

COURSE OFFERED

Name of the course	Polish	Metody komputerowe
	English	Computer-based methods

1. LOCATION OF THE COURSE OF STUDY WITHIN THE EDUCATION SYSTEM

1.1. Section ¹	Section of Exact and Natural Sciences
1.2. Discipline ²	Physical Sciences
1.3. Type of education	Full-time
1.4. Level of education	Doctoral School
1.5. Person preparing the course description	dr hab. inż. Rafał Porowski, prof. UJK
1.6. Contact	rafal.porowski@ujk.edu.pl

2. GENERAL CHARACTERISTICS OF THE COURSE OF STUDY

2.1. Type of course ³	Specialised subject in the discipline – elective course (item 3.14.5 of the curriculum, Resolution No. 28/2026)
2.2. Language of the course	English

3. DETAILED CHARACTERISTICS OF THE COURSE OF STUDY

3.1. Type of classes ⁴	Lecture
3.2. The number of hours ⁵	15
3.3. Location of classes	Classes held in a UJK teaching room (computer laboratory with access to Mathematica, Matlab or Python)
3.4. Type of assessment	Graded pass
3.5. Didactic methods	Problem-based lecture with multimedia presentation, combined with live demonstrations of calculations in Wolfram Mathematica; solving sample physics problems at the computer; project method (individual computational project); discussion; consultations.
3.6. Literature	basic 1. S. Wolfram, An Elementary Introduction to the Wolfram Language, 3rd ed., Wolfram Media, Champaign 2023 (also freely available online). 2. R. L. Zimmerman, F. I. Olness, Mathematica for Physics, 2nd ed., Addison-Wesley, San Francisco 2002. 3. P. T. Tam, A Physicist's Guide to Mathematica, 2nd ed., Academic Press/Elsevier, Amsterdam 2008.

¹ Section of Humanities; Social Sciences, Section of Exact and Natural Sciences, Section of Medical and Health Sciences, Section of Arts.

² History, Linguistics, Literary Studies, Medical Sciences, Health Sciences, Political and Administrative Sciences, Legal Sciences, Security Sciences, Pedagogy, Communication and Media Studies, Management and Quality Studies, Biological Sciences, Chemical Sciences, Physical Sciences, Earth and related Environmental Sciences, Visual Arts and Artwork Conservation, Musical Arts.

³ General courses, domain specific subjects in the section, disciplinary subjects in the sections, specialized subjects in the discipline.

⁴ Classes, lecture, seminar.

⁵ Consistent with the education program at the Doctoral School Jan Kochanowski University in Kielce.

		4. Wolfram Language & System Documentation Center, https://reference.wolfram.com/language/
	supplementary	1. R. H. Landau, M. J. Páez, C. C. Bordeianu, Computational Physics: Problem Solving with Python, 3rd ed., Wiley-VCH, Weinheim 2015. 2. M. Newman, Computational Physics, CreateSpace, 2013. 3. W. H. Press, S. A. Teukolsky, W. T. Vetterling, B. P. Flannery, Numerical Recipes: The Art of Scientific Computing, 3rd ed., Cambridge University Press, Cambridge 2007.

