Министерство науки и высшего образования Российской Федерации
НАЦИОНАЛЬНЫЙ ИССЛЕДОВАТЕЛЬСКИЙ
ТОМСКИЙ ГОСУДАРСТВЕННЫЙ УНИВЕРСИТЕТ (НИ ТГУ)

Механико-математический факультет

УТВЕРЖДАЮ:
Декан
_____Л. В.Гензе
«30» 06 2022 г.

Рабочая программа дисциплины

**Математическое моделирование научных и инженерных задач**

по направлению подготовки

**01.04.01 Математика**

Направленность (профиль) подготовки :
**Математический анализ и моделирование (Mathematical Analysis and Modelling)**

Форма обучения
**Очная**

Квалификация
**Магистр**

Год приема
**2022**

Код дисциплины в учебном плане: Б1.В.2.01

СОГЛАСОВАНО:
Руководитель ОП
_____А.В.Старченко

Председатель УМК
_____Е.А.Тарасов

Томск – 2022

Tomsk-2022

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|---|---|---|---|---|---|
| Programm arranged | | | | | |
| *Associate professor* | | | | | |
| _____ Gurina Elena Ivanovna | | | | | |
| | *(sign)* | | | | |
| Reviewer | | | | | |
| Professor, Adv. Doc. of Phys. and Math. | | | | | |
| _____ Starchenko Aleksandr Vasilyevich | | | | | |
| | *(sign)* | | | | |
| | | | | | |
| The working program of the discipline " Mathematical modeling of problems of science and technologies" was developed in accordance with the SUOS of NR TSU:<br>*Independently established educational standard of NR TSU in the field of training 01.04.01 Mathematical analysis and modeling (Approved by the Scientific Council of NR TSU, Protocol No. 03 dated 28.03.2019)* | | | | | |
| | | | | | |

The working program was approved at the meeting of the MMF UMK

Protocol No. 1 of January 30, 2020

## 1. The purpose of mastering the discipline

The main purpose of the discipline is formation of systematic knowledge in the field of: modeling of engineering and natural science problems, difference methods for solving Cauchy problems and difference methods for solving boundary value problems for partial differential equations, economical difference schemes for solving multidimensional problems of mathematical physics.

Preparation of a master of program *Mathematical analysis and modeling* for the effective use of modern methods of computer simulation of related problems of technology and natural science

## 2. The place of discipline in the structure MEP

The discipline belongs to the general professional cycle. Block B1.V.2.

Prerequisites of the discipline – *Programming, Equations of mathematical physics, Continuum mechanics.*

Post-requirements of the discipline: *Modern computer technologies, modern methods of data analysis and visualization, methods of parallel computing, solution of conjugate problems of MJG, research work, execution and defense of the final qualifying work.*

## 3. Competencies and learning outcomes formed as a result of mastering the discipline

Table 1

| **Competence** | **Indicator of Competence** | **Code and name of learning outcomes** (planned results of training in the discipline, characterizing the stages of competence formation) |
|---|---|---|
| GPC 2: - The student is able to build and analyze mathematical models in modern natural science, technology, economics and management. | IGPC 2.1: - The student analyzes, selects and substantiates mathematical models for solving problems in the field of modern natural science, technology, economics and Management.<br><br>IGPC 2.2: - The student develops new and/or adapts/improves mathematical models for the problems of modern natural science, technology, economics and management under the guidance of a more skilled worker. | LO-2.1: The student is able to formulate the problem statement in terms of mathematical modeling methods and choose the optimal solution method with justification of the choice made.<br><br>LO-2.1: The student has the skills to build mathematical models, highlight parameters and work with application of Mathcad for analytical transformations and numerical calculations in typical problems of modern natural science, technology, economics and management. |

## 4. Structure and content of the discipline

### 4.1. The structure and labor intensity of the types of academic work in the discipline

The total labor intensity of the discipline is 2 credit units, 72 hours.

Table 2

| Type of educational work | Labor intensity in academic hours | |
|---|---|---|
| **Total labor intensity** | 1-st semetr | total |
| **Contact work (CW):** | 38,05 | 38,05 |
| Lectures(L): | 18 | **18** |
| Practical classes (P) | 18 | **18** |
| Group consultations | 2,05 | **2,05** |
| Intermediate certification | 0 | 0 |
| **Independent work of the student:** | 33,95 | **33,95** |
| Preparation of report | 10 | 10 |
| Execution of settlement and graphic works | 16 | 16 |
| Preparation and defending the report | 4 | 4 |
| **Type of intermediate certification** | Credit | 3,95 |

