**Practical course of the optimization control theory**

**Tickets**

**Part 1**

1. General optimization control problem. Problem statement.
2. General optimization control problem. Necessary condition of optimality.
3. General optimization control problem. Idea of numerical solving.
4. Example of the easiest optimization control problem. Maximum principle.
5. Example of the easiest optimization control problem. Iterative method.
6. Example of the insufficient conditions of optimality. Problem statement.
7. Example of the insufficient conditions of optimality. Necessary conditions of optimality.
8. Example of the insufficient conditions of optimality. Non-uniqueness of the optimal control.
9. Example of the insufficient conditions of optimality. Non-sufficiently of the optimality conditions.
10. Analysis of the sufficiently of the optimality conditions for the general optimization control problem.
11. General theorem of uniqueness of the optimal control.
12. Example of the singular control. Problem statement.
13. Example of the singular control. Necessary conditions of optimality.
14. Example of the singular control. Phenomenon of the singular control.
15. The singular control for the maximization problem.

**Part 2**

1. Example of the optimization problem with unique singular control.
2. Kelly’s condition for the singular control.
3. Example of the non-sufficiently of Kelly’s condition
4. General optimization control problem with singular control.
5. Example of the insolvable optimization control problem. Problem statement.
6. Example of the insolvable optimization control problem. Maximum principle.
7. Example of the insolvable optimization control problem. Analysis of the optimality conditions.
8. Example of the insolvable optimization control problem. Infimum of the functional.
9. Example of the insolvable optimization control problem. Absence of the optimal control.
10. Convexity of the set and the functional.
11. General theorem of existence of the optimal control.
12. General optimization control problem with fixed final state. Necessary conditions of optimality.
13. General optimization control problem with fixed final state. Practical solving.
14. Example of the insolvable optimization control problem fixed final state. Problem statement.
15. Example of the insolvable optimization control problem fixed final state. Maximum principle.

**Part 3**

1. Example of the insolvable optimization control problem fixed final state. Analysis of the optimality conditions.
2. Example of the insolvable optimization control problem fixed final state. Proof of the insolvability of the optimization control problem.
3. Example of the insolvable optimization control problem fixed final state. Proof of the insolvability of the optimality conditions.
4. Stationary condition for the function with one variable.
5. Example of Tihonov ill-posed control problem. Problem statement.
6. Example of Tihonov ill-posed control problem. Maximum principle.
7. Example of Tihonov ill-posed control problem. Optimal control.
8. Example of Tihonov ill-posed control problem. Proof of the ill-posedness.
9. Tihonov well-posedness of the optimization control problem.
10. Tihonov ill-posedness of the optimization control problem and regularization method.
11. Example of Hadamard ill-posed control problem. Maximum principle.
12. Example of Hadamard ill-posed control problem. Optimal control.
13. Example of Hadamard ill-posed control problem. Proof of the ill-posedness.
14. Hadamard well-posedness of the optimization control problem.
15. Hadamard ill-posedness of the optimization control problem and regularization method.

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| **9** | **Lecture 9. Existence and uniqueness of the optimal control. II.** Example of the insolvable problem without sufficiently of the optimality condition. | 1 | 2 |
| **Practical work 9.** Insolvable problem without sufficiently of the optimality condition. | 1 | 3 |
| **Homework 9.** Insolvable problem without sufficiently of the optimality condition. | 1 | 8 |
| **Module 4. Well-posedness of the optimization control problems** | | | |
| **10** | **Lecture 10. Tihonov’s well-posed problem.** Example of Tihonov’s ill-posed problem.ProofofTihonov’s well-posedness. Regularization methods. | 1 | 1 |
| **Practical work 10.** Tihonov’s well-posed problem. | 1 | 3 |
| **Homework 10.** Tihonov’s well-posed problem. | 1 | 8 |
| **11** | **Lecture 11. Hadamard’s well-posed problem.** Example of Hadamard’s ill-posed problem.ProofofHadamard’s well-posedness. | 1 | 2 |
| **Practical work 11.** Hadamard’s well-posed problem. | 1 | 3 |
| **Homework 11.** Hadamard’s well-posed problem. | 1 | 8 |
| **Module 5. Additions** | | | |
| **12** | **Lecture 12. Optimization problems with isoperimetric conditions.** Necessary conditions of minimum. Example. | 1 | 1 |
| **Practical work 12.** Necessary conditions of minimum for optimization problem with isoperimetric condition. | 1 | 3 |
| **Homework 12.** Necessary conditions of minimum for optimization problem with isoperimetric condition. | 1 | 8 |
| **13** | **Lecture 13. Optimization problems with isoperimetric conditions.** Nonuniqueness of the solutions for the boundary problem. | 1 | 2 |
| **Practical work 13.** Necessary conditions of minimum for optimization problem with isoperimetric condition. | 1 | 3 |
| **Homework 13.** Necessary conditions of minimum for optimization problem with isoperimetric condition. | 1 | 8 |
| **14** | **Lecture 14**. **Bifurcation of extremals.** Cheffey-Infante problem. | 1 | 1 |
| **Practical work 14.** Bifurcation of extremals. | 1 | 3 |
| **Homework 14.** Bifurcation of extremals. | 1 | 8 |
| **15** | **Lecture 15. Bifurcation of extremals.** Bifurcation of solutions and bifurcation of extremals. | 1 | 2 |
| **Practical work 15.** Bifurcation of solutions. | 1 | 3 |
| **Homework 15.** Bifurcation of solutions. | 1 | 8 |
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| **Border control 2** |  | **100** |
|  | **Examination** |  | **100** |
|  | **TOTAL** |  | **100** |

