**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)  "\_\_\_"\_\_\_\_\_\_\_\_\_\_20\_\_ |

### EDUCATIONAL-METHODICAL COMPLEX OF DISCIPLINE

### Code «Mathematical physics equations»

Specialty "5B060500 - Mechanics"

Course – 2

Semester – spring

Number of credits – 2

**Almaty 2019**

Educational-methodical complex of the discipline is made by Serovajsky Simon, Doctor of science, professor

Based on the working curriculum on the specialty mechanics

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Considered and recommended at the meeting of the department of Differential Equantions and Control Theory

on “\_\_\_”\_\_\_\_\_\_\_\_\_20\_\_, protocol №\_\_\_

Head of the department\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_Kh.Khompysh

(signature)

### Recommended by the methodical bureau of the faculty

on “\_\_\_”\_\_\_\_\_\_\_\_\_20\_\_, protocol №\_\_\_

Chairman of the methodical bureau

of the faculty\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_U.R.Kusherbayeva

(signature)

**Syllabus***Spring semester, 2018-2019 Academic year*

Academic course information

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| Discipline’s code | Discipline’s title | Type | No. of hours per week | | | Number of credits | | ECTS |
| Lect. | Pract. | Lab. |
|  |  |  |  |  |  |  | |  |
| Lecturer | Serovajsky Simon, Doctor of science, professor | | | Office hours | | | Scheduled | |
| e-mail | [serovajskys@mail.ru](mailto:serovajskys@mail.ru) | | |
| Telephone number | +7 701 8315197 | | | Auditory | | |  | |

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| Academic presentation of the course | **Type of university**:  **Aim of course:** The main aim of the course is to familiarize students with the fundamental concepts of mathematical physics equation  **As a result of the course PhD students must be able to:**   1. To know the applications of mathematical physics equations; 2. To know the classification of mathematical physics equations; 3. To know the general mathematical physics equations; 4. To know the general boundary problem for mathematical physics equations; 5. To analyze the mathematical physics equations. |
| Prerequisites | Ordinary differential equations, mathematical analysis, physics |
| Post requisites | Numerical methods, calculus of variations |
| Information resources | **literature**:   1. Тихонов А.Н., Самарский А.А. Уравнения математической физики. – М.: Изд-во МГУ, 1999. 2. Tikhonov A.N., Samarskii A.A. Equations of Mathematical Physics. – New York, Dover Publ., 1990. 3. Полянин А.Д., Зайцев В.Ф. Справочник по нелинейным уравнениям математической физики: Точные решения. – М.: Физматлит, 2002. 4. Тирринг В. Курс математической и теоретической физики. – К.: TIMPANI, 2004. 5. Фарлоу С. Уравнения с частными производными для научных работников и инженеров. – М.: Мир, 1985. 6. Kusse B. Mathematical Physics: Applied Mathematics for Scientists and Engineers. – Germany: Wiley-VCH, 2006. 7. Stakgold I. Boundary value problems of mathematical physics. – Philadelphia: SIAM, 2000.   **Internet-resources:**   1. Boas M. [Mathematical Methods in the Physical Sciences](https://en.wikipedia.org/wiki/Mathematical_Methods_in_the_Physical_Sciences) , Hoboken: John Wiley & Sons, 2006. 2. Courant R., Hilbert D. [Methods of Mathematical Physics](https://en.wikipedia.org/wiki/Methods_of_Mathematical_Physics), New York: Interscience Publishers, 1989. 3. Владимиров В.С*.*[Что такое математическая физика?](http://www.mi.ras.ru/preprints/06_001.pdf)– Препринт, Математический институт им. В.А. Стеклова РАН. – М.: МИАН, 2006*.* |
| 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-  85% - 89%: В+ 80% - 84%: В 75% - 79%: В-  70% - 74%: С+ 65% - 69%: С 60% - 64%: С-  55% - 59%: D+ 50% - 54%: D- 0% -49%: F |

Calendar (schedule) the implementation of the course content**:**

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| **Week** | **Topics** | **Hours** | **Max point** |
|  | **Module 1. Equations of mathematical physics  as mathematical models** |  |  |
| 1 | **Lecture 1.** *Equations of mathematical physics as mathematical models*. Derivative and its geometric and mechanical interpretation.  Determining of a curve by a known tangent.  Equation of the fall of the body as a mathematical model.  Cauchy problem for differential equations.  Determining of a surface on a tangent plane.  Partial differential equations of the first order. Characteristics. | 1 | 4 |
| **Practical class 1.** Ordinary differential equations. |  |  |
| **Independent work of student with teacher 1**. Ordinary differential equations. | 1 | 10 |
| 2 | **Lecture 2.** *Mathematical physics equations as mathematical models*. Heat equation and its different interpretations.  Vibrating string equation.  Poisson and Laplace equations and their interpretation. | 1 | 1 |
| **Practical class 2.** | 1 | 3 |
| **Independent work of student with teacher 2**. Partial differential equations of the first order. |  | 10 |
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|  | **Module 2. Classification of mathematical physics equations** |  |  |
| 3 | **Lecture 3.** *Classification of second order partial differential equations***.** Reduction of partial differential equations of the second order with two independent variables to the canonical form.  Classification of second order partial differential equations. | 1 | 1 |
| **Practical class 3.** Reduction of equations to the canonical form. | 1 | 3 |
| **Independent work of student with teacher 3**. Reduction of equations to the canonical form. |  | 10 |
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|  | **Module 3. Hyperbolic equations** |  |  |

