This module aims to introduce Precalculus high school students to the basic capabilities of Matlab by using functions. Matlab will be used in subsequent modules to help to teach research related concepts or to help emphasize classroom learning. This Introduction to Matlab package includes a lesson plan, a PowerPoint presentation, a worksheet and a reference sheet.
# Science Lesson Plan

**Teacher:**

**Period:**

**Class:** AP Precalc

**Date(s):** Lesson #1 Introduction to Matlab using Functions

## Setting the Stage

<table>
<thead>
<tr>
<th>Essential Question</th>
<th>How to visualize functions, their domain and range?</th>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Content Objective(s) (Student-friendly)</th>
<th>Introduces basic Matlab commands for creating functions, defining variables and specifying their domain. Visualization through one-dimensional plots will also be introduced, to compare different functions.</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Connection to previous or future lessons</th>
<th>Material in this lesson plan will serve as a background for future lessons which will be used to show Precalculus concepts in an alternate way and to demonstrate research related concepts.</th>
</tr>
</thead>
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<table>
<thead>
<tr>
<th>Critical Thinking Questions</th>
<th>What is the importance of knowing what the graphical representation of a function looks like? What are some benefits of being able to manipulate the scale of a graph?</th>
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<table>
<thead>
<tr>
<th>Key Vocabulary</th>
<th>Variables</th>
<th>Functions</th>
<th>Scale</th>
<th>Domain</th>
<th>Range</th>
<th>Maxima</th>
<th>Minima</th>
<th>Linear</th>
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<table>
<thead>
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<th>Materials Needed/Safety</th>
<th>Computers with Matlab software</th>
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<tbody>
<tr>
<td></td>
<td>Matlab reference guide.</td>
</tr>
<tr>
<td></td>
<td>Matlab code</td>
</tr>
</tbody>
</table>

## Active Instruction

- **Launch (Engage)**

  Display some 2-d or 3-d visualization from Matlab using an existing demo application. Ask students questions about what they see and how they think this was generated. Explain briefly what the simulation is about and give them a hands on activity where they can change some parameter of this application and see a difference.

  Students will also see a short video titled “Matlab is Cool” The intention of showing the video is to convey other students’ excitement for a software tool like Matlab.

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*This template is available in electronic form.*
### Science Lesson Plan

**Teacher:**

- **Investigation** (Explore)
  
  Following the launch, students will be introduced to some basic commands and will learn how to create a basic linear function and its graph, \( F(x) = 2x + 3 \). They will later be asked to change the slope of the function and will be asked what changes they notice when the slope changes. Students will not be told that the coefficient in front of \( x \) is the slope. They will be asked to describe the graph in terms of decrease or increase and rate of change.

### TIME FOR REFLECTION

- **Summarization** (Explain & Extend)
  
  We will discuss the importance of being able to find the domain and range of a function with an appropriate scale for graphing. If time permits, students will be asked to compare the functions:
  
  \[ \begin{align*}
  G(x) &= 3x^2, \ x < 1 \\
  F(x) &= 3x^2, \ x > 1
  \end{align*} \]
  
  Discuss the use of simulation and how it is helpful to visualize the data. Explain thoroughly the plot that was generated. Explain what is to be presented next class. Ask the students to identify what was the most useful component in the computational exercises. Discuss why and how the students would use the software. Ask the students to note their observations in their journals.

- **Assessment** (Evaluate)
  
  Written notes in their journals will be reviewed.

- **Homework**
Matlab Introduction

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Matlab

- Matlab is Cool!
Outline

- M-files
- Matlab desktop
- Variables
- Arrays
- Plots
M-files

- Save set of commands in a file
- Long code that requires more than a couple of commands
- Allows you to save code
- Extension that is used in matlab

Examples -- Filename.m, anyname.m
How to create an m-file

- Click on File in upper left hand side
- Click on new
- Click on blank m-file
- Type code
- Save as
How to open/edit/close an m-file

- Click on file
- Click on open
- Then choose the m-file
- Make any changes needed to the file
- Click on save
- Then close the file by the x located in the upper right hand or File -> Close
Matlab Desktop

- Command Window
- Workspace
- Command History
Variable Assignment

>>a=4  -- Simple numerical assignment

>>t = 10 - 4  -- Result of an operation

>>p= pi  -- Special assignment

>>z = 3 + y  -- Result of an operation with variables
Arrays

- MATLAB variables are arrays of numbers. An array consisting of one element is called a scalar.