**LITERATURE**

**Basic:**

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. <http://www.amazon.com/Optimal-Control-Theory-Introduction-Engineering/dp/0486434842>

**Additional:**

1. Васильев Ф.П. Методы оптимизации. В двух томах. – М.: МЦНМО, 2011.
2. Лутманов С.В. Курс лекций по методам оптимизации. – Ижевск, 2001.
3. Габасов Р., Кириллова Ф. Качественная теория оптимальных процессов. – М., Наука, 1907. – 507 с.
4. Иоффе А. Д., Тихомиров В. М. Теория экстремальных задач. – М., Наука, 1974. – 480 с.
5. Канторович Л. В., Акилов Г. П. Функциональный анализ. – М., Наука, 1977. – 744 с.

АКАДЕМИЧЕСКАЯ Политика курса

Все виды работ необходимо выполнять и защищать в указанные сроки. Студенты, не сдавшие очередное задание или получившие за его выполнение менее 50% баллов, имеют возможность отработать указанное задание по дополнительному графику. Студенты, пропустившие лабораторные занятия по уважительной причине, отрабатывают их в дополнительное время в присутствии лаборанта, после допуска преподавателя. Студенты, не выполнившие все виды работ, к экзамену не допускаются. Кроме того, при оценке учитывается активность и посещаемость студентов во время занятий.

будьте толерантны, уважайте чужое мнение. Возражения формулируйте в корректной форме. Плагиат и другие формы нечестной работы недопустимы. Недопустимы подсказывание и списывание во время сдачи СРС, промежуточного контроля и финального экзамена, копирование решенных задач другими лицами, сдача экзамена за другого студента. Студент, уличенный в фальсификации любой информации курса, несанкционированном доступе в Интранет, пользовании шпаргалками, получит итоговую оценку «F».

За консультациями по выполнению самостоятельных работ (СРС), их сдачей и защитой, а также за дополнительной информацией по пройденному материалу и всеми другими возникающими вопросами по читаемому курсу обращайтесь к преподавателю в период его офис-часов.

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| --- | --- | --- | --- |
| Letter mark | Number mark | % | Traditional mark |
| А | 4,0 | 95-100 | Very good |
| А- | 3,67 | 90-94 |
| В+ | 3,33 | 85-89 | Good |
| В | 3,0 | 80-84 |
| В- | 2,67 | 75-79 |
| С+ | 2,33 | 70-74 | Satisfactory |
| С | 2,0 | 65-69 |
| С- | 1,67 | 60-64 |
| D+ | 1,33 | 55-59 |
| D- | 1,0 | 50-54 |
| F | 0 | 0-49 | Non satisfactory |
| I  (Incomplete) | - | - | «The course is not finished»  (*do not take into consideration of GPA)* |
| P  (Pass) | **-** | **-** | «given a credit»  (*do not take into consideration of GPA)* |
| NP  (No Рass) | **-** | **-** | «did not give a credit»  (*do not take into consideration of GPA)* |
| W  (Withdrawal) | - | - | «renunciation of the course»  (*do not take into consideration of GPA)* |
| AW  (Academic Withdrawal) |  |  | Renunciation of the course by academic cause  (*do not take into consideration of GPA)* |
| AU  (Audit) | - | - | «the course is listen»  (*do not take into consideration of GPA)* |
| Атт. |  | 30-60  50-100 | Attested |
| Не атт. |  | 0-29  0-49 | No attested |
| R (Retake) | - | - | Retake the course |

Session № \_\_ of « \_\_ » \_\_\_\_\_\_\_\_\_\_\_ 2013.

**Head of the Department S. Muhambetzhanov**

**Lecturer S. Serovajsky**