**RESEARCH SEMINAR**

**1 GENERAL CHARACTERISTICS OF THE DISCIPLINE Research Seminar**

|  |  |
| --- | --- |
| 1. Prerequisites | History of science  Methodology of research |
| 2. Corequisites | - |
| 3. Postrequisites | Final state attestation |
| 4. Work input of the discipline module, credits | 6 |

**1.1. Objectives of the discipline**

The objectives of the discipline are

* to generate knowledge about the role of methods and types of the research activities aimed at mathematical modelling of various processes in applied sciences and technologies, the current state and trends in the development of various equations, computational methods, mathematical modelling and modern information technologies;
* to master modern methods and apparatus of the theory of differential equations and numerical methods including the theory of ill-posed problems, for use in their future professional activities;
* to generate research skills, use the best traditions of the Ural mathematical research schools.

The study of the discipline is aimed at generating the competencies among students as follows:

* the ability to critically analyse and evaluate current scientific achievements, generate new ideas in solving research and practical problems, also in inter-disciplinary areas (Universal Competence-1);
* the readiness to participate in the work of Russian and international research teams in solving research and academic problems (Universal Competence-3);
* the readiness to use contemporary methods and technologies of the scientific communication in the state and foreign languages (Universal Competence-4);
* the ability to plan and pose their own professional and personal development challenges (Universal Competence-5);
* the ability to independently carry out research activities in the relevant professional field by applying state-of-the-art research methods as well as information and communication technologies (OShS 1);
* the readiness for teaching activities according to the main higher education programmes (General Professional Competence-2).
* the mastery of the mathematical modelling methods in the analysis of global problems on the basis of deep knowledge of fundamental mathematical disciplines and computer sciences (Professional Competence-1);
* the mastery of the mathematical and algorithmic modelling methods in the analysis of problems of natural science (Professional Competence-2);
* the ability to intensive research and scientific and research activities (Professional Competence-3);
* independent analysis of the physical aspects in classical statements of mathematical problems (Professional Competence-4);
* the ability to publicly present their own new research outcomes (Professional Competence-5);
* independent construction of a complete picture of the discipline (Professional Competence-6);
* the ability to be up to speed on modern algorithms of computer mathematics, improve, deepen and develop the mathematical theory underlying them (Professional Competence-7);
* own vision of the applied aspect in mathematical formulations (Professional Competence-8);
* the ability to use, develop and implement mathematically complex algorithms in modern software systems (Professional Competence-9);
* definition of common forms, patterns and tools for groups of disciplines (Professional Competence-10);
* the ability to represent and adapt mathematical knowledge in various ways taking into account the audience level (Professional Competence-11);
* the ability to manage and guide the research work in teams (Professional Competence-12);
* the ability to formulate in the problem-specific form non-mathematical types of knowledge (also from the humanities) (Professional Competence-13);
* the ability to apply basic models and algorithms of computational mathematics to solving applied problems (Professional Competence-14);
* the ability to develop, analyse and justify the adequacy of mathematical models (Professional Competence-15);
* the ability to perform a comparative analysis and reasonably choose algorithmic tools, software and hardware (Professional Competence-16);
* the ability to model and design data and knowledge structures, application and information processes (Professional Competence-17).
* the ability to use the basic natural science laws, apply the mathematical apparatus in professional activity, to identify the essence of problems arising in the course of professional activities (Professional Competence-18);
* the ability to understand the essence and importance of information in the development of modern society, apply the achievements in computer science and computer technology, process large amounts of information, conduct targeted searches in various sources of information on the profile of activities including the global computer systems (Professional Competence-19);

**1.2. Discipline outcome requirements**

As a result of mastering the discipline, a student should:

Know:

* the current state and trends in the development of differential equations, computational methods, mathematical modelling and modern information technologies;
* the possibility of using differential equations and numerical methods for mathematical modelling, modern information technologies and the further use of research methods in their professional activities;
* the main scientific achievements in the field of mathematical modelling, numerical methods and modern information technologies of both fundamental and applied orientation.

Be able:

* to operate with the contemporary apparatus in the field of mathematical modelling, numerical methods and modern information technologies;
* to conduct research using both classical and modern sections in the field of mathematical modelling, numerical methods and modern information technologies.

