Co-funded by the Erasmus+ Programme of the European Union

SUBJECT:	Numerical methods for ODE
ECTS CREDITS:	6 ECTS
TEACHERS, UNIVERSITY AND EMAILS:	Rysbaiuly Bolatbek (IITU, b.rysbaiuly@iitu.kz)
RESPONSIBLE TEACHER:	Rysbaiuly B.
LANGUAGE OF INSTRUCTION:	Russian (Rysbaiuly B.) English (Rysbaiuly B.)
ACADEMIC COURSE:	2016-17
NAME OF THE MASTER'S DEGREE:	Master's in Mathematical Engineering.

COURSE AIMS:

- Introducing students to the differential equations and its solutions
- Numerical methods for initial value problems for ordinary differential equations.
- Numerical methods for boundary value problems for ordinary differential equations.
- Being aware of exact, approximate and numerical methods to solve the resulting equations.
- Emphasizes practical solution of problems using C++.

LEARNING OUTCOMES:

At the end of the module you should be able to...

- apply several of the most important numerical methods for solving initial value problems and boundary value problems;
- derive some of the simpler methods from first principles;
- know the strengths and weaknesses of the various methods and be able to decide which ones are appropriate for a particular problem;
- decide whether a numerical method is stable and to give simple error estimates;
- write a program in C++ to implement various algorithms for the solution of differential equations;
- solve systems of linear equations by direct methods;
- use iterative methods to solve systems of non-linear equations.

COURSE SYLLABUS:

1. THE THEORY OF DIFFERENCE SCHEMES
1.1. Basic concepts of the theory of difference schemes
1.1.1. Grids and grid functions
1.1.2. The notion of convergence of the difference scheme
1.1.3. Approximation of a differential boundary value problem
1.1.4. The stability of the difference scheme
1.1.5. The relationship between approximation, stability and convergence

1.2. Methods of constructing difference schemes
1.2.1. The method of undetermined coefficients
1.2.3. Finite difference method

1.3. Investigation of the stability of difference schemes
1.3.1. Sufficient condition for stability of difference schemes for the solution of the Cauchy problem
1.3.2. Spectral stability criterion

2. CAUCHY PROBLEM, NUMERICAL METHODS FOR ORDINARY DIFFERENTIAL EQUATIONS
2.1. Taylor-expansion method
2.2. Euler's method
2.3. Runge-Kutta methods
2.4. Multi-step methods for the solution of the Cauchy problem
2.5 Extrapolation formula
2.6 Interpolation formula
2.7. Investigation of the stability of one-step and multi-step methods

3. NUMERICAL METHODS FOR SOLVING BOUNDARY PROBLEMS FOR ORDINARY DIFFERENTIAL EQUATIONS
3.1. Formulation of the problem
3.2. Approximation of boundary value problem
3.3. Methods of solving the grid boundary value problem

LITERATURE:

- Basic literature:

[1]. Ernst Hairer, Syvert P. Nørsett, Gerhard Wanner. Solving Ordinary Differential Equations I: Nonstiff Problems (Springer Series in Computational Mathematics) 2nd ed. 1993. Corr. 3rd printing 2009 Edition

[2]. Ernst Hairer, Gerhard Wanner. Solving Ordinary Differential Equations II: Stiff and Differential-Algebraic Problems (Springer Series in Computational Mathematics) 2nd ed. 1996 Edition

[3]. David Griffiths, Desmond J. Higham. Numerical Methods for Ordinary Differential Equations: Initial Value Problems (Springer Undergraduate Mathematics Series) 2010th Edition

[4]. Susanne Brenner, Ridgway Scott. The Mathematical Theory of Finite Element Methods (Texts in Applied Mathematics) 3rd Edition

[5]. Ernst Hairer, Syvert P. Nørsett, Gerhard Wanner. Solving Ordinary Differential Equations I: Nonstiff Problems (Springer Series in Computational Mathematics) 2nd ed. 1993. Corr. 3rd printing 2009 Edition

- Further reading:

[1]. Rudra Pratap. Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers 1st Edition

[2]. Claes Johnson. Numerical Solution of Partial Differential Equations by the Finite Element Method (Dover Books on Mathematics)

[3]. Randall LeVeque. Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-Dependent Problems (Classics in Applied Mathematics) Classics in Applied Mathematics Edition

[4]. J. C. Butcher. Numerical Methods for Ordinary Differential Equations 2nd Edition

[5]. R. W. Hamming. Numerical Methods for Scientists and Engineers (Dover Books on Mathematics) 2nd Revised ed. Edition

TEACHING METHOD:

Face-to-face lectures, tutorial and lab classes, online lecture notes, tutorial solutions, peer mentoring, 'help day' by tutors/lecturers and selection of textbooks having interactive solutions of numerical problems. Videoconference to all CA partners.

METHOD OF ASSESSMENT:

60% for **Knowledge and understanding**:

- written examination which includes examination on theory taught in the lectures and practical/seminar/laboratory classes

40% for **Practical issues**:

- includes solved exercises on personal studies,
- attendance to the lab/practical/seminar classes
- Oral and written responses based on individual experience

Method of REASSESSMENT:
60% for **Knowledge and understanding**:

- written examination which includes examination on theory taught in the lectures and practical/seminar/laboratory classes

40% for **Practical issues**:

- written examination which includes solved exercises during the reassessment examination

STUDENT WORKLOAD:

On-site work at the classroom (attendance to classes and participation on them) = 60 hours.
Lecture hours: 1 hours per week
Practical/Lab hours: 3 hours per week
Mid term exam: 2 academic hours
Final exam: 2 academic hours

Self-study (autonomous study, doing exercises, programming, recommended readings) = 84 hours.

RECOMMENDATIONS:

OTHER COMMENTS: