

**Subject card**

<b>Subject name and code</b>	Essential Numerical Analysis for Physicists, PG_00182303						
<b>Field of study</b>	Physics						
<b>Date of commencement of studies</b>	October 2026	<b>Academic year of realisation of subject</b>			2027/2028		
<b>Education level</b>	Bachelor's studies	<b>Subject group</b>			Obligatory subject group in the field of study Subject group related to scientific research in the field of study		
<b>Mode of study</b>	full-time studies	<b>Mode of delivery</b>			at the university		
<b>Year of study</b>	2	<b>Language of instruction</b>			Polish		
<b>Semester of study</b>	4	<b>ECTS credits</b>			3.0		
<b>Learning profile</b>	academic	<b>Assessment form</b>			credit		
<b>Conducting unit</b>	Laboratory for Physics Teaching -> Institute of Experimental Physics -> Faculty of Mathematics, Physics and Informatics -> Rector						
<b>Name and surname of lecturer (lecturers)</b>	<b>Subject supervisor</b>		dr Adrian Kołodziejski				
	Teachers						
<b>Lesson types</b>	<b>Lesson type</b>	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						
<b>Learning activity and number of study hours</b>	<b>Learning activity</b>	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
<b>Subject objectives</b>	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_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: <ul style="list-style-type: none"> <li>- numerical methods for solving the Cauchy problem for ordinary differential equations, including predictor-corrector and multistep methods;</li> <li>- numerical methods for solving boundary value problems for ordinary differential equations, including the shooting method and the finite difference method;</li> <li>- the basics of the finite element method;</li> <li>- methods for solving matrix eigenvalue problems (power method, Jacobi method, Lanczos algorithm);</li> <li>- methods for computing the discrete Fourier transform;</li> <li>- the Verlet algorithm used in molecular dynamics simulations;</li> <li>- LU and Cholesky decompositions;</li> <li>- methods for minimizing functions of one or multiple variables, including the golden-section method, quadratic interpolation, steepest descent, and the simplex method.</li> </ul>	[SW2] presentation/project/paper/report
	[FIZL3_K02] can precisely formulate problems aimed at deepening the understanding of a given topic	The student is able to: <ul style="list-style-type: none"> <li>- formulate a physical problem in a way that allows its numerical analysis;</li> <li>- identify which aspects of the problem require more detailed investigation and simulation;</li> <li>- select numerical methods appropriate to the nature of the problem and anticipate potential computational difficulties.</li> </ul>	[SK2] presentation/project/paper/report
	[FIZL3_U12] can write, compile, run, test and document a computer program written by himself	The student is able to: <ul style="list-style-type: none"> <li>- numerically determine the solution of the Cauchy problem for ordinary differential equations;</li> <li>- numerically solve boundary value problems for ordinary differential equations;</li> <li>- numerically compute the eigenvalues and eigenvectors of a matrix;</li> <li>- compute the discrete Fourier transform using the FFT method;</li> <li>- determine the LU and Cholesky decomposition of a matrix;</li> <li>- numerically find the local minimum of a function of one or multiple variables.</li> </ul>	[SU2] 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: <ul style="list-style-type: none"> <li>- apply a chosen numerical method to analyze a physical problem;</li> <li>- use symbolic computation software to obtain analytical results or simplify the problem;</li> <li>- construct a computer simulation describing the dynamics of physical phenomena;</li> <li>- interpret results obtained through numerical methods and simulations in a physical context.</li> </ul>	[SU2] presentation/project/paper/report

