**Al-Farabi Kazakh National University**

**Faculty of Mechanics and Mathematics**

**Department of Differential Equations and Control Theory**

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|  | APPROVED by **Dean of Faculty**  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ D.B.Zhakebaev  (signature)  "\_\_\_" \_\_\_\_\_\_\_\_\_2019 |

### EDUCATIONAL-METHODICAL COMPLEX OF DISCIPLINE

### « Inverse problems of stochastic differential systems»

**6D060100 – Mathematics**

Course – 2

Semester – 3

Number of credits – 2

**Almaty 2019**

Educational-methodical complex of the discipline is made by Simon Serovajsky, doctor of science, professor

Based on the classing curriculum on the specialty 6D060100 – Mathematics

Considered and recommended at the meeting of the department of Differential Equations and Control Theory

on “\_\_\_” \_\_\_\_\_\_\_\_\_, 2019, protocol № \_\_

Head of the department\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Kh.Khompysh

(signature)

### Recommended by the methodical bureau of the faculty

on “\_\_\_” \_\_\_\_\_\_\_\_\_, 2019, protocol № \_\_

Chairman of the methodical bureau

of the faculty\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_G.E.Abduakhitova

(signature)

**Syllabus**

**By Educational Program «-------------------»  
…. Semester …. Academic year**

Academic course information

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Discipline’s code | Discipline’s title | | IWS |  | | | | Number of credits | | IWST |
| Lect. | Pract. | | Lab. |
|  | Inverse problems of stochastic differential systems | |  | 1 | 1 | | - | 2 | |  |
| Lecturer | | Simon Serovajsky, doctor of science, professor | | | | Office hours | | | Scheduled | |
| e-mail | | [serovajskys@mail.ru](mailto:serovajskys@mail.ru) | | | |
| Telephone number | | +7 701 8315197 | | | | Auditory | | |  | |
| Assistant | | Full name, academic degree, academic rank. | | | | Office hours | | |  | |
| e-mail | | E-mail: | | | |
| Telephone number | | Telephone: | | | | Auditory | | |  | |

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| Academic presentation of the course | **Aim of course:** Analysis of general methods of inverse problems and its applications  **As a result of studying the discipline, students should be able to:**   1. To know the applications of the inverse problems; 2. To know the classification of the inverse problems; 3. To be able to analyze inverse problems; 4. To know the numerical methods for inverse problems; 5. To know the ill-posedness of inverse problems. |
| Prerequisites | Mathematical analysis, mathematical physics equations, optimization methods, differential equations, numerical methods, |
| Post requisites | Special courses |
| Information resources | **literature**:   1. Кабанихин С.И. Обратные и некорректные задачи. – Новосибирск, Сибирское научное изд-во, 2009. 2. Гольцман Ф. М. Статистические модели интерпретации. - М., Наука, 1971. - 323 c. 3. Серовайский С.Я. Оптимизация и дифференцирование. – Алматы, Prinr-S, 2006. 4. Serovajsky S. Practical Course of the Optimal Control Theory with Examples. – Almaty, Қазақ университеті, 2011. 5. Алексеев В. М., Тихомиров В. М., Фомин С. В. Оптимальное управление. – М., Наука, 1979. 6. Serovajsky S. Counterexamples in optimal control theory. – Utrecht-Boston, VSP, 2004. 7. Серовайский С.Я. Контрпримеры в теории оптимального управления. – Алматы, Қазақ университеті, 2001. 8. Васильев Ф.П. Методы оптимизации. В двух томах. – М.: МЦНМО, 2011. 9. Канторович Л. В., Акилов Г. П. Функциональный анализ. – М., Наука, 1977. 10. Serovajsky, S. Differentiation and Optimization. – London, CRS Press, 2018.   **Internet-resources:**  Kirk D. E. Optimal Control Theory: An Introduction. – New Jersey, Englewood Cliffs, 2004. <http://www.amazon.com/Optimal-Control-Theory-Introduction-Engineering/dp/0486434842> |
| Academic policy of the course in the context of university moral and ethical values | **Academic Behavior Rules:** Obligatory attendance of classes, intolerance for being late, commitment to deadlines for completion and delivery of assignments (CDS, Practical classes, midterm exams, individual projects).  **Academic values:** According to Article 5 of the Code of Honor of students of Al-Farabi Kazakh National University, a student must strictly fulfill his academic duties and prevent academic and legal violations (plagiarism, forgery, use of cribs, deceit of and disrespectful attitude to teaching stuff, absenteeism and coming late without respectful reasons).  All students can receive counseling assistance in person, by phone at the numbers indicated or by e-mail provided. |
| Evaluation and attestation policy | **Criteria-based evaluation:** evaluation of achieving learning outcomes in accordance with the descriptors (checking competencies acquired at weeks of the intermediate control, midterm and final examinations)  **Summative evaluation:**  Final score of the discipline =  IC1, IC2, are intermediate controls, МТ is Midterm, FE – final exam.  Percent-rating letter system for assessing of achievements of leaning outcomes by students:  95% - 100%: А 90% - 94%: А- 75% - 79%: В-  85% - 89%: В+ 80% - 84%: В 60% - 64%: С-  70% - 74%: С+ 65% - 69%: С 25% -49%: FX  55% - 59%: D+ 50% - 54%: D- 0% -24%: F |
|  |  |

