

COURSE DESCRIPTION

Theoretical Mechanics and Applications

Academic year 2026-2027

1. Programme-related data

1.1. Higher Education Institution	Babeş-Bolyai University
1.2. Faculty	Mathematics and Computer Science
1.3. Department	Mathematics
1.4. Field	Mathematics
1.5. Level of study	Bachelor
1.6. Degree programme / Qualification	Mathematics and Computer Science
1.7. Form of education	Full-Time

2. Course-related data

2.1. Course title	Theoretical Mechanics and Applications			Course code	MLE0102
2.2. Course coordinator	Prof. dr. Teodor Grosan				
2.3. Seminar coordinator	Prof. dr. Teodor Grosan				
2.4. Year of study	2	2.5. Semester	4	2.6. Type of assessment	Exam
2.7. Course status	Compulsory		2.8. Course type	Core subject	

3. Total estimated time (hours per semester of teaching activities)

3.1. Number of hours per week	4	of which: 3.2. course	2	3.3. seminar/ laboratory/ project	2
3.4. Total of hours in the curriculum	56	of which: 3.5. course	28	3.6. seminar/ laboratory	28
Time allocation for individual study (IS) and self-taught activities (ST)					hours
Learning from textbooks, course materials, bibliography, and notes (IS)					22
Additional research in the library, on subject-specific electronic platforms, and on-site					12
Preparing seminars/ laboratories/ projects, assignments, reports, portfolios, and essays					20
Tutoring (professional guidance)					7
Examinations					8
Other activities					-
3.7. Total hours of individual study (IS) and self-taught activities (ST)				69	
3.8. Total hours per semester				125	
3.9. Number of credits				5	

4. Prerequisites (where applicable)

4.1. curriculum-related	Calculus 2 (Differential and Integral Calculus in R^n); Analytical Geometry; Differential Geometry of Curves and Surfaces; Differential Equations
4.2 skills-related	There are useful logical thinking and mathematical notions and results from the above-mentioned fields

5. Specific conditions (where applicable)

5.1. course-related	Classroom with blackboard/video projector
5.2. seminar/laboratory-related	Classroom with blackboard/video projector

6.1. Competencies resulting from the completion of the degree programme (as referred to in the curriculum)¹

¹ The professional and/or transversal skills targeted by the subject for which the course description is prepared will be copied from the curriculum of the degree programme. For each competency, the complete entry, including the competency code, will be copied with the exact wording that appears in the curriculum, without any changes. If no competency is copied from either of the two categories, the row corresponding to that category is deleted from the table.

Professional competencies	
Competency code	Competency
CP1	develop problem-solving strategies
CP2	perform analytical mathematical calculations
CP5	synthesize information
CP7	communicate mathematical information
Transversal competencies	
Competency code	Competency
CT1	Interpret mathematical information
CT4	Solve problems

6.2. Learning outcomes relevant to the degree programme (as referred to in the curriculum)²

Learning outcomes targeted by the subject		
Competency code	Knowledge and comprehension	Specific academic skills
CP1, CT4	2. The student/graduate compares and distinguishes related notions and their properties from the core disciplines of mathematics.	2. The student/graduate recognizes and analyses the necessary and/or sufficient conditions in the statements of mathematical assertions and specifies their role in the proof.
CP2	7. The student/graduate selects, explains, and specifies the mathematical foundations applied in computer science, including formal logic, algebra, probability, and statistics.	7. The student/graduate applies, evaluates, and proposes mathematical methods for modeling, simulating, and solving computer science problems.
CP5, CT1	4. The student/graduate defines the basic concepts from advanced mathematics disciplines in the curriculum.	4. The student/graduate answers questions and correctly and rigorously formulates the statements of mathematical assertions (lemmas, propositions, theorems) from the disciplines in the curriculum.
CP7	1. The student/graduate defines the fundamental concepts from the core disciplines of mathematics.	1. The student/graduate provides examples of how fundamental concepts and theoretical results are used in solving exercises and problems related to the topics covered in the curriculum disciplines.

7. Subject-specific learning outcomes

Knowledge and comprehension
1. The graduate knows fundamental notions related to Theoretical Mechanics and methods of applying them to areas of science related to Mathematics, Mechanics and Engineering.
Specific academic skills
1. The graduate is able to explain theoretical notions, problem-solving methods, paradigms, etc. used in various branches of Mathematics related to secondary education.
2. The graduate is able to introduce new and innovative elements in the instructive-educational process of the field Mathematics, if it is considered necessary/useful.

² The learning outcomes relevant for the degree programme and targeted by the subject for which the course description is prepared will be listed. The entries, copied without any changes from the Curriculum by subject type (Core Subject/Specialisation Subject/Complementary Subject), are listed under the corresponding competency.