	<table border="1"> <thead> <tr> <th>Course outcome</th> <th>Subject outcome</th> <th>Method of verification</th> </tr> </thead> <tbody> <tr> <td>[FIZL3_U11] can use various application software packages to present results and analyze data</td> <td>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.</td> <td>[SU2] presentation/project/paper/report</td> </tr> </tbody> </table>	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			
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Subject contents	<ol style="list-style-type: none"> <li>1. Ordinary differential equations solving the Cauchy problem predictor-corrector and multistep methods.</li> <li>2. Ordinary differential equations solving boundary value problems shooting method, finite difference method.</li> <li>3. Richardson extrapolation.</li> <li>4. Basics of the finite element method.</li> <li>5. Matrix eigenvalue problems power method, similarity transformations, Jacobi/Givens methods, Lanczos algorithm.</li> <li>6. Fourier transform fast Fourier transform (FFT).</li> <li>7. Molecular dynamics simulations Verlet algorithm.</li> <li>8. Matrix factorizations: LU and Cholesky decomposition.</li> <li>9. Function minimization: single- and multi-variable functions golden-section method, quadratic interpolation, steepest descent, simplex method, genetic algorithms.</li> </ol>									
Prerequisites and co-requisites	<p>A. Formal requirements: passed exams in Mathematical Analysis for Physicists, Differential Equations and Probability Theory, and Linear Algebra; completed Computational Methods in Physics.</p> <p>B. Prerequisites: mastery of elementary mathematical tools for physics; proficiency in programming in Python.</p>									
Assessment methods and criteria	<table border="1"> <thead> <tr> <th>Subject passing criteria</th> <th>Passing threshold</th> <th>Percentage of the final grade</th> </tr> </thead> <tbody> <tr> <td>not applicable</td> <td>51.0%</td> <td>25.0%</td> </tr> <tr> <td>not applicable</td> <td>51.0%</td> <td>75.0%</td> </tr> </tbody> </table>	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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Recommended reading	Basic literature	<p>-Z. Altaç, Numerical Methods for Scientists and Engineers, CRC Press 2025.</p> <p>-E.B.M. Bashier, Practical Numerical and Scientific Computing with MATLAB® and Python, Taylor &amp; Francis 2020.</p> <p>-F. Bittmann, Python 3 for Science and Engineering Applications, Elektor International Media BV 2020.</p> <p>-L. Brieda, J. Wang, R. Martin, Introduction to Modern Scientific Programming and Numerical Methods, CRC Press 2025.</p> <p>-Å. Björck, G. Dahlquist, Metody numeryczne PWN 1987.</p> <p>-W. Cheney, D. Kincaid, Analiza numeryczna, Wydawnictwo Naukowo-Techniczne, 2006.</p> <p>-D.E. Clough, S.C. Chapra, Engineering and Scientific Computing with Python, CRC Press 2023.</p> <p>-J.-P. Corriou, Numerical Methods and Optimization, Springer Nature Switzerland AG 2021.</p> <p>-R.V. Dukkipati, Applied Numerical Methods Using MATLAB®, NEW AGE International Publishers 2019.</p> <p>-P.L. de Vries, A first course in computational physics, John Wiley &amp; Sons, Inc. New York 1994.</p> <p>-H. Fangohr, Introduction to Python for Computational Science and Engineering 2024.</p> <p>-W.P. Fox, R.D. West, Numerical Methods and Analysis with Mathematical Modelling, CRC Press 2025.</p> <p>-A. Gilat, V. Subramaniam, Numerical Methods for Engineers and Scientists, John Wiley &amp; Sons 2014.</p> <p>-G.N. Giordano, Computational Physics, Prentice-Hall, 1997.</p> <p>-J.M. Jankowscy, Przegląd algorytmów numerycznych, Wyd. Naukowo-Techniczne 1988.</p> <p>-Z. Kamont, Równania różniczkowe zwyczajne. Wydawnictwo UG 1999.</p> <p>-J.M. Kinser, Modeling and Simulation in Python, CRC Press 2022.</p> <p>-S. Rajasekar, Numerical Methods, CRC Press 2024.</p> <p>-A.J. Salgado, S.M. Wise, Classical Numerical Analysis, Cambridge University Press 2023.</p> <p>-J. Stoer, R. Burlisch, Wstęp do analizy numerycznej, PWN 1987.</p>
	Supplementary literature	not applicable
	eResources addresses	

Example issues/ example questions/ tasks being completed	not applicable
Work placement	Not applicable

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