The CS 100 MATLAB Syllabus

This handout outlines (through examples) the CS 100 "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

```
>> x = [ 10 20 30 ]

x =

   10 20 30

>> x = [10; 20; 30]

x =

10

20

30

>> x = [10 20 30;40 50 60]

x =

10 20 30

40 50 60

>> x = linspace(1,3,5)

x =

   1.5 2.0 2.5 3.0

>>

u = [1 2]; v = [3 4];

>> x = [u v u]

x =

1 2 3 4 1 2

>> x = [u;v;u]

x =

1 2

3 4

1 2

>> x = rand(2,3)

x =
```

Square brackets delimit arrays. Row vector entries are separated by blanks.

For columm vector entries are separated by semicolons.

Matrix rows are separated by semicolons.

`linspace(a,b,n)` sets up a length-n row vector of equally spaced values from a to b inclusive.

Row vectors can be concatenated to build longer row vectors. Blanks in between the vectors entries.

Column vectors can be "stacked" to build longer column vectors. Semicolons in between the vector entries.

`rand(n,m)` generates an n-row, m-column matrix of random numbers, each selected from the uniform(0,1) distribution.

```
.293029 .343293

.292930 .411275
```

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

Some Built-In 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 sorts 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 i sdefined by the number of its rows and the number of its columns.

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 function library.

Array-Level Operations

```
>> x = [5 8 -2];
>> y = [1 2 3];
>> z = x+y
z =
6 10 1
```

You can add to 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.

This is a shortcut for `z = x + [7 7 7]`.

```
>> z = x+7
z =
12 15 5
```

Componentwise multiplication. Again, the vectors involved must have the same length and orientation.

```
>> z = x.*y
z =
15 16 -6
>> 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.

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

Numerical Input/Output

```
>> x = pi

x =

  3.1416

>> format long

>> x = pi

x =

3.14159265358979
```

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.

```
x = input(`Enter x:');

y = sqrt(x);

s = sprintf(`sqrt = %10.6f',y);

disp(s)
```

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.

Use `help` to learn more about `format`, `disp`, `sprintf`, `input`, and `num2str`.

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

If a sequence of Matlab commands is stored in a file *name.m*, then 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.

Use `help` to learn more about `script`, `echo`, `type`, `cd`, `dir`, and `path`.

Function Files

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 "%".

Type `help function` for more details.

Control Structures

```
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. You need the `end` statement.

```
if (x>y) & (x>z)

   maxval = x;

elseif y>z

   maxval = y;

else

   maxval = z;

end
```

Parenthesis are advised for boolean expressions.

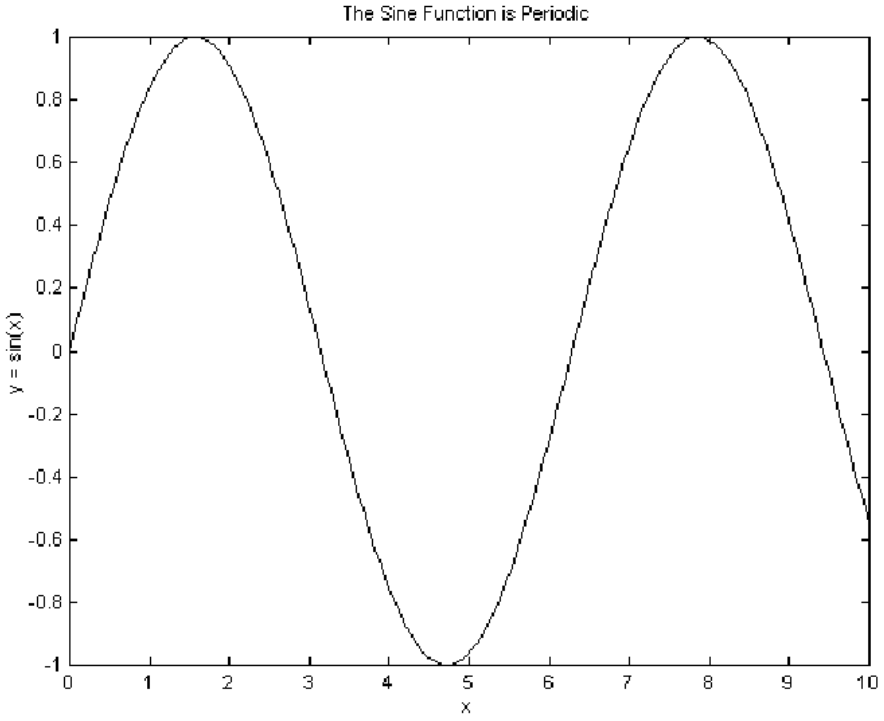
`if (x < 4) | (x > 5)` `  disp(`x not in [4,5]')` `end`	The "or" operation.
`for k=i:j` `  y = k^2;` `  disp(sprintf(`%3d %3d',k,y))` `end`	Prints k and k^2 for k = i,i+1,...,j. If the value of i is bigger than j, the loop is skipped.
`k=i` `while (k<=j)` `  y = k^2;` `  disp(sprintf(`%3d %3d',k,y))` ` k=k+1;` `end`	Equivalent to the above `for`-loop.

