Syllabus

1. Data about the program of study

1.1 Institution	Technical University of Cluj-Napoca
1.2 Faculty	Automation and Computer Science
1.3 Department	Automation
1.4 Field of study	Automation. Applied Informatics and Intelligent Systems
1.5 Cycle of study	Bachelor of Science
1.6 Program of study/Qualification	Automation and Applied Informatics (English)
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	***Mechanics***			Discipline code	28.00
2.2 Course responsible/lecturer	Lect.dr.Eng. Rad Ciprian - ciprian.rad@mdm.utcluj.ro				
2.3 Teachers in charge of applications	Lect.dr.Eng. Rad Ciprian - ciprian.rad@mdm.utcluj.ro				
2.4 Year of study	2	2.5 Semester	4	2.6 Assessment *(E/C/V)*	C
2.7 Type of subject	*DF – fundamental, DS – specialty, DC – complementary*				DF
	DOB – compulsory, DOP – elective, DFA – optional				DOB

3. Estimated total time

3.1 Number of hours per week	3	of which:	Course	2	Seminar	1	Laboratory	0	Project 0
3.2 Number of hours per semester	42	of which:	course	28	Seminar	14	Laboratory	0	Project 0

3.3 Individual study	
(a) Manual, lecture material and notes, bibliography	12
(b) Supplementary study in the library, online and in the field	20
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	20
(d) Tutoring	3
(e) Exams and tests	3
(f) Other activities:	0

3.4 Total hours of individual study (sum of (3.3(a)…3.3(f)))	58
3.5 Total hours per semester (3.2+3.4)	100
3.6 Number of credit points	4

4. Pre-requisites (where appropriate)

4.1 Curriculum	Physics, Mathematics
4.2 Competence	Mathematics, Physics, Measurement Techniques, Technical Drawing

5. Requirements (where appropriate)

5.1. For the course	Face to face: video projector, blackboard with white and colored chalk, whiteboard with colored markers.
5.2. For the applications	Face to face: video projector, blackboard with white and colored chalk, whiteboard with colored markers, hands on sessions on representative equipment from laboratory.

6. Specific competences

Professional competences	C1 - Operating with basic Mathematical and Physical knowledge, Measurement Techniques, Technical Drawing, Mechanical Engineering, Chemistry and Electronics in the field of Automation and Applied Informatics (4 credits).

Cross competences	CT2 - Identify roles and responsibilities in an interdisciplinary team, making decisions and assigning tasks, applying techniques and effective work relationships within the team.

7. Expected learning outcomes

Knowledge	By the end of the course, students will be able to: • Explain the Architecture of Mechatronic Systems: Describe the hardware structure of mechatronic systems and clearly define the roles, classification, and functions of basic mechanisms and mechanical transmissions. • Understand Planar Mechanism Structural Topology: Define concepts of planar motion, kinematic elements, joints, and degrees-of-freedom (DoFs), while identifying passive links, passive mobilities, and structural constraints in planar mechanisms. • Articulate Kinematic and Force Principles: Grasp the core principles governing static and dynamic equilibrium, including Loop Closure Equations, Free-Body Diagrams (FBDs), D'Alembert's principle, and Dynamically Equivalent Systems. • Comprehend Transmission and Cam Design Criteria: Explain the fundamental law of gearing (ordinary, planetary, combined, and differential gear trains) and the kinematics of cam profiles under various motion laws (SVAJ diagrams: constant acceleration, simple harmonic, and cycloidal).
Skills	By the end of the course, students will be able to: • Perform Structural and Kinematic Modeling: Sketch accurate kinematic diagrams from physical systems and solve for position, velocity, and acceleration using both graphical and analytical methods (such as transfer functions and loop-closure equations). • Execute Static and Dynamic Force Analysis: Construct Free-Body Diagrams (FBDs) to calculate reaction forces in kinematic joints, perform topology optimization, compute mass moments of inertia using the parallel axis theorem, and size actuators for driving mechanisms. • Synthesize Gears and Cam Profiles: Design spur gears according to involute tooth profile geometries and develop mechanical cam profiles based on specified follower movements (translating/electronic cams) using CAD tools.
Responsibilities and autonomy	By the end of the course, students will be able to: • Autonomously Conduct Technical Diagnostics: Independently setup, analyze, and interpret experimental data from physical laboratory mechanism setups, mapping physical behaviors back to theoretical mathematical models. • Take Responsibility for Design Decisions: Make informed, autonomous engineering choices when choosing and sizing transmissions, gears, and actuators based on structural constraints and desired kinematic outputs. • Commit to Technical Precision and Validation: Show accountability in verifying analytical solutions against graphical methods or CAD/CAE simulations, ensuring designed mechanisms comply with safety, manufacturing constraints, and operational requirements.

