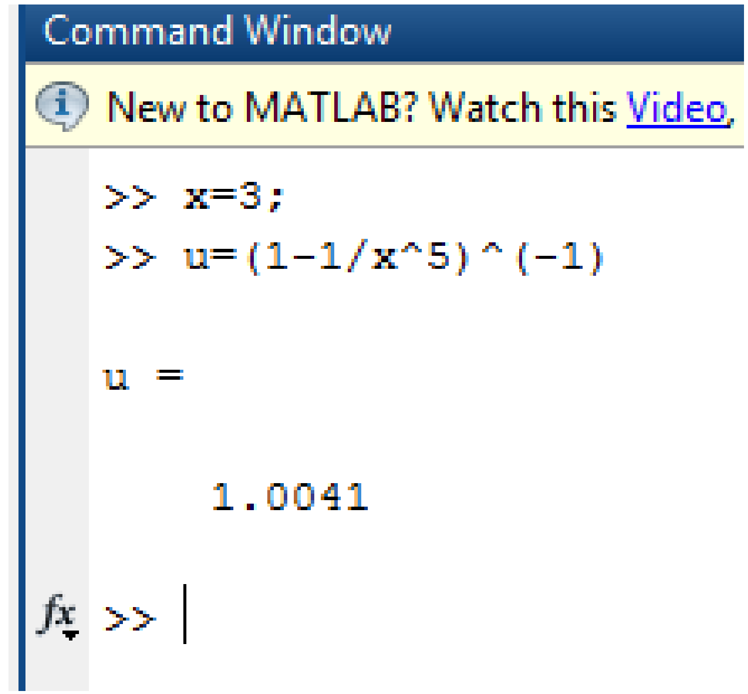
"Replace variable **x** with the current contents of variable **x** raised to the second power."



Use MATLAB to solve Problem 1.3(a) as shown below:

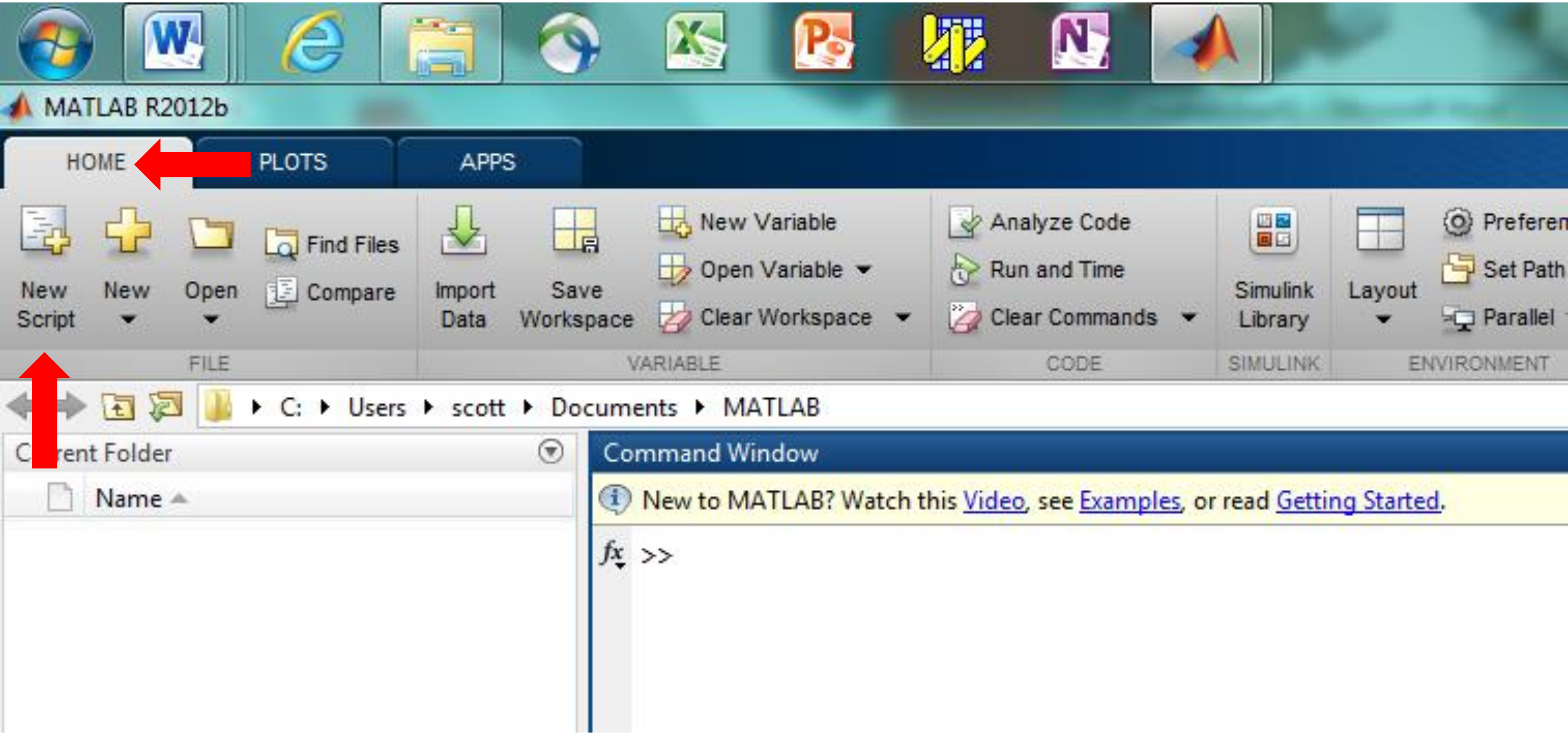
3. Suppose that $x = 3$ and $y = 4$. Use MATLAB to compute the following, and check the results with a calculator.

a. $\left(1 - \dfrac{1}{x^5}\right)^{-1}$ *b.* $3\pi x^2$ *c.* $\dfrac{3y}{4x - 8}$ *d.* $\dfrac{4(y - 5)}{3x - 6}$

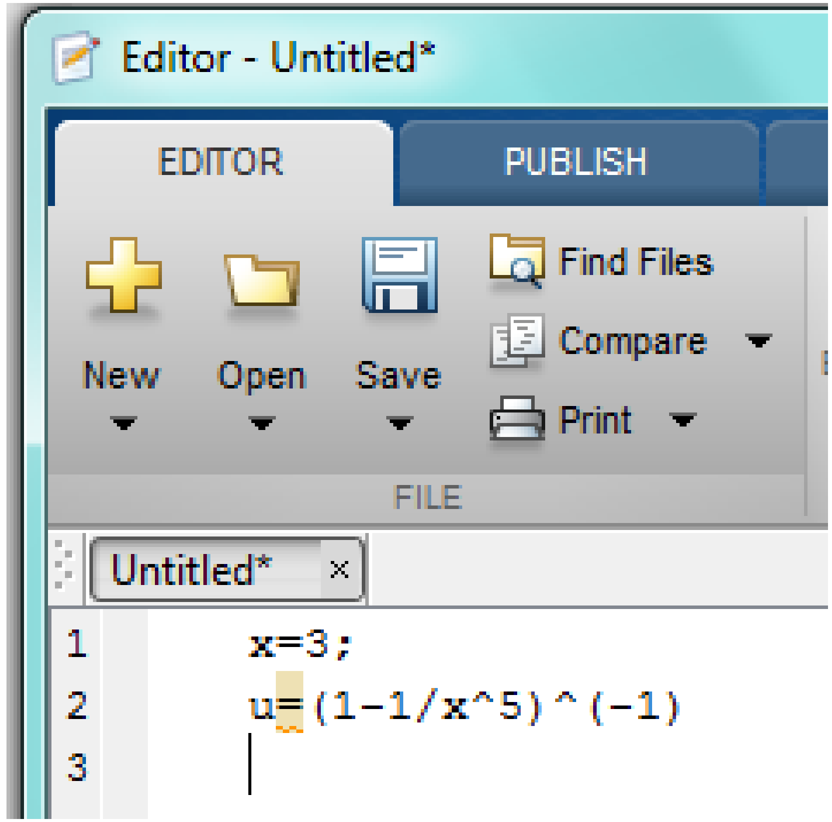

Command Window
New to MATLAB? Watch this Video,
>> x=3;
>> u=(1-1/x^5)^(-1)
u =
1.0041
>>

Using MATLAB Script Files

Another method of computation is to create a **Script File**, which is a way to store commands to be executed in the **Command Window**. Use the **Home/New Script** tab to create a new **Script File**:



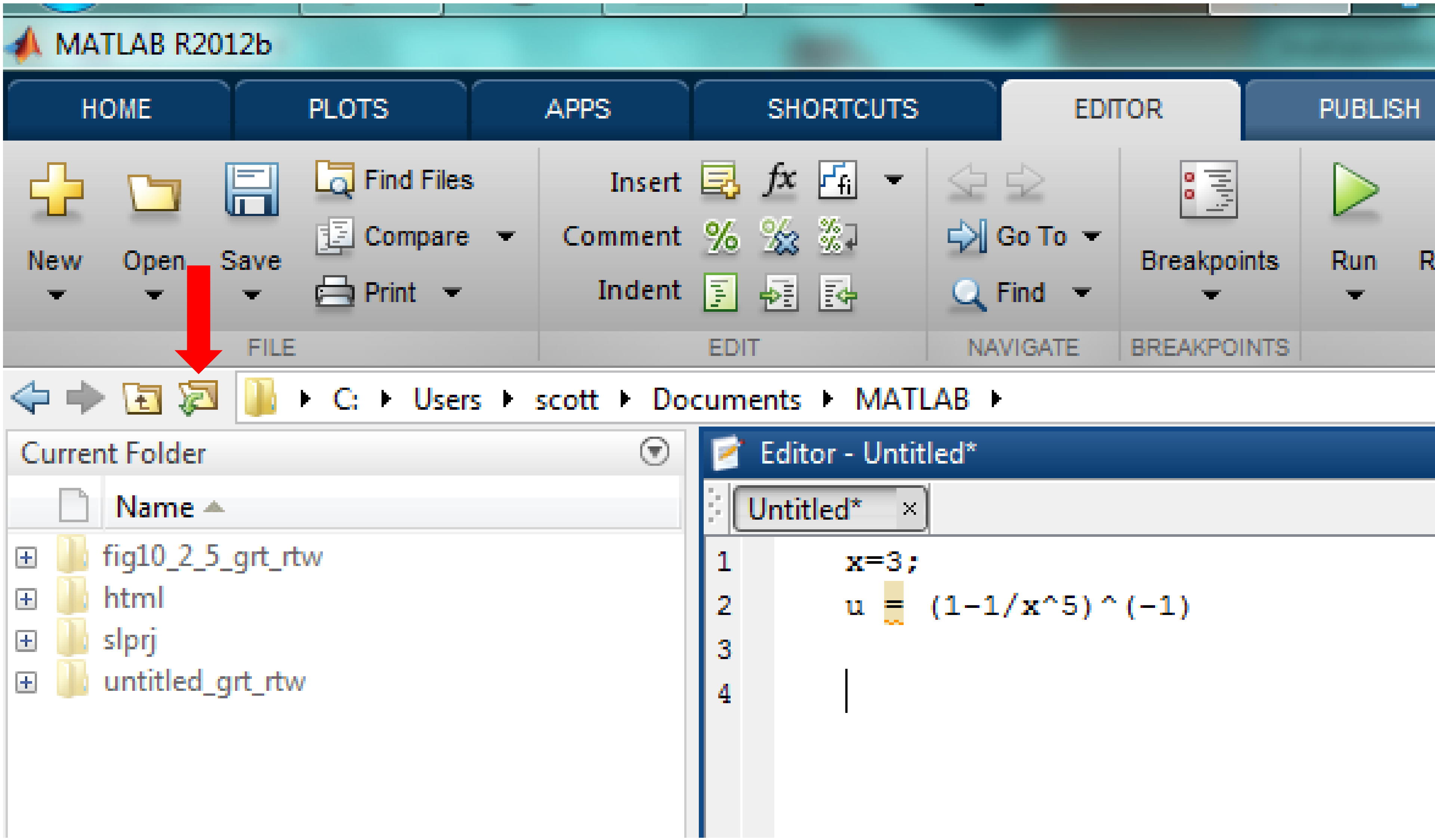
The new window that has appeared is called the **Editor/Debugger**. Use the **Editor** in MATLAB to solve Problem 1.3(a) by typing the following.



