

Syllabus

Daniel B. Rowe, Ph.D.

Professor

Department of Mathematical and Statistical Sciences



Department of Mathematical and Statistical Sciences

Marquette University

Syllabus

Fall 2024

Course: MSSC 6010 Computational Probability

Time: TuTh 5:00-6:15 Cudahy Hall 131

Instructor: Daniel B. Rowe, Ph.D.

Help Desk: Tu 2:30-3:30 pm

Office Hours: Th 2:30-3:30 pm

Office: Cudahy Hall 313

E-mail: daniel.rowe@marquette.edu

Text: None. Material will be delivered via lectures. Heavy Matlab computational component.

Grading: An in-class and take-home midterm on **Oct 15**, weekly homework & class participation, and a final project presented on **Dec 10**, 5:45 pm – 7:45 pm.

Homework & Participation (30%), Mid-Term (30%), Final (40%).

Matlab Introduction

- Arithmetic and Variables, Arrays and Indexing, Programming, Plotting, Functions and m-files, Importing and Exporting Images

Math Review

- Differentiation, Integration

Discrete Distributions

- properties, moments, expectation, MGF, transformation of variable

- Bernoulli, binomial, Poisson, hypergeometric

Continuous Distributions

- properties, expectation, moments, MGF, transformation of variable
- uniform, beta, normal, chi square, gamma, exponential, student t, F,
- random samples, likelihood, MLE, hypothesis testing, LRT

Multivariate Distributions

- normal, student t, Wishart, inverse Wishart

Numerical Flavor

All slides are a summary of the material and do not contain all detail.

Matlab Introduction

Daniel B. Rowe, Ph.D.

Professor

Department of Mathematical and Statistical Sciences



Outline

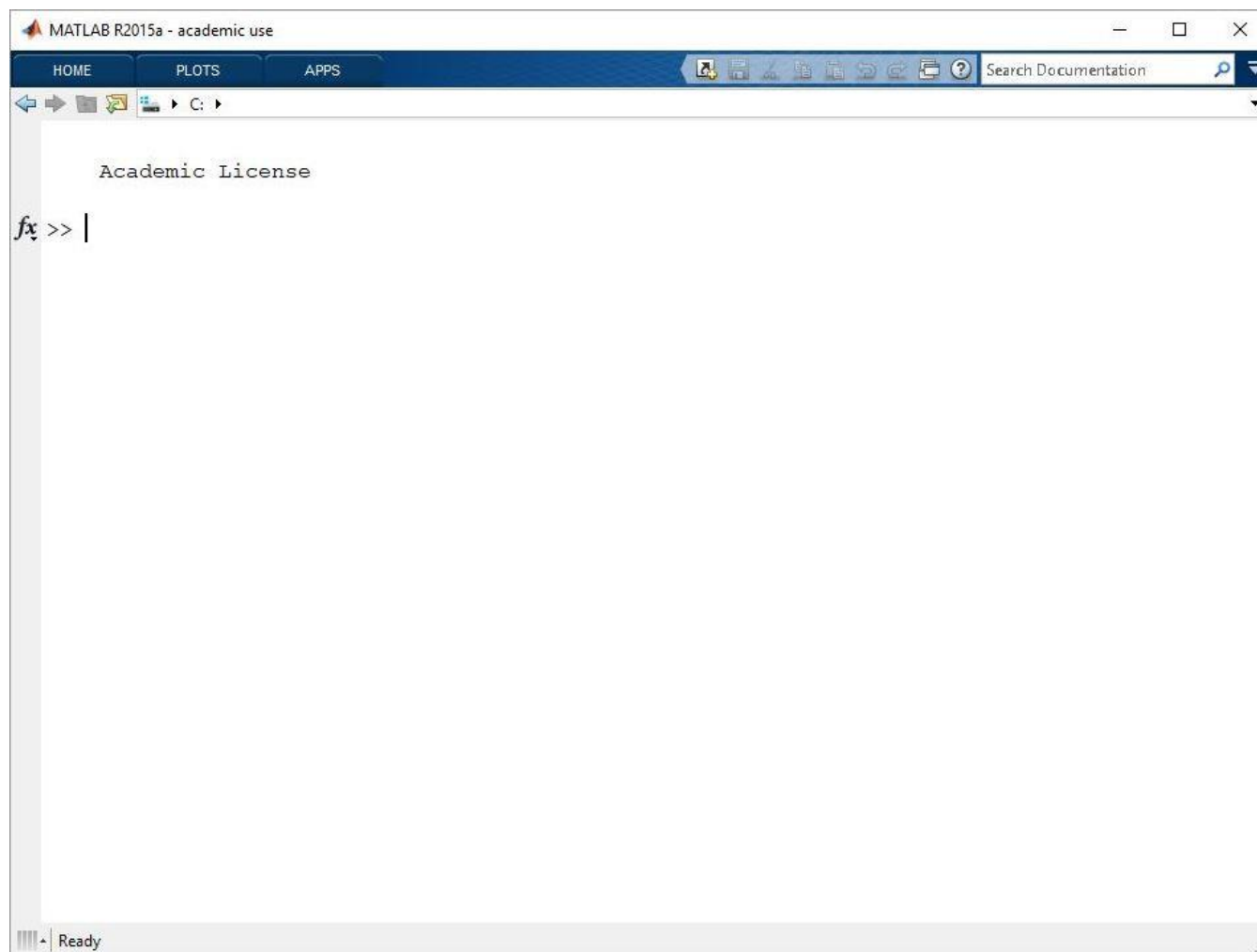
- About Matlab
- Arithmetic and Variables
- Arrays and Indexing
- Programming
- Plotting
- Functions and m-files
- Importing and Exporting
- Images
- Summary

About MATLAB

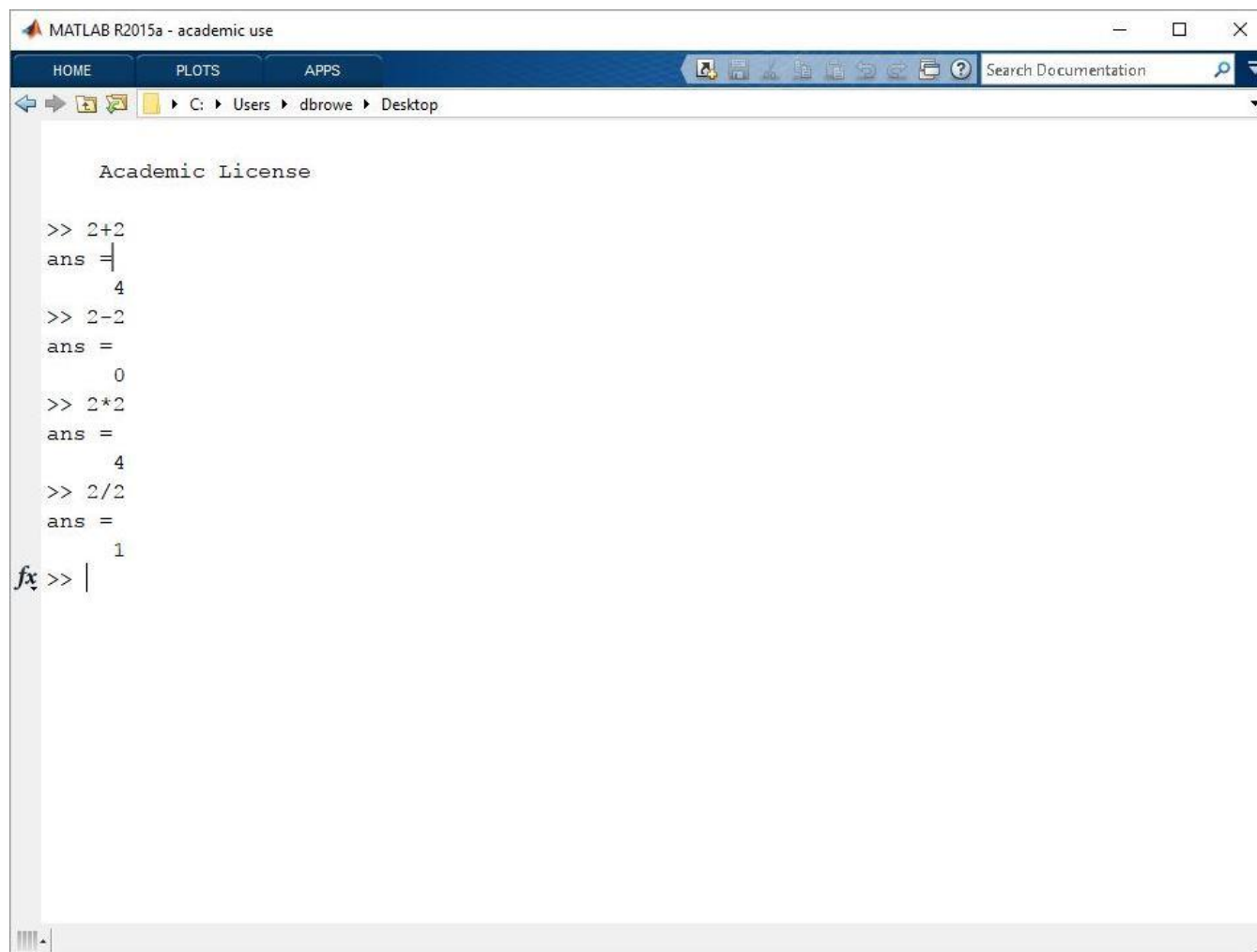
“MATLAB[®] is a high-level language and interactive environment that enables you to perform computationally intensive tasks faster than with traditional programming languages such as C, C++, and Fortran.”

