**Al-FARABI KAZAKH NATIONAL UNIVERSITY**

**Faculty of Mechanics and Mathematics**

**Department of Mathematical and Computer Modeling**

**“5B070500-Matematical and computer modeling”**

**Syllabus**

**Autumnal semester 2018 – 2019 academic year, PhD, 1 course**

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| **Course code** | | **Course name** | | **Type** | Hour per week | | | | | | | **Credits** | **ECTS** |
| **Lecture** | **Seminar** | | **Laboratory** | | | |
|  | | **Inverse Problems and Optimization Methods** | | ED | **2** | **1** | | **0** | | | | **3** | **5** |
| **Lecturer** | | | **Kanat Shakenov, Doctor of Physical and Mathematical Sciences, Professor** | | | | **Office-time** | | | According to timetable | | | |
| **e-mail:** | | | [shakenov2000@mail.ru](mailto:shakenov2000@mail.ru), [shakenov.kanat@kaznu.kz](mailto:shakenov.kanat@kaznu.kz). | | | |
| **Phone** | | | **+7 727 2211591, +7 705 182 3129** | | | | **Lecture hall** | | | **319** | | | |
| Academic presentation of the course | | | 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 | | | | | | | | | | |
| Prerequisites | | | Mathematical Analysis, Algebra and Geometry, Information Science, Probability Theory and Mathematical Statistic, Stochastic Processes, ODE, PDE, Numerical Methods, Calculus, Calculations, Computations. | | | | | | | | | | |
| **Literature and resources** | | | 1. Романов В.Г. Обратные задачи математической физики. – М.: Наука, 1984. – 262 с. 2. Лаврентьев М.М., Романов В.Г., Васильев В.Г. Многомерные обратные задачи для дифференциальных уравнений. – Новосибирск, Наука, 1969. – 67 с. 3. Лаврентьев М.М., Резницкая К.Г., Яхно В.Г. Одномерные обратные задачи математической физики. – Новосибирск, Наука, 1982. – 88 с. 4. Серовайский С.Я. Оптимизация и дифференцирование. – Издательство Print-S, Алматы, 2006. – 216 с. 5. Васильев Ф.П. Численные методы решения экстремальных задач. – М.: Наука, 1980. – 518 с. 6. Самарский А.А., Вабищевич П.Н. Численные методы решения обратных задач математической физики. Издание третье. – М.: Издательство ЛКИ, 2009. – 480 с. 7. Кабанихин С.И., Бектемесов М.А., Нурсеитова А.Т. Итерационные методы решения обратных и некорректных задач с данными на части границы. – Алматы-Новосибирск: ОФ «Международный фонд обратных задач», 2006. – 432 с. 8. Shakenov I. Two Approximation Methods of the Functional Gradient for a Distributed Optimization Control Problem // Applied and Numerical Harmonic Analysis. Methods of Fourier Analysis and Approximation Theory © Springer International Publishing Switzerland. Birkhäuser. 2016. – P. 225-235. 9. Shakenov I. Comparing different degrees of nonlinearity for inverse problem for parabolic equation // Bulletin Al-Farabi Kazakh National University, Mathematics, Mechanics, Computer Science Series. – 2014. № 4 (83). – P. 3-11. | | | | | | | | | | |
| **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. | | | | | | | | | | |
| **Grading policy** | | | **Description of assignment** | | | | | **Weight** | **Learning outcomes** | | | | |
| Individual tasks  Group project  Analytical problem  Examinations.  Total | | | | | 35%  10%  15%  40%  100% | 1,2,34,5,6  2,3,4  4,5,6  1,2,3,4,5,6 | | | | |
| **Discipline policy** | | | 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. | | | | | | | | | | |
| **Calendar for the implementation of the content of the training course:** | | | | | | | | | | | | | |
| **Week** | **Topic** | | | | | | **Number of hours** | | | | **Maximum grade** | | |
| **1 – 2** | **Lecture 1 – 4.** Conception of Inverse Problem. The Examples of Inverse Problems. Correctness of Direct and of Inverse Problems. Correctness on Tihonov. (Tychonoff Correctness). | | | | | | **4** | | | | **8** | | |
