Syllabus Cursus Master's Degree in Engineering, Mechanics.

Sorbonne University CMI5

Advanced Systems and Robotics (SAR)

List of Teaching Units

Semester 9

Core Units

- Technoscience, ethic and society

Advanced Systems and Robotics (SAR)

- Advanced control and estimation in the status space
- System Dynamics and Physical Simulation
- Modelling and control of robotic systems
- Mobile Robotics
- Vision and Perception
- Mini-project

Thematic Intelligent Systems

- Advanced automation and control of robotic systems
- Navigation and planning for robotics
- Learning and RDF
- Management for engineering
- Perception for intelligent systems
- Integrative project

Semester 10

- Certification *
- Deepening Project *
- Graduation internship

Title Teaching Unit - Master Cycle – CMI5			Code	Lecture	Discussion sessions	Lab	SSA	Hours Attendance	Work Personal	ECTS
CMI5 S9	Technoscience, ethic and society		MU5EEG03	16	8		24	24	40-60	6 *
	Advanced Systems and Robotics (SAR)									
		Advanced control and estimation in the status space	MU5RBE03	30	22	8		60	60-90	6
		System Dynamics and Physical Simulation	MU5RBE02	40	14	6		60	60-90	6
		Modelling and control of robotic systems	MU5RBE01	32	20	8		60	60-90	6
		Mobile Robotics	MU5RBE04	36	24			60	60-90	6
		Vision and Perception	MU5RBE05	16		12		28	30-40	3
		Mini-project	MU5RBE08				40		50–60	3
Total Common Core 6* ECTS - Total Thematic 30 ECTS - Total CMI5 S9 SAR = 30 ECTS + 6*										

Title Teaching Unit - Master Cycle – CMI5		Code	Lecture	Discussion sessions	Lab	SSA	Hours Attendance	Work Personal	ECTS
CMI5 S10	TOIC /TOEFL certification	MU4LVANT				30		30-40	3*
	Deepening Project	MU5EEG04				40		50-60	3*
	Graduation internship	MU5MES03					800	80-100	30
Total CMI5 - S10 30 ECTS + 6 *									

*Units outside the contract (not included in the calculation of the semester average) are included in the diploma supplement.

SCIENCES SORBONNE UNIVERSITÉ

Semester 9

Technosciences, Ethic and Society

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5EEG03 - Master's **mention**

Pedagogical presentation.
The objective of this course is to bring students to reflect on the social and ethical dimensions of the engineering profession. It focuses on the complex relations between society and technology, and in particular on the role of technology as a value carrier. Based on these analyses, the course then explores the ethical questions and dilemmas that engineers may encounter in the course of their work. Particular attention is paid to examining classic cases in engineering ethics, such as Three Mile Island and the Quebec Bridge. By the end of this course, students will be able to identify ethical issues raised by professional practices. They will also be reflective on their future profession. The course is taught in English.

Content of the Teaching Unit.
- Introduction
- Technical determinism and social construction. Read: T. Pinch and W. Bijker, The Social Construction of Facts and Artifacts? Presentation: (also) Robert Heilbroner, Do Machines Make History?
- Devices, systems, and their power of action on society. Read: B. Latour, Where are the Missing Masses? The Sociology of a Few Mundane Artifacts. Presentation: (also) T. Hughes, Technological Momentum.
- Techniques et valeurs. Lire : J. Wetmore, A. Technology : Reinforcing Values, Building Community. Exposé : (aussi) LangdonWinner, Do Artifacts Have Politics ? et R. Weber, Manufacturing Gender in Commercial and Military Cockpit Design.
- Complexity and uncertainty. Bring: Proposal for a dissertation Read: D. Vinck, Engineers in everyday life. Lecture : (also) JamesonWetmore, Engineering Uncertainty.
- Engineering and experimentation. Read, lecture: M. Martin and R. Schinzinger, Introduction to Engineering Ethics, pp. 77-103.
- Technical disasters. Reading and presentation: S.K.A. Pfaitteicher, Lessons amid the Rubble, pp. 36-61.
- Engineering and security. Reading and presentation: Mike Martin and Roland Schinzinger, Ethics in Engineering, pp. 117-145.
- Engineering and environment. Reading, presentation: Mike Martin and Roland Schinzinger, Ethics in Engineering, pp. 219-242.
- Nanotechnologies, génétique et robotique. Lire: Bill Joy, Why the Future Doesn't Need Us. Exposé : Interagency Working Group on Nanoscience, Engineering, and Technology, Nanotechnology : Shaping theWorld Atom by Atom.

