INSA Toulouse

National Institute of Applied Sciences

Course Catalogue

Available Courses for Exchange Students
Courses organized by specialization

Academic Year 2026–2027

Last updated: May 18, 2026

International Relations Office
INSA Toulouse
135 Avenue de Rangueil
31077 Toulouse Cedex 4
France

Email: welcome@insa-toulouse.fr
Phone: +33 (0)5 61 55 95 13
Website: www.insa-toulouse.fr

Welcome to INSA Toulouse 3
Introduction . . . 3
Becoming an exchange student at INSA Toulouse . . . 3
The structure of an academic module at INSA Toulouse . . . 4
Academic calendar . . . 4

How to read the course structure ? 5
3^{rd} year engineering courses (bachelor level) . . . 5
4^{th} and 5^{th} year engineering courses (master level) . . . 6

Academic options to explore 7
French as a Foreign Language, Foreign Languages and English-taught Humanities Courses . . . 7
European Consortium of Innovative Universities (ECIU) . . . 7
Summer Schools . . . 7

Engineering Courses 8
Biological engineering . . . 9
Chemical Engineering: Water, Energy, Environment . . . 12
Applied Physics . . . 15
Automatic Control and Electronics . . . 18
Mechanical Engineering . . . 23
Civil Engineering . . . 28
Computer Science and Networks . . . 31
Applied Mathematics . . . 36

Humanities Courses 39
Humanities and Social Sciences . . . 40

Masters of Science Courses 42
Engineering for Durability, Research and Innovation in Materials and Structures . . . 43
Industrial BioTechnology for a Bio-Based Economy . . . 44
Fluids Engineering for Industrial Processes . . . 45

Cross-Disciplinary Courses 46
Urban Engineering . . . 47
Innovative Smart Systems . . . 48
Energy . . . 49

Course Syllabus 50

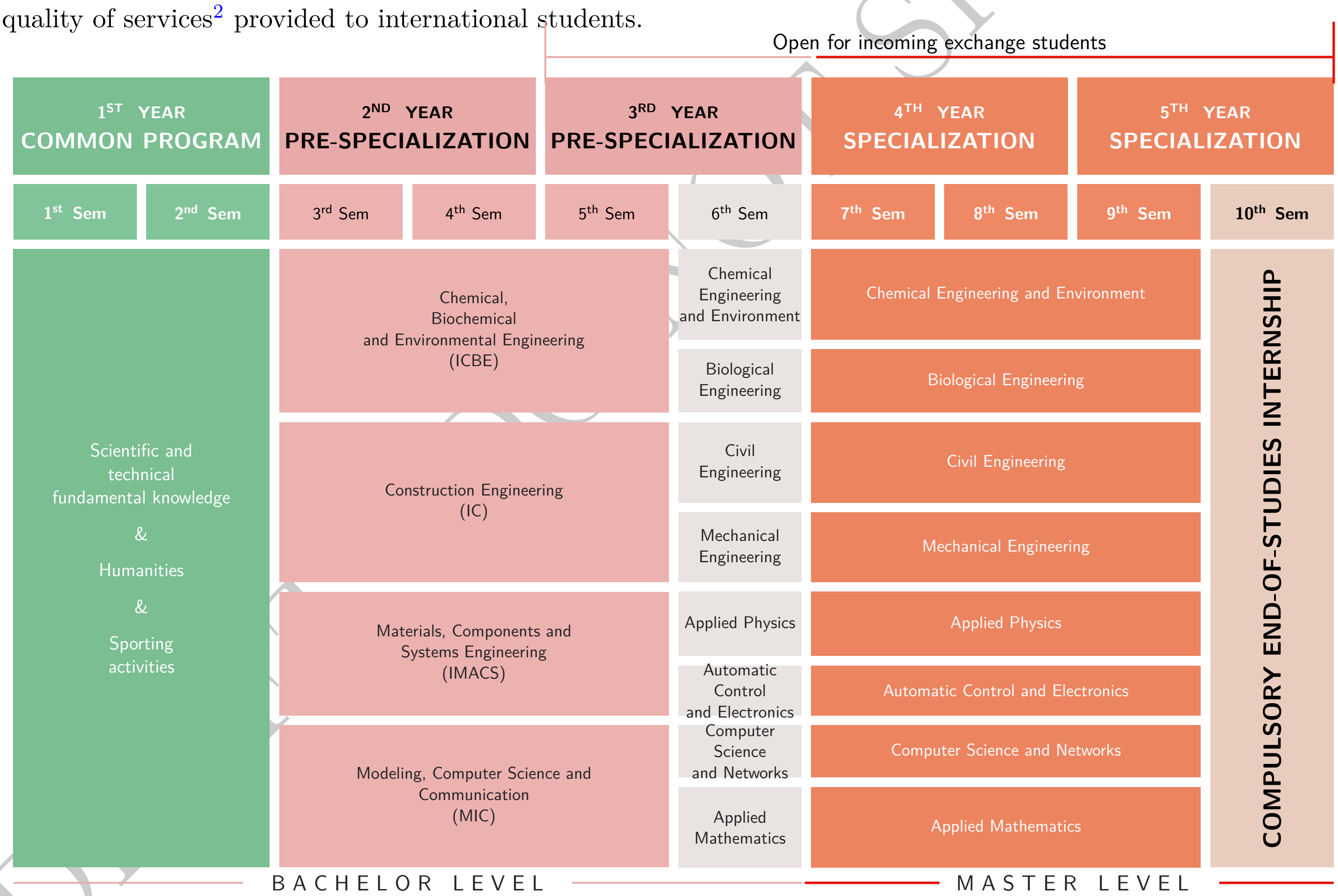
Welcome to INSA Toulouse

Introduction

Founded in 1963, INSA Toulouse is an international and multidisciplinary public engineering school[1] that offers a 5-year higher education degree programme leading to the "Engineering Degree", equivalent to a Master of Science. The curriculum, which begins right after the French baccalauréat (equivalent to A-levels), is divided into three phases:

- Year 1: a common track for all engineering students to acquire fundamental knowledge
- Year 2 and 3 (Bachelor level): 4 pre-specializations
- Year 4 and 5 (Master level): 8 specializations

The curriculum was designed to develop students' autonomy, allowing them to build their own professional projects step by step while acquiring robust scientific knowledge and developing both specific and transversal skills. INSA Toulouse students have the opportunity to explore different activities and careers by visiting companies, completing short- to medium-term internships, and attending conferences and professional meetings. INSA Toulouse has also been awarded the "Bienvenue en France" label - with the highest rating of three stars - which recognizes the quality of services[2] provided to international students.



Becoming an exchange student at INSA Toulouse

All students may be exchange students at INSA Toulouse, provided that their home institution signed a Cooperation Agreement (Erasmus+ or bilateral agreement) with INSA Toulouse. Exchange students are welcome to all INSA Toulouse for up to 2 semesters. Students are strongly encouraged to choose their courses in one speciality in order to prevent scheduling conflicts, except for courses from humanities and social sciences center, which can be chose in addition to engineering courses. 1 ECTS credit represents around 30 hours including in-class lectures and personal academic work. The learning agreement must be set up in close collaboration with the international academic coordinator of the host department and his/her counterpart in your home university.

[1] French "Grande École", highly selective based on academic criterias
[2] welcoming and supporting international students before, during, and after their arrival

The structure of an academic module at INSA Toulouse

Lectures

A lecture course brings together all students enrolled in the same specialization and last 1 hour 15 minutes. The lecture is delivered by a single professor to the entire class, typically in a lecture hall.
The lecture aims to provide the overall framework and core concepts of the specialization, rather than detailed technical calculations, except when needed to illustrate key mathematical relationships.
For the undergraduate level (3^{rd} year), lectures are conducted in french, but the course materials will be printed in English for non-French-speaking students.

Tutorials

Tutorial sessions are conducted in small groups, typically composed of around 24 students, and last 1 hour 15 minutes. During these sessions, the professor solves on the board an exercise that students have prepared beforehand. These classes are designed to allow students to ask specific questions and seek clarification directly from the professor. The professor may also revisit sections of the lecture that were not fully understood.
These are highly interactive sessions, fostering mutual exchange between students and the professor. Tutorials are also the time to delve into the technical aspects of calculations and problem-solving. They serve as essential preparation for the final examination of the course.

Laboratory works

Practical sessions, whether in laboratories or workshops, allow students to apply the concepts learned in lectures and tutorials. They provide hands-on experience and the opportunity to test theoretical principles in real or simulated conditions. Conducted in small groups—often with students working in pairs—these sessions promote collaboration, discussion, and peer learning. Practical sessions are taught in English, with all materials and documentation provided in English, and serve as an essential complement to lectures and tutorials, helping students consolidate their understanding through direct application.

Projects

This project aims to foster student autonomy by engaging them in a specific and well-defined topic. Under the guidance of a professor, students—often working in pairs—are introduced to the project, its objectives, and constraints. Projects may be experimental or theoretical, and are typically connected to the research activities of the supervising professor. The duration and scope of each project vary depending on the number of allocated hours and ECTS credits. Through this hands-on experience, students develop their ability to work independently while applying their knowledge to real academic or scientific challenges.

Exams

Most exams are written and last between 1 hour 15 minutes and 2 hours, depending on the module. Laboratory sessions are assessed either through a practical exam or by continuous evaluation during the session.

Academic calendar

Semester Dates	First semester : September (dates non-determined yet) *(2025 – 2026 = September 8^{th}, 2025 to January 16^{th}, 2026)* Exam Session dates: January
	Second semester : January (dates non-determined yet) *(2025 – 2026 = January 26^{th} to June 12^{th}, 2023)* Exam Session dates: June

How to read the course structure ?

3rd year engineering courses (bachelor level)

Internal code associated with a course unit. Click on the code to display the corresponding ECTS description.

ECTS credits associated with each course unit.

