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| **Al-FARABI KAZAKH NATIONAL UNIVERSITY**Faculty of Mechanics and Mathematics**Department of Mathematical and Computer Modeling****SYLLABUS** Numerical Solution of the Rheology ProblemAutumnal semester (First half-year) 2016 – 2017 academic year, the bachelor, 4 course |
| **Course code** | **Course name** | **Type** | Hour per week  | **Credits**  | **ECTS** |
| **Lecture**  | **Seminar** | **Laboratory**  |
|  | **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 Science, Professor**  | **Office-time** | According to timetable |
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| **Phone**  | **+7 727 2211591, +7 705 182 3129** | **Lecture hall**  | **319** |
| **Teacher (laboratory studies)** | **Saule1 Zamanova** **+7 701 773 0010** |  |  |
| **e-mail:** | **saule\_zamanova@mail.ru** | **Lecture hall** | **404** |
| **Course description** | Research of the stochastic models and theirs computer simulation.  |
| **Course aims** | Destination of the course: construction of the stochastic models and computer realization.  |
| **Learning outcomes**  | 1. Intimate knowledge of the stochastic process – Markov chains. Monte Carlo Methods.
2. Ability simulate of the stochastic process.
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| **References and resources**  | 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).
7. Ermakov S.M., Mihailov G.A. The Statistical Modelling. Moscow, Nauka, 1983. (In Russian).
8. Shakenov K.K. Monte Carlo Methods and Applications. Methodical working. Almaty, KazSU, 1993. (In Russian).
9. Smagulov Sh., Shakenov K.K. Monte Carlo Methods in Hydrodynamic and Filtration Problems. Publishing House “Kazakh University”, 1999. P. 270. (In Russian).
10. 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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| **Course organization**  | 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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| **Grading policy**  | **Description of assignment** | **Weight**  | **Learning outcomes** |
| Individual tasksGroup projectAnalytical problem Examinations. Total | 35%10%15%40%100% | 1,2,34,5,62,3,44,5,61,2,3,4,5,6 |
| Your final score will be calculated by the formula $$The final grade on discipline=\frac{LC1+LC2}{2}∙0,6+0,1MT+0,3FC$$Below are minimum grades in percent: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 |
| **Discipline policy** | 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. |
| **Discipline schedule** |
| **Week**  | **Topic** | **Number of hours** |  **Maximum grade**  |
| **1 – 2**  | **Lecture 1 – 4.** Theory and underlying principles and equations of relaxation filtration.  | **4** | **8** |
| **1 – 2** | **Laboratory 1 – 4.** Setting of a mathematical problem. Algorithms of solution by Monte Carlo and probability difference methods. | **4** | **8** |
| **1 – 2** | **Students self-instruction (SSI) by subject (Homework, Project beginning etc. ) 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** |
| **3 – 4** | **Laboratory 5 – 8.** Setting of mathematical problems. Solution of the problems by Monte Carlo and probability difference methods.  | **4** | **8** |
| **3 – 4** | **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** |
| **5 – 6** | **Laboratory 9 – 12.** Algorithm of solution by Monte Carlo and probability difference methods.  | **4** | **8** |
| **5 – 6** | **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** |
| **7 – 8**  | **Laboratory 13 –16.** Algorithm of solution by Monte Carlo and probability difference methods.  | **4** | **8** |
| **7 – 8**  | **SSI 13 –14.** The filtration model by primary nonequilibrium law in elastic porous environment. |  | **4** |
| **7** | **IC 1** |  | **100** |
| **7** | **Midterm Exam** |  | **100** |
| **9 – 10**  | **Lecture 17 –20.** Mathematical problems (Dirichlet, Neumann and mixed) for primary filtration model with spread of steady speed perturbation. | **4** | **8** |
| **9 – 10**  | **Laboratory 17 –20.** Algorithm of solution by Monte Carlo and probability difference methods.  | **4** | **8** |
| **9 – 10**  | **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** |
| **11 – 12** | **Laboratory 21 – 24.** 1.Relaxation kernel of filtrationlaw. 2. Relaxation kernel of fluid mass.  | **4** | **8** |
| **11 – 12** | **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** |
| **13 – 15** | **Laboratory 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** |
| **13 – 15** | **SSI 25 – 30.** Estimate of derivative of solution on parameter. Unbiased Estimate of the Solution.  |  | **6** |
|  | **IC 2** |  | **100** |
|  | **Exam**  |  | **100** |
|  | **Total** |  | **100** |

**Reviewed at the department meeting**

***Report №\_\_ from «\_\_» \_\_\_\_\_\_\_\_\_\_\_\_2016***

**Head of department D. Zhakebayev**

**Lecturer K. Shakenov**