Prerequisite. The corpus of societal and cultural opening lessons of the LECTUREI course followed since the 1st year.

Références bibliographiques. Bowen R. 2012. Engineering Innovation in Health Care : Technology, Ethics and Persons. HRGE, pp. 204-221. Collins, Harry & Trevor Pinch. 2002. The Golem at Large : What You Should Know about Technology. Cambridge University Press. Didier. Ch. 2008. Penser l'éthique des ingénieurs. Paris, PUF. Didier, C.. 2008. Les ingénieurs et l'éthique : pour un regard sociologique. Hermes Science publications. Heilbroner, Robert. 1967. Do Machines Make History? Technology and Culture, pp. 335-345. Hughes, T. 1994. Technological Momentum, in Marx, Leo & Merritt Roe Smith, Does Technology Drive History? The Dilemma of Technological Determinism. Cambridge: MIT Press, pp. 101-113. Interagency Working Group on Nanoscience, Engineering, and Technology, Nanotechnology: Shaping the World Atom by Atom, in Johnson, Deborah et Jameson Wetmore. Technology and Society: Building Our Sociotechnical Future. MIT Press Johnson, D. & Jameson W.. 2008. STS and Ethics: Implications for Engineering Ethics, in Hackett, Edward, Olga Amsterdamska, M. Lynch et J. WajLecturean, The Handbook of Science and Technology Studies. Cambridge, MIT Press, pp. 567-582. Joy, Bill. Avril 2000. Why the Future Doesn't Need Us,Wired, pp. 238-262. Latour, B. 1992. Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts in Wiebe Bijker et John Law, Shaping Technology/Building Society: Studies in Socio-technical Change. Cambridge, MIT Press, pp. 225-258. Martin, Mike & Roland Schinzinger. 2005. Ethics in Engineering. McGraw-Hill. Martin, M. & Roland S.. 2010. Introduction to Engineering Ethics. New York : McGraw- Hill. Pfattaicher, S. K. A. 2010. Lessons Amid the Rubble. Johns Hopkins University Press. Pinch, Trevor & Wiebe Bijker. 1987. The Social Construction of Facts and Artifacts in Wiebe Bijker, Thomas H.,Trevor P., The Social Construction of Technological Systems. Cambridge, MIT Press, pp. 17-50. Vinck, D. 1999. Ingénieurs au

quotidien : ethnographie de l'activité de conception et d'innovation. Presses universitaires de Grenoble. Weber R.. 1997. Manufacturing Gender in Commercial and Military Cockpit Design, Science, Technology, & Human Values, pp. 235-253. Jameson. 2008. Engineering with Uncertainty: Monitoring Air Bag Performance, Science and Engineering Ethics, pp. 201-218. Jameson. 2009. Amish Technology: Reinforcing Values, Building Community in Johnson, D. et Jameson W.. Technology and Society: Building Our Sociotechnical Future. Cambridge: MIT Press. -Winner, Langdon. 1986. Do Artifacts Have Politics? The Whale and the Reactor: a Search for Limits in an Age of High Technology. University of Chicago Press, pp. 19-39.

Resources available to students. Lecture materials. List of books.

Scientific knowledge developed in the unit.

- Knowledge of the social and ethical dimensions of the engineering profession.

Skills developed in the unit.

- Improvement of the knowledge of English. Improvement of written expression.
- Forms of reasoning practiced in the social sciences.

Hourly volumes in and out of the classroom.

Total attendance hours: 24 hours divided into 16 hours of class, 8 hours of discussion session. Personal work 40-60 hours.

Evaluation. Attendance at sessions: 20%, Presentation: 20%, Essay: 40%, Essay defence: 20%.

Teacher. C. Lecuyer

Advanced command and estimation in the status space.

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5RBE03 - Master's degree in Automatic and Robotics

Pedagogical presentation.
This EU is intended to provide the basics in automatic: state feedback control and state estimation. Although focused on control techniques and linear estimation, the course also shows how these techniques can be exploited for the control of some non-linear systems.

Content of the Teaching Unit.
Part 1: Ordering
1. *Introduction and basic tools*. Introductory examples. Rappels on differential equations. Notions of stability in the Lyapunov sense. Tools for stability analysis of equilibrium points.
2. *Linear systems*. Commandability and observability of control systems linéaires Formes canonics of commandability and observability. Pole Placement Stabilization. Principle of separation
3. *Non-linear systems.* Stabilization via tangent linearization. Linearization by changing state and/or control variables. Techniques of the Lyapunov type.

