Exercise 1, September 26, 2017 (ex01)

1 General Information

Each week you are expected to do an exercise (may contain more than one task) as a complementary to what you learn in the lectures. The solution of each week's exercise is to be handed over during the following week, before the next session. In order to receive the *Testat*, you need to do at least 70% of the exercises (at least 9 out of the 13 exercises).

To each exercise an *exercise sheet* is associated where you can find the description of the assigned tasks. They can be found at:

`http://www.ifb.ethz.ch/education/bsc-courses/bsc-intro-comphys.html`

While the exercise session is mainly a time for you to ask questions, we usually give also a brief description of the tasks at the beginning (may include additional information to the exercise sheet). For most exercises the major part of the work can be done in the exercise session, where we will be available to help you directly. Therefore, we recommend you to be present and save much of the time you would need to solve the tasks alone.

Your solutions should include results (usually graphical output) and some discussion, combined into one pdf file. Please follow the link *template* on the web page of the course, where you can find a template for the report (`report.pdf`). The template is very basic and is there to give you an idea of how the report should be structured. You can use it, modify it or use your own style. Included, there is also the latex source file for those of you who want to use LaTeX to write the report (see `https://en.wikibooks.org/wiki/LaTeX` to learn more). Of course, you are welcome to use any other word processor, as long as the report is submitted in pdf format. For those who wish to use `gnuplot` to plot the results, there is a script `figure.gplt` which you can modify and use to create your own figure files.

The solutions should be sent to us by email in the following way:

- Create a directory with its name containing the number of the exercise and your name: `mkdir ex01_meier_thomas`.
- Copy the files related to the solution into this directory. The files should be formatted in a readable way, e.g. your report (pdf), and code (plain text).
- Change into parent directory and zip the directory:
  `zip -r ex01_meier_thomas.zip ex01_meier_thomas`
- Send only the zipped file to the following email address: `cpexethz@gmail.com`.

2 Tasks

Task 1

Write a program generating random numbers using a congruential random number generator. First, use small values for c (< 50) and p (< 50), e.g. $c = 3$ and $p = 31$.

- Check for correlations using the square test, i.e. create the corresponding plot. (What is the maximum number of random numbers which have to be created until you can see all possible lines/planes for this specific random number generator?)
- Create the 3D-plot for the cube test. (Optional)
- Do the same for other random number generators (at least one!), e.g. by changing c and p. You may also compare the built-in generators `rand()` and `drand48()`.

Task 2

Generate a homogeneous distribution of random points inside a circle. How should the coordinates r and ϕ be chosen using uniformly distributed random numbers?

Task 3

Test your random number generator for different c and p using the χ^2-test described in the following:

- Divide the range of random numbers into k bins, i.e. discrete intervals of same size, so that the probability of a random number to be in interval i is $p_i = 1/k$.
- Using each random number generator, generate at least one sequence of n numbers. For each sequence, measure the count N_i in each interval i (choose n such that all $np_i \geq 5$).
- Compute the χ^2 value for one specific sequence s of random numbers

  $$\chi_s^2 = \sum_{i=1}^{k} \frac{(N_i - np_i)^2}{np_i}$$

  and use the table in the script `chi_square_description.pdf` (from Donald E. Knuth, The Art of Computer Programming, Volume 2) to check the reliability of different random number generators.
- Calculate χ_s^2 for different sequences (i.e. different seeds of the RNG). You can then plot the cumulative probability for the χ^2 in comparison to the theoretical expectancy (values again from the table, see above). (Optional)