**SYLLABUS**

**1. Information regarding the programme**

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| 1.1 Higher education institution | Babeş-Bolyai University Cluj-Napoca |
| 1.2 Faculty | Faculty of Mathematics and Computer Science |
| 1.3 Department | Department of Mathematics |
| 1.4 Field of study | Mathematics |
| 1.5 Study cycle | Master |
| 1.6 Study programme / Qualification | Didactic Mathematics |

**2. Information regarding the discipline**

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| 2.1 Name of the discipline | | | Topics of Mathematical Analysis III (teacher specialization) | | | | |
| 2.2 Course coordinator | | | Prof. Nicolae Popovici, Ph.D. habil. | | | | |
| 2.3 Seminar coordinator | | | Prof. Nicolae Popovici, Ph.D. habil. | | | | |
| 2.4. Year of study | 2 | 2.5 Semester | 4 | 2.6. Type of evaluation | Exam | 2.7 Type of discipline | Optional |

**3. Total estimated time** (hours/semester of didactic activities)

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|---|---|---|---|---|---|
| 3.1 Hours per week | 3 | Of which: 3.2 course | 2 | 3.3 seminar/laboratory | 1 |
| 3.4 Total hours in the curriculum | 36 | Of which: 3.5 course | 24 | 3.6 seminar/laboratory | 12 |
| Time allotment: | | | | | hours |
| Learning using manual, course support, bibliography, course notes | | | | | 56 |
| Additional documentation (in libraries, on electronic platforms, field documentation) | | | | | 23 |
| Preparation for seminars/labs, homework, papers, portfolios and essays | | | | | 40 |
| Tutorship | | | | | 10 |
| Evaluations | | | | | 35 |
| Other activities | | | | | - |
| 3.7 Total individual study hours | 164 | | | | |
| 3.8 Total hours per semester | 200 | | | | |
| 3.9 Number of ECTS credits | 8 | | | | |

**4. Prerequisites** (if necessary)

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| 4.1. curriculum | • Mathematical Analysis 1 (on R)<br>• Mathematical Analysis 2 (Calculus on $R^n$) |
| 4.2. competencies | Ability to use abstract notions, theoretical results and practical methods of Mathematical Analysis. |

**5. Conditions** (if necessary)

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| 5.1. for the course | • Lecture hall equipped with blackboard and beamer |
| 5.2. for the seminar /lab activities | • Classroom equipped with blackboard |

**6. Specific competencies acquired**

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| **Professional competencies** | To use appropriate theoretical results and methods for solving different classes of mathematical analysis problems. |
| **Transversal competencies** | To apply rigorous and efficient work rules, by adopting a responsible attitude towards the scientific and didactic activities. To develop the own creative potential in specific areas, following the professional ethical norms and principles. |

**7. Objectives of the discipline** (outcome of the acquired competencies)

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| 7.1 General objective of the discipline | Enhanced understanding of some special topics in Mathematical Analysis useful to high-school teachers. |
| 7.2 Specific objective of the discipline | Students should acquire solving skills for challenging problems, by an in-depth study of key notions and fundamental theoretical results. |

**8. Content**

| 8.1 Course | Teaching methods | Remarks |
|---|---|---|
| 1. Sequences of (extended) real numbers; limit points; limit inferior and limit superior. | Direct instruction, mathematical proof, exemplification | |
| 2. Sequences defined by linear recurrences with constant coefficients; special classes of sequences defined by nonlinear recurrences. | Direct instruction, mathematical proof, exemplification | |
| 3. Toeplitz theorem and some of its consequences (Stolz-Cesaro and Cauchy theorems). | Direct instruction, mathematical proof, exemplification | |
| 4. Series of real numbers: Cauchy and Riemann theorems concerning the permutations of absolutely convergent and of conditionally convergent series, respectively. | Direct instruction, mathematical proof, exemplification | |
| 5. Abel, Cauchy and Mertens theorems concerning the product of two series. | Direct instruction, mathematical proof, exemplification | |
| 6. Semi-continuous functions; characterizations of semi-continuity by means of the epigraph/hypograph, level sets, and sequences. | Direct instruction, mathematical proof, exemplification | |
| 7. Uniformly continuous functions and their sequential characterization; Lipschitz and Hölder continuous functions. | Direct instruction, mathematical proof, exemplification | |
| 8. The Darboux property and antiderivability. | Direct instruction, mathematical proof, exemplification | |
| 9. Riemann integrable functions. | Direct instruction, mathematical proof, exemplification | |
| 10. Convex functions (one variable); | Direct instruction, mathematical | |

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|---|---|---|
| characterizations and regularity properties (one sided derivability, continuity). | proof, exemplification | |
| 11. Characterizations of convexity by means of tangent lines, first and second order derivatives. | Direct instruction, mathematical proof, exemplification | |
| 12. Convex functions (several variables) and their characterizations; subdifferențiability of convex functions. | Direct instruction, mathematical proof, exemplification | |