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| 4 | | **Lecture 4.** *Cauchy problem for the vibrating string equation.*  Motion of unlimited string.  Formulation of the Cauchy problem for the vibrating string equation.  D'Alembert method.  Running waves. | 1 | 1 |
| **Practical class 4.** Cauchy problem for the vibrating string equation. | 1 | 3 |
| **Independent work of student with teacher 4**. Cauchy problem for the vibrating string equation. |  | 10 |
| 5 | | **Lecture 5.** *Vibrating string equation with fixed ends.*  First boundary value problem for the vibrating string equation.  Method of variable separation.  Sturm – Liouville problem.  Solution of the first boundary value problem for the vibrating string equation. | 1 | 1 |
| **Practical class 5.** Vibrating of string with fixed ends. | 1 | 3 |
| **Independent work of student with teacher 5**. Vibrating of string with fixed ends. | 1 | 10 |
| 6 | | **Lecture 6.** *Vibrating string equation with free ends* Problem statement. Second boundary value problem for the vibrating string equation.  Method of variable separation.  Sturm – Liouville problem.  Solution of the second boundary value problem for the vibrating string equation. | 1 | 2 |
| **Practical class 6.** Vibrating of string with free ends. | 1 | 3 |
| **Independent work of student with teacher 6.** Vibrating of string with free ends. |  | 10 |
| 7 | | **Lecture 7.** *Forced vibrating of the string.*  Inhomogeneous vibrating string equation.  Fourier method.  Solution of boundary value problems for the inhomogeneous vibrating string equation. | 1 | 2 |
| **Practical class 7.** Forced vibrations of the string. | 1 | 3 |
| **Independent work of student with teacher 7.** Forced vibrations of the string. | 1 | 10 |
| Border control 1 | | |  | 100 |
| Midterm | | |  | 100 |
|  |  | |  |  |
|  | **Module 4. Parabolic equations** | |  |  |
| 8 | | **Lecture 8.** *Heat equation with known temperature at the boundary.* First boundary problem for the heat equation.  Method of variable separation.  Sturm – Liouville problem.  Solution of the first boundary value problem for the heat equation. | 1 | 1 |
| **Practical class 8.** Heat equation with known temperature at the boundary. | 1 | 1 |
| **Independent work of student with teacher 8.** Heat equation with known temperature at the boundary. |  | 10 |
| 9 | | **Lecture 9.** *Heat equation with known heat flux through the boundary.* Second boundary problem for the heat equation.  Method of variable separation.  Sturm – Liouville problem.  Solution of the second boundary value problem for the heat equation. | 1 | 1 |
| **Practical class 9.** Heat equation with known heat flux through the boundary. | 1 | 2 |
| **Independent work of student with teacher 9.** Heat equation with known heat flux through the boundary. |  | 10 |
| 10 | | **Lecture 10.** *Heat equation in the presence of heat sources.*  Inhomogeneous heat equation.  Fourier method.  Solution of boundary value problems for the inhomogeneous heat equation. | 1 | 1 |
| **Practical class 10.** Heat equation in the presence of heat sources. | 1 | 1 |
| **Independent work of student with teacher 10.** Heat equation in the presence of heat sources. | 1 | 10 |
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|  | | **Module 5. Elliptic equations** |  |  |
| 11 | | **Lecture 11.** *Laplace equation and its connection with theory of functions of a complex variable and variational calculus.*  Analytical and harmonic functions.  Minimization of functions and stationary condition.  Dirichlet integral and variational method. | 1 | 1 |
| **Practical class 11.** | 1 | 2 |
| **Independent work of student with teacher 11.** Variational method in mathematical physics problems. |  | 10 |
| 12 | | **Lecture 12.** *Electrostatic field equation in a circle.*  Potential of the electrostatic field of a point charge and an infinite wire.  Laplace equation in a circle.  Method of variable separation.  Solution of the inner and outer boundary value problem for the Laplace equation in a circle. | 1 | 1 |
| **Practical class 12.** Laplace equation in a circle. |  | 1 |
| **Independent work of student with teacher 12.** Laplace equation in a circle. | 1 | 10 |
| 13 | | **Lecture 13.** *Green functions method for the Laplace and Poisson equations.*  Integration by parts and Green formulas.  Integral representation of the harmonic function.  Green function method for mathematical physics problems. | 1 | 1 |
| **Practical class 13.** Green function method mathematical physics problems. | 1 | 2 |
| **Independent work of student with teacher 13.** Green function method mathematical physics problems. |  | 10 |
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|  | | **Module 6. Approximate solution  of mathematical physics problems** |  |  |
| 14 | | **Lecture 14**.*Finite difference method for mathematical physics problems.* Approximation of derivatives.  Euler method for ordinary differential equations.  Finite difference method for the heat equation.  Explicit difference scheme for the heat equation. | 1 | 1 |
| **Practical class 14.** Finite difference method for mathematical physics problems. | 1 | 1 |
| **Independent work of student with teacher 14.** Finite difference method for mathematical physics problems. |  | 10 |
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|  | | **Module 7. Inverse problems of mathematical physics** |  |  |
| 15 | | **Lecture 15.** *Inverse problems of mathematical physics***.**  Identification of the mathematical models.  Direct and inverse problems of mathematical physics.  Inverse problems of mathematical physics and the theory of extremum. | 1 | 1 |
| **Practical class 15.** | 1 | 2 |
| **Independent work of student with teacher 15.** Inverse problems of mathematical physics. |  | 10 |
| Border control 2 | | |  | 100 |
| Total | | |  | 100 |

Head of the department of DE and CT Kh.Khompysh

Chairman of the Faculty Methodical Bureau U.R.Kusherbayeva

Lecturer S. Serovajsky