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MAMH10-exc	Hamiltonian mechanics	FR	1		13.75		
I3MAAN10-exc	Numerical analysis	FR	2	10.0		16.5	
I3MALC10-exc	Programming in C	EN/FR	2	6.25	6.25	5.5	
I3MAPH10-exc	Physical meas. and statistical modelling	EN/FR	4		7.5	37.5	
I3MACE10-exc	In-depth study of electronic circuits	EN/FR	4	13.75	15.0	5.5	
I3MASC10-exc	Semiconductors	EN/FR	4	22.5	12.5		7.0
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	
I3MAOP10-exc	Waves and propagation	EN/FR	3	17.5	7.5	8.25	

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MAPAM20-exc	Applied material physics	FR	3	1.25		37.5	
I3MADD20-exc	Dislocations and deformations	FR	1	6.25	5.0		
I3MAPJ20-exc	Scientific project	EN/FR	1				5.5
I3MASS20-exc	Structure of solids	EN/FR	3	13.75	7.5	15.0	
I3MATH20-exc	Thermodynamics	EN/FR	2	23.75	15.0		
I3MADI20-exc	Point defects and diffusion	EN/FR	1	8.75	6.25		
I3MAAN20-exc	Anisotropic physical properties of materials	EN/FR	2	15.0	10.0		
I3MACO20-exc	Cohesion	EN/FR	1	6.25	1.25		
I3MAPQ20-exc	Quantum physics	EN/FR	2	13.75	7.5		
I3MAPS20-exc	Statistical physics	EN/FR	3		31.25		
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		

Course unit title

FR indicates that the language and instructional materials are in French. EN/FR indicates that all instructional materials are in English, and that the language of instruction is English except for lectures.

The data listed in columns L, T, LW, and P correspond respectively to Lecture hours, Tutorial hours, Lab Work hours, and Project hours.

4^{th} and 5^{th} year engineering courses (master level)

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

When ECTS credits are specified for the constituent components, they are divisible and can be selected independently of one another. When they are not specified, the components cannot be separated and the course unit must be selected as a whole.

Internal code associated with a course unit. Click on the code to display the corresponding ECTS description.

ECTS credits associated with each course unit.

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GBBM11-exc	Eukaryotic molecular biology and enzyme engineering	7	Eukaryotic molecular biology	EN		30.0	6.25	15.0	6.25
			Enzyme engineering	EN		10.0		13.5	
I4GBBC11-exc	Cellular metabolism and regulation	6	Metabolic biochemistry	EN	3	26.25	2.5	9.0	
			Microbial physiology	FR	3	16.25		9.0	
I4GBBC21-exc	Biochemical kinetics and bioreactor	5	Bioprocess engineering	FR		16.25	7.5	13.5	
			Bioreactor engineering	FR		15.0	10.0	9.0	3.75
I4GBTF11-exc	Mass transfer	5	Mass transfer operations	FR		30.0	7.5	4.0	

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GBBC41-exc	Cell culture for biotherapies	6	Cell culture for biotherapies	EN		30.0	2.5	45.0	3.75
I4GBBC31-exc	Microbial cultures	6	Microbial cultures	EN		31.25	15.0	31.5	
I4GBTF21-exc	Unit operations	5	Unit operations	FR		20.0	7.5	54.0	
I4GBPJ11-exc	Pluridisciplinary projects	5	Quality and safety management	FR		11.25	12.5		
			Project management	FR		7.5	2.5		
			Multidisciplinary project	FR					35.0

Course unit title

Description of the constituent components of a course unit

EN indicates that lectures, tutorials, lab sessions, and projects are conducted in English, with materials provided in English. FR indicates the same in French. EN/FR indicates that either language may be used, typically in group-based teaching where the instructor adapts to the students' language.

The data listed in columns L, T, LW, and P correspond respectively to Lecture hours, Tutorial hours, Lab Work hours, and Project hours.

Academic options to explore...

French as a Foreign Language, Foreign Languages and English-taught Humanities Courses

INSA Toulouse offers 2 types of French language courses for its international students: in August as a Summer School and throughout the year via its Humanities Department (CSH). Students are advised to choose FLE courses even if they only take courses taught in English. INSA Toulouse also offers its international students other foreign languages courses (Spanish, German, Italian, Japanese, Chinese and Sign Language).

European Consortium of Innovative Universities (ECIU)

Contact : eciu-university@insa-toulouse.fr

An enriching and innovative way to complement an exchange experience or complete a study plan is offered through ECIU University. Participation in real-life challenges allows involvement in international and multidisciplinary teams working on concrete issues. These challenges are proposed by cities, regions, companies, or public institutions, providing direct interaction with external partners and engagement with topics of real societal impact. Throughout this experience, guidance is provided by experienced teachers who facilitate collaboration. Innovative solutions are developed while a wide range of skills essential for a professional career are strengthened. These learning activities award ECTS credits and can be flexibly integrated into a study plan. In addition, ECIU University micro-modules are available to support the acquisition of specific knowledge and skills required to address challenges or to deepen expertise. Upon successful completion, micro-credentials are awarded, formally recognizing achievements and contributing to both academic and professional development. More information and applications: https://engage.eciu.eu/

Summer Schools

Contact : Marine Hatier

INSA Toulouse offers two international summer schools every year in June, providing students with a unique two-week (or four-week) experience that combines academic excellence, practical learning, and cultural immersion in the south of France. Both programs are designed as all-inclusive packages, including on-campus accommodation, lunches, guided city tours, cultural activities, and the discovery of local gastronomy, allowing participants to fully enjoy both the academic and social dimensions of their stay in Toulouse.

The MINATO Summer School focuses on micro- and nano-fabrication technologies, nanoscience, and applied electronics. Participants benefit from lectures, laboratory sessions, and interdisciplinary projects in cutting-edge technological fields. A major highlight of the program is the access to a high-level clean room facility — one of only five facilities of this kind in France — offering students a rare hands-on experience in advanced micro- and nanotechnologies. https://www.aime-toulouse.fr/summer-school-minato/

The SECOIAS Summer School is dedicated to security and communication in aerospace embedded systems. The program combines theoretical courses, hands-on activities, and industrial visits in areas such as avionics, telecommunications, cybersecurity, and embedded systems. Located in Toulouse — widely recognized as the European capital of aerospace — the summer school gives students direct exposure to one of Europe's leading aerospace ecosystems. https://gei.insa-toulouse.fr/fr/international/secoias.html

Beyond the academic content, both summer schools offer an enriching cultural program including guided visit of Toulouse, excursions to UNESCO World Heritage sites, and opportunities to discover the rich gastronomy and cultural heritage of the Occitanie region. These activities create a dynamic international atmosphere and encourage exchanges between students from around the world.

Engineering Courses

by Field of Specialization

Biological engineering

The objective of the Biological Engineering specialization is to train engineers who master the whole set of methodologies dealing with the biological conversion of biotic and non-biotic materials, from the laboratory to the industrial scale. Biological engineers design and develop new biocatalysts (enzymes and microorganisms) that meet industrial constraints, and calculate and optimize the performance of biological reactors and extraction-purification processes.

3^{rd} year (bachelor level)

Contact: Claude Maranges

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3BEMF10-exc	Fluid mechanics	EN/FR	5	20.0	22.5	9.0	
I3BETT10-exc	Heat transfer	EN/FR	4	12.5	13.75	10.5	
I3BEGH10-exc	Hydraulic engineering	EN/FR	3	7.5	16.25	9.0	10.0
I3BEPT10-exc	Process engineering	EN/FR	3		25.0		
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	
I3BEMI10-exc	Microbiology	EN/FR	2	10.0	2.5	1.25	
I3BEGB11-exc	Bacterial genetics	EN/FR	3	18.75	11.25	7.5	

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3BEEZ20-exc	Enzymology	EN/FR	4	23.75	10.0	22.5	
I3BEBP20-exc	Biophysics	EN/FR	3	16.25	10.0	1.25	
I3BECO20-exc	Organic chemistry	EN/FR	3	3.75	7.5		26.25
I3BECS21-exc	Structural chemistry	EN/FR	3	12.5	13.75	4.0	
I3BEBS20-exc	Bioseparation	EN/FR	3	11.25	3.75	15.0	
I3BEGG20-exc	Genetics engineering	EN/FR	3	17.5		18.75	6.25
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		

[1] When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4^{th} year (Master 1 level)

Contact : Jean-Pascal Capp

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GBBM11-exc	Eukaryotic molecular biology and enzyme engineering	7	Eukaryotic molecular biology	EN		30.0	6.25	15.0	6.25
			Enzyme engineering	EN		10.0		13.5	
I4GBBC11-exc	Cellular metabolism and regulation	6	Metabolic biochemistry	EN	3	26.25	2.5	9.0	
			Microbial physiology	FR	3	16.25		9.0	
I4GBBC21-exc	Biochemical kinetics and bioreactor	5	Bioprocess engineering	FR		16.25	7.5	13.5	
			Bioreactor engineering	FR		15.0	10.0	9.0	3.75
I4GBTF11-exc	Mass transfer	5	Mass transfer operations	FR		30.0	7.5	4.0	

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GBBC41-exc	Cell culture for biotherapies	6	Cell culture for biotherapies	EN		30.0	2.5	45.0	3.75
I4GBBC31-exc	Microbial cultures	6	Microbial cultures	EN		31.25	15.0	31.5	
I4GBTF21-exc	Unit operations	5	Unit operations	FR		20.0	7.5	54.0	
I4GBPJ11-exc	Pluridisciplinary projects	5	Quality and safety management	FR		11.25	12.5		
			Project management	FR		7.5	2.5		
			Multidisciplinary project	FR					35.0

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5th year (Master 2 level)

Contact : Jean-Pascal Capp

Semester 1, starting from September

Major Microbiology and Industrial Biocatalysis

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GBBC1101-exc	Microbiology *	12	Microbiology	FR		35.0		100.0	
I5GBBC1103-exc	Biocatalyse *	12	Biocatalyse	EN		35.0		100.0	
I5GBPJ21-exc	Design project	12	Design project	EN					120.0

Major Structural Biology

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GBBM11-exc	Systems and Synthetic Biology for biotech.	12	Systems and Synthetic Biology for biotechnologies	EN		45.0		100.0	
I5GBPJ21-exc	Design project	12	Design project	EN					120.0

Major Bioinformatics

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GBioComp11-exc	Programming and Applications	10	Digital Tools and Fundamentals	FR			60.0		
			Bioinformatics Challenge Project	FR		2.5	23.75		
			RNA-Seq Project	FR					23.75
I5GBioComp21-exc	From Genome to Systems	14	Genomics	FR	4		63.0		
			Post-genomics	EN	3		45.0		
			Integrative Biology	EN	4		42.0		
			Structural and Computational Biology	EN	3		35.0		

(*) Students can only choose one.

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

Chemical Engineering: Water, Energy, Env.

