MASTER's programme

in Engineering of complex systems:

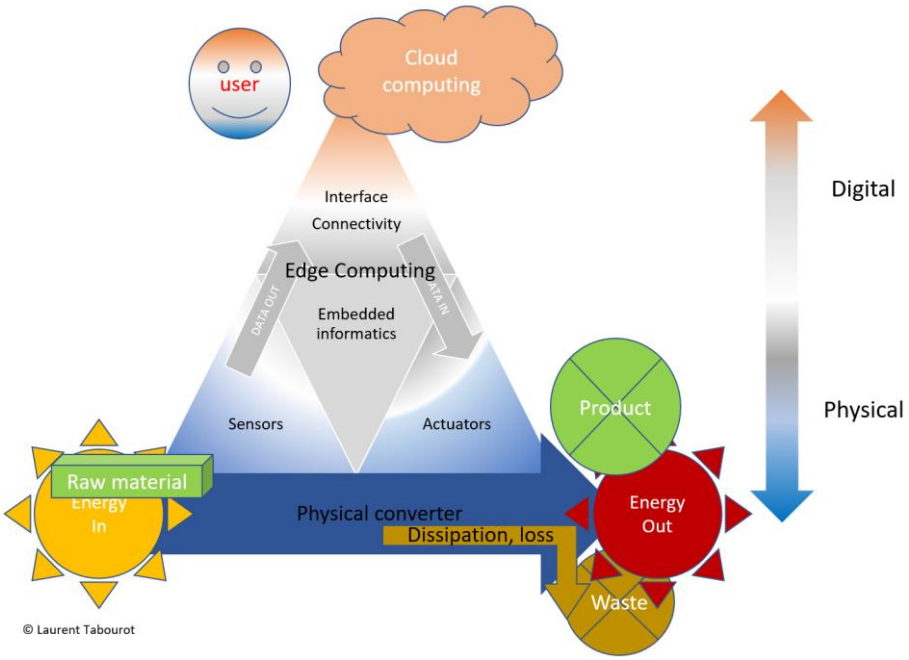
Advanced Mechatronics

MASTER'S in Engineering of complex systems - Advanced Mechatronics

Location: Annecy

OBJECTIVE

At the meeting point of the physical world and the digital world, Mechatronics is a synergistic and integrated process of several sciences and skills such as control science, computer engineering, electronics and mechanics. It allows to conceive and to design products and systems with increased or improved functionality. This requires the design of the product or system to be considered in its overall life cycle, in a collaborative interdisciplinary approach.



The objective is to enable students to imagine, design, implement and operate a Mechatronic system or product in the context of research projects, or research and development projects, and to prepare them for a PhD track.

Thus, upon completion of this programme, the students are prepared for doctoral studies. They can also work as engineers or in high-level technical and scientific positions in research centres, research and development departments and specialist consultancies.

COMPETENCIES AND KNOW-HOW:

The Master's students develop the necessary skills to meet the requirements of a multidisciplinary project in Mechatronics and become familiar with the requirements of a research activity through blended learning.

3 main skills are developed during the programme through supervised sessions, online courses, self-study and project- and problem-based learning.

These 3 main skills are:

1. Defining and solving research problems
   1.1. by identifying the issue (= *problématique* in French) and challenge of the research project, as well as its uncertainties and social, environmental, ethical, economic issues**.**
   1.2. By making an exhaustive analysis of the project context, including state of play (situational analysis), intellectual property and bibliographic study.
   1.3. by carrying out a methodological analysis and by choosing the appropriate method to develop the project work, by defining realistic objectives for the project.
   1.4. by producing original content, critical review, perspectives (vs. issues), with respect to ethical standards.

2. Managing a (research) project
   2.1. by knowing research organisation, research funding and by understanding project funding.
   2.2. by organising the project with a suitable and justified project method and adequate time management.
   2.3. By producing quality deliverables regarding indicators.
   2.4. by having appropriate team management (Project Owner, Team Members).
   2.5. by producing suitable written documents throughout the project.
   2.6. by communicating and interacting efficiently with people throughout the project.
   2.7. by managing the data during the project and by applying product life cycle follow-up.

3. Contributing to the design and realisation of a Mechatronic system.
   3.1. by defining the functional specifications and the global architecture of the system.
   3.2. by understanding, designing and developing the physical core of the system.
   3.3. by understanding, choosing, designing and implementing the required sensors and corresponding instrumentation.
   3.4. by understanding, designing, and developing data management routine, and their interfaces (human-machine interface, network).

