**SYLLABUS**

**Approximation and Numerical Calculus Techniques (Tehnici de aproximare si de calcul numeric)**

University year 2025-2026

**1. Information regarding the programme**

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|---|---|
| 1.1. Higher education institution | Babeş-Bolyai University |
| 1.2. Faculty | Mathematics and Computer Science |
| 1.3. Department | Mathematics |
| 1.4. Field of study | Mathematics |
| 1.5. Study cycle | Master |
| 1.6. Study programme/Qualification | **Metode Moderne in Predarea Matematicii** |
| 1.7. Form of education | frecventa |

**2. Information regarding the discipline**

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|---|---|---|---|---|---|---|---|
| 2.1. Name of the discipline | **Approximation and Numerical Calculus Techniques** | | | | | Discipline code | MME3162 |
| 2.2. Course coordinator | | | | Assoc. Prof. Teodora Catinas | | | |
| 2.3. Seminar coordinator | | | | Assoc. Prof. Teodora Catinas | | | |
| 2.4. Year of study | 2 | 2.5. Semester | 2 | 2.6. Type of evaluation | E | 2.7. Discipline regime | Optional (DS) |

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

| | | | | | |
|---|---|---|---|---|---|
| 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/laborator | **12** |
| **Time allotment for individual study (ID) and self-study activities (SA)** | | | | | **hours** |
| Learning using manual, course support, bibliography, course notes (SA) | | | | | 54 |
| Additional documentation (in libraries, on electronic platforms, field documentation) | | | | | 30 |
| Preparation for seminars/labs, homework, papers, portfolios and essays | | | | | 55 |
| Tutorship | | | | | 20 |
| Evaluations | | | | | 30 |
| Other activities: | | | | | |
| **3.7. Total individual study hours** | **189** | | | | |
| **3.8. Total hours per semester** | **225** | | | | |
| **3.9. Number of ECTS credits** | **9** | | | | |

**4. Prerequisites** (if necessary)

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| 4.1. curriculum | • knowledge of main notions and procedures of numerical analysis and ability to work with them.<br>• Ability to program in MATLAB for implementing numerical algorithms. |
| 4.2. competencies | • ability to work and solve problems with concepts of Numerical Analysis.<br>• Improvment of programming skills in MATLAB for implementing numerical algorithms.<br>• Comparative assessment and efficient use of various methods of demonstration |

**5. Conditions** (if necessary)

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| 5.1. for the course | Blackboard, projector |
| 5.2. for the seminar /lab activities | Laboratory with computers. |

**6.1. Specific competencies acquired** [1]

| | |
|---|---|
| **Professional/essential competencies** | • C1.1: Identifications of notions, descriptions of theories and use of the specific language<br>• C3.1 Description of concepts, theory and models used in application domain<br>• C3.2 Identify and explain the basic computer science models corresponding to application domain<br>• C3.3 Use of computer science and mathematical models and tools for solving specific problems in the application field<br>• C3.4 Data and model analysis<br>• C4.1 Defining basic concepts, theory and mathematical models<br>• C4.2 Interpretation of mathematical models<br>• C4.3 Identifying the appropriate models and methods for solving real-life problems<br>• C4.5 Embedding formal models in applications from various areas |
| **Transversal competencies** | • CT1 Application of efficient and organized work rules, of responsible attitudes towards the didactic-scientific domain, to creatively value one's own potential, with the respect towards the principles and norms of professional etic.<br>• CT3 Use of efficient methods and techniques to learn, inform, research and develop the abilities to value the knowledge, to adapt to requirements of a dynamic society and to communicate in Romanian language and in a language of international circulation. |

**6.2. Learning outcomes**

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|---|---|
| **Knowledge** | The student knows:<br>- fundamental notions of Numerical Anlysis and knows how to apply them in other domains of Mathematics and Computer Science. |
| **Skills** | The student is able to:<br>- solve problems applying Numerical Analysis concepts<br>- proof some theorems using mathematical language<br>- implement numerical algorithms using MATLAB |
| **Responsibility and autonomy:** | The student has the ability to work independently to obtain<br>- extended results for some others areas of Mathematics or Computer Science<br>- numerical algorithms that can be applied in practical problems from real life. |

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

[1] One can choose either competences or learning outcomes, or both. If only one option is chosen, the row related to the other option will be deleted, and the kept one will be numbered 6.

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|---|---|
| **7.1 General objective of the discipline** | • to understand and use basic concepts of Numerical Analysis<br>• be able to implement numerical algorithms in order to solve practical problems.<br>• Assimilation of modern techniques of approximation of functions.<br>• Knowledge, understanding and use of some classical and modern concepts of Numerical Analysis |
| **7.2 Specific objective of the discipline** | • Consolidation of theoretical and practical knowledge about the basic numerical algorithms.<br>• Acquire some theoretical and practical knowledge regarding classical and modern procedures of numerical analysis<br>• Ability to understand and manipulate advanced concepts, results and theories in the fields of mathematics.<br>• Ability to use mathematical software and advanced methods of numerical analysis and programming for numerical solving of problems.<br>• Ability to apply numerical algorithms to solve practical and real life problems.<br>• Ability to model and analyze from a mathematical point of view real processes from other sciences, economics and engineering |