Part 2: Estimation
1. *Estimation theory*. Introductory and problematic examples. Elements of Probability and Process aléatoires. Properties of estimators. Some methods of synthesis d 'estimators. Kalman filter.
2. *Observation theory.* Principle of linear state observers. Full or reduced order observer. Synthesis of state/observer feedback. Optimal observer. Robust observer.
3. *Non-linear systems.* Introduction. Kalman filter extended. Kalman filter unscented. Non-linear observers.
4. *Extension to parametric identification and fault detection.*

Prerequisites. Linear algebra, analysis, basic principles of differential equations, notions of probability.

Resources available to students. Course handout.

Bibliography

- B. D'Andréa-Novel, M. Cohen de Lara, Linear control of dynamical systems. Transvalor- Presses des Mines, 2000.
- H.K. Khalil, Nonlinear systems. Prentice Hall, 3rd edition, 2002
- T. Kailath, A.H. Sayed, B. Hassibi, Linear estimation. Prentice Hall, 2000.
- S.G. Mohinder, P.A. Angus, Kalman Filtering: Theory and Practice. Prentice Hall, 1993.

Scientific knowledge developed in the unit.
- Controlled dynamic systems, open loop or closed loop.
- Stability and stabilization of dynamic systems.
- Filtering principles and methods for the design of estimators in the state space.

Skills developed in the unit.
- Know how to analyse a non-linear controlled system; design controllers and observers for linear or non-linear systems.
- Know how to design state/filter estimators.

Hourly volumes in and out of the classroom.
Total attendance hours: 60 hours divided into 30 hours Lectures, 22 hours discussion session and 8 hours TP.
Expected personal work: 60 - 90 hrs.

Evaluation. The evaluation is based on two written examination notes and assignments to be handed in.

Teacher. M. N. Mechbal and P. Morin

SCIENCES SORBONNE UNIVERSITÉ

Systems dynamics and physical simulation.

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code MU5RBE02-** Automatic and Robotics Master's Degree

Pedagogical presentation.

Physical simulation is increasingly used for video games, evaluation of robotic systems or interactive robotics (exoskeleton, cobotics, rehabilitation or surgical robots). This module introduces the dynamics of interacting systems with the aim of automatically generating the mechanical equations of rigid and deformable multi-body systems with cycles and with unilateral contacts (inter-solids collision and with the environment) frictionnal or not, as well as their numerical resolution. The formulation of their parametrisation, the constraints introduced by kinematic links, dynamic equations and finally their resolution by numerical methods, in the various problems that arise either in simulation or in control problems, will be addressed here. Emphasis will be placed on the efficiency and robustness of numerical methods, necessary for the main applications which are control prototyping in robotics, numerical modelling in manufacturing industry and virtual reality.

Content of the Teaching Unit.

- Strict parameters, Cartesian and articular, 3D rotation and Euler-Rodriguez parameters. Recall of velocities and energies of a system of rigid solids, mass matrix. Principle of virtual work, Holonomic and non-holonomic constraints. Lagrange equations with and without multipliers.
- Joint and Cartesian Dynamics, Direct and Inverse Dynamics. Newton-Euler equations, Recursive methods for tree chains.
- Solving equations of motion: integration of ODEs, EDAs, stress stabilization, geometric integration methods. Unilateral contacts, impacts and dry friction: Modelling, regularized formulations, non-regular formulations (Signorini's law, Coulomb model, advanced contact models). Numerical integrators for non-regular mechanical systems: event capture methods, Moreau-Jean scheme, special case of inelastic shocks, NSCD method. Digital solvers for non-regular integrators with event capture: LCP, MLCP, reformulations in the form of non-regular optimization problems, projective formulations, fixed point methods, non-regular Gauss-Seidel and Jacobi solvers.
- Implementation issues: matrix assembly, numbering of degrees of freedom, profile matrix structure, parallelisation of calculations. Collision detection and associated geometric algorithm: geometric determination of contacts, interference detection, proximity and distance calculations, geometric calculations for robotic sensor Modelling.
- Flexible segment robots, umbilicals and cables: introduction to large displacement beam models, geometrically accurate approaches, associated finite elements.

