**Federal State Autonomous Educational Institution of Higher Education "Moscow Institute of Physics and Technology (National Research University)"**

**APPROVED**
**Head of the Phystech School of Applied Mathematics and Informatics**
**A.M. Raygorodskiy**

**Work program of the course (training module)**

| | |
|---|---|
| **course:** | Matlab/Matlab |
| **major:** | Information Science and Computer Engineering |
| **specialization:** | Computer Science/Информатика |
| | Phystech School of Applied Mathematics and Informatics |
| | Chair of Discrete Mathematics |
| **term:** | 2 |
| **qualification:** | Bachelor |

Semester, form of interim assessment: 4 (spring) - Grading test

Academic hours: 60 AH in total, including:
lectures: 0 AH.
seminars: 60 AH.
laboratory practical: 0 AH.

Independent work: 75 AH.

In total: 135 AH, credits in total: 3

Author of the program: A.M. Raygorodskiy, doctor of physics and mathematical sciences, head of chair

The program was discussed at the Chair of Discrete Mathematics 05.03.2020

**Annotation**

This course examines the basic capabilities of Matlab programming environments for solving telecommunication problems. First of all, students get acquainted with the interface and basic elements of Matlab, study the space of variables, data types, the simplest functions and graphs. After that, they learn to work with datasets, 2D and 3D charts, and manage charts. Having studied the features of the Matlab environment, students become familiar with numerical methods and the basics of digital signal processing used to solve telecommunication problems. After receiving the necessary theoretical base, students move on to model-based design of radio systems based on Matlab.

In practical and seminars, practical work is carried out in Matlab environments in order to consolidate the mastered theoretical material, as well as to study the implementation of telecommunication tasks.

To successfully complete the course, it is necessary to attend and take notes of lectures, complete practical tasks and independent work with additional literary sources.

**1. Study objective**

**Purpose of the course**

- The course is devoted to the implementation of mathematical models based on MATLAB;
- the main goal is to master the practical aspects of choosing suitable modeling approaches, numerical methods and applied tools for effective software implementation.

**Tasks of the course**

- The main features of MATLAB for scientific calculations will be demonstrated, the most commonly used numerical methods and criteria for their selection will be considered;
- to consolidate the knowledge gained at the seminars, it is proposed to solve computational problems.

**2. List of the planned results of the course (training module), correlated with the planned results of the mastering the educational program**

Mastering the discipline is aimed at the formation of the following competencies:

| Code and the name of the competence | Competency indicators |
|---|---|
| Gen.Pro.C-2 Use modern IT and software tools to perform professional tasks in compliance with information security requirements | Gen.Pro.C-2.1 Apply modern computing tools and Internet services in professional settings |
| | Gen.Pro.C-2.2 Apply numerical mathematical methods and use software applications for scientific problem-solving in professional settings |
| | Gen.Pro.C-2.3 Fulfill basic information security requirements |
| Pro.C-1 Assign, formalize, and solve tasks, develop and research mathematical models of the studied phenomena and processes, systematically analyze scientific problems, obtain new scientific outcomes | Pro.C-1.1 Locate, analyze, and summarize information on current research findings within the subject area |
| | Pro.C-1.2 Make hypotheses, build mathematical models of the studied phenomena and processes, evaluate the quality of the developed model |
| | Pro.C-1.3 Apply theoretical and/or experimental research methods to a specific scientific task and interpret the obtained results |
| Pro.C-2 Conduct scientific research and testing independently or as a member (leader) of a small research team | Pro.C-2.1 Apply the principles of scientific work, methods of collecting and analyzing the obtained data and ways of argumentation |
| | Pro.C-2.2 Conduct scientific research independently or as a member (leader) of a small research team |
| | Pro.C-2.3 Present research results through scientific publications and participation in conferences |

**3. List of the planned results of the course (training module)**

As a result of studying the course the student should:

know:

The main tools for scientific computing language MATLAB and their functionality.

be able to:

Use the basic means of scientific computing of the MATLAB language to solve typical applied problems and adapt them to your needs during the implementation of research.

master:

Tools for creating applications on MATLAB, the basic principles of computing using MATLAB.

**4. Content of the course (training module), structured by topics (sections), indicating the number of allocated academic hours and types of training sessions**

4.1. The sections of the course (training module) and the complexity of the types of training sessions

| № | Topic (section) of the course | Types of training sessions, including independent work | | | |
|---|---|---|---|---|---|
| | | Lectures | Seminars | Laboratory practical | Independent work |
| 1 | The simplest symbolic and numerical calculations. | | 12 | | 12 |
| 2 | Numerical solution of boundary and initial-boundary value problems for equations of mathematical physics. | | 12 | | 15 |
| 3 | Numerical solution of ODE systems. | | 12 | | 16 |
| 4 | Time Series Analysis. | | 12 | | 16 |
| 5 | Solution of systems of linear equations. | | 12 | | 16 |
| AH in total | | | 60 | | 75 |
| Exam preparation | | 0 AH. | | | |
| Total complexity | | 135 AH., credits in total 3 | | | |

4.2. Content of the course (training module), structured by topics (sections)

Semester: 4 (Spring)

1. The simplest symbolic and numerical calculations.

Visualization, export and import of data, interaction with external libraries.

