

# SYLLABUS

## MATHEMATICAL MODELING

University year 2025-2026

### 1. Information regarding the programme

|                                    |                                             |
|------------------------------------|---------------------------------------------|
| 1.1. Higher education institution  | Babes-Bolyai University Cluj-Napoca         |
| 1.2. Faculty                       | Faculty of Mathematics and Computer Science |
| 1.3. Department                    | Department of Mathematics                   |
| 1.4. Field of study                | Computer Science                            |
| 1.5. Study cycle                   | Master                                      |
| 1.6. Study programme/Qualification | Databasis                                   |
| 1.7. Form of education             | Full time                                   |

### 2. Information regarding the discipline

|                             |   |                       |   |                         |                                        |                        |                 |          |         |
|-----------------------------|---|-----------------------|---|-------------------------|----------------------------------------|------------------------|-----------------|----------|---------|
| 2.1. Name of the discipline |   | Mathematical Modeling |   |                         |                                        |                        | Discipline code |          | MME3030 |
| 2.2. Course coordinator     |   |                       |   |                         | Assoc. Prof. PhD. Marcel-Adrian Şerban |                        |                 |          |         |
| 2.3. Seminar coordinator    |   |                       |   |                         | Assoc. Prof. PhD. Marcel-Adrian Şerban |                        |                 |          |         |
| 2.4. Year of study          | 1 | 2.5. Semester         | 1 | 2.6. Type of evaluation | E                                      | 2.7. Discipline regime |                 | Optional |         |

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

|                                                                                       |            |                      |           |             |              |
|---------------------------------------------------------------------------------------|------------|----------------------|-----------|-------------|--------------|
| 3.1. Hours per week                                                                   | <b>3</b>   | of which: 3.2 course | <b>2</b>  | 3.3 seminar | <b>1</b>     |
| 3.4. Total hours in the curriculum                                                    | 42         | of which: 3.5 course | <b>28</b> | 3.6 seminar | <b>14</b>    |
| <b>Time allotment for individual study (ID) and self-study activities (SA)</b>        |            |                      |           |             | <b>hours</b> |
| Learning using manual, course support, bibliography, course notes (SA)                |            |                      |           |             | 20           |
| Additional documentation (in libraries, on electronic platforms, field documentation) |            |                      |           |             | 20           |
| Preparation for seminars/labs, homework, papers, portfolios and essays                |            |                      |           |             | 20           |
| Tutorship                                                                             |            |                      |           |             | 20           |
| Evaluations                                                                           |            |                      |           |             | 28           |
| Other activities:                                                                     |            |                      |           |             |              |
| <b>3.7. Total individual study hours</b>                                              | <b>108</b> |                      |           |             |              |
| <b>3.8. Total hours per semester</b>                                                  | <b>150</b> |                      |           |             |              |
| <b>3.9. Number of ECTS credits</b>                                                    | <b>6</b>   |                      |           |             |              |

### 4. Prerequisites (if necessary)

|                   |  |
|-------------------|--|
| 4.1. curriculum   |  |
| 4.2. competencies |  |

### 5. Conditions (if necessary)

|                                      |  |
|--------------------------------------|--|
| 5.1. for the course                  |  |
| 5.2. for the seminar /lab activities |  |

### 6.1. Specific competencies acquired <sup>1</sup>

<sup>1</sup> 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.

|                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Professional/essential competencies | <ul style="list-style-type: none"> <li>• C1.2 Correct explanation and interpretation of mathematical concepts, using specific language</li> <li>• C 2.4 Comparative analysis of the results obtained by solving problems with pre-existing data</li> <li>• C4.2 Explain and interpret mathematical models</li> </ul>                                                                                                                                                                                                                      |
| Transversal competencies            | <ul style="list-style-type: none"> <li>• CT 1. Applying the rules of rigorous and efficient work, manifesting responsible attitudes towards the scientific and didactic field, for the optimal and creative capitalization of one's own potential in specific situations, respecting the principles and norms of professional ethics.</li> <li>• CT 3. Efficient use of information sources and resources of communication and assisted professional training, both in Romanian and in a language of international circulation</li> </ul> |

## 6.2. Learning outcomes

|                              |                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Knowledge                    | <p>The student knows:</p> <ul style="list-style-type: none"> <li>• Specific concepts related to mathematics disciplines necessary for completing assignments.</li> <li>• Fundamental concepts of discrete and continuous dynamical systems.</li> <li>• Methods for creating and analyzing mathematical models from different fields of science modeled by difference equations and differential equations using MAPLE</li> </ul> |
| Skills                       | <p>The student is able to:</p> <ul style="list-style-type: none"> <li>• Construct clear and well-supported mathematical arguments to explain problems, topics, and mathematical ideas in writing.</li> <li>• Improved modeling abilities: mathematical modelling, model analysis, numerical simulations using MAPLE</li> </ul>                                                                                                   |
| Responsibility and autonomy: | <p>The student has the ability to:</p> <ul style="list-style-type: none"> <li>• Independently explore certain mathematical content, relying on already acquired ideas and tools, to expand their knowledge.</li> <li>• Independently extend already acquired mathematical ideas and arguments to a mathematical topic that has not been previously studied.</li> </ul>                                                           |

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

|                                          |                                                                                                                                                                                                                                                                                            |
|------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7.1 General objective of the discipline  | <ul style="list-style-type: none"> <li>• Be able to describe real world phenomena in mathematical language</li> <li>• Improved modeling abilities: mathematical modelling, model analysis, numerical simulations using MAPLE</li> </ul>                                                    |
| 7.2 Specific objective of the discipline | <ul style="list-style-type: none"> <li>• Acquire knowledge about discrete and continuous dynamical systems</li> <li>• Apply discrete and continuous dynamical systems in mathematical modelling of real world phenomena</li> <li>• Understand and work with mathematical models</li> </ul> |