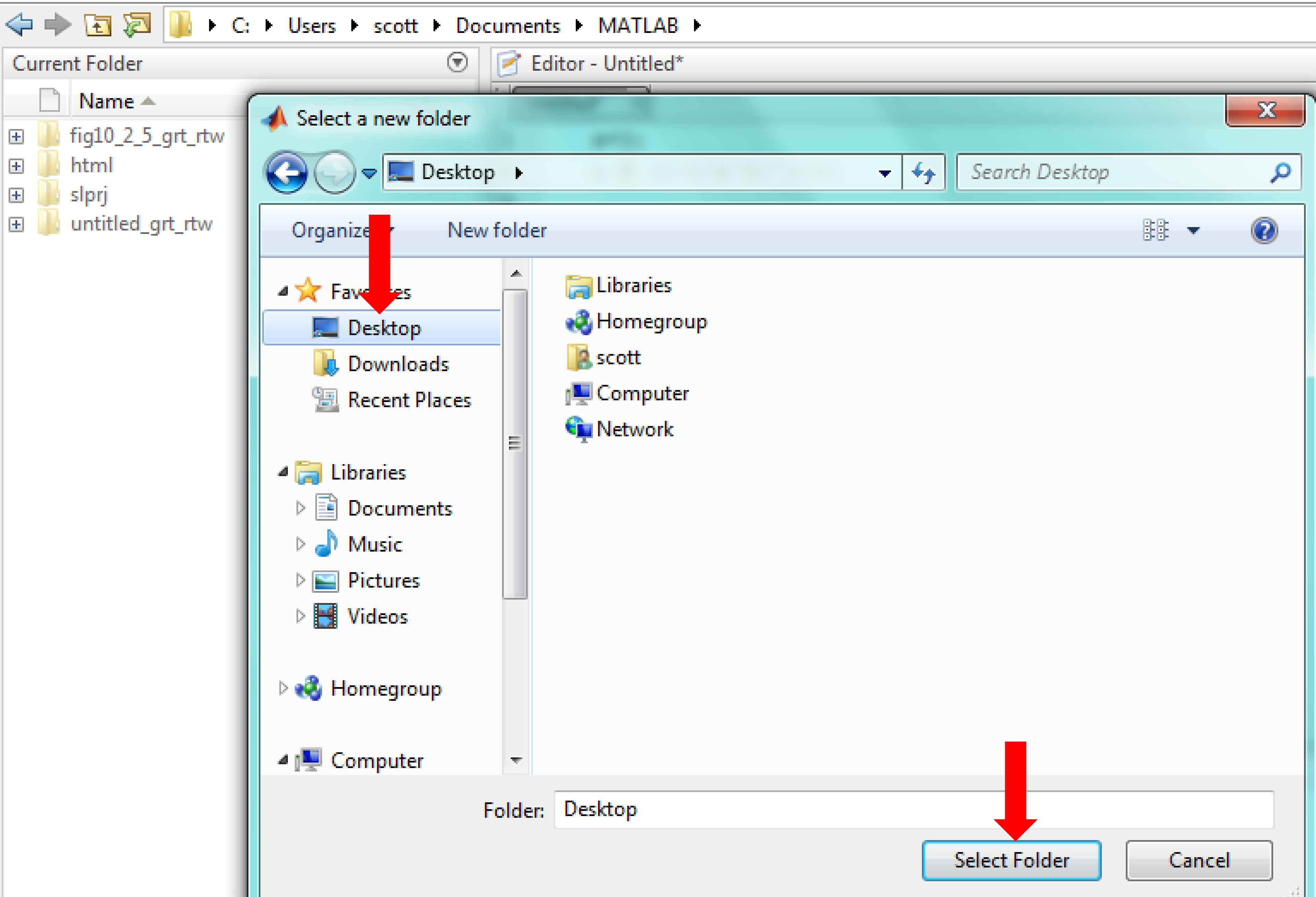
3. Suppose that $x = 3$ and $y = 4$. Use MATLAB to compute the following, and check the results with a calculator.

a. $\left(1 - \frac{1}{x^5}\right)^{-1}$ *b.* $3\pi x^2$ *c.* $\frac{3y}{4x - 8}$ *d.* $\frac{4(y - 5)}{3x - 6}$

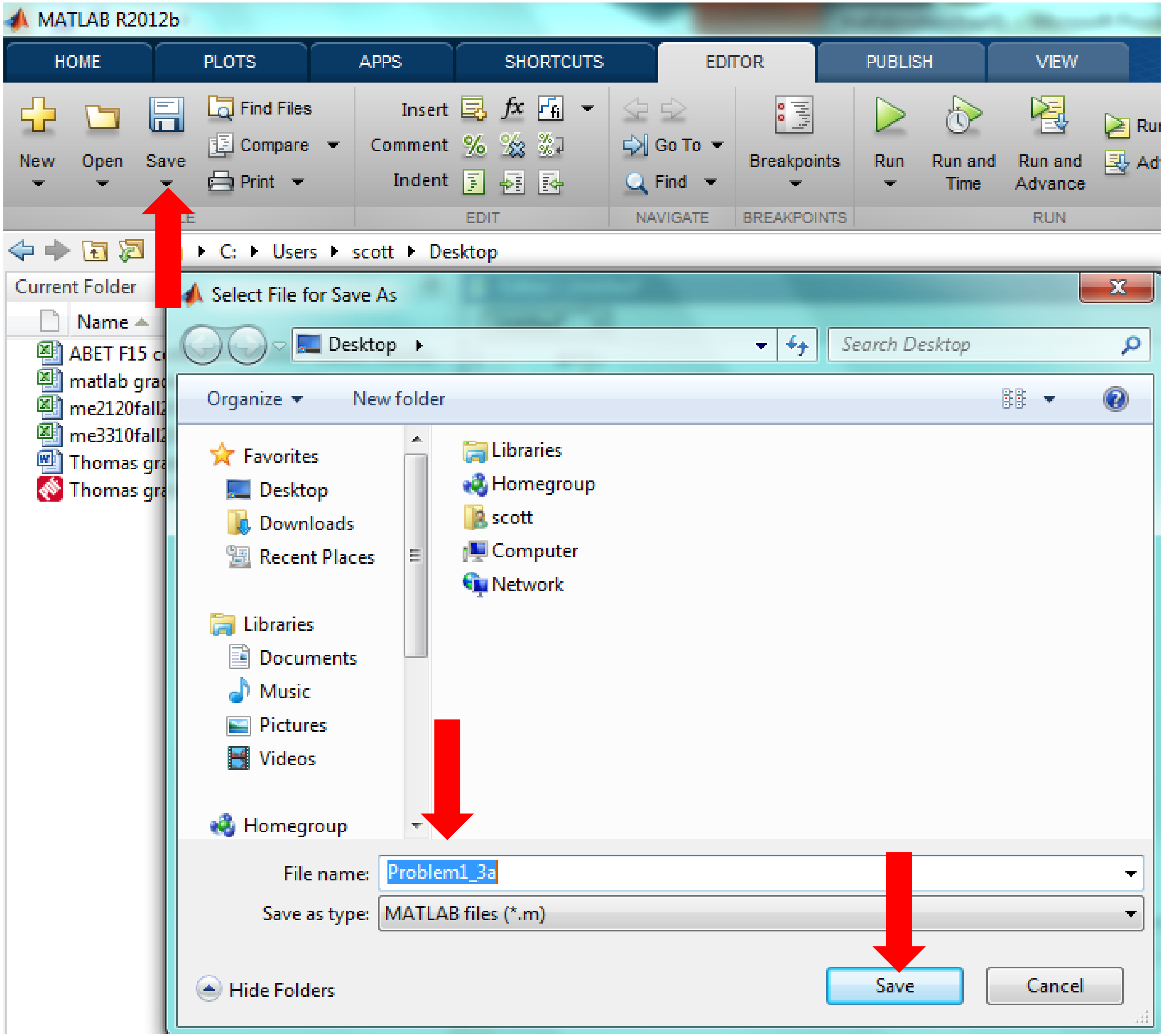
Before saving, change the folder that MATLAB saves files to (the **Destination Folder**) by pushing the **Browse for Folder** button:



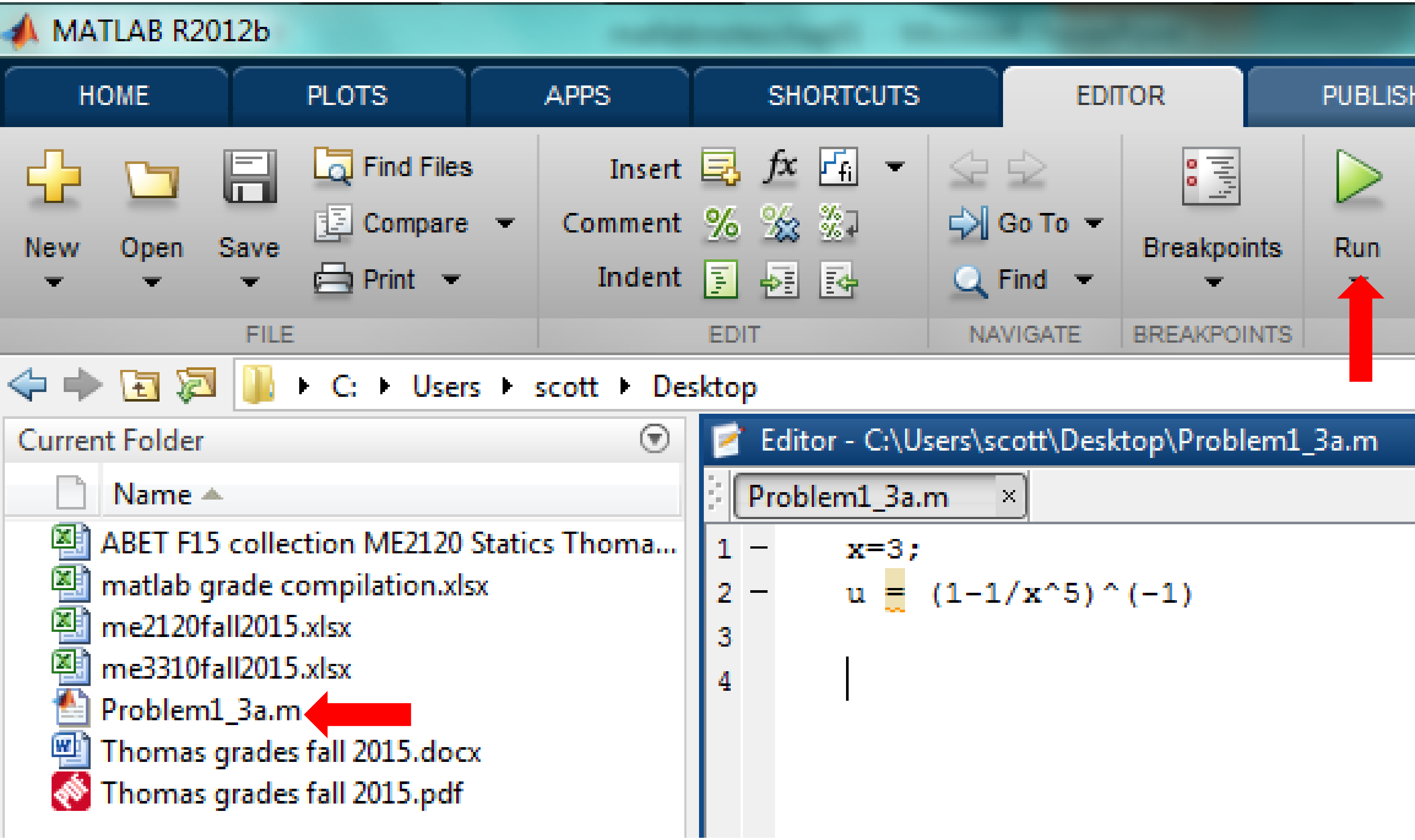
Select the **Desktop** folder to be the **Destination Folder**.



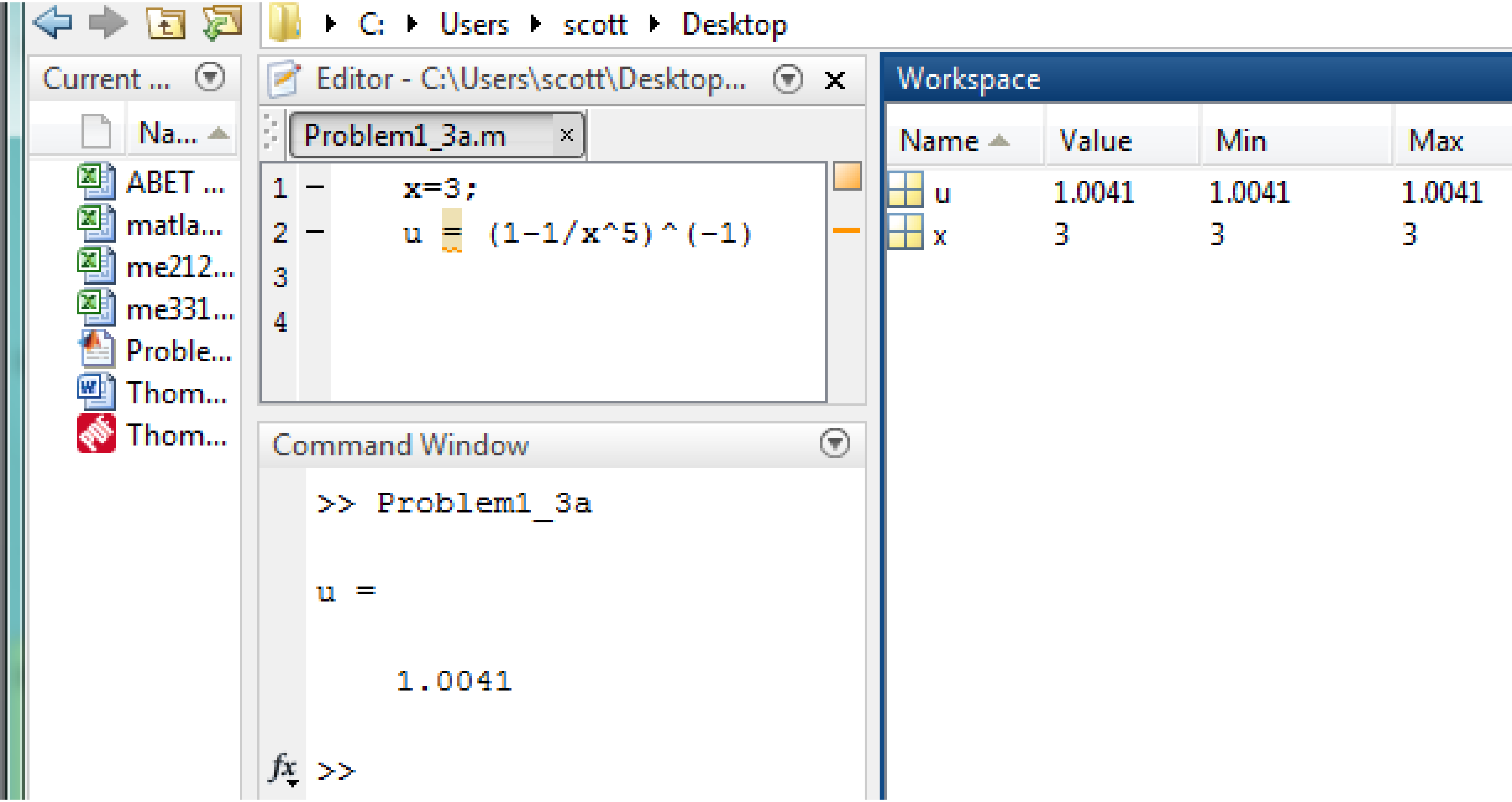
Save the file using the **Save** button. MATLAB **Script File** names must start with a letter, and the only special character allowed is the underscore. Numbers are allowed, as long as the number is not the first character. Spaces are not allowed.



