University of Gdańsk

Subject card

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| Subject name and code | Numerical methods and programming - lecture, PG_00091525 | | | | | | |
| Field of study | Water Management and Protection of Water Resources | | | | | | |
| Date of commencement of studies | October 2024 | | Academic year of realisation of subject | 2025/2026 | | | |
| Education level | Bachelor's studies | | Subject group | Obligatory subject group in the field of study<br>Subject group related to scientific research in the field of study<br>Subject group related to practical vocational preparation | | | |
| Mode of study | full-time studies | | Mode of delivery | at the university | | | |
| Year of study | 2 | | Language of instruction | Polish | | | |
| Semester of study | 4 | | ECTS credits | 2.0 | | | |
| Learning profile | practical | | Assessment form | credit | | | |
| Conducting unit | Laboratory of Marine Geology -> Department of Chemical Oceanography and Marine Geology -> Faculty of Oceanography and Geography -> Rector | | | | | | |
| Name and surname of lecturer (lecturers) | Subject supervisor | | dr hab. Wiesław Miklaszewski, prof. UG | | | | |
| | Teachers | | dr hab. Wiesław Miklaszewski, prof. UG | | | | |
| Lesson types | Lesson type | Lecture | Tutorial | Laboratory | Project | Seminar | SUM |
| | Number of study hours | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 30 |
| | 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 | 30 | | 10.0 | 10.0 | | 50 |
| Subject objectives | The lectures will provide the basic knowledge of numerical methods as well as the basic programming skills allowing you to understand the content of the lectures in the further course of study and also allows you to perform the calculations necessary to carry out the tasks of a specialist in water management and protection. | | | | | | |

## Learning outcomes

| Course outcome | Subject outcome | Method of verification |
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| [GWOZWL3-W04] research techniques, methods and tools currently used in water management and protection of water resources both in the field of natural sciences and social sciences, including basic statistical and information technology tools that make it possible to describe, model and interpret data on phenomena and processes occurring in the aquatic environment, as well as tools for describing relationships in social-ecological systems | K_W04 - knows and understands basic programming to describe, model and interpret data on phenomena and processes in the aquatic environment and to describe relationships in social-ecological systems | [SW4] test/exam - oral or written |
| [GWOZWL3-W02] the importance of knowledge in the sciences allowing to understand the processes and phenomena occurring in the hydrosphere, as well as knowledge of the social sciences and of the Earth's geographic environment - as a a system of interrelated and interacting components | K_W02 - knows and understands numerical methods and algorithms to study and understand the processes and phenomena occurring in the hydrosphere | [SW4] test/exam - oral or written |
| [GWOZWL3-U07] use literature and other available sources of information, including information technology, multimedia, Internet, databases, and select and critically evaluate information | K_U07 - is able to use the literature and other available sources of information, including information technology, multimedia, Internet resources, databases, and to select and critically evaluate information | [SU4] test/exam - oral or written |

## Subject contents

1. Computer arithmetic and sources of error.

2.Basic calculus facts used in elementary numerical algorithms.

3. Introduction to Python: data types, basic operations, flow control, functions, classes, accessing data files.

4. Roots of equations: bisection, fixed point method, Newton-Raphson method. (Python: scipy.optimize.fsolve)

5. Interpolation: Lagrange, splines, Runge effect. (Python: numpy.polyfit, numpy.polyval, scipy.Cubic.Spline)

6. Approximation: linear least squares, normal equations, linearization of certain nonlinear problems. (Phyton,numpy.polyfit)

7. Numerical integration: Newtona- Cotesa quadrature rules (trapezoidal, Simpson, composite), Gauss quadrature rules (Gaussa-Legendre), (Python: scipy.integrate.trapezoid, scipy.integrate.quad), Monte Carlo integration (pseudorandom number generation - Python: numpy.random).

8. Numerical linear algebra: numerical solution of linear systems (Gaussa elimination, pivoting, LU factorization, vector i matrix norms, condition number of a matrix, iterative methods (Jacobi, Gauss-Seidel), (Python: numpy.linalg, scipy.linalg).

9. Numerical differentiation: finite difference approximations.

10. Numerical solution of initial value problem for ordinary differential equations: Euler method - explicit and implicit, stability. (Python: scipy.integrate.solve_ivp)

11.Introduction to Object-oriented programming.

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| Prerequisites and co-requisites | | |
| Assessment methods and criteria | | |

| Subject passing criteria | Passing threshold | Percentage of the final grade |
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| Test on line (min. 16pkt./30pkt.) | 51.0% | 100.0% |

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| Recommended reading | Basic literature |

1. F. Bittmann, Python 3 for Science and Engineering Applications, Elektor International Media BV 2020.

2. D. E. Clough, S. C. Chapra, Engineering and Scientific Computing with Python 2024, CRC Press 2023.

3. H. Fangohr, Introduction to Python for Computational Science and Engineering, Introduction to Python for Computational Science and Engineering (fangohr.github.io).

4. W. P. Fox and R. D. West, Numerical Methods and Analysis with Mathematical Modelling, CRC Press,2025.

5. J. V. Guttag, Introduction to Computation and Programming Using Python, The MIT Press 2021.

6. L. Brieda, J. Wang, R. Martin, Introduction to Modern Scientific Programming and Numerical Methods, CRC Press 2025.

7. H. P. Langtangen, A Primer on Scientific Programming with Python, Springer-Verlag Berlin Heidelberg 2016.

8. J. Ernesti, P. Kaiser, Python 3, Rheinwerk Publishing 2022.

9. J. Keyser, How to Program, The Teaching Company 2016.

10. B. Korites, Python Graphics, Apress Media 2023.

Supplementary literature

1. E. B. M. Bashier, Practical Numerical and Scientific Computing with MATLAB® and Python, Taylor & Francis 2020

2. J. M. Kinser, Modeling and Simulation in Python, CRC Press 2022.

3. Z. Altaç, Numerical Methods for Scientists and Engineers, CRC Press 2025.

4. A. J. Salagado, S. M. Wise, Classical Numerical Analysis, Cambridge University Press 2023.

5. S. Rajasekar, Numerical Methods, CRC Press 2024.

6. G. Stoyan, A. Baran, Elementary Numerical Mathematics for Programmers and Engineers, Springer Nature Switzerland 2024.

7. B. Jayne, Python Standard Library, BarCharts Publishing 2020.

eResources addresses

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

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