**SYLLABUS**

**Fall semester 2022-2023 academic years**

**on the educational program “……………… ”**

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| **Discipline’s code** | **Discipline’s title** | **Independent work of students (IWS)** | **Number of credits** | | | | | **Number of credits** | **Independent work of student with teacher (IWST)** |
| **Lectures (L)** | **Practical training (PT)** | | **Laboratory (Lab)** | |
|  | Geometric control theory |  | 1 | 2 | | - | | 3 |  |
| **Academic course information** | | | | | | | | | |
| **Form of education** | **Type of course** | **Types of lectures** | | | **Types of practical training** | | **Form of final control** | | |
| Full-time |  |  | | |  | |
| Lecturer | Serovajsky Simon | | | | | |  | | |
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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) |
| The aim of the course is to analyze the most important difficulties that arise in the practical solution of optimal control problems | 1. To know function minimization problems | 1.1. Stationary conditions  1.2. Gradient methods |
| 2. To know optimization control problems | 2.1. Maximum principle for the system with fray ends  2.2. Maximum principle for the system with fixed ends |
| 3. To know practical methods of optimality condition solving | 3.1. Iterative method of optimality condition solving  3.2. Shouting method |
| 4. To know general difficulties of optimization control problems | 4.1. Existence of optimal control  4.2. Uniqueness of optimal control  4.3. Well-posedness of problems |
| **Prerequisites** | Variational calculus and optimization methods, differential equations, numerical methods? functional analysis | |
| **Post requisites** | Optimal control problems for the distributed control problems, inverse problems | |
| **Information resources \*\*** | **Literature:\*\***   1. Serovajsky S. Practical Course of the Optimal Control Theory with Examples. – Almaty, Қазақ университеті, 2011. 2. Serovajsky S. Counterexamples in optimal control theory. – Utrecht-Boston, VSP, 2004. 3. Серовайский С.Я. Контрпримеры в теории оптимального управления. – Алматы, Қазақ университеті, 2001. 4. Алексеев В. М., Тихомиров В. М., Фомин С. В. Оптимальное управление. – М., Наука, 1979. 5. Kirk D. E. Optimal Control Theory: An Introduction. – New Jersey, Englewood Cliffs, 2004. 6. Gill, P. E.; Murray, W.; Wright, M. H. Practical Optimization. London: Academic Press, 1982. 7. Snyman, J. A.; Wilke, D. N. Practical Mathematical Optimization : Basic Optimization Theory and Gradient-Based Algorithms (2nd ed.). Berlin: Springer, 2018.   **Internet resources:**  1. <http://www.amazon.com/Optimal-Control-Theory-Introduction-Engineering/dp/0486434842>  2.  [Numerical Optimization](http://www.ece.northwestern.edu/~nocedal/book/num-opt.html)  3. [Convex Optimization](https://web.stanford.edu/~boyd/cvxbook/) | |

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| **Academic policy of the course in the context of university moral and ethical values** | **Academic Behavior Rules:**  All students are required to register for the MOOC. The deadlines for completing the modules of the online course must be strictly observed in accordance with the schedule for studying the discipline. Leave in case of current MOOC or SPOC courses.  **ATTENTION!** Failure to meet deadlines results in loss of points! The deadline for each task is indicated in the calendar (schedule) for the implementation of the content of the training course, as well as in the MOOC. Leave in case of current MOOC or SPOC courses.  **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:**

|  |  |  |  |
| --- | --- | --- | --- |
| week | Topic name | Number of hours | Max.  score\*\*\* |
| **Module 1 Introduction** | | | |
| 1 | **Lec 1.** Introduction. Function minimization problems. Stationary condition |  | 5 |
| 1 | **Sem 1.** Function minimization problems. Stationary condition |  | 5 |
| 2 | **Lec 2.** Gradient methods |  | 5 |
| 2 | **Sem 2.** Gradient methods |  | 5 |
| **Module 2 Optimization problems with free final state** | | | |
| 3 | **Lec 2.** Maximum principle |  | 5 |
| 3 | **Sem 2.** Maximum principle |  | 5 |
| 3 | **IWST 1.** Consultation on the implementation of IWS1 |  |  |
| 3 | **SIW 1.** Maximum principle |  | 60 |
| 4 | **Lec 4.** Sufficiently of optimality conditions |  | 5 |
| 4 | **Sem 4.** Sufficiently optimality conditions |  | 5 |
|  | **IWST 2.** Consultation |  |  |
| 5 | **Lec 5.** Uniqueness of optimal control |  | 5 |
| 5 | **Sem 5.** Uniqueness of optimal control |  | 5 |
| 6 | **Lec 6.** Singular controls |  | 5 |
| 6 | **Sem 6.** Singular controls |  | 5 |
| 7 | **Lec 7.** Solvability of the problem |  | 5 |
| 7 | **Sem 7.** Solvability of the problem |  | 5 |
| 7 | **IWST 3.** Consultation |  |  |
|  | **LEVEL CONTROL 1** |  | **100** |
| 8 | **Lec 8.** Well-posedness of the problem |  | 5 |
| 8 | **Sem 8.** Well-posedness of the problem |  | 5 |
| 8 | **IWS 2.** Optimization problems with free final state |  | 30 |
| **Module 3. Optimization problems with fixed final state** | | | |
| 9 | **Lec 9.** Optimality conditions for the system with fixed final state |  | 5 |
| 9 | **Sem 9.** Optimality conditions for the system with fixed final state |  | 5 |
| 10 | **Lec 10** Sufficiently of optimality conditions |  | 5 |
| 10 | **Sem 10.** Sufficiently of optimality conditions |  | 5 |
| 10 | **IWST 3.** Consultation |  |  |
| 11 | **Lec 11** Solvability of the problem |  | 5 |
| 11 | **Sem 11.** Solvability of the problem |  | 5 |
| 12 | **Lec 12** Bifurcation of extremals |  | 5 |
| 12 | **Sem 12.** Bifurcation of extremals |  | 5 |
| 12 | **IWST 5.** Consultation |  |  |
| **Module 4. Optimization problems with isoperimetric conditions** | | | |
| 13 | **Lec 13** Optimality conditions for the systems with isoperimetric conditions |  | 5 |
| 13 | **Sem 13** Optimality conditions for the systems with isoperimetric conditions |  | 5 |
| 13 | **IWS 3.** Optimization problems with isoperimetric conditions |  | 30 |
| 14 | **Lec 14** Sufficiently of optimality conditions |  | 5 |
| 14 | **Sem 14.** Sufficiently of optimality conditions |  | 5 |
|  | **IWST 6.** Consultation |  |  |
| 15 | **Lec 15** Uniqueness of optimal control |  | 5 |
| 15 | **Sem 15.** Uniqueness of optimal control |  | 5 |
| 15 | **IWST 7**. Consultation on examination issues |  |  |
|  | **LEVEL CONTROL 2** |  | **100** |

Dean \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

Lecturer \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**NOTE:**

The total volume of the syllabus is no more than 5 pages, font 10, Times New Roman

\* LO is based on cognitive (1-2), functional (2-3), systemic (1-2) competencies, total 4-7.

The types and number of competencies (out of 5) are compiled according to the level of education.

\*\* Give no more than 5-7 sources of literature (full bibliographic description), in depth for the last 10 years. (in exceptional cases, 20-30% of irreplaceable classical textbooks), for natural directions - 10 years. Humanitarian direction -5 years

Literature and resources:

1. Basic literature

2. Additional reading

3. Software

4. Internet resources

5. Professional databases

\*\*\*Spreading the assessment of students' knowledge is at the discretion of the compilers of the syllabus.

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