The aim of this program is to train engineers capable of addressing the major challenges related to water, energy, and the environment, empowering them to become proactive contributors to today's socio-economic landscape and future leaders in the energy transition, circular economy, and climate change adaptation.

3rd year (bachelor level)

Contact: Stephanie Laborie-Manton

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3BEPC10-exc	Physical chemistry	FR	2	12.5	2.5	3.0	
I3BEMF10-exc	Fluid mechanics	EN/FR	5	20.0	22.5	9.0	
I3BETT10-exc	Heat transfer	EN/FR	4	12.5	13.75	10.5	
I3BEGH10-exc	Hydraulic engineering	EN/FR	3	7.5	16.25	9.0	10.0
I3BEPT10-exc	Process engineering	EN/FR	3		25.0		
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	
I3BESD10-exc	Dispersed systems	EN/FR	3	10.0	16.25	12.0	

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3BEAN23-exc	Analytical methods 2	FR	3				35.0
I3BETH23-exc	Thermodynamics and energy	FR	4	27.5	21.25		
I3BEER23-exc	Water, environment and risks	FR	4	28.75	16.25		5.0
I3BETM23-exc	Mass transfer	EN/FR	3	15.0	12.5	7.0	5.0
I3BERR23-exc	Chemical reaction engineering II	EN/FR	4	11.25	30.0	3.5	
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		

[1]When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4^{th} year (Master 1 level)

Contact : Etienne Paul

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4PEFM10-exc	Filtration and mixing operations		Membrane filtration	FR		6.25	8.75	7.0	
			Depth filtration	FR		2.5	2.5		
			Mixing and agitation	FR		3.75	5.0		
I4PESE10-exc	Thermal separation operations		Phase equilibria	FR		3.75	2.5	8.75	
			Distillation and evaporation operations	FR		6.25	8.75	14.0	
I4PESQ10-exc	Phase equilibria and separation processes		Liquid–liquid extraction	FR		6.25	3.75	7.0	6.25
			Adsorption processes	FR		3.75	3.75		6.25
			McCabe–Thiele method	FR		2.5	1.25		
I4PERH12-exc	Heterogeneous reactions engineering		Heterogeneous reaction engineering	FR		10.0	25.0	7.0	
I4PESI10-exc	Processes simulation	4	ProSim process simulation software	EN		1.25		18.0	
			Umberto sustainability modelling software	EN		8.75		18.0	
			ANSYS Fluent computational fluid dynamics software	EN		5.0		15.0	
I4PERE10-exc	Electrochemical reactors for water, energy and environment		Electrochemical reactors for water, energy and the environment	FR		8.75	8.75	3.0	
I4PEBE12-exc	Careers in Chemical Engineering (2)		Job opportunites for GPE	FR		6.0	6.0		

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4PEEC20-exc	Heat exchangers	3	Heat exchangers and coupled heat transfer	EN		10.0	11.25	12.5	
			Heat exchanger networks	EN		1.25	3.75		
I4PEPT20-exc	Thermodynamic processes for energy systems		Steam power plants	FR		5.0	6.25	6.25	
			Thermodynamic power generators	FR		2.5	6.25	6.25	
			Gas liquefaction	FR		1.25	1.25		
I4PEPE20-exc	Renewable energy production		Wind energy	FR		7.5	5.0		2.5
			Solar energy	FR		3.75	3.75		
			Hydropower	FR		2.5			
I4PEME20-exc	Metrology for water and the environment	3	Metrology for water and the environment	EN		3.75	6.25	24.0	
I4PERB21-exc	Biological reactors	4	Biological reactors	FR		18.75	13.75		
I4PEEA20-exc	Processes for water production and the circular water economy	4	Processes for water production and the circular water economy	EN		18.75	11.25	10.5	
I4PEPI20-exc	Introductory research project	4	Introductory research project	EN		3.75	2.5		15.0

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5^{th} year (Master 2 level)

Contact : Etienne Paul

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5PEPR10-exc	Design project	12	Design Project	EN					15.0
			Eco-Design and Bioeconomy	EN		8.75	2.5		
I5PEEM10-exc	Energy and Value Creation	?	Waste Recovery Processes	FR	?	11.25	26.25		
			Biological Processes for Water Treatment	EN	4	15.0	20.0	7.0	
			Green Energy Processes	FR	?	25.0	18.75		
I5PEME10-exc	Drive and operate efficiently	12	Process Control	EN		11.25	10.0	16.25	
			Optimization of Sustainable Processes	EN		8.75	12.5	18.75	
			Reactor Design and Multiphase Flow	EN		12.5	5.0		3.75

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

Applied Physics

The Applied Physics specialization trains engineers with a broad scientific background to tackle tomorrow's technical and scientific challenges. The main areas of study include materials and component physics, nanotechnology, sensors, instrumentation, as well as testing and measurement

3^{rd} year (bachelor level)

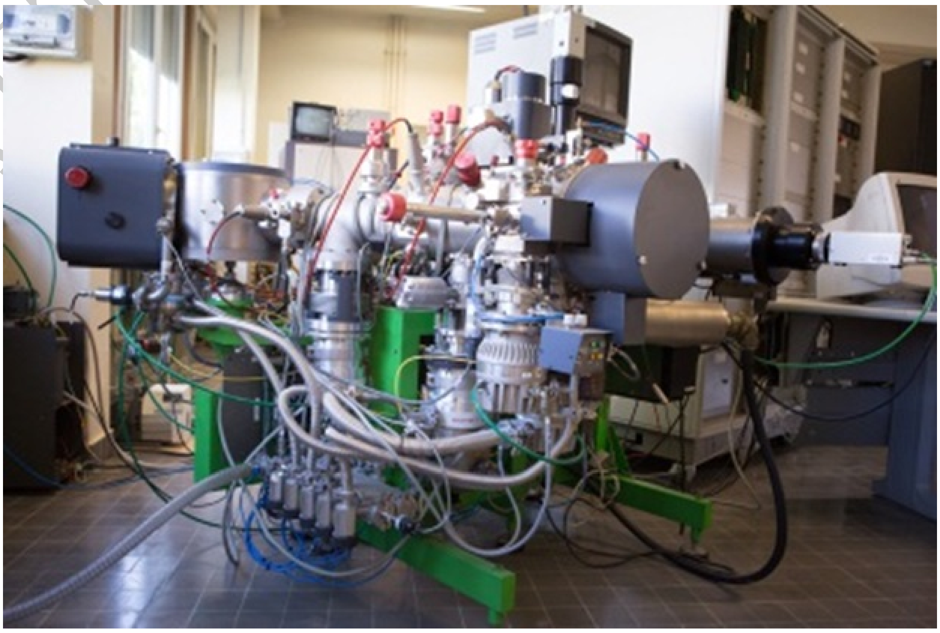
Contact: Guillaume Auriol

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MAMH10-exc	Hamiltonian mechanics	FR	1		13.75		
I3MAAN10-exc	Numerical analysis	FR	2	10.0		16.5	
I3MALC10-exc	Programming in C	EN/FR	2	6.25	6.25	5.5	
I3MAPH10-exc	Physical meas. and statistical modelling	EN/FR	4		7.5	37.5	
I3MACE10-exc	In-depth study of electronic circuits	EN/FR	4	13.75	15.0	5.5	
I3MASC10-exc	Semiconductors	EN/FR	4	22.5	12.5		7.0
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	
I3MAOP10-exc	Waves and propagation	EN/FR	3	17.5	7.5	8.25	

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MAPAM20-exc	Applied material physics	FR	3	1.25		37.5	
I3MADD20-exc	Dislocations and deformations	FR	1	6.25	5.0		
I3MAPJ20-exc	Scientific project	EN/FR	1				5.5
I3MASS20-exc	Structure of solids	EN/FR	3	13.75	7.5	15.0	
I3MATH20-exc	Thermodynamics	EN/FR	2	23.75	15.0		
I3MADI20-exc	Point defects and diffusion	EN/FR	1	8.75	6.25		
I3MAAN20-exc	Anisotropic physical properties of materials	EN/FR	2	15.0	10.0		
I3MACO20-exc	Cohesion	EN/FR	1	6.25	1.25		
I3MAPQ20-exc	Quantum physics	EN/FR	2	13.75	7.5		
I3MAPS20-exc	Statistical physics	EN/FR	3		31.25		
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		



[1] When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4th year (Master 1 level)

Contact : Pier Francesco FAZZINI

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GPPM11-exc	Condensed Matter Physics I	6	Quantum physics	EN		18.75	15.0		
			Solid state physics I	EN		18.75	10.0		
I4GPLP11-exc	Laboratory Works Multiphysics Measurements I	3	Microstructural Characterisation I	EN	1	3.75		14.0	
			Optical, Magnetic and Electronic Characterisation I	FR	1			14.0	
			Advanced Optics	EN	1	11.25	3.75	4.0	
I4GPPJ11-exc	Multidisciplinary project I	3	Multidisciplinary project I	EN/FR		6.25	3.75		25.0
I4GPEL11-exc	Electronic and signal processing	5	Electronics	FR		8.75	8.75	24.0	
			Signal processing	FR			13.75		
I4GPII11-exc	Instrumentation	5	Laboratory classes in instrumentation	EN				32.0	
			Project-based learning	EN		2.0			18.75
			Laboratory classes in LabVIEW	EN		2.0		6.0	
			Laboratory classes in LabWindows/CVI	EN				4.0	
			Laboratory classes in Python	EN			2.0		

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GPPM21-exc	Physical properties of Condensed Matter II	6	Dielectrics	FR			11.25		
			Magnetism	FR		10.0	7.5		
			From molecule to material	FR		10.0	8.75		
I4GPLP21-exc	Laboratory Works Multiphysics Measurements II	3	Electronic, optical and magnetic characterisation II	EN				14.0	
			Microstructural characterisation II	EN				14.0	
			Atomic force microscopy	EN				7.0	
I4GPSE21-exc	Ecological transition scenarios	3	Nuclear instrumentation	FR	1	5.0			
			Ecological transition scenarios (STE)	EN	2	6.25			16.25
I4GPMH21-exc	From the sensor to the test bench in open source hardware	3	Microcontroleurs et open source hardware	EN		1.25	26.25		
			Sensors	EN		5.0	7.5		
			Analogue electronics	EN			2.5		
			Shield development	EN			2.5		
			Test bench development	EN			1.25		
I4GPPJ21-exc	Multidisciplinary project II (*)	2	Multidisciplinary project II (*)	EN/FR					25.0
I4GPSQ21-exc	Safety, quality and applications to measurement	7	Introduction to quality management	FR		2.5	2.5		
			Design of experiments	FR		5.5	12.5		
			Micro- and nanotechnologies	FR		8.75		26.0	
			Physics of advanced devices	FR		10.0	7.5		

(*) Multidisciplinary Project II may only be selected if Multidisciplinary Project I has been completed.

