BME1901 – Introductory Computer Sciences
Laboratory Handout – 8

OBJECTIVES

Learn about,

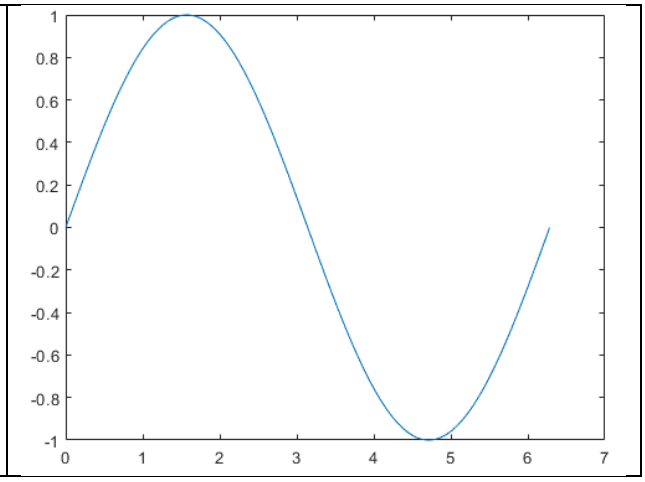
- Graphical representation of data
- Drawing multiple plots
- Formatting plot graphs
- Recursive functions
- Solving various questions

TOOLS

Graphical representation of data

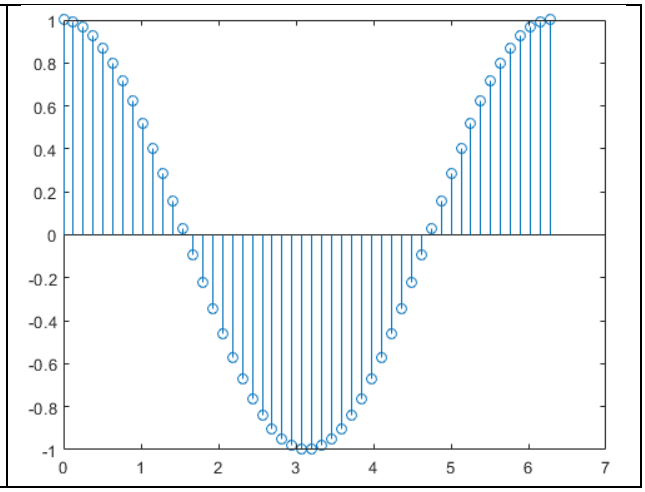
plot()[1]: plot(X, Y) creates a 2-D line plot of the data in Y versus the corresponding values in X. The X and Y inputs must be vectors or matrices of the same size.

```
>> x = 0:pi/100:2*pi;

>> y = sin(x);

>> plot(x,y)
```



stem()[2]: stem(X, Y) plots the data sequence, Y, at values specified by X. The X and Y inputs must be vectors or matrices of the same size.

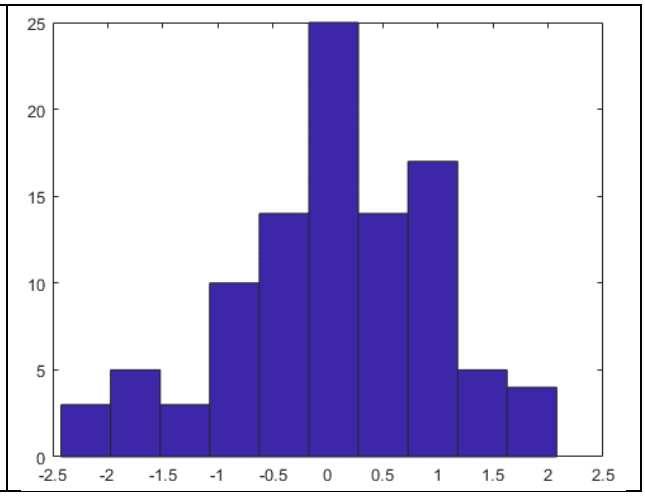
```
>> X = 0:pi/25:2*pi;

>> Y = cos(X);

>> stem(X,Y)
```