Incredible for piloting and development!

About MATLAB



Arithmetic and Variables



The image shows a screenshot of the MATLAB R2015a - academic use interface. The window title is "MATLAB R2015a - academic use". The interface includes a top menu bar with "HOME", "PLOTS", and "APPS" tabs, and a search bar for "Search Documentation". The current directory is "C:\Users\dbrowe\Desktop". The Command Window displays the following text:

```
Academic License  
  
>> 2+2  
ans =  
    4  
>> 2-2  
ans =  
    0  
>> 2*2  
ans =  
    4  
>> 2/2  
ans =  
    1  
fx >> |
```

Arrays and Indexing

```
MATLAB R2015a - academic use
C:\Users\dbrowe\Desktop
>> x=2+2
x =
    4
>> x=(1:5)
x =
    1    2    3    4    5
>> x=(1:5)'  
x =
    1
    2
    3
    4
    5
fx >> |
```

```
MATLAB R2015a - academic use
C:\Users\dbrowe\Desktop
>> x=(1:5) '* (1:5)
x =
    1    2    3    4    5
    2    4    6    8   10
    3    6    9   12   15
    4    8   12   16   20
    5   10   15   20   25
>> y=x(3:5,2:4)
y =
    6    9   12
    8   12   16
   10   15   20
>> z=zeros(5,5)
z =
    0    0    0    0    0
    0    0    0    0    0
    0    0    0    0    0
    0    0    0    0    0
    0    0    0    0    0
fx >> |
```

Arrays and Indexing

```
MATLAB R2015a - academic use
C:\Users\dbrowe\Desktop

>> x=[1,2,3;4,5,6]
x =
     1     2     3
     4     5     6

>> x=ones(3,3)
x =
     1     1     1
     1     1     1
     1     1     1

>> x=eye(4)
x =
     1     0     0     0
     0     1     0     0
     0     0     1     0
     0     0     0     1

fx >> |
```

```
MATLAB R2015a - academic use
C:\Users\dbrowe\Desktop

>> x=randn(3)
x =
     0.5377     0.8622    -0.4336
     1.8339     0.3188     0.3426
    -2.2588    -1.3077     3.5784

>> x(3,:)=[]
x =
     0.5377     0.8622    -0.4336
     1.8339     0.3188     0.3426

>> x=[x;1,2,3]
x =
     0.5377     0.8622    -0.4336
     1.8339     0.3188     0.3426
     1.0000     2.0000     3.0000

fx >> |
```

Arithmetic and Variables

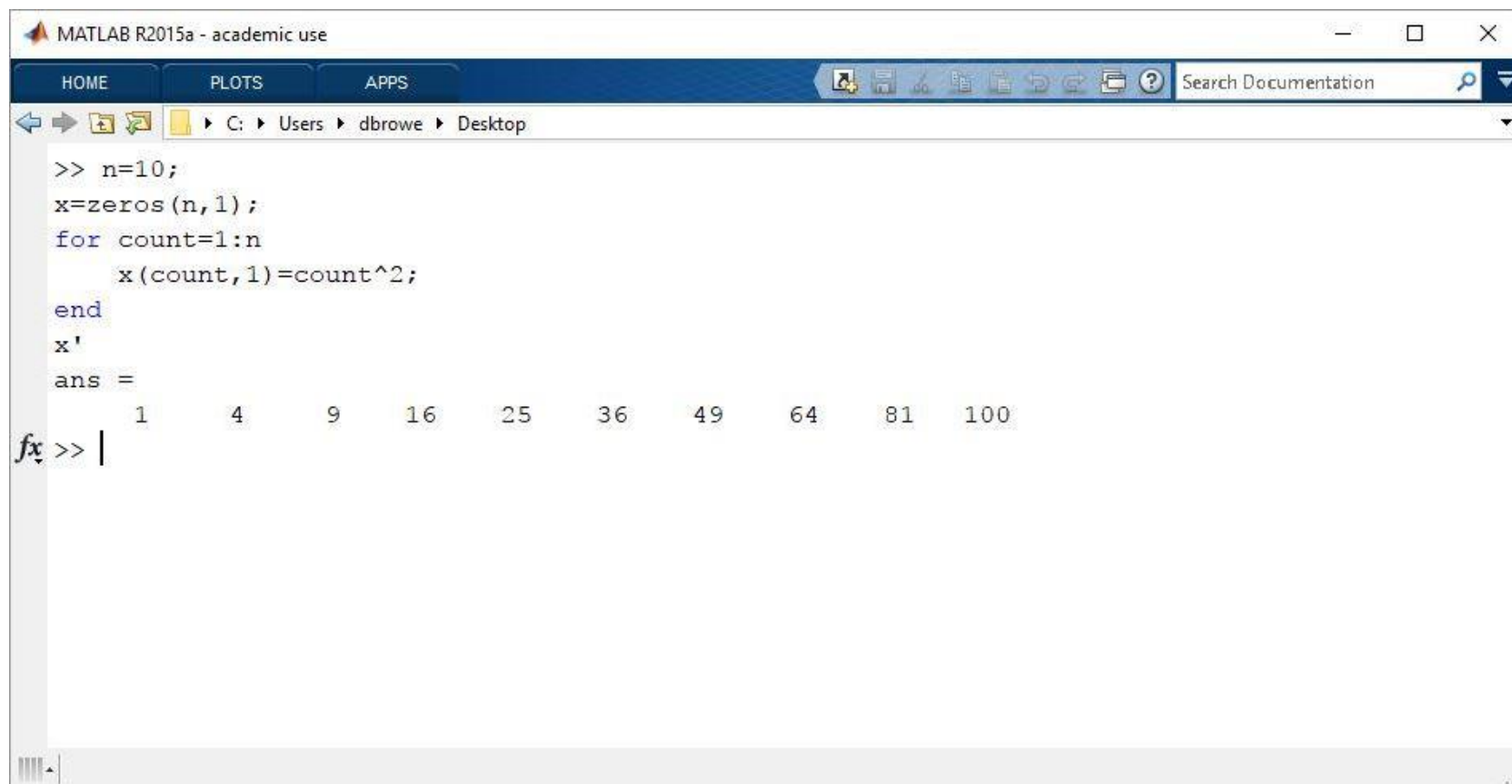
Matrix Operations:

$+$, $-$, $*$, $/$, $\text{sqrt}()$, $\text{sin}()$, $\text{det}()$, $\text{eig}()$, $\text{rank}()$, ...