2. Numerical solution of boundary and initial-boundary value problems for equations of mathematical physics.

MATLAB tools for solving hypothetical boundary value problems in partial derivatives (hyperbolic, elliptic, parabolic equations).

3. Numerical solution of ODE systems.

Different ways to solve homogeneous differential equations.

4. Time Series Analysis.

Time series analysis. Scheduling

5. Solution of systems of linear equations.

Systems of linear equations. Solving optimization problems.

**5. Description of the material and technical facilities that are necessary for the implementation of the educational process of the course (training module)**

The classroom is equipped with personal computers, a multimedia projector and a screen.

**6. List of the main and additional literature, that is necessary for the course (training module) mastering**

Main literature

1. MATLAB 7 [Текст] : программирование, численные методы / Ю. Л. Кетков, А. Ю. Кетков, М. М. Шульц .— СПб. : БХВ-Петербург, 2005 .— 737 с.

2. Параллельное программирование в среде MATLAB для многоядерных и многоузловых вычислительных машин [Текст] : [учеб. пособие для вузов] / Дж. Кепнер ; науч. ред. Д. В. Дубров .— М. : Изд-во Моск. ун-та, 2013 .— 296 с.

Additional literature

1. MATLAB 7 [Текст] : в подлиннике : наиболее полное руководство / И. Е. Ануфриев, А. Б. Смирнов, Е. Н. Смирнова .— СПб. : БХВ-Петербург, 2005 .— 1104 с.

**7. List of web resources that are necessary for the course (training module) mastering**

http://www.mou.mipt.ru

http://www.exponenta.ru/educat/free/matlab/gs.pdf

**8. List of information technologies used for implementation of the educational process, including a list of software and information reference systems (if necessary)**

Software Development Tool on MATLAB.

**9. Guidelines for students to master the course**

A student studying a course must, on the one hand, master the general conceptual apparatus, and on the other hand, must learn to put theoretical knowledge into practice.

Successful development of the course requires intense independent work of the student. The course program provides the minimum necessary time for the student to work on the topic. Independent work includes:

- reading and taking notes of recommended literature;
- study of educational material (according to lecture notes, educational and scientific literature), preparation of answers to questions intended for independent study;
- solving problems offered to students in practical classes and as a course assignment;
- preparation for practical exercises.

The management and control of the student's independent work is carried out in the form of individual consultations.

An indicator of material ownership is the ability to solve problems.

It is important to gain an understanding of the material being studied, and not its mechanical memorization.

If it is difficult to study individual topics, questions, you should seek advice from a lecturer or teacher conducting practical classes.

**SUPPLEMENT**

## Assessment funds for course (training module)

| | |
|---|---|
| **major:** | Information Science and Computer Engineering |
| **specialization:** | Computer Science/Информатика<br>Phystech School of Applied Mathematics and Informatics<br>Chair of Discrete Mathematics |
| **term:** | 2 |
| **qualification:** | Bachelor |

Semester, form of interim assessment: 4 (spring) - Grading test

**Author:** A.M. Raygorodskiy, doctor of physics and mathematical sciences, head of chair

**1. Competencies formed during the process of studying the course**

| Code and the name of the competence | Competency indicators |
|---|---|
| Gen.Pro.C-2 Use modern IT and software tools to perform professional tasks in compliance with information security requirements | Gen.Pro.C-2.1 Apply modern computing tools and Internet services in professional settings |
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| | Pro.C-2.2 Conduct scientific research independently or as a member (leader) of a small research team |
| | Pro.C-2.3 Present research results through scientific publications and participation in conferences |

**2. Competency assessment indicators**

As a result of studying the course the student should:

**know:**

The main tools for scientific computing language MATLAB and their functionality.

**be able to:**

Use the basic means of scientific computing of the MATLAB language to solve typical applied problems and adapt them to your needs during the implementation of research.

**master:**

Tools for creating applications on MATLAB, the basic principles of computing using MATLAB.

**3. List of typical control tasks used to evaluate knowledge and skills**

The course contains a set of practical tasks, as a result of which the student receives an assessment.