[1] https://www.mathworks.com/help/matlab/ref/plot.html
[2] https://www.mathworks.com/help/matlab/ref/stem.html

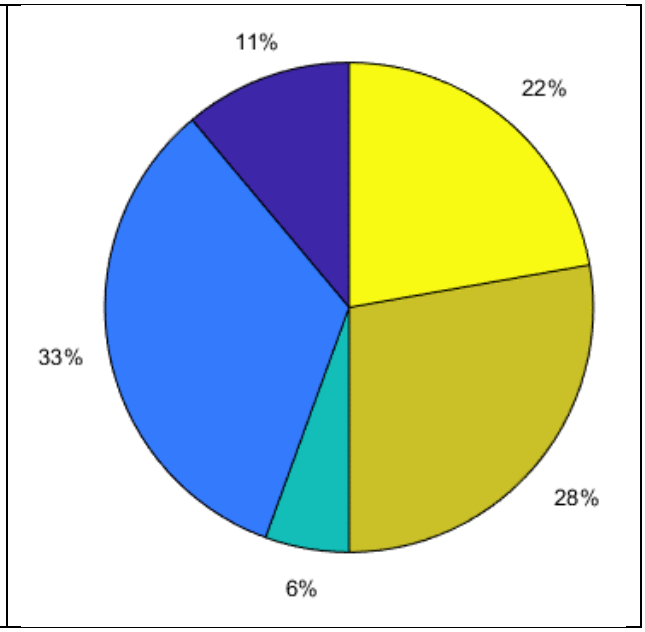
hist()[3]: hist(x) creates a histogram bar chart of the elements in vector x.

```
>> x = randn(100,1);

>> hist(x)
```



pie()[4]: pie(X) draws a pie chart using the data in X. Each slice of the pie chart represents an element in X. If sum(X) ≤ 1, then the values in X directly specify the areas of the pie slices. pie draws only a partial pie if sum(X) < 1. If sum(X) > 1, then pie normalizes the values by X/sum(X) to determine the area of each slice of the pie.

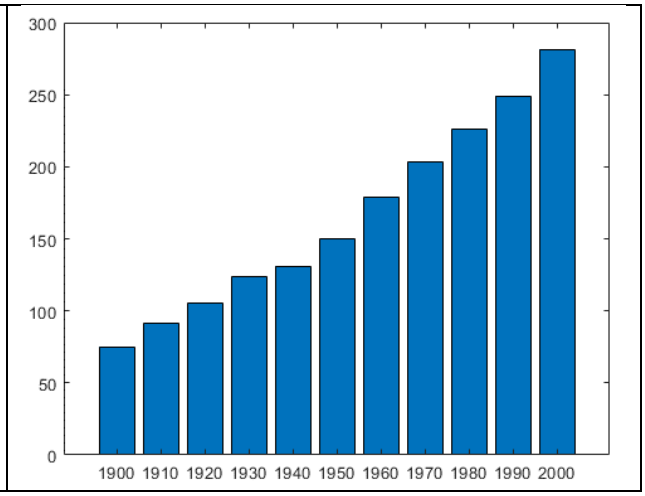
```
>> X = [1 3 0.5 2.5 2];

>> pie(X)
```



[3] https://www.mathworks.com/help/matlab/ref/hist.html
[4] https://www.mathworks.com/help/matlab/ref/pie.html

