**AL-FARABI KAZAKH NATIONAL UNIVERSITY**

**Faculty of Mechanics and Mathematics**

**Department of Fundamental Mathematics**

**Educational program in the specialty «5M060100-Mathematical and Computer Modeling».**

**SYLLABUS**

**The basic compulsory module №2**

**Numerical Solution of the Rheology Problem**

**Fall semester, 2018-2019**

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| **Discipline’s code** | **Discipline’s title** | **Type** | **No. of hours per week** | **Number of credits** | **ECTS** |
| **Lect.** | **Pract.** | **Lab.** |
| **МА1401** | Numerical Solution of the Rheology Problem | ED | 2 | 0 | 1 | 3 | 5 |
| **Prerequisites** | Mathematical Analysis, Algebra and Geometry, Information Science, Probability Theory and Mathematical Statistic, Stochastic Processes, ODE, PDE, Numerical Methods, Calculus, Calculations, Computations, Monte Carlo methods, Mathematical Modelling, Hydrodynamics, Filtration Process.  |
| **Lecturer**  | Kanat Shakenov, Doctor of Physical and Mathematical Sciences, Professor | **Office hours** | Scheduled |
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| **Telephone number** | Telephone: +7 727 2211591, +7 705 182 3129 | **Auditory** | room 319 |
| **Teacher (laboratory studies)** | Saule Zamanova  | **Office hours** | Scheduled |
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| **Description of the discipline** | Research of the stochastic models and theirs computer simulation.  |
| **Course Objective** | The main purpose of the course is construction of the stochastic models and computer realization.  |
| **Learning Outcomes** | By the end the course, students should be able to: * Intimate knowledge of the stochastic process – Markov chains. Monte Carlo Methods.
* Ability simulate of the stochastic process.
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| **Literature and Information resources** | **Recommended Textbooks (main):**1. MolokovichY.M., Osipov P.P. Basics of relaxation filtration theory. Proceeding of Kazan University, 1987. Pages 106. (In Russian).
2. Christian P. Robert, George Casella. Monte Carlo Statistical Methods. Second Edition. Springer. 2004.
3. Kushner Harold J. Probability Methods of Approximations in Stochastic Control and for Elliptic Equations. Academic Press, New York – San-Francisco – London, 1977.
4. Sobol’ I.M. Monte Carlo Method. Moscow, 1985. (In Russian).
5. Sobol’ I.M. Monte Carlo Numerical Methods. Moscow, Nauka, 1973. (In Russian).
6. Ermakov S.M. Monte Carlo Methods and Adjacent Questions. Moscow, Nauka, 1975. (In Russian).

**Additional textbooks:**1. Ermakov S.M., Mihailov G.A. The Statistical Modelling. Moscow, Nauka, 1983. (In Russian).
2. Shakenov K.K. Monte Carlo Methods and Applications. Methodical working. Almaty, KazSU, 1993. (In Russian).
3. Smagulov Sh., Shakenov K.K. Monte Carlo Methods in Hydrodynamic and Filtration Problems. Publishing House “Kazakh University”, 1999. P. 270. (In Russian).
4. Kanat Shakenov. Numerical Modeling of the one Model of Filtration Process by Monte Carlo Methods. Series "Applied and Numerical Harmonic Analysis". Book "Methods of Fourier Analysis and Approximation Theory". Springer. Berkhäuser. 2016. P. 237 – 258.
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| **Organization of the course** | Structure of the course: 1.Lectures, 2. Laboratory**.** At a lectureto give the theoretical materials.At a laboratory to give stochastic calculations on PC. The homework may be preset (specified) according to the requirements. |
| **Course Requirements** | 1. The students at first of theoretical materials (lectures) attend. They must to know theoretical materials. 2. Next, to conduct PC Laboratory. Student with PC must construct the numerical model and graphic plot. 3. Student on one's own (or with teacher) must know how computational process analyses. To draw a right conclusion and the model identify.
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| **Evaluation system** | Criteria-based evaluation: assessment of learning outcomes in correlation with descriptors (verification of formation of competences on attestation controls and examinations).Summative assessment: evaluation of attendance and activity in the classroom; evaluation of assignments and Student’s Individual Studies (SIS1, SIS2). These types of evaluation are given in the table below:

|  |  |
| --- | --- |
| Types of work | % |
| Individual tasks | 35% |
| Group project | 10% |
| Analytical problem  | 15% |
| Exams | 40% |
| TOTAL | 100% |

Your final grade is calculated by the formula:Total = 0.6\*(At1+At2)\2+0.1\*MidTermExam+0.3\*FinalExam The final grade will be calculated according to the evaluation system accepted in University: 95% - 100%: А 90% - 94%: А-85% - 89%: В+ 80% - 84%: В 75% - 79%: В-70% - 74%: С+ 65% - 69%: С 60% - 64%: С-55% - 59%: D+ 50% - 54%: D- 0% -49%: F |
| **Policy of Discipline** | All work must be performed and defend within a specified time. Students who do not pass a regular job or received for his performance at least 50 % of points, have the opportunity to work on additional specified job schedule. Students who missed labs for a good reason, and spend their extra time in the presence of a laboratory, after the admission of the teacher. Students who have not complied with all types of work for the exam are not allowed. Also, take into account when assessing the activity and attendance of students during class be tolerant and respect other people's opinions. Objections formulated in the correct form. Plagiarism and other forms of cheating are not allowed. Unacceptable prompting and copying during delivery SSS intermediate control and final exam, copying solved problems others, exam for another student. Student convicted of falsifying any information rate, unauthorized access to the Intranet using cribs, with a final grade «F».For advice on the implementation of independent work (SSS), and surrender their protection as well as for more information on the studied material and all other emerging issues by reading a course, contact the instructor during his office hours. |

