The CS 100J MATLAB Description

This handout outlines (through examples) the CS 100J "subset" of MATLAB. The MATLAB `help` facility should be used for details. The book *Getting Started With Matlab* by Rudra Pratap is an excellent and inexpensive reference.

One-dimensional arrays are called *vectors* and two-dimensional arrays are called *matrices.* Scalars are 1-by-1 matrices. The memory manager takes care of the necessary storage allocations. There are no declarations. The entries in a Matlab array may be real or complex.

When in the *command window*, you are prompted to enter commands with a double arrow ">>"

Setting Up Arrays	Use `help` to learn more about `linspace`, `logspace`, `ones`, `zeros`, `rand`, and `randn`.

`>> x = [ 10 20 30 ]`
`x =`
`10 20 30`
	Square brackets delimit arrays. Row vector entries are separated by blanks.

`>> x = [10; 20; 30]`
`x =`
`10`
`20`
`30`
	For column vector, entries are separated by semicolons.

`>> x = [10 20 30;40 50 60]`
`x =`
`10 20 30`
`40 50 60`
	Matrix rows are separated by semicolons.

`>> x = linspace(1,3,5)`
`x =`
`1 1.5 2.0 2.5 3.0`
	`linspace(a,b,n)`: create a length-n row vector of equally spaced values from a to b inclusive.

`>> u = [1 2]; v = [3 4];`
`>> x = [u v u]`
`x =`
`1 2 3 4 1 2`
	Row vectors can be catenated to build longer row vectors. Blanks in between the vectors entries.

`>> x = [u;v;u]`
`x =`
`1 2`
`3 4`
`1 2`
	Column vectors can be "stacked" to build longer column vectors. Semicolons in between the vector entries.

`>> x = rand(2,3)`
`x =`
`.293029 .343293`
`.292930 .411275`
	`rand(n,m)`: generate an n-row, m-column matrix of random numbers, each selected from the uniform(0,1) distribution.

Some Built-In Functions	Use `help` to learn more about `length`, `size`, `max`, `min`, `sum`, `cumsum`, `prod`, `cumprod`, `sort` and `median`.. Elementary functions like `abs`, `sqrt`, `exp`, `log`, `log10`, `sin`, `cos`, `tan`, `asin`, `acos`, `atan`, `floor`, `fix`, `ceil`, `round`, `rem`, `real`, and `imag` accept array arguments and return the corresponding array of function evaluations. Try `help elfun` for a synopsis of Matlab's elementary functions.

`>> x = [30 10 80 20 60];`
 	
`>> n = length(x)`
`n =`
`5`
	The length of a vector equals the number of components.

`>> [z,idx] = max(x)`
`z =`
`80`
`idx =`
`3`
	Use max to find the largest (i.e. most positive) entry in a vector. Two values are returned. The size of the largest value and the index that identifies its location. Works for row or column vectors.

`>> z = sort(x)`
`z =`
`10 20 30 60 80`
	Sort the entries in a vector from smallest to largest (i.e. from most negative to most positive.)

`>> x = [1 2 3; 4 5 6]`
`x =`
`1 2 3`
`4 5 6`
 	
`>> [m n] = size(x)`
`m =`
`2`
`n =`
`3`
	The size of a two-dimensional array is defined by the number of its rows and the number of its columns.

Array-Level Operations	Array operations for column vectors and matrices are similarly defined. Learn more about array-level operations by typing `help ops`.

>> `x = [5 8 -2];`
`>> y = [1 2 3];`
`>> z = x+y`
`z =`
`6 10 1`
	You can add vectors as long as they have the same length and orientation.

`>> z = 3*x`
`z =`
`15 24 -6`
	This is how you multiply every entry in an array by the same scalar.

`>> z = x+7`
`z =`
`12 15 5`
	This is a shortcut for `z = x + [7 7 7]`.

`>> z = x.*y`
`z =`
`15 16 -6`
	Componentwise multiplication. Again, the vectors involved must have the same length and orientation.

`>> z = x./y`
`z =`
`5 4 -.66667`
	Componentwise division and exponentiation.

`>> z = x.^y`
`z =`
`5 64 -8`	

`>> z = x.^2`
`z =`
`25 64 4`
	A shortcut for `z = x.^[2 2 2]`.