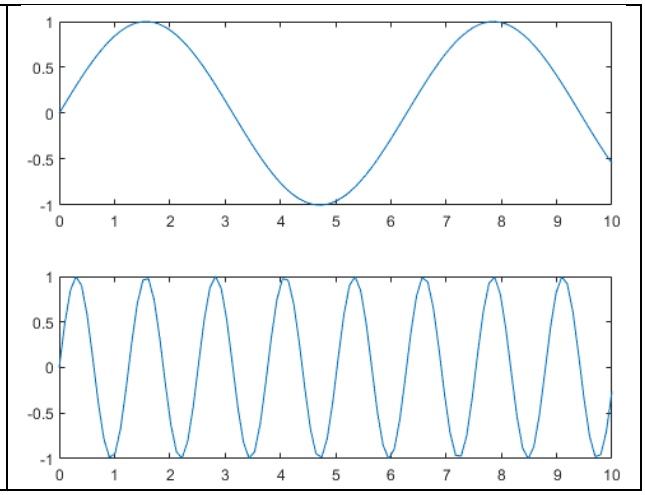
bar()[5]: bar(x, y) creates a bar graph with one bar for each element in y at the locations specified by x.

```
>> x = 1900:10:2000;

>> y = [75 91 105 123.5 131 150 179 203
226 249 281.5];

>> bar(x,y)
```



subplot()[6]: subplot(m, n, p) divides the current figure into an m-by-n grid and creates axes in the position specified by p. MATLAB® numbers subplot positions by row. The first subplot is the first column of the first row, the second subplot is the second column of the first row, and so on.

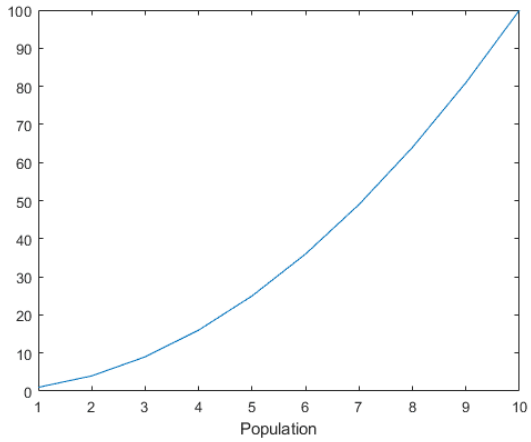
```
>> x = 0:0.1:10;

>> y1 = sin(x);

>> subplot(2,1,1);

>> plot(x,y1)


>> y2 = sin(5*x);

>> subplot(2,1,2);

>> plot(x,y2)
```



[5] https://www.mathworks.com/help/matlab/ref/bar.html
[6] https://www.mathworks.com/help/matlab/ref/subplot.html

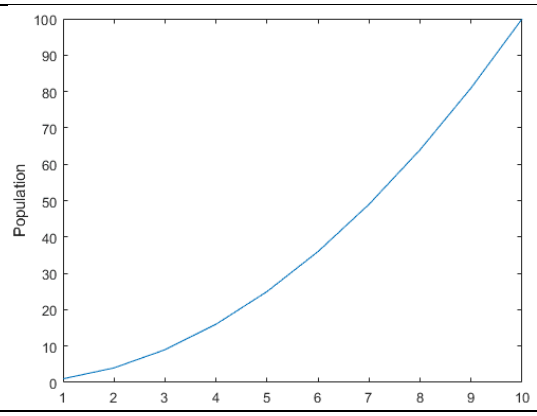
xlabel()[7]: xlabel('txt') labels the x-axis of the current axes or chart.

```
>> x = 0:10;

>> plot(x, x.^2)

>> xlabel('Population')
```



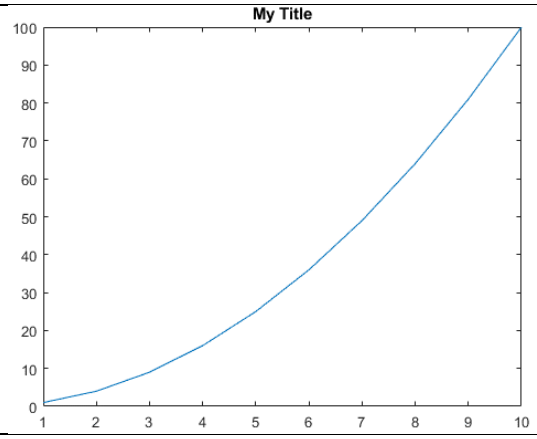
ylabel()[8]: ylabel('txt') labels the y-axis of the current axes or chart.

```
>> x = 0:10;

>> plot(x, x.^2)

>> ylabel('Population')
```



title()[9]: title('txt') adds the specified title to the current axes or chart.

