#### card of course

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| Subject name | Numerical methods |

1. The placement of the subject in the study system

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| 1.1. Field of study | Computer science |
| 1.2. Form and path of study | Full-time/Part-time |
| 1.3. Level of education | First-cycle studies |
| 1.4. Study profile | Practical |

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| 1. 5. Specialty | - |
| 1.6. Subject Coordinator | Dr inż. Tomasz Giżewski |

2. General characteristics of the subject

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| 2.1. Belonging to a subject group | Directional/Practical |
| 2.2. Number of ECTS | 3 |
| 2.3. Language of lectures | English |
| 2.4. Semesters in which the subject is taught | V |
| 2.5.Criteria for selecting course participants | - |

1. Learning outcomes and course delivery
   1. Subject Objectives

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| No. | Subject Objectives |
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| C1 | To provide the student with a comprehensive introduction to the theory and practical application of numerical methods in applied sciences and engineering. |
| C2 | Gain the skills necessary to solve complex mathematical and engineering problems using numerical tools. |
| C3 | Learning about numerical methods and their application areas, as well as acquiring the ability to select a numerical method for a given problem |
| C4 | Learning the mathematical foundations of methods for interpolation and integration. |
| C5 | To familiarize the student and acquire skills in the methods of programming numerical algorithms. |

* 1. Subject-specific learning outcomes, divided into knowledge , skills and competences , with reference to the directional learning outcomes

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| No. | Description of subject  learning outcomes | Reference to  directional effects  learning (symbols) | Method of implementation (mark "X") | | | |
| ST | | NST | |
| Classes at the University | Activities on  the platform | Classes at the University | Activities on  the platform |
| After passing the course, the student knows and understands **the knowledge** | | | | | | |
| W1 | The student knows the basic numerical algorithms for solving nonlinear equations, performing interpolation, function approximation, numerical differentiation and integration, and solving systems of linear equations. | INF\_W02  INF\_W11  INF\_W19 |  | X |  | X |
| W2 | The student knows and understands the basics of independent use of numerical methods to analyze and solve a wide range of scientific and engineering problems. |  | X |  | X |
| W3 | The student knows the computational complexity and sources of errors of basic numerical methods. |  | X |  | X |
| W4 | The student knows and understands the mathematical foundations of methods for interpolation, integration, generating pseudorandom numbers and solving ordinary differential equations. |  | X |  | X |
| After passing the course, the student is **able** to: | | | | | | |
| U1 | The student is able to apply and understand basic numerical methods appropriate to solving typical mathematical problems. Has the skills to implement basic numerical algorithms in any programming language. | INF\_U03 INF\_U13 INF\_U17 INF\_U18 INF\_U26 | X |  | X |  |
| U2 | The student is able to select a numerical method for the appropriate algorithm and knows error minimization techniques. | X |  | X |  |
| U3 | The student is able to critically evaluate the validity of the obtained results, analyze possible sources of error and determine whether and when a numerical method is appropriate to apply to a given problem. | X |  | X |  |
| After completing the course, the student is ready to take part in **social competences.** | | | | | | |
| K1 | identifying problems arising when solving tasks related to numerical calculations. | INF\_K05  INF\_K06 | X |  | X |  |
| K2 | The ability to express thoughts and information in a clear and understandable way, is able to analyze situations, identify problems and generate effective solutions. | X |  | X |  |
| K3 | adapting to changing circumstances and taking on new challenges, including the ability to cope with stress and uncertainty. | X |  | X |  |

3.3. Forms of teaching and their number of hours - Full-time studies (ST), Part-time studies (NST)

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| Path | Lecture | Exercises | Design | Workshop | Laboratory | Seminar | Lecturer | Classes conducted using distance learning methods and techniques in the form of a lecture | Other | **ECTS points** |
| **ST** |  |  |  |  | 30 |  |  | 20 |  | 3 |
| **NST** |  |  |  |  | 15 |  |  | 10 |  | 3 |