Topics of practical exercises:

1. Acquaintance with Matlab.
2. Working with arrays.
3. Working with different types of data. Processing of the results obtained.
4. Numerical methods.
5. Digital signal processing. Processing an audio file. Spectral signal processing
6. Model-Based Design. Simulink.
7. SDR. Building an FM receiver using RTL-SDR

For each task, the student receives an assessment in accordance with the table of the assessment criterion

**4. Evaluation criteria**

1. What data types in Matlab are intended for storing matrices of linear equation systems? What are their areas of applicability?

2. What methods of numerical solution of linear equation systems do you know? What tools for exact and approximate solution of systems of linear equations are available in Matlab?

3. Does the appearance of uncertain values (NaN) in a numerical solution always indicate an error in the solver code or an incorrect choice of grid parameters?

4. What are the conditions of Karush-Kun-Tucker? Introduce the code for solving quadratic programming problems in Matlab.

5. What is the stochastic gradient method? Give the implementation of this method in Matlab.

6. Define the Hurst exponent of a time series. Give the code to calculate this indicator in Matlab. What information on the time series does this indicator give?

7. List the main properties of stochastic matrices. Give a simplified implementation of the PageRank algorithm in Matlab.

8. Using the Dirichlet problem as an example for the Poisson equation, propose a method for selecting the grid and estimating the error of the numerical solution. Bring the appropriate code in Matlab.

9. Introduce code for solving linear programming problems in Matlab.

10. List the advantages and disadvantages of the support vector method over the stochastic gradient method and neural networks. Demonstrate these advantages and disadvantages with code in Matlab.

Assessment “excellent (10)” is given to a student who has displayed comprehensive, systematic and deep knowledge of the educational program material, has independently performed all the tasks stipulated by the program, has deeply studied the basic and additional literature recommended by the program, has been actively working in the classroom, and understands the basic scientific concepts on studied discipline, who showed creativity and scientific approach in understanding and presenting educational program material, whose answer is characterized by using rich and adequate terms, and by the consistent and logical presentation of the material;

Assessment “excellent (9)” is given to a student who has displayed comprehensive, systematic knowledge of the educational program material, has independently performed all the tasks provided by the program, has deeply mastered the basic literature and is familiar with the additional literature recommended by the program, has been actively working in the classroom, has shown the systematic nature of knowledge on discipline sufficient for further study, as well as the ability to amplify it on one’s own, whose answer is distinguished by the accuracy of the terms used, and the presentation of the material in it is consistent and logical;

Assessment “excellent (8)” is given to a student who has displayed complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently performed all the tasks stipulated by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (7)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in the answer, has independently performed all the tasks provided by the program, studied the basic literature recommended by the program, worked actively in the classroom, showed systematic character of his knowledge of the discipline, which is sufficient for further study, as well as the ability to amplify it on his own;

Assessment “good (6)” is given to a student who has displayed a sufficiently complete knowledge of the educational program material, does not allow significant inaccuracies in his answer, has independently carried out the main tasks stipulated by the program, studied the basic literature recommended by the program, showed systematic character of his knowledge of the discipline, which is sufficient for further study;

Assessment “good (5)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, mastered the basic literature recommended by the program, made some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors by himself;

Assessment “satisfactory (4)” is given to a student who has discovered knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, who while not being sufficiently active in the classroom, has nevertheless independently carried out the main tasks stipulated by the program, learned the main literature but allowed some errors in their implementation and in his answer during the test, but has the necessary knowledge for correcting these errors under the guidance of a teacher;

Assessment “satisfactory (3)” is given to a student who has displayed knowledge of the basic educational program material in the amount necessary for further study and future work in the profession, not showed activity in the classroom, independently fulfilled the main tasks envisaged by the program, but allowed errors in their implementation and in the answer during the test, but possessing necessary knowledge for elimination under the guidance of the teacher of the most essential errors;

Assessment “unsatisfactory (2)” is given to a student who showed gaps in knowledge or lack of knowledge on a significant part of the basic educational program material, who has not performed independently the main tasks demanded by the program, made fundamental errors in the fulfillment of the tasks stipulated by the program, who is not able to continue his studies or start professional activities without additional training in the discipline in question;

Assessment “unsatisfactory (1)” is given to a student when there is no answer (refusal to answer), or when the submitted answer does not correspond at all to the essence of the questions contained in the task.

**5. Methodological materials defining the procedures for the assessment of knowledge, skills, abilities and/or experience**

The test is carried out on the basis of the current performance and delivery of tasks and term paper.

Submission of term paper is carried out in the form of an oral report for 15-20 minutes.

The topic of the course work is selected by the student, but must be previously agreed with the teacher and must comply with the course program. In the course work, the solution to the applied problem using mathematical modeling methods implemented in the Matlab environment should be presented (other software packages can be used by agreement with the teacher).