Prerequisites. Solid mechanics.
Resources available to students. Course handout.
Bibliography

- Jorge Angeles. Fundamentals of Robotic Mechanical Systems : Theory, Methods and Algorithms.Springer, 1997.
- Ahmed A. Shabana. Computational Dynamics. Wiley & sons, 2001.
- Parviz Nikravesh. Computer-Aided Analysis of Mechanical Systems. PrenticeHall, London, 1989.
- Vincent Acaryet Bernard Brogliato. Numerical Methods for Nonsmooth Dynamical Systems. Lecture Notes in Applied and Computational Mechanics.Springer, 2008.
- Christer Ericson. Real Time Collision Detection. Morgan Kaufmann Publishers,Elsevier, 2005.

Scientific knowledge developed in the unit.

- Digital resolution of EDOs and EDAs

Skills developed in the unit.

- Know how to implement a "solver" to simulate the dynamic equations of a robot, which may contain flexibilities.

Hourly volumes in and out of the classroom.

Attendance hours: 60 hours divided into 40 hours of Lecture, 14 hours of discussion session and 6 hours of Lab.
Expected personal work: 60 -90 h.

Evaluation. The evaluation is done on a written note (/60), a LAB and project note (/40).

Teacher. M. M. Guskov and X. Merlhiot

SCIENCES SORBONNE UNIVERSITÉ

Modelling and control of robotic systems.

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5RBE01 - **Mention** Master SPI

Pedagogical presentation.

This course introduces the methods of mechanical modelling, behavioural analysis and control of robotic systems. It aims to give students the opportunity to independently undertake the resolution of a number of basic robotics problems such as configuration, trajectory generation, dynamic control, as well as to be able to analyse the behaviour of biomechanical or simply mechanical systems from the point of view of their force transmission properties, their static and dynamic equilibrium. It also aims to provide an overview of the control techniques used in robotic handling, to introduce the definition of control architectures and their properties on the basis of the tasks to be performed, and to present the practical and theoretical difficulties posed by the control of robotic systems.

Examples of suggested topics.

- Modelling and theoretical analysis: Geometric description and parameterization of systems. Holonomic and non-holonomic binding constraints. Homogeneous transformations. Direct and inverse geometric model by analytical, numerical and homotopic methods. Motion transmission laws in simple and complex systems. Symbolic elimination methods for obtaining input/output laws. Singularities. Solving inverse kinematic problems - constrained systems and redundant systems. Dynamic model by general theorems and equations of motion by Lagrange equations. Generation of articular and Cartesian trajectories. (16 h LECTURE + 16 h DISCUSSION SESSIONS)
- Control techniques and implementation: physical architecture for controlling the movements of a manipulator robot. Choice of the control space, influence of dynamics, effect of sampling, effect of friction, effect of flexibility. Augmented dynamic model (rigid body + transmission + actuation). Parametric identification of the dynamic model. Servo control adjustment on a 2R plane system (TPs on real robots). (16 h LECTURE + 4 h DISCUSSION SESSIONS + 8 h TP)

Prerequisites. Linear automatic and servo control. Solid mechanics.

Resources available to students. Copies of course notes.

Scientific knowledge developed in the unit.

- Geometric, kinematic, and dynamic models of serial or parallel robots.
- Methods of stabilizing manipulator robots.
- Principles of setting correctors for manipulator robots.

Skills developed in the unit.

- Model a mechanical architecture of a serial or parallel robot.
- Designing a control law for a serial manipulator robot.

Hourly volumes in and out of the classroom.

Total attendance hours: 60 hours with 32 hours of lecture, 20 hours of discussion session and 8 hours of Lab.
Expected personal work: 60 - 90 h

Evaluation.

The evaluation is based on written exams (/80) and Lab reports (/20).

Teacher. Mr P. Bidaud and Mrs B. d'Andrea-Novel.

SCIENCES SORBONNE UNIVERSITÉ

Mobile robotics.

Level CMI5 - **Semester** S9 - **Credits** 6 ECTS - **Code** MU5RBE04 - Master's degree in Automation and Robotics

Pedagogical presentation.

The objective of this EU is to introduce concepts related to the implementation of autonomous mobile robots: modelling and control of wheeled mobile robots - localisation and perception of the environment - planning and generation of trajectories. The theoretical concepts are presented in class and put into practice on robots in practical sessions. This module also includes the intervention of an industrialist from the mobile robotics sector who makes a presentation of case studies.

Topics covered.