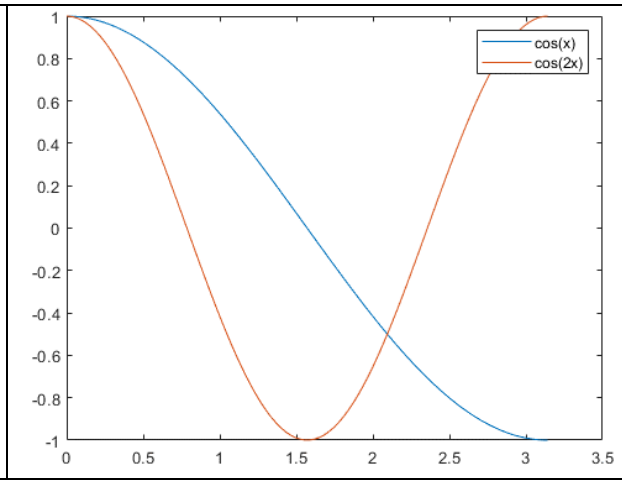
```
>> x = 0:10;

>> plot(x, x.^2)

>> title('My Title')
```



[7] https://www.mathworks.com/help/matlab/ref/xlabel.html
[8] https://www.mathworks.com/help/matlab/ref/ylabel.html
[9] https://www.mathworks.com/help/matlab/ref/title.html

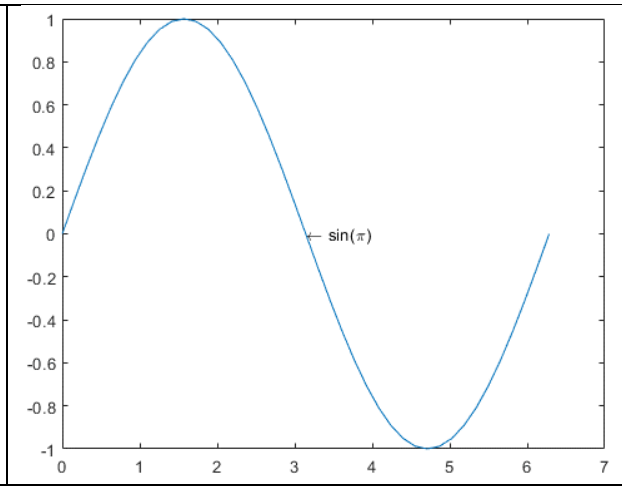
legend()[10]: legend('label1', …, 'labelN') creates a legend with descriptive labels for each plotted data series. For the labels, the legend uses the text from the DisplayName properties of the data series. If the DisplayName property is empty, then the legend uses a label of the form 'dataN'. The legend automatically updates when you add or delete data series from the axes. This command creates a legend for the current axes or chart

```
>> x = 0:pi/100:pi;

>> y1 = cos(x);

>> plot(x,y1)

>> hold on

>> y2 = cos(2*x);

>> plot(x,y2)

>> legend('cos(x)','cos(2x)')
```



text()[11]: text(x, y, 'txt') adds a text description to one or more data points in the current axes using the text specified by txt. To add text to one point, specify x and y as scalars. To add text to multiple points, specify x and y as vectors with equal length.

```
>> x = 0:pi/20:2*pi;

>> y = sin(x);

>> plot(x,y)

>> text(pi,0,'\leftarrow sin(\pi)')
```



[10] https://www.mathworks.com/help/matlab/ref/legend.html
[11] https://www.mathworks.com/help/matlab/ref/text.html