USMB laboratories directly involved in the curriculum:
System and Materials for Mechatronics Laboratory (SYMME)
Computer Science, Systems, Information and Knowledge Processing Laboratory (LISTIC)
Laboratory for Design Optimization and Environmental Engineering (LOCIE)

Other USMB laboratories involved:
Annecy Laboratory for Particle Physics (LAPP)
Inter-university Laboratory of Human Movement Biology (LIBM)

SOME OF OUR INTERNATIONAL RELATIONSHIPS:

Fachhochschule Technikum Wien	Austria
Hochschule Kaiserslautern – University of Applied Sciences	Germany
University of Genoa	Italy
Universidad de Jaén	Spain
Technical University of Cluj-Napoca	Romania
AGH University of Science & Technology	Poland

Possibility to apply for a double Master's degree: Master in Systems Engineering - Advanced Mechatronics / Laurea Magistrale in Computer Engineering (industrial computer science or cyber-physical systems curricula) of the University of Genoa in Italy.

GENERAL STRUCTURE OF THE MASTER'S PROGRAM:

4 semesters (30 ECTS/semester) based on blended learning allowing the customization of the students' curriculum according to their background, their research project and their professional project:

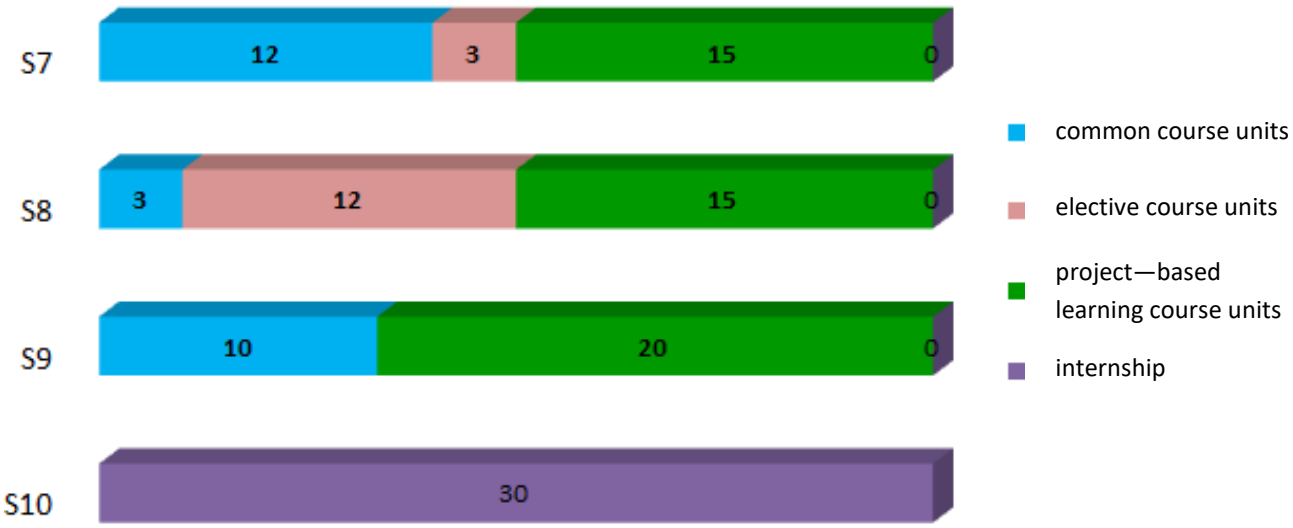
- ✓ Lectures/tutorials/practicals
- ✓ Self-learning through e-learning platforms
- ✓ Individual and collaborative project-based learning in research laboratories
- ✓ Participation in an international challenge (Robocup)
- ✓ Internship during the final semester (related to Research or to R&D)

DETAILED ACADEMIC STRUCTURE:

From semester S7 to semester S9:

- Project-based learning through research topics and through preparation for a participation in an international challenge (Robocup Challenge)
- Academic learning with a common core curriculum as well as elective courses

ECTS Distribution (1 ECTS~25 worked hours/student):



Semesters 7, 8 and 9 consist of 3 Teaching Units (“Unité d’enseignement” = UE). A teaching unit consists of one or more course units, some of which are project-based learning course units.

Semester 10 consists of a single teaching unit corresponding to the final internship (minimum 16 weeks).

The content of the programme is described in the following pages. The figures correspond to the number of hours (lecture, tutorials, practicals, self-learning) or to the number of credits (ECTS).