Bibliography


1. BRECKNER, B.E., POPOVICI, N.: Convexity and Optimization. An Introduction. Editura EFES, Cluj-Napoca, 2006.
2. BRECKNER, W.W., TRIF, T.: Convex Functions and Related Functional Equations. Selected Topics. Presa Universitară Clujeană, 2008.
3. COBZAŞ, Şt.: Analiză matematică (Calcul diferenţial). Presa Universitară Clujeană, Cluj-Napoca, 1997.
4. MARUŞCIAC, I: Analiză matematică. Partea II. Universitatea "Babeş-Bolyai" Cluj-Napoca, 1983.
5. MEGAN, M.: Bazele analizei matematice. Vol. I şi II, Editura EUROBIT, Timişoara, 1997. Vol. III, Editura EUROBIT, Timişoara, 1998.
6. NICOLESCU, M.: Analiză matematică. Vol. II, Editura Tehnică, Bucureşti, 1958.
7. ROBERTS, A.W., VARBERG, D.E.: Convex Functions. Academic Press, 1973.
8. RUDIN, W.: Principles of Mathematical Analysis. 2nd Edition, McGraw-Hill, New York, 1964.
9. SIREŢCHI, Gh.: Calcul diferenţial şi integral. Vol. 1: Noţiuni fundamentale. Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1985.


| 8.2 Seminar / laboratory | Teaching methods | Remarks |
|---|---|---|
| 1. Sequences: limit points; limit inferior and limit superior; convergence. | Problem-based instruction, debate, mathematical proofs | |
| 2. Sequence for which the set of limit points is an interval; Dirichlet and Kronecker theorems. | Problem-based instruction, debate, mathematical proofs | |
| 3. Sequences defined by linear recurrences. | Problem-based instruction, debate, mathematical proofs | |
| 4. Sequences defined by nonlinear recurrences. | Problem-based instruction, debate, mathematical proofs | |
| 5. Applications of Toeplitz and Stolz-Cesaro theorems. | Problem-based instruction, debate, mathematical proofs | |
| 6. Remarkable series of real numbers. | Problem-based instruction, debate, mathematical proofs | |
| 7. Wallis and Stirling formulae. | Problem-based instruction, debate, mathematical proofs | |
| 8. Taylor series. | Problem-based instruction, debate, mathematical proofs | |
| 9. Semicontinous functions. | Problem-based instruction, debate, mathematical proofs | |
| 10. Uniform continuity; Lipschitz continuous functions. | Problem-based instruction, debate, mathematical proofs | |
| 11. The Darboux property and antiderivability. | Problem-based instruction, debate, mathematical proofs | |
| 12. Convex functions; applications to inequalities. | Problem-based instruction, debate, mathematical proofs | |

Bibliography


1. APOSTOL, T. M.: Modular functions and Dirichlet series in number theory. Springer-Verlag, New

York, 1990.
2. BORWEIN, J.M., LEWIS, A.S.: Convex Analysis and Nonlinear Optimization. Theory and Examples. CMS Books in Mathematics, Springer, 2000.
3. BRECKNER, B.E., POPOVICI, N.: Probleme de analiză convexă în $R^n$. Casa Cărţii de Ştiinţă, Cluj-Napoca, 2003.
4. BUCUR, G., CÂMPU, E., GĂINĂ, S.: Culegere de probleme de calcul diferenţial şi integral. Vol. II, Editura Tehnică, Bucureşti, 1966. Vol. III, Editura Tehnică, Bucureşti, 1967.
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6. RĂDULESCU, S., RĂDULESCU, M.: Teoreme şi probleme de analiză matematică. Editura Didactică şi Pedagogică, Bucureşti, 1982.
7. SIREŢCHI, Gh.: Calcul diferenţial şi integral. Vol. 2: Exerciţii, Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1985
8. TRIF, T.: Probleme de calcul diferenţial şi integral în $R^n$. Casa Cărţii de Ştiinţă, Cluj-Napoca, 2003.

**9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program**

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| The course ensures a solid theoretical background, according to national and international standards |

**10. Evaluation**

| Type of activity | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Share in the grade (%) |
|---|---|---|---|
| 10.4 Course | - Knowledge of theoretical concepts and theoretical results;<br>- Ability to solve practical exercises and theoretical problems | Written exam | 75% |
| 10.5 Seminar/lab activities | Active participation to tutorials (problem solving). | Continuous evaluation | 25% |
| 10.6 Minimum performance standards | | | |
| The final grade should be greater than or equal to 5. | | | |

| Date | Signature of course coordinator | Signature of seminar coordinator |
|---|---|---|
| 03.05.2019 | Prof. Nicolae Popovici, Ph.D. habil. | Prof. Nicolae Popovici, Ph.D. habil. |

| Date of approval | Signature of the head of department |
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| ..... | Prof. Octavian Agratini, Ph.D. |