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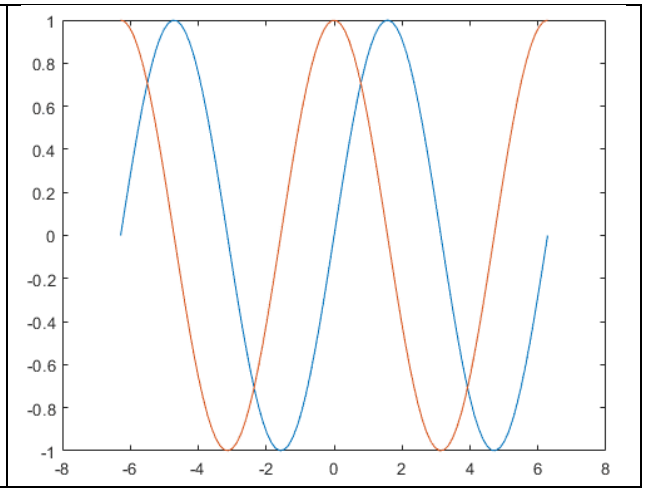
Drawing multiple plots

Using plot()[12]: plot(X1, Y1, ..., Xn, Yn) plots multiple X, Y pairs using the same axes for all lines.

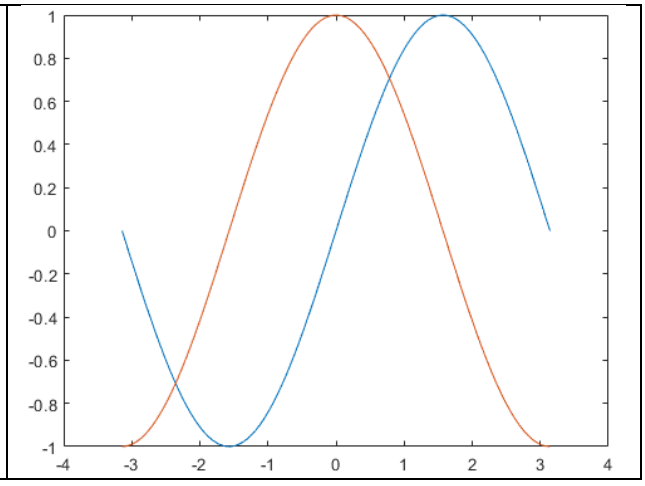
```
>> x = -2*pi:pi/25;2*pi

>> y1 = sin(x);

>> y2 = cos(x);

>> plot(x,y1,x,y2)
```



Using hold __[13]:

- hold on retains plots in the current axes so that new plots added to the axes do not delete existing plots.
- hold off sets the hold state to off so that new plots added to the axes clear existing plots and reset all axes properties.

```
>> x = -pi:pi/50:pi;

>> y1 = sin(x);

>> plot(x,y1)

>> hold on

>> y2 = cos(x);

>> plot(x,y2)

>> hold off
```

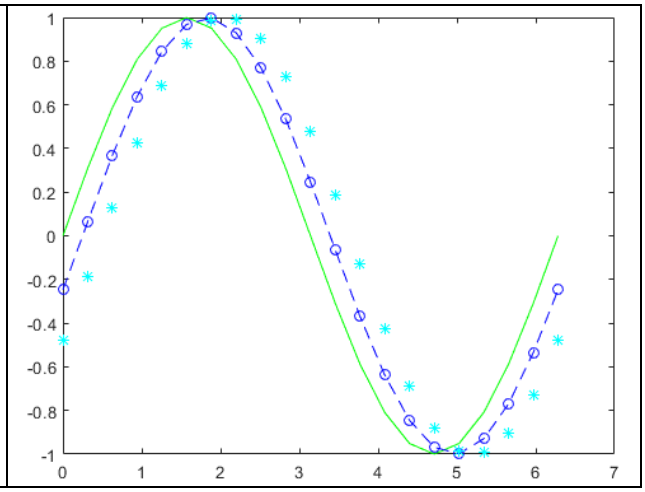


[12] https://www.mathworks.com/help/matlab/ref/plot.html
[13] https://www.mathworks.com/help/matlab/ref/hold.html