4. OBJECTIVES, SYLLABUS CONTENT AND INTENDEND LEARNING OUTCOMES

4.1. Course objectives (including the form of classes) C01 – To familiarise doctoral students with the capabilities and limitations of symbolic-numerical computing systems such as Mathematica as tools for solving problems in theoretical and experimental physics. C02 – To develop the ability to translate a physical problem into a computational model, to choose an appropriate (analytical or numerical) method consciously, and to verify the results critically. C03 – To develop the ability to document calculations in a reproducible way and to present results in English, with reference to the topic of the student's own doctoral dissertation.
4.2. Syllabus content Lecture (15 h): 1. Introduction to Wolfram Mathematica: notebooks, Wolfram Language syntax, expressions and lists, functions and patterns, elements of functional programming, using the documentation; overview of alternative tools (e.g. Python with SymPy, NumPy, SciPy) (2 h). 2. Symbolic computation in physics: manipulating and simplifying expressions, differentiation, integration, series and asymptotic expansions, limits, special functions; deriving equations of motion from the Lagrangian formalism (2 h). 3. Linear algebra and eigenvalue problems: matrix operations, eigenvalues and eigenvectors; normal modes of coupled systems, finite-dimensional Hamiltonians in quantum mechanics (two-level system, spin) (2 h). 4. Numerical methods and their limitations: machine precision and arbitrary-precision arithmetic, numerical solution of nonlinear equations, numerical integration, function minimisation (e.g. the variational method in quantum mechanics); assessing accuracy and convergence (2 h). 5. Ordinary differential equations: analytical and numerical solutions (DSolve, NDSolve), initial and boundary value problems; motion in a central force field, bound states of the one-dimensional Schrödinger equation (shooting method) (2 h). 6. Partial differential equations: numerical solution of the heat, wave, Laplace and Poisson equations (electrostatics problems), elements of the finite element method (2 h). 7. Visualisation and documentation of results: 2D and 3D plots, vector fields, animations and interactive models (Manipulate), preparing figures for publication, principles of reproducible computation (1 h). 8. Presentation and discussion of the doctoral students' computational projects (2 h). Topics in nonlinear dynamics and chaos and in statistical analysis of measurement data are covered by separate courses (items 3.14.10 and 3.14.7 of the curriculum) and are not duplicated in this course.

5. SUBJECT LEARNING OUTCOMES

Learning outcomes	A doctoral student who has passed the subject:	Reference to the learning outcomes of Doctoral School (according to the training program at the Doctoral School)
in the area of KNOWLEDGE:		
W01	knows and understands the capabilities and limitations of modern symbolic and numerical computing systems such as Mathematica and their place among the research tools of physics, to a degree that enables a critical assessment of the computational methods used so far in the discipline	SD_W01
W02	knows and understands the main development trends of computational methods in physics, including the growing importance of computer modelling, open-source software and reproducibility of calculations in research	SD_W02
in the area of SKILLS:		
U01	is able, by combining knowledge of physics, mathematics and computer science, to formulate a complex physical problem as a computational model, choose an appropriate symbolic or numerical method, solve it in Mathematica and verify the result (e.g. by comparison with limiting cases or an analytical solution)	SD_U03
U02	is able to use English at B2 level to work with technical documentation and specialist literature and to present and discuss the results of their own computational project	SD_U07
in the area of SOCIAL COMPETENCE:		
K01	is ready to recognise the importance of theoretical knowledge and of critical verification of computer results in solving cognitive and practical problems	SD_K02
K02	is ready to think and act in an entrepreneurial way by independently seeking out and implementing computational tools that improve their own research work	SD_K04

6. METHODS OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

SUBJECT LEARNING OUTCOMES	METHOD OF ASSESSMENT (+/-)																				
	Oral/written exam			Kolokwium			Project			activity in class			Own work			Group work			Others		
	The type of classes			The type of classes			The type of classes			The type of classes			The type of classes			The type of classes			The type of classes		
	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S
W01	–			–			+			+			–			–			–		
W02	–			–			+			+			–			–			–		
U01	–			–			+			–			+			–			–		
U02	–			–			+			+			–			–			–		
K01	–			–			+			+			–			–			–		
K02	–			–			+			–			+			–			–		

7. CRITERIA OF ASSESSMENT OF THE INTENDED LEARNING OUTCOMES

Form of classes	Grade	Criterion of assessment
Lecture (L)	3,0	Computational project completed at a basic level: the model is correctly implemented for a simple case and results are obtained, but verification and documentation are limited; the student answers basic questions about the methods used; 51–60% of the points available for the project.
	3,5	As for 3.0, and in addition the results are verified in at least one limiting case and the notebook is clearly documented; 61–70% of the points.
	4,0	Complete project: appropriate choice of symbolic or numerical method, correct verification of results, clear visualisation, correct presentation in English; 71–80% of the points.
	4,5	As for 4.0, and in addition an analysis of the accuracy and convergence of the numerical solution and an independent, in-depth physical interpretation of the results; 81–90% of the points.
	5,0	Outstanding project: original application of computational methods to a problem related to the topic of the doctoral dissertation, full analysis of the limitations of the method used, reproducible and exemplarily documented code, confident discussion of results in English; 91–100% of the points.

Accepted for execution

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