



Subject card

Subject name and code		Differential equations II, PG_00070304						
Field of study		Mathematics						
Date of commencement of studies		October 2025	Academic year of realisation of subject			2025/2026		
Education level		second-cycle studies	Subject group			Specialty subject group Subject group related to scientific research in the field of study		
Mode of study		Full-time studies	Mode of delivery			at the university		
Year of study		1	Language of instruction			Polish		
Semester of study		2	ECTS credits			5.0		
Learning profile		general academic profile	Assessment form			exam		
Conducting unit		Department of Differential Equations and Mathematical Applications -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)		Subject supervisor		dr inż. Marcin Styborski				
		Teachers		dr inż. Marcin Styborski				
Lesson types		Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
		Number of study hours	30.0	30.0	0.0	0.0	0.0	60
		E-learning hours included: 0.0						
		eNauczanie source addresses: Moodle ID: 5001 Równania różniczkowe II https://enauczanie.pg.edu.pl/2025/course/view.php?id=5001						
Learning activity and number of study hours		Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM		
		Number of study hours	60	5.0	60.0	125		
Subject objectives		Acquiring basic knowledge about the qualitative theory of differential equations. Review of classical equations						
Learning outcomes		Course outcome	Subject outcome			Method of verification		
		[K7_U07] at an advanced level and covering modern mathematics, applies and presents in speech and in writing the content and methods of a selected branch of mathematics	The student is able to analyze elementary nonlinear equations. Creates a phase portrait, examines the stability of solutions.			[SU4] Assessment of ability to use methods and tools		
		[K7_U03] uses differential and integral calculus, elements of complex analysis, algebraic methods, applies them in typical practical	The student is able to apply methods of calculus to analyze differential equations.			[SU4] Assessment of ability to use methods and tools		
		[K7_W05] demonstrates knowledge the numerical methods used to find approximate solutions to mathematical problems posed by applied fields	The student is able to use available software to analyze nonlinear equations.			[SW1] Assessment of factual knowledge		
		[K7_W01] has enhanced knowledge of basic branches of mathematics, demonstrates knowledge theorem and hypotheses, has understanding of the role and importance of mathematical reasoning structure.	The student is able to apply the methods of linear algebra, mathematical analysis and topology to the qualitative study of differential equations.			[SW1] Assessment of factual knowledge		

Subject contents	<p>Course content – lecture</p> <ol style="list-style-type: none"> 1. Introduction. What are dynamical systems and why do they matter? Flow, orbits, phase portrait. Course overview. Assessment criteria. 2. Planar classification of linear systems (TrDet diagram). Topological conjugacy. 3. Topological classification in \mathbb{R}^n. Hyperbolic and non-hyperbolic cases. Topological conjugacy vs. matrix similarity. 4. Stable, unstable, and center manifolds. Hyperbolic fixed points. Stable and unstable manifold theorem. Example: Duffing equation. 5. Straightening-out Theorem. Regular points vs. equilibria. Local structure of trajectories. Poincaré section introduction. 6. Lyapunov stability. Definitions: stability, asymptotic stability, instability. Lyapunov stability theorem. 7. Lyapunov functions construction methods. Instability theorem. Estimation of basins of attraction. Examples: harmonic oscillator, pendulum. 8. Applications of the Lyapunov method. Gradient systems. Energy as a Lyapunov function. Examples: van der Pol oscillator, Lorenz system. 9. Center manifold. Existence and regularity theorem. Dimension reduction. Dynamics on the center manifold. 10. Hamiltonian systems and first integrals. Conservation of energy. Examples: pendulum, Duffing. Liouville's theorem on measure. 11. Poincaré-Bendixson theorem part I. Omega-limit sets. Limit cycles. 12. Poincaré-Bendixson theorem part II. Criteria excluding cycles: Bendixson, Dulac. Applications: population models (Lotka-Volterra), van der Pol. 13. Poincaré map. Periodic orbits and their stability. Poincaré-Hopf index theorem. 14. Deterministic chaos. Lorenz attractor. Sensitivity to initial conditions. <p>Course content – exercises</p> <p>During the exercises, students receive worksheets on which they work in groups. Each worksheet covers a topic covered in the lecture.</p>											
Prerequisites and co-requisites	The knowledge of Mathematical Analysis, Differential Equations I											
Assessment methods and criteria	<table border="1" data-bbox="448 792 1487 898"> <thead> <tr> <th data-bbox="448 792 794 831">Subject passing criteria</th> <th data-bbox="794 792 1141 831">Passing threshold</th> <th data-bbox="1141 792 1487 831">Percentage of the final grade</th> </tr> </thead> <tbody> <tr> <td data-bbox="448 831 794 869">worksheet</td> <td data-bbox="794 831 1141 869">50.0%</td> <td data-bbox="1141 831 1487 869">90.0%</td> </tr> <tr> <td data-bbox="448 869 794 898">exam</td> <td data-bbox="794 869 1141 898">50.0%</td> <td data-bbox="1141 869 1487 898">10.0%</td> </tr> </tbody> </table>			Subject passing criteria	Passing threshold	Percentage of the final grade	worksheet	50.0%	90.0%	exam	50.0%	10.0%
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Recommended reading	<p>Basic literature</p> <p>Supplementary literature</p> <p>eResources addresses</p>	<ol style="list-style-type: none"> 1. M. W. Hirsch, S. Smale, R. L. Devaney, Differential Equations, Dynamical Systems, and an Introduction to Chaos, Academic Press (Elsevier), wyd. 2 / 2nd ed., 2004. Główny podręcznik kursu. Geometryczna intuicja, klasyfikacja układów liniowych, twierdzenie Poincarégo-Bendixsona, van der Pol, Lorenz. 2. L. Perko, Differential Equations and Dynamical Systems, Springer, wyd. 3 / 3rd ed., 2001. (Texts in Applied Mathematics, vol. 7) Precyzja i kompletność. Rozmaitości stabilne (§2.7), stabilność Lapunowa (§2.9), rozmaitość centralna (§2.12), układy hamiltonowskie (§2.14). 3. G. Teschl Ordinary Differential Equations and Dynamical Systems, American Mathematical Society, 2012. 										
Example issues/ example questions/ tasks being completed	<p>Exercise 1. Investigate the stability of the equilibrium point of the system using a Lyapunov function</p> <p>Exercise 2. For the system find all equilibrium points, classify them via linearization, and sketch the phase portrait.</p>											
Practical activities within the subject	Not applicable											

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