Geov112 - Exercise Set 1 (Deadline: 4 September 2017)

Note: These exercises cover Chapter 1 and part of Chapter 2 of McMahon. Also remember that in the anglosaxon numerical notation, which Matlab uses, commas are replaced by dots. So, for example, 'two and a half' is denoted by 2.5 *and not* 2,5.

Learning Outcomes for Exercise Set 1

In this exercise set you will learn:

1. How to open Matlab and do simple calculations (as done on a calculator)
2. How to define variables in Matlab and use these in the calculations
3. How to define vectors in Matlab and use these in calculations
4. How do write a small Matlab script, save this and print the results in a pdf file
5. Make simple computations in Matlab that are of relevance in geophysics

1. **Matlab as a calculator**

   (a) Give the Matlab commands for the following expressions:

      i. $6. * 7.0003$

      ii. $7 + (1 - 9.2)/(44.1 + 9)$

      iii. $(8 + 7.43)/(-324 - 61 * 7)$

   (b) It is always important to check whether the results of a computation make sense. Check therefore whether the answers that you got in (a) make sense, for example by roughly guessing the answer, and briefly explain your answer (using full sentences).

   (c) Find out how Matlab computes $\cos(x)$ if x is given in radians and if x is given in degrees. (Hint: type '`help cos`' at the Matlab prompt.) Explain briefly what you found out.
   Tip: When giving your answer to this exercise (and also 1c-1g) start your sentence in the Matlab script with the percentage sign % . This way Matlab will not interpret your answer as if it were a Matlab command.

   (d) Find out how to use other trigonometric functions, and their inverses, in Matlab. Give a list of the trigonometric functions.

   (e) Find out what the natural logarithm (ln) function is in Matlab and compute the natural logarithm of 30.

   (f) Find out how Matlab computes factorials and compute 23!

   (g) Find out how the exponential function is defined in Matlab and compute e^4.
   Tip: You will have found out by now that you can type
   >help tan
   and then find information on the tangent function. Another way to find information on functions is to type
   >doc tan
   This will automatically bring you to Matlab's documentation pages. The explanations given here are longer and include examples.

   (h) Find out how Matlab defines large numbers and compute 1 million squared in Matlab.

   (i) Do the exercises 1-3 at the end of Chapter 1 in McMahon (the answers can be found at the end of the book, but do not trust these answers, because there are typos). When handing in the answers also give the Matlab commands that you used.

   (j) Give the Matlab commands and answers for the following expressions:

i. $\tan 32^\circ/\pi^3$
ii. $e^{13.2} + 5i$
iii. $8^{5/3}$
iv. $6/0$
v. $6\backslash 0$
vi. Explain the answers of the last two computations.

2. (a) **Scalar variables in Matlab** Repeat exercise 1a), but now using (two or more) variables.
Tip: Use not only variables for the numbers in the given expression but also for the final answer. For example type:
>x=7
>y=8.0001
*>z=x*y*
and do not type:
>x=7
>y=8.0001
*>x*y*
The latter formally is correct and for these examples this does not matter too much. But for later exercises this will be important as the final answer (z in this case) can then be used in further computations.

(b) **Seismic Velocities.** In seismology the velocity is sometimes given as a linear function of depth. In this case we have: $v = az + b$ where v is the velocity (in m/s), z depth (in m) and a and b are two known constants. For $a = 0.1$ and $b = 2000$ use Matlab to compute the velocity at the following depths: $z = 0$, $z = 100$, $z = 200$, $z = 300$ and $z = 1000$.

(c) Again check whether the answers you get in (b) make sense.

Background: This is the first exercise in which geophysics appears. We assume that you already know some geophysics (for example from Geov111) but you do not need to know much. The concept of seismic velocity, the topic of this exercise, is of fundamental importance in geophysics. You already know that when you hear the thunder caused by a thunderstorm then the thunder travels from the place of the thunderstorm to your ear. Moreover if you can see the lightning you can estimate the time it takes for the thunder to reach your ear. This is because the light from the lightning travels with a velocity that is much faster than the velocity of the sound of the thunder. In other words we are dealing with two velocities here: the velocity of light through the atmosphere (which is about 300000 km/s) and the velocity of sound through the atmosphere (which is about 300 m/s). Seismic waves are like sound waves through air except that they travel through rocks. The velocity through rocks is higher than that through air and depends on a number of parameters the most important of which are rock type and depth. The velocity through rocks in the Earth varies roughly from 2000 m/s to 13000 m/s.