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5^{th} year (Master 2 level)

Contact : Pier Francesco FAZZINI

Semester 1, starting from September

Core courses

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GPAP11-exc	Applied physics and Scientific Communication	3	Laser Physics	EN		16.25			
			Optoelectronics	EN		10.0			
			Energy Engineering	EN		12.5	1.25		
I5GPPV11-exc	Physics Engineering and knowledge Transfer	7	Physical Eng. for Biology, Health and Envir.	EN	1	12.5			
			Microwave Engineering	FR	1	13.75			
			Plasma Physics	FR	1	8.75			
			Advanced Materials and Technologies	FR	1	13.75			
			Electromagnetic Compatibility (EMC)	FR	1	10.0			
			Failure Analysis	FR	1	5.0			
			Technology Transfer and Innovation	FR	1	2.5			

Major 1 – Instrumentation

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GPII11-exc	Advanced intrumentation 1	5	VXI (VME eXtensions for Instrumentation)	FR		13.75		10.0	
			VISA (Virtual Instrument Software Architecture)	FR		11.25		12.5	
			Design and Qualification of an Indus. Meas. Sys.	FR		15.0			
I5GPII12-exc	Advanced intrumentation 2	5	CAN Bus (Controller Area Network)	FR			7.5	7.5	
			Advanced Virtual Instrumentation	FR		8.75		4.0	
			Real-Time Instrumentation	FR		10.0		12.0	

Major 2 – Nano-electronics

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GPTI11-exc	Innovative technologies, devices and materials	5	Advanced Physics Laboratory	EN	1			12.0	
			Radiation–Matter Interaction	EN	2	2.5		11.0	
			Near-field microscopy	FR	2	12.5		10.0	
I5GPNN11-exc	NanoPhysics and Nanochemistry	5	Nanoelectronics and Spintronics	EN		21.25			
			Nanochemistry	EN		10.0			
			Quantum Technologies	EN		6.25		12.0	

Minors – students can only choose one.

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GPNB11-exc	Nano-bioengineering	2	NanoBio – Biomedical Applications	EN			10.0		
			NanoBio – Devices and Experimental Methods	EN			8.0	11.5	
I5GPPC11-exc	Charged particle optics	2	Charged Particle Optics	EN			17.5	12.5	
I5GPNC11-exc	Gas Sensor	2	Nanosensors	FR			3.0	25.0	

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

Automatic Control and Electronics

The Automatic Control and Electronics specialization trains engineers to design complex systems using skills in control, signal processing, electronics, and computer science, including the development of control and electronic subsystems with appropriate IT tools.

3rd year (bachelor level)

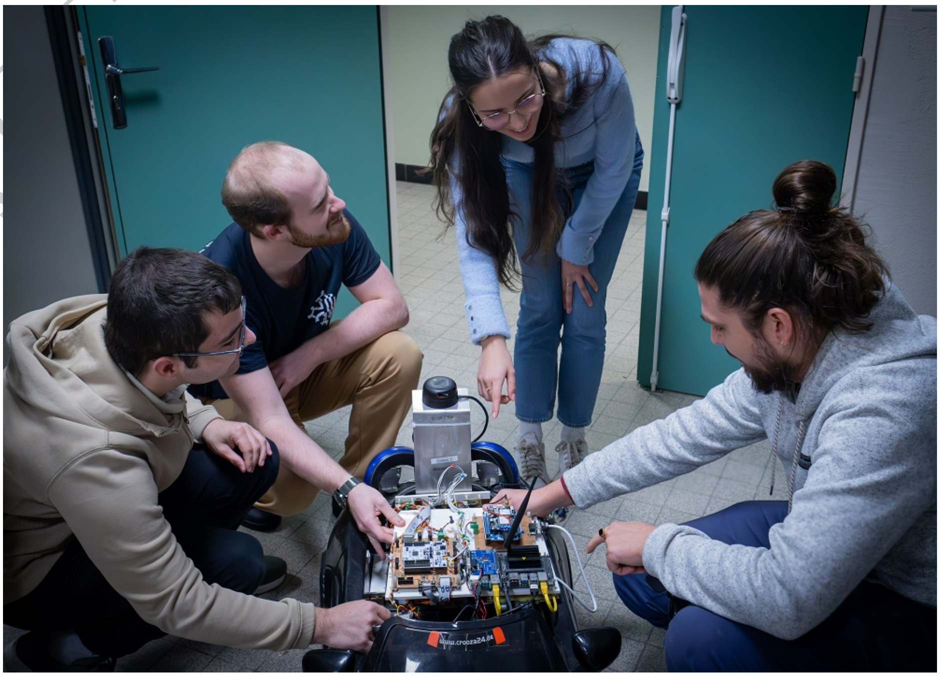
Contact: Guillaume Auriol

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MAFI10-exc	Digital filtering	FR	2	7.5	7.5	8.25	
I3MAAN10-exc	Numerical analysis	FR	2	10.0		16.5	
I3MALC10-exc	Programming in C	EN/FR	2	6.25	6.25	5.5	
I3MAPH10-exc	Physical meas. and statistical modelling	EN/FR	4		7.5	37.5	
I3MACE10-exc	In-depth study of electronic circuits	EN/FR	4	13.75	15.0	5.5	
I3MASC10-exc	Semiconductors	EN/FR	4	22.5	12.5		7.0
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	
I3MAAU10-exc	Modeling and analysis of cont. linear sys.	EN/FR	2	13.75	8.75		

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MAIR20-exc	Introduction to networks	FR	2	12.5	6.25	2.75	
I3MACR20-exc	C language and networks	FR	1	2.5	2.5	13.75	
I3MABD20-exc	Databases	FR	1	3.75	8.75		
I3MALA20-exc	Assembly language	FR	3	10.0	5.0	16.5	
I3MAAM20-exc	Hardware architecture	FR	1	6.25		11.0	
I3MASA20-exc	Random signals	EN/FR	1	6.25	5.0	2.75	
I3MABE20-exc	Electronics project	EN/FR	3			35.75	
I3MAST20-exc	Telecommunication systems	EN/FR	2	8.75	6.25	11.0	
I3MASC20-exc	Control of continuous linear systems	EN/FR	4	13.75	8.75	22.0	
I3MASD20-exc	Modeling and control of discrete-event sys.	EN/FR	1	6.25	3.75	8.25	
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		



[1] When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4^{th} year (Master 1 level)

Contact : Alexandre BOYER

Major 1 – Automatic Control and Electronics

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4AESE31-exc	Analog electronic system architecture	5	Active filtering and modelling of noise sources	FR		10.0	6.25		
			Analogue architectures for info. Transmission	FR		8.75	6.25		
			Mini-project on analogue archi. for embedded sys.	FR				19.25	
I4AESE41-exc	Device modeling and digital circuits architectures (reconfigurable computing)	4	Study and modelling of active components	FR	2	10.0	6.25	11.0	
			VHDL and programmable digital circuits	EN	2	10.0		13.75	
I4AEIM11-exc	Embedded Computing -µcontroller	3	Embedded computing - microcontrollers	FR		1.25		30.25	
I4AEML11-exc	Machine Learning	1	Supervised learning	FR		7.5		8.25	
I4AESY11-exc	Analysis of complex systems	4.5	Multivariable systems	FR		11.25	6.25		
			Analysis of nonlinear systems	FR		16.25	11.25	5.5	
I4AEIL11-exc	Software engineering	4.5	Object-oriented design	FR		3.75	6.25		
			C++ programming	FR		8.75	6.25	19.25	
			Java programming	FR				2.75	
I4AEQSE11-exc	Quality, safety and environment	1	Quality, safety and environment	FR		10.0		8.25	

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4AEAU11-exc	Digital signal acquisition architectures and computed controlled systems	3	Electronic information acquisition systems	FR		8.75	8.75		
			Acquisition systems and digital control	FR				19.25	
I4AESE51-exc	Energy management for embedded systems	3	Electrical energy storage and conversion	FR		1.25	20.0	13.75	
I4AERT21-exc	Networks and real time	4	Network interconnection	FR		13.75	1.25	8.25	
			Real-time systems	FR		8.75	2.5	11.0	
I4AESY21-exc	Discrete systems optimisation	4	Graph theory and linear programming	FR		12.5	11.25	2.75	
			Stochastic processes and queueing theory	FR		7.5	5.0		
			Petri nets	FR		6.25	2.5		
I4AEPJ11-exc	Research project	3	Project management	FR	1		5.0		
			Research project	EN	2				22.0
I4AECA21-exc	Advanced control	5	Optimal control	FR		10.0	7.5	2.75	
			Digital control	FR		11.25	7.5	2.75	
			Control engineering mini-project	FR		3.75		13.75	

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

4^{th} year (Master 1 level)

Major 2 – Systems Engineering

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4ISME71-MP-exc	Multiphysical modeling	7	Multiphysics modelling project	FR		1.25	10.0	2.75	
			Fundamentals of 0D/1D modelling	FR		10.0	21.25		
			Mechanical systems and structures	FR		5.0	5.0	6.25	
			Electromagnetic circuits and actuators	FR		5.0	13.75		
I4ISME71-EI-exc	Architectures of power transmission systems	4	Architecture of power transmissions	FR		11.25	12.5	5.5	
			Computer-aided design and digital twin	FR		1.25	7.5		
I4ISTI71-AU-exc	Automatic control	5	Numerical control	FR		7.5	8.75	11.0	
			Rapid Prototyping with Hardware-in-the-Loop	FR		1.25	1.25	8.25	
			Graph theory and linear programming	FR		10.0	11.25		
I4ISTI71-EI-exc	Architectures of information system chains	2	Embedded computing and electronics	FR		2.5		16.5	
			Documentary research and research project	FR			6.25		
I4ISTI71-IE-exc	Modeling tools and systems engineering process	4	Standards and systems engineering methods	FR		1.25	3.75		
			Analysis benefits and requirements	FR		7.5	2.5		
			Analysis and architecture - Processus transverse	FR		10.0	3.75		
			Systems modelling, SysML	FR		10.0	2.5	11.0	
I4ISME71-RAE-exc	Remedial course on automatics and electronics*	1	Introduction to rigid body dynamics	FR			5.0		
			Mechanism analysis	FR			5.0	2.75	
I4ISTI71-RGM-exc	Remedial course on mechanical engineering*	1	Engagement with industrial networks	FR			7.5		