## 4.2. The content and labor intensity of the discipline sections

Table 3

| Class code | The name of sections and topics and their content | Type of educational work, classes, control | Semester | hours in electronic form | Total (hr.) | Literature | Learning result(s) code(s) |
|---|---|---|---|---|---|---|---|
| 1.1 | **Section 1.** Introduction<br><br>Supercomputers and digital twins. 4G and 5G technology. GLONASS system. Types of boundary value problems and systems of equations, coordinate systems. Anisotropic media | L | 1 | 0 | 4 | | LO -2.1, LO -2.2 |
| 2.1 | **Section 2**. Mathematical modeling of logistics problems<br><br>Network planning and management. The problem of the maximum flow in the network, the problem of the shortest distance. Gini index and function elasticity. | L | 1 | 0 | 8 | | LO -2.1, LO -2.2 |
| 2.2 | Steiner network. | L | 1 | 0 | 4 | | LO -2.1, LO -2.2 |
| 3.1 | **Section 3.** Mathematical models in biology<br><br>The Cauchy problem for epidemic modeling. | L | 1 | 0 | 6 | | LO -2.1, LO -2.2 |
| 3.2 | Rigid ODE system for modeling the population of the Earth. | L | 1 | 0 | 4 | | LO -2.1, LO -2.2 |
| 4.1 | **Section 4.** Boundary Value Problem for a Second-Order Equation<br><br>Boundary value problem of heating a multilayer ring. Thomas algorithm (Cycle). | L | 1 | 0 | 18 | | LO -2.1, LO -2.2 |
| 4.2 | 2D grids, Delaunay triangulation and Voronoi dagrams. | L, P | 1 | 0 | 18 | | LO -2.1, LO -2.2 |
| 5.1 | **Section 5. Consultation**<br>Consultations<br>Defending of an individual report on 3 individual tasks. | P | 1 | 0 | 2,054 | | LO -2.1, LO -2.2 |
| 6.1 | **Section 6. Intermediate certification**<br>Admission of the credit in the discipline | CW | 1 | 0 | 3,95 | | |

## 5. Educational technologies, educational, methodological and informational support for the development of the discipline

During the implementation of the discipline, classical educational technologies are used - practical exercises; independent study of the recommended literature and the implementation of individual tasks; intermediate certification in the form of checking individual tasks.

Independent work includes: theoretical development of the lecture course, practical implementation of tasks, and preparation for the credit. To perform independent work, access to the information resources of the course is provided:

- materials of lectures;
- a list of questions for self-testing knowledge and preparing for the test;
- a list of references, including textbooks and books on the issues studied in the course;

All laboratory work and individual tasks are selected in such a way as to maximally stimulate the psychological attitude of mathematics students to form a connection between mathematical theory and its practical application. The report on each laboratory work includes a theoretical part, a completed practical task and an analysis of the results.

### 5.1. Literature and educational and methodological support

***a) List of basic educational literature.***


1. Samarskii A. A., Mikhailov A. P. Mathematical modeling. Ideas. Methods. Examples. 2001.320s.
2. Kapitsa S. P. Phenomenological theory of the growth of the Earth's population: 1996, Val. 166 №1. – p. 63-80.
3. Marchuk G. I. Methods of computational mathematics: textbook / G. I. Marchuk – Val.4: St. Petersburg, 2009 – 608p.
4. Samarsky A.A., Nikolaev E.S. Methods for solving grid equations ONLINE. 07/23/2013 - M .: Nauka: 1978. — 592 p.
5. A.A. Samarsky, P.V. Vabishchevich, Computational heat transfer, M., Editorial URSS, 2003. - 784 p.
6. M. P. Galanin, I. A. Shcheglov, “Development and implementation of algorithms for three-dimensional triangulation of complex spatial domains: direct methods”, Keldysh Institute preprints. M. V. Keldysha, 2006, 010, 32 p.

Patankar S. V. Numerical solution of problems of heat conduction and convective heat transfer during flow in channels, M., MPEI, 2004. - 312 p.


***b) List of additional educational literature.***


1. Bertsun V.N. Splines of grid functions. Tomsk: TML-Press, 2007. – 137 p.
2. V. K. Sauliev, Integration of equations of parabolic type by the grid method. Moscow: 1960.
3. Mikheev. Fundamentals of Heat Transfer, 1977.
4. D.K. Firsov, Control volume method on an unstructured grid in computational mechanics. – Tomsk: 2007. 57p.

Tikhomirova A.N., Sidorenko E.V. Mathematical models and methods in logistics. – Moscow, 2010. -320 p.


### 5.2. Databases and information and reference systems, including foreign ones

https://e.lanbook.com/book/131723
http://matlab.exponenta.ru/imageprocess/liter/liter.php
http://intuit.ru http://www.intuit.ru/studies/courses/1012/168/info

### 5.3. List of licensed and software

1) OS Windows 7 or Windows 10 https://www.microsoft.com/ru-ru/software-download/windows10

### 5.4. Equipment and technical means of training

The classrooms of the MMF educational and computing laboratory are used for laboratory work and independent work. When performing individual tasks and report, free and licensed software is used:

- Microsoft Office 2010 (reports preparation);
- Visual Studio;
- Lazarus;
- mathematical package PTC Mathcad 15;
- mathematical package Maple 15;
- mathematical package Matlab R2011b.

## 6. Methodological guidelines for students on the development of the discipline

For the successful mastering of the material, students need to attend classes, and during independent work use the basic and additional literature, databases and information and reference systems that are presented in the list of references. Independent work of students consists in repeating material from practical classes and independent study of additional issues, a deeper study of topics with the help of literature and preparing the individual report.

## 7. Teaching staff implementing the discipline

Gurina Elena Ivanovna, *Associate professor*.

## 8. Teaching language

Russian, English

**Update sheet**

Work program discipline «Methods of Machine Learning with Python»

Program Fundamentals of Research in Mathematics and Computer Science

Direction 01.04.01 Mathematical analysis and modeling

| Chapter (subsection) in which changes are made | Reasons for change | Brief description of the changes | Date and number of the protocol of the meeting of the educational and methodological commission |
|---|---|---|---|
| | | | |