**Calendar (schedule) the implementation of the course content:**

|  |  |  |  |
| --- | --- | --- | --- |
| **Week / date** | **Topic title (lectures, practical classes, laboratory classes,** **Independent class of students)** | **Number of hours** | **Maximum score** |
| **1** | **2** | **3** | **5** |
| 1 | **Lecture 1. Conception of inverse problems. Examples:** the fall of the body, the synthesis of the hydrochloric acid, “the predator-prey” model. Direct and inverse problems. Basic idea of solving of the inverse problems. Well-posedness of problems. | 1 | 5 |
| **Practical work 1**. Examplesof easiest inverse problems. | 1 | 15 |
| Laboratory class 1. |  |  |
| 2 | **Lecture 2. Minimization of functions.** Stationary condition. Gradient method. | 1 | 5 |
| **Practical work 2**. Minimization of functions. | 1 | 15 |
| Laboratory class 2. |  |  |
| 3 | **Lecture 3. Differentiation of functionals.** Gateaux derivative. Examples. | 1 | 5 |
| **Practical work 3**. Calculation of Gateaux derivatives. | 1 | 15 |
| IWST. Colloquium (orally). |  |  |
| 4 | Lecture 4. |  |  |
| **Lecture 4. Minimization of functionals.** Stationary condition. Gradient method. | 1 | 5 |
| **Practical work 4**. Minimization of functionals. | 1 | 15 |
| 5 | **Lecture 5. Source inverse problem for Poisson equation.** Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 5**. Source inverse problem for Poisson equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 5. |  |  |
| **INTERMEDIATE CONTROLS 1.** | |  | **100** |
| 6 | **Lecture 6. Boundary inverse problem for Poisson equation.** Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 6.** Boundary inverse problem for Poisson equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 6. |  |  |
| 7 | **Lecture 7. Coefficient inverse problem for Helmholtz** **equation.** Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 7.** Coefficient inverse problem for Helmholtz equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 7. |  |  |
| IWST. Colloquium (orally). |  |  |
| 8 | **Lecture 8. Source inverse problem for the heat equation**. Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 8.** Source inverse problem for the heat equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 8. |  |  |
| 9 | **Lecture 9. Time inverse problem for the heat equation**. Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 9.** Time inverse problem for the heat equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 9. |  |  |
| IWST. Submission of IWS 2. «Theme» Control class. |  |  |
| 10 | **Lecture 10. Boundary inverse problem for the heat equation**. Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 10.** Boundary inverse problem for the heat equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 10. |  |  |
| **INTERMEDIATE CONTROLS. (MIDTERM)** | |  | **100** |
| 11 | **Lecture 11. Coefficient inverse problem for the heat equation**. Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 11.** Coefficient inverse problem for the heat equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 11. |  |  |
| IWST. Colloquium (orally). |  |  |
| 12 | **Lecture 12. Source inverse problem for the wave equation**. Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 12.** Source inverse problem for the wave equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 12. |  |  |
| 13 | **Lecture 13. Boundary inverse problem for the wave equation**. Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 13.** Boundary inverse problem for the wave equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 13. |  |  |
| IWST. Colloquium (orally). |  |  |
| 14 | **Lecture 14**. **Coefficient inverse problem for the wave equation**. Stationary conditions and gradient method. | 1 | 5 |
| **Practical work 14**. Coefficient inverse problem for the wave equation. Calculation of the functional gradient. | 1 | 15 |
| Laboratory class 14. |  |  |
| 15 | **Lecture 15. Well-posedness of the optimization control problems and regularization methods.** Example of Tihonov’s ill-posed problem.Example of Hadamard’s ill-posed problem.Regularization methods. | 1 | 5 |
| **Practical work 15.** Regularization methods for the concrete problems. | 1 | 15 |
| IWST. Submission of IWS 3. «Theme» Control class. |  |  |
| **INTERMEDIATE CONTROLS 2.** | |  | **100** |
| **EXAM** | |  | **100** |
| **GENERAL** | |  | **100** |
| *Note:* IWST *is planned in the amount of 7 hours per semester, points are not put, only the type of class is written (examination, Colloquium).* IWS *is planned in the amount of 3 hours per semester, points must be weight, not less than 20 points. All the CDs it must be the name of the theme. Points for the lecture are not put.* | | | |

Head of the Department of DE and CT KH.KHompysh

Chairman of the Faculty Methodical Bureau G.E.Abduakhitova

Lecturer S. Serovajsky