University of Gdańsk

Subject card

Subject name and code	Computational Mathematics of Evolutionary Equations, PG_00171117					
Field of study	Mathematical Modeling and Data Analysis					
Date of commencement of studies	October 2024		Academic year of realisation of subject		2025/2026	
Education level	Master's studies		Subject group			
Mode of study	full-time studies		Mode of delivery		at the university	
Year of study	2		Language of instruction		English	
Semester of study	4		ECTS credits		6.0	
Learning profile	academic		Assessment form		exam	
Conducting unit	Institute of Mathematics -> Faculty of Mathematics, Physics and Informatics -> Rector					
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Karolina Kropielnicka				
	Teachers					

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	30.0	0.0	0.0	60
	E-learning hours included: 0.0						

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	10.0	80.0	150

Subject objectives	The aim of this course is to show how solutions of evolutionary equations modelling phenomena in biology, medicine, chemistry and of physics can be approximated with the aid of algorithms and computers.

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[MMiADMU2_W04] knows and understands the theoretical basis of computational methods and IT techniques used to solve problems in a selected field of mathematics	The student understands the theoretical foundations of numerical methods used to solve evolutionary equations and is able to relate them to appropriate computational techniques supporting their implementation.	[SW4] test/exam - oral or written
	[MMiADMU2_K02] is ready to precisely formulate questions to deepen his own understanding of a given topic or to find missing elements of reasoning	The student can formulate precise questions concerning mathematical and computational issues, enabling deeper understanding of the subject and identification of gaps in reasoning.	[SK4] test/exam - oral or written
	[MMiADMU2_K04] is ready to understand and appreciate the importance of intellectual honesty in the actions of himself and others; is ready to act ethically	The student is prepared to act in accordance with the principles of intellectual honesty when analysing literature, developing algorithms, and presenting computational results, and respects the intellectual contributions and authorship of others.	[SK1] oral statement/conversation/ discussion
	[MMiADMU2_K05] is ready to independently search for information in literature, also in foreign languages	The student is prepared to independently search for and analyse information in scientific literature, including in English, in order to broaden their knowledge of numerical methods and evolutionary equations.	[SK1] oral statement/conversation/ discussion
	[MMiADMU2_U11] can evaluate, at a basic level, the usefulness of mathematical methods and IT tools	The student is able to assess the usefulness of selected numerical methods and programming tools (e.g., Python) for solving evolutionary equations and interpreting the results.	[SU1] oral statement/conversation/ discussion
	[MMiADMU2_K01] is ready to recognize the limitations of his own knowledge and is ready to continue his education	The student is aware of the limitations of their own knowledge in numerical and computational methods and is prepared to pursue further independent learning and development in this area.	[SK1] oral statement/conversation/ discussion
	[MMiADMU2_U07] is able to define his interests and develop them; in particular, is able to establish contact with specialists in their field, e.g. understand their lectures intended for young mathematicians	The student is able to identify and develop their interests in computational mathematics and, through participation in an English-taught course, is prepared to engage with specialists and follow research-level lectures aimed at early-career mathematicians.	[SU1] oral statement/conversation/ discussion

Subject contents	Introduction to Evolutionary Equations: • Examples from wave, diffusion, and Schrödinger-type problems. Foundations of Computational Mathematics for Evolution Equations: • Space-time discretisation: grid concepts, time/space steps. • Algorithmic quality criteria: accuracy, stability, convergence, efficiency. Time Discretisation: • Explicit and implicit methods (Euler, Crank-Nicolson, Runge-Kutta). • Stability and stiffness (A-stability, L-stability). Space Discretisation: • Finite difference methods (FDM). • Finite element methods (FEM). • Introduction to spectral methods and applications. Solving Evolutionary Equations: • Coupling space and time discretisation. • Schemes for parabolic, hyperbolic, and Schrödinger-type equations. Numerical Analysis of Algorithms: • Error sources: truncation, rounding. • CFL condition and its implications. • Conservation of physical quantities (e.g. energy) in numerical schemes. Implementation and Visualisation: • Python implementation (NumPy, Matplotlib, SciPy). • Visualising solutions time evolution, spatial profiles. Selected Topics and Student Projects: • Applications to realistic problems (e.g. wave propagation, heat transfer). • Projects using real-world physical or biological models.

Prerequisites and co-requisites	Prerequisites: • Basic knowledge of calculus (derivatives, integrals, elementary differential equations). • Familiarity with linear algebra (systems of linear equations, matrices, vector spaces). • Basic programming skills in Python (variables, loops, functions, use of numerical libraries like NumPy). • Ability to communicate in English at a level sufficient for following lectures and participating in exercises. Additional recommended preparation: • Completion of the *Foundations of Computational Mathematics* course (not required but helpful). • Familiarity with basic numerical methods (e.g. Eulers method, interpolation, numerical integration). • Interest in applications of mathematics to natural sciences and engineering.
Assessment methods and criteria	see table below

Subject passing criteria	Passing threshold	Percentage of the final grade
egzam	51.0%	100.0%

Recommended reading	Basic literature	1. Peter Deuflhard, Folkmar Bornemann, Scientific computing with ordinary differential equations, Springer, 2002. 2. Peter Deuflhard, Martin Weiser, Adaptive numerical solution of pdes, DeGruyter, 2012. 3. Ernst Hairer, Gerhard Wanner, Solving ordinary differential equations II, 2nd edition, Springer, 1996. 4. A. Iserles, A First Course in the Numerical Analysis of Differential Equations, CUP, 2009.
	Supplementary literature	1. Ben Leimkuhler, Sebastian Reich, Simulating Hamiltonian dynamics, CUP, 2004. 2. C. Lubich, From Quantum to Classical Molecular Dynamics: Reduced Models and Numerical Analysis, EMS, 2008.
	eResources addresses	
Example issues/ example questions/ tasks being completed	• Differences between explicit and implicit time discretisation methods. • Numerical stability the concept of A-stability and its importance. • Space discretisation: comparison of finite difference, finite element, and spectral methods.	
Work placement	Not applicable	