AEEE345 - Control Engineering with Lab

Course Title	Control Engineering with Lab				
Course Code	AEEE345				
Course Type	Compulsory				
Level	BSc (Level 1)				
Year / Semester	3^{rd} / 1^{st}				
Teacher's Name	Assoc. Prof. Marios Lestas				
ECTS	6	Lectures / week	3	Laboratories/week	1
Course Purpose	The aim of the course is to familiarize the students with the concepts and the principles of control systems in order to identify and implement their basic arrangements in open but mostly in closed loop configurations and to design controllers which achieve their objectives with respect to steady state and transient behavior using tools such as final value theorem, Routh Hurwitz criterion, Nyquist stability criterion, root locus and frequency response methods.				
Learning Outcomes	By the end of the course, students must be able to: 1. Manipulate Laplace Transform theory to define the block diagram representation of the open and closed-loop transfer function concept in engineering control systems. Appreciate the advantages of closed loop systems relative to open loop systems. 2. Derive the mathematical model of basic electrical, mechanical and hydraulic control systems. Introduce MATLAB and SIMULINK software tools. 3. Analyse the basic parameters of the closed-loop transfer function and the static characteristics of a control system. Determine experimentally and simulate the basic parameters of a DC Servo Motor Control System. 4. Examine the action of aperiodic signals in the transient-response analysis of first-, second- and higher-order control systems. Implement transient response analysis of first-order and second order control systems using MATLAB and SIMULINK. 5. Analyse the performance of closed loop control systems with respect to steady state and transient performance metrics as for example steady state error, position and velocity constants, settling time, rise time and percentage overshoot. 6. Examine the action of the Proportional, Integral and Derivative Controllers on the steady state and transient characteristics of control systems. Model and simulate the effects of basic controllers on a DC Servo Motor Control using MATLAB and SIMULINK. 7. Interpret the meaning of stability of control systems in terms of the transfer function with reference to poles and zeros, focusing on input output stability. Judge the stability of a closed-loop control system				

	from the Routh-Hurwitz Criteria. 8. Draw Bode and Nyquist Plots. Judge the stability of a control system using the Nyquist stability criterion and the Phase and Gain margin criteria in frequency domain plots. 9. Interpret Root-locus design concepts and draw Root-Locus plots. Examine the effect of open-loop zeros and poles in Root-Locus Plots. 10. Design phase lead and phase lag compensators using frequency response as well as root locus methods.		
Prerequisites	AMAT223, AMAT204, PHY112	Corequisites	None
Course Content	**Control Systems Fundamentals:** Control Objective, Main Components a Control System, Open loop Systems, Closed Loop Systems, Control Design Procedure. **Modelling Dynamical Systems**: Derivation of Differential Equations for Electrical and Mechanical systems, Laplace Transforms, Transfer Functions, Block Representation of Closed Loop Systems, Closed Loop Transfer functions, Masons Rule. **Control System Performance:** Final Value theorem, Steady State Error, Position-Velocity Constants, Step Response, Impulse Response, Percentage Overshoot, Settling Time, Time Constant. **Stability:** Input-Output Stability, Poles, Zeros, Complex Numbers, Routh-Hurwitz Criterion. **Frequency Response Methods:** Bode Plots, Nyquist Plots, Nyquist Stability Criterion, Phase Margins, Gain Margins, Bandwidth. **Controller Design:** Proportional, Derivative, Integral Control Action, Loop Shaping, Phase Lead, Phase Lag Compensators, Root Locus Method. **Laboratory work:** Individual and small group experiments are performed with the use of the DC Servo Motor and Rectilinear Control experimental setups, measuring instruments and simulation packages. Experiments include system identification of a DC servo system whose obtained model is implemented on Matlab/Simulink to exemplify the controller design and analysis concepts taught in theory. Feedback Control System design is also demonstrated via the Rectilinear Electromechanical Control System involving springs and dampers appropriately interconnected and monitored and controlled using a DC servo motor as the actuating device. Measurement units such as tachometers and potentiometers are used as well as Digital Signal Processors.		
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. 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 carried out in small groups and lab reports are required two weeks after the laboratory class resulting in a cumulative mark.
Bibliography	**<u>Textbooks:</u>** • R.C. Dorf and R.H. Bishop, ***Modern Control Systems***, Pearson Prentice Hall 12th Edition, 2011. **<u>References:</u>** • G.F. Franklin, J.P. Powell and Enami-Naeini, ***Feedback Control of Dynamic Systems***, Pearson Prentice Hall 7th Edition, 2015. • N.S. Nise, ***Control Systems Engineering***, John Willey & Sons 7th Edition, 2015.
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 10% • Homework 10% • Mid-Term written exams 30% • Design Project 20% • Laboratory Work 20% • Quizzes 10% 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**