al-Farabi Kazakh National University

Faculty of Mechanics and Mathematics

Mathematics Department

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|  | APPROVED  Dean of the Faculty of Mechanics and Mathematics \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ D. Zhakebaev  "\_\_\_"\_\_\_\_\_\_\_\_\_2021 |

EDUCATIONAL COMPLEX FOR DISCIPLINE

"Optimization problems for partial differential systems"

Specialty - Mathematics (5B060100)

Course - 4

Semester - 7

Number of credits - 3

Almaty 2021

The educational-methodical complex was developed by Doctor of Physical and Mathematical Sciences, Professor S.Ya. Serovajsky.

Developed on the basis of the curriculum for the specialty 5B060100 – Mathematics

Reviewed and recommended at a meeting of the Department of Mathematics

"\_\_\_" \_\_\_\_\_\_\_\_\_\_\_\_\_\_ 2021, protocol No. \_\_\_.

Head of the Department \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Recommended by the methodical bureau of the faculty

"\_\_\_\_" \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, 2021, protocol No. \_\_\_\_\_.

Head of the Methodology Bureau of the Faculty \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**SYLLABUS**

**Fall semester 2020-2021 academic years**

**on the educational program “\_\_\_\_\_\_\_\_\_\_\_\_”**

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| **Discipline’s code** | **Discipline’s title** | **Independent work of students (IWS)** | **No. of hours per week** | | | | | **Number of credits** | **Independent work of student with teacher (IWST)** |
| **Lectures (L)** | **Practical training (PT)** | | **Laboratory (Lab)** | |
|  | Optimization problems |  | 1 | 2 | | 0 | | 3 |  |
| **Academic course information** | | | | | | | | | |
| **Form of education** | **Type of course** | **Types of lectures** | | | **Types of practical training** | | **Number of IWS** | | **Form of final control** |
|  |  |  | | |  | |  | |  |
| Lecturer | S. Ya. Serovajsky, doctor of science, professor | | | | | |  | | |
| e-mail | [serovajskys@mail.ru](mailto:serovajskys@mail.ru) | | | | | |
| Telephone number | +7 701 8315197 | | | | | |

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| **Academic presentation of the course** |

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| **Aim of course** | **Expected Learning Outcomes (LO)**  As a result of studying the discipline the undergraduate will be able to: | **Indicators of LO achievement (ID)**  (for each LO at least 2 indicators) |
| Knowledge of the optimization methods for partial differential systems | LO1 Introduction into inverse problems theory | ID1.1 Direct and inverse problems  ID1.2 Optimization methods for solving inverse problems |
| LO2 Functional minimization | ID2.1 Function minimization methods  ID2.2 Functional minimization methods  ID2.3 Conditional minimization methods |
| LO3 Optimization problems for linear lumped and stationary systems | ID3.1 Abstract Optimization problem  ID3.2 Optimization problem for lumped system  ID3.3 Source Optimization problem for Poisson equation  ID3.4 Boundary Optimization problem for Poisson equation |
| LO4 Optimization problems for parabolic systems | ID4.1 Source Optimization problem for the heat equation  ID4.2 Time Optimization problem for the heat equation  ID4.3 Boundary Optimization problem for the heat equation  ID4.4 Lumped Optimization problem for the heat equation |
| LO5 Optimization problems for hyperbolic systems | ID5.1 Distributed Optimization problem for the wave equation  ID5.2 Boundary Optimization problem for the wave equation |
| LO6 Non-smooth Optimization problems | ID6.1 Non-smooth Optimization problems |
| **Prerequisites** | Mathematical analysis, mathematical physics equations, optimization methods, differential equations, numerical methods | |
| **Post requisites** | Special courses | |
| **Information resources** | 1. Fletcher R. Practical optimization methods. – John Wiley & Son, Chichester, 1987. 2. Ahmed K. L., Teo K. L. Optimal control of distributed parameter systems. – North Holland, Amsterdam, 1981. 3. Lasiecka I., Triggiani R. Deterministic Control Theory for Partial Differential Equations. Vol. 1, Cambridge Univ. Press, Boston, 1998. 4. Kabanikhin S. I. Inverse and Ill-Posed Problems. Theory and Applications. De Gruyter, Germany, 2011 5. Кабанихин С.И. Обратные и некорректные задачи. – Новосибирск, Сибирское научное изд-во, 2009. 6. Serovajsky S. Optimization and Differentiation. CRS Press, Taylor & Francis, London, 2017. 7. Serovajsky S. Practical Course of the Optimal Control Theory with Examples. – Almaty, Қазақ университеті, 2011. 8. <https://www.nbi.ku.dk/english/research/pice/solid-earth-physics-and-geostatistics/> 9. <https://www.degruyter.com/view/journals/jiip/jiip-overview.xml> | |