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Description of the programme

Acronym definitions: L = Lectures T =Tutorials Lab =Laboratory (= practicals) S-L =Self-learning (e-learning platforms)
ECTS: European Credit Transfer System

Semester 7

Teaching Unit	UE701: Mechatronics framework (10 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
MCTR701	Mechatronics common framework	Mechatronic product, specifications of a complex product, product lifecycle, understanding of the standards. Implementation of the process of the reliability prediction of mechatronic systems. Statistics and probabilities for measurements and reliability, data interpretation.	7,5	10,5	0	45	**3**
		Engineering and integration of systems (Systems Modelling Language)					
MCTR702	Metrology for mechatronic systems	Quality, measurement, repeatability, reproducibility	0	4,5	8	40	**3**
		Knowledge to choose an appropriate sensor, design a conditioning electronics, implement the constituting elements of the acquisition chain of an analogic or digital signal					
PROJ702	S7 international collective project: to take part in a collective project in the framework of an international challenge (Robocup challenge)						**4**

Teaching Unit	UE702: Tools for a research project (12 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
RECH701	Bibliographical tools & Project management	Main databases of bibliographic information (Isi Web of science, sciencedirect...), web search strategies – bibliographical tools (specialized search engines, meta-crawlers), sites to share (Researchgate, Academia.edu, ORCID…), grabbers (Zotero, Mendeley)	3	12	0	10	**2**
		Project management: project management methodology, planning techniques, project risk analysis and management, deliverables					
LANG701	Communication for research	Oral and written presentation tools, development of speaking in autonomy, understanding and use of technical and scientific English, Training for project presentations in English through the student S7 projects	0	28	0	12	**4**
PROJ703	S7 collective research project: to propose a technological solution of a problem which is part of a research project						**6**

Teaching Unit	UE703: Individual project and openness courses (8 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
PROJ701	S7 individual project: Mechatronic case study - To study the scientific and technological answers proposed to solve a given problem						**5**
+ 3 ECTS to choose in the courses below:							
MATE701	Materials for Mechatronics	Physical properties of materials: electrical, magnetic and thermal properties of materials	0	0	0	18	**2**
		Classification of materials and process and corresponding features, main methods and tools to select materials (databases, software), Specifications	4,5	6	8	6	
PHYS701	Heat transfer in mechatronic systems	Heat transfer: conductivity, convection, radiation applied to mechatronic systems	0	4,5	0	15	**1**
EASI701	Signals and systems, Continuous control	Basics of linear dynamical systems, Signal representation, Transfer functions, Frequency analysis, Basics of stability and control of dynamic systems, Stability of linear dynamical systems, Standard controllers, Robustness	0	1,5	8	30	**2**
INFO701	Development and deployment frameworks	Framework principles and implementation, integration with software engineering tools and use in the context of software engineering methodologies	0	0	12	6	**1**
LANG702	French for non-French speaking people (FLE)						**1**

Semester 8

Teaching Unit	UE 801: Toolbox for research in mechatronics (9 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
MCTR801	Modelling, simulation and numerical analysis	Digital data treatment, digital solving of differential equations, digital filtering	0	15	0	24	2
		Modelling of multiphysics systems, simulation (computer codes, dedicated software)					
RECH801	Core skills, Research organizations and standards	Management techniques and leadership	3	3	0	0	1
		Presentation of the profession of researcher by researchers working in academic organizations (CNRS, INRIA, etc.) and in companies,	7,5	0	0	0	
		Organization of Research: France and International / public and private - specialized and general organizations	3	0	0	0	
		French and international organization for standardization Terminology (standards, directives, regulation…) European directives impacting the mechatronic field: WEEE (Waste Electrical & Electronic Equipment), RoHS (Restriction of Hazardous Substances), CEM (electromagnetic compatibility) …	0	0	0	6	
PROJ803	S8 collective research project: to take part in the research project of a member of the permanent academic staff (or in a project proposed by an M2 student), to study a bottleneck of this project and propose a solution.						**6**

Teaching Unit	UE 802: International project and Design tools for mechatronics (11 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
PROJ802	Project to take part in a collective project in the framework of an international challenge (Robocup)						**4**
+ 7 ECTS to choose in the courses below:							
MCTR802	Design of experiments	Design of experiments: mathematical modelling of the response of a system, properties of design of experiments, how to define a design of experiment and to analyze the corresponding data	0	7,5	0	10	**1**
MECA801	Computer-aided design (CAD)	General presentation of the main business tools of mechanical design (Catia, Topsolid, Solidworks, Créo…), learning a business tool by the achievement of digital models, introduction to the management of the CAD-rapid prototyping (3D-printing) and CAD-PCB (printed circuit board) interfaces	0	0	18	10	**3**
EASI801	Instrumentation electronics, MEMS and actuators	Diodes, transistors, op-amp (amplification, filtering), Openness towards microelectronics and MEMS (micro-electromechanical systems)	0	0	20	20	3
		Electrical machines (asynchronous, synchronous, continuous, step-by-step, brushless), piezoelectric, hydraulic, pneumatic actuators					
INFO802	Architecture and robotics	Architecture for autonomous robotics, perception of the environment, models and tools for decision making, middleware for robotics (e.g. Ros) Architecture principles, services, applications	12	12	20	12	4
INFO801	Data science	Basic knowledge on processing, collection, handling and management of big amounts of data, on data mining, artificial intelligence, machine learning	6	6	8	20	2