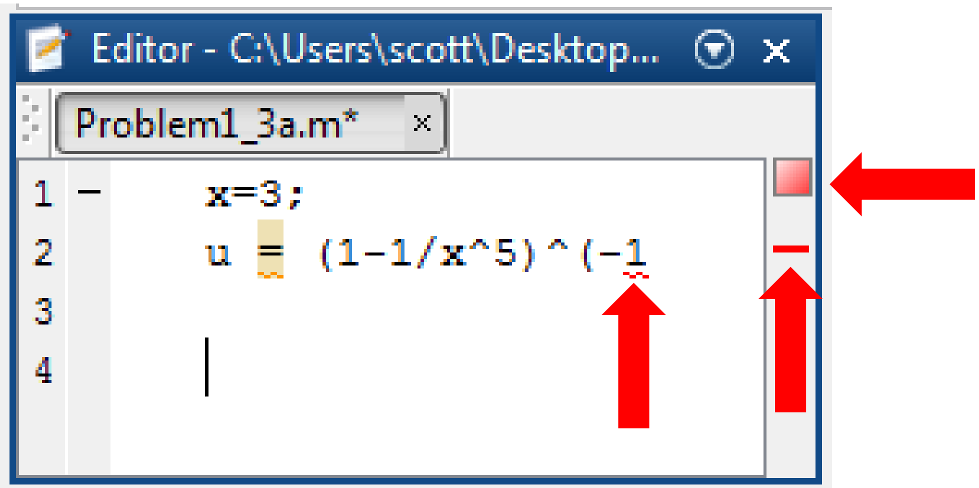
The file appears in the Desktop folder as a ***.m file**. The **Script File** must be saved prior to execution. Press the green **Run** button to execute the Script file. Alternatively, pressing the **Run** button will automatically save the **Script File**.



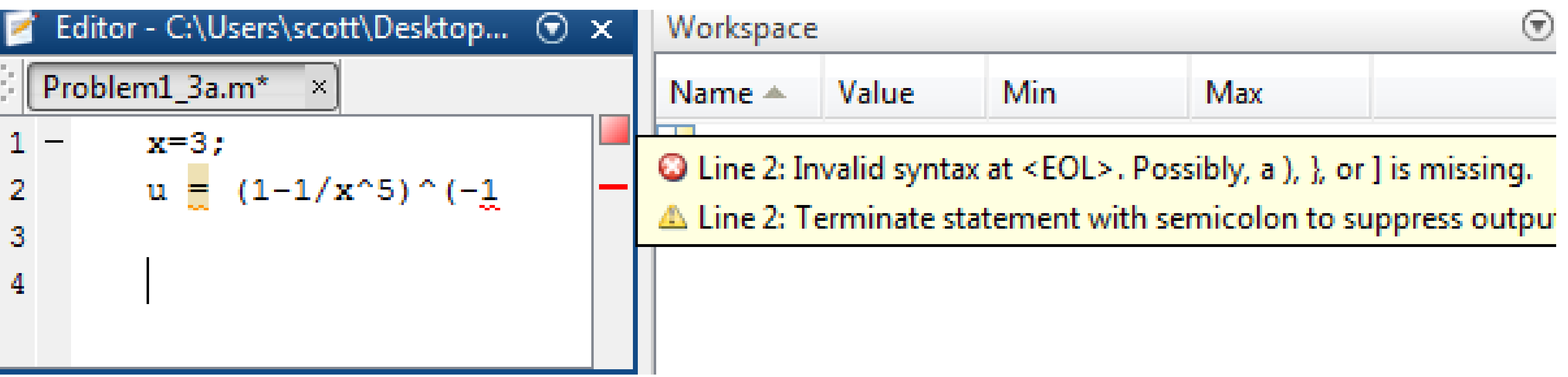
The results of the calculation appear in the **Command Window**. Notice that the values shown in the **Workspace Window** have changed.



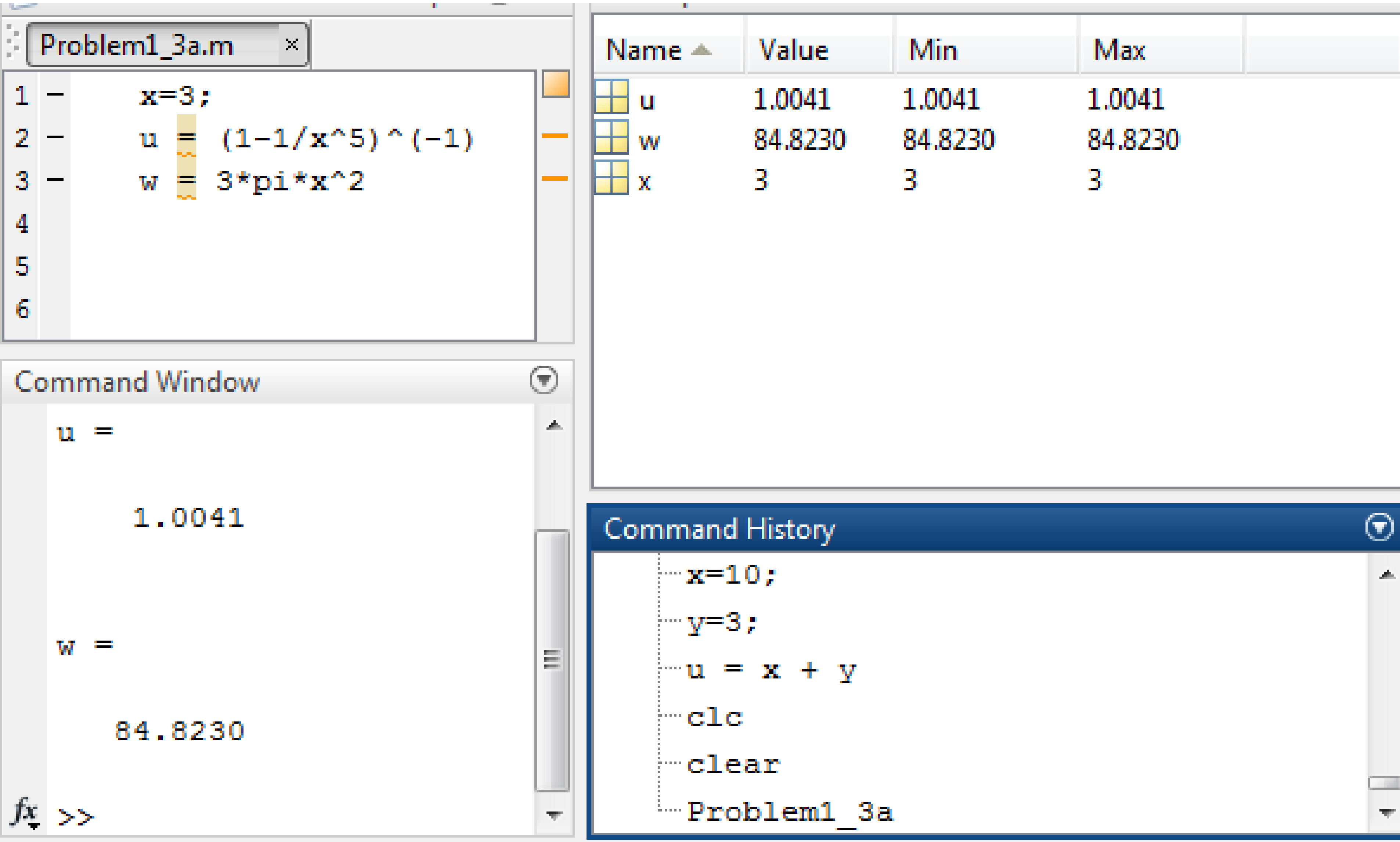
MATLAB will give you clues when you make a mistake in your equations. Delete the last parenthesis in the equation. Notice that the square becomes red, and a red line appears at the line that has the mistake. Also, a squiggly line appears where MATLAB thinks the error lies.



Hover the cursor over the red line: EOL stands for End Of Line.



Make the following change in the **Script File** and save the program using the **Save Button** under the **Editor** drop-down menu prior to running the program.



In the modified **Script File**, the built-in variable **pi** was used. Other built-in functions exist, as shown in the following session where Problem 1.16(a) is to be solved.

Function	MATLAB syntax[1]
e^x	`exp(x)`
$\sqrt{x}$	`sqrt(x)`
$\ln x$	`log(x)`
$\log_{10} x$	`log10(x)`
$\cos x$	`cos(x)`
$\sin x$	`sin(x)`
$\tan x$	`tan(x)`
$\cos^{-1} x$	`acos(x)`
$\sin^{-1} x$	`asin(x)`
$\tan^{-1} x$	`atan(x)`

[1] The MATLAB trigonometric functions use radian measure.

16. Use MATLAB to calculate

a. $6\pi \tan^{-1}(12.5) + 4$

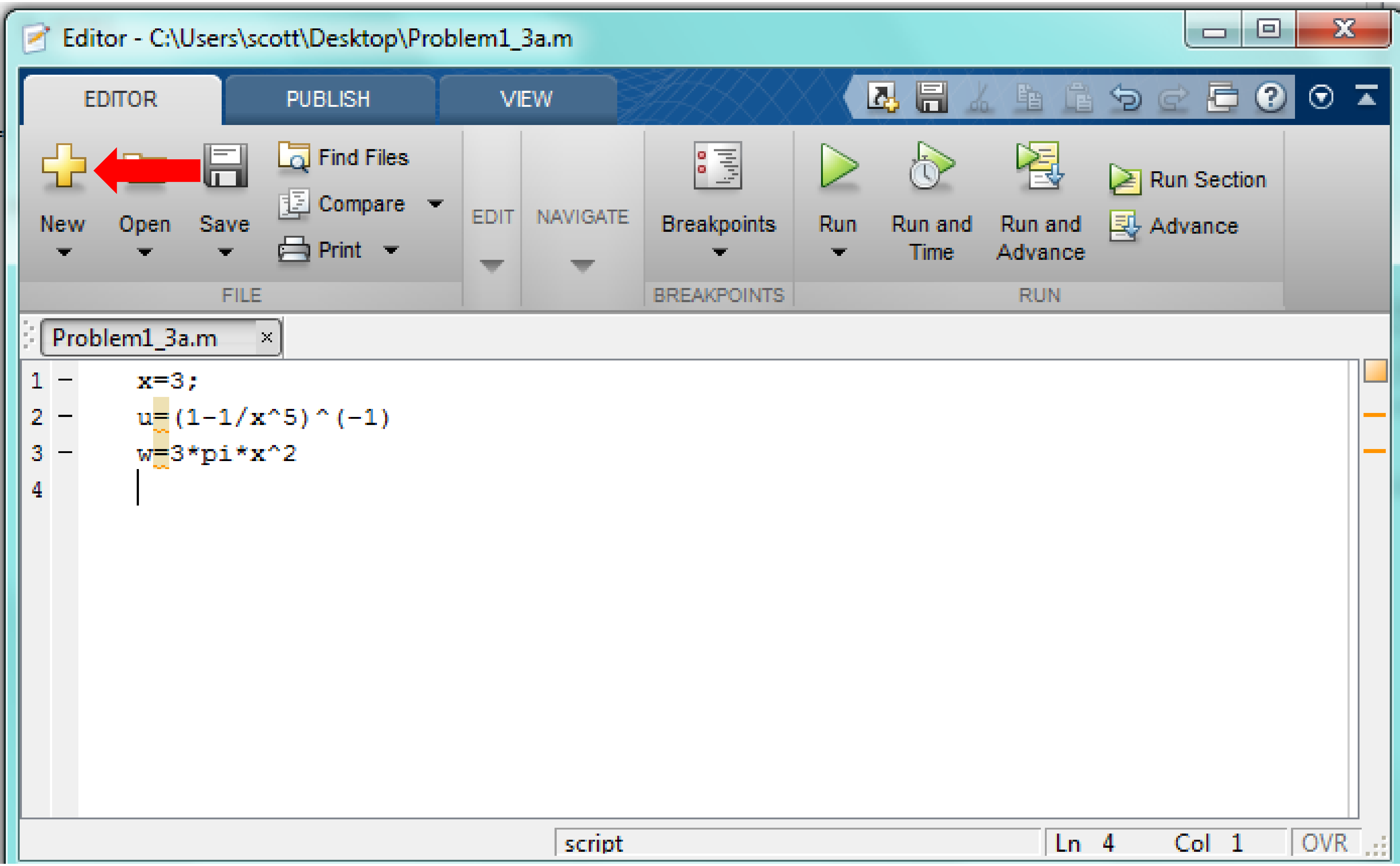
b. $5 \tan[3 \sin^{-1}(13/5)]$

c. $5 \ln(7)$

d. $5 \log(7)$

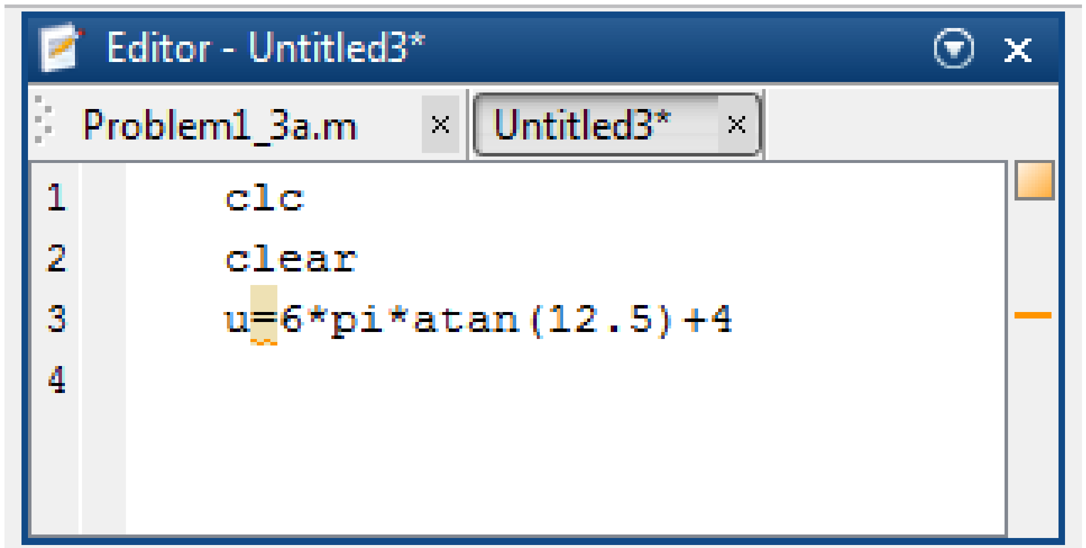
Check your answers with a calculator.