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| **Academic policy of the course in the context of university moral and ethical values** | **Academic Behavior Rules:**  All students have to register at the MOOC. The deadlines for completing the modules of the online course must be strictly observed in accordance with the discipline study schedule.  ATTENTION! Non-compliance with deadlines leads to loss of points! The deadline of each task is indicated in the calendar (schedule) of implementation of the content of the curriculum, as well as in the MOOC.  **Academic values:**  - Practical trainings/laboratories, IWS should be independent, creative.  - Plagiarism, forgery, cheating at all stages of control are unacceptable.  - Students with disabilities can receive counseling at e-mail \*\*\*\*\*\*\*@gmail.com. |
| **Evaluation and attestation policy** | **Criteria-based evaluation:**  assessment of learning outcomes in relation to descriptors (verification of the formation of competencies in midterm control and exams).  **Summative evaluation:** assessment of work activity in an audience (at a webinar); assessment of the completed task. |

**CALENDAR (SCHEDULE) THE IMPLEMENTATION OF THE COURSE CONTENT:**

|  |  |  |  |  |  |  |  |
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| weeks | Topic name | LO | ID | amount of hours | Maximum score | Form of Knowledge Assessment | The  Form of the lesson  / platform |

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| **Module I. Introduction** | | | | | | | |
| 1 | **L.1 Introduction into Optimization problems theory**. Direct and Optimization problems. Idea of solving Optimization problems for partial differential systems | LО 1 | ID 1.1., 1.2 | 1 | 5 |  | Video lecture  in MS Teams |
| 1 | **PT 1** Idea of solving Optimization problems | LО 1 | ID 1.2. | 2 | 15 | Analysis | Webinar  in MS Teams |
| **Module П Functional minimization** | | | | | | | |
| 2 | **L.1 Functional minimization.** Stationary condition. Gradient method | LО 2 | ID 2.1. | 1 | 5 |  | Video lecture  in MS Teams |
| 2 | **PT 1** Stationary condition | LО 2 | ID 2.1. | 2 | 15 |  | Webinar  in MS Teams |
| 3 | **L.2 Functional minimization.** Gateau derivative. Functional minimization methods | LО 2 | ID 2.2. | 1 | 5 |  | Video lecture  in MS Teams |
| 3 | **PT 2** Gateau derivative | LО 2 | ID 2.2. | 2 | 15 |  | Webinar  in MS Teams |
| 4 | **L.3 Functional minimization.** Conditional minimization problems. Variational inequalities |  |  | 1 | 5 |  | Video lecture  in MS Teams |
| 4 | **PT 3** Variational inequalities |  |  | 2 | 15 |  | Webinar  in MS Teams |
| **Module IП** Optimization problems for linear lumped and stationary systems | | | | | | | |
| 5 | **L.1 Abstract Optimization problem** | LО 3 | ID 3.1. | 1 | 5 |  |  |
| 5 | **PT 1** Abstract Optimization problem | LO 3 | ID 3.1. | 2 | 15 |  |  |
| 5 | **MT 1** | LО 1-3 |  |  | 100 |  |  |
| 6 | **L.2 Optimization problem for lumped system** | LО 3 | ID 3.2. | 1 | 5 |  | Video lecture  in MS Teams |
| 6 | **PT 2** Optimization problem for lumped system | LО 3 | ID 3.2. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 7 | **L.3 Source Optimization problem for Poisson equation** | LО 3 | ID 3.3. | 1 | 5 |  | Video lecture  in MS Teams |