**8. Content**

| **8.1 Course** | Teaching methods | Remarks |
|---|---|---|
| 1. Introductive notions. Least squares approximation. | Exposure: description, explanation, examples. | |
| 2. Discrete least squares approximation: linear and polynomial least squares. | Exposure: description, explanation, examples, proofs. | |
| 3. Gram-Schmidt process. Least squares approximation using orthogonal polynomials. QR and SVD decompositions. | Exposure: description, explanation, examples. | |
| 4. Numerical methods for solving differential equations. | Exposure: description, explanation, examples. | |
| 5. Positive linear operators: preliminaries, definitions properties, Bohman-Korovkin theorems. Modulus of continuity. Properties. | Exposure: description, explanation, examples, proofs. | |
| 6. Modulus of smoothness. Properties. The approximation error. | Exposure: description, explanation, examples, proofs. | |
| 7. Bernstein operators. Casteljau algorithm. Bernstein operators on square and triangle | Exposure: description, explanation, examples, proofs, dialogue. | |
| 8. Operators of Bernstein type: Schurer, Cheney-Sharma | Exposure: description, explanation, examples. | |
| 9. Operators of Bernstein type: Stancu, Kantorovich and Durrmeyer operators. | Exposure: description, explanation, examples. | |
| 10. Extensions of some classical univariate interpolation methods to multivariate case. | Exposure: description, explanation, examples. | |
| 11. Some applications of the interpolation processes to surfaces generation. | Exposure: description, explanation, examples. | |
| 12. Presentation of a synthesis work. | Exposure: description, explanation, examples. | |

Bibliography


1. O. Agratini, I. Chiorean, Gh. Coman, R.T. Trîmbitaş, *Analiză Numerică şi Teoria Aproximării*, vol. III, Ed. Presa Univ. Clujeană, 2002;
2. R. L. Burden, J. D. Faires, *Numerical Analysis,* PWS Publishing Company, 2010.
3. I. Chiorean, T. Cătinaş, R. Trîmbitaş, *Analiză numerică*, Ed. Presa Univ. Clujeană, 2010.
4. Gh. Coman, T. Cătinaş, şi alţii, *Interpolation operators*, Ed. Casa Cărţii de Ştiinţă, Cluj-Napoca, 2004.

5. Gh. Coman, I. Chiorean, T. Cătinaş, *Numerical Analysis. An Advanced Course*, Ed. Presa Univ. Clujeană, 2007.
6. S. D. Conte, Carl de Boor, *ELEMENTARY NUMERICAL ANALYSIS. An Algorithmic Approach,* SIAM, 2017.
7. W. Gander, M.J. Gander, F. Kwok, *Scientific Computing,* Springer Internat. Publishing, 2014.
8. W. Gautschi, *Numerical Analysis. An introduction*, Birkhauser, Basel, 1997
9. R. Plato, *Concise Numerical Mathematics*, Amer. Math. Soc., 2003.
10. D.D. Stancu, Gh. Coman, O. Agratini, R. Trimbitas, *Analiză Numerică şi Teoria Aproximării*, vol. I, Ed. Presa Univ. Clujeană, 2001;
11. D.D. Stancu, Gh. Coman, P. Blaga, *Analiză Numerică şi Teoria Aproximării*, vol. II, Ed. Presa Univ. Clujeană, 2002;
12. R. Trîmbitaş, *Numerical Analysis*, Ed. Presa Univ. Clujeană, 2007.

| **8.2 Seminary/Laboratory** | Teaching methods | Remarks |
|---|---|---|
| **1-2** Introductory examples and problems. | Explanation, dialogue. | |
| **3-4** Discrete least square approximation (linear and polynomial) and continuous least square approximation. Practical examples. | Explanation, dialogue, examples. | |
| **5-6** Gram-Schmidt algorithm. QR and SVD decompositions. | Explanation, dialogue, practical examples. | |
| **7-8** Numerical methods fro differential equations | Explanation, dialogue, practical examples. | |
| **9-10** Generation of some Bernstein-type operators. Casteljau algorithm. | Explanation, dialogue, practical examples. Evaluation. | |
| **11-12** Some applications of extensions of classical univariate interpolation methods to multivariate case.<br>Ending of evaluation for seminar/lab work | Explanation, dialogue, practical examples. Evaluation. | |

Bibliography
1. R. L. Burden, J. D. Faires, *Numerical Analysis,* PWS Publishing Company, 2010.
2. W. Gander, M.J. Gander, F. Kwok, *Scientific Computing,* Springer Internat. Publishing, 2014.
3. A. Kharab, R. B. Guenther, *An introduction to numerical methods. A Matlab approach,* Taylor&Francis Group, 2006.
4. R. Trîmbitaş, *Numerical Analysis*, Ed. Presa Univ. Clujeană, 2007.

**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**

- The content of the course is important for seeing the application of mathematical knowledge in solving practical and real life problems.

**10. Evaluation**

| Activity type | 10.1 Evaluation criteria | 10.2 Evaluation methods | 10.3 Percentage of final grade |
|---|---|---|---|
| 10.4 Course | - know the basic principles of Numerical Analysis; | Written exam | 60% |
| | - apply the course concepts in problem solving | | |
| 10.5 Seminar/laboratory | - be able to implement course concepts and algorithms | Evaluation and continuous observations during the semester. | Lab 30% |

| | | | |
|---|---|---|---|
| | - apply techniques for different practical problems | Study for preparing a synthesis work. | 10% |
| 10.6 Minimum standard of performance | | | |
| • At least grade 5 (from a scale of 1 to 10) at both written exam and laboratory work. | | | |

**11. Labels ODD (Sustainable Development Goals)[2]**

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|---|---|---|---|---|---|---|---|---|
| | General label for Sustainable Development | | | | | | | |
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| | | | | | | | | |

Date:
27.03.2025

Signature of course coordinator

Conf. Dr. Teodora Cătinaș

Signature of seminar coordinator

Conf. Dr. Teodora Cătinaș

Date of approval:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuș

[2] Keep only the labels that, according to the *Procedure for applying ODD labels in the academic process*, suit the discipline and delete the others, including the general one for *Sustainable Development* – if not applicable. If no label describes the discipline, delete them all and write „*Not applicable.*”.