`>> z = [1 2 3]'`
`z =`
`1`
`2`
`3`
	You can change the orientation of an array this way. Row-vectors become column-vectors and vice versa.

Numerical Input/Output	Use `help` to learn more about `format`, `disp`, `sprintf`, `input`, and `num2str`.
`>> x = pi` `x =` `  3.1416` `>> format long` `>> x = pi` `x =` `  3.14159265358979` `x= input(`Enter x:');`  `y= sqrt(x);` `s= sprintf(`sqrt = %10.6f',y);` `disp(s)`	The effect of a command is displayed if there is no semicolon after the command. The `format` command is used to establish the current display style. The `short` format (5 decimal places) is in force when Matlab is first entered. The `long` format displays full working precision. Scientific notation is available via the `short e` and `long e` formats. To solicit scalar input with a prompt, use `input`. `Disp` displays strings and `sprintf` can be used to produce formatted output strings. `%10.6f` specifies a decimal format with 6 decimal places and total space allocation of 10 characters. Use `e` format for scientific notation and d for integers.

As You Learn More Mathematics...
Matlab supports matrix-vector multiplication, linear equation solving, data fitting, differential equation solving, nonlinear equation solving, numerical integration, and many other important mathematical activities.

Script Files	Use `help` to learn more about `script`, `echo`, `type`, `cd`, `dir`, and `path`.
If a sequence of Matlab commands is stored in a file *name.m*, that sequence is invoked whenever the name of the file is entered. Thus, if the file Expo.m has the commands `x = input(`Enter the exponent x:')` `y = 2^x`  then by typing `Expo` you will be prompted for a value of `x` and `2^x` is assigned to `y` and displayed.	

Function Files	Type `help function` for more details.

New functions may be added to Matlab's vocabulary if they are expressed in terms of other existing functions. The commands that define the new function must be put in a separate file. The name of file must be the name of the function with a "`.m`" suffix. The first line in the file must be a valid function line that specifies the input and output parameters. Consider a file called `stat.m` with the following lines:

```
function [mean,stdev] = stat(x)
% Yields the mean and standard deviation of a vector x
   n= length(x);
   mean= sum(x)/n;
    stdev= sqrt(sum(x-mean).^2)/n);
```

This defines a new function called "`stat`" that calculates the mean and standard deviation of a vector. The variables within the body of the function are all local variables. Comments in Matlab begin with a "%".

Control Structures	Try `help lang` for a review of Matlab as a programming language including the `for`, `while`, and `if` constructs. The usual symbols are used for booleans: ">" (greater than), ">=" (at least), "==" (equal), "<=" (at most), "<" (less than), and "~=" (not equal). The "and", "or", "not" operations are written as "&" , "| ", "~". See also `any` and `all`.

```
d= sqrt(b^2 -4*a*c;

if d>0
   r1= (-b+d)/(2*a);
   r2= (-b-d)/(2*a);
else
   disp(`Complex
roots')
end
```

A simple if-else construct. Don't forget the `end` keyword.

```
if (x>y) & (x>z)
   maxval= x;
elseif y>z
   maxval= y;
else
   maxval= z;
end
```

Parenthesis are advised for boolean expressions.

```
if (x < 4) | (x > 5)
   disp(`x not in
[4,5]')
```

The "or" operation.

```
end

for k=i:j
   y= k^2;
   disp(sprintf(`%3d
%3d',k,y))
end
```

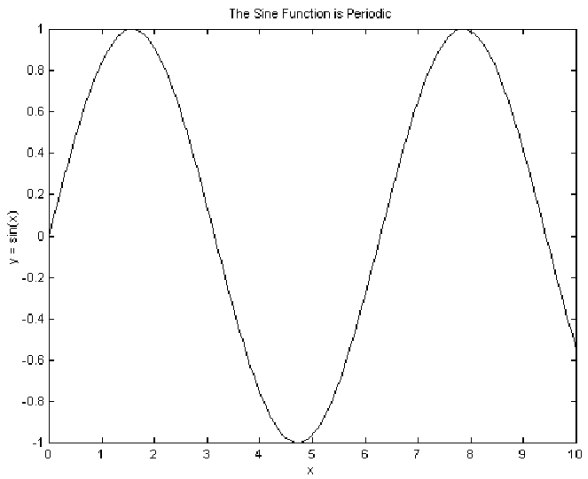
Print k and k^2 for k = i,i+1,...,j. If i > j, nothing is printed.

```
k=i
while (k<=j)
   y= k^2;
   disp(sprintf(`%3d
%3d',k,y))
   k= k+1;
end
```