Element Operations:

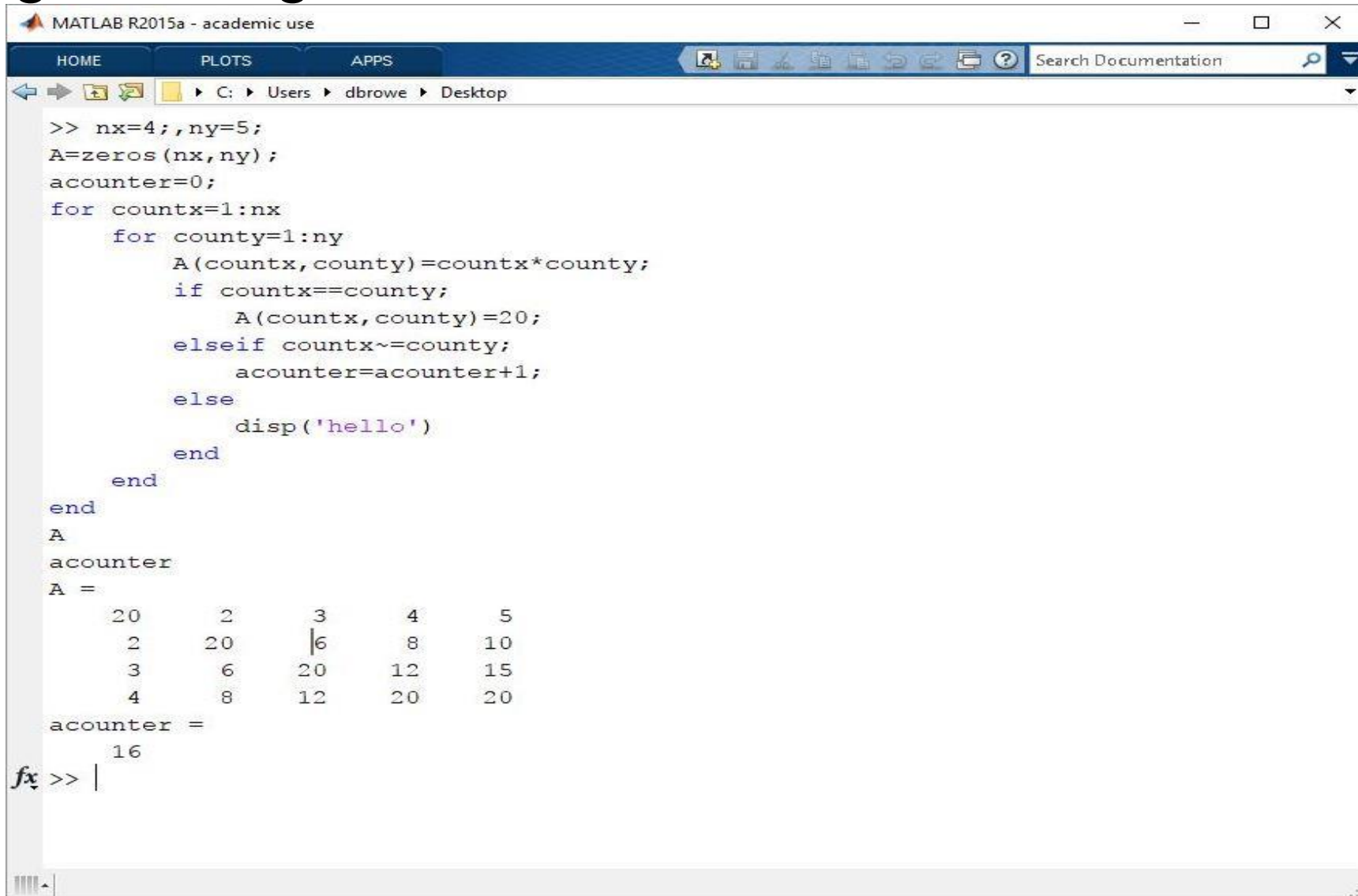
$.$, $*$, $./$, $.^2$, $A.*B$, $A./B$, ...

Programming



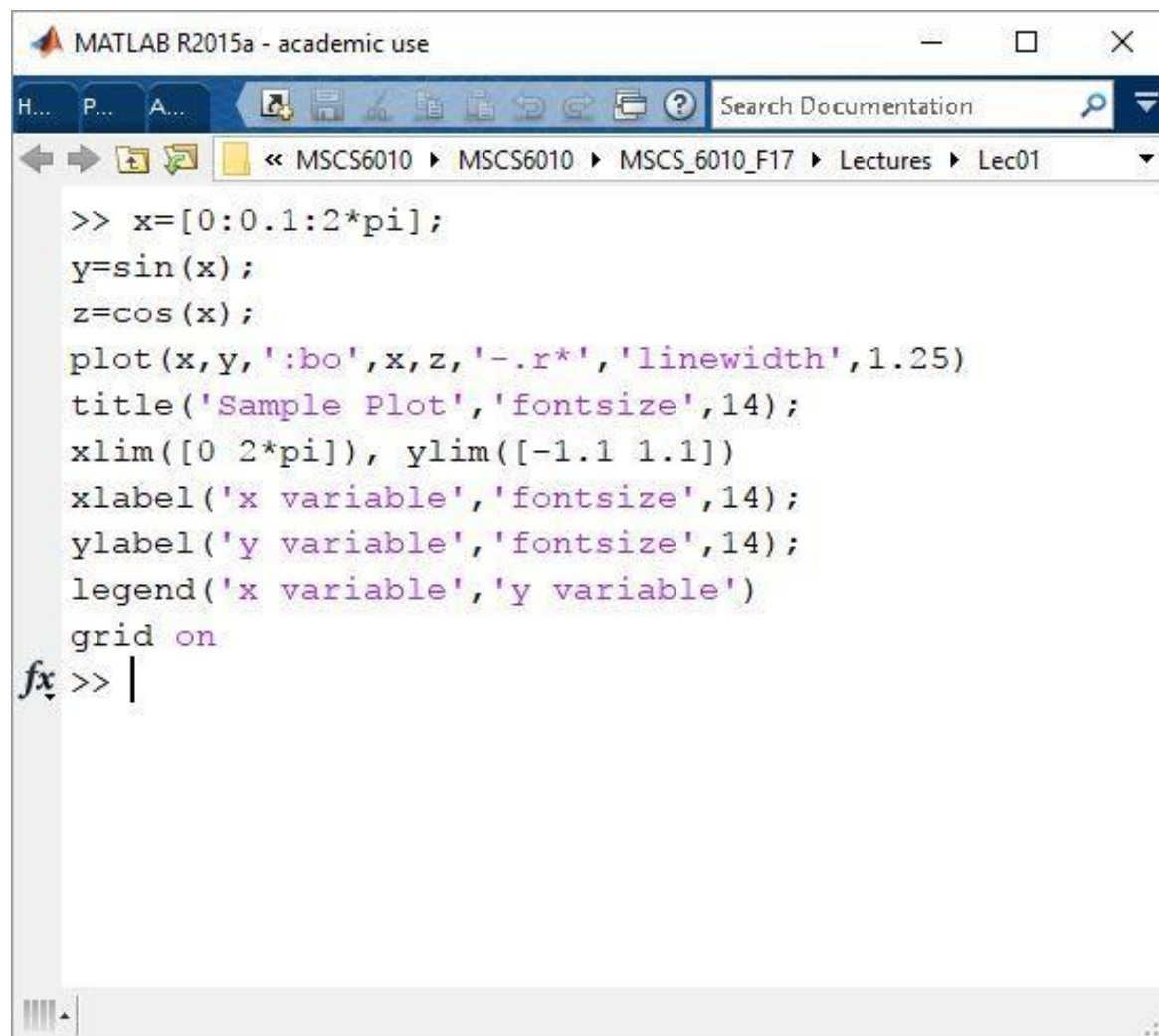
```
MATLAB R2015a - academic use
HOME PLOTS APPS Search Documentation
C:\Users\dbrowe\Desktop
>> n=10;
x=zeros(n,1);
for count=1:n
    x(count,1)=count^2;
end
x'
ans =
    1     4     9    16    25    36    49    64    81   100
fx >> |
```