- General Concepts on Earth System Mobility
- Modelling of wheeled mobile robots
- Sensor and Perception in Mobile Robotics
- Control of non-holonomous systems
- UAV Modelling
- Synthesis of control laws and state estimators for multi-propeller UAVs
- Trajectory generation
- Location and Mapping (SLAM)
- Path and trajectory planning
- Industrial Seminar

Prerequisite. Kinematic Modelling, solid mechanics, control and state space, C/C++ programming.

Resources available to students. Overheads used in lectures, handouts and book chapters.

Bibliography

- J-P. Laumond. Mobile Robotics, Hermes, 2001.
- R. Siegwart, I.R. Nourbakhsh. Introduction to Autonomous Mobile Robots, The MIT Press, 2004.
- G. Dudek, M. Jenkin. Computational principles of mobile robotics, Cambridge University Press, 2000.
- J.P. Latombe, Robot motion planning, 1991
- J. Angeles, Fondamental of robotic mechanical systems, 1999

Scientific knowledge developed in the unit.

- Modelling and control of mobile, land or airborne robots
- Planning, SLAM

Skills developed in the unit.

- Model a robot and design a control law according to the operational objective ;
- Choose and implement a planning or SLAM algorithm.

Hourly volumes in and out of the classroom.

Total attendance hours: 60 hours with 36 hours of class and 24 hours of discussion session.
Expected personal work: 60-90 h

Evaluation.

Practical work (/40) and article study with oral presentation (/60).

Teacher. M. R. Chatila and P. Morin

Vision and perception.

Level CMI5 - **Semester** S9 - **Credits** 3 ECTS - **Code** MU5RBE05 - Master's Degree in Automation and Robotics

Pedagogical presentation.

Vision is one of the essential modalities to allow a robot to apprehend its environment.
This EU aims to provide the basis for vision and image processing useful to robotics, presenting point of interest detection, geometric Modelling and camera calibration, enabling robots to locate and move in a 3D environment. The use of active vision via laser rangefinders will also be introduced to complement the passive vision of cameras, due to their high accuracy.

Contents of the unit.

- Detection of points of interest
- Optical flow
- Elements of projective geometry
- Vision sensor calibration - Camera Modelling
- Epipolar geometry
- 3D Reconstruction
- Odometry algorithms/laying estimation
- Extension to laser sensors

The students will apply these theoretical teachings in 3 sessions of Lab (Matlab) and a mini-project.

Prerequisite.

Basic knowledge of image formation and numerical representation (sensors, colour spaces, histograms); Linear algebra; Euclidean geometry; Optimization methods; Programming (Matlab/Python).

Resources available to students. Documents presented. Annals.

Bibliography :

R. Hartley and A. Zisserman, “Multiple view geometry in computer vision”, Cambridge university press, 2003.

Scientific knowledge developed in the unit.

- Projective geometry
- Image processing algorithms

Skills developed in the unit.

- Know how to calibrate a camera and use it as a metrological instrument.
- Know how to process images, 3D reconstruction by triangulation using one or more calibrated cameras.
- Interpret visual information

Hourly volumes in and out of the classroom.

The overall hourly volume is 28 hours with 16 hours of classes and 12 hours of practical work.

Evaluation.

Project (50%) and 2-hour written exam (50%).

Teacher. M. X. Clady, S. Ieng and Daniel Racoceanu.

Mini project.

Level CMI5 - **Semester** S9 - **Credits** 3 ECTS - **Code MU5RBE08-** Automatic and Robotics Master's Degree

Pedagogical presentation.
The purpose of this compulsory EU is to carry out a bibliographical study project which may give rise to simulations or experiments. It is supervised by a teacher-researcher from the backing laboratories who proposes the subjects and which are then submitted to the students for them to make their choice. The duration of the project is about two months. This project is evaluated through the assessments of the teacher who proposed it as well as a report and an oral defence before a jury. These projects can be a preparation for internship subjects and are therefore an opportunity to get in touch with the actors of the different laboratories. The themes of the projects cover robotics, mechatronics, control, perception, mechanics, movement study and can be extended to other fields that could seem relevant to the SAR specialty.

Examples of suggested topics.
- Manufacturing tolerancing in the digital chain.
- Realistic" geometric Modelling of the contact between surfaces.
- Integration of collision detection module.
- Shift algorithms for shape metrology.
- Design of a binaural head for the PR2 robot.
- Realization of a taxonomy of human postures.
- Optimization of a calculation for laying a tracked robot on uneven ground.
- Comparative study of trajectory tracking controllers for mobile robot type skid-steering.
- Robot teaching of sensory-motor capacities.
- State of the art grippers for palletizing.
- State of the art solutions for the deviation.
- Study of laser distance measurement solutions ...

