**Advanced Modelling of Robots**

**Credits:** 5  
**Semester:** 3 (ECN)  
**Compulsory:** Yes

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**Lecturer:** S. Briot, S. Caro

**Objectives:**
This course presents advanced modelling techniques (geometric, kinematic and dynamic) of robots (tree structure robots, parallel robots, and hybrid robots) composed of rigid links.

**Contents:**
The following topics are treated:
- Description of complex mechanical systems (tree-structured or closed loop systems),
- Geometric and kinematic models of closed-loop structure robots, constraints equations, mobility analysis, singularity analysis (introduction to DHm convention of tree-structured and closed loop systems)
- Workspace analysis of full-mobility and lower-mobility parallel robots
- Calibration of geometric parameters
- Recalls of dynamics principle (Newton-Euler, Euler-Lagrange, Principle of virtual works) for open and closed-loop mechanism systems
- Dynamic modelling of rigid tree-structure robots: the inverse and direct dynamic problems, the base inertial parameters, computation of the ground forces.
- Dynamic modelling of rigid parallel robots without and with actuation redundancy: the inverse and direct dynamic problems, the base inertial parameters, computation of the ground forces.
- Analysis of the degeneracy conditions of the dynamic model of rigid parallel robots, and singularity crossing
- Identification of dynamic parameters

**Practical Work:** Exercises will be set, involving modelling, identification and simulation of robots. Advanced technical papers from recent international conferences will be analysed and reviewed.

**Abilities:** After completing this course, the students will be able to:
- Understand the fundamentals of the mathematical models of robots and their applications in robot design, control and simulation.
- Analyse the mobility of parallel robots and understand the notion of operation modes
- Analyse, identify and illustrate the serial and parallel (including the constraint) singularities of parallel robots
- Identify the geometric and dynamic parameters of a robot
- Use of the best methods to develop the required models of a given architecture
- Apply the given techniques to other systems such as mobile robots or passenger cars
- Use the convenient numerical schemes for numerical integration.
- Use modelling, optimization, and signal processing tool boxes software packages (Matlab, Adams).

**Assessment:** 30% continuous assessments, 70% from end of semester examination.

**Recommended texts:**
- S. Caro, lecture notes on “Geometric and Kinematic Modelling of Serial and Parallel Robots”
Further readings:
will be provided during the course