| 7 | **PT 3** Source Optimization problem for Poisson equation | LО 3 | ID 3.3. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 8 | **L.4 Boundary Optimization problem for Poisson equation** | LО 4 | ID 3.4. | 1 | 5 |  | Video lecture  in MS Teams |
| 8 | **PT 4** Boundary Optimization problem for Poisson equation | LО 4 | ID 3.4. | 2 | 15 | Analysis | Webinar  in MS Teams |
| **Module IV Optimization problems for parabolic systems** | | | | | | | |
| 9 | **L.4 Parabolic equation**. Distributed Optimization problem | LО 4 | ID 4.3. | 1 | 5 |  | Video lecture  in MS Teams |
| 9 | **PT 4** Parabolic equation. Distributed Optimization problem | LО 4 | ID 4.3. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 10 | **L.5 Parabolic equation**. Boundary Optimization problem | LО 4 | ID 4.3. | 1 | 5 |  | Video lecture  in MS Teams |
| 10 | **PT 5** Parabolic equation. Boundary Optimization problem | LО 4 | ID 4.3. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 10 | **МТ (Midterm Exam)** | LО 4 | ID 4.1-4.3. |  | 100 |  |  |
| 11 | **L.6 Parabolic equation**. Time Optimization problem | LО 4 | ID 4.4. | 1 | 5 |  |  |
| 11 | **PT 6** Parabolic equation. Time Optimization problem | LО 4 | ID 4.4. | 2 | 15 | Analysis | Video lecture  in MS Teams |
| 12 | **L.7 Parabolic equation**. Lumped Optimization problem | LО 4 | ID 4.4. | 1 | 5 |  | Webinar  in MS Teams |
| 12 | **PT 7** Parabolic equation. Lumped Optimization problem | LО 4 | ID 4.4. | 2 | 15 | Analysis | Video lecture  in MS Teams |
| Module V. **Optimization problems for hyperbolic systems** | | | | | | | |
| 13 | **L.1 Hyperbolic equation**. Distributed Optimization problem | LО 5 | ID 5.1,5.2 | 1 | 5 |  | Video lecture  in MS Teams |
| 13 | **PT 1** Hyperbolic equation. Distributed Optimization problem | LО 5 | ID 5.1. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 14 | **L.2 Hyperbolic equation**. Boundary Optimization problem |  |  |  |  |  |  |
| 14 | **PT.2** Hyperbolic equation. Boundary Optimization problem |  |  |  |  |  |  |
| Module VI. **Non-smooth Optimization problems** | | | | | | | |
| 15 | **L.1** **Non-smooth Optimization problems** | LО 6 | ID 6.1. | 1 | 5 |  | Video lecture  in MS Teams |
| 15 | **PT 1** Non-smooth Optimization problems | LО 6 | ID 6.1. | 2 | 15 | Analysis | Webinar  in MS Teams |
|  | **MT 2** | LО 4-6 |  |  | 100 |  |  |

[Abbreviations: QS - questions for self-examination; TK - typical tasks; IT - individual tasks; CW - control work; MT - midterm.

Comments:

- Form of L and PT: webinar in MS Teams / Zoom (presentation of video materials for 10-15 minutes, then its discussion / consolidation in the form of a discussion / problem solving / ...)

- Form of carrying out the CW: webinar (at the end of the course, the students pass screenshots of the work to the monitor, he/she sends them to the teacher) / test in the Moodle DLS.

- All course materials (L, QS, TK, IT, etc.) see here (see Literature and Resources, p. 6).

- Tasks for the next week open after each deadline.

- CW assignments are given by the teacher at the beginning of the webinar.]

**Dean**

**Chairman of the Faculty Methodical Bureau**

**Head of the Department**

**Lecturer**