Programming



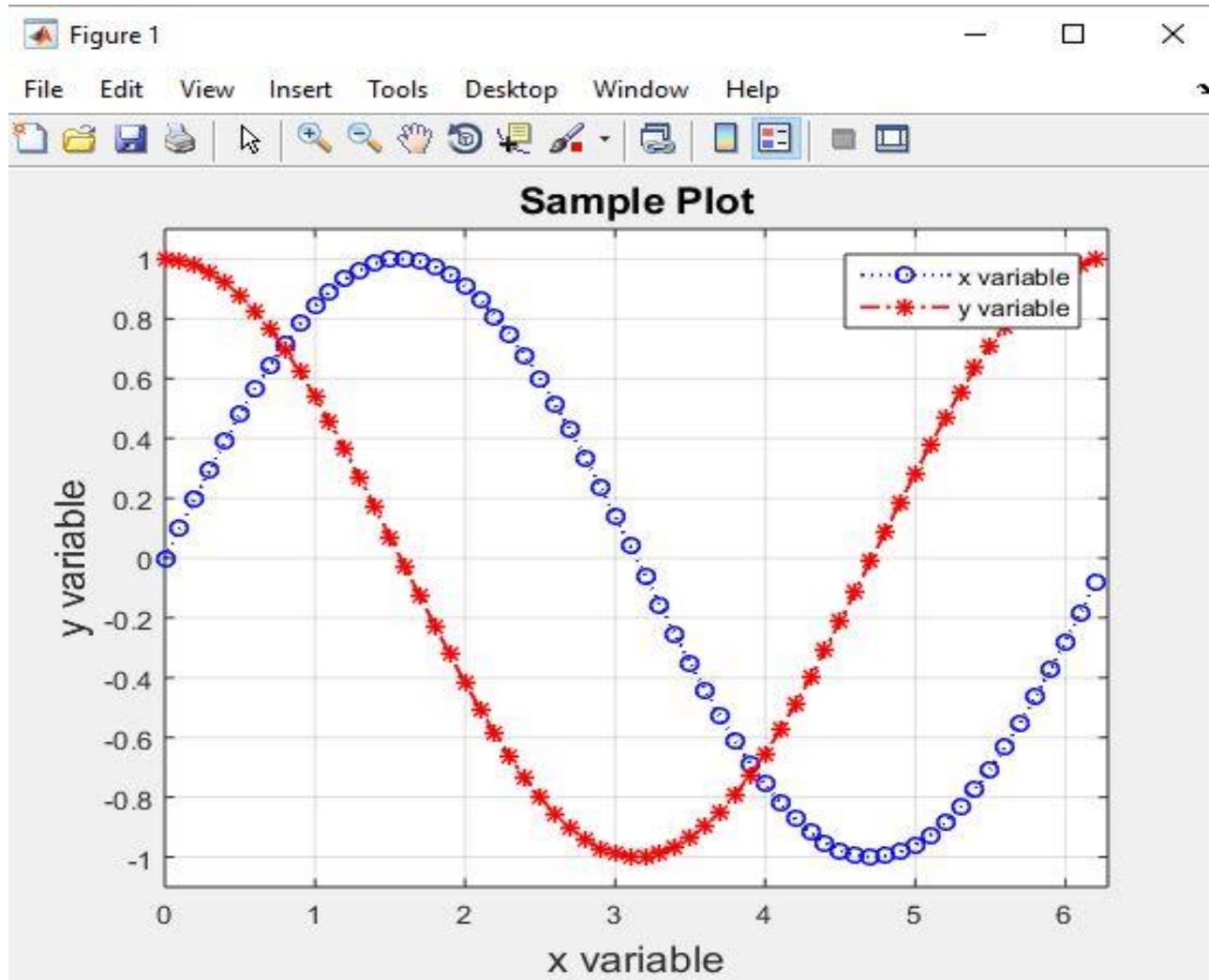
```
MATLAB R2015a - academic use
HOME PLOTS APPS
C:\Users\dbrowe\Desktop
>> nx=4; ny=5;
A=zeros(nx,ny);
acounter=0;
for countx=1:nx
    for county=1:ny
        A(countx,county)=countx*county;
        if countx==county;
            A(countx,county)=20;
        elseif countx~=county;
            acounter=acounter+1;
        else
            disp('hello')
        end
    end
end
A
acounter
A =
    20     2     3     4     5
     2    20     6     8    10
     3     6    20    12    15
     4     8    12    20    20
acounter =
    16
fx >> |
```

Plotting

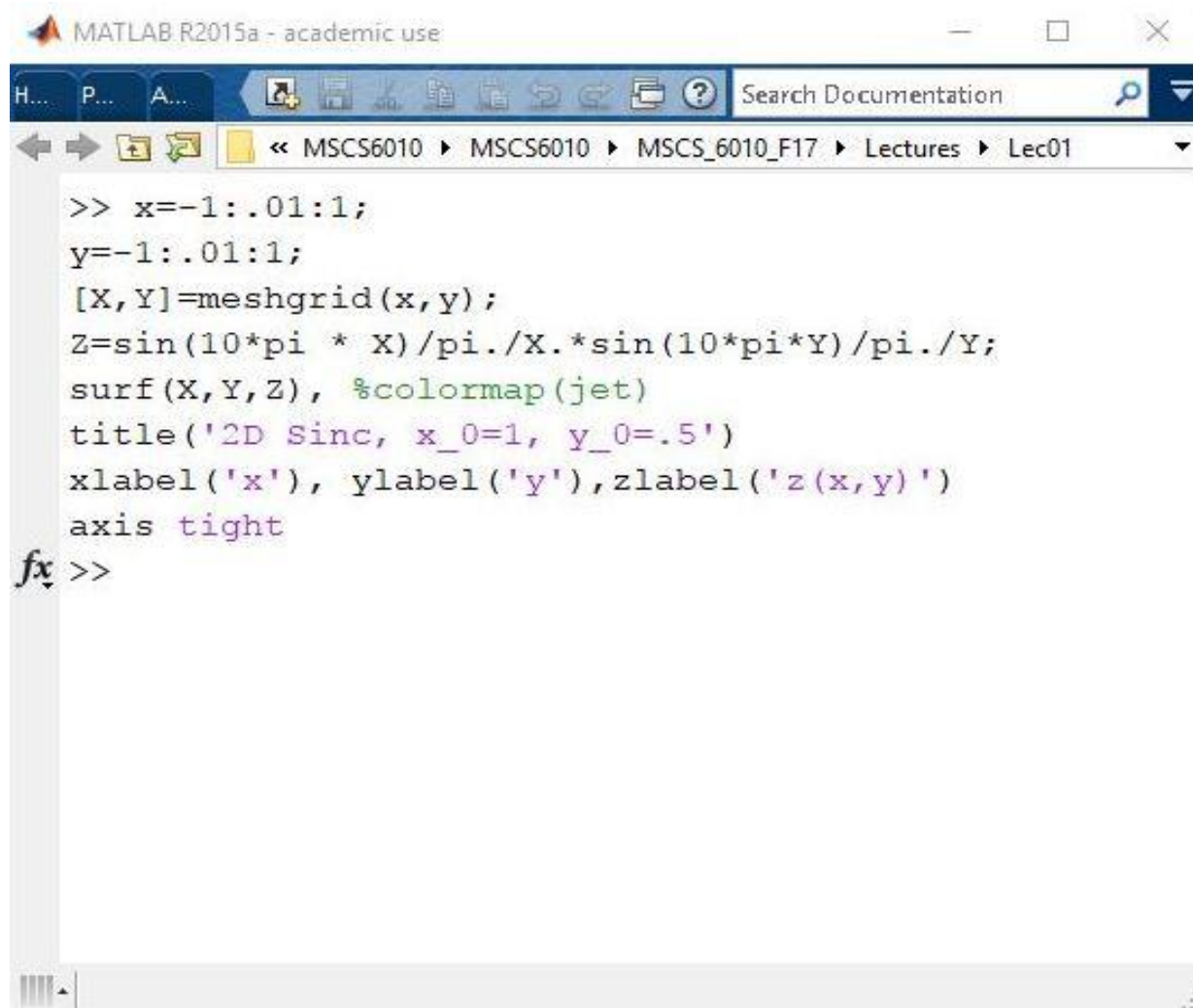


```
MATLAB R2015a - academic use
H... P... A... Search Documentation
<< MSCS6010 >> MSCS6010 >> MSCS_6010_F17 >> Lectures >> Lec01
>> x=[0:0.1:2*pi];
y=sin(x);
z=cos(x);
plot(x,y,':bo',x,z,'-.r*','linewidth',1.25)
title('Sample Plot','fontsize',14);
xlim([0 2*pi]), ylim([-1.1 1.1])
xlabel('x variable','fontsize',14);
ylabel('y variable','fontsize',14);
legend('x variable','y variable')
grid on
fx >> |
```