Formatting plot graphs[14]

plot(X1, Y1, LineSpec1, ..., Xn, Yn, LineSpecn) sets the line style, marker type, and color for each line. You can mix X, Y, LineSpec triplets with X, Y pairs. For example, plot(X1, Y1, X2, Y2, LineSpec2, X3, Y3).

```
>> x = 0:pi/10:2*pi;

>> y1 = sin(x);

>> y2 = sin(x-0.25);

>> y3 = sin(x-0.5);

>> plot(x,y1,'g',x,y2,'b--o',x,y3,'c*')
```



Line style, marker, and color, specified as a character vector or string containing symbols. The symbols can appear in any order. You do not need to specify all three characteristics (line style, marker, and color). For example, if you omit the line style and specify the marker, then the plot shows only the marker and no line.

Tables containing detailed line style, marker and color information may be found at:

https://www.mathworks.com/help/matlab/ref/plot.html#btzitot-LineSpec

[14] https://www.mathworks.com/help/matlab/ref/plot.html

Recursive functions[15, 16]

Recursive functions are functions that call themselves directly or indirectly within their execution processes. Each recursive function requires a base case for termination.

Example: Write a recursive function called "matryoshka()" which accepts a single positive integer for how many matryoshka dolls (nesting dolls, stacking dolls) are nested within (Figure 1). Then splits each doll starting from outside (from greatest number or number of nested dolls) towards inside (smallest number or 1) while displaying number for each doll.

```
function matryoshka(n)

fprintf('Doll number %d\n',n)

if n>1

    matryoshka(n-1)

end

end
```

```
>> matryoshka(5)

Doll number 5
Doll number 4
Doll number 3
Doll number 2
Doll number 1
```

Figure 1: Matryoshka dolls (nesting dolls, stacking dolls)[17]

[15] https://en.wikipedia.org/wiki/Recursion_(computer_science)
[16] http://pages.cs.wisc.edu/~calvin/cs110/RECURSION.html
[17] https://upload.wikimedia.org/wikipedia/commons/d/d2/Russian-Matroshka_no_bg.jpg

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PROBLEMS

1. Using load('data.mat') function load data saved into "data.mat" file. Then follow the steps below. Draw each graph in the specified positions in the 3 by 3 subplot area. Name all axes and give titles to each graph accordingly.
    a. Create a plot graph for scores for all students in subplot position 1.
    b. Create a stem graph for scores for all students in subplot position 2.
    c. Create a histogram graph for all scores in subplot position 3.
    d. Which graph above (a, b, c) gives meaningful information?
    e. Find numbers of male and female students.
    f. Create a pie graph for numbers of male and female students with legend in subplot position 4.
    g. Create a bar graph for numbers of male and female students in subplot position 5. (Note: use categorize({'Male', 'Female'}) function for x axis.)
    h. Find average scores of male and female students.
    i. Create a bar graph for average scores of male and female students in subplot position 6. (Note: use categorize({'Male', 'Female'}) function for x axis.)
    j. Which graph above (f, g, i) gives what kind of information?
    k. Find numbers of students who enrolled in 2018 and 2019.
    l. Create a pie graph for numbers of students who enrolled in 2018 and 2019 with legend in subplot position 7.
    m. Create a bar graph for numbers numbers of students who enrolled in 2018 and 2019 in subplot position 8.
    n. Find average scores of students who enrolled in 2018 and 2019.
    o. Create a bar graph for average scores of students who enrolled in 2018 and 2019 in subplot position 9.
    p. Which graph above (l, m, o) gives what kind of information?

2. Create a recursive function called "fact()" which accepts a single positive integer as input and calculates its factorial, then gives the result as output.