UNIVERSITÀ DEGLI STUDI DI PALERMO

SCHOOL	POLYTECHNIC SCHOOL
ACADEMIC YEAR	2016/2017
SECOND CYCLE (7TH LEVEL) COURSE	AEROSPACE ENGINEERING
SUBJECT	COMPLEMENTS OF AUTOMATIC CONTROL
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20907-Attività formative affini o integrative
CODE	02103
SCIENTIFIC SECTOR(S)	ING-INF/04
HEAD PROFESSOR(S)	ALONGE FRANCESCO Professore Ordinario Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**ALONGE FRANCESCO** Monday 12:00 13:00 DEIM Edificio 10 Wednesday 12:00 13:00 DEIM Edificio 10 Thursday 12:00 13:00 DEIM Edificio 10

DOCENTE: Prof. FRANCESCO ALONGE

TEACHING METHODS	Lessons, Tutorials using PC and Matlab/Simulink software
ASSESSMENT METHODS	The written exam deals with two/three tutorial topics covered during the course. Minimum mark for passing the test is 18/30. Before taking the oral test the Student have to pass the written exam. The oral exam consists of some questions on course topics. For each question, the Student will have to address the following aspects: significance and importance of the topic, for example giving formal definitions and putting in evidence the related application fields; choice of the most suitable methods of study. Finally, the Student will have to answer the questions with correct use of language, clearness and fluency in presentation. At the end of the oral examination, the examination board assigns the final mark, or alternatively, informs the student that the exam is failed. In case of passed exam, the final mark is assigned taking into account the following criteria: a) correctness of problem formulation, problem solving and achieved results in the written test (30% of the final mark); b) knowledge of the topics discussed during the oral exam, autonomy in making judgements and disciplinary connections within the course topics (60% of the final mark); c) correct use of language, clearness and fluency (10% of the final mark).
LEARNING OUTCOMES	EXPECTED LEARNING RESULTS Knowledge and understanding • The course of Advanced Automatic Control deals with the study of controllers for real systems consisting of aircrafts or, more generally, aerial unmanned vehicles After completing the course, the Students will learn new methods of study of linear and non-linear mathematical models, single-input and single-output (SISO) and multi-inputs and multi-outputs (MIMO). Moreover, they will acquire knowledge and understanding in designing controllers that allow to achieve high static and dynamic performances, usually requested to the aforementioned real systems. In particular, mandatory requirements for the systems in question are: robustness with respect to the stability and behavior, properties that the system must possess in presence of both parametric uncertainties and unmodeled dynamics; robustness against disturbances, for example wind, to which a flying object is surely subjected. Both of the above requirements are covered during the course. In order to pursue the above objectives, the course consists of lessons, tutorials, experimental tests carried out in the laboratory, analysis and discussions about case studies. In order to verify these objectives, the exam consists also of oral discussions about topics covered in the course Applying knowledge and understanding • The Students will be able to apply their knowledge, understanding and skills, acquired during the course, to the analysis of linear and nonlinear dynamic systems, SISO and MIMO. In particular, they will be able to: a) linearize the model in the neighborhood of the interest dynamic situation, design a controller for the linearized model, and validate the obtained controller in Matlab / Simulink environment; b) carry out the analysis of the non-linear model and design the model-based controller using control techniques based on input - output linearization, active compensation of the equivalent disturbance, which includes both endogenous and exogenous disturbances, and sliding mode techniques . In order to verify this objective, the Students have to prepare and discuss an essay on a topic covered during the course. Making judgements • The Students will be able to determine the essential properties of the mathematical model of the real system, and choose the correct approach for solving the control problem, after defining the design requirements. Moreover, they will be able to validate the designed controller by means of simulation. Moreover, the Students will acquire ability in making judgements that will allow to apply also the theoretical and practical knowledge to more general control problems. The development of the essay will allow to the Students to apply the acquired knowledge to cases not covered during the course, effecting bibliographic searches and choosing autonomously the scientific materials to be used. The discussion of the essay will allow to verify the reaching of this objective. Communication skills • The Students will acquire communication skills, which allow them to

	communicate and/or discuss with experts in various sectors, the properties of the dynamic model describing the real system, the motivations of the followed approach for designing the controller, and the realization aspects of a prototype of the whole control system. Moreover, the Students will be also able to interact with other experts for understanding and satisfying the demand of the users, thanks to the multidisciplinary characteristics of the laurea degree course. In order to pursue this objective, tutorials will be executed by the Students under the supervision of the teacher, with the aim of motivating the Students to discuss between them and with the teacher about the topic object of the current tutorial. The verification of the acquired skill will take place thanks to the tutorials, the essay, and the oral exam. Learning skills • The degree course is aimed also to motivate the Students towards a systematic approach for the study of dynamical systems and control them. The Students will acquire learning skill, and generalization skill, which will allow he to autonomously address an solve problems different from those considered in the course itself. In order to pursue this objective, the lessons will be held so as to transfer to the Students a systematic methodology of study. The validation of the objective will take place during the discussion of the essay and the oral exam.
EDUCATIONAL OBJECTIVES	The course is aimed at giving to the Students suitable knowledge about the analysis of the dynamical systems, and controller design for aircraft and unmanned aerial vehicles. In particular, both the analysis and design techniques are model-based, take into account model uncertainties, and cope with exogenous and endogenous disturbances acting on the system at hand. Advanced control techniques are illustrated and validated in Matlab/Simuling environment, such as H-2 e H-infinity optimal control, mu-analysis and mu-synthesis, sliding mode control and active disturbance rejection control.
PREREQUISITES	Automatic Control
SUGGESTED BIBLIOGRAPHY	• Lecture notes, by the teacher • S. Skogestad, I. Postlethwaite, Multivariable feedback Control, Analysis and design • D. Alazard,C. Cumer, P. Apkarian, M. Gauvrit, G. Ferreres, Robustess et Commande Optimale, CepaduesEditions, Toulouse,France • O.H. Bosgra, H. Kwakernaak, G.Meinsma, Design Methods for Control Systems • Slotine, J.J.E., and Li, W., Applied Nonlinear Control, Prentice-Hall, 1991

SYLLABUS

Hrs	Frontal teaching
3	Modelling of uncertainties for MIMO systems.
5	Linear Fractional Transformations (LFT)
3	Robust stability in presence of unmodelled dynamics
2	Robust behavior
4	Structured Singular Value (μ). Tecniques of μ -analysis e μ -synthesis
7	Sliding mode control for linear and nonlinear models
4	Feedback linearization and actice disturbance rejection control (ADRC)

Hrs	Practice
4	Singular Value Decomposition of tranfer matrices in the omega-domain
4	LFT for linear and time-invariant (LTI) models
6	Designing robust controllers by using the μ -synthesis approach
6	Designing Controllers and Observers by using sliding mode techniques
6	Control of a quadrotor using ADRC