(*) Students must choose between these two courses depending on their background

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4ISMM81-PM-exc	Mechatronics project	4	Mechatronics project, eco-design and prototyping	EN**	2	2.5		23.75	
			Project management	FR	1		7.5		
			Research projects	EN	1				12.5
I4ISMM81-CM-exc	Mechatronics design	2	Preliminary design in mechatronic	FR		6.25	10.0	5.5	
I4ISMM81-AGM-exc	Advanced lectures for mechnaical engineering	1	Local (3D) modelling of structures	FR			11.25		
I4ISMM81-CS-exc	Modeling and control of structures	2	Local (3D) modelling of structures	FR		2.5	5.0	11.0	
			Control of articulated systems and flexible structures	FR		3.75	5.0		
I4ISTI81-CM-exc	Instrumentation	2	Instrumentation	FR		2.5	13.75	5.5	
I4ISTI81-IL-exc	Object oriented programming and real-time	4	Object-oriented programming (OOP)	FR		5.0	6.25	5.5	
			Real-time systems (RTS)	FR		7.5	2.5		
			OOP and RTS pratical work	FR			5.0	16.5	
I4ISTI81-RGM-exc	Remedial course on mechanical engineering	0.5	Introduction to object-oriented programming	FR			5.0		
I4ISTI81-OM-exc	Modeling tools	4	Optimisation	FR		6.25	3.75	2.75	
			Introduction to machine learning	FR		5.0	3.75	5.5	
			Petri nets	FR		6.25		8.25	
			Performance evaluation	FR		7.5	5.0		
I4ISTI81-AC-exc	Model Based System Engineering	3	Arcadia/Capella systems engineering methodology	FR		2.5	6.25	27.5	

(**) The lecture (L) only is in French

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5^{th} year (Master 2 level)

Major 1 – Critical Embedded Computer Systems

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5AISF11-exc	Operating safety	5.5	Principles of dependability engineering	FR		10.0	5.0	5.5	
			Program verification	FR		3.75		13.75	
			Fault diagnosis	FR		5.0		2.75	
			Synchronous programming	FR		6.25		8.25	
			Temporal models	FR		7.5		8.25	
I5AIMI11-exc	Engineering processes	5.5	Systems engineering	FR		10.0		8.25	
			Agile methods	FR			3.75		
			MOOC Critical embedded systems	FR			7.5		
			Machine learning	FR		7.5		5.5	
			IR Track: Model verification	FR		10.0		5.5	
			AE Track: Kalman filtering	FR		5.0		5.5	
I5AISE51-exc	Embedded Computer Architecture	3	Networks and middleware	FR		8.75		5.5	
			Embedded operating systems	FR		7.5		8.25	
			Architecture sizing and evaluation	FR		2.5	2.5	2.75	
I5AIPI11-exc	Interdisciplinary Project	7	Project	EN				41.25	
			English	EN			30.0		
I5IRRS41-exc	Service Robotics	4	Introduction to service robotics	FR		10.0	5.0		
			Service robotics lab	FR				11.0	
			Humanoid robotics lab	FR				24.75	

Major 2 – Embedded Electronic Systems

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5AEEE11-exc	Electronic architecture for energy	4	Reconfigurable power converters for emb. systems	FR		12.5		11.0	
			Versatile sensors and instrumentation	FR		12.5		11.0	
I5AEAOC11-exc	Energy autonomy for connected objects	2.5	Electrical energy management and energy harvesting	FR	1	2.5		16.5	
			Low-power programming for IoT	EN	1	2.5		11.0	
			Energy characterization of an IoT module	FR	0.5			8.25	
I5AEIA11-exc	Embedded AI	3	Hardware implem. of AI and neuromorphic circuits	FR		7.5		13.75	
			Energy charac. of an autonomous embedded system	FR				11.0	
I5AEPRJ11-exc	Project I	3.5	Project I	EN					13.75
			English	EN			30.0		
I5AEINA11-exc	Industrialisation and assembly	2.5	Industrialization and qualification	FR		12.5			
			PCB Manufacturing and assembly	FR		5.0		8.25	
			PCB Manufacturing internship (Micropacc)	FR				8.25	
I5AEFCE11-exc	Reliability and robustness for energy conversion	2	Reliability, robustness and emerging power devices	FR	0.5	8.75			
			High-performance packaging and cooling	FR	0.5	7.5			
			EMC of power converters	EN	1	5.0		13.75	
I5AETO11-exc	Techniques for optimising electronic control	2	High-frequency challenges in electronic control	FR	1	2.5		8.25	
			Machine learning for electronic design	EN	1	2.5		11.0	
I5AEECD11-exc	Electronics and control for power conversion	3	Control of static power converters	FR		12.5		5.5	
			Next-generation power converters	FR		10.0		11.0	
I5AEPRJ12-exc	Project II	1.5	Project II	EN				11.0	

5th year (Master 2 level)

Contact : Alexandre BOYER
Contact: Anna Carla Araujo

Major 3 – Systems Engineering

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5ISPR22-exc	Industrialization and Logistics	5	Production and logistics optimization	FR	1.5	15.0	5.0		
			Manufacturing and industry 4.0	EN	1.5	5.0	7.5	5.5	
			Design of Experiments (DoE)	FR	1	3.75	3.75	5.5	
			Maintenance engineering	FR	1	12.5		2.75	
I5ISMD11-exc	Mechatronic/Technological systems for sustainable mobility	3.5	Needs analysis, scenarios and requirements	FR		2.5		2.75	
			Converter and actuator technologies	FR		2.5	5.0	8.25	
			Eco-design and life cycle assessment (LCA)	FR		2.5	6.25	5.5	
			Control of converters and actuators	FR		2.5	6.25	2.75	
I5ISGR22-exc	Reliable systems	3.5	Dependability engineering	FR	1	11.25		2.75	
			Reliability engineering	EN	1	6.25	6.25		
			Safety assessment (Model-Based Safety Assessment)	FR	1.5	8.75	10.0		
I5ISPJ21-exc	Research project and industrial property	8	Intellectual Property (IP)	FR	0.5	2.5	3.75		
			English	EN	3		30.0		
			Interdisciplinary challenge	EN	4	1.25		44.0	
			Physical security (Quality, security, environment)	FR	0.5	3.75	6.25		
I5ISEC11-exc	Systems on chip *	4	Systems-on-Chip (SoC)	EN		20.0		30.25	
I5ISTH12-exc	Thermal engines and systems *	4	Introduction to thermal machines	FR		6.25	6.25		
			Modeling of thermal systems	FR		6.25	6.25	11.0	
			Num. simulations in fluid mechanics and thermal eng.	FR		1.25		11.0	

(*) Minor courses: students can only choose one

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

Mechanical Engineering

The objective of the Mechanical Engineering specialization is to train general engineers with a proper balance of scientific, technological and systems knowledge. The training offered by this program takes into account all the data related to the life of a product or system, from its preliminary design to its production and potential recycling, all within a concurrent engineering approach. INSA Toulouse mechanical engineers intervene in the following areas: systems architecture, automatic control, thermodynamics, fluid mechanics, computational mechanics, design, industrialization, etc.).

3rd year (bachelor level)

Contact: Anna Carla Araujo

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3ICMT51-exc	Partial diff. equations and Fourier series	FR	3	12.5	13.75	7.5	
I3ICMS51-exc	Continuum mechanics	FR	4	1.25	30.0	6.0	
I3ICMF51-exc	Fluid mechanics I	EN/FR	3	12.5	15.0	6.0	
I3ICSD51-exc	Dynamic systems	EN/FR	4	15.0	17.5	6.0	
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	
I3ICCM51-exc	Mechanical design I	FR	3	1.25	30.0		
I3ICFA51-exc	Introd. manufacturing and tolerancing	FR	3	3.75	22.5	5.0	

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3ICSL61-exc	Digital Logic systems	FR	2.5	6.25	13.75	9.0	
I3ICIS61-exc	Introduction to systems engineering	FR	1	5.0	7.5	6.25	
I3ICCM61-exc	Mechanical design II	FR	6		43.25	10.0	25.0
I3ICCN61-exc	CNC and computer-aided manufact.	EN/FR	2		2.5	16.0	
I3ICME61-exc	Metrology	FR	2	8.75	10.0	8.0	
I3ICTH61-exc	Heat treatment and welding	FR	1			4.0	8.0
I3ICTTGM61-exc	Heat transfer I	EN/FR	3	11.25	13.75	9.0	
I3ICCS61-exc	Control systems	EN/FR	2.5	10.0	11.25	8.0	
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		

[1] When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4th year (Master 1 level)

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Contact: Anna Carla Araujo

Major 1 - Mechanical Engineering

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GMFS71-MT-exc	Thermal machines	2.5	Thermal machines	FR		6.25	13.75	9.0	
I4GMFS71-MA-exc	Materials and Non-Destructive Testing	3.5	Materials	FR		12.5	13.75	2.5	
			Non-destructive testing	FR		2.5		9.0	
I4GMFS71-CS-exc	Structural Analysis I	5	Finite element methods	FR		12.5	12.5	12.0	
			Vibrations	FR		12.5	11.25		
I4GMCF71-FA-exc	Manufacturing Processes I	5	High-speed machining	FR		7.5	7.5	9.0	
			Additive manufacturing	FR		6.25	3.75	3.0	
			Casting processes	FR		5.0	7.5	6.0	
I4GMCF71-TM-exc	Mechanical Transmission and Introduction to Research Project	7	Mechanical power transmissions	FR	6.5		80.0		
			Scientific literature review	EN	1				6.25

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GMFS81-FT-exc	Fluid Mechanics and Heat Transfer II	5	Fluid mechanics II	FR*	2.5	12.5	12.5	7.5	
			Heat transfer II	FR	2.5	12.5	12.5	7.5	
I4GMFS81-MC-exc	Composite materials	3	Composite materials	FR		17.5	5.0	6.0	
			Design using composite materials	FR					12.0
I4GMFS81-CS-exc	Structural Analysis II	4	Finite element project	EN/FR	2				12.0
			Vibrations Laboratory	EN/FR	1			15.0	
			Reliability engineering	FR	1	7.5	6.25		
I4GMCF81-MM-exc	Advanced Mechanical Modeling	6	Advanced mechanical modelling and Eco-design	FR			25.0	15.0	
			Design office in mechanical eco-design	FR			40.0		
I4GMCF81-FP-exc	Manufacturing processes II and Research Project	4	Research project	EN/FR	2				18.75
			Manufacturing management	EN	1	3.75	3.75		
			Plastic deformation	FR	1	2.5	6.25		

(*) The course was recorded by the professor and is available in English as digital content.