Create a new **Script File** using the **New File Button** on the **Editor**. MATLAB gives the new file the temporary name **Untitled2.**

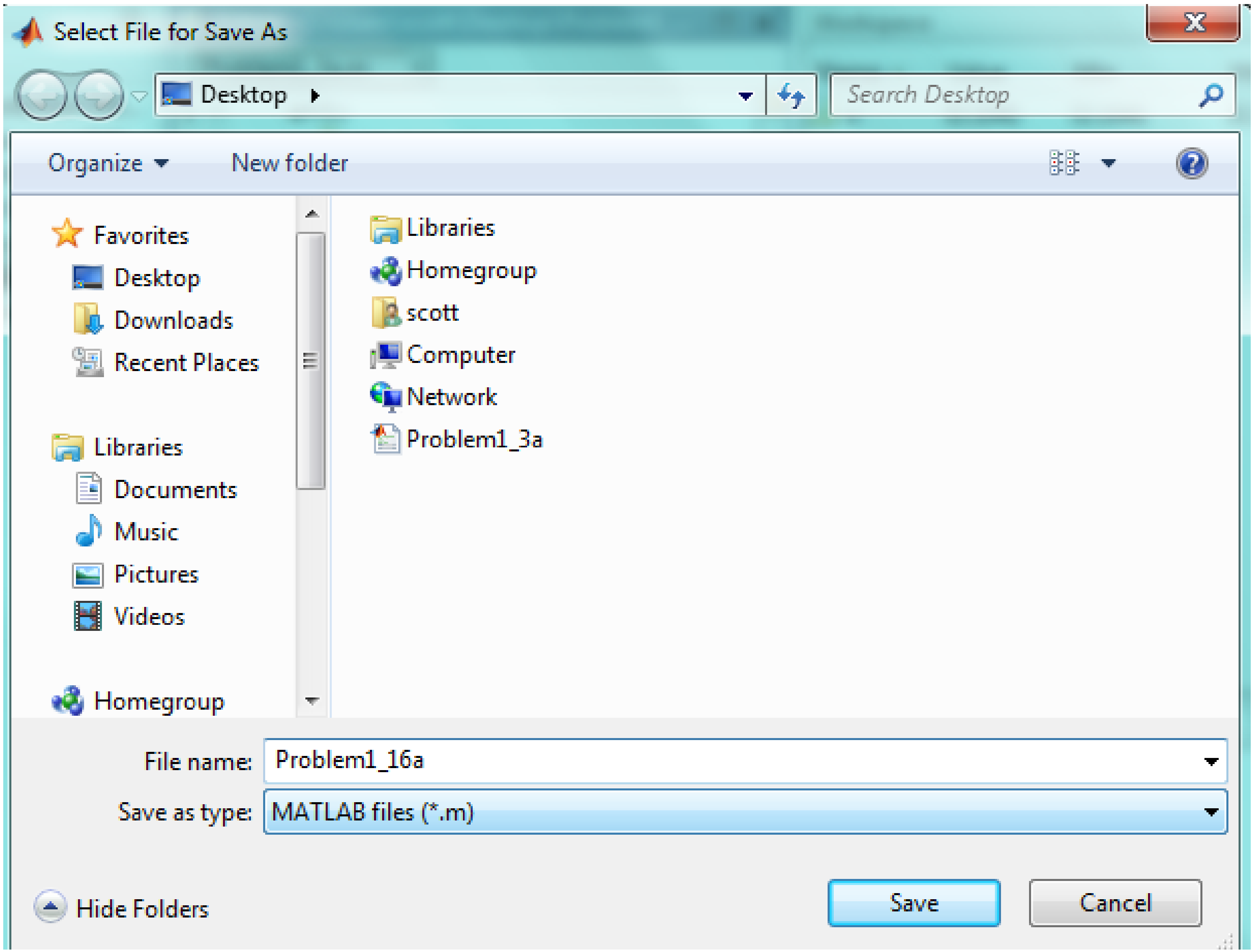

Editor - C:\Users\scott\Desktop\Problem1_3a.m
EDITOR
PUBLISH
VIEW
New
Open
Save
Find Files
Compare
Print
FILE
EDIT
NAVIGATE
Breakpoints
BREAKPOINTS
Run
Run and Time
Run and Advance
Run Section
Advance
RUN
Problem1_3a.m
x=3;
u=(1-1/x^5)^(-1)
w=3*pi*x^2
script
Ln 4
Col 1
OVR

Type in the following to calculate the equation given in Problem 1.16(a). Get in the habit of typing in the first two commands to clear the command window and to clear the variables stored in memory.

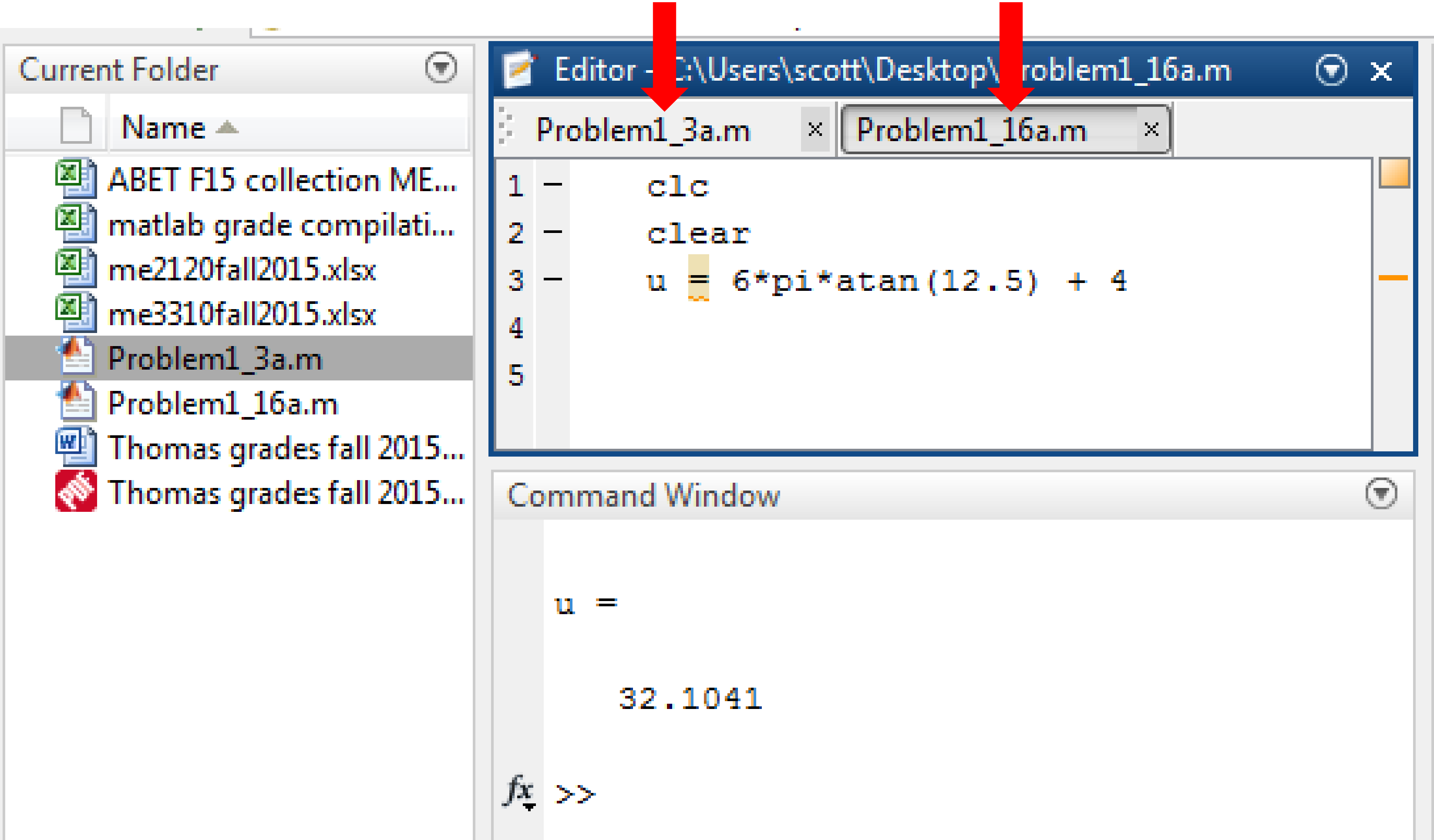
$$6\pi \tan^{-1}(12.5) + 4$$



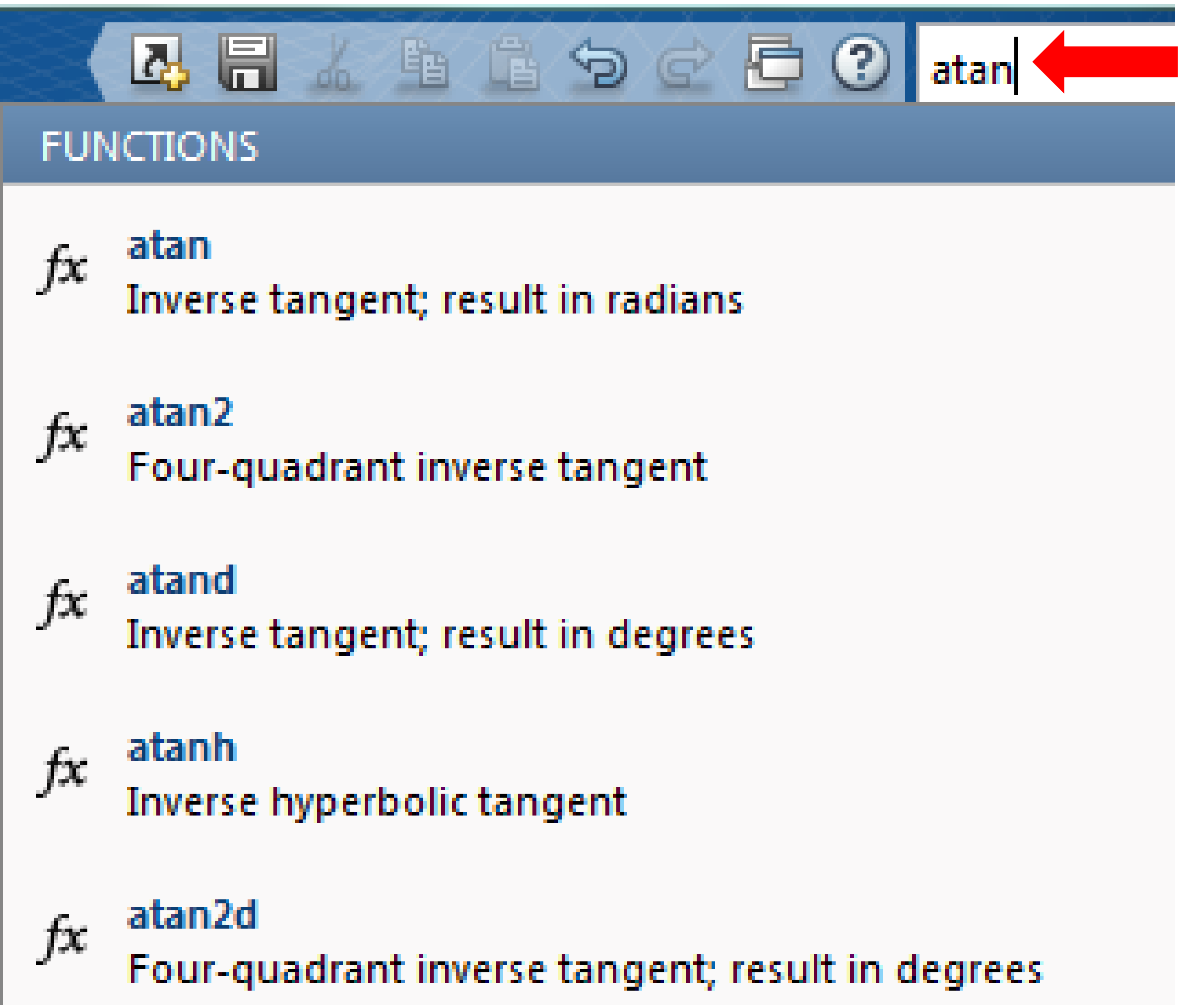
Save it to the Desktop using the **Save As** drop-down menu:

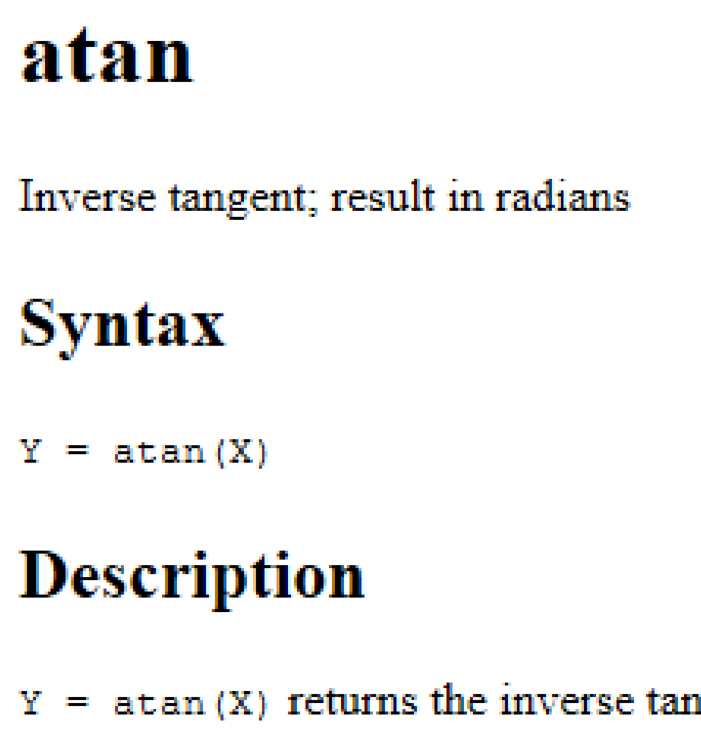


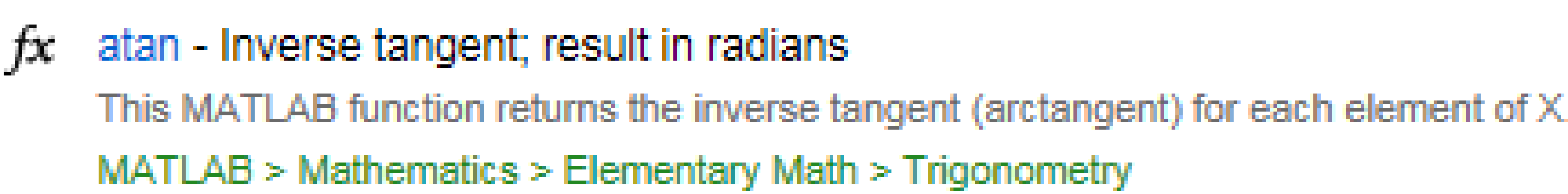
Notice that you can toggle back and forth between the two saved files by clicking on the names in the **Editor Window**. Try it! Press the **Run** button to execute the new **Script File**.


