Appendix No. 1.5 to the Resolution No. 7/2023

of the Rector of the University of Rzeszów

**SYLLABUS**

**regarding the qualification cycle FROM 2024TO 2025**

1. Basic Course/Module Information

|  |  |
| --- | --- |
| Course/Module title | Numerical methods |
| Course/Module code \* |  |
| Faculty (name of the unit offering the field of study) | *College of Natural Sciences* |
| Name of the unit running the course | *Institute of Mathematics* |
| Field of study | Mathematics |
| Qualification level | First degree |
| Profile | *Academic* |
| Study mode | *Full-time* |
| Year and semester of studies | *2 Year, 2 semester* |
| Course type | *Basic* |
| Language of instruction | English |
| Coordinator | Ewa Rak, PhD |
| Course instructor | Ewa Rak, PhD |

\* - as agreed at the faculty

1.1.Learning format – number of hours and ECTS credits

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Semester  (n0.) | Lectures | Classes | Colloquia | Lab classes | Seminars | Practical classes | Internships | others | **ECTS credits** |
| 1 |  | 30 |  |  |  |  |  |  | 5 |

1.2. Course delivery methods

☒ conducted in a traditional way

☒ involving distance education methods and techniques

1.3. Course/Module assessment (exam, pass with a grade, pass without a grade)

Exam

2. Prerequisites

|  |
| --- |
| Algebra, Calculus I, II, III, Mathematical Analysis, Basics of procedural programming (Java, C/C++, Python). |

3. Objectives, Learning Outcomes, Course Content, and Instructional Methods

3.1. Course/Module objectives

|  |  |
| --- | --- |
| O1 | To familiarize students with sources of numerical errors. Numerical errors assessing. |
| O2 | To familiarize students with numerical methods of solving nonlinear equations. Zeros of polynomials. |
| O3 | To familiarize students with selected methods of function interpolation and polynomial approximation. |
| O4 | To familiarize students with numerical integration. |
| O5 | To familiarize students with direct methods for solving linear systems and ordinary differential equations. |

3.2. Course/Module Learning Outcomes (to be completed by the coordinator)

|  |  |  |
| --- | --- | --- |
| Learning Outcome | The description of the learning outcome  defined for the course/module | Relation to the degree programme outcomes |
| LO\_01 | understand the concept of errors and calculate the errors; | K\_W05, K\_U11 |
| LO\_02 | is able to determine the roots of nonlinear equations with several methods; | K\_W05, K\_U11 |
| LO\_o3 | is able to understand numerical techniques to find the roots of non-linear equations and solution of system of linear equations; | K\_ U11 |
| LO\_04 | knows Newton’s interpolation methods for forward interpolation, backward interpolation and Newton’s divided interpolation method, Langrange’s interpolation methods, Stirling’s interpolation methods, Cubic spline interpolation, interpolation by iteration; approximation methods; | K\_W05, K\_U11, K\_K03 |
| LO\_05 | is able to integrate and differentiate functions numerically; | K\_W05, K\_U11, K\_K03 |
| LO\_06 | is able to solve ordinary differential equations (ODE) numerically; | K\_W05, K\_U11, K\_K03 |
| LO\_07 | can formulate algorithms of the concerned issues and represent them by means of flowcharts;  knows C++/Java/Python environment for numerical calculations and can use it for the purposes of solving practical issues; | K\_W05, K\_U11, K\_K01 |
| LO\_08 | can formulate questions to better understand the concepts, examples and theorems (and their proofs) in the field of numerical methods and express their own opinions on its basic issues; | K\_K01, K\_K02, K\_W08 |
| LO\_09 | knows the limitations of his own knowledge and own abilities; understands the need for further education; independently searches in the literature and on the Internet for information on the subject. | K\_K01, K\_K02, K\_K03 |