8. Course objectives

General objective	This course introduces the fundamental principles of mechatronic and mechanical systems, focusing on their structure, operation, and design integration with electrical and software technologies. Students will explore the primary types of mobile mechanical systems (mechanisms), including the fundamentals of mechanism theory, robotic systems, and flexible manufacturing setups. Additionally, the course covers core analytical problems, standard industry terminology, and modern CAD methodologies used in system design.
Specific objectives	• To communicate effectively in writing and orally with specialists from the field of mechanical engineering. • To use methods and systems for measuring functional parameters of various mobile mechanical systems. • To use mathematical concepts and suitable methods and software packages to simulate various rigid and mobile mechanical systems. • To participate and apply the obtained knowledge in interdisciplinary research and design teams. • To analyze and interpret experimental data from the field of mechanical engineering.

	• To understand and to critically analyze technical solutions from the field of mechanical engineering.

9. Contents

9.1 Lecture	No. hours	Teaching methods	Notes
C1. Introduction to Mechanical Engineering. Mechatronics Engineering. Hardware structure of mechatronic systems. Basic mechanisms and mechanical transmissions.	2	Free exposure at blackboard combined with multimedia presentations	-
C2. Structural analysis of planar mechanisms – Part 1. Degrees-of-Freedom (DoFs). Planar motion. Kinematic elements. Kinematic pairs (joints). Kinematic diagrams.	2		
C3. Structural analysis of planar mechanisms – Part 2. Kinematic chains. Mechanisms. Mobility of mechanisms. Passive links/joints and passive mobilities. Representative planar mechanisms from industry.	2		
C4. Kinematic analysis of planar mechanisms – Part 1. Scalars and vectors. Position, velocity and acceleration analysis of the four-bar and slider-crank mechanisms using graphical methods.	2		
C5. Kinematic analysis of planar mechanisms – Part 2. Joint variables, Loop Closure Equations, Solution Techniques for Loop Closure Equations. Method of transfer functions. Examples.	2		
C6. Static force analysis of planar mechanisms. Define and identify a force. Calculate the moment of a force. Forces acting throughout a mechanism. Free-body diagrams (FBDs). Static equilibrium.	2		
C7. Dynamic force analysis of planar mechanisms. Mass and weight. Topology optimization. Center of mass (gravity). Mass moment of inertia. Parallel axis theorem. Dynamically Equivalent Systems. Principle of D'Alembert. Dynamic equilibrium.	2		
C8. Analysis and synthesis of gear mechanisms – Part 1. Gears, Gear ratio, Gearboxes, Ordinary (simple and compound) Gear Trains.	2		
C9. Analysis and synthesis of gear mechanisms – Part 2. Planetary Gear Trains (single-stage, multiple-stage). Kinematic properties. Combined Gear Trains. Differential Mechanism.	2		
C10. Spur gear design. Terminology and definitions. Fundamental law of gearing. Involute tooth profile. Geometrical parameters of involute gears. Manufacturing technologies of gears.	2		
C11. Analysis and synthesis of cam mechanisms – Part 1. Common cam mechanisms. Main geometrical parameters. SVAJ diagrams. Zero acceleration law. Constant acceleration Law. Simple Harmonic Law. Cycloidal Motion Law.	2		
C12. Analysis and synthesis of cam mechanisms – Part 2. Cam profile. CAD design of a cam mechanism with translating movement of the follower. Electronic cams.	2		
C13. Balancing of planar mechanisms. Static balancing of four-bar mechanism. Static balancing of slider-crank mechanism.	2		
C14. Introduction to robotics. Serial robots. Parallel robots. Mobility. Direct and inverse kinematic problems. Closed-from and numerical solution.	2		

Bibliography

[1] Robert L. Norton, Design of Machinery: An Introduction to The Synthesis and Analysis of Mechanisms and Machines, Fifth Edition, McGraw Hill, 2011.
[2] Robert L. Norton, Machine Design: An Integrated Approach, Fifth Edition, Prentice Hall, 2011.
[3] David H. Myszka, Machines & Mechanisms: Applied Kinematic Analysis, 4th Edition, Pearson, 2011.
[4] Eric Constants, Karl B. Dyer, Introduction to Mechanism design with computer applications, 1st edition, CRC Press, 2018.
[5] Antonio Simón Mata et al., Fundamentals of Machine Theory and Mechanisms, Springer, 2018.

