

COURSE OUTLINE

(1) GENERAL

SCHOOL	Engineering		
ACADEMIC UNIT	Mechanical Engineering		
LEVEL OF STUDIES	Undergraduate		
COURSE CODE	EP0901	SEMESTER	9 th
COURSE TITLE	Modern Control Theory		
INDEPENDENT TEACHING ACTIVITIES <i>if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits</i>	WEEKLY TEACHING HOURS	CREDITS	
Lectures and coursework	5	6	
<i>Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).</i>			
COURSE TYPE <i>general background, special background, specialized general knowledge, skills development</i>	Special Background		
PREREQUISITE COURSES:	-		
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	English		
IS THE COURSE OFFERED TO ERASMUS STUDENTS	Yes (tutoring)		
COURSE WEBSITE (URL)	https://www.mie.uth.gr/?page_id=18491&lang=en		

(2) LEARNING OUTCOMES

<p>Learning outcomes <i>The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.</i></p> <p><i>Consult Appendix A</i></p> <ul style="list-style-type: none"> • <i>Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area</i> • <i>Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B</i> • <i>Guidelines for writing Learning Outcomes</i>
<p>This course will introduce students to the analysis and design of linear multivariable (Multiple-Input Multiple-Output (MIMO)) control systems in continuous-time. The course focuses on the analysis and design of control systems in the state-space and their applications to electrical, hydraulic, and mechanical systems. Controllability and observability. Lyapunov Stability. Description of disturbances and their effects. Emphasis is given on the controller synthesis using state-feedback control, the linear quadratic (LQ) theory and the separation theorem (separation of control and estimation problems). Design of observers (Luenberger) and optimal state estimators (Kalman filters). Linear-quadratic-gaussian (LQG) control. The course will also prepare the students for further study in control theory (robust control, adaptive control, system identification and model predictive control).</p> <p>By the end of this course students will be able to:</p> <ul style="list-style-type: none"> • Work in state-space with transfer matrix and state models for linear multivariable systems. • Check the controllability, observability, detectability, stabilizability and minimality of linear multivariable systems. • Analyse linear multivariable systems with respect to stability, controllability, observability, detectability, stabilizability and minimality. • Perform stability analysis of nonlinear systems using Lyapunov functions. • Design state-feedback controllers in state-space via pole-placement and the linear-quadratic control theory. • Design observers (Luenberger type) and optimal state estimators (Kalman filters). • Design controllers via the Linear-quadratic-gaussian (LQG) control theory for stochastic linear multivariable control systems.

- Tackle robustness issues and design H^∞ controllers for robust stabilization.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?

Search for, analysis and synthesis of data and information, with the use of the necessary technology	Project planning and management
multiculturalism Adapting to new situations	Respect for difference and Respect for the natural environment
Decision-making	Showing social, professional and ethical responsibility and sensitivity to gender issues
Working independently	Criticism and self-criticism
Team work	Production of free, creative and inductive
Working in an international environment
thinking Working in an interdisciplinary environment	Others
Production of new research ideas	

- Search for, analysis and synthesis of data and information with the use of the necessary technology
- Decision making
- Working independently
- Team work
- Application of theory to practice
- Production of new research ideas
- Project planning and management

(3) SYLLABUS

1. Introduction to linear multivariable control systems (SISO/MIMO limitations)
2. Mathematical modelling in state-space domain for multivariable systems
 - a. Time response multivariable systems
 - b. Controllability, observability, detectability, stabilizability and minimal realizations
 - c. Poles, eigenvalues and stability of multivariable linear systems
3. Lyapunov stability for linear and nonlinear systems
4. State-feedback control (pole placement) and state observers (Luenberger)
5. Optimal state-feedback control (Linear-Quadratic Control) and optimal state estimation (Kalman Filters)
6. The H_2 optimal control problem
7. The H_∞ control problem and robustness