Master:

* the main theoretical positions in the field of mathematical modelling, numerical methods and modern information technologies that are included in the programmes for minimum requirements for the Ph.D. degree;
* the methods for the qualitative and analytical research of mathematical systems including the linear and non-linear analysis of complex dynamic objects;
* computer technologies for the implementation of numerical algorithms for investigating the behaviour of dynamic systems of complex nature.

**1.3. Brief description of the discipline**

The educational and scientific seminar is based on the presentations made at the traditional scientific seminar of the Department of Computational Mathematics. The seminar brings together research in the key research areas of the Department, such as differential equations including functional differential equations, the theory of dynamical systems and control theory; computational mathematics including methods for solving ill-posed and unstable problems, difference methods for solving inverse problems of dynamics and mathematical physics, numerical methods for solving functional-differential equations; mathematical modelling especially mathematical modelling in cardiac physiology; system programming and web programming. At the seminar all Ph.D. students make reports on their research materials. It became a tradition to listen to the seminar Ph.D. theses presented to the Thesis Board on the specialty Mathematical Modelling, Numerical Methods and Programme Systems. In addition, the seminar is attended by leading researchers in the areas, not only from Ekaterinburg.

The main task of the seminar is to introduce PhD students to serious research, develop skills and technologies of modern scientific reports and their presentations, develop scientific communication skills.

All the reports presented at the seminar should satisfy the main requirement, scientific novelty, therefore the topics are unique and have a scientific value, and, due to the specifics of the department, practical value. As a rule, according to the materials of the reports made at the research and educational seminar, scientific publications are published.

**1.4. The proportion of sessions conducted in an interactive form:**

The proportion of sessions conducted in an interactive form is 100% of the volume of classroom workload by discipline.

**1.5. The difficulties in mastering the discipline**

intramural form of study

|  |  |  |  |
| --- | --- | --- | --- |
| Types of educational work, forms of control | Total, hours | Number of the academic semester |  |
| 5 | 6 |
| Face-to-face learning, hours | 54 | 27 | 27 |
| Lectures, hours |  |  |  |
| Practical exercises, hours | 54 | 27 | 27 |
| Laboratory-based work, hours |  |  |  |
| Self-study, hours | 162 | 81 | 81 |
| Type of interim assessment (test, exam) |  |  |  |
| Total work intensity according to the curriculum, hours | 216 | 108 | 108 |
| Total work intensity according to the curriculum, credits | 6 | 3 | 3 |

**2. CONTENTS OF THE DISCIPLINE**

|  |  |  |
| --- | --- | --- |
| Code of sections and topics | Section, topic of the  **DISCIPLINE** | **Contents** |
| Р1 | Modern problems of differential equations, dynamical systems and control theories | On the conditions for unique solvability of linear boundary value problems for functional-differentiating equations.  Positive solvability of non-linear boundary value problems for delay equations.  Hutchinson’s equation with diffusion and Kolmogorov-Petrovskii-Piskunov delay.  Tracking non-extendable paths with Euler polygons.  Stabilisation of linear delay systems in coordinates and control.  Restoration of controls in a parabolic problem by the Tikhonov method with a non-smooth stabiliser. Optimisation of the guarantee in case of management lag. |
| Р2 | Modern problems of computational mathematics | Numerical solution of hyperbolic delay equations.  Two-stage Rosenbrock methods with complex coefficients.  A review of programmes by numerical methods for solving delay systems.  Simulation of inverse boundary problems of stationary thermal convection of a high-viscosity liquid.  The alternating directions method for solving a two-dimensional delay equation of parabolic type.  Non-linear iterative methods for operator equations in Banach spaces. |
| РЗ | **Modern problems of mathematical modelling of physiology and biophysics of the myocardium** | One-dimensional model of the heart muscle. Modelling the calcium-mechanical bond in the heart muscle.  Change in and verification of the parameters of the cardiac muscle contraction model.  Identifiability and sensitivity analysis of parameters in mathematical models of the cardiac cells.  Analysis of the image of the left ventricle of the human heart.  According to the preliminary diagnosis of the vibration disease based on the results of the examination of the cardiovascular system of industrial workers. |
| Р4 | **Modern problems of system programming and web programming** | Web access to the solvers of partial differential delay equations.  Evaluation of the proximity of images  Implementation of algorithms using the language of equipment description on microcircuits.  Creation of a system for the recognition and synthesis of the Russian speech.  Strategies for the dynamic memory recovery policy.  3-d - video reconstruction.  Identify the proximity of the pages of the social question-answer services.  Recognition of musical instruments in audio recordings.  Development of networks of the protocols for interaction between organisations and special clients.  A set of tools for decompiling programmes. Development of a software package for testing and pre-expulsion preparation of robotic devices for in-pipe diagnostics.  Management and planning systems of parallel tasks.  Automatic definition of the author’s text in natural languages. |