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 boolean work: ">" (greater than), ">=" (greater than or equal to), "==" (equal to), "<=" (less than or equal to), "<" (less than), and "~=" (not equal to). The "and", "or" and "not" operations are also legal and for this the symbols "&" , "| ", and "~" are used. See also `any` and `all`.

Example 1: A Simple Plot

```
x = linspace(0,10,200);

y = sin(x);

plot(x,y)

xlabel(`x')

ylabel(`y = sin(x)')

title(`The Sine Function is Periodic')
```

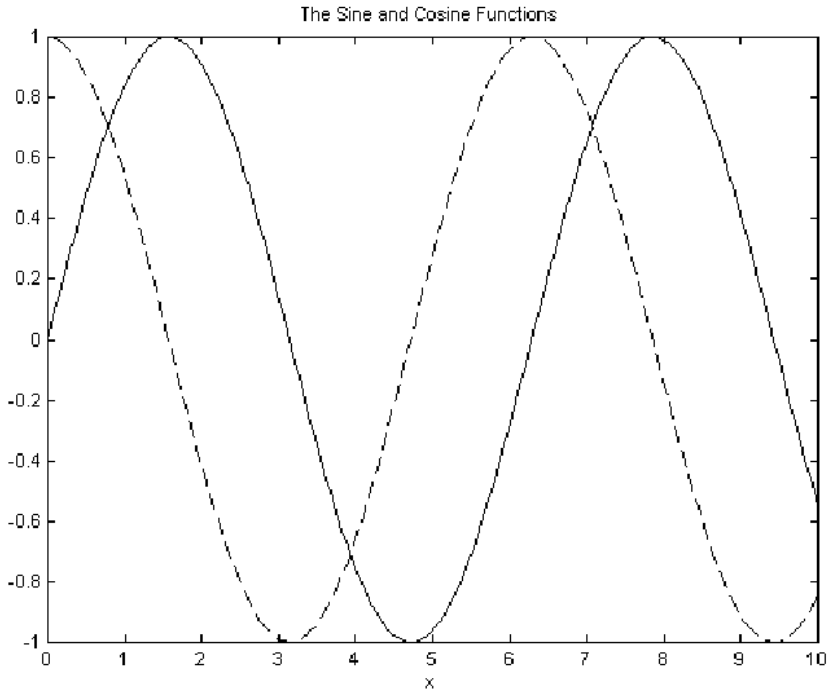
Use `help` to learn more about `plot, xlabel, ylabel,` and `title`. See also `semilogx, semilogy, loglog, hist, bar, contour,` and `color`. More general overviews of Matlab graphics can be obtained by using help to read about `plotxy, plotxyz,` and `graphics`.



Example 2: Plotting More than One Function

```
x = linspace(0,10,200);

y = sin(x);

z = cos(x);

plot(x,y,x,z,'--')

xlabel('x')

title('The Sine and Cosine Functions')
```