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

4th year (Master 1 level)

Major 2 – Systems Engineering

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4ISME71-MP-exc	Multiphysical modeling	7	Multiphysics modelling project	FR		1.25	10.0	2.75	
			Fundamentals of 0D/1D modelling	FR		10.0	21.25		
			Mechanical systems and structures	FR		5.0	5.0	6.25	
			Electromagnetic circuits and actuators	FR		5.0	13.75		
I4ISME71-EI-exc	Architectures of power transmission systems	4	Architecture of power transmissions	FR		11.25	12.5	5.5	
			Computer-aided design and digital twin	FR		1.25	7.5		
I4ISTI71-AU-exc	Automatic control	5	Numerical control	FR		7.5	8.75	11.0	
			Rapid Prototyping with Hardware-in-the-Loop	FR		1.25	1.25	8.25	
			Graph theory and linear programming	FR		10.0	11.25		
I4ISTI71-EI-exc	Architectures of information system chains	2	Embedded computing and electronics	FR		2.5		16.5	
			Documentary research and research project	FR			6.25		
I4ISTI71-IE-exc	Modeling tools and systems engineering process	4	Standards and systems engineering methods	FR		1.25	3.75		
			Analysis benefits and requirements	FR		7.5	2.5		
			Analysis and architecture - Processus transverse	FR		10.0	3.75		
			Systems modelling, SysML	FR		10.0	2.5	11.0	
I4ISME71-RAE-exc	Remedial course on automatics and electronics*	1	Introduction to rigid body dynamics	FR			5.0		
			Mechanism analysis	FR			5.0	2.75	
I4ISTI71-RGM-exc	Remedial course on mechanical engineering*	1	Engagement with industrial networks	FR			7.5		

(*) Students must choose between these two courses depending on their background

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4ISMM81-PM-exc	Mechatronics project	4	Mechatronics project, eco-design and prototyping	EN**	2	2.5		23.75	
			Project management	FR	1		7.5		
			Research projects	EN	1				12.5
I4ISMM81-CM-exc	Mechatronics design	2	Preliminary design in mechatronic	FR		6.25	10.0	5.5	
I4ISMM81-AGM-exc	Advanced lectures for mechnaical engineering	1	Local (3D) modelling of structures	FR			11.25		
I4ISMM81-AAE-exc	Advanced lecture for automatic and eletronics	1	Control of articulated systems and flexible structures	FR			12.5		
I4ISMM81-CS-exc	Modeling and control of structures	2	Local (3D) modelling of structures	FR		2.5	5.0	11.0	
			Control of articulated systems and flexible structures	FR		3.75	5.0		
I4ISTI81-CM-exc	Instrumentation	2	Instrumentation	FR		2.5	13.75	5.5	
I4ISTI81-IL-exc	Object oriented programming and real-time	4	Object-oriented programming (OOP)	FR		5.0	6.25	5.5	
			Real-time systems (RTS)	FR		7.5	2.5		
			OOP and RTS pratical work	FR			5.0	16.5	
I4ISTI81-RGM-exc	Remedial course on mechanical engineering	0.5	Introduction to object-oriented programming	FR			5.0		
I4ISTI81-OM-exc	Modeling tools	4	Optimisation	FR		6.25	3.75	2.75	
			Introduction to machine learning	FR		5.0	3.75	5.5	
			Petri nets	FR		6.25		8.25	
			Performance evaluation	FR		7.5	5.0		
I4ISTI81-AC-exc	Model Based System Engineering	3	Arcadia/Capella systems engineering methodology	FR		2.5	6.25	27.5	

(**) The lecture (L) only is in French

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5th year (Master 2 level)

Contact: Anna Carla Araujo

Major 1 - Mechanical Engineering

Semester 1, starting from September

Core courses

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GMPP91-MS-exc	Modeling and Sim. of multi-domain systems	2	Modeling and Sim. of multi-domain systems	FR		8.75	5.0	15.0	
I5GMPP91-PJ-exc	Multidisciplinary Project	10	Multidisciplinary Project or Research Project	EN		2.5	68.0		
			Intellectual Property	EN		2.5	3.75		
			Project Management and QSE	EN		12.5	8.0		
			English	EN			30.0		

Major courses – students can only choose one.

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GMMAJ91-CM-exc	Computational Mechanics	10	Materials	EN			13.75	10.0	
			Aerospace Composite Structures	EN			15.0	5.0	
			Dynamics	EN			12.5	7.5	
			Multiscale Modeling	EN			10.0	12.5	
			Artificial Intelligence	EN			13.75	12.5	
I5GMMAJ91-SM-exc	Smart Manufacturing	10	Advanced Machining	EN	3	6.0	12.0	12.0	
			Lean Manufacturing and Industrial Production	FR	2	6.0	22.0		
			Energy Efficiency in Production	EN	2	2.0	20.0		
			Special Manufacturing Processes	EN	3	8.0	11.0	14.0	
I5GMMAJ91-FE-exc	Fluids Engineering	10	Microfluidics	EN		6.25	17.5		
			Advanced Computational Fluid Dynamics	EN				40.0	
			Aerodynamics	EN		2.5	7.5	2.5	
			Compressible Fluid Mechanics	EN			18.75		
			Thermal Turbomachinery	EN		3.75	13.75		

Minor courses – students can only choose one - subject to availability.

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GMMAJ91-MO-GC-exc	Configuration Management	2	Configuration Management				30.0		
I5GMMAJ91-MO-BM-exc	Biomechanics	2	Biomechanics				30.0		
I5GMMAJ91-MO-SH-exc	Hydraulic Systems	2	Hydraulic Systems				30.0		
I5GMMAJ91-MO-TO-exc	Tolerancing	2	Tolerancing				30.0		

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5^{th} year (Master 2 level)

Contact : Alexandre BOYER
Contact: Anna Carla Araujo

Major 2 – Systems Engineering

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5ISPR22-exc	Industrialization and Logistics	5	Production and logistics optimization	FR	1.5	15.0	5.0		
			Manufacturing and industry 4.0	EN	1.5	5.0	7.5	5.5	
			Design of Experiments (DoE)	FR	1	3.75	3.75	5.5	
			Maintenance engineering	FR	1	12.5		2.75	
I5ISMD11-exc	Mechatronic/Technological systems for sustainable mobility	3.5	Needs analysis, scenarios and requirements	FR		2.5		2.75	
			Converter and actuator technologies	FR		2.5	5.0	8.25	
			Eco-design and life cycle assessment (LCA)	FR		2.5	6.25	5.5	
			Control of converters and actuators	FR		2.5	6.25	2.75	
I5ISGR22-exc	Reliable systems	3.5	Dependability engineering	FR	1	11.25		2.75	
			Reliability engineering	EN	1	6.25	6.25		
			Safety assessment (Model-Based Safety Assessment)	FR	1.5	8.75	10.0		
I5ISPJ21-exc	Research project and industrial property	8	Intellectual Property (IP)	FR	0.5	2.5	3.75		
			English	EN	3		30.0		
			Interdisciplinary challenge	EN	4	1.25		44.0	
			Physical security (Quality, security, environment)	FR	0.5	3.75	6.25		
I5ISEC11-exc	Systems on chip *	4	Systems-on-Chip (SoC)	EN		20.0		30.25	
I5ISTH12-exc	Thermal engines and systems *	4	Introduction to thermal machines	FR		6.25	6.25		
			Modeling of thermal systems	FR		6.25	6.25	11.0	
			Num. simulations in fluid mechanics and thermal eng.	FR		1.25		11.0	

(*) Minor courses: students can only choose one

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

Civil Engineering

The Civil Engineering department's teaching and research focus on construction sciences, training engineers to manage all stages of construction projects. Civil engineers work in areas such as building systems and equipment, public infrastructure including bridges and roads, and urban planning projects such as public spaces and networks.

3rd year (bachelor level)

Contact: Sophie Claude

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3ICMT51-exc	Partial diff. equations and Fourier series	FR	3	12.5	13.75	7.5	
I3ICMS51-exc	Continuum mechanics	FR	4	1.25	30.0	6.0	
I3ICMF51-exc	Fluid mechanics I	EN/FR	3	12.5	15.0	6.0	
I3ICSD51-exc	Dynamic systems	EN/FR	4	15.0	17.5	6.0	
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	
I3ICMC51-exc	Cementitious materials	FR	4	12.5	11.25	6.0	
I3ICCO51-IB-exc	Concrete mix design	FR	2	10.0	5.0	5.0	4.0
I3ICCO51-EC-exc	Ecodesign	FR	1	3.75	18.75		
I3ICCO51-TC-exc	Building technology	FR	3	10.0	3.75	10.0	
A3GCMM11-02-exc	Materials (subject to schedule availability)	EN/FR	3	15.0	15.0		

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3ICMF61-exc	Fluid mechanics	FR	2	10.0	16.25	7.5	
I3ICTTGC61-exc	Heat transfer	FR	3	10.0	12.5	7.5	
I3ICAS61-exc	Analysis of static structures	FR	3	12.5	13.75		8.5
I3ICAPPRO61-exc	Civil engineering in-depth study	FR	0				
I3ICAD61-exc	Deepening in structures	FR	2	17.5	12.5		
I3ICAC61-exc	Climatics - Aerolitics - Fluid Mechanics	FR	2		20.0		9.0
I3ICBA61-exc	Reinforced concrete	FR	5	25.0	20.0	6.0	15.0
I3ICBPC61-exc	Prestressed Concrete	FR	1	7.5	5.0		
I3ICMS61-exc	Geotechnic I	EN/FR	3	16.25	15.0	12.0	
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		

[1]When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4^{th} year (Master 1 level)