Current Folder
Name
ABET F15 collection ME...
matlab grade compilati...
me2120fall2015.xlsx
me3310fall2015.xlsx
Problem1_3a.m
Problem1_16a.m
Thomas grades fall 2015...
Thomas grades fall 2015...
Editor - :\Users\scott\Desktop\ roblem1_16a.m
Problem1_3a.m
Problem1_16a.m
clc
clear
u = 6*pi*atan(12.5) + 4
Command Window
u =
32.1041
>>

To learn how to use the **atan** (arc tangent) command, use the **Search Documentation** window:







The **Order of Precedence** is a very important concept for properly performing calculations.

Precedence	Operation
First	Parentheses, evaluated starting with the innermost pair.
Second	Exponentiation, evaluated from left to right.
Third	Multiplication and division with equal precedence, evaluated from left to right.
Fourth	Addition and subtraction with equal precedence, evaluated from left to right.

Using Order of Precedence principles, create a MATLAB script file to calculate Problem 1-15(a).

15. Use MATLAB to calculate

a. $e^{(-2.1)^3} + 3.47\log(14) + \sqrt[4]{287}$

Function	MATLAB syntax*
e^x	`exp(x)`
$\sqrt{x}$	`sqrt(x)`
$\ln x$	`log(x)`
$\log_{10} x$	`log10(x)`
$\cos x$	`cos(x)`
$\sin x$	`sin(x)`
$\tan x$	`tan(x)`
$\cos^{-1} x$	`acos(x)`
$\sin^{-1} x$	`asin(x)`
$\tan^{-1} x$	`atan(x)`

15. Use MATLAB to calculate

a. $e^{(-2.1)^3} + 3.47\log(14) + \sqrt[4]{287}$

problem1_15a.m

```
clc
clear

u = exp((-2.1)^3)+3.47*log10(14)+(287)^(1/4)

```

Command Window

```
u =

    8.0931
```

15. Use MATLAB to calculate

a. $e^{(-2.1)^3} + 3.47\log(14) + \sqrt[4]{287}$

b. $(3.4)^7\log(14) + \sqrt[4]{287}$

c. $\cos^2\left(\dfrac{4.12\pi}{6}\right)$

d. $\cos\left(\dfrac{4.12\pi}{6}\right)^2$

Function	**MATLAB syntax***
e^x	`exp(x)`
$\sqrt{x}$	`sqrt(x)`
$\ln x$	`log(x)`
$\log_{10} x$	`log10(x)`
$\cos x$	`cos(x)`
$\sin x$	`sin(x)`
$\tan x$	`tan(x)`
$\cos^{-1} x$	`acos(x)`
$\sin^{-1} x$	`asin(x)`
$\tan^{-1} x$	`atan(x)`

MATLAB can perform calculations on **Arrays** with the same ease as it does with single numbers (**Scalars**). Create and run a new **Script File** for Problem 1.13:

Editor - C:\Users\scott\Desktop\Problem1_13.m

m | Problem1_16a.m | problem1_15a.m | Problem1_13.m

```
clc
clear
disp('Problem 1.13 by Scott Thomas')

x(1) = 0;
x(2) = 1;
x(3) = 2;
x(4) = 3;
x(5) = 4;
x(6) = 5;

x
```

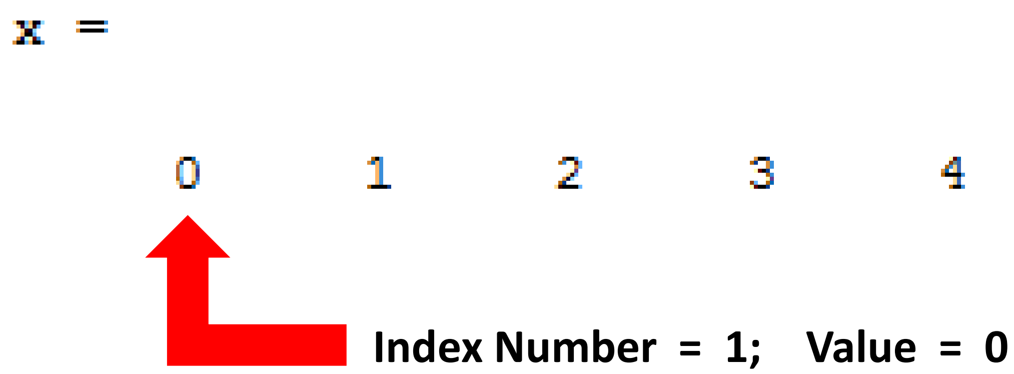
Command Window

```
Problem 1.13 by Scott Thomas

x =

     0     1     2     3     4     5
```

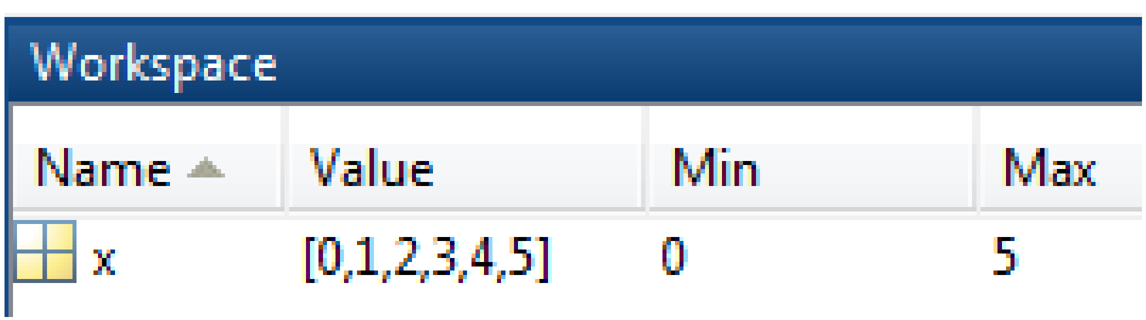
The new variable **x** is an **Array** of six separate numbers that can be acted on as a single unit. The syntax for an **Array** is

Variable_name(Index_number) = Value

The **Index Number** shows where the particular **Value** resides within the **Array**. Index numbers are integers starting with 1.

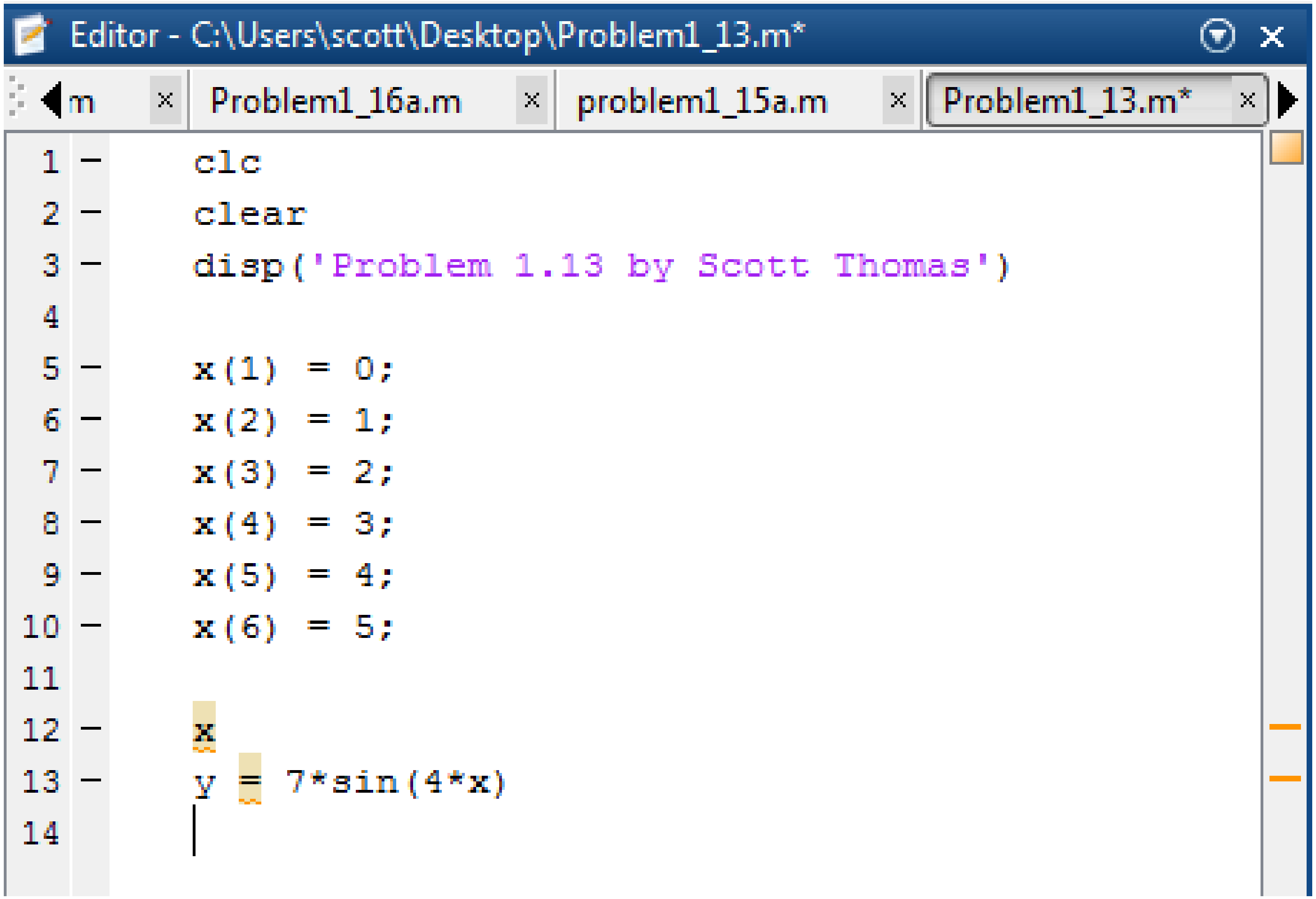


Notice that the **Workspace Window** shows all of the **Values** of variable **x**:



Calculate the new variable **y** (**Array**) using the following equation in terms of variable **x**:

$$y = 7\sin(4x)$$



Command Window

```
Problem 1.13 by Scott Thomas

x =

     0     1     2     3     4     5


y =

  Columns 1 through 5

         0   -5.2976    6.9255   -3.7560   -2.0153

  Column 6

    6.3906

>>
```

Workspace

Name	Value	Min	Max
x	[0,1,2,3,4,5]	0	5
y	[0,-5.2976,6.9255,-3.7560,-2.0153,6.3906]	-5.2976	6.9255

