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| **Course unit title** | **MATHEMATICAL MODELS AND TOOLS** |
| **Course unit code** | InfT6015 |
| **Type of course unit** | A part – Compulsory part |
| **Level of course unit** | 2nd cycle (Master) |
| **Year of study** | - |
| **Semester** | IV |
| **Number of ECTS credits** | 3 |
| **Name of lecturer(s)** | Jevgeņijs Kaupužs, Dr.phys. |
| **Learning outcomes of the course unit** | **Aims of the course**  The aim of the course is to impart knowledge and skills, which are required for making mathematical models and doing practical tasks, as well as develop skills in versatile usage of appropriate computerized tools for solving problems of modelling.  **Objectives of the course**  To master practical skills in doing tasks and programming.  Acquire different Monte Carlo's modelling algorithms and master practical skills in realizing them, using available programming tools.  To acquire basics of mathematical technology, using mathematical programme packets DERIVE, MatLab, MATHEMATICA.  **Results of the course (competences to be developed)**  Knowledge and skills, which are needed for making mathematical models and doing practical tasks |
| **Mode of delivery** | Face-to-face |
| **Prerequisites and co-requisites** | Differential equations, basics of programming |
| **Recommended optional programme components** | - |
| **Course contents** | In introduction of the course are considered basic equation of mathematical physics: waves’ equation, equation of diffusion and thermal conductivity, Poisson's equation, Fokker–Planck equation and Navier–Stokes equation, which define physical processes in optics and acoustics, processes of thermal transfer and diffusion, as well as electro dynamic and hydrodynamic processes in material environments.  In the course are considered current problems with modelling traffic flow and different types of mathematical models of traffic flow: Brando model, Nagel-Schreckenberg model and scholastic models, which are based on Master equation. These equations describe group of automobiles as interacting multi-piece system and development of traffic jams as phases’ transition, which can be modelled on a computer.  Basics of Monte Carlo modelling are considered, as an example using Ising model. In the concrete algorithms of Metropolis and Wolf are considered, to gain functions and average quantity of thermodynamic balance division, which describes model's performance in order of temperature and size of grid. |
| **Course plan** | |  |  | | --- | --- | | **Theme** | **Sub-theme** | | 1. Mathematical models. Fundamental notions of mathematical modelling. | * 1. Basic equations of mathematical physics      1. Waves equation      2. Equation of diffusion and thermal conductivity      3. Poisson's equation      4. Fokker–Planck equation      5. Navier–Stokes equation | | 1. Methods and techniques of mathematical modelling in investigation of traffic flow | 2.1 Dynamic models of traffic flow and Bando model  2.2 Analysis of stability of automobiles flow in Brando model  2.2.1 Dimensional homogeneous stationary flow's stability area  2.2.2 Dynamic system's limit cycle as dimensional no homogeneous state  2.3 Differential equations' system numerical solution within the framework of Bando model of traffic flow  2.4 Usage of Markov scholastic processes in modelling traffic flow  2.4.1 Introduction in scholastic processes  2.4.2 Master equation and its usage in description of automobiles cluster or development of traffic jams dynamic  2.4.3 Analytical solving of Master equation in simple cases  2.4.4 Numerical solution of Master equation with scholastic trajectory generating method  2.4.5 Traffic flow's dependence on density of automobiles and phases transition  2.5 „Cellular automaton models and Nagel-Schreckenberg model. | | 1. Methods and techniques of Monte Carlo mathematical modelling | 3.1 Introduction in statistical mechanics  3.2 Thermo dynamical balance and fluctuations   * 1. Basic principles of Monte Carlo modelling of thermodynamic balance      1. Estimation of average dimension of distribution of Bolcman      2. Markov process      3. Ergodicitity      4. Detailed balance and transitional | |  | probability relations   * 1. Usage of Monte Carlo methods for Ising model      1. Ising model      2. Metropolis algorithm      3. Consummation of thermodynamic balance      4. Monte Carlo measurement and evaluation of statistic mistakes      5. Systematic mistakes   2. Other Monte Carlo algorithms for Ising model      1. Wolf algorithm and its characteristics      2. Svensson-Wang algorithm   3. Processing of Monte Carlo data set      1. Construction of flexion with smallest square method      2. Criteria for validity   3.7. Accidental number generators | |
| **Recommended or required reading** | C. W. Gardiner, Handbook of Stochastic Methods for Physics, Chemistry, and Natural Sciences, Springer, Berlin, 1983  M. E. J. Newmann, G. T. Barkema, Monte Carlo Methods in Statistical Physics, Clarendon Press, Oxford, 1999  B.Kutzler, V.Kokol-Voljc. Ievads datoralgebras sistēmā Derive5.  R. Mahnke, J. Kaupužs, I. Lubashevsky, Probabilistic description of traffic flow, Physics Reports, vol. 408, 2005 |
| **Planned learning activities and teaching methods** | Lectures, practical works, seminars, student's individual work |
| **Assessment methods and criteria** | **Test**  All practical works has to be done. Successfully passed credit test, where has to be acknowledged skills in solving tasks and in knowledge in theory |
| **Language of instruction** | English |
| **Work placement(s)** | N/a |