**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)** | |
|  | Inverse 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 | | | | | |  | | |
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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 identification methods of mathematical models | LO1 Introduction into inverse problems theory | ID1.1 Direct and inverse problems  ID1.2 Idea of solving inverse problems |
| LO2 Functional minimization | ID2.1 Function minimization methods  ID2.2 Functional minimization methods  ID2.3 Conditional minimization methods |
| LO3 Inverse problems for linear lumped and stationary systems | ID3.1 Abstract inverse problem  ID3.2 Inverse problem for lumped system  ID3.3 Source inverse problem for Poisson equation  ID3.4 Boundary inverse problem for Poisson equation |
| LO4 Inverse problems for linear evolutional systems | ID4.1 Source inverse problem for the heat equation  ID4.2 Time inverse problem for the heat equation  ID4.3 Boundary inverse problem for the heat equation |
| LO5 Know the idea of composite objects | ID5.1 Coordination of structures  ID5.2 Topological algebraic objects |
| LO6 Know the synthesis mathematical theories | ID6.1 Structures  ID6.2 Categories |
| **Prerequisites** | Mathematical analysis, mathematical physics equations, optimization methods, differential equations, numerical methods | |
| **Post requisites** | Special courses | |
| **Information resources** | 1. Kabanikhin S. I. Inverse and Ill-Posed Problems. Theory and Applications. De Gruyter, Germany, 2011 2. Кабанихин С.И. Обратные и некорректные задачи. – Новосибирск, Сибирское научное изд-во, 2009. 3. Aster R., Borchers B., and Thurber C. Parameter Estimation and Inverse Problems, Elsevier, 2018. 4. Groetsch C. Inverse Problems: Activities for Undergraduates. Cambridge University Press, 1999. 5. Serovajsky S. Optimization and Differentiation. CRS Press, Taylor & Francis, London, 2017. 6. Serovajsky S. Practical Course of the Optimal Control Theory with Examples. – Almaty, Қазақ университеті, 2011. 7. <https://www.nbi.ku.dk/english/research/pice/solid-earth-physics-and-geostatistics/> 8. <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:**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| 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 inverse problems theory**. Direct and inverse problems. Idea of solving inverse problems | LО 1 | ID 1.1., 1.2 | 1 | 5 |  | Video lecture  in MS Teams |
| 1 | **PT 1** Idea of solving inverse 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** Inverse problems for linear lumped and stationary systems | | | | | | | |
| 5 | **L.1 Abstract inverse problem** | LО 3 | ID 3.1. | 1 | 5 |  |  |
| 5 | **PT 1** Abstract inverse problem | LO 3 | ID 3.1. | 2 | 15 |  |  |
| 5 | **MT 1** | LО 1-3 |  |  | 100 |  |  |
| 6 | **L.2 Inverse problem for lumped system** | LО 3 | ID 3.2. | 1 | 5 |  | Video lecture  in MS Teams |
| 6 | **PT 2** Inverse problem for lumped system | LО 3 | ID 3.2. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 7 | **L.3 Source inverse problem for Poisson equation** | LО 3 | ID 3.3. | 1 | 5 |  | Video lecture  in MS Teams |
| 7 | **PT 3** Source inverse problem for Poisson equation | LО 3 | ID 3.3. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 8 | **L.4 Boundary inverse problem for Poisson equation** | LО 4 | ID 3.4. | 1 | 5 |  | Video lecture  in MS Teams |
| 8 | **PT 4** Boundary inverse problem for Poisson equation | LО 4 | ID 3.4. | 2 | 15 | Analysis | Webinar  in MS Teams |
| **Module IV Inverse problems for linear evolutional systems** | | | | | | | |
| 9 | **L.4 Topological objects**. Topological spaces | LО 4 | ID 4.3. | 1 | 5 |  | Video lecture  in MS Teams |
| 9 | **PT 4** Topological spaces | LО 4 | ID 4.3. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 10 | **L.5 Topological objects**. Metric spaces | LО 4 | ID 4.3. | 1 | 5 |  | Video lecture  in MS Teams |
| 10 | **PT 5** Metric spaces | 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 Measurable objects.**Measures | LО 4 | ID 4.4. | 1 | 5 |  |  |
| 11 | **PT 6** Measures | LО 4 | ID 4.4. | 2 | 15 | Analysis | Video lecture  in MS Teams |
| 12 | **L.7 Measurable objects**. Integrals | LО 4 | ID 4.4. | 1 | 5 |  | Webinar  in MS Teams |
| 12 | **PT 7** Integrals | LО 4 | ID 4.4. | 2 | 15 | Analysis | Video lecture  in MS Teams |
| Module V. Composites | | | | | | | |
| 13 | **L.1 Composites.** Coordination of structures  Topological algebraic objects | LО 5 | ID 5.1,5.2 | 1 | 5 |  | Video lecture  in MS Teams |
| 13 | **PT 1** Topological algebraic objects | LО 5 | ID 5.1. | 2 | 15 | Analysis | Webinar  in MS Teams |
| Module VI. Synthesis | | | | | | | |
| 14 | **L.1** **Synthesis**. Structures | LО 6 | ID 6.1. | 1 | 5 |  | Video lecture  in MS Teams |
| 14 | **PT 1** Structures | LО 6 | ID 6.1. | 2 | 15 | Analysis | Webinar  in MS Teams |
| 15 | **L.2 Synthesis**. Categories | LО 6 | ID 6.2. | 1 | 5 |  | Video lecture  in MS Teams |
|  | **PT 2** Categories | LО 6 | ID 6.2. | 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**