| **1 – 2** | **Seminar 1 – 4.**  Classificationof Inverse Problems. Examples of Inverse Problems. | | | | | | **4** | | | | **8** | | |
| **1 – 2** | **Students self-instruction (SSI) by subject (Homework, Project beginning etc. ) 1 – 4.**  Classificationof Inverse Problems. Examples of Inverse Problems. | | | | | |  | | | | **4** | | |
| **3 – 4** | **Lecture 5 – 8.** Inverse Problems for Two-Dimensional Parabolic and Elliptic Equations. The Problem on Definition of Heat Source Density. | | | | | | **4** | | | | **8** | | |
| **3 – 4** | **Seminar 5 – 8.** Solutionof the Problem on Definition of Heat Source Density. | | | | | | **4** | | | | **8** | | |
| **3 – 4** | **SSI 5 – 8.** Theorem 6.1 | | | | | |  | | | | **4** | | |
| **5 – 6** | **Lecture 9 – 12.** The Problem on Definition of Diffusion Coefficient. The Connection between Inverse Problems for Parabolic, Elliptic and Hyperbolic Equations. | | | | | | **4** | | | | **8** | | |
| **5 – 6** | **Seminar 9 – 12.** Numerical Solution of Inverse Problem for Diffusion Equation. | | | | | | **4** | | | | **8** | | |
| **5 – 6** | **SSI 9 – 12.** Numerical Solution of Inverse Problems for Parabolic, Elliptic and Hyperbolic Equations. | | | | | |  | | | | **4** | | |
| **7** | **Lecture 13 –14 .** Special Statement of Inverse Problems. | | | | | | **2** | | | | **4** | | |
| **7** | **Seminar 13 –14.** Special Statement of Inverse Problems. The Assignable Coefficient Independent from one of Variables. | | | | | | **2** | | | | **4** | | |
| **7** | **SSI 13 –14.** Cauchy Problem for Parabolic Equation. | | | | | |  | | | | **2** | | |
|  | **IC 1** | | | | | |  | | | | **100** | | |
|  | **Midterm Exam** | | | | | |  | | | | **100** | | |
| **8** | **Lecture 15 –16.** BoundaryInverse Problem for Parabolic Equation. Statement of Problem. Optimization Method of Solution. Functional of Solution. Convexity of Functional. Lemma. Theorem. | | | | | | **2** | | | | **4** | | |
| **8** | **Seminar 15 –16.** Proof of Lemma and Theorem. | | | | | | **2** | | | | **4** | | |
| **8** | **SSI 15 –16.** Principle of Maximum. | | | | | |  | | | | **2** | | |
| **9 – 10** | **Lecture 17 –20.** Principle of Maximum for BoundaryInverse Problem for Parabolic Equation. | | | | | | **4** | | | | **8** | | |
| **9 – 10** | **Seminar 17 –20.** Proof Applicability Principle of Maximum. | | | | | | **4** | | | | **8** | | |
| **9 – 10** | **SSI 17 –20.** Principle of Maximum for BoundaryInverse Problem for Parabolic Equation. | | | | | |  | | | | **4** | | |
| **11 – 12** | **Lecture 21 – 24.** The Gateaux Derivative. Theorem. | | | | | | **4** | | | | **8** | | |
| **11 – 12** | **Seminar 21 – 24.** Proof of Theorem. | | | | | | **4** | | | | **8** | | |
| **11 – 12** | **SSI 21 – 24.** TheFreshet Derivative. | | | | | |  | | | | **4** | | |
| **13 – 15** | **Lecture 25 – 30.** Adjoint Problem. Numerical Algorithm of Solution. Method of Quickest Descent. Iterative Method. Decision of Optimization Parameter. | | | | | | **6** | | | | **10** | | |
| **13 – 15** | **Seminar 25 – 30.** Numerical Solution on PC. Method of Quickest Descent. Iterative Method. Decision of Optimization Parameter. | | | | | | **6** | | | | **10** | | |
| **13 – 15** | **SSI 25 – 30.** Numerical Solution on PC. Method of Quickest Descent. Iterative Method. Decision of Optimization Parameter. | | | | | |  | | | | **6** | | |
|  | **IC 2** | | | | | |  | | | | **100** | | |
|  | **Exam** | | | | | |  | | | | **100** | | |
|  | **Total** | | | | | |  | | | | **100** | | |

Dean D. Zhakebaev

Chairman of the Faculty Methodical Bureau U. Kosherbayeva

Head of Department A. Isakhov

Lecturer K. Shakenov