

# Intro to Matlab for GEOL 1520: Ocean Circulation and Climate or, Notions for the Motions of the Oceans

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## 1 Contacts

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## 2 Getting Help!

I am usually available by email. You can make an appointment other times. Just check my calendar at <http://fox-kemper.com/contact> and suggest a time that works for you.

The most important commands in matlab are ‘help’ and ‘lookfor’. The first one allows to to get a description of any matlab function, for example, ‘`>> help plot`’ tells you about the function named ‘plot’. The second one allows to to search for keywords within a function description (in case you don’t know or can’t remember the name of the function).

## 3 The Basics: Matlab is Matrix Laboratory

Matlab is based on matrix algebra. So, when you think about data, you think about making arrays/vectors/matrices of data. In that way, it can be a lot like a spreadsheet program, but it is much more powerful because 1) it can handle much larger quantities of data, and 2) you can use pre-programmed solver routines to get things done.

The following contains a number of examples. Type them into matlab and see what happens! Try changing them up a bit, and see what happens then. Good hunting!

### 3.1 Scalars

Some simple examples of matlab scalar (that is one number arrays) at work::

```
>> A=1
```

```
A =
```

```
1
```

```
>> B=2
```

```
B =
```

```

    2
>> B*A
ans =
    2
>> B+A
ans =
    3
>> size(A)
ans =
    1    1
>> size(B)
ans =
    1    1
>> sqrt(B)+exp(A)
ans =
    4.1325

```

### 3.2 Vectors

Now, let's consider vectors. You can make a horizontal vector:

```

>> A=[1 1 1 1]
A =
    1    1    1    1

```

Or a vertical one:

```

>> B=[1;1;1;1]
B =
    1
    1
    1
    1

```

You can't add together a horizontal and a vertical vector:

```

>> A+B
??? Error using ==> plus
Matrix dimensions must agree.

```

But you can use the transpose single quote ' to transpose a matrix, or in this case convert an horizontal vector to a vertical one.

```

>> A'+B
ans =
    2
    2
    2
    2

```

The \* operator is a vector or matrix multiply, which in this case is the dot-product of A and B:

```
>> A*B
ans =
     4
```

While the `.*` operator multiplies component-by-component (if the vectors are the same shape...):

```
>> A' .* B
ans =
     1
     1
     1
     1
```

### 3.3 Matrices

Matrices behave in much the same way as vectors, except now there are both rows and columns.

```
>> A=[1 2 3; 4 5 6]
A =
```

```
     1     2     3
     4     5     6
```

```
>> B=[1 4; 2 5; 3 6]
```

```
B =
     1     4
     2     5
     3     6
```

```
>> A+B
```

```
??? Error using ==> plus
Matrix dimensions must agree.
```

```
>> A+B'
```

```
ans =
     2     4     6
     8    10    12
```

```
>> A.*B
```

```
??? Error using ==> times
Matrix dimensions must agree.
```

```
>> A.*B'
```

```
ans =
     1     4     9
    16    25    36
```

```
>> A*B
```

```
ans =
    14    32
    32    77
```

There are many special commands for generating matrices. The most important are:

```
>> ones(5)
```

```

ans =
    1    1    1    1    1
    1    1    1    1    1
    1    1    1    1    1
    1    1    1    1    1
    1    1    1    1    1
>> ones(3,2)
ans =
    1    1
    1    1
    1    1
>> zeros(5)
ans =
    0    0    0    0    0
    0    0    0    0    0
    0    0    0    0    0
    0    0    0    0    0
    0    0    0    0    0
>> zeros(3,2)
ans =
    0    0
    0    0
    0    0
>> eye(5)
ans =
    1    0    0    0    0
    0    1    0    0    0
    0    0    1    0    0
    0    0    0    1    0
    0    0    0    0    1
>> rand(5)
ans =
    0.8147    0.0975    0.1576    0.1419    0.6557
    0.9058    0.2785    0.9706    0.4218    0.0357
    0.1270    0.5469    0.9572    0.9157    0.8491
    0.9134    0.9575    0.4854    0.7922    0.9340
    0.6324    0.9649    0.8003    0.9595    0.6787

```

### 3.4 Accessing a Submatrix

You don't have to use the whole matrix all at once. The colon `:` plays a special role in accessing a subset of the matrix. Used alone, it means 'that whole row'. Used with a number before (A) and after(B), it means, 'that whole row from A to B'. Used with three numbers it means, 'that whole row from A to B jumping by C (A:C:B). For example:

```

>> C=[1 2 3 4 5 6; 7 8 9 10 11 12]
C =
    1    2    3    4    5    6
    7    8    9   10   11   12

```

```

>> C(1,:)
ans =
     1     2     3     4     5     6
>> C(2,:)
ans =
     7     8     9    10    11    12
>> C(:,2)
ans =
     2
     8
>> C(2,4:5)
ans =
    10    11
>> C(2,1:2)
ans =
     7     8
>> C(2,1:2:end)
ans =
     7     9    11
>> C(2,1:3:end)
ans =
     7    10
>> C(2,1:1:end)
ans =
     7     8     9    10    11    12
>> C(2,end:-1:1)
ans =
    12    11    10     9     8     7