Plotting - 2D



Plotting - 3D



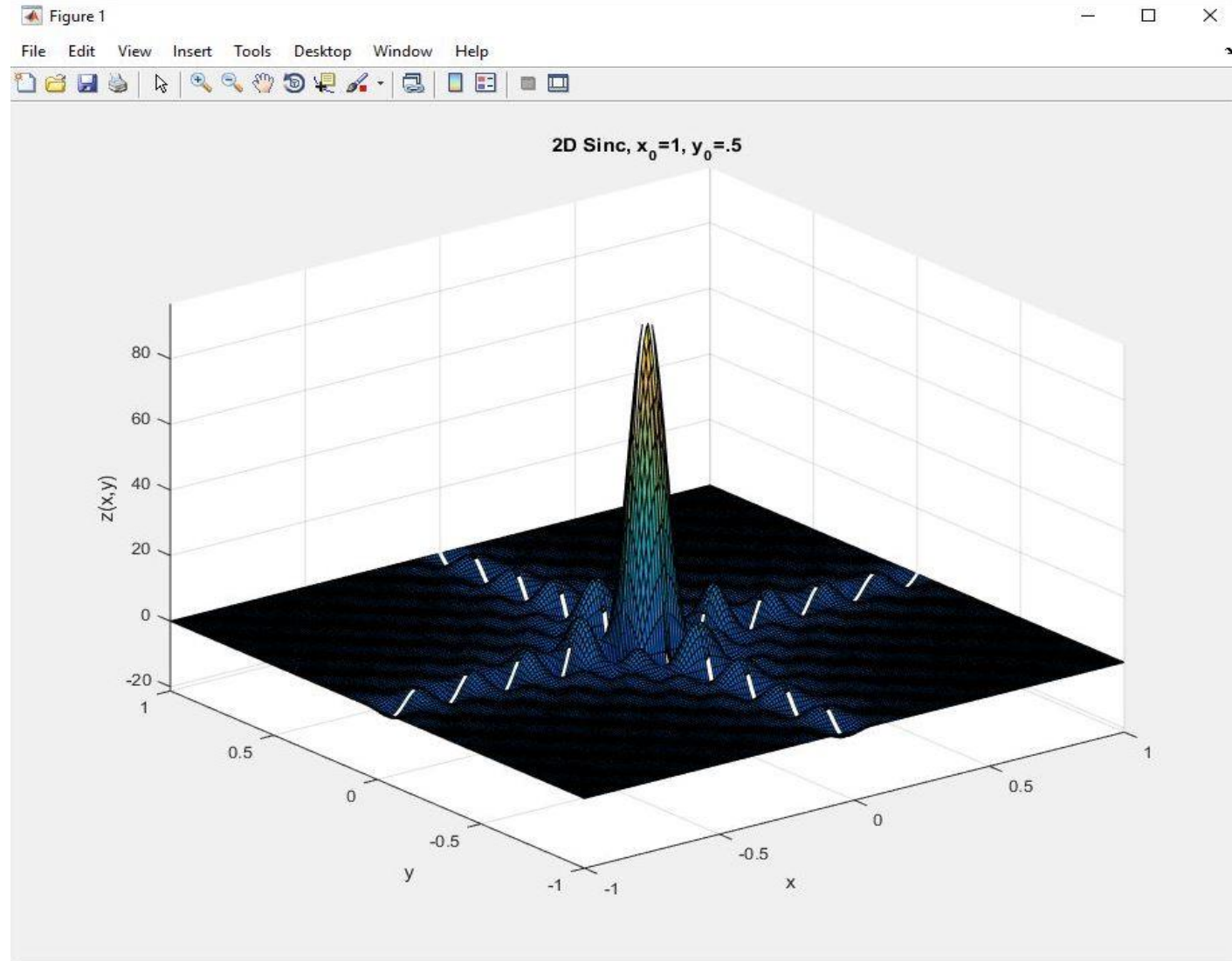
The image shows a MATLAB R2015a window titled "MATLAB R2015a - academic use". The window contains a script editor with the following code:

```
>> x=-1:.01:1;
y=-1:.01:1;
[X,Y]=meshgrid(x,y);
Z=sin(10*pi * X)/pi./X.*sin(10*pi*Y)/pi./Y;
surf(X,Y,Z), %colormap(jet)
title('2D Sinc, x_0=1, y_0=.5')
xlabel('x'), ylabel('y'),zlabel('z(x,y)')
axis tight
```

The script defines a 2D sinc function $Z = \frac{\sin(10\pi X)}{\pi X} \cdot \frac{\sin(10\pi Y)}{\pi Y}$ and plots it using the `surf` function with a `jet` colormap. The plot is titled "2D Sinc, x_0=1, y_0=.5" and has axes labeled 'x', 'y', and 'z(x,y)'. The `axis tight` command is used to fit the axes to the data.

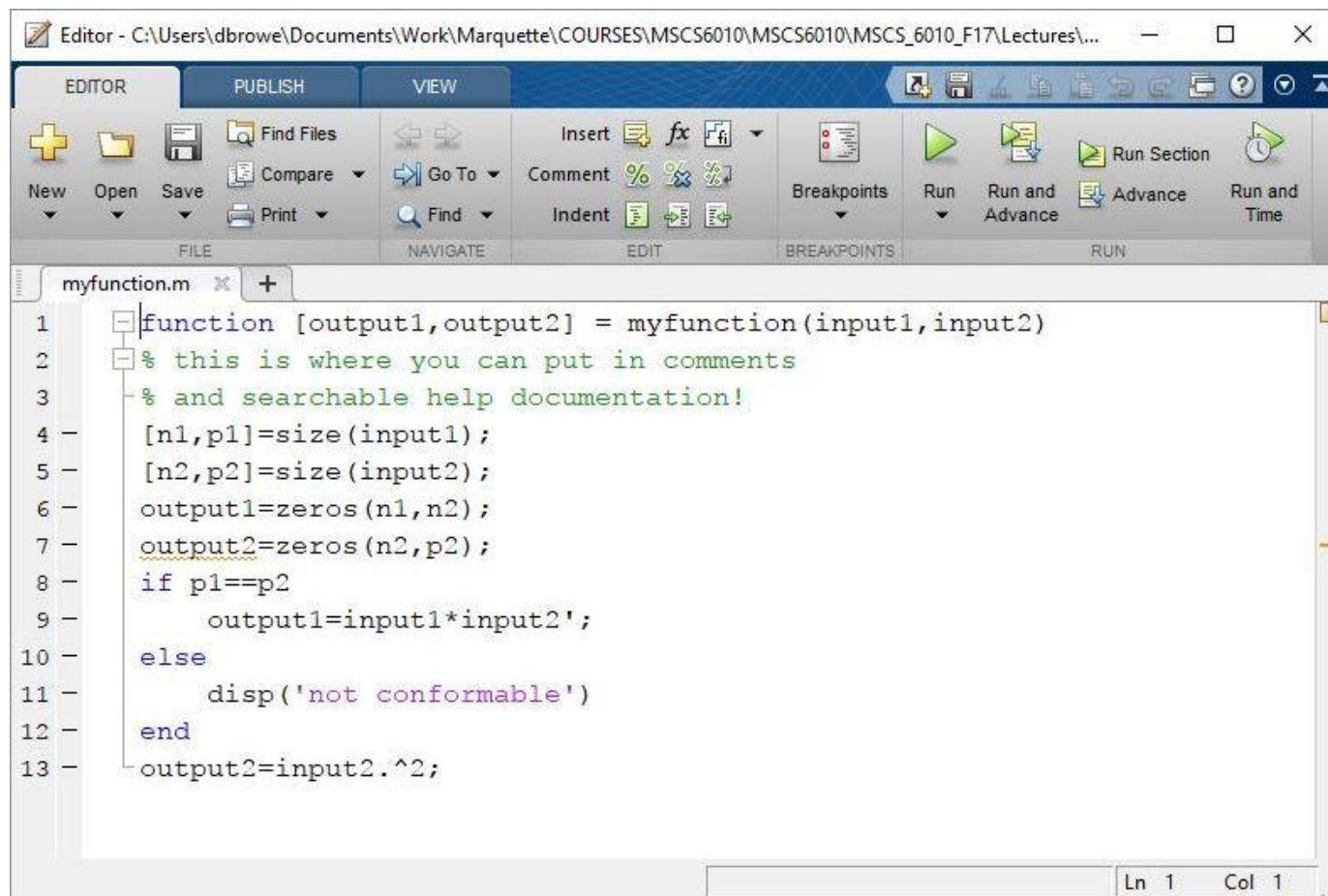
Below the code, there is a cursor icon and the prompt `>>`.

Plotting - 3D



Functions and m-files

Create your own functions!



