Basic MATLAB

Getting MATLAB (for MIT students)

http://web.mit.edu/matlab/www/home.html

Creating matrices and vectors

```
>> rowvector = [10 20]
rowvector =
     10    20

>> columnvector = [10; 20]
columnvector =
     10
     20

>> matrix = [10 20; 30 40]
matrix =
     10    20
     30    40

>> zeromatrix = zeros(3)
zeromatrix =
     0    0    0
     0    0    0
     0    0    0

>> zerorowvector = zeros(1,3)
zerorowvector =
     0    0    0
```

Some operation of matrices/vectors. The "dot" modifier

```
>> rowvector + [1 2]
ans =
     11    22

>> rowvector * 2
ans =
     20    40

>> matrix ^ 2
ans =
      700    1000
     1500    2200

>> matrix .^ 2
ans =
      100     400
      900    1600
```

For operations that are naturally defined on matrices the dot (`.`) makes the operation to apply to every matrix element, overriding the default behavior.

```
>> rowvector .^ 2
ans =
     100     400
```

Note that `rowvector ^ 2` doesn't make sense!

```
>> 1 ./ matrix
ans =
    0.1000    0.0500
    0.0333    0.0250
```

The inverse of every element of a matrix.

```
>> matrix ^ -1
ans =
   -0.2000    0.1000
    0.1500   -0.0500
```

The inverse of the matrix.

```
>> inv(matrix)
ans =
   -0.2000    0.1000
    0.1500   -0.0500
```

Other way of obtaining the same result.

```
>> rowvector'
ans =
    10
    20
    30
```

Transposing a row vector.

```
>> matrix'
ans =
     10    30
     20    40
```

Transposing a matrix.

```
>> sum(rowvector)
ans =
    60
```

Summing the components of a vector.

What would `sum(matrix)` give us?.... Check the help!

```
>> help sum

 SUM Sum of elements.
    For vectors, SUM(X) is the sum of the elements of X. For
    matrices, SUM(X) is a row vector with the sum over each
    column. For N-D arrays, SUM(X) operates along the first
    non-singleton dimension.

    SUM(X,DIM) sums along the dimension DIM.

    Example: If X = [0 1 2
                     3 4 5]

    then sum(X,1) is [3 5 7] and sum(X,2) is [ 3
                                              12];

    See also PROD, CUMSUM, DIFF.

 Overloaded methods
    help sym/sum.m
```

```
>> sum(matrix)
ans =
    40    60
```

Remember to check the help system often! It is really easy! If you know the command that you want to obtain some info about it is as easy as typing `help command` where command is the command that you are interested in.

Exercise: Write a line that would compute the norm of a row vector.

Checking dimensions

```
>> size(matrix)
ans =
     2     2

>> size(rowvector)
ans =
     1     3

>> length(vector)
ans =
     3
```

Accessing different parts of a matrix. The "colon" modifier

```
>> matrix(1, 1)
ans =
    1

>> matrix(2, :)
ans =
     30     40

>> matrix(:, 1)
ans =
     10
     30

>> matrix(:, :)
ans =
     10     20
     30     40
```

Eigenvalues and eigenvectors

```
>>eig(matrix)
ans =
   -3.7228
   53.7228

>>[d, v] = eig(matrix)
d =
   -0.8246   -0.4160
    0.5658   -0.9094
```

```
v =
   -3.7228         0
         0   53.7228
```

Functions

If we create a file named `f.m` in the **current working directory** with this code[1]…

```
% f.m
function y = f(x, a)
y = a * x ^ 2;
```

Then, from the command window we can just evaluate the function f…

```
>> f(3, 4)
ans = 36
```

Just remember to name your .m file with the name of the function you are creating.
Note that the way we have written our function, it can also be applied to matrices (but not to vectors… why?).

```
>> f(matrix, 4)
ans =
     2800     4000
     6000     8800
```

Symbolic math

```
>> a = g ^ 2
??? Undefined function or variable 'g'.
```
Every symbol that we use has to be declared previously!

```
>> clear
```
Erase all the things that we've loaded into memory.

```
>> syms g h
```
Declare `g` and h as symbols

```
>> a = g * h
a =
      g * h
```
`a` is now a symbolic expression!

```
>> a^2
ans =
      g ^ 2 * h ^ 2
```
And we can manipulate it symbolically. We can take its square…

```
>> diff(a ^ 2, g)
ans =
      2 * g * h ^ 2
```
...differentiate its square with respect to `g`... and so on

```
>> g = 1; h = 2;
```
If we now want to evaluate for particular values of `g` and `h` we can just assign some values to them...

```
>> a
a =
      g * h
```

```
>> eval(a)
ans =
      2
```
… and then use the command `eval`.

[1] Obs: Lines that start with % are just comments

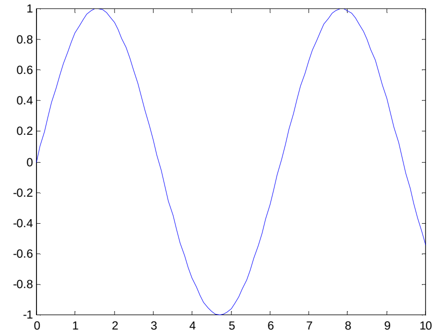
Plotting

```
>> t = 0 : 0.1 : 10;
```
We create a vector `t` that consists of all the values between 0 and 10 with a `0.1` spacing.

```
>> y = sin(t);
```
We compute the sin of all the points in `t`.

