Transilvania University of Braşov, Romania

Study program: Virtual Engineering in Automotive Design (in English)

Faculty: Mechanical Engineering
Study period: 2 years (master)
Academic year structure: 2 semesters (14 weeks per semester)
Examination sessions (two): winter session (January/February)
summer session (June/July)

1st Year

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Multi-physics Simulations	VAD.I.01	7	1	-	-	1

Course description (Syllabus): Dynamic systems in Matlab; Programming in Matlab; Problems of kinematic systems solved in Matlab; Problems of dynamic systems solved in Matlab; Graphic representations in Matlab; Animations in Matlab; Fractals in Matlab.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
CAD and Graphics programming	VAD.I.02	6	2	-	1	1

Course description (Syllabus): Current automotive design requirements; Product development using CAD / CAE and 3D graphics; Geometric modeling – Curve entities: analytic and synthetic, surface entities, Bezier and B-spline surfaces, advance surface modeling; Methods for creating solid models: Boundary Representation (B-rep), Constructive Solid Geometry (CSG), primitive solids, boolean operations, parametric modeling, feature-based modeling; CAD assembly: Top-Down and Bottom-Up design, degrees of freedom, mating components; Architecture of CAD software. CAD development kernels; Intelligent CAD systems (KBD), knowledge representation; CAD applications developed using Visual Basic: VBA syntax elements, common programming techniques. 3D graphics programming using OpenGL and VRML: modeling of primitives, generic surface modeling, 3D transformations, 3D viewing, advanced lighting techniques; Creating interactive virtual environments using OpenGL and VRML languages; Applications of CAD systems and advanced 3D graphics programming in automotive design.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Multi-body Systems Dynamics: Theory and Simulation	VAD.I.03	7	2		1	1

Course description (Syllabus): Kinematic analysis of multibody systems: formulation of the kinematic model, constraint equations imposed by joints, the multi-body algorithm for kinematics. Dynamic analysis of multibody systems: formulating dynamic model, Newton-Euler equations with Lagrange multipliers. Numerical solution methods for differential-algebraic equations. Determination of the joint forces. Invers dynamics. Equilibrium analysis. Optimization of complex multibody systems

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Tribology	VAD.I.04	6	2		2	

Course description (Syllabus): The discipline of Tribology provide the students with the fundamental concepts of tribology as a science of foresight friction, lubrication and wear in the context of practical applications. The purpose of the laboratory is to introduce the student with modern equipment used in relation with analyses of friction, lubrication and wear. Surfaces topography of solids, model of contact, friction and wear, stick-slip. Wear (abrasive, erosive and cavitation wear, fatigue wear (sliding, rolling). Boundary and extreme pressure lubrication (model of adsorbtion on sliding surfaces, lubrication mechanism); Lubricants (dynamic and kinematic viscosity, viscosity-temperature relationship, viscosity-pressure relationship, measurements, classification, types of lubricants and their description - mineral and synthetic oils, greases; additives). Hydrodynamic lubrication (conditions for HDL, simplifying assumptions, Reynolds equation, simplifications, bearing parameters from Reynolds eq., application for journal bearings - pressure distribution, load capacity, friction, power loss; Stribeck curve, squeeze films and Reynolds eq.). Improving the tribological properties of metallic parts by diffusion surface treatments - surface modification (high temperature diffusion treatments; low temperature diffusion treatments). Integrating tribological coating systems into the surfaces design process – surfaces modification by adding new material onto the surface (tribological coatings and their properties, deposition technologies and technological parameters). Micro-nanotribology (surfaces topography by AFM and STM, micro-scale and atomic scale friction, directionality effect on microfriction, micro/nano indentation and wear, scratching). Analysis of internal stress (mechanical equilibrium, Stoney formula, Techniques for measuring internal stress in coatings and thin films).

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Advanced Simulation in Automotive Design	VAD.II.01	7	2			2

Course description (Syllabus): State-space modeling and the bond graphs; Bond graph elements. Causality in the bond graphs; Bond graph synthesis and equation derivation; Laplace transforms and the transfer function; Time domain and frequency domain analysis.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Product Development and Simulation	VAD.II.02	4	1			1

Course description (Syllabus): Theoretical and applicative training in design and simulation in product development in automotive field: Trends in Automotive Industry. Life cycle assessment; Product development in automotive industry. Introduction (background, methods, history); Life cycle for automotive products; Models for product developing process. Simulation in product development; Projects management in product development; How Simulation adds Value to the Product Development Process.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Finite Element Analysis in Automotive Design (FEA)	VAD.II.03	6	2			1

Course description (Syllabus): The discipline of the Finite Element Analysis in Automotive Design aims at advanced geometric modeling, finite element modeling and the analysis of the behavior of machine components and mechanical systems under various operating conditions. The principle of the finite element method, the steps to solve a problem using the finite element method, general considerations on the choice of elemental elements, meshing domain analysis for continuous structures, obtaining finite element numerical model. Calculation methods of engineering structures. Using finite element method in engineering. Physical and Engineering Opportunities limits. Basis of the theory of elasticity: tension, displacement fields and strain states; Laws of behavior / criteria limits of elasticity: Tresca criterion, Von Mises criterion. Mechanical Fundamentals of finite element method. Equilibrium equations. Laws of behavior. Approximation by finite elements. The finite element method in elasticity, led by displacement calculation, deformation tensor, vector efforts, the element stiffness matrix. Types of finite elements and criteria of their choice. Practical problems using the finite element method. Interpretation of finite element analysis results.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Virtual and Augmented Reality in Automotive Design and Maintenance	VAD.II.04	6	1	-	1	1

Course description (Syllabus): Introduction to human-computer interaction: terminology, definitions and characteristics of virtual reality (VR) and augmented reality (AR), available technologies for virtual and augmented reality; Software systems and standards for virtual and augmented reality: Unity, InstantReality, ARCore; Virtual and augmented reality hardware: technology and stereoscopic 3D visualization systems, haptic and audio systems, tracking systems, voice commands, gloves for gesture commands, brain-computer interfaces; 3D interaction techniques for virtual and augmented reality; Designing VR/AR user interfaces and applications for automotive design and maintenance.

