Course title	**Fundamentals of the theory of ordinary differential equations**
Course code	Mate5015
Branch of science	Mathematics
Sub-branch	Differential equations
Credit points	4
ECTS credit points	6
Total contact hours Lectures Seminars	64 48 16

Course authors
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Prerequisites (course title, part of the program)
None

Course abstract
This course is designed for Master study program "Mathematics" (sub-branch "Differential equations") students. The course continues Bachelor study program's "Mathematics" course "Ordinary Differential Equations" and aims to deepen the knowledge of analytical methods and qualitative theory options for the ordinary differential equations, to introduce students to the numerical solving methods and stability theory.

Results
• get an depth understanding of analytical methods and qualitative theory options for the ordinary differential equations; • get an idea of numerical solving methods of ordinary differential equations; • be able to find the fundamental matrix of the linear system of differential equations with constant coefficients; • be able to explore a stability of ordinary differential equation or equation's system.

Course content:
Lectures – 48 contact hours, seminars – 16 contact hours Classification of ordinary differential equations. Analytical solving methods of ordinary differential equations. Linear differential systems. Fundamental matrix. Basic questions of the theory of ordinary differential equations: an existence and uniqueness of solutions, extendability of a solution, continuous dependence on initial conditions. Ordinary differential equations and contraction mappings. Ordinary differential equations and integral equations. Numerical methods for ordinary differential equations. Stability theory of ordinary differential equations.

Course plan:
Lecture topics 1. Classification of the ordinary differential equations. The n-th order differential equation, normal System of differential equations. 2. Linear and nonlinear ordinary differential equations. 3.-4. Solvable and non-solvable ordinary differential equations. Elementary analytical methods of the first order differential equations.

5.-6. The higher order linear ordinary differential equations.
7.-9. Linear systems of differential equations. Fundamental matrix concept and its finding techniques. General and particular solution.
10.-13. Basic questions of the theory of ordinary differential equations: an existence and uniqueness of solutions, extendability of a solution, continuous dependence on initial conditions.
14.-15. Ordinary differential equations and contraction mappings.
16.-17. Ordinary differential equations and integral equations.
18.-20. Numerical methods for ordinary differential equations: Taylor methods, Euler-Cauchy method, algorithms of Runge-Kutta method.
21.-24. Stability of a solution of ordinary differential equation. Systems of autonomous differential equations, their equilibrium points. Stability via linearization. Lyapunov direct method.

Seminar topics

1. Elementary analytical solving methods of the first order ordinary differential equations.
2. Solving of linear higher order ordinary differential equation.
3. Solving of linear system of differential equations.
4. An existence, uniqueness and extendability of a solution to ordinary differential equation.
5. Ordinary differential equations and integral equations.
6. Solving of ordinary differential equations using Taylor methods.
7.-8. Stability of solutions of ordinary differential equations and their systems.

Independent work of students:
The course provided a systematic control tasks solving. During semester students must complete 4 homeworks:
- analytical solving methods of ordinary differential equations;
- linear systems of differential equations, their fundamental matrices;
- solving of ordinary differential equations using Taylor methods;
- stability of solutions of ordinary differential equations.

Each of the students' independent work options is individual.
All entries must be satisfied and positively evaluated by the beginning of the session.

Course requirements:

Acquisition and presentation of knowledge and skills described within the course.
Final evaluation form for the course – exam. The exam is offered in 2 theoretical questions, fulfilment of independent works is taken into account the exam evaluation.
Course requirements – regular attendance and active work in 60%, independent work execution of 40%.
Study methods and forms – lectures, seminars, independent work.

Main literature:

1. S. Ahmad, A. Ambrosetti. A Textbook on Ordinary Differential Equations, Springer, 2014.
2. R. P. Agarwal, D. O'Regan. An Introduction to Ordinary Differential Equations, Springer, 2008.
3. R. P. Agarwal, D. O'Regan. Ordinary and Partial Differential Equations: with Special Functions, Fourier Series, and Boundary value problems, Springer, 2008.
4. L. Barreira, C. Valls. Ordinary Differential Equations: Qualitative Theory (Graduate Studies in Mathematics), AMS, 2012.
5. P. Blanchard, R. L. Devaney, G. R. Hall. Differential Equations, Thomson Brooks Cole, 2006.
6. W. E. Boyce, R. C. DiPrima. Elementary Differential Equations and Boundary Value Problems, John Wiley & Sons, 2000.
7. W. Kelley, A. Peterson. The Theory of Differential Equations: Classical & Qualitative, Prentice Hall, 2004.
8. J. Cepītis. Pirmās kārtas parastais diferenciālvienādojums, Rīga, LU, 1994.
9. S. Čerāne. Diferenciālvienādojumi, Rīga, 2002.
10. S. Čerāne. Diferenciālvienādojumi un modeļi, Rīga, 1999.
11. Понтрягин Л.С. Обыкновенные дифференциальные уравнения. М., Наука, 1982.

Auxiliary literature:

1. K. E. Atkinson, W. Han, D. Stewart. Numerical Solution of Ordinary Differential Equations, John Wiley & Sons, 2009.
2. P.J. Antsaklis, A.N. Michel. Linear systems, New York, McGraw-Hill, 1997.
3. J. Butcher. Numerical Methods for Ordinary Differential Equations, John Wiley & Sons, 2008.
4. D. Betounes. Differential Equations: Theory and Applications, Springer; 2009.
5. D. A. Sanchez. Ordinary Differential Equations and Stability Theory: An Introduction Summary, Dover Publications , 1979.
6. A. Pedas, G. Vanikko. Harilikud diferentsiaalvorrandid, Tartu, 2011.
7. W. E. Boyce, R. C. Di Prima. Student Solutions Manual to accompany Elementary Differential Equations and Boundary Value Problems, 7th Edition, John Wiley & Sons, Inc, 2000.
8. P. Collins. Differential and integral equations, OUP, 2006.
9. J.D. Logan. A First Course in Differential Equations, Springer, 2006.
10. J.C. Robinson. An Introduction to Ordinary Differential Equations, Cambridge University Press, 2005.
11. I. I. Vrabie. Differential equations, World Scientific, 2004.
12. A. Polyanin, V. Zaitsev. Handbook of Exact Solutions for Ordinary Differential Equations, Chapman & Hall/CRC, 2002.
13. Егоров А. И. Обыкновенные дифференциальные уравнения с приложениями, М., 2005.
14. В.С. Козлова, В.М. Любимов. Обыкновенные дифференциальные уравнения, М., 2005.
15. Пантелеев А.В., Якимова А.С., Босов А.В. Обыкновенные дифференциальные уравнения в примерах и задачах. - М.: МАИ, 2000.
16. Филиппов А.Ф**.** Сборник задач по дифференциальным уравнениям, Ижевск, 2000.

Periodical and other sources of information:

1. Differential Equations http://www.sosmath.com/diffeq/diffeq.html
2. Arthur Mattuck Differential Equations MIT Course (video) http://academicearth.org/courses/differential-equations
3. Notes on Diffy Qs: Differential Equations for Engineers http://www.jirka.org/diffyqs/
4. Ordinary Differential Equations http://eqworld.ipmnet.ru/en/solutions/ode.htm
5. http://mathworld.wolfram.com/OrdinaryDifferentialEquation.html
6. http://www.aw-bc.com/ide/

Relevant study programs and their parts (A, B, C, D):

Master study program „Mathematics” , part A.