3.4. Content of education (separately for each form of classes: (W, ĆW, PROJ, WAR, LAB, LEK, OTHER). It should be marked (X) how the given content will be implemented (classes at the university or classes on the e-learning platform conducted using distance learning methods and techniques)

TYPE OF CLASS: LECTURE

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| --- | --- | --- | --- | --- | --- | --- |
| No. | Content of the course | Reference to subject-specific learning outcomes | Method of implementation (mark "X") | | | |
| ST | | NST | |
| **Classes at the University** | **Activities on  the platform** | **Classes at the University** | **Activities on  the platform** |
| 1. | Introduction to numerical analysis, introduction to errors and stability of algorithms with selected issues from the theory and practice of numerical methods. | W1, W2, W3, W4 |  | X |  | X |
| 2. | Methods of finding roots: bracket methods (bisection method), open methods (Newton-Raphson method, secant method). | W1, W2, W3, W4 |  | X |  | X |
| 3. | Methods for solving systems of linear equations – direct methods (Gaussian elimination, LU decomposition) | W1, W2, W3, W4 |  | X |  | X |
| 4. | Methods of solving systems of linear equations – iterative methods (Jacobi, Gauss-Seidel). | W1, W2, W3, W4 |  | X |  | X |
| 5. | Techniques for constructing new data points from a discrete set of known data points (Lagrangian polynomials , Newton's divided differences, spline interpolation). | W1, W2, W3, W4 |  | X |  | X |
| 6. | Numerical differentiation and integration. | W1, W2, W3, W4 |  | X |  | X |
| 7. | Numerical optimization methods. | W1, W2, W3, W4 |  | X |  | X |
| 8. | Summary of classes and discussion of grades. |  |  | X |  | X |

TYPE OF CLASS: LABORATORY

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| No. | Content of the course | Reference to subject-specific learning outcomes | Method of implementation (mark "X") | | | |
| ST | | NST | |
| **Classes at the University** | **Activities on  the platform** | **Classes at the University** | **Activities on  the platform** |
| 1. | Introduction to numerical methods | U1, K1 | X |  | X |  |
| 2. | Data representation in computer systems: data types and their limitations (integer, floating point, character); data structures used in the analysis of numerical methods; using spreadsheets to store and manipulate data. | U1, K1 | X |  | X |  |
| 3. | Basics of numerical errors: types of errors: rounding error, truncation error; influence of errors on calculation results; techniques for minimizing errors in calculations. | U1, U2 | X |  | X |  |
| 4. | Basic operations on matrices and vectors: arithmetic operations on matrices and vectors; transposition, multiplication of matrices, inversion of matrices; | U1, U2 | X |  | X |  |
| 5. | Solving systems of linear equations: direct methods: Gaussian elimination; iterative methods: Jacobi method, Gauss-Seidel method. | U1, U2, U3, | X |  | X |  |
| 6. | Solving nonlinear equations: iterative methods: bisection method, Newton-Raphson method, secant method; numerical integration; rectangular, trapezoidal and Simpson methods; applications of numerical integration in practical applications. | U1, U2, U3, K1 | X |  | X |  |
| 7. | Numerical differentiation: forward, backward, and central differentiation methods; applications to data analysis and physical modeling. | U1, U2, U3, | X |  | X |  |
| 8. | Numerical methods for solving ordinary differential equations (ODE library) | U1, U2, U3, K2 | X |  | X |  |
| 9. | Practical applications of numerical methods. | U4,U3,K1,K2 | X |  | X |  |
| 10. | Summary of classes and discussion of grades. |  | X |  | X |  |

3.5 . Methods of verifying learning outcomes (indication and description of methods of conducting classes and verification of achievement of learning outcomes and method of documentation)