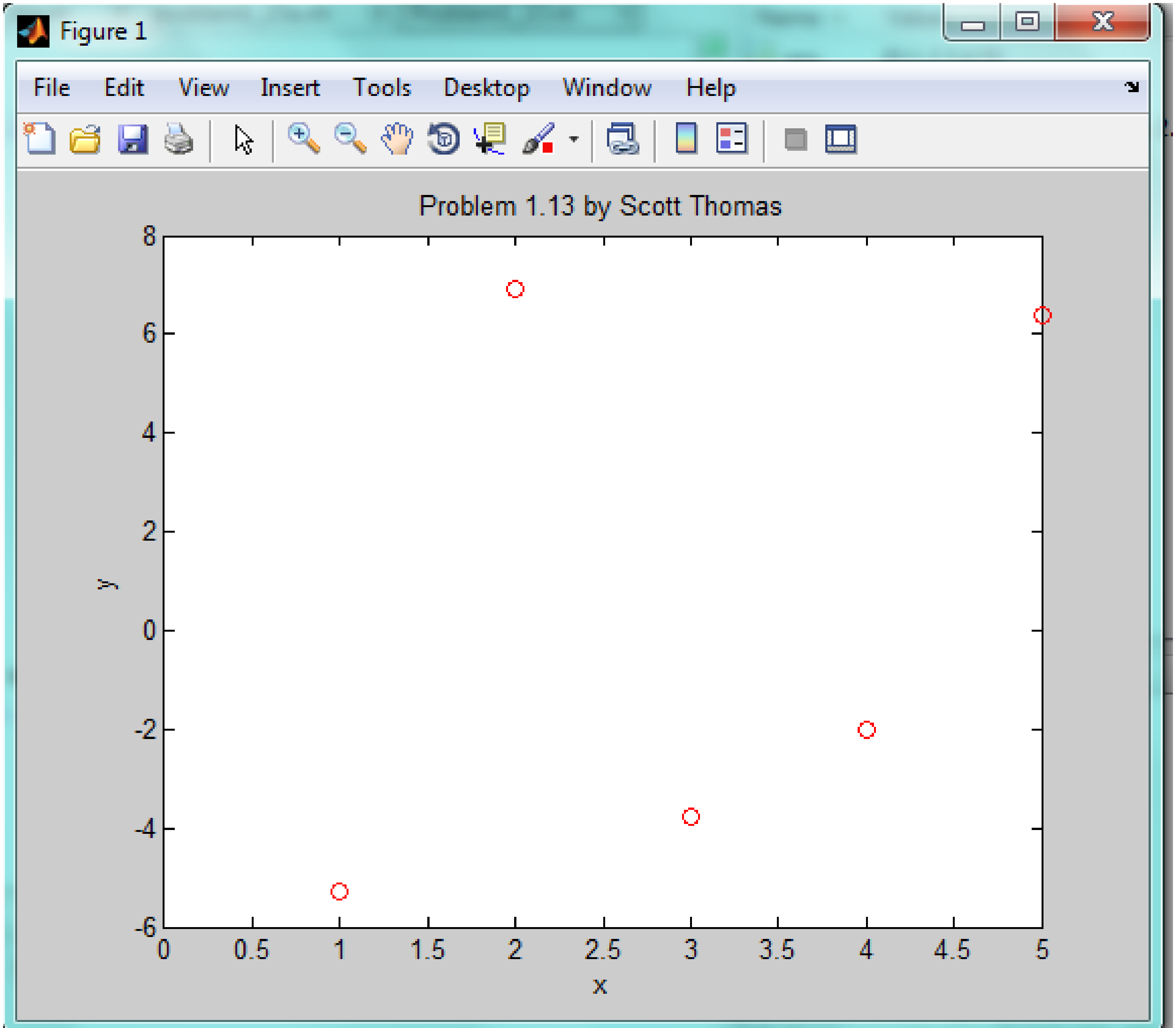
Plot the resulting **y Array** versus the **x Array** :

Editor - C:\Users\scott\Desktop\Problem1_13.m

Problem1_3a.m | Problem1_16a.m | problem1_15a.m | Problem1_13.m

```
clc
clear
disp('Problem 1.13 by Scott Thomas')

format short

x(1) = 0;
x(2) = 1;
x(3) = 2;
x(4) = 3;
x(5) = 4;
x(6) = 5;

x;
y = 7*sin(4*x);

figure
plot(x,y,'ro'), xlabel('x'),ylabel('y')
title('Problem 1.13 by Scott Thomas')
```

The Graphics Window appears, showing the graph of **y** versus **x**:



Create a new **Array x2**, use it to create a new **Array y2**, and plot **y2** versus **x2**:

```
clc
clear
disp('Problem 1.13 by Scott Thomas')

format short

x(1) = 0;
x(2) = 1;
x(3) = 2;
x(4) = 3;
x(5) = 4;
x(6) = 5;

x;
y = 7*sin(4*x);
x2 = 0:0.5:5;
y2 = 7*sin(4*x2);
figure
plot(x,y,'ro',x2,y2), xlabel('x'),ylabel('y')
title('Problem 1.13 by Scott Thomas')
```

The **Array x2** is created using an automated system, with syntax as follows:

Variable_Name = Start : Step : Stop

where **Start** and **Stop** are the initial and final values (Range), and **Step** is the step size used to go between **Start** and **Stop.**

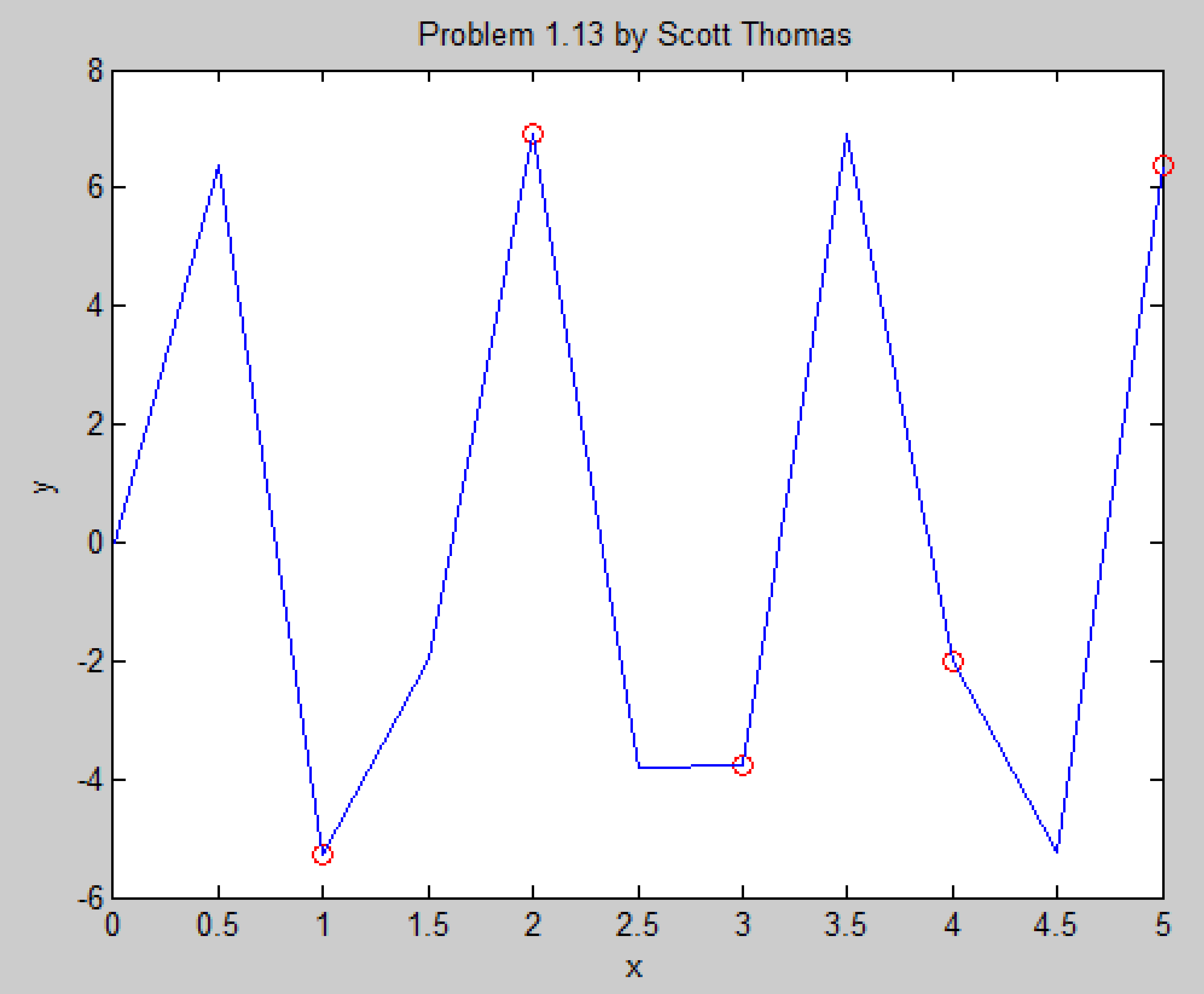
The Workspace Window now shows the new x2 and y2 variables as:

<1x11 double>

This means that they each have eleven numbers, arranged in one row and eleven columns:

Workspace

Name	Value	Min	Max
ans	[0,1,2,3,4,5]	0	5
x	[0,1,2,3,4,5]	0	5
x2	<1x11 double>	0	5
y	[0,-5.2976,6.9255,-3.7560,-2.0153,6.3906]	-5.2976	6.9255
y2	<1x11 double>	-5.2976	6.9343

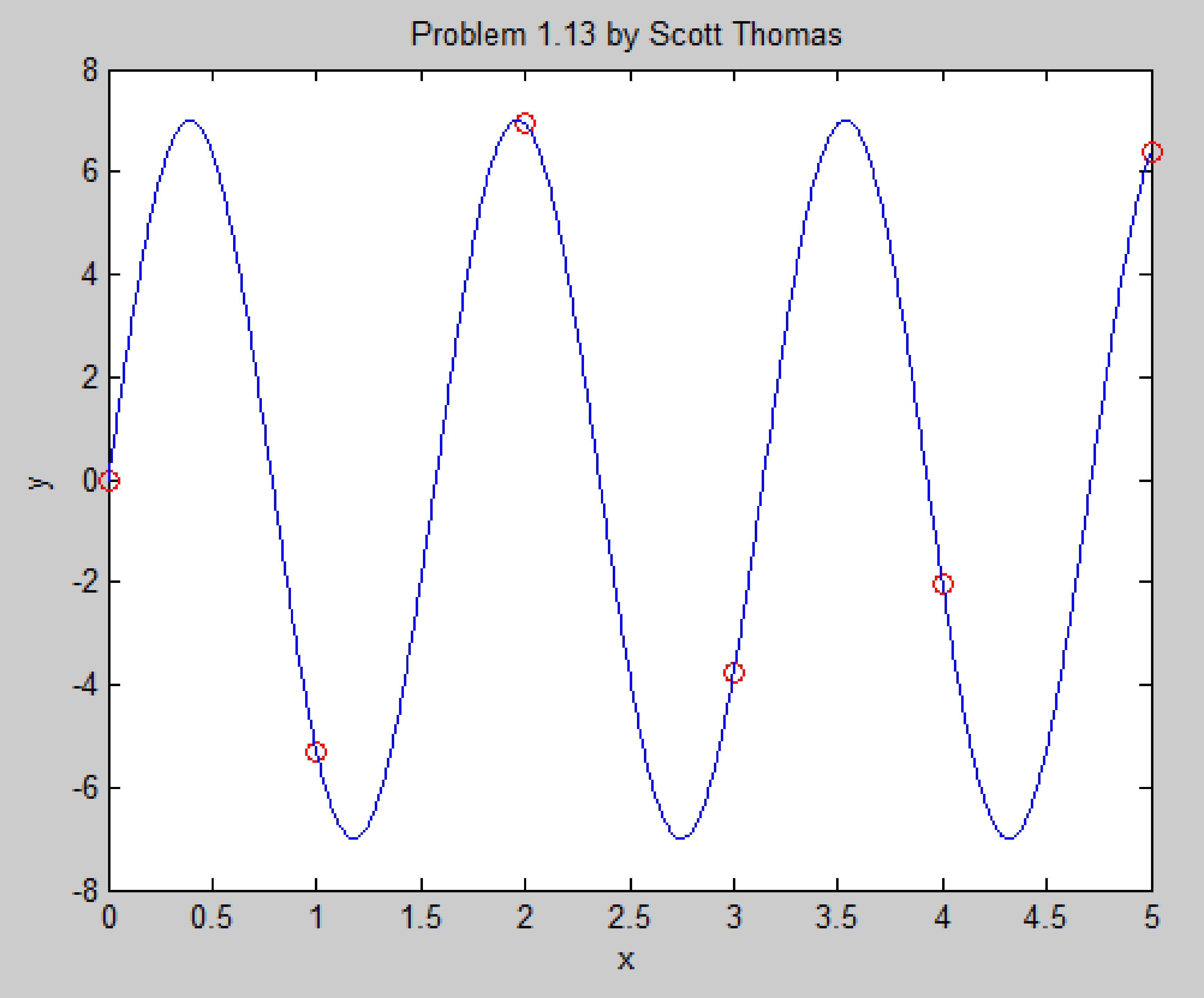

Problem 1.13 by Scott Thomas
8
6
4
2
0
-2
-4
-6
y
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
x

Refine the plot by making the value for **Step** much smaller:

Editor - C:\Users\scott\Desktop\Problem1_13.m*

Problem1_3a.m | Problem1_16a.m | problem1_15a.m | Problem1_13.m*

```
clc
clear
disp('Problem 1.13 by Scott Thomas')

format short

x(1) = 0;
x(2) = 1;
x(3) = 2;
x(4) = 3;
x(5) = 4;
x(6) = 5;

x;
y = 7*sin(4*x);
x2 = 0:0.005:5;
y2 = 7*sin(4*x2);
figure
plot(x,y,'ro',x2,y2), xlabel('x'),ylabel('y')
title('Problem 1.13 by Scott Thomas')

```


Problem 1.13 by Scott Thomas
8
6
4
2
0
-2
-4
-6
-8
y
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
x

Notice that the number of values in **x2** and **y2** is now 1001.

Workspace

Name ▲	Value	Min	Max
ans	[0,1,2,3,4,5]	0	5
x	[0,1,2,3,4,5]	0	5
x2	<1x1001 double>	0	5
y	[0,-5.2976,6.9255,-3.7560,-2.0153,6.3906]	-5.2976	6.9255
y2	<1x1001 double>	-7.0000	7.0000

What happens when you try to plot **y2** versus **x**? Try it!