Course title	Code	No. of credits	Number of hours per week			
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Advanced mechanical transmissions in automotive engineering	VAD.II.06a	3	1	-	-	1

Course description (Syllabus): Vehicle transmissions (working principles, terminology, classification, development trends); Kinematics and dynamics of planetary mechanisms; Automatic planetary transmissions (ATs); Mechanical-friction continuously variable transmissions (CVTs); Hydromechanical transmissions; Torque vectoring systems; all-wheel drive transmissions; Hybrid propulsion systems.

2nd Year

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Experimental Systems for Testing the Automotive Elements	VAD.III.01	4	1		1	

Course description (Syllabus): The discipline of the Experimental Systems for Testing the Automotive Elements aims at testing planning, testing design, testing and discussions of results regarding the behavior of automotive elements, under various functioning conditions. Testing planning. Parameters. Control. Values. Accuracy. Equipments. Data storage. Data analysis. Errors. Statistics. Graphs. Measuring the loads. Forces and Moments. Stresses and Strains. Measuring the displacements. Displacements. Velocities. Accelerations. Test design. Testing the mechanical transmissions (gears, chain drives, belt transmissions). Testing the bearings. Tribological tests. Data acquisition. Report. Presentation.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Virtual Instrumentation	VAD.III.02	6	1		1	

Course description (Syllabus): Virtual Instrumentation course explains the concepts of virtual instrumentation from the perspective of their use in modelling, simulation and optimization of specialty engineering processes and systems; The following topics are discussed: Introduction of the Virtual Instrumentation and Graphical System Design concepts. Graphical Programming Language – LabVIEW. Modular Programming. Programming Structures. Advanced Programming Architectures. Control and Simulation add-on. Data acquisition in LabVIEW. Measurements and data logging in auto-vehicles. Drivers and communication interfaces with mechatronic systems in auto-vehicles. Virtual Instrumentation applications. Combining the LabVIEW software with CAD software.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Vehicle Dynamic Simulation of Systems in MATLAB and C ++	VAD.III.03b	7	2	-	-	2

Course description (Syllabus): Introduction to C++ and Matlab: Terminology, definitions and characteristics for C++ and Matlab IDE, available technologies for dynamic simulation of vehicle systems; Fundamentals of C++ Language: Getting Started with Microsoft Visual Studio IDE, variables, data types, expressions, operators, pointers, arrays, functions and structures in C++; Concepts and Principles for Object Oriented Programming: Classes, objects, class hierarchies, Polymorphism; Introduction to Simulink; Simulink: Creating and Simulating a Model. Modeling Programming Constructs. Modeling Discrete Systems. Modeling Continuous Systems; Simulink: Solver Selection. Developing Model Hierarchy; Modeling Conditionally Executed Algorithms. Combining Models into Diagrams; Case studies for dynamic simulation.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Virtual Crash Modeling and Testing	VAD.III.03a	6	2		2	

Course description (Syllabus): The discipline of Virtual Crash Modeling and Testing aims at using software to reconstruct vehicle accidents in order to analyses the conditions that caused the accident and also to understand the accident dynamics. Accident reconstruction is achieved in PC-Crash software where the user can use the vehicle database to reconstruct the accident using the appropriate vehicles and their parameters. Accidents involving pedestrians and occupants can be accurately simulated using the included multibody human models. Reconstruction of real accidents in the virtual environment using photographs, schematics and know conditions from the accident site. Vehicle dynamics can be simulated such as suspensions behavior, braking, turning and environmental terrain simulation. Determining the impact velocity of a vehicle based on the deformation of that vehicle included in a database composed of deformations obtained from controlled crash testing. Custom vehicles can be simulated such as tractors, combine harvesters and large trucks with semitrailers. Output results from the simulation such as vehicle velocity variation, deceleration, rotation angles and impact forces.

Course title	Code	No. of credits	Number of hours per week			
			course	seminar	laboratory	project
Sensory and Control Systems for Vehicles	VAD.III.05b	4	1		1	0

Course description (Syllabus): The goal of the course is to introduce students to the various technologies and systems used to implement advanced driver assistance systems. The basics of automotive electronics, fundamentals of electronic control systems, and the evolution of these systems is also introduced. The course learning outcomes are that the students: Understand the rational for and evolution of automotive electronics; Understand which automotive systems have been replaced by electronic control systems and the advantage of doing so; Understand the fundamental theory of operation of electronic control systems; Understand the basics of sensors and transducers; Become familiar with the various types of advanced driver assistance systems; Understand the concept of remote sensing and the types of sensor technology needed to implement remote sensing; Understand the fundamentals of on-board vehicle networks.