**3. DISTRIBUTION OF HOURS BY SECTIONS AND ASSESSMENT**

(Full-time study)

Learning semester 5, 6 Scope of discipline (credits)

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Discipline section | | | Face-toface load  (hours) | | | | Type, quantity and volumes of activities | | | | | | | | | | | | | | | | | | | | |
| Code of section, topic | Name of section, topic | Total of section, topic (hours) | Total | Lectures | Practical exercises | Laboratory-based work | Preparation for face-to-face learning (hours) | | | | | Total (hours) | Performing independent extracurricular activities (quantity) | | | | | | | | | Total (hours) | Preparation for the control qualification activities (quantity) | | | | |
| Total | Lectures | Pract. seminar classes | Laboratory-based work | Research seminars, conference seminars and colloquiums | Homework\* | Graphical work\* | Research paper, essay, creative work\* | Individual or group project\* | Translation of foreign literature\* j | Calculation wok, programme development\* | Calculation and graphical work\* | Term paper/ multi-disciplinary term work\* | Term paper/ multi-disciplinary term project\* | Review work (test)\* | Colloquium\* | Credit/test\* (given there is an exam) | Credit/test\* (graded given there is no exam) | Exam\* |
| 1 | Contemporary problems of differential equations, dynamical systems and control theory | 54 | 13 |  | 13 |  | 5 |  | 5 |  |  | 36 |  |  | 6 |  |  |  |  |  |  | 0 |  |  |  |  |  |
| 2 | Contemporary problems of computational mathematics | 50 | 14 |  | 14 |  | 6 |  | 6 |  |  | 30 |  |  | 5 |  |  |  |  |  |  | 0 |  |  |  |  |  |
| 3 | Contemporary problems of mathematical modelling of physiology and biophysics of the myocardium | 54 | 13 |  | 13 |  | 5 |  | 5 |  |  | 36 |  |  | 6 |  |  |  |  |  |  | 0 |  |  |  |  |  |
| 4 | Contemporary problems of system programming and web programming | 58 | 14 |  | 14 |  | 8 |  | 8 |  |  | 36 |  |  | 6 |  |  |  |  |  |  | 0 |  |  |  |  |  |
|  | **Discipline, total (hours)** | 216.0 | 54 | 0 | 54 | 0 | 24 | 0 | 24 | 0 | 0 | 0 | 138 | 138 | 0 | 23 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |  |  |

The total amount in hours per activity is indicated in the line Total (hours)

**4 ORGANISATION OF PRACTICAL CLASSES AND SELF-STUDY OF STUDENTS ON THE DISCIPLINE**

**4.1. Laboratory practicum**

not available

**4.2. Practical exercises**

* Functional-differential equations.
* Delay equations.
* A review of programmes by numerical methods for solving delay systems.
* Modelling inverse boundary problems of stationary thermal convection of a high-viscosity liquid.
* The method of variable directions for solving a two-dimensional delay equation of parabolic type.
* Non-linear iterative methods for operator equations in Banach spaces.
* One-dimensional model of the heart muscle.
* Modelling the calcium-mechanical bond in the heart muscle.
* Analysis of the image of the left ventricle of the human heart.
* On the preliminary diagnosis of the vibration disease according to the results of examination of the cardiovascular system of industrial workers
* Web access to the solvers of partial differential delay equations.
* Evaluation of the proximity of images.
* Implementation of algorithms using the language of equipment description on microcircuits.
* Creation of a system for the recognition and synthesis of the Russian speech.
* Strategies of dynamic memory recovery policy.
* З-d video reconstruction.
* Definition of proximity of the social question-answer service pages.
* Recognition of musical instruments in audio recordings.
* Development of networks of the protocols for interaction between organisations and special clients.
* A set of tools for decompiling programmes.
* Development of a software package for testing and pre-deployment preparation of robotic devices for in-pipe diagnostics.
* Systems for the control and planning of parallel tasks.
* Automatic definition of the author’s text in natural languages.