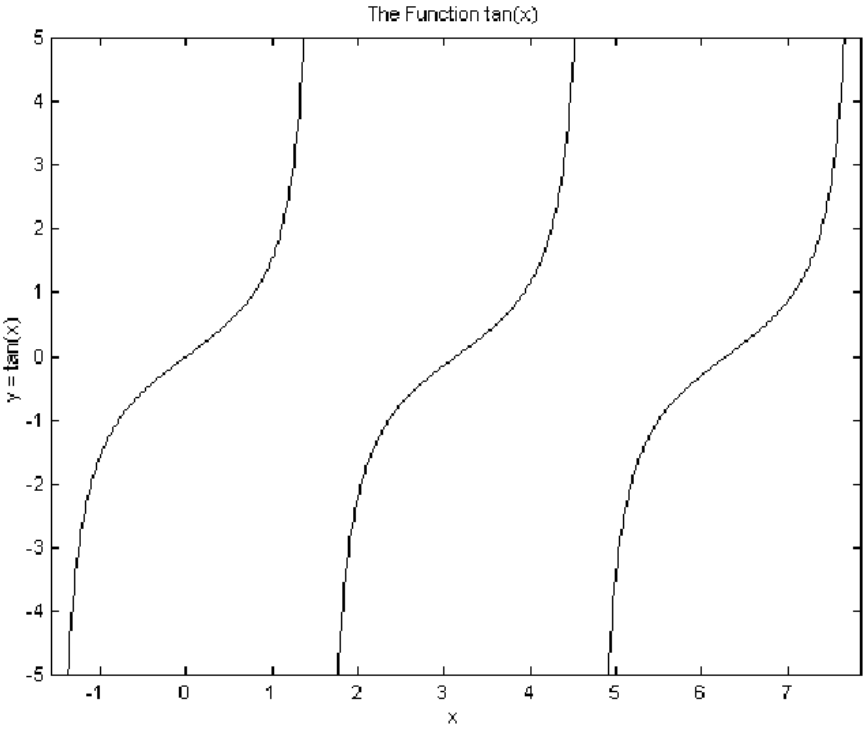
Use `help` to learn more about `plot`.



Example 3: Contolling the Axes

```
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)')
```

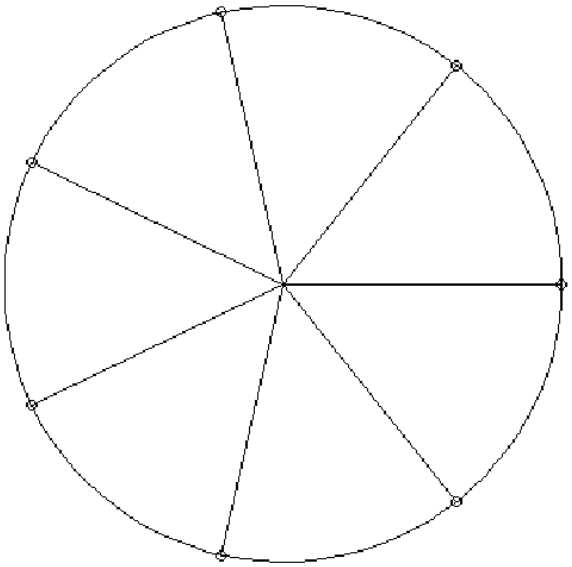
Use `help` to learn more about `axis`.



Example 4: Superpositioning

```
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
```

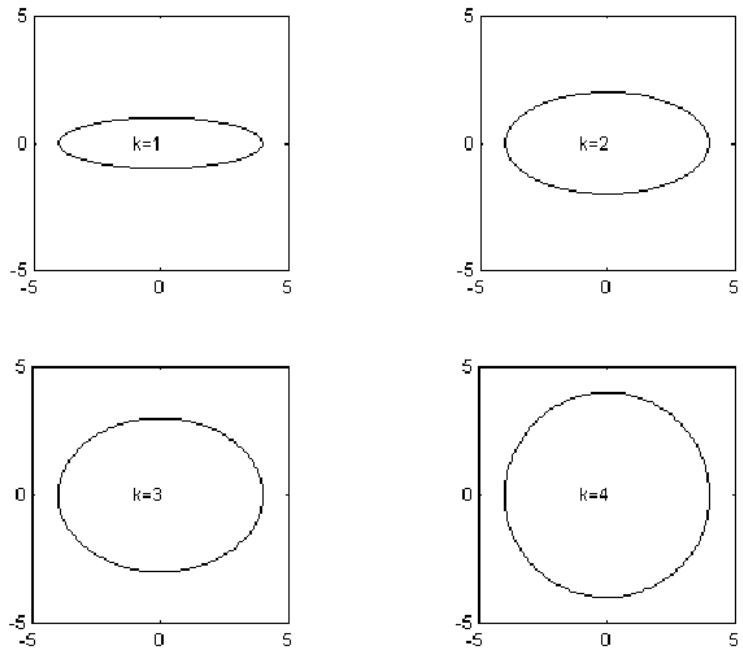
Use `help` to learn more about `axis` and `hold`.



Example 5: Subplotting

```
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
```

Use `help` to learn more about `subplot`, `axis`, and `text`.


5
0
-5
-5
0
5
k=1
k=2
k=3
k=4