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY <i>Face-to-face, distance learning, etc.</i>	Face-to-face	
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY <i>Use of ICT in teaching, laboratory education, communication with students</i>	<ul style="list-style-type: none"> • Use of Simulink (Matlab) for the simulation and analysis of control systems • Use of the "Control Toolbox" (Matlab) for controller design • Use of internet for notes and additional material on control systems • Communication with students via the eclass platform 	
TEACHING METHODS <i>The manner and methods of teaching are described in detail.</i> <i>Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.</i> <i>The student's study hours for each learning activity are given as well as the hours of non-directed study according to the principles of the ECTS</i>	<i>Activity</i>	<i>Semester workload</i>
	Lectures	40
	Tutorials	12
	Laboratory work	6
	Coursework/Project work (at home)	42
	Private study	50
	Course total	150

<p>STUDENT PERFORMANCE EVALUATION</p> <p><i>Description of the evaluation procedure</i></p> <p><i>Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open-ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other</i></p> <p><i>Specifically-defined evaluation criteria are given, and if and where they are accessible to students.</i></p>	<ul style="list-style-type: none"> • Language of evaluation: Greek (or English) • Assessment: <ul style="list-style-type: none"> ○ Examination (70%) ○ Coursework and/or laboratory work (30%) <p>Description of Coursework and/or laboratory work</p> <ul style="list-style-type: none"> • Coursework: 6 sets of exercises and/or • 1-2 laboratory assignments or small project on the application of automatic control to real life problems (students can work in teams)
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(5) ATTACHED BIBLIOGRAPHY

Suggested bibliography:

- Åström, K.J., Murray, R. M., "Feedback Systems: An Introduction for Scientists and Engineers," 2nd Edition, Princeton University Press, 2021.
- Skogestad, S., Postlethwaite, I., "Multivariable Feedback Control, Analysis and Design," 2nd Edition. John Wiley and Sons, 2005.
- Franklin, G. F., Powell, J. D., Emami-Naeini, A., "Feedback Control of Dynamic Systems," 8th Edition, Pearson, 2019.
- Dorf R.C., Bishop R.H., "Modern Control Systems," 13th Edition, Prentice Hall, 2016.
- Ogata, K., "Modern Control Engineering," 5th Edition, Prentice-Hall, 2011.
- Zhou, K., Doyle, J. C., "Essentials of Robust Control," Prentice Hall, 1999.
- Antsaklis, P. J., Michel, A., N., "A Linear Systems Primer," Birkhauser, Boston, 2007.
- D'Azzo J.J, Houpis C.H., "Linear Control System Analysis And Design: Conventional and Modern", 4th Edition, McGraw-Hill, 1988.
- Chen, C.T., "Linear System Theory and Design," 4th Edition, Oxford University Press, 2012.
- Simon, D., "Optimal State Estimation," John Wiley & Sons, 2006.
- Anderson, B.D.O., Moore, J.B., "Optimal Filtering," Dover Publications, 2005,
- Stengel, R.F. "Optimal Control and Estimation", Dover Publications, 1994,
- Rossiter, J.A., "Model Based Predictive Control: A Practical Approach," CRC Press, 2005.
- Camacho E.F., Bordons, C., "Model Predictive Control", Springer, 1999.
- Kouvaritakis B., Cannon, M., "Non-Linear Predictive Control: Theory & Practice", IEE Publishing, 2001.
- Maciejowski, J., "Predictive Control with Constraints", Pearson Education POD, 2002.
- Burl, J.B. "Linear Optimal Control: H_2 and H_∞ Methods," Addison-Wesley, Menlo Park, CA, 1999.

Related academic journals:

- *Automatica*
- *Control Engineering Practice*
- *IEEE Transactions on Automatic Control*
- *IEEE Transactions on Control of Network Systems*
- *IEEE Transactions on Control Systems Technology*
- *IET Control Theory and Applications*
- *International Journal of Control*
- *International Journal of Robust and Nonlinear Control*
- *Systems and Control Letters*