Teaching Unit	UE 803: Individual project and specialisation/openness courses (10 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
PROJ801	S8 individual project: to study a group of patents related to a mechatronic system						**5**
+ 5 ECTS to choose in the courses below:							
MECA802	Finite element simulation	Mechanics, mechanical behaviour law of materials, experimentation, material parameters identification, data collection, result interpretation, principles of finite element codes	4,5	3	12	15	2
MATE801	Multiphysics coupling in materials	Materials with combined properties: electrostrictive, magnetostrictive, electro/magnetocaloric, thermomechanical materials Phase-change materials	0	6	9	20	2
PHYS801	Physics for autonomous wireless systems	Electromagnetism: propagation of waves, antennae, basics of electromagnetic compatibility	0	4,5	0	15	1
EASI802	Embedded control and computer science	Introduction to discrete time control: Discretization of continuous controllers, stability of discrete time systems, standard controller, implementation of discrete time controller Embedded system programming: real time issue, multi-task, sequencing, synchronization, competition, optimization / OS for embedded systems Technologies for networks, test tools / validation / checking of the requirements, deployment tools	15	3	16	40	3
INFO803	Security: protect the system from intrusion	Prevention of attacks/intrusions (security mechanism, Initiation to cryptology) Legal aspects (for example when usurping a user's identity – when accessing to confidential data – when setting up a contract for services in the cloud, etc.)	3	3	8	24	2
LANG802	French for non-French speaking people (FLE)						1

Semester 9

Teaching Unit	UE901: Embedded systems and supervision (13 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
MCTR901	Embedded systems Introduction to supervision methods, models and tools	Embedded computing system (microprocessors, FPGA, PSOC …), wireless communication technologies (WIFI, Zigbee, Bluetooth…), integrated sensors (analog or digital)	0	7,5	9	0	**3**
		Introduction to methods, models and tools for supervision of process and applications and more generally of systems (information systems, robots, etc., demonstration of a supervision system (e.g. supervision of a network)	3	0	3	12	
PROJ901	Collective project to take part in the research project of a member of the permanent academic staff or in a project proposed by an M2 student. To study a bottleneck of this project and to propose a solution.						**10**

Teaching Unit	UE902: Rights, ethics and scientific diffusion (9 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
RECH901	Intellectual property, contracts, Law	Intellectual property: definitions, rights and obligations French, European and international organisms	4,5	6	0	12	**2**
		Software protection: software licenses, collaborative works					
		Principles of labor law (in the context of research, research and development in Europe) Contract and contractual liability Work on examples of research contracts (French, European, private), comparison between a few countries					
RECH902	Ethics and Scientific diffusion	Introduction to Ethics, issues studied through the analysis of exemplary cases consequences of new technologies on citizens' private life: risks of the internet of things, use of personal data	9	7,5	0	11	**2**
		Reviews and conferences / best practices for writing a scientific publication / how to submit a communication / private/public access / open access - Patents = What is a patent / patent structure / registering organization / process of application					
		Plagiarism definition, corresponding risks, legal consequences, plagiarism detection tools, protection against plagiarism					
PROJ902	Individual project to write a scientific article based on the S8 research project or the state of the art on a given mechatronic system						**5**

Teaching Unit	UE903: Preparation for doctoral studies (8 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
RECH903	Research funding and PhD Communication	Research funding (Research projects, doctoral grants) and innovation funding (technology transfer, Start-up creation)	3	0	0	0	3
		The doctoral studies					
		TOEFL or TOEIC preparation (for students who plan to apply for a doctoral position in an English-speaking country)	3	22	0	15	
		Conversation analysis, negotiation, argumentative techniques, written communication					
PROJ903	Collective S9 project to take part in a collective project in the framework of an international challenge (Robocup)						5

Semester 10: Internship and Master thesis

Teaching Unit	UE 1001: Internship devoted to a research topic (30 ECTS)						
Course Unit	**Title of the course unit**	**Content**	**L**	**T**	**Lab**	**S-L**	**ECTS**
PROJ1001	Internship devoted to a research topic and Master Thesis						**30**