Course Syllabus for
DAUSY National Ph.D. Program in Autonomous Systems
(year 2023-24)

Course title	Game Theory for Controlling Autonomous Systems
Scientific Discipline Sector	ING-INF/04
Hours of instruction	20 hours
CFU	2 CFU
Semester, period	June-July 2024
Goal	This course is designed to provide PhD students with the necessary modeling and methodological tools for analyzing and designing algorithms to solve game equilibrium problems. The course will include lectures, numerical examples, simulations, and analysis of case studies.
Syllabus	1. Introduction and motivation 2. Background a. Convex Optimization: Convex sets and functions. Set-valued mappings. Normal cone and tangent cone operators. Projection and proximal operators. Lagrangian duality and KKT conditions. b. Monotone Operator Theory: Fixed points, zeros, and contraction mappings. Averaged and nonexpansive mappings. Fixed point theorems and algorithms. 3. Nash equilibrium a. Background, Nash equilibrium problem and best response mapping. b. Applications and models: Linear complementarity problems and variational inequalities. c. Existence and uniqueness of equilibria. d. Algorithms. 4. Generalized Nash equilibrium a. Background, Generalized Nash equilibrium problem. b. Applications and models: Quasi-variational inequalities and mixed complementarity problems. c. Existence and uniqueness of equilibria. d. Algorithms.
Bibliography	References: [1] Boyd, Stephen P., and Lieven Vandenberghe. *Convex optimization*. Cambridge university press, 2004. [2] Bauschke, Heinz H., and Patrick L. Combettes. *Convex analysis and monotone operator theory in Hilbert spaces*. Vol. 408. Springer, 2011. [3] Facchinei, Francisco, and Jong-Shi Pang, eds. *Finite-dimensional variational inequalities and complementarity problems*. Springer , 2003. [4] Osborne, Martin J. An introduction to game theory. Vol. 3. No. 3. New York: Oxford university press, 2004. [5] Basar, Tamer, and Georges Zaccour, eds. Handbook of dynamic game theory. Berlin: Springer, 2018. Slides and supporting material from lecturer.
Examination method	• End-course examination based on a project work, which involves applying the learned concepts and techniques to a real-world problem. • Evaluation of class participation, including active engagement in lectures, discussions, and case study analysis.