- Scalar: a scalar is a single value (i.e. a number)
  
  ```matlab
  >> b = 2
  b = 2
  ```

- Vector: a vector is an ordered series of numbers

  ```matlab
  >> c = [0, 2, 4, 6, 8, 10, 12, 14]
  c =
   0   2   4   6   8  10  12  14
  >> d = 0:2:14
  d =
   0   2   4   6   8  10  12  14
  ```

What do you observe?
Helpful Commands

• >>save -- saves the file from the command window
• >>clear -- clears the workspace
• >>clc -- clears the command window
• >>load -- load the specified file from the command window
Plots

Let’s graph \( f(x) = 2x + 3, \quad x \leq 1 \)

It’s almost like making a table, what values of \( x \) do we want?  --Anything less than or equal to zero, so are maximum \( x \) value is 1

\[
>> x = -100:6:1 \quad --\text{What does this do?}
\]

\[
>> fx = 2x + 3
\]

\[
>> \text{plot}(x,fx) \quad --\text{plots 2-d data with } x \text{ axis with values of } x \text{ and } y \text{ axis with values of } y
\]
Change plot line color

For example

```matlab
>> plot(x,fx,'b')
```
will make the plot line color blue

- **Color options**
  - `g` green
  - `r` red
  - `c` cyan
  - `m` magenta
  - `k` black
Multiple Functions in one Plot

- \( \text{fx} = 2x + 3 \)
- \( \text{fx1} = -10x + 3 \)
- \( \text{fx2} = 10x + 3 \)

Now try:

- \( \text{plot(x,fx,'r',x,fx1,'b',x,fx2,'c')} \)

How can you tell which line belong to the correct function?
Change Line Style

For example

```
>>plot(x,y,'-') will make the line style solid
```

**Other line styles:**

- dashed
- dotted
- dash dot
Change plot marker

`>> plot(x, y, 'd')` diagonal cross

- Other marker options
  + vertical cross
  * star
  d diamond ◊
Plot types

- Bar graph
  \[ \text{bar}(x,y) \]

- Stem graph
  \[ \text{stem}(x,y) \]
Annotating Plots

- To make a label for the x-axis
  >>xlabel(‘The label for x’)

- To make a label for the y-axis
  >>ylabel(‘ The label for y’)

- To make a title for the Plot
  >>title(‘Our First Plot’)

Plotting data

Type in the following code (excluding the comments denoted by %):

- \( y_{\text{xmin}} = -20; \) %assign starting value of \( x \)
- \( y_{\text{xmax}} = 20; \) %assign end value of \( x \)
- \( dt = 2; \) % assign increment
- \( x = x_{\text{min}}:dt:x_{\text{max}}; \) %define independent vector
- \( f_x \) = \( 2 \cdot x + 5; \) %define the function
- \( g_x \) = \( 15 \cdot x + 3; \) % define second function
- \( \text{plot}(x,f_x,'r',x,g_x,'b'); \) %plot first function with color of red. 'r'-red and second function with blue
- grid on %shows grid lines
- \( \text{xlabel}('x = -20 \text{ to } 20'); \) %set label for x axis
- \( \text{ylabel}('\text{labeling the y axis}'); \) %set label for y axis
- \( \text{title}('\text{My first graph in Matlab}'); \) %set title
Let’s Compare

- Write your observations and sketch the functions in your notebooks
  - \( G(x) = 5x^2 \) \( x < 1 \)
  - \( P(x) = 5x^3 \) \( x < 1 \)

And:
- \( G(x) = 5x^2 \) \( x > 1 \)
- \( P(x) = 5x^3 \) \( x > 1 \)
Using Matlab to Plot Functions

Name: ___________________________                        Date: ______________

First identify the grandmother function, then plot and describe the transformation of the following functions:

<table>
<thead>
<tr>
<th>Grandmother Function</th>
<th>Function 1</th>
<th>Function 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$g(x) = x^3 - 2$</td>
<td>$h(x) = (x + 3)^3 + 2$</td>
</tr>
<tr>
<td></td>
<td>$y = 4</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>$p(x) = 2 - (x + 5)^2$</td>
<td>$q(x) = -(x + 10)^2 + 5$</td>
</tr>
</tbody>
</table>
M-Files

