ANNEX 2 – COURSE DESCRIPTION

Course Title	Vehicle Dynamics and Control				
Course Code	AU303				
Course Type	Compulsory				
Level	BSc (Level 1)				
Year / Semester	3rd (Spring)				
Teacher's Name	Evagoras Xydas				
ECTS	6	Lectures / week	3	Laboratories/week	1
Course Purpose	The aim of the course is to introduce students to the basic concepts and principles of dynamics and control with focus on topics from vehicle engineering such as suspension testing, active suspension, simple cruise-control model and other topics. Building on Newtons Laws and Laplace Transforms as well as modern dynamics and control systems theory, the course equips the students with the background necessary for modeling common automotive problems and designing simple yet effective controllers, as well as tuning such controllers. The theoretical analysis is validated using practical laboratory experiments.				
Learning Outcomes	By the end of the course, students must be able to: 1. Create mathematical models of mechanical and electrical systems from the context of vehicle engineering by using Newton's Laws, Newton-Euler Equations, Kirchhoff's circuit laws and the impedance method. 2. Develop competence in using the Laplace Transform to derive transfer functions. 3. Analyse first and second order systems for different inputs using Laplace's transforms. 4. Identify dynamic parameters from transient system response and derive the dynamic equations. 5. Specify system parameters (i.e., spring stiffness, circuit resistance) to achieve a desired transient response. 6. Analyse and compare open and closed loop control systems. 7. Investigate a system's stability range using Routh-Hurwitz and Root-Locus methods. 8. Design P, PI and PID controllers for stability and to specifications using Routh-Hurwitz, Ziegler-Nichols, Root-Locus and other tools. 9. Derive the equations of motion, specify system parameters and design control systems for vehicle systems in common dynamic scenarios. 10. Design/tune controllers using software tools.				

Prerequisites	AU211	Corequisites	None
Course Content	**Mathematical modelling of mechanical and electrical systems:** common types of suspension systems, coil or torsion spring characteristic, shock absorber types, differential equations of motion for ¼, ½ vehicle model. Inductor, capacitor, resistor, common circuits in automotive systems, excitation sources, frequency and time domain response. Laplace's transforms, transfer functions. **First and second order systems:** Gain and time-constant, damping ratio, natural and damped frequencies, settling time, rise time, peak time, percentage overshoot etc. From the system to the differential equation, to the transfer function and graph, and vice-versa. **Control System design and Performance:** Final Value theorem, Steady State Error, Step Response, Impulse Response of First and Second Order Systems, P, PI and PID controllers. **Stability:** Types of Stability, Poles, Zeros, Complex Numbers, Routh-Hurwitz Criterion. **Controller Design:** Proportional, Derivative, Integral Control Action, Loop Shaping, Phase Lead, Phase Lag Compensators, Root Locus Method. Ziegler-Nichol's method for monotonic systems and systems with overshoot. **Active suspension systems:** modelling and analysis of active and semi-active suspension systems. Design of a controller for an active suspension system using analytical tools and MATLAB/Simulink. **Topics in vehicle control:** simplified dynamic analysis and control design for cruise control, collision detection and other road-vehicle scenarios. **Laboratory work:** Individual and small group experiments are performed with the use of the Rectilinear Control System experimental setup available in the Control Systems Laboratory. Experiments include identification of plant parameters such as, mass, spring and damping parameters in a classical two spring-mass configurations and measuring the response of the application of excitation signals, in an attempt to validate the material taught in lectures.		
Teaching Methodology	Students are taught the course through lectures (3 hours per week) in classrooms or lectures theatres, by means of traditional tools or using computer demonstration as well as laboratory exercises (1 hour per week). Auditory exercises, where examples regarding matter represented at the lectures, are solved and further, questions related to particular open-ended topic issues are compiled by the students and answered, during the lecture or assigned as homework. Topic notes are compiled by students, during the lecture which serve to cover the main issues under consideration and can also be downloaded from the e-learning platform or the lecturer's webpage. Students are also advised to use the subject's textbook or reference books for further reading and practice in solving related exercises. Tutorial problems are also submitted as homework and these are solved during lectures or privately during lecturer's office hours.		

	Furthermore, design projects may be assigned to the students, where literature search is encouraged to identify a specific problem related to some issue, gather relevant scientific information about how others have addressed the problem, implement to implement the design and report the results in written or orally. Where appropriate, taught material as well as examples and design problems are drawn from the recent research activities of the lecturer or other faculty members. Laboratory experiments are caried out in small groups and lab reports are required two weeks after the laboratory class resulting in a cumulative mark.
Bibliography	**(a) Textbooks:** • R.C. Dorf and R.H. Bishop, ***Modern Control Systems***, Pearson Prentice Hall 13th Edition, 2022. • J. Y. Wong, **Theory of Ground Vehicles**, Wiley-Interscience, 4th edition, 2008 • R. Rajamani, **Vehicle Dynamics & Control,** Springer, 2nd Edition, 2012. **(b) References:** • T. D. Gillespie, **Fundamentals of Vehicle Dynamics**, SAE International, 1992 • W. F. Milliken, et al, **Chassis Design: Principles and Analysis**, Society of Automotive Engineers, 2002. • M. Blundell, **The Multibody Systems Approach to Vehicle Dynamics**, Butterworth-Heinemann, 2004 • H. Pacejka, **Tire and Vehicle Dynamics**, SAE International, 3rd Edition, 2012
Assessment	The students are assessed via continuous assessment throughout the duration of the Semester, which forms the Coursework grade and the final written exam. The coursework and the final exam grades are weighted 40% and 60%, respectively, and compose the final grade of the course. Various approaches are used for the continuous assessment of the students, such as mid-term written exam, oral exam, quizzes, design assignments, design projects and laboratory experiments. The assessment weight, date and time of each type of continuous assessment is being set at the beginning of the semester via the course outline. An indicative weighted continuous assessment of the course is shown below: • Assignments 8% • Mid-Term written exams 14% • Final Exam 60% • Laboratory Work 18% (3x6%) Students are prepared for final exam, by revision on the matter taught, problem solving and concept testing and are also trained to be able to deal with time constrains and revision timetable. The criteria considered for the assessment of each type of the continuous assessment and the final exam of the course are: (i) the comprehension of the fundamental concepts and theory of each topic, (ii) the application of the theory in solving related problems and (iii) the ability to apply the above knowledge in more complex design problems. The above criteria are weighted 30%, 40% and 30%, respectively.

	The final assessment of the students is formative and summative and is assured to comply with the subject's expected learning outcomes and the quality of the course
Language	**English**