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Contact : Sophie Claude

Semester 1, starting from September

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GCBA12-exc	Concrete and timber structures	6	Timber engineering	FR		15.0	12.5		
			Reinforced concrete	FR		2.5	27.5		
			Eurocode 1	FR		3.75	2.5		
I4GCTF11-exc	Comfort Engineering	5	Air conditioning 1	FR		16.25	11.25		
			Acoustics	FR		7.5			
			Heating systems 1	FR		16.25	10.0		
I4GCMS21-exc	Geotechnics 2	5	Geotechnics 2	FR		26.25	22.5		
I4GCRM11-exc	Advanced Mechanics and Finite Elements	7	Advanced Mechanics and Finite Elements	FR		27.5	13.75	9.0	36.0
I4GCTF71-exc	Building facilities	6	Experimental sciences	FR		2.5	3.75	16.0	
			Thermodynamics	FR		7.5	2.5		
			Electrical engineering fundamentals	FR		12.0	12.0		
I4GCTF31-exc	Building networks	6	Heating systems 2	FR		8.0	24.0		
			Heat transfer 2	FR		5.0	12.0		
			Hydraulics	FR		5.0	15.0		

Semester 2, starting from January

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4GCPJ22-exc	Building project	7	Reinforced concrete	FR					40.0
			Urban engineering	FR		8.0			
			Heating, ventilation and air conditioning	FR					8.0
			Specialisation (elective)	FR					20.0
			Quality, safety and environmental management	FR					16.0
I4GCOE11-exc	Existing structures and buildings	2	Existing structures and buildings	FR		12.5			15.0
I4GCRE11-exc	Introduction to research	2	Introduction to research	FR		1.25	2.5		21.0
I4GCCO21-exc	Bracing and steel structures	5	Steel structures	FR		22.5	12.5		
			Structural bracing	FR		10.0	10.0		
I4GCBA32-exc	Prestressed concrete structures and bridges	6	Prestressed concrete	FR		13.75	15.0		16.0
			Bridge engineering	FR		21.25			
I4GCTF51-exc	Air Conditioning	6	Air conditioning 2	FR		10.0	6.25		32.0
			Dynamic thermal simulation	FR		6.25	4.0	16.0	
I4GCAC22-exc	Acoustics	5	Building services acoustics	FR		20.0	11.25	12.0	8.0
A4GCEC21-exc	Eco Construction*		International Civil Engineering	EN		10.0	10.0		
			Sustainable materials	EN		10.0	10.0		

(*) subject to timetable compatibility.

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5th year (Master 2 level)

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Contact : Sophie Claude

Semester 1, starting from September

Major 1 - Public works and civil engineering structures

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GCBP11-exc	Bridge		Bridges	FR		25.0			75.0
I5GCGE42-exc	Roads and methods PW	5	Quality Management in Construction	FR		3.0			
			Road Engineering	FR		20.0			5.0
			Tunnel Engineering	FR		10.0	5.0		
			Infrastructure Asset Management	FR		10.0	10.0		

Major 2 - Building engineering

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GCBA11-exc	Concrete structures 3 and masonry	8	Earthquake Engineering	FR		20.0			50.0
			Masonry Structures	FR		10.0	5.0		
			Structural Fire Engineering	FR		10.0	10.0		
I5GCBE31-exc	Frames and site management	5	Composite Structures	FR		15.0	10.0		
			Structural Frameworks	FR		20.0	15.0		

Major 3 - Heating, Ventilation, and Air Conditioning

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GCBE41-exc	Climatic Engineering Project		HVAC Engineering Project	FR		10.0	60.0		20.0
I5GCNR12-exc	Future buildings	6	High Environmental Quality (HEQ)	FR	1	7.5	7.5		
			Renewable Energy Systems	EN	2	10.0	10.0		
			Building Management Systems (BMS)	FR	1	7.5	7.5		
			Building Energy Simulation with TRNSYS	EN	2	10.0	10.0		

Minor courses (Students can only choose one)

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5GCPJ12-exc	Project Management Assistance (PMA)	5	PMA Client-Side Advisory	FR		27.5	27.5		
I5GCMOBE01-exc	BIM Environnement	5	Building Information Modeling and Environment	FR		27.5	27.5		
I5GCTF11-exc	Eco building and Environmental impact	5	Eco-Design and Environmental Impact	FR		27.5	27.5		
A5GCMA11-exc	Construction Methods*		Construction Methods	FR		35.0	45.0		15.0

(*) subject to timetable compatibility.

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Computer Science and Networks

The objective of the Computer Science and Networks specialization is to train engineers who master the software development process and the design of complex, communicating and networked-distributed computer systems, while complying with safety standards and/or real-time constraints.

3rd year (bachelor level)

Contact: Sami Yangui

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MIAA10-exc	Advanced algorithmics	FR	2	8.75	10.0		
I3MIBD11-exc	Databases I	FR	2	7.5	10.0		
I3MIBD10-exc	Databases II	FR	2	3.75	7.5	8.25	
I3MIAD10-exc	Data analysis	FR	3	12.5	3.75	13.75	4.0
I3MIOP10-exc	Optimization and linear programming	EN/FR	3	13.75	12.5	11.0	
I3MISE10-exc	Operating system	EN/FR	2	7.5	3.75		
I3MICM10-exc	Markov chains	EN/FR	2	7.5	8.75	2.75	
I3MIPW10-exc	Web progamming	FR	1	5.0	7.5	8.25	
I3MIRE10-exc	Networks	FR	2	17.5	5.0	2.75	
I3MIIC10-exc	Theory of information and coding	FR	1	10.0	6.25		
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MIPS20-exc	System programming and multithreading	FR	3	11.25	6.25	11.0	
I3MIAI20-exc	Internet app. and socket programming	FR	2	6.25	3.75	19.25	
I3MIFN20-exc	Digital filtering	FR	1	8.75	7.5		
I3MISA20-exc	Random signal	FR	1	6.25	5.0		
I3MICH20-exc	Concepts and hardware for data trans.	FR	2			30.25	
I3MIGR20-exc	Graphs	FR	3	8.75	8.75	16.5	
I3MIAM20-exc	Hardware architecture	EN/FR	3	15.0	5.0	22.0	
I3MIPO20-exc	Object oriented programming	EN/FR	1	6.25	8.75		
I3MIST21-exc	Telecommunication systems	EN/FR	3	12.5	12.5	11.0	
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		

[1] When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4^{th} year (Master 1 level)

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Contact : Alexandre BOYER

Semester 1, starting from September

Core courses

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4IRIL11-exc	Object Oriented Design and Object Oriented Programming	7.5	UML and design patterns	FR		10.0	16.25		
			Advanced Java programming	FR		7.5	13.75	27.5	
			Project management	FR			5.0		
			Automated software development processes	FR		1.25	8.75		
I4IRRS11-exc	Internet and Security	5.5	Network interconnection	FR		15.0	1.25	8.25	
			Distributed algorithms	FR		10.0			
			Computer and Internet security	FR		17.5	2.5	8.25	

Major 1 - Communicating systems

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4IRRS21-exc	Mobiles networks and wireless networks	5	Wireless local and personal area networks	FR		7.5	3.75	8.25	
			Mobile networks	FR		20.0	3.75	11.0	
I4IRTC11-exc	Transmission systems and techniques	5	Noisy channels	EN	0.5	6.25	2.5		
			Transmission systems laboratory	FR	2.5	2.5		27.5	
			Antennas and propagation models	FR	2	12.5	1.25	5.5	

Major 2 - Computer systems

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4IRIF11-exc	Fundamentals in Computer Science	7	Functional programming	FR		6.25	10.0	11.0	
			Logic and logic programming	FR		16.25	7.5	11.0	
			Complexity	FR		6.25	3.75		
I4IRIF31-exc	Hardware Computing µcontrollers	3	Embedded computing – microcontrollers	FR		1.25		30.25	

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

4^{th} year (Master 1 level)

Contact : Alexandre BOYER

Semester 2, starting from January

Core courses

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4IRTR11-exc	Concurrent and real time system	6	Modelling of concurrent systems	FR		15.0		13.75	
			Real-time systems	FR		8.75	2.5	13.75	
I4GEIQSEAPS2-exc	Quality, Security and the environment	1	Quality, safety and environmental management	FR		7.5		5.5	
I4IRML21-exc	Machine learning	2	Supervised learning	FR		7.5		8.25	
I4IRPJ11-exc	Research Initiating Project	3	Research project	EN	2				22.0
			Project management	FR	1		5.0		

Major 1 - Communicating systems

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4IRRS31-exc	Advanced interconnection and long distance networks	6.5	Advanced network interconnection	FR		16.25	2.5	16.5	
			Wide area networks	FR		15.0	2.5	5.5	
			Internet quality of service (QoS)	FR			2.5	13.75	
			Models and algorithms for traffic engineering	FR		10.0	3.75		
			Protocol verification	FR		7.5		5.5	
I4IRTC21-exc	Architecture of telecommunication systems	3.5	Radio interface dimensioning for mobile networks	FR	1.5	5.0		13.75	
			Medium access control laboratory	EN	1.5	6.25		16.5	
			Optical communication networks	FR	0.5	7.5			

Major 2 - Computer systems

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4IRSD11-exc	Logic and problem solving artificial intelligence	4.5	Artificial intelligence	FR		10.0		11.0	
			Semantic web	FR		5.0		11.0	
			Metaheuristics	FR		7.5		13.75	
I4IRIM11-exc	Software and hardware architecture for computer systems	5.5	Automata and formal languages	FR	2	15.0	5.0		
			Computer architectures	EN	1	10.0	5.0		
			Computer systems project	EN	2.5			30.25	

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5th year (Master 2 level)