[6] Ye Zhonghe, Lan Zhaohui, M.R. Smith, Mechanisms and Machine Theory, Higher Education Press, 2001.
[7] Cyrus Raoufi, Design of Mechanism with SolidWorks Motion Analysis and MATLAB/Simscape, KYRA Engineering Serices Inc., Canada, 2019.
[8] John J. Uicker, Jr. et al., Theory of Machines and Mechanisms, Fifth Edition, Oxford University Press, 2016.
[9] Calin Rusu, Mecanisme, U.T. Press, Cluj-Napoca, 2021.
[10] V. Handra-Luca, Organe de mașini și mecanisme, Editura didactică și pedagogică București, 1975.
[11] Voinea, R., ş.a., Introducere în mecanica solidului cu aplicații în inginerie, Ed.Academiei, București, 1985.
[12] Szekely, E., Dali, A., Mecanisme, Ed.UT Pres, Cluj-Napoca, 1993.

9.2 Applications (seminar/laboratory/project/practical work)	No. hours	Teaching methods	Notes
S1. The role of mechanisms and mechanical transmissions in the structure of mechatronic systems. Case studies and Examples.	2	Free exposure at blackboard combined with multimedia presentations	-
S2. Structural analysis of planar mechanisms. Kinematic elements, kinematic pairs (joints), kinematic diagrams, mobility. Examples, specific symbols used for representation in the kinematic diagrams. Hands-on sessions on representative equipment from laboratory.	2		
S3. Kinematic analysis of planar mechanisms. Graphical and analytical methods. Slider-crank mechanism.	2		
S4. Static analysis of planar mechanisms. Calculation of the reaction forces in the kinematic joints and sizing the actuators used to drive the mechanism.	2		
S5. Dynamic analysis of planar mechanisms. Calculate the center of mass (gravity) of an object. Calculate the mass moment of inertia of an object either by analytical or experimental methods. Transfer the mass moment of inertia to an alternative reference axis.	2		
S6. Gear mechanisms (gearings). Ordinary (simple and compound) gear trains (to be used the experimental setups). Structural and Kinematic Analysis.	2		
S7. Gear mechanisms (gearings). Planetary and combined gear trains (to be used the experimental setups). Structural and Kinematic Analysis.	2		

Bibliography

[1] Robert L. Norton, Design of Machinery: An Introduction to The Synthesis and Analysis of Mechanisms and Machines, Fifth Edition, McGraw Hill, 2011.
[2] Robert L. Norton, Machine Design: An Integrated Approach, Fifth Edition, Prentice Hall, 2011.
[3] David H. Myszka, Machines & Mechanisms: Applied Kinematic Analysis, 4th Edition, Pearson, 2011.
[4] Olimpiu Tatar, Elemente de inginerie mecanică : îndrumător de laborator. Partea 1, U.T.Press, Cluj-Napoca, 2013.
[5] Calin Rusu, Mecanisme, U.T. Press, Cluj-Napoca, 2021.
[6] Handra-Luca, V., Mecanisme, Ed.UT Pres, Cluj-Napoca, 1981.
[7] Handra-Luca, V., ş.a.– Introducere în teoria mecanismelor, Editura Dacia, Cluj-Napoca, vol. I-II, 1982, 1983.
[8] Maros, D., ş.a. – Mecanisme, Indrumător de lucrări, Lito. I.P.C-N, Cluj-Napoca, 1984.
[9] Szekely, E., Dali, A., Mecanisme, Ed.UT Pres, Cluj-Napoca, 1993.

10. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

The course curriculum exists in universities and faculties in the country and abroad. Its content is in conjunction with the expectations of community representatives, professional associations, and employers in the field of Automation and Applied Informatics.
By learning theoretical concepts and addressing practical aspects included in the discipline entitled Mechanical Engineering, students acquire a consistent stock of knowledge, in accordance with partial competencies required for possible occupations provided in Grid 1 – RNCIS.

11. Evaluation

Activity type	11.1 Assessment criteria	1.2 Assessment methods	11.3 Weight in the final grade
11.4 Course	Correctness of answers to theoretical questions Degree of assimilation of technical specialized language	Summative evaluation: Written exam in the form of a multiple-choice answers test, marked with a grade MC from 1 to 10	100%
11.5 seminar/laboratory/project/ practical work	Solving mini projects from the topic of the seminary applications	Continuous evaluation: Individual student report (optional assignments). These points can be used for improving the MC mark.	0%
11.6 Minimum performance standard Minimum standard of performance: Passing condition: MC ≥ 5			

Date of filling in:		Title Firstname NAME	Signature
10.07.2026	Course	Lect.dr.Eng. Ciprian RAD	
	Applications	Lect.dr.Eng. Ciprian RAD	

Date of approval by the Department Board	Head of Department Prof.dr.Eng. Honoriu VĂLEAN
Date of approval by the Faculty Council	Dean Prof.dr.Eng. Vlad MUREȘAN