SYLLABUS

Theoretical Mechanics and Applications

University year 2025-2026

1. Information regarding the programme

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	Bachelor
1.6. Study programme/Qualification	Mathematics and Computer Science
1.7. Form of education	Full-Time

2. Information regarding the discipline

2.1. Name of the discipline	**Theoretical Mechanics and Applications**					Discipline 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	**2**	2.6. Type of evaluation	**E**	2.7. Discipline regime	**DF**

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

3.1. Hours per week	**4**	of which: 3.2 course	**2**	3.3 seminar/laboratory	**2**
3.4. Total hours in the curriculum	**56**	of which: 3.5 course	**28**	3.6 seminar/laborator	**28**
Time allotment for individual study (ID) and self-study activities (SA)					**hours**
Learning using manual, course support, bibliography, course notes (SA)					22
Additional documentation (in libraries, on electronic platforms, field documentation)					12
Preparation for seminars/labs, homework, papers, portfolios and essays					20
Tutorship					7
Evaluations					8
Other activities:					-
3.7. Total individual study hours	**69**				
3.8. Total hours per semester	**125**				
3.9. Number of ECTS credits	**5**				

4. Prerequisites (if necessary)

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

5. Conditions (if necessary)

5.1. for the course	Classroom with blackboard/video projector
5.2. for the seminar /lab activities	Classroom with blackboard/video projector

6.1. Specific competencies acquired [1]

[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.

Professional/essential competencies	• C2.3 Application of theoretical methods of analysis adequate to the issue data. • C4.3 Construction of mathematical model using methods, techniques and appropriate tools. • Knowledge of the basic concepts of Mechanics • Ability to understand and use fundamental results in geometry, differential and integral calculus, and the theory of differential equations to study particular problems of motion and to provide applications.
Transversal competencies	• CT1 Applying rigorous and effective work rules, manifest responsible attitude to science and teaching, and creative order to maximize their potential in specific situations, the principles and rules of professional ethics. • Ability to apply the studied concepts, to inform themselves, to work independently or in a team in order to carry out studies and to solve complex problems. • Ability for continuous self-perfecting and study.

6.2. Learning outcomes

Knowledge	The graduate knows fundamental notions related to Theortical Mechanics and methods of applying them to areas of science related to Mathematics, Mechanics and Engineering.
Skills	The graduate is able to explain theoretical notions, problem-solving methods, paradigms, etc. used in various branches of Mathematics related to secondary education. 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.
Responsibility and autonomy:	The student has the ability to work independently to obtain and solve mathematical models in Mechanics.

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

7.1 General objective of the discipline	Knowledge, understanding and use of main concepts and results of Mechanics.
7.2 Specific objective of the discipline	Acquiring basic and advanced knowledge in Mechanics. Acquiring basic concepts of kinematics of material point and kinematics of rigid body. Acquiring basic concepts of dynamics of material point and of systems of material points. Understanding fundamental problems and results in rigid body dynamics. Ability to apply and use mathematical models to describe and analyze problems of Mechanics.

8. Content

8.1 Course	Teaching methods	Remarks
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, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
Curvilinear coordinates. Examples of orthogonal curvilinear coordinates: cylindrical, polar, and spherical coordinates.	Lectures, modeling, didactical demonstration, conversation. Presentation of alternative explanations.	
Kinematics of rigid body: Euler's angles. Motion equations. Poisson's formulas.	Lectures, modeling, 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, modeling, 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 velocitis and accelerations, Coriolis' formulas, Coriolis' Theorem.	Lectures, modeling, 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.	
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 center.	Lectures, modeling, didactical demonstration, conversation.	

Angular momentum and kinetic energy in the fixed axis rigid body motion. Moment of inertia.	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. Brãdeanu, P., Theoretical Mechanics, Vols. 1 and 2, Babeş-Bolyai University Press, Cluj-Napoca, 1988 (in Romanian).
3. Iacob, C., Theoretical Mechanics, Editura Didactică şi Pedagogică, Bucharest, 1980 (in Romanian)
4. Dragoş, L., Principles of Analytical Mechanics, Technical Publishing House, Bucharest, 1976 (in Romanian)
5. Goldstein, H., Poole, C., Safko, J., Classical Mechanics, Reading, MA: Addison-Wessley Publ. Co. (3rd edition), 2014
6. Bose, S., Chattoraj, 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 methods**	**Remarks**
Kinematics of material point in Cartesian and orthogonal curvilinear coordinates (cylindrical, shperical, 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, shperical, 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

1. Kohr, M., Special Topics in Mechanics, Cluj University Press, Cluj- Napoca, 2005 (in Romanian)
2. Turcu, A., Kohr-Ile, M., Collection of Theoretical Mechanics Problems, Babeş- Bolyai University Press, Cluj-Napoca, 1993 (in Romanian)
3. Brãdeanu, P., Theoretical Mechanics, Vols. 1 and 2, Babeş- Bolyai University Press, Cluj-Napoca, 1988
4. Brãdeanu, P., Pop, I., Bradeanu D., Technical Publishing House, Bucharest, 1979 (in Romanian)
5. Brãdeanu, P., Pop, I., Stan, I., Turcu, A., Collection of Theoretical Mechanics Problems, Babeş- Bolyai University Press, Cluj-Napoca, 1976 (in Romanian)
6. Aaron, F.D., Analytical Mechanics, BIC ALL Publishing House, Bucharest, 2002 (in Romanian)
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8. Landau, L.D., Lifshitz, E.M., Mechanics, Elsevier-Butterworth-Heinemann, (3rd edition), 2005
9. Russo, R., Classical Problems in Mechanics, Aracne, Roma, 199

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 this discipline is in accordance with the curricula of the most important universities in Romania and abroad, where the applied mathematics plays an essential role. This discipline is useful in preparing future teachers and researchers in applied mathematics, as well as those who use mathematical models and methods of study in other areas (physics, chemistry, engineering, computer science).

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	Written exam at midterm and at the end the semester	100%
	Ability to justify by proofs theoretical results		
10.5 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		
10.6 Minimum standard of performance			
At least grade 5 (from a scale of 1 to 10) at both written exam			

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

	General label for Sustainable Development							
								

Date:
11.04.2025

Signature of course coordinator

Prof. Dr. Teodor Grosan

Grosan Teodor

Signature of seminar coordinator

Prof. Dr. Teodor Grosan

Grosan Teodor

Date of approval:
25.04.2025

Signature of the head of department

Prof. dr. Andrei Mărcuş

[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.*”.