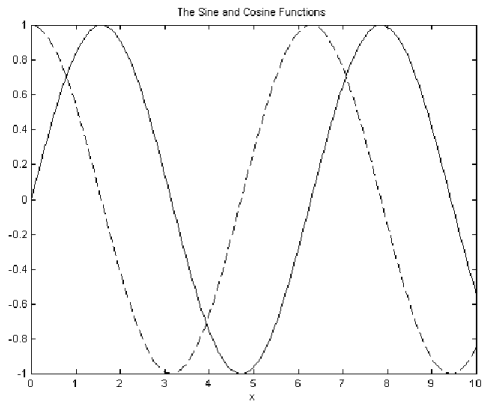
Equivalent to the above `for`-loop.

Example 1: A Simple Plot	Use `help` to learn more about `plot, xlabel, ylabel,` and `title`. See also `semilogx, semilogy, loglog, hist, bar, contour,` and `color`. More general overviews of Matlab graphics can be obtained by using help to read about `plotxy, plotxyz,` and `graphics`.

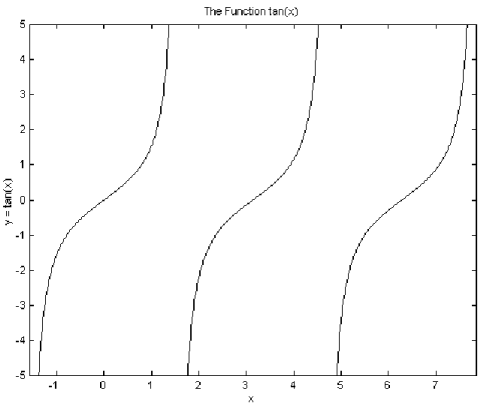
```
x= linspace(0,10,200);
y= sin(x);
plot(x,y)
xlabel(`x')
ylabel(`y= sin(x)')
title(`The Sine Function is
Periodic')
```



Example 2: Plotting More than One Function	Use `help` to learn more about `plot`.

`x= linspace(0,10,200);`
`y= sin(x);`
`z= cos(x);`
`plot(x,y,x,z,'--')`
`xlabel('x')`
`title('The Sine and Cosine Functions')`
	

Example 3: Controlling the Axes	Use `help` to learn more about `axis`.

`x= linspace(-pi/2,pi/2,200);`
`y= tan(x);`
`plot(x,y,x+pi,y,'-',x+2*pi,y,'-')`
`axis([-pi/2,2.5*pi,-5,5])`
`xlabel('x')`
`ylabel('y = tan(x)')`
`title('The Function tan(x)')`
	

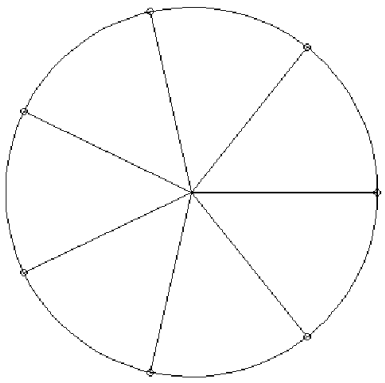
Example 4: Superpositioning	Use `help` to learn more about `axis` and `hold`.

```
a= linspace(0,2*pi);
plot(cos(a),sin(a))
axis('equal','off')
a0= linspace(0,2*pi,8);
x0= cos(a0);
y0= sin(a0);

hold on

for k=1:8
   plot([0
x0(k)],[0,y0(k)],
          x0(k),y0(k),'o')
end

hold off
```



Example 5: Subplotting	Use `help` to learn more about `subplot`, `axis`, and `text`.

```
a= linspace(0,2*pi,200);
c= cos(a);
s= sin(a);

for k=1:4
    subplot(2,2,k)
   plot(4*c,k*s)
   axis('equal')
    axis([-5 5 -5 5])
    text(-1,0,sprintf('k=
%1d',k))
end
```