Course Syllabus

1. Course Title:

Modern Numerical Methods in Mathematical Modeling

2. Academic Level:

Master

3. ECTS Credits:

5 ECTS

4. Semester:

2, spring semester

5. School/Department:

Institute of Mathematics, Mechanics, and Computer Science named after I.I. Vorovich

6. Location:

8-A Milchakova St., Rostov-on-Don

7. Instructor:

Assoc. Prof. Konstantin Nadolin, email: kanadolin@sfedu.ru

8. Language of Instruction:

English

9. Course Description:

Course deals with advanced concepts and techniques of mathematical modeling in applied mathematics, which are based on differential equations (ODE and PDE). The subject of the course is focused on the ideas of different numerical methods, analyses of their distinctive features and comparison of their effectiveness for applications. Also, this course includes discussions and analysis of programming tricks and coding techniques in C++ for the efficient numerical solution of problems in science and engineering.

10. Course Aims:

While the major emphasis is on the study of finite element method (FEM) because of its well-structured computer-oriented scheme, universality, and adaptability for 2D and 3D problems in domains with complicated geometry, the course also draws attention to finite difference method (FDM) and some popular Galerkin-based techniques: Bubnov method; method of least squares; collocation methods (single and multiple collocation points, collocation in cells), etc.

11. Specific entry requirements (if any):

BSc. courses of analysis, linear algebra, ODE, PDE, calculus, scientific computing (Maple, Matlab)

12. Course Content:

Role of mathematical modeling and computational experiment in natural science and engineering. ODE and PDE as mathematical models. Fundamental PDEs, its classification and basic initial and boundary-value problems. Basic formulas for differential operators, their characteristics and transformations. Operator representation for problems of mathematical physics.

Exact solution of PDE. Green operator and its representation as series or integral. Calculation of values of exact solution in fixed points. Numerical solution of PDE vs. its classical exact solution. Dirichlet and Neumann problems for Poisson equation in regular domains. Numerical (MATLAB, Maple) and analytical (Fourier technique and separation of variables) approaches.

13. Intended Learning Outcomes:

On successful completion of the course, students are expected to be able to:

• describe and compare different approaches to the discretization procedure for the typical initial and boundary-value problems for ODE and PDE;

• choose and implement a suitable numerical method for given regular initial and boundary-value problems for ODE and PDE;

• ascertain basic properties of regular differential and discrete problems and analyze their correlations;

• define and analyze the influence of calculations errors (both absolute and relative).

14. Learning and Teaching Methods:

Lectures, laboratory and pre-laboratory work, self-study with writing a report

15. Methods of Assessment/Final assessment information:

Exam

16. Reading List:

- Zienkiewicz O.C., Morgan K. Finite Elements and Approximation. 1983. John Wiley & Sons.
- Fletcher C.A.J. Computational Galerkin Methods. 1984. Springer-Verlag.
- Encyclopedia of Computational Mechanics, Edited by Erwin Stein, Ren´e de Borst and Thomas J.R. Hughes. Volume 1: Fundamentals. Volume 2: Solids and Structures. Volume 3: Fluids. 2004. John Wiley & Sons.
- Efendiev Y., Hou T. Y. Multiscale Finite Element Methods: Theory and Applications. – B. : Springer, 2009.