## 8. Content

|                                                                   |                                     |         |
|-------------------------------------------------------------------|-------------------------------------|---------|
| 8.1 Course                                                        | Teaching methods                    | Remarks |
| 1. Mathematical Models. Modelling Change with Difference Equation | Interactive exposure<br>Explanation |         |

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                 |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Conversation<br>Didactical demonstration                                        |  |
| 2. Solving Difference Equations with MAPLE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 3. First Order Difference Equations.<br>Equilibrium Points. Periodic Points. Stability                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 4. Higher Order Difference Equations, Systems<br>of Difference Equations. Equilibrium Points.<br>Stability                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 5. Mathematical Models Given by Difference<br>Equations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 6. Mathematical Models Given by Systems of<br>Difference Equations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 7. Solving Differential Equations with MAPLE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 8. Approximate Solutions for Differential<br>Equations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 9. Autonomous Differential Equations.<br>Equilibrium Solutions. Stability                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 10. Mathematical Models Given by First Order<br>Differential Equations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 11. Mathematical Models for Single Population                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 12. Mathematical Models for Interacting<br>Populations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 13. Mathematical Models in Epidemiology                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| 14. Trends and Future Directions in<br>Mathematical Modeling with Dynamical<br>Systems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Interactive exposure<br>Explanation<br>Conversation<br>Didactical demonstration |  |
| Bibliography<br>1. Saber Elaydi, An Introduction to Difference Equations, Springer, 2005<br>2. F.R. Giordano, M.D. Weir, W.P. Fox, A first course in mathematical modeling, Brooks/Coole, 2003.<br>3. D.K. Arrowsmith, Dynamical systems, Differential equations, maps and chaotic behaviour, Chapman and Hall, 1992.<br>4. Lynch S. Dynamical systems with applications using MAPLE, Birkhauser, 2001.<br>5. Ronald W. Shonkwiler, Mathematical Biology. An Introduction with Maple and Matlab, Springer, 2009.<br>6. J.D. Murray, Mathematical biology, Springer, 2001 |                                                                                 |  |

| 8.2 Seminar / laboratory                                                                                                                                                                                                                                                            | Teaching methods                                    | Remarks |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|---------|
| 1. Modelling Change with Difference Equations                                                                                                                                                                                                                                       | Exercise<br>Explanation<br>Didactical demonstration |         |
| 2. Solving Difference Equations with MAPLE                                                                                                                                                                                                                                          | Exercise<br>Explanation<br>Didactical demonstration |         |
| 3. Mathematical Models Given by Difference Equations and Systems of Difference Equations                                                                                                                                                                                            | Exercise<br>Explanation<br>Didactical demonstration |         |
| 4. Solving Differential Equations with MAPLE                                                                                                                                                                                                                                        | Exercise<br>Explanation<br>Didactical demonstration |         |
| 5. Mathematical Models Given by Differential Equations                                                                                                                                                                                                                              | Exercise<br>Explanation<br>Didactical demonstration |         |
| 6. Mathematical Models Given by Systems of Differential Equations                                                                                                                                                                                                                   | Exercise<br>Explanation<br>Didactical demonstration |         |
| 7. Mathematical Models in Epidemiology                                                                                                                                                                                                                                              | Exercise<br>Explanation<br>Didactical demonstration |         |
| Bibliography<br>1. Saber Elaydi, An Introduction to Difference Equations, Springer, 2005<br>2. Lynch S. Dynamical systems with applications using MAPLE, Birkhauser, 2001.<br>3. Ronald W. Shonkwiler, Mathematical Biology. An Introduction with Maple and Matlab, Springer, 2009. |                                                     |         |

**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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|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>The content of this discipline is in accordance with the curricula of the most important universities in Romania and abroad. This discipline is useful in preparing future researchers in pure and applied mathematics, as well as those who use mathematical models and advanced methods of study in other areas.</li> </ul> |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**10. Evaluation**

| Activity type           | 10.1 Evaluation criteria                                                            | 10.2 Evaluation methods                       | 10.3 Percentage of final grade |
|-------------------------|-------------------------------------------------------------------------------------|-----------------------------------------------|--------------------------------|
| 10.4 Course             | Knowledge of concepts and basic results                                             |                                               |                                |
|                         | Ability to justify by proofs theoretical results                                    | Final written exam                            | 80%                            |
| 10.5 Seminar/laboratory | Ability to apply concepts and results acquired during the course in problem solving | Two problem-solving assignment with solutions | 20%                            |
|                         | Ability to apply concepts and results acquired                                      |                                               |                                |

|                                                                                                                                             |                                                                                 |  |  |
|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--|--|
|                                                                                                                                             | during the course in<br>problem solving using<br>mathematical software<br>MAPLE |  |  |
| 10.6 Minimum standard of performance                                                                                                        |                                                                                 |  |  |
| <ul style="list-style-type: none"> <li>Successful passing of the exam is conditioned by the final grade that must be at least 5.</li> </ul> |                                                                                 |  |  |

## 11. Labels ODD (Sustainable Development Goals)<sup>2</sup>

Not applicable.

Date:  
11.04.2025

Signature of course coordinator  
Assoc. Prof. PhD. Marcel-Adrian ȘERBAN

Signature of seminar coordinator  
Assoc. Prof. PhD. Marcel-Adrian ȘERBAN

Date of approval:  
25.04.2025

Signature of the head of department  
Prof. Dr. Andrei-Dorin MĂRCUȘ

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<sup>2</sup> 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.*”.