```

### 3.5 Higher-order Tensors

Of course, you can have more indices on your variables,

```

>> A=ones(3,4,5)
ans(:,:,1) =
     1     1     1     1
     1     1     1     1
     1     1     1     1
ans(:,:,2) =
     1     1     1     1
     1     1     1     1
     1     1     1     1
ans(:,:,3) =
     1     1     1     1
     1     1     1     1
     1     1     1     1
ans(:,:,4) =
     1     1     1     1

```

```

    1    1    1    1
    1    1    1    1
ans(:,:,5) =
    1    1    1    1
    1    1    1    1
    1    1    1    1

```

But you won't be able to easily use the matrix multiply and other matrix-based arithmetic. However, it is easy to convert a submatrix into a real matrix:

```

>> A(:,2,:)
ans(:,:,1) =
    1
    1
    1
ans(:,:,2) =
    1
    1
    1
ans(:,:,3) =
    1
    1
    1
ans(:,:,4) =
    1
    1
    1
ans(:,:,5) =
    1
    1
    1
>> squeeze(A(:,2,:))
ans =
    1    1    1    1    1
    1    1    1    1    1
    1    1    1    1    1

```

### 3.6 Quiet Mode

To stop matlab from spitting everything back at you, end each statement with a semi-colon

```

>> A=ones(3)
A =
    1    1    1
    1    1    1
    1    1    1
>> A=ones(3);
>>

```

## 4 Getting and Saving Data: load, save, and loaddap

Matlab is very good at loading and saving its own kind of files, .mat files. Another useful function is 'who' which tells you the names of defined variables.

```
>> who
```

Your variables are:

```
A    B    C    ans
```

To make a .mat file, you just do the following:

```
>> save vars.mat
```

To save only a few of the variables, you list them after the desired filename:

```
>> save varsAB.mat A B
```

Now, to check what's in the files, we first clear the memory with 'clear', then

```
>> clear
```

```
>> load varsAB.mat
```

```
>> who
```

Your variables are:

```
A    B
```

```
>> load vars.mat
```

```
>> who
```

Your variables are:

```
A    B    C    ans
```

Load/Save are also capable of handling text files (with the flag `-ascii`), but you usually need to pretreat the text files, e.g., by deleting headers on columns.

Furthermore, standard unix and ms-dos commands, e.g., `ls`, `dir`, `cd`, work as expected showing the contents of directories and changing the local directory,

### 4.1 nload

The add-on function `nload` is available from the `ncx` toolbox linked from the course webpage. It allows you to load a `netcdf`-formatted dataset from a webpage almost as though it were a matlab file.

### 4.2 loaddap

The add-on function `loaddap` is available from the Matlab `OPenDap` toolbox linked from the course webpage. It allows you to load an oceanographic dataset from a webpage almost as though it were a matlab file.

## 5 Making Plots

The important plot commands are (use help 'command' for more detail):

- plot (plots scatter and line plots), e.g., `plot(1:10,exp(1:10))`
- plot3 (plots 3d scatter and line plots), e.g., `plot231:10,exp(1:10),sin(1:10))`
- figure (generates a new figure and window)
- subplot (generates a subplot within a figure for making paneled figures)
- contour (generates a contour plot), e.g., `contour(1:10,1:20,sin((1:20)'*(1:10)))`
- contourf (generates a filled contour plot), e.g., `contourf(1:10,1:20,sin((1:20)'*(1:10)))`
- axis (subselects the figure axes)
- saveas (allows you to save a figure as a jpg or pdf, etc.)
- pcolor (generates a shaded plot), e.g., `pcolor(1:10,1:20,sin((1:20)'*(1:10)))`, often used with `shading('interp')` or `shading('flat')`

## 6 Doing Stats and Calculations

These are really easy! Some examples:

```
>> A=rand(4,5)
A =
    0.7577    0.1712    0.0462    0.3171    0.3816
    0.7431    0.7060    0.0971    0.9502    0.7655
    0.3922    0.0318    0.8235    0.0344    0.7952
    0.6555    0.2769    0.6948    0.4387    0.1869
>> mean(A)
ans =
    0.6371    0.2965    0.4154    0.4351    0.5323
>> mean(A(1,:))
ans =
    0.3348
>> mean(A(:,1))
ans =
    0.6371
>> std(A(:,1))
ans =
    0.1694
>> std(A)
ans =
    0.1694    0.2909    0.4009    0.3829    0.2975
>> var(A)
ans =
    0.0287    0.0846    0.1607    0.1466    0.0885
```



## 7 Saving a Script or Function

The last piece worth mentioning here is the `.m` file format. You can type a series of commands into a file named (for example) `doit.m`. Then, while in the same directory as `doit.m`, if you type

```
>> doit
```

it will execute the commands. Whatever name you choose, followed by `.m` will be executed by typing the name. You can get a lot fancier, but we'll leave that for later.

If you define a function (see `help function`), then you can call that function from within the directory.