University of Gdańsk

Subject card

Subject name and code	Essential Numerical Analysis for Physicists, PG_00182303		
Field of study	Physics		
Date of commencement of studies	October 2025	Academic year of realisation of subject	2026/2027
Education level	Bachelor’s studies	Subject group	Obligatory subject group in the field of study 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	2	Language of instruction	Polish Classes may be conducted in English in the following cases: - when the course is taught by an English-speaking instructor, - when a non-Polish-speaking international student is present in the group, - when the course is delivered by an invited external expert, - at the request of the students in the group.
Semester of study	4	ECTS credits	3.0
Learning profile	academic	Assessment form	credit
Conducting unit	Laboratory for Physics Teaching -> Institute of Experimental Physics -> Faculty of Mathematics, Physics and Informatics -> Rector		
Name and surname of lecturer (lecturers)	Subject supervisor	dr Adrian Kołodziejski	
	Teachers		

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	0.0	0.0	45.0	0.0	0.0	45
	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	45	0.0	45.0	90

Subject objectives	Introducing students to intermediate numerical methods used in physics. The completion of computational projects aims to reinforce programming skills.

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZL3_U11] can use various application software packages to present results and analyze data	The student is able to: – numerically determine the solution of the Cauchy problem for ordinary differential equations; – numerically solve boundary value problems for ordinary differential equations; – numerically compute the eigenvalues and eigenvectors of a matrix; – compute the discrete Fourier transform using the FFT method; – determine the LU and Cholesky decomposition of a matrix; – numerically find the local minimum of a function of one or multiple variables.	[SU2] presentation/project/paper/ report
	[FIZL3_U12] can write, compile, run, test and document a computer program written by himself	The student is able to: – numerically determine the solution of the Cauchy problem for ordinary differential equations; – numerically solve boundary value problems for ordinary differential equations; – numerically compute the eigenvalues and eigenvectors of a matrix; – compute the discrete Fourier transform using the FFT method; – determine the LU and Cholesky decomposition of a matrix; – numerically find the local minimum of a function of one or multiple variables.	[SU2] presentation/project/paper/ report
	[FIZL3_W12] knows the methods of numerical analysis, knows at least one package for symbolic calculations at an advanced level, knows application software packages for presentation of results and data analysis; knows one programming language fluently	The student knows: – numerical methods for solving the Cauchy problem for ordinary differential equations, including predictor–corrector and multistep methods; – numerical methods for solving boundary value problems for ordinary differential equations, including the shooting method and the finite difference method; – the basics of the finite element method; – methods for solving matrix eigenvalue problems (power method, Jacobi method, Lanczos algorithm); – methods for computing the discrete Fourier transform; – the Verlet algorithm used in molecular dynamics simulations; – LU and Cholesky decompositions; – methods for minimizing functions of one or multiple variables, including the golden-section method, quadratic interpolation, steepest descent, and the simplex method.	[SW2] presentation/project/paper/ report
	[FIZL3_U08] can use numerical methods or software for symbolic calculations or simulations to describe and model physical phenomena and processes	The student is able to: - apply a chosen numerical method to analyze a physical problem; - use symbolic computation software to obtain analytical results or simplify the problem; - construct a computer simulation describing the dynamics of physical phenomena; - interpret results obtained through numerical methods and simulations in a physical context.	[SU2] presentation/project/paper/ report

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Course outcome	Subject outcome	Method of verification
[FIZL3_K02] can precisely formulate problems aimed at deepening the understanding of a given topic	The student is able to: - formulate a physical problem in a way that allows its numerical analysis; - identify which aspects of the problem require more detailed investigation and simulation; - select numerical methods appropriate to the nature of the problem and anticipate potential computational difficulties.	[SK2] presentation/project/paper/ report

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<tr><td>Subject contents</td><td>Ordinary differential equations solving the Cauchy problem predictorcorrector and multistep methods.
Ordinary differential equations solving boundary value problems shooting method, finite difference method. Richardson extrapolation.
Basics of the finite element method.
Matrix eigenvalue problems power method, similarity transformations, Jacobi/Givens methods, Lanczos algorithm.
Fourier transform fast Fourier transform (FFT).
Molecular dynamics simulations Verlet algorithm.
Matrix factorizations: LU and Cholesky decomposition.
Function minimization: single- and multi-variable functions golden-section method, quadratic interpolation, steepest descent, simplex method, genetic algorithms.</td></tr>
<tr><td>Prerequisites
and co-requisites</td><td>A. Formal requirements: passed exams in Mathematical Analysis for Physicists, Differential Equations and Probability Theory, and Linear Algebra; completed Computational Methods in Physics.
B. Prerequisites: mastery of elementary mathematical tools for physics; proficiency in programming in Python.</td></tr>
<tr><td>Assessment methods
and criteria</td><td>

Subject passing criteria	Passing threshold	Percentage of the final grade
not applicable	51.0%	25.0%
not applicable	51.0%	75.0%

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<tr><td>Recommended reading</td><td>
<table>
<tr><td>Basic literature</td><td>

- P. L. de Vries, A first course in computational physics, John Wiley & Sons, Inc. New York 1994
- Å. Björck, G. Dahlquist, Metody numeryczne PWN 1987
- J. M. Jankowscy, Przegląd algorytmów numerycznych, Wyd. Naukowo-Techniczne 1988
- J. Stoer, R. Burlisch, Wstęp do analizy numerycznej, PWN 1987
- Z. Kamont, Równania różniczkowe zwyczajne.Wydawnictwo UG 1999
- W. Cheney, D. Kincaid, Analiza numeryczna, Wydawnictwo Naukowo-Techniczne, 2006
- G.N. Giordano, Computational Physics, Prentice-Hall, 1997

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<tr><td>Supplementary literature</td><td>not applicable</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
</table>
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<tr><td>Example issues/
example questions/
tasks being completed</td><td>not applicable</td></tr>
<tr><td>Work placement</td><td>Not applicable</td></tr>
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