Course Syllabus for
DAUSY National Ph.D. Program in Autonomous Systems
(year 2022-23)

Course title	Analysis and control of cyber-physical systems
Scientific Discipline Sector	ING-INF/04
Hours of instruction	30 hours
CFU	3 CFU
Semester, period	Second semester, 2023
Goal	The course will introduce students with a formal method approach to modeling, analysis and control of Cyber Physical Systems (CPS). We first recall notions and results for stability of nonlinear and hybrid control systems and for theoretical computer science. We then show how these results are useful for the control of CPS with possibly heterogeneous dynamics where the control objective is expressed in terms of regular languages. Over the years it has been shown how regular languages offer a useful framework for modeling specifications of interest for CPS, as e.g. reachability problems with nonconvex constraints, obstacle avoidance, synchronization specification. Part of the course will also be devoted to the analysis of CPS via formal methods, in particular approximate diagnosability and predictability will be addressed. Extensions of the proposed framework to time-delay systems, networked control systems, decentralized control will be discussed. Some case studies in the context of power systems, systems biology and chemical processes will be presented to illustrate the effectiveness of the approach.
Syllabus	• Introduction to CPS • Review on stability notions for nonlinear systems • Metric transition systems and their relations • Regular languages • Symbolic models for stable nonlinear systems • Control design and efficient algorithms • Diagnosability and predictability • Extensions to nonlinear systems with disturbances, possibly unstable nonlinear systems, time-delay systems, networked and networks of nonlinear systems

	• Applications to power grids, biological systems and chemical processes
Bibliography	Pola, G., Di Benedetto, M.D. , Control of Cyber–Physical–Systems with Logic Specifications: A Formal Methods Approach , Annual Reviews in Control, 47(2019):178-192 Slides and lecture notes from lecturer.
Examination method	Final written exam (remotely)