SYLLABUS

1. Data about the program of study

1.1 Institution	The Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Automation and Computer Science
1.3 Department	Computer Science
1.4 Field of study	Computer Science and Information Technology
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Computer science / Engineer
1.7 Form of education	Full time

2. Data about the subject

2.1 Subject name	***Mechanics***				Subject code	**104**
2.2 Course responsible / lecturer	Lect. dr. eng. Rad Ciprian - ciprian.rad@mdm.utcluj.ro					
2.3 Teachers in charge of seminars / Laboratory / project	Lect. dr. eng. Rad Ciprian - ciprian.rad@mdm.utcluj.ro					
2.4 Year of study	II	2.5 Semester	4	2.6 Type of assessment (E - exam, C - colloquium, V – verification)		C
2.7 Subject category	Formative category: DF – fundamental, DS – specialty, DC – complementary					DF
	Optionality: DOB – mandatory, DOP – optional (alternative), DFA – optional (free choice)					DFA

3. Estimated total time

3.1 Number of hours per week	4	of which:	Course	2	Seminars	2	Laboratory	-	Project	-
3.2 Number of hours per semester	56	of which:	Course	28	Seminars	28	Laboratory	-	Project	-

3.3 Individual study:	
(a) Manual, lecture material and notes, bibliography	15
(b) Supplementary study in the library, online and in the field	5
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays	16
(d) Tutoring	5
(e) Exams and tests	3
(f) Other activities:	-

3.4 Total hours of individual study (sum (3.3(a)...3.3(f)))	44
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	Whiteboard, projector, computer
5.2. For the applications	Reading and understanding of the lecture notes

6. Specific competence

6.1 Professional competences	C1 – Operating with basic Mathematical, Engineering and Computer Science concepts C1.1 – Recognizing and describing concepts that are specific to the fields of calculability, complexity, programming paradigms, and modeling computational and communication systems

	C1.2 – Using specific theories and tools (algorithms, schemes, models, protocols, etc.) for explaining the structure and the functioning of hardware, software and communication systems C1.4 – Formal evaluation of the functional and non-functional characteristics of computing systems C1.5 – Providing a theoretical background for the characteristics of the designed systems
6.2 Cross competences	N/A

7. Learning outcomes

Knowledge	By the end of the course, students will be able to: • Understand and explain the foundational principles of mechatronic system design, including the V-model methodology, structural analysis, and the classification of mechanical mechanisms. • Describe the mathematical formulations governing mechanism kinematics and dynamics, such as loop closure equations, transfer functions, and Robot Jacobians for both serial and parallel manipulators. • Identify and differentiate various mechanical power transmission systems (gear trains, CVTs, couplings, and belts) as well as advanced robotic architectures, exoskeleton hardware, and flexible fabrication systems. • Recognize structural and performance limits in robotic design, including workspace boundaries, velocity ellipsoids, and singularity conditions.
Skills	By the end of the course, students will be able to: • Model, simulate, and design complex mechanical structures and robotic mechanisms using industry-standard CAD software and simulation tools. • Formulate and solve direct and inverse kinematics, as well as dynamic equations, for both serial and parallel robotic configurations. • Analyze, interpret, and evaluate experimental data and technical schemas to optimize the functional parameters of mechanical power transmissions. • Propose and compare alternative technical solutions for mechatronic applications, selecting appropriate materials, actuators, and integration methods based on design constraints.
Responsibility and Autonomy	By the end of the course, students will be able to: • Independently manage and execute design projects involving integrated mechanical, electrical, and software systems, moving systematically from concept to simulation. • Take responsibility for solving complex engineering problems, demonstrating technical self-reliance when diagnosing system singularities, workspace limitations, or transmission inefficiencies. • Collaborate effectively in laboratory and project teams, responsibly coordinating tasks related to the hardware design, programming, and testing of robotic or flexible manufacturing setups. • Demonstrate a proactive commitment to continuous professional development by independently researching and adapting to new CAD tools, emerging exoskeleton technologies, and evolving automation standards.

8. Discipline objective (as results from the *key competences gained*)

8.1 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.
8.2 Specific objectives	• Apply analytical methods to determine the functional parameters of diverse mechanical systems. • Utilize mathematical formulas and simulation software to model mechanical systems and robotic mechanisms. • Analyze and evaluate experimental data commonly used in mechanical engineering. • Understand, analyze, and compare technical solutions specific to the mechanical engineering field.

