AEEE432 - Dynamic Control System Laboratory

Course Title	Dynamic Control System Laboratory				
Course Code	AEEE432				
Course Type	Technical Elective				
Level	BSc (Level 1)				
Year / Semester	4^{th}				
Teacher's Name	Assoc. Prof. Marios Lestas				
ECTS	6	Lectures / week	3	Laboratories/week	0
Course Purpose	The aim of the course is to familiarize students with the practical application of control algorithms on experimental control setups available in the Control Systems Laboratory. The objective is for the students to undergo the entire controller design, from system identification, controller design, controller application and performance evaluation utilizing tools such as PID control, state feedback, LQR control, steady state and transient responses.				
Learning Outcomes	By the end of the course, students must be able to: 1. Tortional Control System Identification (Model 205a): Identify plant parameters. Use fundamental properties of lightly damped 2nd order systems to indirectly measure inertia, spring and damping constants in classical mass spring configurations. 2. Rectilinear Control System Identification (Model 210a): Identify plant parameters such as, mass, spring and damping parameters in a classical two spring-mass configurations. 3. Industrial Emulator / Servo Trainer System Identification (Model 220): Estimate the inertia, gain and damping of the various system components by measuring their effect on the system response. 4. Magnetic Levitation System Identification (Model 730): Identify Plant parameters such as input/ output characteristics of the laser sensor, magnet/coil actuators. 5. Demonstrate key concepts associated with proportional plus derivative (PD) control and the effects of adding integral action (PID). 6. Apply the techniques of Successive Loop Closure / Pole Placement to design controllers for a 2 Degrees of Freedom Plant. 7. Implement a Linear Quadratic Regulator (LQR) using full state feedback.				
Prerequisites	AEEE345, AMAT223	Corequisites	None		
Course Content	**Rectilinear Control System Identification (Model 210a)** – Identifies plant parameters such as, mass, spring and damping parameters in a classical two spring-mass configurations.				

	Industrial Emulator / Servo Trainer System Identification (Model 220) – The inertia, gain and damping of the various system components are found by measuring their effect on the system response. This is implemented by a Proportional-plus rate feedback loop about the drive feedback encoder. **Magnetic Levitation System Identification (Model 730)** – Plant parameters such as input/ output characteristics of the laser sensor, magnet/coil actuators and magnet/magnet interactions as they vary with relative position are measured. Strong magnetic field non-linearities via SISO System with non linear elements are also investigated. **Rigid Body PD and PID Control (Models: 205a, 210a, 220 or 730)** – Demonstrates key concepts associated with proportional plus derivative (PD) control and the effects of adding integral action (PID). **Collocated PD Control with 2 DOF Plant (Model: 205a, 210a, 220 or 730)** – PD control of a 2 Degree Of Freedom (DOF) system, where the controlled output is rigidly coupled to the actuator input (referred as collocated scheme). The increase of the order of the system (from 1 DOF to 2) can be effectively considered as dynamic disturbance to the plant. **Successive Loop Closure / Pole Placement Design for 2 DOF Plant (Model: 205a, 210a, 220 or 730)** – A position loop is initially closed about the collocated position with a relatively high bandwidth (close tracking) PD Control. Then a low pass filter is implemented to attenuate high PD gains. Pole placement Control methodology is finally applied via outer loop. **LQR Control (Model: 205a, 210a, 220 or 730)** – A linear Quadratic regulator is implemented using full state feedback. **Practical Control Implementation (Model: 205a, 210a, 220 or 730**) – Non-ideal behaviours that affect many control applications, such as drive saturation, sensor quantisation, and discrete time sampling, drive flexibility and various forms of disturbances that affect many control applications are demonstrated and guidelines to mitigate their effects are given.
Teaching Methodology	Students are taught through laboratory experiments (3 hours per week) in the Control Systems Laboratory, where the learning outcomes, the theory, the methodology and practical hints are explained before each experiment by the lecturer or the teaching assistant, by means of traditional tools or using computer demonstration. Laboratory experiments are carried out in small groups and lab reports are required two weeks after the laboratory class resulting in a cumulative mark. To support the lab experiments with the theoretical foundations of the applied tools, auditory exercises are conducted, where relevant examples are solved and further, questions related to particular open-ended topic issues are compiled by the students and answered, during the lab experiment or assigned as homework. Topic notes are compiled by students, during the lab experiments sessions which serve to theoretically support the practical experiments 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.
Bibliography	**<u>Textbooks:</u>** Dynamic Control Systems (ECP) Laboratory Manual **<u>References:</u>** • G.F. Franklin, J.P. Powell and Enami-Naeini, ***Feedback Control of Dynamic Systems***, Pearson Prentice Hall 7th Edition, 2015. • R.C. Dorf and R.H. Bishop, **Modern Control Systems**, Pearson Prentice Hall 12th Edition, 2011.
Assessment	The Students are assessed via continuous assessment throughout the duration of the Semester, which forms the coursework grade counting 100% towards their final grade. Beyond the lab reports which account for a significant percentage of the final grade, various approaches are used for the continuous assessment of the students, such as mid-term written exam, oral exam, quizzes and homework and design assignment. 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: • Lab Reports 60% • Oral Exam 10% • Quizes 10% • Homework 10% • Mid-Term written exams 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**