University of Gdańsk

Subject card

Subject name and code	Computational Methods of Medical Physics, PG_00182148		
Field of study	Medical 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
Semester of study	3	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	Familiarization with the theoretical foundations of numerical methods essential in medical physics. Mastery of the theoretical basis of numerical techniques used to solve problems encountered in medical physics. Development of practical skills in performing numerical computations using numerical libraries provided in the Python programming language. Acquisition of techniques for preparing concise research-oriented scientific reports.

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZMEDL3_U01] He can formulate, analyse, and solve complex problems in physics and medicine, using mathematical formalism, based on the physical phenomena, principles, and theories he has learned.	The student is able to: – perform numerical computations using numerical libraries, – identify a given numerical problem and apply appropriate functions or procedures provided in Python to solve it, – create a script in Spyder/Python that implements a specific numerical problem and utilizes its graphical capabilities,	[SU2] presentation/project/paper/ report
	[FIZMEDL3_W05] Knows and understands the most important computational and programming techniques used to solve physical and medical problems, present results, and analyse data.	The student knows: - the theoretical foundations of mathematical methods used in solving problems of medical physics; - the interface and command syntax of the Spyder environment and the scientific Python packages integrated with it: NumPy, SciPy, matplotlib; - selected numerical and graphical functions and procedures implemented in this environment; - the most common types of numerical problems encountered in physico-medical applications; - the principles of preparing scientific research reports.	[SW5] implementation of a problem task
	[FIZMEDL3_U05] Can program and use specialised software for calculations and data analysis, including in the field of imaging diagnostics, radiotherapy and biomedical signal analysis.	The student is able to: – use the Spyder environment as an advanced "calculator"; – write a report using the LaTeX typesetting system, documenting the implementation of a project related to medical physics that requires the use of numerical methods and the Spyder environment;	[SU2] presentation/project/paper/ report

Subject contents	1. Basics of Python programming: Spyder environment, mathematical operations, standard functions, numerical and graphical libraries, arrays: matrices and vectors. 2. Programming in Python: importing libraries, loops, conditional statements, function definitions. 3. Numerical computations in Python: root finding, optimization, linear systems, linear regression, least squares method, polynomial interpolation, splines, integration, ordinary differential equations (Cauchy problem), random numbers. 4. Numerical errors and instabilities. 5. Linear systems: Gaussian elimination, norms and condition numbers, LU and Cholesky decompositions, Jacobi and Gauss-Seidel methods. 6. Nonlinear equations: bisection method, fixed-point iteration, regula falsi, secant and Newton-Raphson methods. 7. Numerical differentiation, Newton-Cotes and Gaussian quadrature. 8. Polynomial interpolation, spline functions, approximation, least squares method, linear regression. 9. Solving the Cauchy problem for ordinary differential equations: Euler and Runge-Kutta-Fehlberg methods, single-step and multi-step methods, explicit and implicit schemes, stability. 10. Boundary value problems for ordinary differential equations. 11. Elliptic partial differential equations. 12. Fourier and Radon transforms. 13. Elements of probability and statistics Monte Carlo method.
Prerequisites and co-requisites	Completed courses: Mathematical Analysis, Linear Algebra with Geometry, Introduction to Programming.
Assessment methods and criteria	

Subject passing criteria	Passing threshold	Percentage of the final grade
The assessment covers both the correctness of the problem task execution and the presentation of the solution.	51.0%	100.0%

Recommended reading	Basic literature	J. Kiusalaas, Numerical Methods with Python, Cambridge University Press 2013 Ch. Dierbach, Introduction to Computer Science Using Python: A Computational Problem-Solving Focus, John Wiley & Sons, 2013 C. Führer, J. E. Solem, O. Verdier, Scientific Computing with Python 3, Packt Publishing 2016 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 Leah Edelstein-Keshet, Mathematical Models in Biology, SIAM, 2005
	Supplementary literature	not applicable
	eResources addresses	
Example issues/ example questions/ tasks being completed	not applicable	
Work placement	Not applicable	

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