9. Contents

9.1 Lectures	Hours	Teaching methods	Notes
1. Introduction to mechanical engineering and mechatronic systems design. V-model design methodology for mechatronic system.	2	Lectures, visual presentations, demonstrations.	
2. Structural analysis of linkages. Degree of Freedom, Classification of Mechanisms.	2		
3. Position Analysis of Mechanisms. Joint variables, Loop Closure Equations, Solution Techniques for Loop Closure Equations.	2		
4. Kinematic analysis of linkages. Transfer function method.	2		
5. Dynamic analysis of linkages.	2		
6. Mechanical Power Transmission. Bar Linkages.	2		
7. Variators. Continuously variable transmission (CVT). Belt drives. Chain drive.	2		
8. Couplings, gearboxes, gears, reducers and timing belts. Simple Gear Trains, Planetary Gear Trains.	2		
9. The role of dynamics and kinematics of robotic devices in design of mechatronics systems. Kinematics and dynamics of robotic type devices, articulation, speed, accuracy, bandwidth, inertia, vibration, static and dynamic loading, materials, and integration of design requirements.	2		
10. Serial robots. Introduction. Direct and inverse kinematics problems, Examples of kinematics of common serial robots, workspace of a serial robot.	2		
11. Parallel robots. Degrees of Freedom of parallel mechanisms and manipulators, Active and passive joints, Constraint and loop-closure equations, Direct kinematics problem, Mobility of parallel manipulators, Closed-from and numerical solution, Inverse kinematics of parallel manipulators and mechanisms, Direct kinematics several parallel robots.	2		
12. Robot Jacobians for serial and parallel manipulators, Velocity ellipse and ellipsoids, Singularity analysis for serial and parallel robots.	2		
13. Exoskeleton systems. Hardware Design of the Exoskeleton systems. Mechanical Design. Actuators.	2		
14. Flexible systems of fabrication.	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.

9.2 Applications – Seminars/Laboratory/Project	Hours	Teaching methods	Notes
1. Identification of basic elements from the structure of mechanical systems (linkages). Kinematic schema and construction design.	2	Lectures, visual presentations, demonstrations.	
2. Elements of CAD design, modelling and simulation of mechanical structures. Design of mechanical systems. Specific materials from the mechanical systems.	2		

3. Position analysis of linkages. Problems.	2		
4. Kinematic analysis of linkages. Problems.	2		
5. Dynamic analysis of linkages. Problems.	2		
6. Study of Mechanical Power Transmission.	2		
7. Variators. Continuously variable transmission, gear trains problems.	2		
8. Kinematics and dynamics of robotic systems.	2		
9. Examples of kinematics of common serial robots, workspace of a serial robot.	2		
10. Inverse kinematics of parallel manipulators and mechanisms, workspace of several parallel robots.	2		
11. Inverse kinematics of parallel robots.	2		
12. Singularity analysis for serial and parallel robots.	2		
13. Study of the hardware Design of the Exoskeleton systems. Mechanical Design.	2		
14. Study of flexible systems of fabrication.	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.
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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.

**The following will be specified, as appropriate: seminar topics, laboratory work, project topics and design phases.*

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

Application of the mechanical engineering concepts are specific to most of the engineering disciplines. The course level is introductory, and the intent is to motivate and prepare students for further study in mechanical engineering areas and to conduct projects in real-life applications. The course content combines theoretical knowledge with applications and focuses on the formulation and solution of specific problems that may occur in various engineering fields.

11. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
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	70%
Seminar	* Answer simple questions from the topic of the seminary applications * Submitting and defending a mini project on a given subject	Continuous and summative evaluation: * Seminary test marked with a grade MS from 1 to 10 * Individual student report (optional)	30%
Laboratory	-	-	-
Project	-	-	-

Minimum standard of performance: M(mark)=0.70%MC(course)+0.30%MS(seminary); Passing condition: MC ≥ 5, MS ≥ 5, M ≥ 5;

Date of filling in:	**Responsible**	**Title First name Last name**	**Signature**
19.05.2026	Course	Lect. dr. eng. Ciprian RAD	
	Applications	Lect. dr. eng. Ciprian RAD	

Date of approval in the department	Head of department, Prof.dr.eng. Rodica Potolea
Date of approval in the Faculty Council	Dean, Prof.dr.eng. Vlad Mureșan