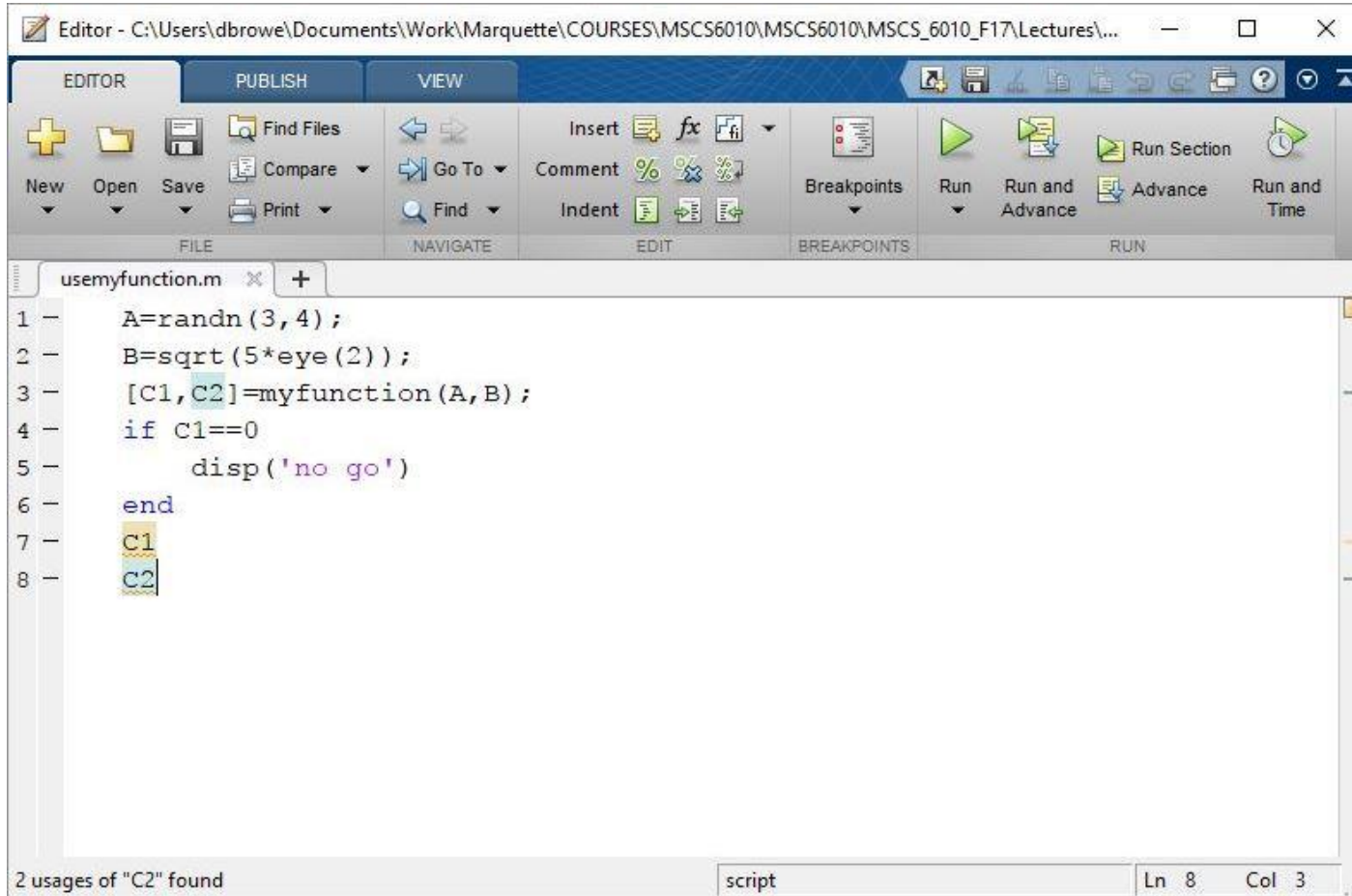
The screenshot shows the MATLAB Editor interface with a file named 'myfunction.m' open. The code in the editor is as follows:

```
1 function [output1,output2] = myfunction(input1,input2)
2 % this is where you can put in comments
3 % and searchable help documentation!
4 [n1,p1]=size(input1);
5 [n2,p2]=size(input2);
6 output1=zeros(n1,n2);
7 output2=zeros(n2,p2);
8 if p1==p2
9     output1=input1*input2';
10 else
11     disp('not conformable')
12 end
13 output2=input2.^2;
```

The status bar at the bottom right indicates 'Ln 1 Col 1'.

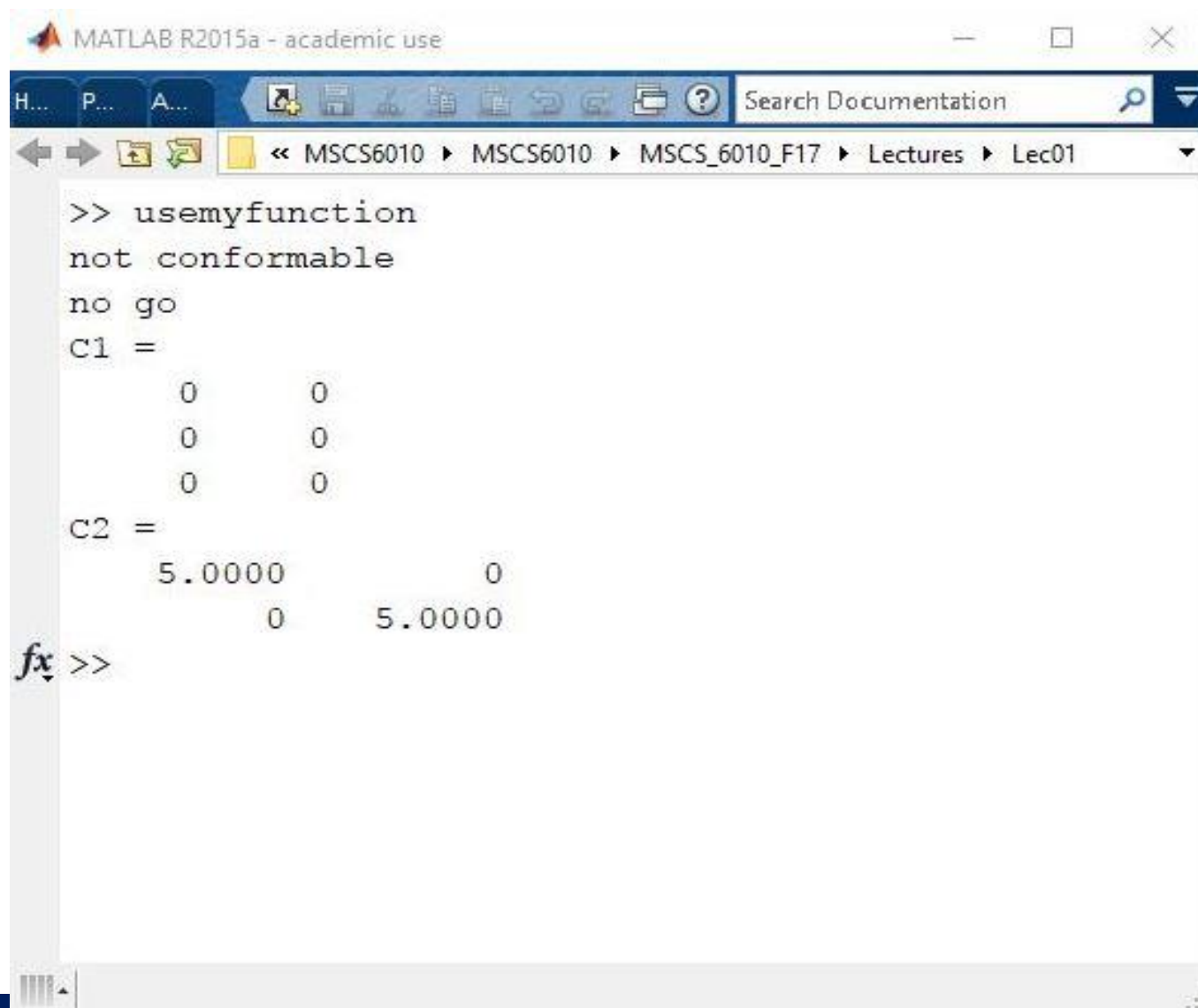
Functions and m-files

Create your own functions!



```
Editor - C:\Users\dbrowe\Documents\Work\Marquette\COURSES\MSCS6010\MSCS6010\MSCS_6010_F17\Lectures\...
EDITOR PUBLISH VIEW
New Open Save Find Files Compare Print Go To Find Insert Comment Indent Breakpoints Run Run and Advance Run Section Advance Run and Time
FILE NAVIGATE EDIT BREAKPOINTS RUN
usemyfunction.m x +
1 - A=randn(3,4);
2 - B=sqrt(5*eye(2));
3 - [C1,C2]=myfunction(A,B);
4 - if C1==0
5 -     disp('no go')
6 - end
7 - C1
8 - C2
2 usages of "C2" found script Ln 8 Col 3
```

