PRA1004 Scientific Computing - Lab Assignments

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Week 1

General Introduction Lab Sessions

Scientific Computing is a skill course. As such, the lab assignments are the most important part of the course and will constitute a major component of your grade.

Here are some practicalities:

- You have to work together with your lab partner.
- Every lab session results in a small report, that should **briefly** describe the assignment and your implementation.
- This report should be handed in within two days (48 hours) after the lab ends, in person or via email.
- If you have any questions: do not hesitate to ask for help!
- However, keep in mind: you are in university and you are taught to think and learn by yourself. This means that, in some cases, I will not give you a (completely) satisfactory answer, but will encourage you to try and figure it out yourself!

Overview Lab 1: Matlab, Programming and Non-linear Equations

In this first lab session, you will get acquainted with Matlab, some of the basics of programming and some simple methods for solving non-linear equations. This is a lot, but hopefully you can appreciate what you learn. For instance, at the end of this lab you...

- ...understand Matlab as a advanced calculator.
- ...will know that Matlab can execute scripts, called *m-files*.
- ...know about simple programming constructs such as `if...else...` and `for` and `while` loops.
- ...understand how *functions* allow you to reuse your code.
- ...can compute the digits (up to machine precision) of $\sqrt{n}$.

NOTE: if both of you are familiar with Matlab and programming, you can choose to do only assignment 4, plus both bonus exercises.

1 Getting to know Matlab

1. Start Matlab.
2. Watch the "MATLAB On-Ramp" tutorial located at `http://www.mathworks.nl/academia/student_center/tutorials/mltutorial_launchpad.html`and try to answer the questions. Of course, just watching these videos it a bit boring. . . try out the things that are demonstrated while watching!
3. Download the "Tutorial example files" (`http://www.mathworks.nl/academia/student_center/tutorials/ML_tutorial.zip`) and save them in your home directory (you need to extract the zip file). Inspect the directory. It should contain a number of .m files.
4. From "MATLAB for Problem Solving" you should at watch the first 6 topics. The 7nd topic ("Publishing MATLAB Programs") is optional. Again, try to copy many of the things you see in matlab, don't just watch.

2 Scripts, Loops and Conditions

1. Find out in what directory you are (use the `pwd` command).
2. Create a directory `SCassign1` for your code for this first lab in your home directory. Change to this directory in Matlab (using `cd` or the navigator).
3. Create a new matlab script called `script1.m`. Why is it important to create the script in the same directory as you are currently at in matlab?
4. Edit the script such that it computes and displays (use `disp`) the following things:
   (a) an estimate of the volume of the class room
   (b) an estimate of the volume of air per person in the class room
   (c) an estimate of the time that all the air in the class room has been breathed in when each person breaths 8 litres per minute.

   Remember to create variables with meaningful names. Also add comments (using '%') to complex lines.
5. Do you remember `do`, `while` and `if`? If not, look them up again using help.
   - Still confused? Then watch the "Programming in MATLAB" tutorial at this point.
6. Create a new script `script2.m` that performs the following tasks:

(a) print out the numbers 1–25 using a `for` loop. (use `disp` to display the numbers.)
(b) print all the powers of 2 that are smaller than 100 using a `while` loop.
(c) loop through the numbers 1-50 and print the number if it is divisible by 3 or 7.
(d) print out all the prime numbers between 1 and 50. Tip: use the `factor` function.

3 (User defined) Functions

Now it is time to write your own functions.

3.1 Functions as in an M-file

Here you will learn to define your own functions in an .m file.

1. Watch the "Programming in MATLAB" at this point (if you did not do so before).
2. Make a copy of the part of `script2.m` you used for 5(d) and call it `print_primes.m`.
3. Adapt it such that it becomes a function that let's you specify the range in which you want to search for primes.
4. Adapt it such that it makes use of a new function called `is_prime`.

3.2 Anonymous functions

Sometimes it is convenient to give a short function a name, but defining an m-file is too burdensome. In this case, we can use what are called *anonymous functions.* For instance, we can define a function called 'add' as follows

```
> add = @(a,b) a+b
add =
@(a, b) a + b
> add(3,2)
ans = 5
> feval(add,3,2)
ans = 5
```

Now you should try the following in a new m-file

1. define an anonymous function that performs substraction (`sub`) and multiplication (`mul`).
2. make a copy of one of the substraction function (use `copy_name = old_function_name`)
3. swap the definitions of `sub` and `mul.`
4. Question: why (i.e., when?) would you want to use the `feval` function?

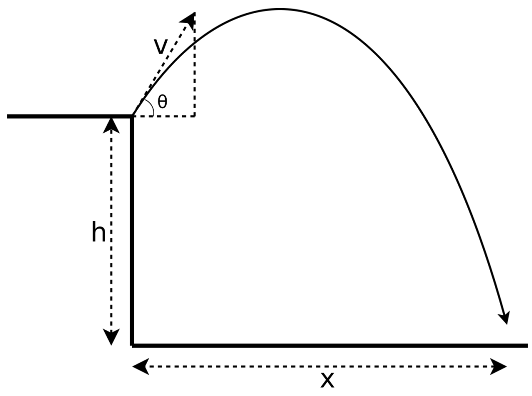

Figure 1: The cliff problem.

4 Newton's Method

In this assignment you will implement Newton's method to compute the digits of $\sqrt{2}$.

1. Write down the function f for which $\sqrt{2}$ is a root.
2. Write down the derivative f'.
3. Derive (2.7) on page 47 of the book.
4. Implement Newton's method to find the digits of $\sqrt{2}$. Use `format` to display all 16 significant digits.
5. Compare your implementation to the one in the book. What are the differences? Are there parts of your implementation that you think could be improved?

5 BONUS Assignments

As a bonus excercise you may chose to one of the following bonus exercises.

5.1 Bonus 1

Implement Newton's method for the following problem. Anne is standing at the edge of a cliff of height h (m) and throws a rock with speed v (m/s) under an angle θ. See Figure 1 for an illustration of this problem. We assume there is no friction, but that otherwise the experiment takes place on earth (so the gravitational acceleration $g = 9.8m/s^2$). How far does the rock travel horizontally before hitting the ground when $h = 14.5$m, $v = 30$m/s and $\theta = 34°$?

5.2 Bonus 2

Implement the bisection method to compute $\sqrt{2}$.