**SYLLABUS**

**Fall semester 2020-2021 academic years**

**on the educational program of the course “\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_”**

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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)** | |
|  | Partial differential equations |  | 2 | 1 | | 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) |
| The main aim of the course is to familiarize students with the fundamental concepts of partial differential equation | LO1 Introduction | ID1.1 Ordinary differential equations  ID1.2 First order partial differential equations  ID1.3 Reduction of partial differential equations to the canonical form |
| LO2 Hyperbolic equations | ID2.1 Cauchy problem for the vibrating string equation  ID2.2 Vibrating of string with fixed ends  ID2.3 Vibrating string equation with free ends  ID2.4 Forced vibrations of the string |
| LO3 Parabolic equations | ID3.1 Heat equation with known temperature at the boundary  ID3.2 Heat equation with known heat flux through the boundary.  ID3.3 Heat equation in the presence of heat sources |
| LO4 Elliptic equations | ID4.1 Variational method in mathematical physics problems  ID4.2 Laplace equation in a circle  ID4.3 Green function method |
| LO5 Approximate solving and inverse problems | ID5.1 Finite difference method  ID5.2 Inverse problems of mathematical physics. |
| **Prerequisites** | Mathematical analysis, differential equations, numerical methods | |
| **Post requisites** | Special courses | |
| **Information resources** | 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. 8. Boas M. [Mathematical Methods in the Physical Sciences](https://en.wikipedia.org/wiki/Mathematical_Methods_in_the_Physical_Sciences) , Hoboken: John Wiley & Sons, 2006. 9. Courant R., Hilbert D. [Methods of Mathematical Physics](https://en.wikipedia.org/wiki/Methods_of_Mathematical_Physics), New York: Interscience Publishers, 1989. 10. 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 | |

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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 Ordinary and partial differential equations**. General definitions. First order partial differential equations | LО 1 | ID 1.1,1.2 | 2 | 5 |  | Video lecture  in MS Teams |
| 1 | **PT 1** Ordinary differential equations | LО 1 | ID 1.1 | 1 | 15 |  | Webinar  in MS Teams |
| 2 | **L 2 Partial differential equations as mathematical models.** Heat equation. Wave equation. Poisson equation. | LO 1 | ID 1.2 | 2 | 5 |  | Video lecture  in MS Teams |
| 2 | **PT 2** First order partial differential equations. | LO 1 | ID 1.2 | 1 | 15 |  | Webinar  in MS Teams |
| 3 | **L 3 Classification of partial differential equations to the canonical form.** Reduction of partial differential equations to the canonical form | LO 1 | ID 1.3 | 2 | 5 |  | Video lecture  in MS Teams |
| 3 | **PT 3** Reduction of partial differential equations to the canonical form | LO 1 | ID 1.3 | 1 | 15 |  | Webinar  in MS Teams |
| **Module П Hyperbolic equations** | | | | | | | |
| 4 | **L 4 Cauchy problem for the vibrating string equation.** Movement of unlimited string. Cauchy problem for the vibrating string equation. D'Alembert method. Running waves | LО 2 | ID 2.1. | 2 | 5 |  | Video lecture  in MS Teams |
| 4 | **PT 4** Cauchy problem for the vibrating string equation | LО 2 | ID 2.1. | 1 | 15 |  | Webinar  in MS Teams |
| 5 | **L 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. | LО 2 | ID 2.2. | 2 | 5 |  | Video lecture  in MS Teams |
| 5 | **PT 5** Vibrating of string with fixed ends | LО 2 | ID 2.2. | 1 | 15 |  | Webinar  in MS Teams |
| 5 | **MT 1** | LО 1-2 |  |  | 100 |  |  |
| 6 | **L 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. | LО 2 | ID 2.3. | 1 | 5 |  | Video lecture  in MS Teams |
| 6 | **PT 6** Vibrating string equation with free ends | LО 2 | ID 2.3. | 2 | 15 |  | Webinar  in MS Teams |
| 7 | **L 7 Forced vibrating of the string.**Inhomogeneous vibrating string equation.Fourier method. Solution of boundary value problems for the inhomogeneous vibrating string equation. | LО 2 | ID 2.4. | 1 | 5 |  | Video lecture  in MS Teams |
| 7 | **PT 7** Forced vibrations of the string | LО 2 | ID 2.4. | 2 | 15 |  | Webinar  in MS Teams |
| **Module IП Parabolic equations** | | | | | | | |
| 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. | LО 3 | ID 3.1. | 2 | 5 |  | Video lecture  in MS Teams |
| 8 | **PT 8** Heat equation with known temperature at the boundary | LO 3 | ID 3.1. | 1 | 15 |  | Webinar  in MS Teams |
| 9 | **L 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 | LО 3 | ID 3.2. | 2 | 5 |  | Video lecture  in MS Teams |
| 9 | **PT 9** Heat equation with known heat flux through the boundary. | LО 3 | ID 3.2. | 1 | 15 |  | Webinar  in MS Teams |
| 10 | **L 10 Heat equation in the presence of heat sources.** Inhomogeneous heat equation. Fourier method. Solution of boundary value problems for the inhomogeneous heat equation | LО 3 | ID 3.3. | 2 | 5 |  | Video lecture  in MS Teams |
| 10 | **PT 10** Heat equation in the presence of heat sources | LО 3 | ID 3.3. | 1 | 15 |  | Webinar  in MS Teams |
| 10 | **МТ (Midterm Exam)** | LО 2-3 |  |  | 100 |  |  |
| **Module IV Elliptic equations** | | | | | | | |
| 11 | **L 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. | LО 4 | ID 4.1. | 2 | 5 |  | Video lecture  in MS Teams |
| 11 | **PT 11** Variational method in mathematical physics problems | LО 4 | ID 4.1. | 1 | 15 |  | Webinar  in MS Teams |
| 12 | **L 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. | LО 4 | ID 4.2. | 2 | 5 |  | Video lecture  in MS Teams |
| 12 | **PT 12** Laplace equation in a circle | LО 4 | ID 4.2. | 1 | 15 |  | Webinar  in MS Teams |
| 13 | **L 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 | LО 4 | ID 4.3. | 2 | 5 |  |  |
| 13 | **PT 13** Green function method | LО 4 | ID 4.3. | 1 | 15 |  | Video lecture  in MS Teams |
| **Module V. Approximate solving and inverse problems** | | | | | | | |
| 14 | **L 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 | LО 5 | ID 5.1 | 2 | 5 |  | Video lecture  in MS Teams |
| 14 | **PT 14** Finite difference method | LО 5 | ID 5.1. | 1 | 15 |  | Webinar  in MS Teams |
| 15 | **L 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. | LО 6 | ID 5.2. | 1 | 5 |  | Video lecture  in MS Teams |
|  | **PT 15** Inverse problems of mathematical physics | LО 6 | ID 2.2. | 2 | 15 |  | 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**