DeCAIR Course Syllabus Form

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WP Number & Title	Work Package 2: Development of new MSc and BSc programs in AIR		
Activity Number & Title	Activity 2.2: Designing and developing syllabi and content for the agreed upon courses in the new programs		
WP Leader	Francesco Masulli, University of Genoa		
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Revision History

Version	Date	Author	Description	Action *	Page(s)
1	8/11/2021	Adham Alsharkawi	Original (base) document	C	1-5
2	18/12/2021	Adham Alsharkawi	Original (base) document	U	1-5
3					
4					

(*) Action: C = Creation, I = Insert, U = Update, R = Replace, D = Delete

Disclaimer

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Course title	Advanced Control Theory
Course number	0908725
Credit hours (lecture and lab)	3 (3 + 0)
ECTS (weekly contact and self-study load)	6 (3 + 3)
Prerequisites/co-requisites	0908721 (Robotic Systems)
Prerequisites by topic	Understanding of modeling and dynamic response is necessary. An elementary understanding of matrix algebra is necessary too.
Level and type (compulsory, elective)	Masters' elective course
Year of study and semester	First year, second semester
Description	This graduate course concentrates on the analysis and design of feedback control systems. This course has a preferential bias towards robotic applications. The core of this course presents the design method based on state-variable feedback. The course then develops in more detail the tools needed to design feedback control for implementation in a digital computer. Towards the end of the course the nonlinear material includes techniques for the linearization of equations of motion, analysis of zero memory nonlinearity as a variable gain, frequency response as a describing function, the phase plane, Lyapunov stability theory, and the circle stability criterion.
Objectives	1. Introduce students to state-space design. 2. Introduce students to digital control. 3. Introduce students to nonlinear systems. 4. Introduce students to control system design.
Intended learning outcomes	Upon successful completion of this course, students will be able to: (see table below) (*) The PLOs are listed in the appendix
Teaching and learning methods	Development of ILOs is promoted through the following teaching and learning methods:

No	Intended learning Outcome (ILO)	Program learning outcome (PLO)*
1	Acquire knowledge of state-space and compensator design in modern control systems.	2
2	Derive discrete-time mathematical models.	2
3	Demonstrate analysis and design of nonlinear systems.	3
5	Develop design skills in important control problems in robotics.	4

(*) The PLOs are listed in the appendix

	• Lectures will be delivered in person and through Microsoft Teams and will be recorded for later access. • The control lab is open for the students to practice the practical aspects. • The student attends the class presentations and participates in the class discussions. • The student joins the related online team/group and participates in its discussions. • The student studies the reference material, including books and videos. • The student solves the control assignments using appropriate tools. • The student carries out a term project for solving a particular control problem. • The student develops a professional report for the term report. • The student presents the term project in class.
Learning material	Textbook, class handouts, lecture notes, selected YouTube videos and recordings.
Resources and references	A- Required book(s), assigned reading and audio-visuals: 1. Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini. *Feedback Control of Dynamic Systems*. 8th Edition. 2018. B- Recommended book(s), material, and media: 1. Richard C. Dorf and Robert H. Bishop. *Modern Control Systems*. 13th Edition. 2017. 2. Ogata, Katsuhiko. *Modern control engineering*. 5th Edition. 2010.
Topic outline and schedule	

Week	Topic	ILO	Resources
1-4	**State-Space Design**	1	A-1, B-1, B-2
	Advantages of State-Space		
	System Description in State-Space		
	Block Diagrams and State-Space		
	Analysis of the State Equations		
	Control-Law Design for Full-State Feedback		
	Selection of Pole Locations for Good Design		
	Estimator Design		
	Compensator Design: Combined Control Law and Estimator		
	Introduction of the Reference Input with the Estimator		
	Integral Control and Robust Tracking		
	Loop Transfer Recovery (LTR)		
5-8	**Digital Control**	2	A-1, B-1
	Digitization		

	Dynamic Analysis of Discrete Systems		
	Design Using Discrete Equivalents		
	Hardware Characteristics		
	Sample-Rate Selection		
9-12	**Nonlinear Systems**	3	A-1
	Introduction and Motivation: Why Study Nonlinear Systems?		
	Analysis by Linearization		
	Equivalent Gain Analysis Using the Root Locus		
	Equivalent Gain Analysis Using Frequency Response: Describing Functions		
	Analysis and Design Based on Stability		
13-15	**Control System Design: Principles and Robotic Case Studies**	4	A-1

Evaluation tools

Opportunities to demonstrate achievement of the ILOs are provided through the following assessment tools:

Assessment tool	Mark	Topic(s)	Time
Assignments	10%	Nonlinear Systems	W9-W12
Midterm exam	30%	State-Space Design, Digital Control	W8
Term project	20%	Control System Design: Principles and Case Studies	W15
Final exam	40%	All Topics	W16
Total	**100%**		

Student requirements

Students should have access to a computer and internet connection.

Course policies

A- Attendance policies:

- Attendance is required. Class attendance will be taken every class and the university polices will be enforced in this regard.

B- Absences from exams and submitting assignments on time:

- A makeup exam can be arranged for students with acceptable absence causes.
- Assignments submitted late, but before announcing or discussing the solution can be accepted with 25% penalty.
- The project report must be handed in in time.

C- Health and safety procedures:

- All health and safety procedures of the university and the school should be followed.

D- Honesty policy regarding cheating, plagiarism, misbehavior:

	• Open-book exams • All submitted work must be of the submitting student. • Other text or code must be properly quoted with clear source specification. • Cheating will not be tolerated. E- Available university services that support achievement in the course: • Microsoft Teams team and Moodle course page • AI Lab for practicing the practical aspects and solving the programming assignments. • Program announcements Facebook group
Additional information	None

Appendix

Learning Outcomes for the MSc in Artificial Intelligence and Robotics

Students who successfully complete the MSc in Artificial Intelligence and Robotics (AIR) will be able to:

1. Demonstrate a sound understanding of the main areas of AIR including artificial neural networks, machine learning, data science, industrial and service robots, and intelligent and autonomous robots.

2. Apply a critical understanding of essential concepts, principles and practices of AIR, and critically evaluate tools, techniques and results using structured arguments based on subject knowledge.

3. Apply the methods and techniques of the AIR fields in the design, analysis and deployment of AIR solutions and solving practical problems.

4. Demonstrate the ability to produce a substantial piece of research work from problem inception to implementation, documentation and presentation.

5. Demonstrate life-long learning, independent self-learning and continuous professional development skills in the AIR fields.

6. Demonstrate a sound understanding of the ethical, safety and social impact issues of AIR solutions and products.