Editor - C:\Users\scott\Desktop\Problem1_13.m

Problem1_3a.m | Problem1_16a.m | problem1_15a.m | Problem1_13.m

```
13
14 -     x;
15 -     y = 7*sin(4*x);
16 -     x2 = 0:0.005:5;
17 -     y2 = 7*sin(4*x2);
18 -     figure
19 -     plot(x,y2)
20       % plot(x,y,'ro',x2,y2), xlabel('x'),ylabel('y')
21 -     title('Problem 1.13 by Scott Thomas')
22
```

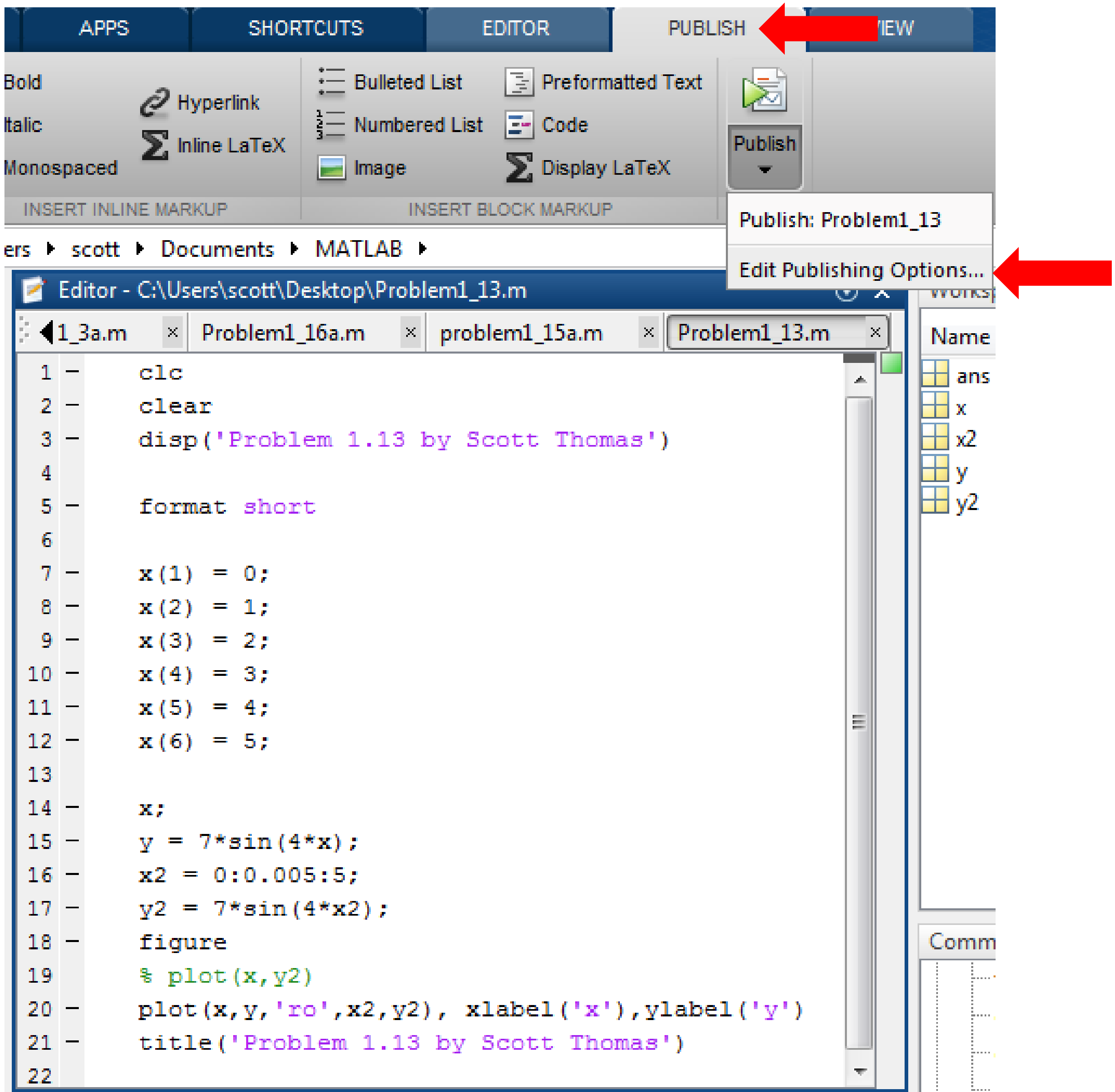
Command Window

```
Problem 1.13 by Scott Thomas
Error using plot
Vectors must be the same lengths.

Error in Problem1_13 (line 19)
plot(x,y2)
```

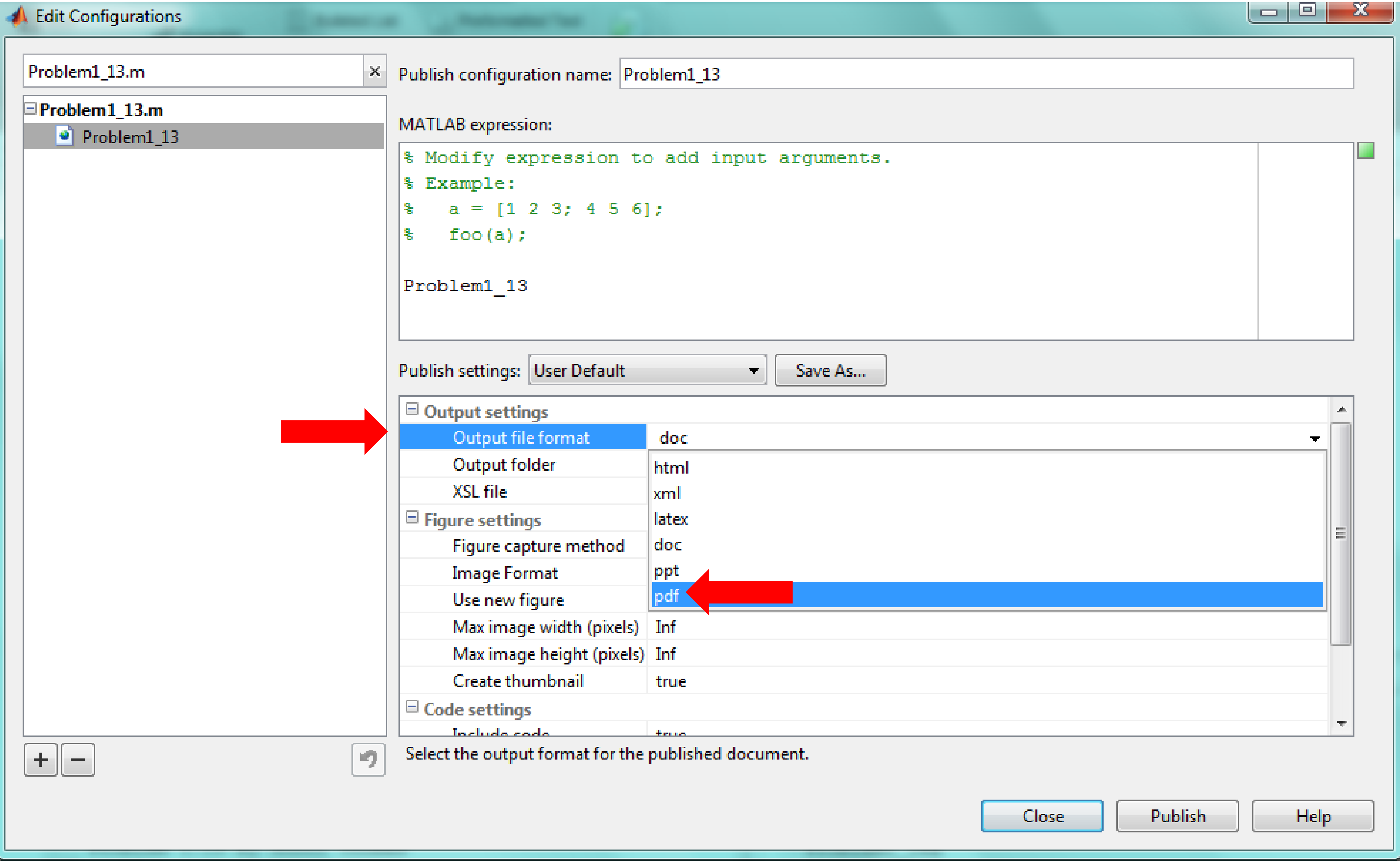
Workspace

Name	Value	Min	Max
ans	[0,1,2,3,4,5]	0	5
x	[0,1,2,3,4,5]	0	5
x2	<1x1001 double>	0	5
y	[0,-5.2976,6.9255,-3.7560,-2.0153,6.3906]	-5.2976	6.9255
y2	<1x1001 double>	-7.0000	7.0000

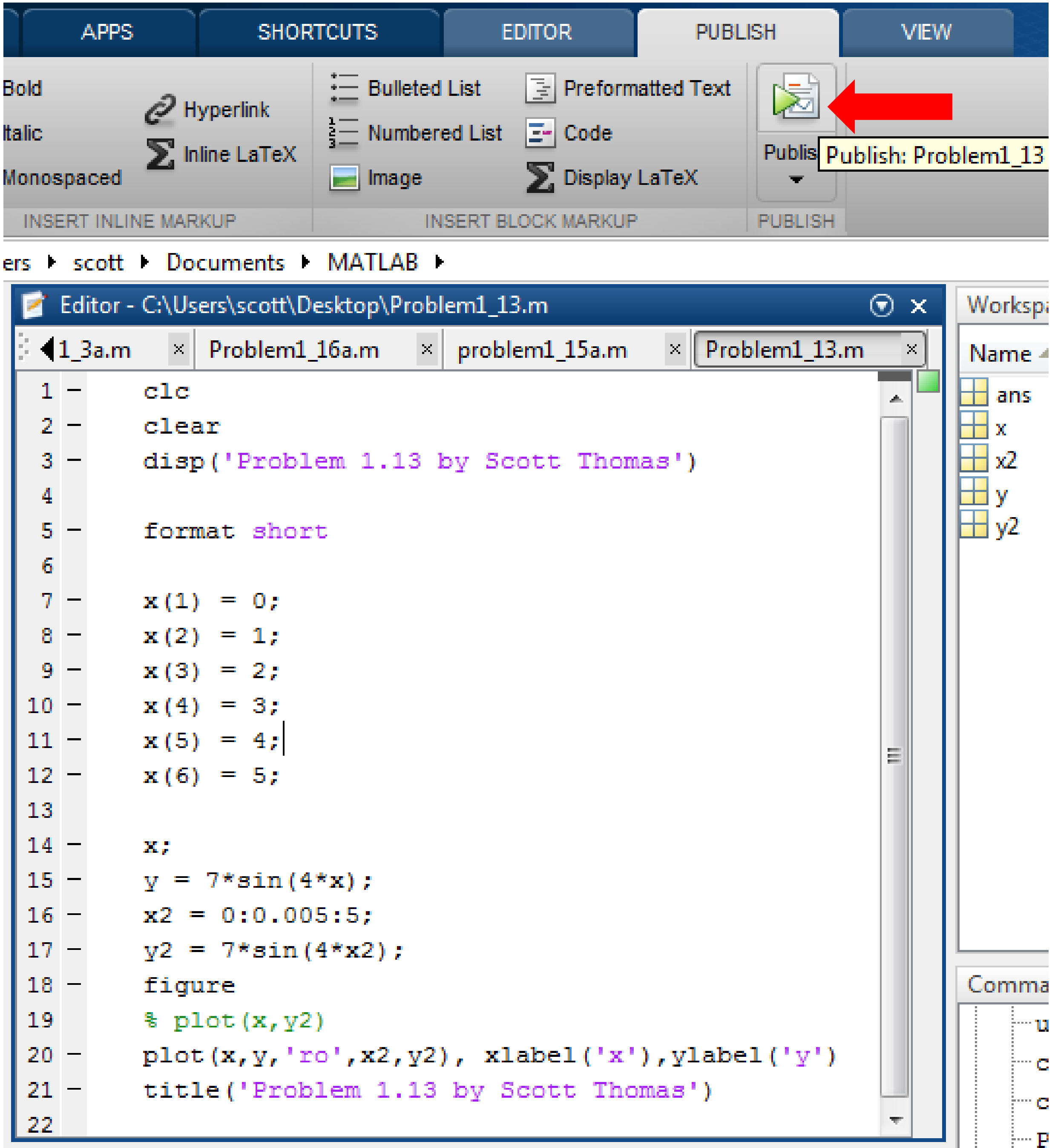
Use the **comment symbol (%)** to comment out the offensive command line. Go to the Publish tab as shown:



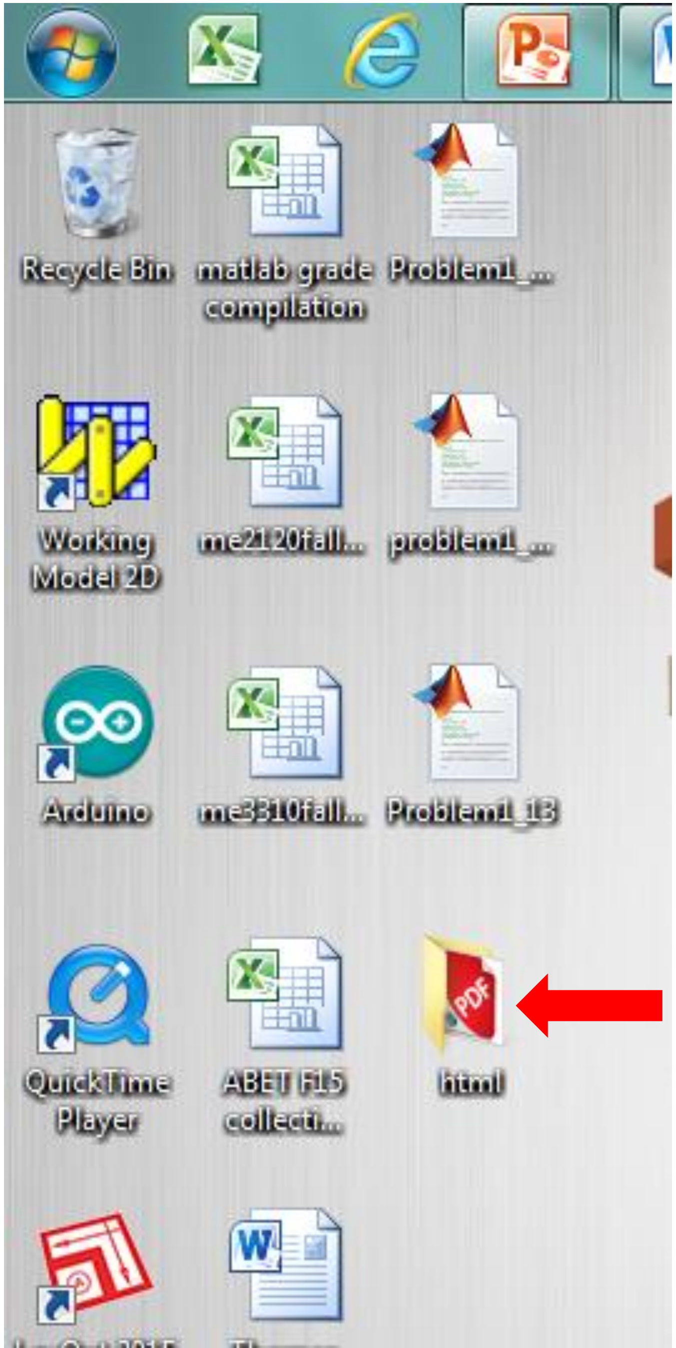
Change the **Output File Format** to **PDF**:



Publish the file:

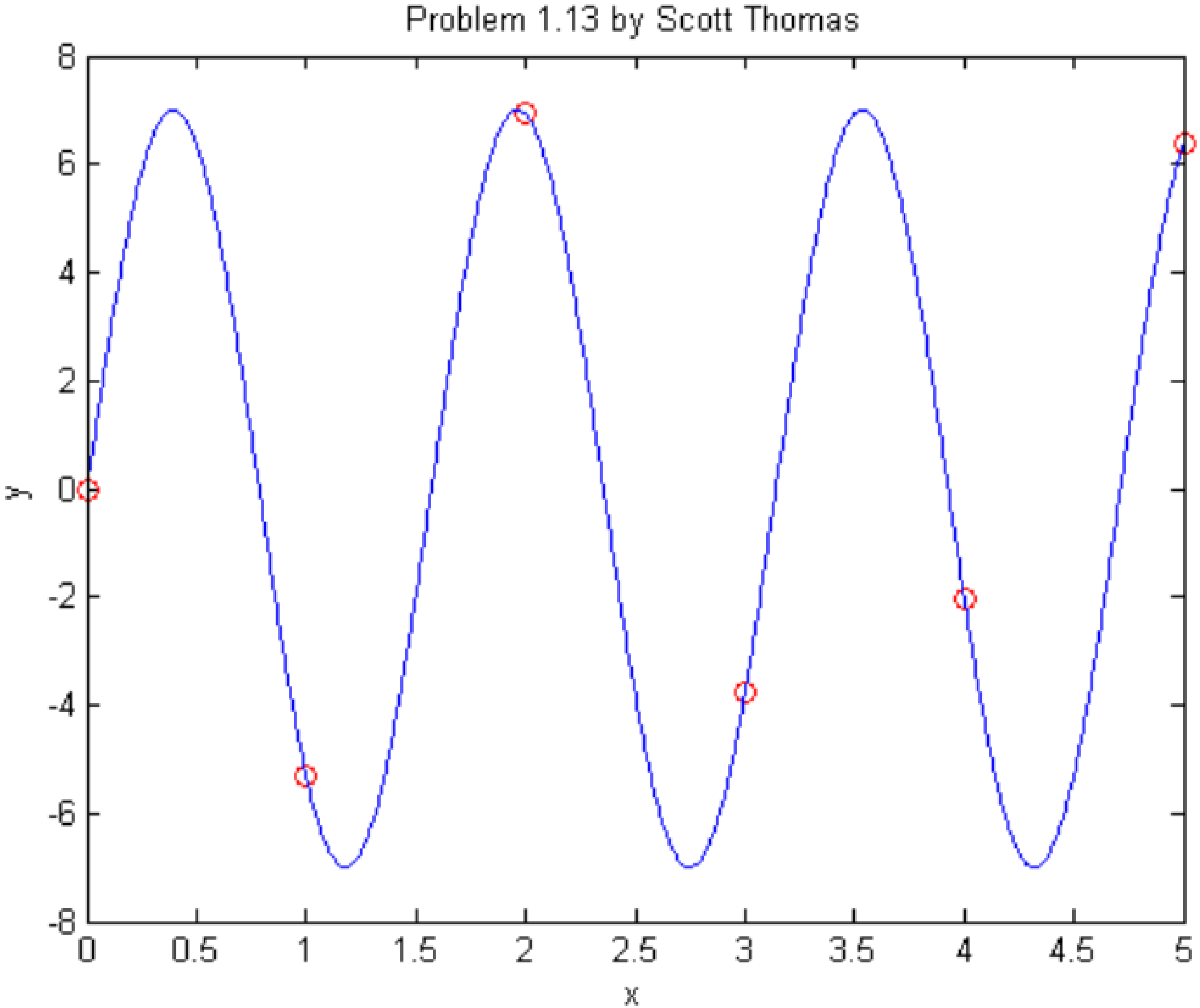


The file gets saved to a folder on the Desktop:



```
clc
clear
disp('Problem 1.13 by Scott Thomas')

format short

x(1) = 0;
x(2) = 1;
x(3) = 2;
x(4) = 3;
x(5) = 4;
x(6) = 5;

x;
y = 7*sin(4*x);
x2 = 0:0.005:5;
y2 = 7*sin(4*x2);
figure
% plot(x,y2)
plot(x,y,'ro',x2,y2), xlabel('x'),ylabel('y')
title('Problem 1.13 by Scott Thomas')
```

Problem 1.13 by Scott Thomas



Problem 1.13 by Scott Thomas
8
6
4
2
0
-2
-4
-6
-8
y
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
x

Use MATLAB to calculate

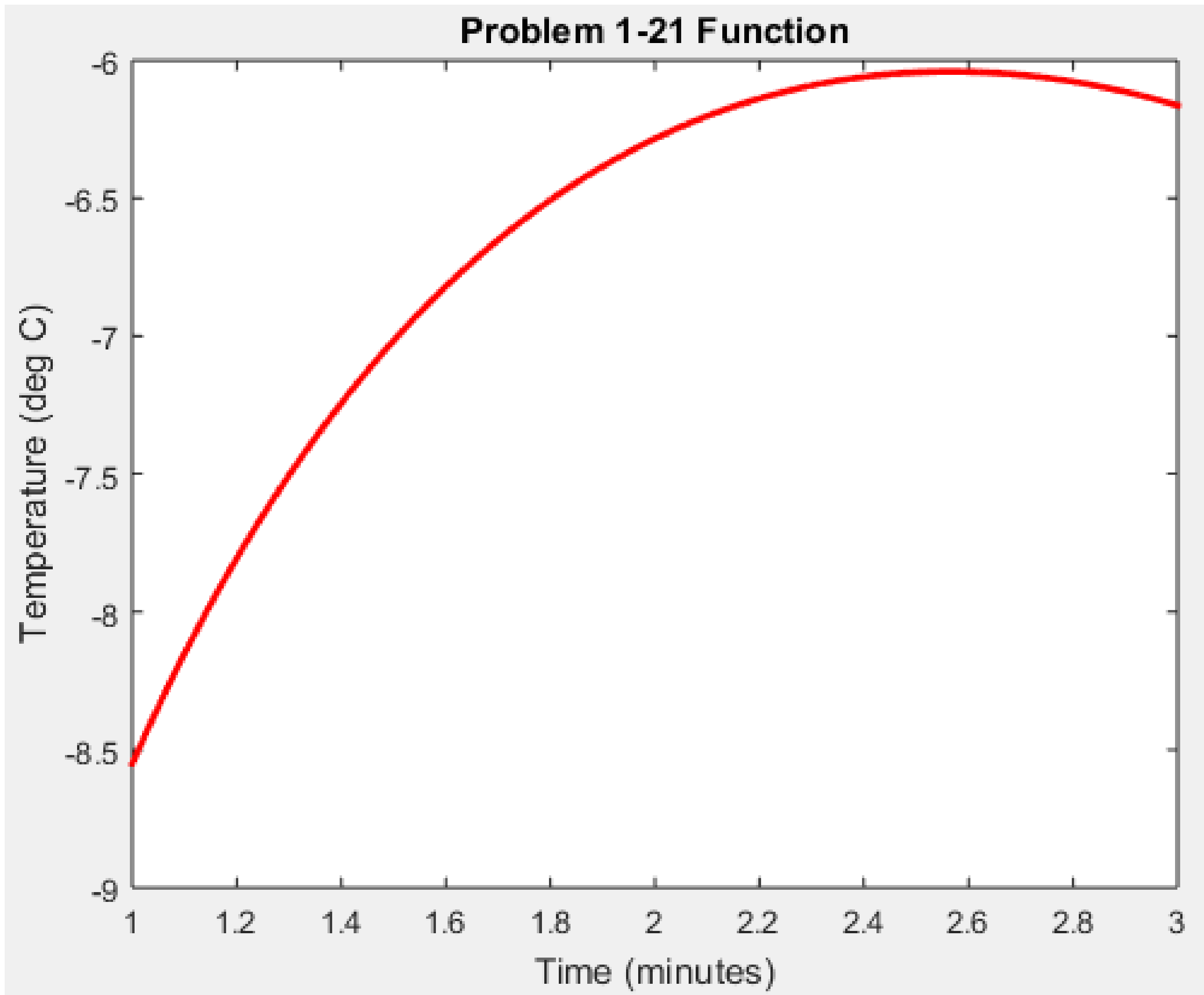
a. $\frac{3}{4}(6)(7^2) + \frac{4^5}{7^3 - 145}$

b. $\frac{48.2(55) - 9^3}{53 + 14^2}$

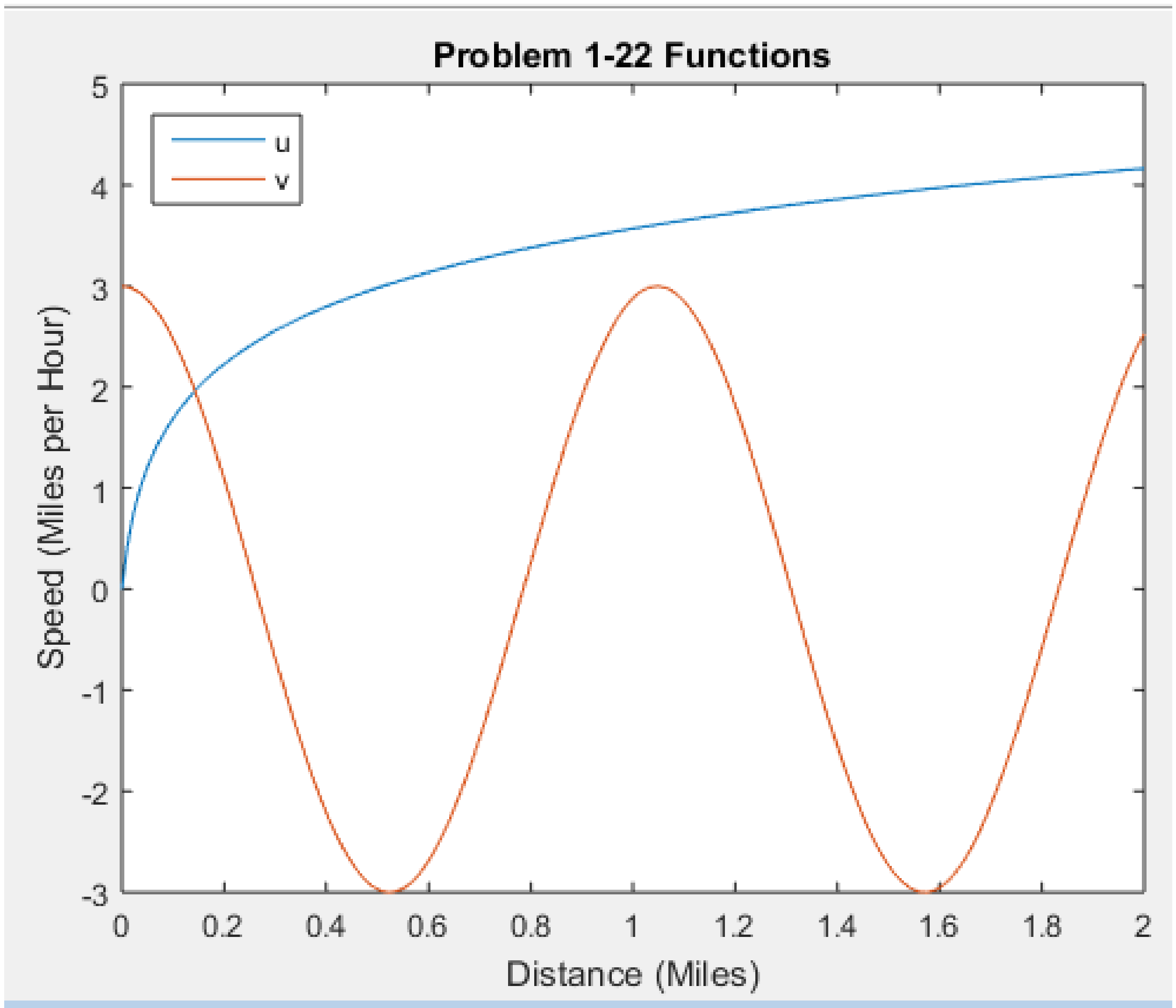
c. $\frac{27^2}{4} + \frac{319^{4/5}}{5} + 60(14)^{-3}$

The volume of a sphere is given by $V = 4\pi r^3/3$, where r is the radius. Use MATLAB to compute the radius of a sphere having a volume 40 percent greater than that of a sphere of radius 4 ft.

Use MATLAB to plot the function $T = 6 \ln t - 7e^{0.2t}$ over the interval $1 \leq t \leq 3$. Put a title on the plot and properly label the axes. The variable T represents temperature in degrees Celsius; the variable t represents time in minutes.



Use MATLAB to plot the functions $u = 2\log_{10}(60x + 1)$ and $v = 3\cos(6x)$ over the interval $0 \le x \le 2$. Properly label the plot and each curve. The variables u and v represent speed in miles per hour; the variable x represents distance in miles.



A *cycloid* is the curve described by a point P on the circumference of a circular wheel of radius r rolling along the x axis. The curve is described in parametric form by the equations

$$x = r(\phi - \sin\phi)$$
$$y = r(1 - \cos\phi)$$

Use these equations to plot the cycloid for $r = 10$ in. and $0 \le \phi \le 4\pi$.