**STRUCTURE AND CONTENT OF DISCIPLINE**

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| --- | --- | --- | --- |
| **Week** | **Topics** | **Hours** | **Max point** |
| **Module 1. Introduction (sets, real numbers).** |
| 1-2 | *Lecture 1-4.* Theory and underlying principles and equations of relaxation filtration.  | 4 | 8 |
| *Tutorial 1-4.* Setting of a mathematical problem. Algorithms of solution by Monte Carlo and probability difference methods. | 4 | 8 |
| *SSI 1 – 4.*Non-stationary equilibrium and nonequilibrium filtration process. |  | 4 |
| 3-4 | *Lecture 5-8.* Mathematical statement of Dirichlet, Neumann and mixed problems of filtration process models in elastic porous environment. | 4 | 8 |
| *Tutorial 5-8.* Setting of mathematical problems. Solution of the problems by Monte Carlo and probability difference methods.  | 4 | 8 |
| *SSI 5 – 8.*The model of filtration in relaxationaly-compressed environment realizable by the linear Darcy law. |  | 4 |
| 5-6 | *Lecture* 9 – 12.Mathematical problems for model relaxation filtration in relaxationaly-compressed environment realizable by the linear Darcy law. | 4 | 8 |
| *Tutorial* 9 – 12. Algorithm of solution by Monte Carlo and probability difference methods.  | 4 | 8 |
| *SSI 9 – 12.*The classical elastic behavior (regime) model of filtration. |  | 4 |
| 7-8 | *Lecture* 13 –16.Mathematical problems (Dirichlet, Neumann and mixed) for classical elastic behavior model of filtration. | 4 | 8 |
| *Tutorial* 13 –16.Algorithm of solution by Monte Carlo and probability difference methods.  | 4 | 8 |
| *SSI 13 –14.*The filtration model by primary nonequilibrium law in elastic porous environment. |  | 4 |
|  | **Attestation №1.** |  | **100** |
|  | ***Mid-term*** |  | **100** |
| 9-10 | *Lecture* 17 –20.Mathematical problems (Dirichlet, Neumann and mixed) for primary filtration model with spread of steady speed perturbation. | 4 | 8 |
| *Tutorial* 17 –20. Algorithm of solution by Monte Carlo and probability difference methods.  | 4 | 8 |
| *SSI 17 –20.*Primary filtration model with spread of steady speed perturbation. |  | 4 |
| 11-12 | *Lecture 21 – 24.*Closed system equations of linear relaxation filtration. 1. Law of conservation of impulse of resistance force. 2. Linearized law of conservation of fluid mass. Example. Closed system equations (PDE) of linear relaxation filtration. 3. Defining relationship for impulse of resistance force. 4. Defining relationship for fluid mass. Example.  | 4 | 8 |
| *Tutorial 21 – 24.*1.Relaxation kernel of filtrationlaw. 2. Relaxation kernel of fluid mass.  | 4 | 8 |
| *SSI 21 – 24.*PDE for pressure and filtration velocity.  |  | 4 |
| 13-15 | *Lecture 25 – 30.*The Solution of the Boundary Value Problem of Poisson and Helmholtz Equations by Monte Carlo and Probability Difference Methods. Green function of Helmholtz operator of the ball. Algorithms “Random walks on spheres” and “Random walks on lattices”. Continuous Markov Chains. Theorem of Variance.The Solution of the Initial Boundary Value Problem of Parabolic Equation by Monte Carlo and Probability Difference Methods. Continuous Markov Chains. Theorem of Variance. The Solution of the Initial Boundary Value Problem of Hyperbolic Equation by Monte Carlo and Probability Difference Methods. Continuous Markov Chains. Theorem of Variance.  | 6 | 10 |
| *Tutorial 25 – 30.* Unbiased Estimate of the Solution of Boundary Value Problem of Poisson and Helmholtz Equations. Modelling of Markov Chains. Unbiased Estimate of the Solution of the Initial Boundary Value Problem of Parabolic Equation. Modelling of Markov Chains. Unbiased Estimate of the Solution of the Initial Boundary Value Problem of Hyperbolic Equation. Modelling of Markov Chains. | 6 | 10 |
| *SSI 25 – 30.*Estimate of derivative of solution on parameter. Unbiased Estimate of the Solution.  |  | 6 |
|  | **Attestation №2.** |  | **100** |
|  | **Final Exam** |  | **100** |
|  | **Total = 0.6\*(At1+At2)\2+0.1\*MidTerm+0.3\*Exam** |  | **100** |

Dean of the Faculty \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ D. B. Zhakebayev

Chairman of the Faculty Methodical Bureau \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ F.R.Gusmanova

Head of the Department \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ A.A. Issakhov

Lecturer: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ K.K. Shakenov