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 | Complex Analysis |
| 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  | Second degree |
| Profile | *Academic* |
| Study mode | *Full-time* |
| Year and semester of studies | *1 Year, 1 semester* |
| Course type | *Basic* |
| Language of instruction | English |
| Coordinator | Ewa Rak, PhD |
| Course instructor | *Edyta Trybucka, 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

|  |
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|  knowledge of Calculus I and II (1-st sem), Elements of topology. |

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

3.1. Course/Module objectives

|  |  |
| --- | --- |
| O1 | Introduction to the basic concepts of analytical and mermorphic functions of a complex variable. |
| O2 | Acquaintance with the basic methods and techniques used in complex analysis. |
| O3 | Presentation and interpretation of similarities and differences between functions defined in the real and complex domain with particular consideration of differentiation. |

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 | defines most of the classic concepts and formulates basic theorems in the field of complex analysis | K\_W01, K\_W03 |
| LO\_02 | has knowledge of the methods proofs used in complex analysis | K\_W02, K\_W05 |
| LO\_o3 | has knowledge of computational techniques used in complex analysis | K\_W06 |
| LO\_04 | outputs and checks the conditions of holomorphy functions | K\_U01, K\_U02 |
| LO\_05 | indicates similarities and differences for functions defined in the real and complex domain | K\_U05, K\_U15 |
| LO\_06 | finding the series (Taylor series, Laurent series) of functions, calculating the residues and poles of functions | K\_U05 |
| LO\_07 | proves the basic theorems of complex analysis | K\_U01, K\_U02 |
| LO\_08 | derives conclusions and suggests the use of the Cauchy integral formula | K\_U01, K\_U02 |
| LO\_09 | calculates complex integrals using various methods, among others using integral formulas and residue theorem | K\_U05 |
| LO\_10 | independently searches for information in the literature and applies it correctly | K\_U19, K\_K01 |
| LO\_11 | formulates opinions on the basic issues of complex analysis | K\_K02 |
| LO\_12 | finds its place in the group; understands the importance of complex analysis in mathematics and other areas of knowledge | K\_K03, K­06 |

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

|  |
| --- |
| Content outline |
| **Preliminary information**: Complex numbers, flat sets, closed plane and Riemann sphere, sequences and number series.**Complex functions of a real variable**: Limit, continuity, derivative, integral. Complex curve, curve length. |
| **Complex functions of a complex variable**: Limit, continuity, differentiability. Real and imaginary part of the complex function, Cauchy-Riemann equation. Analytical functions. Total functions. Harmonic functions.**Elementary functions**: Exponential function and its properties. Trigonometric functions and their properties. Hyperbolic functions. Logarithm and power, branches of logarithm and power. Homography. |
| **Integration of complex functions**: Curvilinear integrals, primary function. Index of the point relative to the curve. Cauchy integral theorem. |
|  **Holomorphic functions**: Cauchy integral formula and its applications: derivatives of higher orders, Morera's theorem, the development of analytic functions into a power series, the maximum principle, Weierstrass theorem. |
| **Singular points and residues**: Develop an analytical function in the Laurent series. Singular points isolated. Casorati-Weierstrass theorem. Meromorphic functions. Function residuum. Residue theorem. Residua logarithmic derivative. Principle of the argument. Identity theorem. |

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 | exam, observation during classes | class |
| LO\_02 | exam, observation during classes | class |
| LO\_03 | exam, observation during classes | class |
| LO\_o4 | test, exam, observation during classes | class |
| LO\_05 | test, exam, observation during classes | class |
| LO\_06 | Test, exam | class |
| LO\_07 | Exam | class |
| LO\_08 | Test, exam | class |
| LO\_09 | test, exam, observation during classes | class |
| LO\_10 | Test, exam | class |
| LO\_11 | observation during classes | class |
| LO\_12 | observation during classes | class |

4.2 Course assessment criteria

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| --- |
| students are Assessed regularly solving tasks writing.The examination of students' knowledge in an 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. Steven G. Krantz, A guide to complex variables, McGraw-Hill Science/Engineering/Math; 2007.
2. Lars Ahlfors, Complex analysis, McGraw-Hill Science/Engineering/Math; 3 edition, 1979.
3. Walter Rudin, Real and complex analysis, McGraw-Hill Science/Engineering/Math; 3 edition, 1986.
4. Robert E. Greene, Steven G. Krantz, Function Theory of One Complex Variable, AMS, 3 edition, 2006.
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| Complementary literature: 1. J. Milnor, Dynamics in One Complex Variable , (3rd ed.), Princeton U. Press. 2006.
2. L. Carlesson, Th. Gamelin, Complex dynamics, Springer; Corrected edition 1996.
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Approved by the Head of the Department or an authorised person