8. Contents

8.1. Course	Teaching and learning methods	Remarks ³
Introduction. Fundamental notions of Mechanics. Kinematics of material point: Trajectory, motion equations, velocity and acceleration of material point. Kinematics of material point in Cartesian and intrinsic coordinates (Frénet's coordinate system).	Lectures, modelling, didactical demonstration, conversation. Presentation of alternative explanations.	
Curvilinear coordinates. Examples of orthogonal curvilinear coordinates: cylindrical, polar, and spherical coordinates.	Lectures, modelling, didactical demonstration, conversation. Presentation of alternative explanations.	
Kinematics of rigid body: Euler's angles. Motion equations. Poisson's formulas.	Lectures, modelling, didactical demonstration, conversation. Presentation of alternative explanations.	
The distribution of velocity and acceleration in rigid body. Translational motion of rigid body. Kinematics of rotation of rigid body around a fixed axis. Kinematics of rotation of rigid body around a fixed point.	Lectures, modelling, didactical demonstration, conversation. Presentation of alternative explanations.	
General motion of free rigid body. Helical motion. Plane motion of rigid body (I): Pure rotation. Instantaneous centre of rotation.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
Plane motion of rigid body (II): Curves described by the instantaneous centre of rotation. Kinematics of relative motion: definitions, distribution of velocities and accelerations, Coriolis' formulas, Coriolis' Theorem.	Lectures, modelling, didactical demonstration, conversation. Presentation of alternative explanations.	
Dynamics of material point: Newton's laws of Dynamics. Newton's equation. Dynamics of free material point.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
General theorems of dynamics of material point.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
Motion under the influence of a central force. Binet's equation. The case when the central force depends only on the distance: $f = f(r)$.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
The universal attraction law. Newton's problem.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
Dynamics of material point subject to constraints: The motion on a fixed surface, or on a fixed curve. Mathematical pendulum.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	

³ For example, organisational aspects, recommendations for students, specific aspects relating to the course/seminar, such as inviting experts in the field, etc.

Dynamics of systems of material points. General theorems of dynamics of systems of material points.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
General theorems of the motion of systems of material points around their mass centre. Angular momentum and kinetic energy in the fixed axis rigid body motion. Moment of inertia.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
Dynamics of the motion of a rigid body about a fixed point. Considerations on the general motion of a free rigid body.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	

Bibliography

1. Kohr, M., Special Topics in Mechanics, Cluj University Press, Cluj- Napoca, 2005 (in Romanian)
2. Brădeanu, P., Theoretical Mechanics, Vols. 1 and 2, Babeş-Bolyai University Press, Cluj-Napoca, 1988 (in Romanian).
3. Iacob, C., Theoretical Mechanics, Editura Didactică și Pedagogică, Bucharest, 1980 (in Romanian)
4. Dragoș, L., Principles of Analytical Mechanics, Technical Publishing House, Bucharest, 1976 (in Romanian)
5. Goldstein, H., Poole, C., Safko, J., Classical Mechanics, Reading, MA: Addison-Wesley Publ. Co. (3rd edition), 2014
6. Bose, S., Chatteraj, D., Elementary Analytical Mechanics, Alpha Science International Ltd. 2000
7. Aaron, F.D., Analytical Mechanics, BIC ALL Publishing House, Bucharest, 2002 (in Romanian)
8. Landau, L.D., Lifshitz, E.M., Mechanics, Elsevier-Butterworth-Heinemann, (3rd edition), 2005
9. Russo, R., Classical Problems in Mechanics, Aracne, Roma, 1997

8.2. Seminar/ laboratory	Teaching and learning methods	Remarks
Kinematics of material point in Cartesian and orthogonal curvilinear coordinates (cylindrical, spherical, and polar coordinates). Motion in the Frénet coordinate system (I).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Kinematics of material point in Cartesian and orthogonal curvilinear coordinates (cylindrical, spherical, and polar coordinates). Motion in the Frénet coordinate system (II).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Translational motion of rigid body. Kinematics of rotation of rigid body around a fixed axis.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Kinematics of rotation of rigid body around a fixed point. Kinematics of free rigid body.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Helical motion. Plane motion of rigid body (I).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Plane motion of rigid body (II). Kinematics of relative motion of material point.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Dynamics of free material point. Motion of material point in a field of conservative forces.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
General theorems of dynamics of material point.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Central forces (I).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	

Central forces (II).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Dynamics of material point subject to constraints. Dynamics of relative motion of material point.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Dynamics of systems of material points. Moment of inertia.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
General theorems of dynamics of systems of material points (I).	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
General theorems of dynamics of systems of material points (II). Dynamics of the motion of a rigid body about a fixed point.	Description of arguments and proofs for solving problems. Direct answers to students. Homework assignments.	
Bibliography		

9. Evaluation

Type of activity	9.1 Evaluation criteria ⁴	9.2 Evaluation methods ⁵	9.3 Percentage in the final grade
9.4. Course	Knowledge of concepts and basic results	Written exam at midterm and at the end the semester	100%
	Ability to justify by proofs theoretical results		
9.5. Seminar/ laboratory	Ability to apply concepts and results acquired in the course in mathematical modeling and analysis of problems in Mechanics		
	There are valid the official rules of the faculty concerning the attendance of students to teaching activities		
9.6 Minimum standard for passing			
At least grade 5 (from a scale of 1 to 10) at both written exam			

10. SDG labels (Sustainable Development Goals)⁶

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⁴ The evaluation criteria must directly reflect the learning outcomes targeted at the level of the degree programme respectively at the level of the subject. More specifically, the learning outcomes set out in the expected learning outcomes are assessed.

⁵ Both final evaluation methods and ongoing evaluation strategies should be established.

⁶ Select a single label which, according to the [Implementation of SDG labels in the academic process](#), best matches the subject. If the subject addresses sustainable development in a generic manner (i.e. by presenting/introducing the general framework of sustainable development, etc.), then the Sustainable Development generic label may be applied. If none of the labels describe the subject, select the last option: "No label applies."

								
								
								No label applies
								

Date of entry:
15.04.2026

Signature of course coordinator

Prof. dr. Teodor Grosan

Signature of seminar coordinator

Prof. dr. Teodor Grosan

Date of approval in the department:
24.04.2026

Signature of the head of department

Prof. dr. Andrei Mărcuș