New M-Files
File → New → M-File (opens blank page)

Open M-Files
File → Open → Select a desired M-File → Click Open

Save M-Files
New
File → Save As…→ Select a desired folder where you want to save your new M-File
Old
File → Save (Ctrl + S)

Vectors

Data Stored as Vectors and Matrices
Row vector
A = [1 2 3 4]; leave space between each number. This generates 1 x 4 row vector

Column vector
B = [1; 2; 3; 4]; add semicolon(;) between each number. This generates 4x1 column vector

Example: 3 x 2 Matrix
C = [ 1 2; 3 4; 5 6]
= [ 1 2
3 4
5 6]

2D plot
plot(x,y) → plots a graph of y = f(x)

Label
Note: first plot a graph than label it
xlabel(‘x-axis’) → labels x-axis, make sure open and close the parenthesis, and add single quotation mark at the beginning and at the end. ‘x-axis’
ylabel(‘y-axis’) → labels y-axis
title(‘y vs. x’) → to display a title at the top location of the graph
legend(‘y = f(x)’); → describes the figure

Subplot
Used to represents multiple graphs in single page
subplot(2,3,4); → Used to place plots on same page:
subplot(r,c,i) i = 1, 2, …, r x c
r=row
c=column
i=placement of graph
Note: First use subplot command then repeat plot, xlabel, ylabel etc. for every subplots.

LineSpec Arguments for plot

<table>
<thead>
<tr>
<th>Line Style</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Solid line (default)</td>
</tr>
<tr>
<td>--</td>
<td>Dashed line</td>
</tr>
<tr>
<td>:</td>
<td>Dotted line</td>
</tr>
<tr>
<td>-</td>
<td>Dash-dot line</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Marker</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>Plus sign</td>
</tr>
<tr>
<td>o</td>
<td>Circle</td>
</tr>
<tr>
<td>*</td>
<td>Asterisk</td>
</tr>
<tr>
<td>.</td>
<td>Point</td>
</tr>
<tr>
<td>x</td>
<td>Cross</td>
</tr>
<tr>
<td>s</td>
<td>Square</td>
</tr>
<tr>
<td>d</td>
<td>Diamond</td>
</tr>
<tr>
<td>^</td>
<td>Upward pointing triangle</td>
</tr>
<tr>
<td>&gt;</td>
<td>Right pointing triangle</td>
</tr>
<tr>
<td>&lt;</td>
<td>Left pointing triangle</td>
</tr>
<tr>
<td>p</td>
<td>Five-pointed star (pentagon)</td>
</tr>
<tr>
<td>h</td>
<td>Six-pointed star (hexagon)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>r</td>
<td>Red</td>
</tr>
<tr>
<td>g</td>
<td>Green</td>
</tr>
<tr>
<td>b</td>
<td>Blue</td>
</tr>
<tr>
<td>c</td>
<td>Cyan</td>
</tr>
<tr>
<td>m</td>
<td>Magenta</td>
</tr>
<tr>
<td>y</td>
<td>Yellow</td>
</tr>
<tr>
<td>k</td>
<td>Black</td>
</tr>
<tr>
<td>w</td>
<td>White</td>
</tr>
</tbody>
</table>
%define a variable x as a 1X4 %vector that contains the numbers % 1 through 4
x = [1 2 3 4]

% find the dimensions of the vector
size(x)

% find the length of the row vector
length(x)
### Random Numbers

**normrnd**

**Syntax**

\[ R = \text{normrnd}(\mu, \sigma, m, n) \]

**Description**

Generates random numbers from the normal distribution with mean parameter \( \mu \) and standard deviation parameter \( \sigma \), where scalars \( m \) and \( n \) are the row and column dimensions of \( R \)

**Example**

\[ R = \text{normrnd}([1 \ 2 \ 3 \ ;4 \ 5 \ 6], 0.1, [3, 2]) \]

\[
\begin{array}{ll}
R &= 0.9299 \quad 1.9361 \\
    & 2.9640 \quad 4.1246 \\
    & 5.0577 \quad 5.9864 \\
\end{array}
\]

**randn**

**Description**

Generates a set of pseudorandom numbers from a standard normal distribution

**randint**

**Syntax**

\[ \text{out} = \text{randint}(m, n, rg) \]

**Description**

**2D plot**

- hist
- state