3. **Computing with Vectors in Matlab**

(a) Given two vectors $(3, 1, 7)$ and $(-3, 8, 0)$. Compute the sum of these vectors in Matlab (if you do not know the Matlab command try looking it up using the help pages). It is always important to check whether the answer that Matlab gives makes sense. Therefore, in this whole exercise, always explain whether and why the answer makes sense to you.
Tip: A useful Matlab command is the 'clear' command. For example you can erase the variable 'x' from memory by typing

>clear x
Similarly you can erase all variables in memory by typing
>clear all
You can check the variables that are in memory by checking the 'Workspace' window (this should be on the far right of your Matlab window). It is useful to use this command at the beginning of each new exercise and at the beginning of each exercise set. This way you do not mistakenly use variables in your computations that were defined in a previous exercise.

(b) Compute the maximum element of each vector.
Tip: Note that in Matlab vectors are defined using straight brackets: [and]. Also, there are two different vectors in Matlab: row vectors and column vectors. Row vectors can be defined either by using a space between the components of the vector
>x=[1 2 3]
or by separating the vector components using a comma:
>x=[1,2,3]
Column vectors are defined by separating the vector components using a semi colon:
>x=[1;2;3]
Column vectors and row vectors are completely different. In particular, it is not possible to add a row vector and a column vector. We will learn about this later on when we work with matrices

(c) Compute the minimum element of each vector.

(d) Compute the transpose of these vectors.

(e) Multiply the first vector by 4 and second vector by i.

(f) Compute the exponent of each component of the first vector.

(g) Multiply the vectors component wise.

(h) Compute the number of elements in each vector.

(i) Compute the inner product of the two vectors.

(j) Compute the cross product of the two vectors.

(k) *Tip: Another useful Matlab command is the 'home' command. If you type 'home' at the Matlab prompt Matlab will clear the Command window and move the prompt to the top of the Command window. This is helpful, for example, when you repeatedly test your script.*

4. **Working with M-files.** Open a new M-file. Give this M-file an appropriate name (for example ExerciseSet1.m). Note how the file appears in the 'Current Directory' window of Matlab.

   (a) Repeat exercises 1-3 above using your newly created .m file (and possibly 'copy' and 'paste' from the Matlab command history window).
   Tip: Use two percentage signs (%%) to separate different exercises. This way you can test these exercises separately (by clicking on the 'run section' button instead of the 'run' button) and when you publish the file Matlab will separate the exercises and the corresponding answers and also make a table of content at the beginning of the html file.

   (b) 'Publish' this .m file (i.e. create a HTML document).

5. **The volume of the Earth and its main layers.** The Earth is approximately a sphere with a radius of 6370 km (see figures 8.1 and 8.4 and table 8.1 in Fowler). To a first degree the Earth consists of 5 different layers. These

layers, with their approximate depths are: the crust (0 km-35 km), the upper mantle (35 km-660 km), the lower mantle (660 km-2900 km), the outer core (2900 km-5150 km) and the inner core (5150 km-6370 km). Use Matlab to determine the volumes and relative volumes of these 5 layers. (The relative volume (in %) is defined as (100*volume of layer/volume of the Earth)). N.B.: before typing the Matlab commands it is important to first understand what is asked and secondly use pen and paper to work out the equations that need to be implemented in detail.
Tip 1: This is the first program in which you have some serious typing. This typing can be minimized in various ways. First of all, it is useful to define the factor $4\pi/3$ *as a constant at the beginning of your programming. Secondly, it is possible to do these computations in only a few lines by defining two vectors. To find out which vectors need to be defined you can write out a couple of the equations. Doing this makes the program shorter and thus more readable and it decreases the chance of making typos.*
Tip 2: When doing computations it is important to check the results to see whether they are correct, or at the very least make sense. In this case the answers can be checked easily: the volumes of the various layers should add up so that they give the total volume of the Earth. Similarly, the relative volumes should add up to 100%. Do these two computations to make sure that your results are correct.

When you are done with exercises 1-5 'publish' them (see exercise 4), print the resulting file out and put it in the Geov112 mailbox in the 3rd floor before the deadline. If you are not sure how to do this please ask one of the teachers or teaching assistants. Also, go back to the learning outcomes on page 1 and make sure that you have mastered these (do this also for the other exercise sets). If something is not clear then think about it, go back to the exercises if necessary or ask!