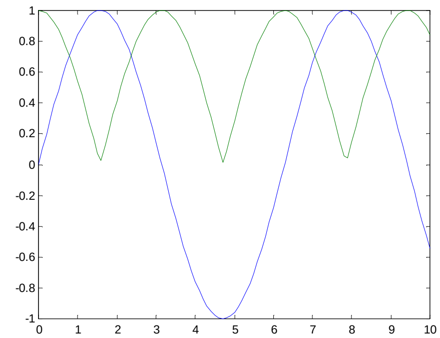
```
>> plot(t, y);
```
And now we just plot one vector vs the other!

After executing the last command we will get a new window with this plot:



Here is a more complicated plot, note that if you want to plot two curves in one figure you have to provide x and y vectors for the two functions that you want to plot.

```
>> plot(t, y, t, sqrt(1 – y .^ 2));
```



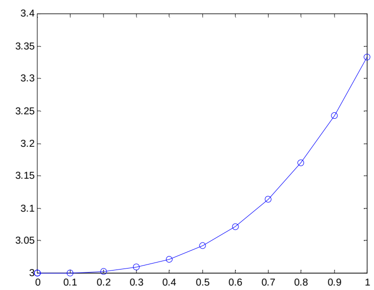
ODE Solver

```
EDU» help ode23

ODE23  Solve non-stiff differential equations, low order method.

[T,Y] = ODE23('F',TSPAN,Y0) with TSPAN = [T0 TFINAL] integrates the system of
differential equations y' = F(t,y) from time T0 to TFINAL with initial conditions
Y0.  'F' is a string containing the name of an ODE file.  Function F(T,Y) must
return a column vector.  Each row in solution array Y corresponds to a time
returned in column vector T.
```

Let’s first create a function that computes the right handside of the ODE `y' = F(t, y).`

```
% f.m
function dy = f(t, y)
dy = t .^ 2;
```

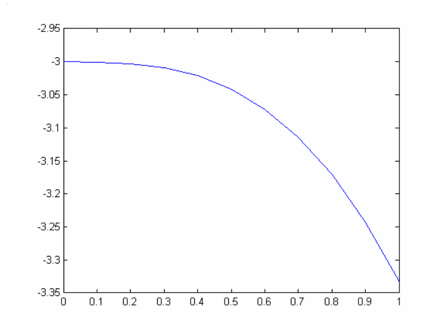
```
>> ode23('f', [0 1], 3)
```



And we automatically get a plot of the solution.

If we want to keep the output of the simulation for later processing (plotting for instance)…

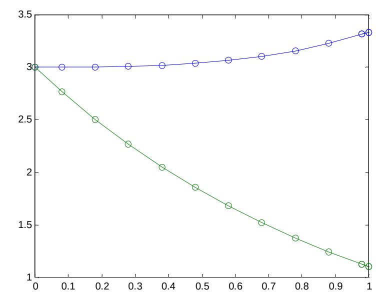
```
>> [t, y] = ode23('f', [0 1], 3);
>> plot(t, -y);
```



It is quite easy to solve multi-dimensional systems as well. Just keep in mind that ode23 requires F to be a column vector

```
% f.m
function dy = f(t, y)
dy = [t .^ 2; -y(2)];
```

```
>> ode23('f', [0 1], [3 3])
```



Matlab code 1

```
% filename: mm.m

k1  = 1e3;          % units 1/(Ms)
k_1 = 1;            % units 1/s
k2  = 0.05;         % units 1/s
E0  = 0.5e-3;       % units M
options = [];

[t y] = ode23('mmfunc', [0 100], [1e-3 0 0], options, k1, k_1, k2, E0);

S   = y(:, 1);
ES  = y(:, 2);
E   = E0 - ES;
P   = y(:, 3);
plot(t, S, 'r', t, E, 'b', t, ES, 'g', t, P, 'c');
```

```
% filename: mmfunc.m

function dydt = f(t, y, flag, k1, k_1, k2, E0)
dydt = [ - k1 * E0 * y(1) + (k1 * y(1) + k_1) * y(2); ...
         k1 * E0 * y(1) - (k1 * y(1) + k_1 + k2) * y(2); ...
         k2 * y(2)];
```

Matlab code 2

```
% filename: hasty.m

alpha   = 50;
gamma   = 20;
sigma1  = 1;
sigma2  = 5;
options = [];

[t1 y1] = ode23('hastyfunc', [0 1], [0], options, alpha, gamma, sigma1, sigma2);
[t2 y2] = ode23('hastyfunc', [0 1], [1], options, alpha, gamma, sigma1, sigma2);
plot(t1, y1(:, 1), 'b', t2, y2(:, 1), 'r');
```

```
% filename: hastyfunc.m

function dydt = f(t, y, flag, alpha, gamma, sigma1, sigma2)
dydt = [alpha * y(1) ^ 2 / (1 + (1 + sigma1) * y(1) ^ 2 + ...
                            sigma2 * y(1) ^ 4) - gamma * y(1) + 1];
```