

# Project 5, deadline December 15, 2019

## Computational Physics I FYS3150/FYS4150

Department of Physics, University of Oslo, Norway

Fall semester 2019

### Studies of social interactions using the Ising model

More text will come

**Introduction.** The aim of this project is to study a widely popular model to simulate phase transitions, the so-called Ising model in two dimensions and apply it to modeling of electoral patterns and social interactions.

In its simplest form the energy of the Ising model is expressed as, without an externally applied magnetic field,

$$E = -J \sum_{\langle kl \rangle}^N s_k s_l$$

with  $s_k = \pm 1$ . The quantity  $N$  represents the total number of spins and  $J$  is a coupling constant expressing the strength of the interaction between neighboring spins. The symbol  $\langle kl \rangle$  indicates that we sum over nearest neighbors only. We will assume that we have a ferromagnetic ordering, viz  $J > 0$ . We will use periodic boundary conditions and the Metropolis algorithm only. The material on the Ising model can be found in chapter 13 of the lecture notes. The Metropolis algorithm is discussed in chapter 12.

**For this project you can hand in collaborative reports and programs.** This project (together with projects 3 and 4) counts 1/3 of the final mark.

**Project 5a):**

**Project 5b): Writing a code for the Ising model.**

**Project 5c): When is the most likely state reached?**

**Project 5d): Analyzing the probability distribution.**

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## Project 5e):

### Background literature

If you wish to read more about the Ising model and statistical physics here are three suggestions.

- [M. Plischke and B. Bergersen](#), *Equilibrium Statistical Physics*, World Scientific, see chapters 5 and 6.
- [D. P. Landau and K. Binder](#), *A Guide to Monte Carlo Simulations in Statistical Physics*, Cambridge, see chapters 2,3 and 4.
- [M. E. J. Newman and T. Barkema](#), *Monte Carlo Methods in Statistical Physics*, Oxford, see chapters 3 and 4.

### Introduction to numerical projects

Here follows a brief recipe and recommendation on how to write a report for each project.

- Give a short description of the nature of the problem and the eventual numerical methods you have used.
- Describe the algorithm you have used and/or developed. Here you may find it convenient to use pseudocoding. In many cases you can describe the algorithm in the program itself.
- Include the source code of your program. Comment your program properly.
- If possible, try to find analytic solutions, or known limits in order to test your program when developing the code.
- Include your results either in figure form or in a table. Remember to label your results. All tables and figures should have relevant captions and labels on the axes.
- Try to evaluate the reliability and numerical stability/precision of your results. If possible, include a qualitative and/or quantitative discussion of the numerical stability, eventual loss of precision etc.
- Try to give an interpretation of your results in your answers to the problems.
- Critique: if possible include your comments and reflections about the exercise, whether you felt you learnt something, ideas for improvements and other thoughts you've made when solving the exercise. We wish to keep this course at the interactive level and your comments can help us improve it.

- Try to establish a practice where you log your work at the computerlab. You may find such a logbook very handy at later stages in your work, especially when you don't properly remember what a previous test version of your program did. Here you could also record the time spent on solving the exercise, various algorithms you may have tested or other topics which you feel worthy of mentioning.

## Format for electronic delivery of report and programs

The preferred format for the report is a PDF file. You can also use DOC or postscript formats or as an ipython notebook file. As programming language we prefer that you choose between C/C++, Fortran2008 or Python. The following prescription should be followed when preparing the report:

- Use Devilry to hand in your projects, log in at <http://devilry.ifi.uio.no> with your normal UiO username and password and choose either 'fys3150' or 'fys4150'. There you can load up the files within the deadline.
- Upload **only** the report file! For the source code file(s) you have developed please provide us with your link to your github domain. The report file should include all of your discussions and a list of the codes you have developed. Do not include library files which are available at the course homepage, unless you have made specific changes to them.
- In your git repository, please include a folder which contains selected results. These can be in the form of output from your code for a selected set of runs and input parameters.
- In this and all later projects, you should include tests (for example unit tests) of your code(s).
- Comments from us on your projects, approval or not, corrections to be made etc can be found under your Devilry domain and are only visible to you and the teachers of the course.

Finally, we encourage you to work two and two together. Optimal working groups consist of 2-3 students.