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| --- | --- | --- | --- |
| Subject Effects | Teaching methods | Methods of verifying learning outcomes | Documentation methods |
| KNOWLEDGE | | | |
| W1-W4 | Explanation of numerical methods for selected mathematical problems with examples | Lecture credit tasks: based on the examples explained, the student must solve the problem using numerical methods indicated by the lecturer | Solved task  placed on the PUW platform |
| SKILLS | | | |
| U1-U3 | Solving tasks - selecting the appropriate numerical method and constructing the appropriate application to solve the problem given by the laboratory instructor | Laboratory credit: the student has to present a solution to a problem given by the laboratory instructor using an application. | Solved task  placed on the PUW platform |
| SOCIAL COMPETENCES | | | |
| K1 | Solving tasks - selecting the appropriate numerical method and constructing the appropriate application to solve the problem given by the laboratory instructor | Laboratory credit: the student has to present a solution to a problem given by the laboratory instructor using an application. | Solved task  placed on the PUW platform |

3.6. Assessment criteria for the achieved learning outcomes

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| Learning effect | For a grade of 3 or "pass."  the student knows and understands/is able to/is ready to | For a grade of 3.5, the student knows and understands/is able to/is ready to | For a grade of 4, the student knows and understands/is able to/is ready to | For a grade of 4.5, the student knows and understands/is able to/is ready to | For a grade of 5, the student knows and understands/is able to/is ready to |
| W | 51-60% of knowledge indicated in learning outcomes | 61-70% of knowledge indicated in learning outcomes | 71-80% of knowledge indicated in learning outcomes | 81-90% of knowledge indicated in learning outcomes | 91-100% of knowledge indicated in learning outcomes |
| U | 51-60% of skills indicated in learning outcomes | 61-70% of skills indicated in learning outcomes | 71-80% of skills indicated in learning outcomes | 81-90% of skills indicated in learning outcomes | 91-100% of skills indicated in learning outcomes |
| K | 51-60% of skills indicated in learning outcomes | 61-70% of skills indicated in learning outcomes | 71-80% of skills indicated in learning outcomes | 81-90% of skills indicated in learning outcomes | 91-100% of skills indicated in learning outcomes |

3.7. Literature

**Basic**

1. Krzyżanowski Piotr, Metody numeryczne, Wydawnictwo Naukowe PWN, Warszawa, 2024
2. Fortuna Z., Macukow B., Wąsowski J., Metody numeryczne, PWN. Warszawa 2024.
3. Sikora J., „Numeryczne metody rozwiązywania zagadnień brzegowych”, Wydawnictwa Uczelniane Politechniki Lubelskiej, Lublin 2009 https://bc.pollub.pl/dlibra/publication/1033/edition/971
4. Jaroszyński L., Łanczont M.: „Laboratorium Metod Numerycznych”. Politechnika Lubelska, Lublin 2014.– <https://bc.pollub.pl/dlibra/publication/8459/edition/7896>
5. Guziak T., Kamińska A., Pańczyk B., Sikora J.:” Metody numeryczne w przykładach”. Politechnika Lubelska, Lublin 2012 - <https://bc.pollub.pl/dlibra/publication/1738/edition/1370>

**Supplementary**

1. Mirosława Zima, Piotr Pusz, Elementy metod numerycznych, Wydawnictwo Uniwersytetu Rzeszowskiego, Rzeszów, 2020
2. Bielski Sebastian, Wstęp do metod numerycznych, Wydawnictwo Politechniki Gdańskiej, Gdańsk, 2015

4. Student workload - ECTS points balance

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| --- | --- | --- |
| **Types of student activity** | **Student Load** | |
| **ST** | **NST** |
| **Classes requiring direct contact between the student and the academic teacher at the university premises** | **50** | **25** |
| Classes included in the study plan | 50 | 25 |
| **Student's own work** | **25** | **50** |
| Ongoing preparation for classes, preparation of project work/presentations/etc. | 15 | 25 |
| Preparation for passing classes | 10 | 25 |
| **TOTAL STUDENT HOURLY LOAD** | **75** | **75** |
| **Number of ECTS points** | **3** | **3** |

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| Last change date | 30/09/2024 |
| The changes were introduced | INF Education Quality Team |
| The changes were approved | Arkadiusz Gwarda, M.A. |