**3.3. Course content (to be completed by the coordinator)**

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| --- |
| Content outline |
| Errors, different type of errors. Representation of numbers in computer, computer arithmetic, zero in floating point number. |
| Solution of non-linear equation containing one variable. Bisection Method, False-Position Method, Simple Fixed Point Iteration, Secant Method, Brent’s and Newton’s methods. Modified Newton-Raphson method. System of non-linear equations-iteration and Newton-Raphson methods; programming. |
| Interpolation. Lagrange’s methods, error terms. Uniqueness of interpolating polynomial. Newton’s fundamental interpolation. Forward, backward and central difference interpolations. Interpolation by iteration. Spline interpolation, comparison with Newton’s interpolation. Hermite’s interpolation. Bivariate interpolation, Lagrange and Newton’s methods. Inverse interpolation; programming. |
| Integration of Equations. Newton-Cotes Algorithm for Equations, Trapezoidal Method, Simpson Method, Adaptive Quadrature, Gauss Quadrature, Improper Integrals; programming. |
| Approximation of function. Least square method. Use of orthogonal polynomials. Approximation by Chebyshev polynomials, Max-min principle. |
| System of linear equations. Iteration methods, rate of convergence. Gaussian Elimination, Gauss-Jordan Elimination, LU Decomposition, Iterative Method, Gauss-Siedel, Case Study.  Eigenvalues and eigenvectors of matrix. Power method. Jacobi’s method, Givens method. |
| Ordinary Differential Equation. Euler’s Method, Improvements of Euler’s Method, Runge-Kutta Methods, Systems of Equations, Adaptive Runge-Kutta Methods. |

3.4. Methods of Instruction

e.g.

*Lecture: a problem-solving lecture/a lecture supported by a multimedia presentation/ distance learning*

*Classes: text analysis and discussion/project work (research project, implementation project, practical project)/ group work (problem solving, case study, discussion)/didactic games/ distance learning*

*Laboratory classes: designing and conducting experiments*

Classes: working in groups and individual - task solving and proving theorems.

4. Assessment techniques and criteria

4.1 Methods of evaluating learning outcomes

|  |  |  |
| --- | --- | --- |
| Learning outcome | Methods of assessment of learning outcomes (e.g. test, oral exam, written exam, project, report, observation during classes) | Learning format (lectures, classes,…) |
| LO-01 | Test, observation during classes | class |
| LO\_02 | Test, Project, observation during classes | class |
| LO\_03 | exam, observation during classes | class |
| LO\_o4 | exam, observation during classes | class |
| LO\_05 | test, exam, observation during classes | class |
| LO\_06 | test, exam, observation during classes | class |
| LO\_07 | test, observation during classes | class |
| LO\_08 | observation during classes | class |
| LO\_09 | observation during classes | class |

4.2 Course assessment criteria

|  |
| --- |
| students are Assessed regularly solving tasks writing.  The examination of students' knowledge in the oral form.  Grading score:  3.0 for 50 - 60%, 3.5 for 61 - 70 %, 4.0 for 71 – 80%, 4.5 for 81 – 90%; 5.0 for 91 – 100 % |

5. Total student workload needed to achieve the intended learning outcomes

– number of hours and ECTS credits

|  |  |
| --- | --- |
| Activity | Number of hours |
| Scheduled course contact hours | 30 |
| Non-contact hours - student's own work (preparation for classes or examinations, projects, etc.) | 70 |
| Total number of hours | 100 |
| Total number of ECTS credits | 5 ECTS |

\* One ECTS point corresponds to 25-30 hours of total student workload

6. Internships related to the course/module

|  |  |
| --- | --- |
| Number of hours |  |
| Internship regulations and procedures |  |

7. Instructional materials

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| Compulsory literature:   1. L. Fausett: Numerical Methods. Algorithms and Applications, Prentice Hall, Pearson Education Inc., Upper Saddle River, New Jersey, 2003. 2. Richard L. Burden, J. Douglas Faires: Numerical analysis, 9 ed. - Brooks/Cole, Cengage Learning, 2005. 3. G. Engeln-Muellges, F. Uhlig: Numerical Algorithms with C, Springer-Verlag Berlin, Heidelberg 1996. |
| Complementary literature:   1. W. Cheney, D. Kincaid, Numerical Mathematics & Computing (Edition 5), Brooks/Cole, 2004. (ISBN 0534-89993-7). |

Approved by the Head of the Department or an authorised person