UNIVERSITÀ DEGLI STUDI DI PALERMO

SCHOOL	POLYTECHNIC SCHOOL
ACADEMIC YEAR	2016/2017
SECOND CYCLE (7TH LEVEL) COURSE	AEROSPACE ENGINEERING
SUBJECT	PLANNING I - STUDIO
TYPE OF EDUCATIONAL ACTIVITY	C
AMBIT	20907-Attività formative affini o integrative
CODE	17647
SCIENTIFIC SECTOR(S)	ING-INF/04
HEAD PROFESSOR(S)	FAGIOLINI ADRIANO Ricercatore Univ. di PALERMO
OTHER PROFESSOR(S)	
CREDITS	6
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54
PROPAEDEUTICAL SUBJECTS	
YEAR	1
TERM (SEMESTER)	2° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**FAGIOLINI ADRIANO** Thursday 9:30 12:30 Viale delle Scienze, Edificio 10

DOCENTE: Prof. ADRIANO FAGIOLINI

TEACHING METHODS	Theory lessons and class exercises.
ASSESSMENT METHODS	During the course, the Students are given a team assignment, concerning one of the typologies of robotic systems that are addressed in the lessons. Each assignment can be developed by a single student as well as by two or three students. It includes a phase of theoretic study and work, a phase of simulation by using Matlab/Simulink, and, depending on the students' interests, a phase of experimental work on a real system. The students are assisted during the assignment work. Upon completion of the work, they are required to write a concise report, describing the achieved results. The exam is passed if at least 50% of the assignment's objectives are reached. The final mark depends on the following evaluation criteria, each of which has a specific weight in contributing its determination: a) correctness and soundness of the proposed solution to te problem addressed during the assignment (80% of the final mark); b) ability of connecting the theoretical topics involved in the assignment with the other topics addressed during the course (10% of the final mark); c) correct use of the technical language (10% of the final mark).
LEARNING OUTCOMES	* Knowledge and Understanding: The course is aimed at Master students in Aerospace Engineering or Automation Engineering. Throughout the course, the students will gain basic knowledge on how to describe the dynamic behavior of physical systems, characterized by nonlinear mathematical models, and that of spatially distributed systems; they will also learn how to study the stability property of equilibria and of trajectories and will finally understand how to abstract the essential properties of any such system, in order to obtain a correct dynamic model. * Applied Knowledge and Understanding: The students will acquire knowledge on the essential characteristics of mobile robots; they will be able to identify the existing kinematic constraints between the state variables of such systems and, accordingly, obtain their correct nonlinear dynamic models. They will understand how to apply the analysis techniques for the stability of equilbiria and trajectories to problems involving validation of algorithms for navigation and control of mobile robots.
EDUCATIONAL OBJECTIVES	The course aims at providing the students with the theoretical tools for the study of the properties of nonlinear dynamical systems and for the design of nonlinear controllers, under knowledge of the nominal behavior of some mobile robots. Moreover, the course has the objective of instructing the students with the use of software tools, mainly Matlab/Simulink, for the simulation of dynamic models, as well as the implementation of controllers by means of electronic boards for rapid prototyping.
PREREQUISITES	No prerequisites.
SUGGESTED BIBLIOGRAPHY	1. Dispense in inglese fornite dal docente sul controllo di sistemi non lineari, sui veicoli e velivoli autonomi (Lecture notes on Nonlinear Control Systems, Autonomous Vehicles and Aircrafts) 2. Hassan K. Khalil, Nonlinear Systems, 3rd Edition, Prentice Hall. 3. Siegwart, Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press, 2010. 4. M. Mesbahi, M. Egerstedt, Graph Theoretic Methods in Multiagent Networks, Princeton University Press, 2010.

SYLLABUS

Hrs	Frontal teaching
3	Introduction to Mobile Robotics. Applications in the Industry and for Services. Locomotion systems. Odometry based on proprioceptive and exteroceptive sensors. Autonomous navigation in known and unknown, structured and unstructured environments. Multi-robot cooperation.
6	Analysis of Nonlinear Dynamic Systems. State forms. Equilibria. Asymptotic stability. Direct and indirect Lyapunov's methods. Quadratic functions and sign definiteness. Speed of convergence. Local and global asymptotic stability (radially bounded functions, Babarshin-Krasovskii's Theorem). Variable Gradient Method. Maximum Invariant Set and Krasovskii-Lasalle's Theorem. Limit Cycles.
4	Control of Nonlinear Dynamic Models. Lyapunov Control Functions. Back-stepping Control Technique. Input-output exact state feedback linearization.
11	Wheeled Robots. Non-holomic Systems and Canonical Forms. Unicycle Vehicles (kinematic and dynamic models, point-to-point motion control, control law for path following and trajectory tracking). Car-like Vehicles (rear and front traction, rear and front reference kinematic models, dynamic models, controllers for path following and automatic parking).
12	Autonomous Aircrafts. Applications. Basic mechanics and under-actuation. Dynamic models. Linear controllers for attitude and position control at quasi-hovering configurations. Nonlinear controllers for tracking of general trajectories. Formation control.

Hrs	Practice
6	Stability analysis of equilibrium points for second and third order systems, using direct and indirect Lyapunov's method as well as the variable gradient method.
6	Simulation with Matlab/Simulink software of examples of physical systems, regulated via linear and nonlinear control schemes. Simulation of control systems for wheeled robots and quadrotors.
6	Emulation of control systems via hardware-in-the-loop techniques with rapid prototyping systems (Arduino, ST-microelectornics, etc.)