Functions and m-files



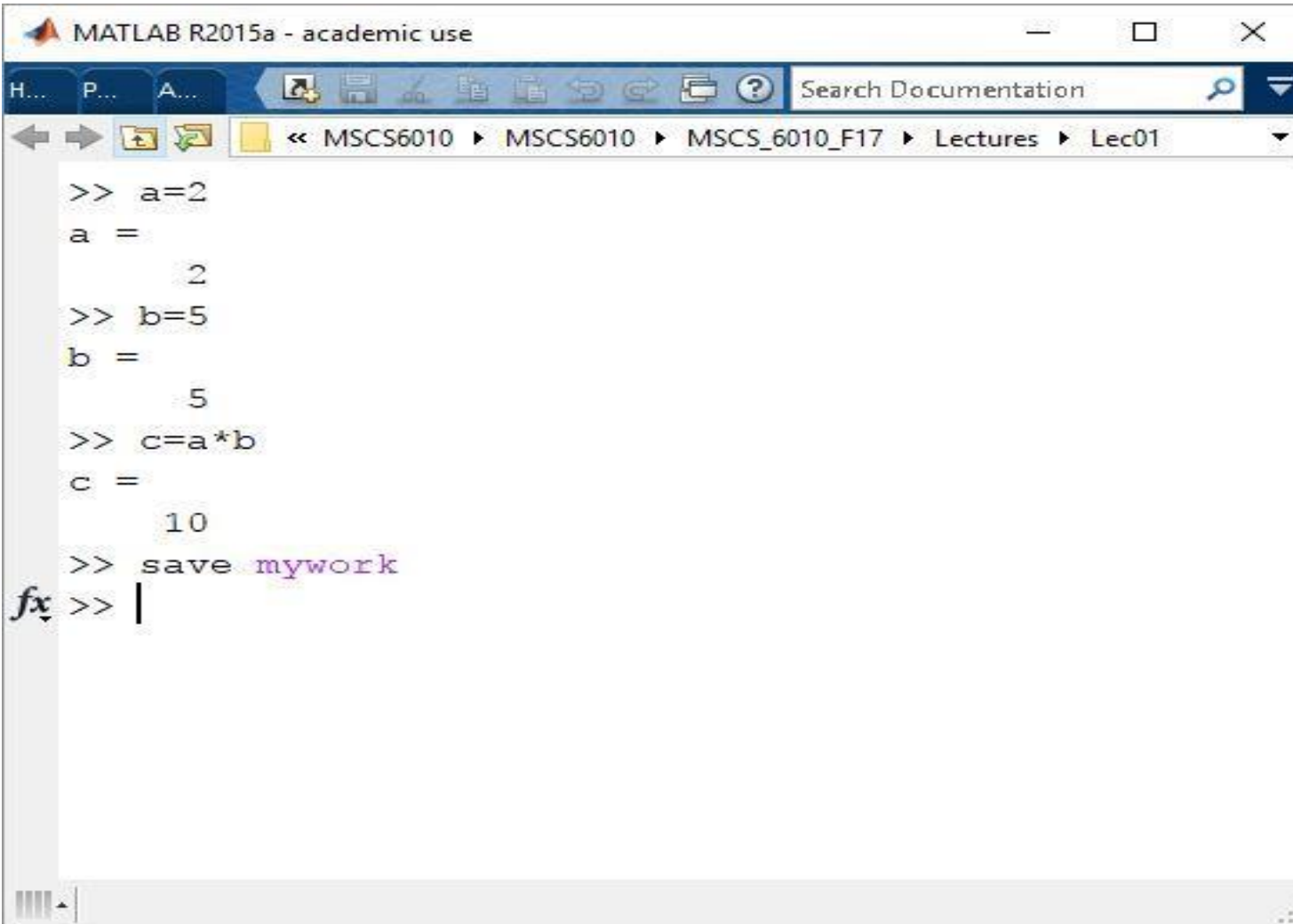
MATLAB R2015a - academic use

H... P... A... Search Documentation

<< MSCS6010 ▶ MSCS6010 ▶ MSCS_6010_F17 ▶ Lectures ▶ Lec01

```
>> usemyfunction
not conformable
no go
C1 =
     0     0
     0     0
     0     0
C2 =
     5.0000         0
         0     5.0000
fx >>
```

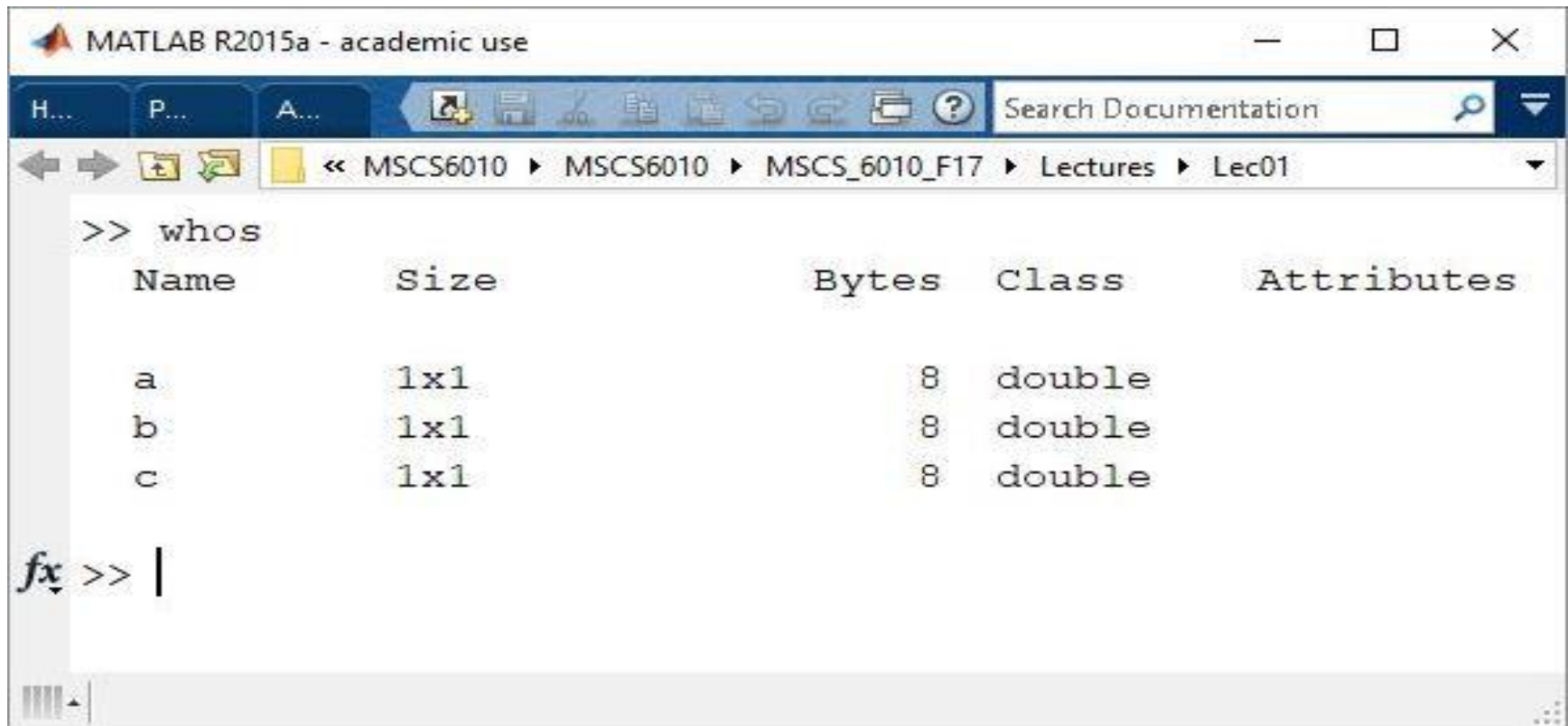

Importing and Exporting



The image shows a screenshot of the MATLAB R2015a - academic use interface. The window title is "MATLAB R2015a - academic use". The interface includes a menu bar with "H...", "P...", and "A..." options, a toolbar with various icons, and a "Search Documentation" search bar. The current directory path is displayed as "MSCS6010 > MScS6010 > MScS_6010_F17 > Lectures > Lec01". The command window shows the following execution:

```
>> a=2
a =
     2
>> b=5
b =
     5
>> c=a*b
c =
    10
>> save mywork
fx >> |
```

Importing and Exporting



The image shows a screenshot of the MATLAB R2015a - academic use interface. The Command Window displays the output of the 'whos' command, which lists the variables 'a', 'b', and 'c' in the workspace. The output is as follows:

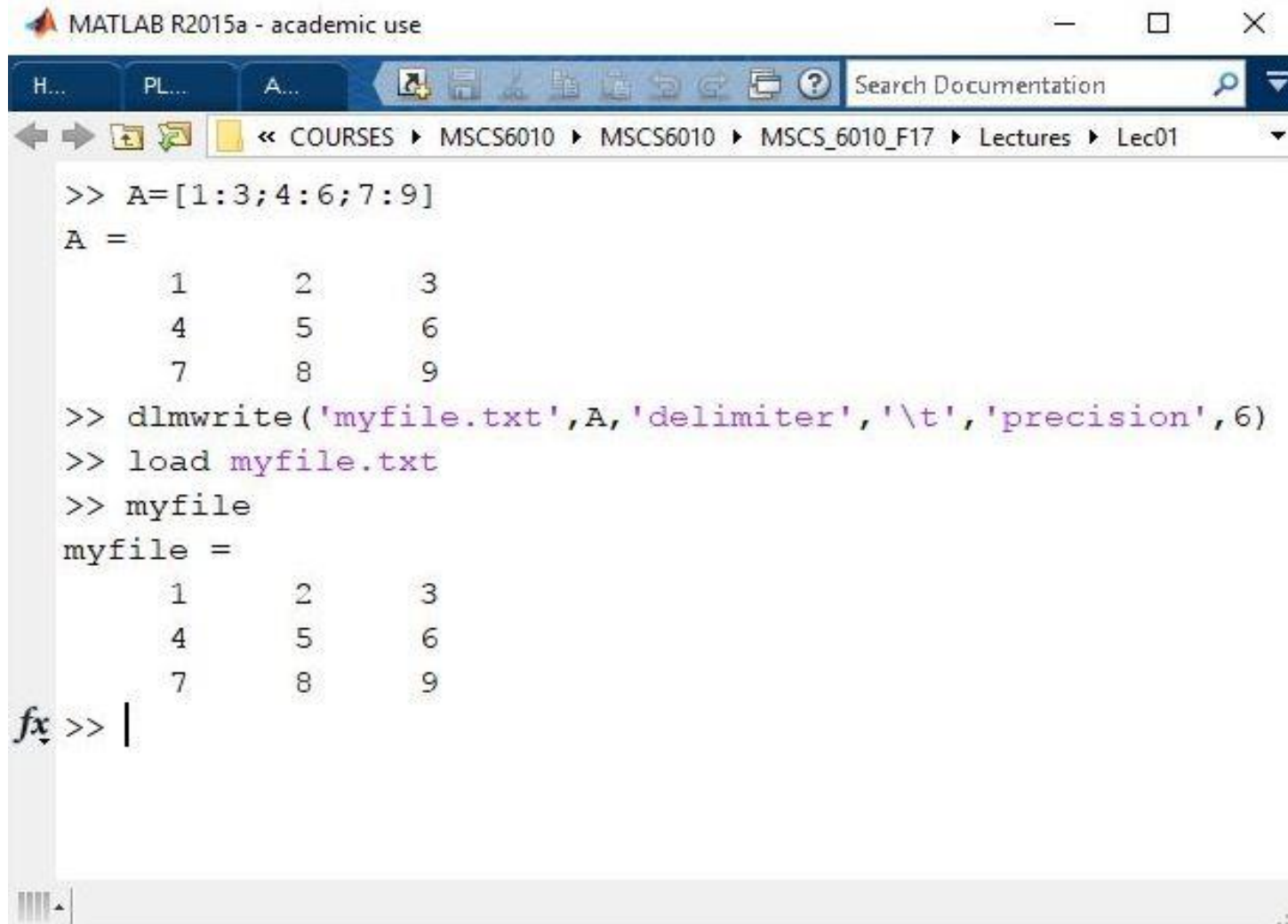
Name	Size	Bytes	Class	Attributes
a	1x1	8	double	
b	1x1	8	double	
c	1x1	8	double	

The Command Window prompt is currently at `fx >> |`.

The file type is .mat

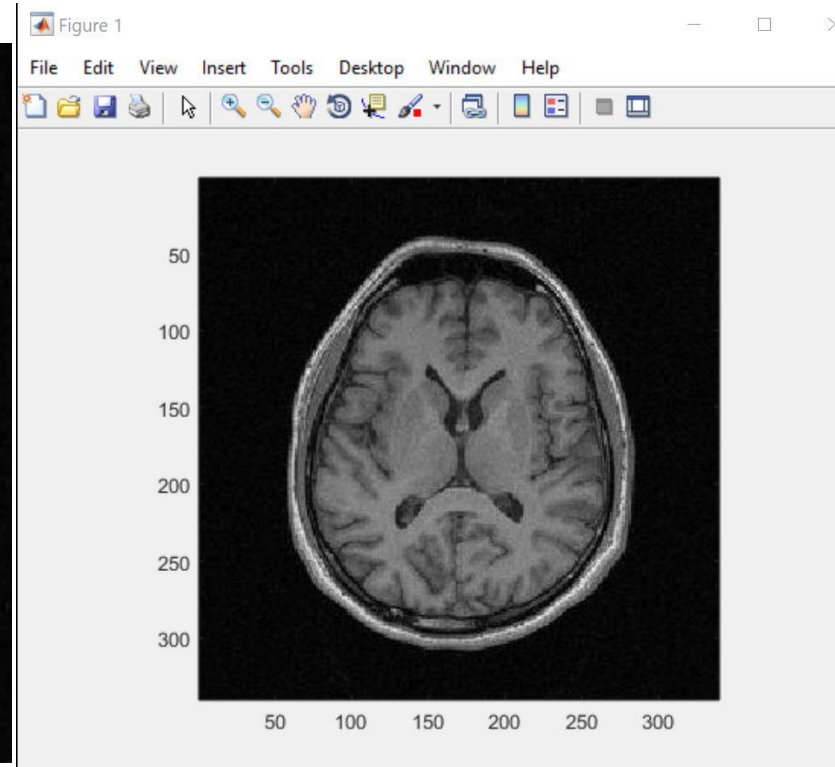
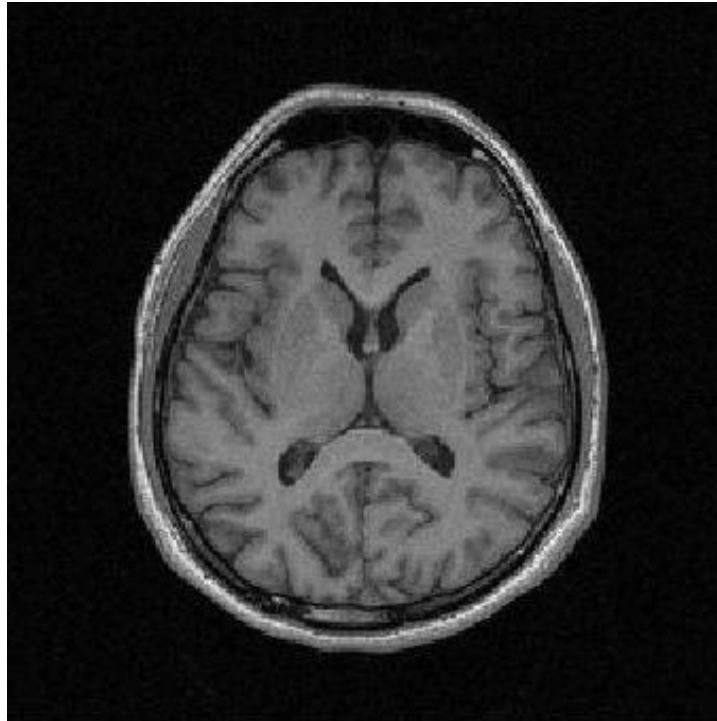
To read back in use “load mywork”

Importing and Exporting



```
MATLAB R2015a - academic use  
H... PL... A... Search Documentation  
« COURSES ▶ MSCS6010 ▶ MSCS6010 ▶ MSCS_6010_F17 ▶ Lectures ▶ Lec01  
>> A=[1:3;4:6;7:9]  
A =  
     1     2     3  
     4     5     6  
     7     8     9  
>> dlmwrite('myfile.txt',A,'delimiter','\t','precision',6)  
>> load myfile.txt  
>> myfile  
myfile =  
     1     2     3  
     4     5     6  
     7     8     9  
fx >> |
```

Images



```
Editor - C:\Users\dbrowe\Documents\Work\Marquette\COURSES\MSCS6010\MSCS6010\MSCS_6010_F17\Lectures\...  
EDITOR PUBLISH VIEW  
New Open Save Find Files Compare Print Go To Find Comment Indent Breakpoints Run Run and Advance Run and Time  
FILE NAVIGATE EDIT BREAKPOINTS RUN  
imageSWI.m x +  
1 - brainimage=imread('imageSWI.jpg');  
2 - figure;  
3 - image(brainimage)  
4 - axis image  
5  
script Ln 1 Col 1
```

Movies

Some Additional Toolboxes

- Bioinformatics Toolbox
- Curve Fitting Toolbox
- Financial Toolbox
- Image Processing Toolbox
- Optimization Toolbox
- Signal Processing Toolbox
- Statistics Toolbox
- Wavelet Toolbox

Summary

- About Matlab
- Arithmetic and Variables
- Arrays and Indexing
- Programming
- Plotting
- Functions and m-files
- Importing and Exporting
- Images