Prerequisite. None

Resources available to students. Specific to each subject, on the decision of the mini-project supervisor.

Bibliography specific to each subject, as decided by the mini-project leader.

Skills developed in the unit.
- Knowing how to apply knowledge
- Working independently and in a team
- Synthesizing work
- Writing and presenting scientific results

Hourly volumes in and out of the classroom.
Work carried out independently, supervised by a tutor.

Evaluation.
The evaluation is based on a written report and an oral presentation.

Teacher. Mrs B. d'Andréa-Novel

Semester 10

Deepening Project

Level CMI5 - **Semester** S10 - **Credits** 3 ECTS - **Code** MU5EEG04 - Master's **degree in** Mechanics

Pedagogical presentation.
This deepening project is complementary to the specialization and can take different forms. It can represent the follow-up of an optional unit of additional specialization in semester S9 to broaden the knowledge base or to enhance a bibliographical part of the internship that would have been significant, or be associated with a scientific production for example in the context of the internship (presentation in a scientific conference, submission of a publication). It can also valorise an important associative investment or translate the validation of a teaching in the form of a MOOC (for example, a shared teaching on the European Virtual Exchange platform of the Sorbonne University Alliance 4eu+ network of partner universities: Charles University of Prague (Czech Republic), Heidelberg (Germany) and Warsaw (Poland), Universities of Milan (Italy) and Copenhagen (Denmark)). This project is usually carried out on an individual basis.

Content of the Teaching Unit.
Depending on the form of the project

Prerequisite miminum. Knowledge acquired in all teaching units since L1.

Bibliographical references. Function of the project subject.

Resources available to students. Function of the project subject and its environment.

Scientific knowledge developed in the unit

- Function of the project subject.

Skills developed in the unit.

- Take a step back from his training path.
- Know how to apply one's knowledge and apply it to a new open subject.
- Work independently and as a team.
- Knowing how to manage a personal project with commitment, defending it with conviction.

Hourly volumes in and out of the classroom.
Expected personal work: about 30 - 40 hours (and often more).

Evaluation. Evaluation usually in the form of a note of the written report, oral defence and involvement.

Teacher. Y. Berthaud, H. Dumontet.

SCIENCES SORBONNE UNIVERSITÉ

Graduation internship

Level CMI5 - **Semester** S10 - **Credits** 30 ECTS - **Code** MU5MES03 - **Mention** Master Mechanics

Pedagogical presentation.
This end-of-study internship takes place over 24 weeks at the end of the course. The objective is to enable the student to acquire an engineering attitude, in particular autonomy and the ability to work effectively in a team in the company, by relying on the knowledge acquired during the training and the skills developed in the simulation activities (projects, and previous internships). He consolidates the specialization and validates these acquired skills.

This internship can take place in France or abroad, in a company (generally in the R&D departments of large industrial groups) or research laboratory (provided that the student then has significant experience of an internship in a company). It leads to the writing of a report and a defence in French or English. The presentation is made in front of a mixed jury composed of members of the teaching team and external experts, including the supervisor in the case of an internship in a company.

Content of the Teaching Unit.
The course leaders validate the coherence of the subject, its adequacy with the speciality of the training, with the student's professional project and his/her academic results. This internship is the subject of an internship agreement signed by the company/laboratory, the university and the student.

Prerequisite miminum. All the knowledge and skills developed since the beginning of the course.

Resources available to students.

- List and description of previous internship topics. Internship offers.
- Validation procedures, drafting guidelines, internship agreements.
- Bibliographical resources according to the subject.

Scientific knowledge developed in the unit.

- Specific to each internship according to the subject area of the company / laboratory and the missions entrusted.

Skills developed in the unit.

- Knowing how to participate in teamwork, take initiatives, know how to situate oneself and acquire autonomy.
- Know how to apply one's knowledge and apply it to a new open subject.
- Be able to respect specifications and deadlines.
- Be Teacher for the quality of his work.
- Take a step back from his experience, gain confidence in professional integration.
- Know how to communicate about your work in writing and orally.

Hourly volumes in and out of the classroom. 24 weeks of full-time internship between March and the end of August.

Evaluation. Placement report (/35, about fifty pages excluding annexes), tutor evaluation (/30),
oral defence (/35 , 25 minutes presentation, 25 minutes questions).

Teacher. Course managers, Mr Y. Berthaud and Mrs H. Dumontet.