**4.3 Self-guided work of students and the current control activities**

***4.3.1. An indicative list of speech topics***

* On the conditions for the unique solvability of linear boundary value problems for functional differential equations.
* Positive solvability of non-linear boundary value problems for delay equations.
* the Hutchinson’s equation with diffusion and the Kolmogorov-Petrovskii-Piskunov delay equation.
* Tracking non-extendable trajectories with Euler polygons.
* Stabilisation of linear delay systems in coordinates and control.
* Restoration of controls in a parabolic problem by the Tikhonov method with a non-smooth stabiliser.
* Optimisation of the guarantee in case of control lag.
* Numerical solution of a delay equation of hyperbolic type.
* Two-stage Rosenbrock methods with complex coefficients.
* Review of the programmes on numerical methods for solving delay systems.
* Modellig inverse boundary problems of the stationary thermal convection of a high-viscosity liquid.
* A method of alternate directions for solving a two-dimensional delay equation of parabolic type.
* Non-linear iterative methods for operator equations in Banach spaces.
* One-dimensional model of the heart muscle.
* Modelling the calcium-mechanical bond in the heart muscle.
* Change in and verification of the parameters of the cardiac muscle contraction model.
* Identifiability and sensitivity analysis of parameters in the mathematical models of cardiac cells.
* Analysis of the image of the left ventricle of the human heart.
* On the preliminary diagnosis of the vibration disease according to the results of examination of the cardiovascular system of industrial workers.
* Web access to the solvers of partial differential delay equations.
* Evaluation of the proximity of images.
* Implementation of algorithms using the language of equipment description on microcircuits.
* Creation of a system for the recognition and synthesis of the Russian speech.
* Strategies for dynamic memory recovery policy.
* З-d video reconstruction.
* Determination of the proximity of the social question-answer service pages.
* Recognition of musical instruments in audio recordings.
* Development of networks of the protocols for interaction between organisations and special clients.
* A set of tools for decompiling programmes.
* Development of a software package for testing and pre-expulsion preparation of robotic in-line diagnostic devices.
* Management and planning systems for parallel tasks.
* Automatic definition of the author’s text in natural languages.

***4.3.2. An indicative list of homework topics***

Not provided.

***4.3.3. An indicative list of test topics***

Not provided.

***4.3.4. An indicative list of the computational work topics***

Not provided.

***4.3.5. An indicative list of topics for the calculation and graphic work***

Not provided.

***4.3.6. The approximate topics of the colloquiums***

Not provided.

***4.3.7. Sample topics of the term project (work)***

Not provided.

**4.4. An indicative list of test questions to prepare for the discipline qualification**

As qualification/attestation, the speech of a post-graduate student with the previous research work is included for each semester of the educational-scientific seminar.

**5. METHODOLOGICAL AND INFORMATION SUPPORT**

**5.1. Recommended literature**

***5.1.1. Main Literature***

**Main Literature**

Vasin V.V., Eremin LI. Operators and Iterative Processes of Fejer Type. Theory and Applications. Berlin-New-York: Wolter de Grugter, 2009.

**5.4. Databases, information and reference systems and search systems**

1) The official Internet portal of legal information. ~ Available at

http://pravo.gov.ru/, free. - Title from the screen.

2) Portal of information and educational resources of the UrFU. - Available at http://study.urfu.ru/info/, free. - Title from the screen.

3) Electronic base of normative documents of GOSTEXPERT. - Available at

http://gostexpert.ru/, free. - Title from the screen.

4) Search engines: www.yandex.ru, google.ru www.rambler.ru,

**5.5. The Evaluation Tool Stock (the tools for monitoring the educational achievements of students as well as attestation and teaching measuring materials)**

Not used