MATR323 Basics of Monte Carlo Simulations (2020-2023)

⚠ HUOM! OPINTOJAKSOJEN TIETOJEN TÄYTTÄMISTÄ KOORDINOIVAT KOULUTUSSUUNNITTELIJAT HANNA-MARI PEURALA JA TIINA HASARI

1. Course title

Monte Carlo -simulointien perusteet
Grunder för Monte Carlo-simuleringar
Basics of Monte Carlo Simulations

2. Course code

MATR323

Aikaisemmat leikkaavat opintojaksot 530006 Monte Carlo simulointien perusteet, 5 op.

3. Course status: optional

-Which degree programme is responsible for the course?
Master's Programme in Materials Research

-Which module does the course belong to?
MATR3002 Computational Materials Physics, Advanced Studies
MATR3003 Medical Physics and Biophysics, Advanced Studies
PAP3001 Astrophysical Sciences, Advanced Studies
PAP3002 Particle Physics and Cosmology, Advanced Studies
TCM300 Theoretical and Computational Methods, Advanced Studies

-Is the course available to students from other degree programmes?
Yes

4. Course level (first-, second-, third-cycle/EQF levels 6, 7 and 8)

Master's level, degree programmes in medicine, dentistry and veterinary medicine = secondcycle degree/EQF level 7
Doctoral level = third-cycle (doctoral) degree/EQF level 8

-Does the course belong to basic, intermediate or advanced studies (cf. Government Decree on University Degrees)?
Advanced studies

5. Recommended time/stage of studies for completion

The course can be taken at any time, when it is available.

6. Term/teaching period when the course will be offered

The course is given annually during the third teaching period (spring term).

7. Scope of the course in credits

5 cr

8. Teacher coordinating the course

Flyura Djurabekova

9. Course learning outcomes

After completion the course you will be able:

- Generate uniform and non-uniform random numbers by using different methods
- Apply pseudo- and quasirandom numbers for different tasks
- Perform Monte Carlo integration of multidimensional functions
- Estimate the statistical error of the mean for different methods
- Generate the synthetic data to improve on estimation of the average and the error of the mean
- Improve the convergence of the Monte Carlo integration result using different methods
- Create your own Game of life by using the Cellular automata principle

10. Course completion methods

The attendance of the lectures is recommended. Returning home completed exercises is mandatory. The exercises are aimed to test the programming skills of students. These will contribute equalliy to the final grade of the exam along with the answers to the exam questions.

11. Prerequisites

The programming skills are mandatory. Basic knowledge of probability theory is recommended.

12. Recommended optional studies

Monte Carlo in Physics

13. Course content

Uniform random numbers

- Pseudo-Random Number Generators (RNG):
    - linear algorithms: congruential and generalised feedback shift register(GFSR)
    - non-linear algorithms: developments of congruential and twisted GFSR and Mersenne Twister RNG
- Stratified methods
- Quasi- RNG

Non-uniform random numbers

- Inversion, hit and miss and combined methods
- Markov chain

Monte Carlo integration, improving convergence of the Monte Carlo integration

Analysis of Monte Carlo integration result: estimation of the error of the mean

Generation of synthetic data to improve the analysis

Cellular automata and self-organized critical phenomena

14. Recommended and required literature

- Lecture notes and Supplementary material
- Numerical Recipes in C,
- The art of scientific computing, 2nd edition
- W.H. Press, S.A. Teukolsky, W.T.Vetterling, B.P.Flannery

15. Activities and teaching methods in support of learning

Exercises are designed to help students to understand better the material of the course. Regular programming will help to implement the received knowledge during the course in practice.

16. Assessment practices and criteria, grading scale

The final exam is held in form of answering theoretical questions in form of essays, however, the grade for the exercises performed during the course give 50% of the total weight.

17. Teaching language

English