**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

### « Stability theory of dynamical systems»

**6D060100 – Mathematics**

Course – 2

Semester – 3

Number of credits – 3

**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

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Discipline’s code | Discipline’s title | | IWS |  | | | | Number of credits | | IWST |
| Lect. | Pract. | | Lab. |
|  | Stability theory of dynamical systems | |  | 2 | 1 | | - | 3 | |  |
| 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 differential games and its applications  **As a result of studying the discipline, students should be able to:**   1. To know the definition of stability. 2. To know the applications of stability theory; 3. To know the classification of the stability; 4. To be able to analyze stability problems; 5. To know the numerical methods for stability problems. |
| Prerequisites | Differential equations, mathematical analysis, mathematical modelling, numerical methods. |
| Post requisites | Special courses |
| Information resources | **literature**:  1. Андронов А. А., Витт А. А., Хайкин С. Э. Теория колебаний. - 2-е изд., перераб. и испр.. - М.: Наука, 1981.  2. Serovajsky S. Practical Course of the Optimal Control Theory with Examples. – Almaty, Қазақ университеті, 2011.  3. Serovajsky S. Counterexamples in optimal control theory. – Utrecht-Boston, VSP, 2004.  4. Серовайский С.Я. Контрпримеры в теории оптимального управления. – Алматы, Қазақ университеті, 2001.  5. Kirk D. E. Optimal Control Theory: An Introduction. – New Jersey, Englewood Cliffs, 2004.  6. Cassel, Kevin W.: Variational Methods with Applications in Science and Engineering, Cambridge University Press, 2013.  7. Snyman, J.A.; Wilke, D.N. Practical Mathematical Optimization: Basic Optimization Theory and Gradient-Based Algorithms (2nd ed.). Berlin: Springer, 2018.  8. Эльсгольц Л.Э. Дифференциальные уравнения и вариационное исчисление. – М., Наука, 1969.  9. Филиппов А.Ф. Введение в теорию дифференциальных уравнений. - Изд. 2-е. – 2007.  10. Камке Э. Справочник по обыкновенным дифференциальным уравнениям. — М.: Наука, 1976.  **Internet-resources:**  [http://www.newlibrary.ru/book/budylin\_a\_m\_/variacionnoe\_ischislenie.html](http://www.newlibrary.ru/book/budylin_a_m_/variacionnoe_ischislenie.html%20) .  <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 |
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**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.** Introduction into mathematical physics equations | 2 | 5 |
| Lecture 1. Introduction. Pontyagin’s maximum principle. Numerical methods for necessary conditions of optimality. | 1 | 15 |
| Practical class 1. Pontyagin’s maximum principle. Example |  |  |
| 2 | Lecture 2. Sufficiently of the optimality conditions. Example of the insufficient conditions of optimality. | 2 | 5 |
| Practical class 2. Proof of the sufficiently of the optimality conditions. | 1 | 15 |
| Laboratory class 2. |  |  |
| 3 | Lecture 3. Sufficiently of the optimality conditions. Proof of the sufficiently of the optimality conditions. | 2 | 5 |
| Practical class 3. Proof of the sufficiently of the optimality conditions. | 1 | 15 |
| IWST. Colloquium (orally). |  |  |
| 4 | Lecture 4. Singular control. Examples. |  |  |
| Practical class 4. Examples of singular control. | 2 | 5 |
|  | 1 | 15 |
| 5 | Lecture 5. Singular control. Kelly’s condition. | 2 | 5 |
| Practical class 5. Kelly’s condition. | 1 | 15 |
| Laboratory class 5. |  |  |
| **INTERMEDIATE CONTROLS 1.** | |  | **100** |
| 6 | Lecture 6. Existence and uniqueness of the optimal control. Example of the insolvable problem with sufficiently of the optimality condition. | 2 | 5 |
| Practical class 6. Uniqueness of the optimal control. | 1 | 15 |
| Laboratory class 6. |  |  |
| 7 | Lecture 7. Existence and uniqueness of the optimal control. Example of the insolvable problem with sufficiently of the optimality condition. | 2 | 5 |
| Practical class 8. Insolvable problem without sufficiently of the optimality condition. | 1 | 15 |
| Laboratory class 7. |  |  |
| IWST. Colloquium (orally). |  |  |
| 8 | Lecture 8. Existence and uniqueness of the optimal control. II. Example of the insolvable problem without sufficiently of the optimality condition. | 2 | 5 |
| **Practical class 8.** Solvability of algebraic equation and convergence of iterative method by contracting mapping theorem. | 1 | 15 |
| Laboratory class 8. |  |  |
| 9 | Lecture 9. Existence and uniqueness of the optimal control. II. Example of the insolvable problem without sufficiently of the optimality condition. | 2 | 5 |
| Practical class 9. Insolvable problem without sufficiently of the optimality condition. | 1 | 15 |
| Laboratory class 9. |  |  |
| IWST. Submission of IWS 2. «Theme» Control class. |  |  |
| 10 | Lecture 10. Tihonov’s well-posed problem. Example of Tihonov’s ill-posed problem. Proof of Tihonov’s well-posedness. Regularization methods. | 2 | 5 |
| Practical class 10. Tihonov’s well-posed problem. | 1 | 15 |
| Laboratory class 10. |  |  |
| **INTERMEDIATE CONTROLS. (MIDTERM)** | |  | **100** |
| 11 | Lecture 11. Hadamard’s well-posed problem. Example of Hadamard’s ill-posed problem. Proof of Hadamard’s well-posedness. | 2 | 5 |
| Practical class 11. Hadamard’s well-posed problem. | 1 | 15 |
| Laboratory class 11. |  |  |
| IWST. Colloquium (orally). |  |  |
| 12 | Lecture 12. Optimization problems with isoperimetric conditions. Necessary conditions of minimum. Example. | 2 | 5 |
| Practical class 12. Necessary conditions of minimum for optimization problem with isoperimetric condition. | 1 | 15 |
| Laboratory class 12. |  |  |
| 13 | Lecture 13. Optimization problems with isoperimetric conditions. Nonuniqueness of the solutions for the boundary problem. | 2 | 5 |
| Practical class 13. Necessary conditions of minimum for optimization problem with isoperimetric condition. | 1 | 15 |
|  |  |  |
| IWST. Colloquium (orally). |  |  |
| 14 | Lecture 14. Bifurcation of extremals. Cheffey-Infante problem. | 2 | 5 |
| Practical class 14. Bifurcation of extremals. | 1 | 15 |
| Laboratory class 14. |  |  |
| 15 | Lecture 15. Bifurcation of extremals. Bifurcation of solutions and bifurcation of extremals. | 2 | 5 |
| Practical class 15. Bifurcation of solutions. | 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