Contact : Alexandre BOYER

Semester 1, starting from September

Major 1 - Distributed Systems and Big Data

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5IRIL12-exc	Cloud native computing and networking	6	Software Lifecycle Automation (DevOps)	FR			2.5	5.5	
			Service-Oriented Architectures (SOA)	FR		7.5	15.0	16.5	
			Virtualization and Cloud Computing	FR		7.5		11.0	
			Network Softwarization (Software-Defined Networking)	FR		3.75		8.25	
I5IRBD12-exc	Frameworks for Big Data	2	Big Data Frameworks	FR		8.75		16.5	
I5IRSF11-exc	Reliability and model-checking	4	Principles of Dependability Engineering	FR		12.5		5.5	
			Temporal Models	FR		6.25		5.5	
			Model Verification	FR		7.5		5.5	
I5IRAD12-exc	Descriptive and predictive analysis	4	Exploratory Data Analysis and Visualization	FR		8.75		13.75	
			Machine Learning	FR		15.0		19.25	
I5IRPR12-exc	Distributed Systems and Big Data Project	4	Design Project	EN	3			22.0	
			English	EN	1		30.0		
I5IRSD12-exc	Prescriptive Analytics *	4	Methods and Tools (MILP, Constraint Prog., SAT)	FR		22.5			
			Practical Applications	FR				27.5	
I5IRRS12-exc	Software Defined Comm. Infrastructure *	4	Automated Deployment of Service Infrastructures	FR		5.0		11.0	
			Software Defined Communication Infrastructure Project	FR			6.25	27.5	

Major 2 - Critical Embedded Computer Systems

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5AISF11-exc	Operating safety	5.5	Principles of dependability engineering	FR		10.0	5.0	5.5	
			Program verification	FR		3.75		13.75	
			Fault diagnosis	FR		5.0		2.75	
			Synchronous programming	FR		6.25		8.25	
			Temporal models	FR		7.5		8.25	
I5AIMI11-exc	Engineering processes	5.5	Systems engineering	FR		10.0		8.25	
			Agile methods	FR			3.75		
			MOOC Critical embedded systems	FR			7.5		
			Machine learning	FR		7.5		5.5	
			IR Track: Model verification	FR		10.0		5.5	
			AE Track: Kalman filtering	FR		5.0		5.5	
I5AISE51-exc	Embedded Computer Architecture	3	Networks and middleware	FR		8.75		5.5	
			Embedded operating systems	FR		7.5		8.25	
			Architecture sizing and evaluation	FR		2.5	2.5	2.75	
I5AIPI11-exc	Interdisciplinary Project	7	Project	EN				41.25	
			English	EN			30.0		
I5IRRS41-exc	Service Robotics	4	Introduction to service robotics	FR		10.0	5.0		
			Service robotics lab	FR				11.0	
			Humanoid robotics lab	FR				24.75	

(*) Minor courses: students can only choose one

Applied Mathematics

The rise of Machine Learning and Artificial Intelligence (AI) has reinforced the evergrowing need of Computer Science and Applied Mathematics skills to process, exploit and analyze this data, perform numerical simulations, gain a deeper understanding of complex systems and high-tech products, and predict their behavior. Data Science and AI are increasingly sought after by the transportation, environment, security, health, e-commerce, and insurance sectors, among others.

3rd year (bachelor level)

Contact: Pierre Cantin

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MIAA10-exc	Advanced algorithmics	FR	2	8.75	10.0		
I3MIBD10-exc	Databases II	FR	2	3.75	7.5	8.25	
I3MIAD10-exc	Data analysis	FR	3	12.5	3.75	13.75	4.0
I3MIOP10-exc	Optimization and linear programming	EN/FR	3	13.75	12.5	11.0	
I3MISE10-exc	Operating system	EN/FR	2	7.5	3.75		
I3MICM10-exc	Markov chains	EN/FR	2	7.5	8.75	2.75	
I3MICP10-exc	Complements of probabilities	FR	3	18.75	18.75		
I3MISD10-exc	Dynamical systems	FR	3	13.75	11.25	11.0	
I3CCIE11-exc	Ecological transition and greenhouse gases	FR	3	5.0	21.25	2.5	

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I3MIDP20-exc	Partial Derivative Equations I	FR	3	11.25	13.75	11.0	
I3MISI20-exc	Inferential statistics	FR	3	16.25	15.0	5.5	
I3MIBE20-exc	Project	FR	3		5.0		25.0
I3MIMC20-exc	MCMC methods	FR	3	15.0	15.0	8.25	
I3MIPO20-exc	Object oriented programming	EN/FR	1	6.25	8.75		
I3MISG20-exc	Signal II	EN/FR	3	12.5	11.25	13.75	
I3MIAF20-exc	Functions approximation	EN/FR	3	10.0	10.0	16.5	
I3CCNU21-exc	Numerical culture and skills II	EN/FR	1	0.5	2.75		

[1] When the language is listed as EN/FR, lectures are delivered in French, while tutorials, laboratory sessions, and projects are conducted in English. All course materials and documents are available in both French and English.

4^{th} year (Master 1 level)

Contact: Pierre Cantin

Semester 1, starting from September

Core courses

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4MATCEMS11-exc	Statistical modelling	5	Elements of statistical modelling	FR		21.25	21.25	13.75	
I4MATCOP11-exc	Optimisation	5	Optimisation	EN		22.5	20.0	13.75	
I4MATCQSE11-exc	Quality, security, environment (QSE)	2	General and specialised QSE management	FR		8.75			
			Cryptography	FR		6.25			
			Computer security	FR		3.75			
			Occupational health and safety	FR		3.75			
I4MATCRS11-exc	Reading seminar	3	Reading seminar	EN/FR					30.0
			Literature review	EN/FR			2.5		
			Project management	EN/FR			2.5		

Minor courses – students can only choose maximum one course.

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4MAOPPA11-exc	Advanced probability	3	Advanced probability	EN		18.75	13.75	5.5	
I4MAOPEDP11-exc	Partial derivative equations	3	Partial differential equations II	EN		18.75	6.25	11.0	

Semester 2, starting from January

Core courses

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4MATCML21-exc	Machine learning	5	Machine learning	EN		21.25	3.75	27.5	
I4MATCSI21-exc	Signal processing	3	Signal processing	EN		11.25	12.5	13.75	
I4MATCPRO21-exc	Research and innovation project	4	Project research/innovation	EN/FR					43.0

Minor courses – students can only choose maximum two courses.

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I4MAOPEF21-exc	Finite element methods	5	Finite element method	EN		15.0	10.0	22.0	
			Model reduction for partial differential equations	EN		3.75		5.5	
I4MAOPMECA21-exc	Models and numerical methods for solid and fluid mechanics	5	Fundamentals of continuum mechanics	FR		6.25	5.0		
			Modelling and num. simulation in fluid mechanics	FR		10.0	5.0	8.25	
			Modelling and num. simulation in struct. mechanics	FR		6.25	2.5	13.75	
I4MAOPPS21-exc	Stochastic processes	5	Time series analysis	EN		15.0	11.25	5.5	
			Poisson processes	EN		10.0	3.75	2.75	8.0

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

5^{th} year (Master 2 level)

Contact: Pierre Cantin

Semester 1, starting from September

Core courses

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5MATCHDDL11-exc	High Dimensional and Deep Learning	3	High Dimensional and Deep Learning (HDDL)	FR		8.75	10.0	16.5	4.0
I5MATCMETA11-exc	Metamodeling	3	Metamodeling	EN		8.75	8.75	11.0	1.0
I5MATCPT11-exc	Rsearch and innovation project	9	Research/innovation Projet	EN/FR					48.0
			English	EN/FR			30.0		

Minor courses – students can only choose maximum three courses.

Code	Course description	ECTS	Component	Lan.[1]	ECTS	L	T	LW	P
I5MAOPIM11-exc	Image processing	3	Image processing	EN		11.25	3.75	22.0	9.0
I5MAOPAD11-exc	Data Assimilation	3	Variational Data Assimilation	EN		8.75	3.75	8.25	
			Hybrid Approaches	EN		2.5		5.5	
			Data Assimilation in Digital Photomechanics	EN		2.5		2.75	
I5MAOPMDFS11-exc	Advanced modeling for fluids and structural mechanics	3	Fluid Mechanics	FR		7.5	3.75	5.5	
			Structural Mechanics	FR		7.5	3.75	5.5	
I5MAOPCSTO11-exc	Stochastic Calculus	3	Stochastic Calculus	FR		13.75	11.25	8.25	
I5MAOPFDV11-exc	Reliability and lifetime analysis	3	Reliability and lifetime analysis	EN		13.75	5.0	11.0	

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

Humanities Courses

The Humanities Department courses can be chosen in addition to engineering courses

Humanities and Social Sciences

The Humanities Department courses can be chosen in addition to engineering courses.

The Humanities Department courses aim to develop both specific knowledge and soft skills in French, English and another foreign language. Students develop general skills in professional communication: oral presentations, report writing, documentary research, document synthesis, etc. The main goal of the teaching teams is to prepare students for the job market and to put their actions into perspective by taking into account social, economic, ethical and cultural contexts.

3rd year (bachelor level)

Contact: Joseph Shea

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I2DHUMLV111-exc	Cultural module and presentation skills *	EN	2		27.5		
I2DHUMECO11-exc	Contemporary Econ. and Eco. Transition *	FR	1.5		18.75		
I3DHUMCE11-exc	Elective course **	EN/FR	2		22.5		
ERASLF21-exc	French as a foreign language (FLE)	FR	3		25.0		
I3DHUMAPS11-exc	Physical education	EN/FR	2		20.0		
I3DHUMJS11-exc	Job search	EN	2		20.0		
I3DHUMTRE11-exc	French job hunting techniques	FR	1		13.75		

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I2DHUMLV121-exc	Structuring an argument and Debating *	EN	2.5		22.5		
I3DHUMMO21-exc	Elective course addressing societal issues **	EN/FR	2		30.0		
ERASLF31-exc	French as a Foreign Language (FLE)	FR	3		25.0		
I3DHUMAPS21-exc	Physical education	EN/FR	2		23.0		
I3DHUMBE21-exc	English business communication	EN	2		20.0		
I3DHUMBG21-exc	Business game	FR	2		19.25		
I3DHUMGF21-exc	Company finance	FR	1	15.0			

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

4^{th} year (Master 1 level)

Contact : Joseph Shea

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I4DHUMFI11-exc	Finance*	FR	2.5	18.75			
I4DHUMSTRAT11-exc	Strategies for Responsible Companies*	FR	2.5	18.75			
I4DHUMDRT11-exc	Law*	FR	2.5				
I4DHUMLV211-exc	Foreign Language		2		20.0		
I4DHUMAPS11-exc	Physical Education	EN/FR	2		22.0		

Semester 2, starting from January

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I4DHUMLV121-exc	Scientific English (**)	EN	3		30.0		
I4DHUMPIF21-exc	Future/Prospective Method	EN/FR	2		30.25		
I4DHUMAPS21-exc	Physical Education	EN/FR	2		24.0		

5^{th} year (Master 2 level)

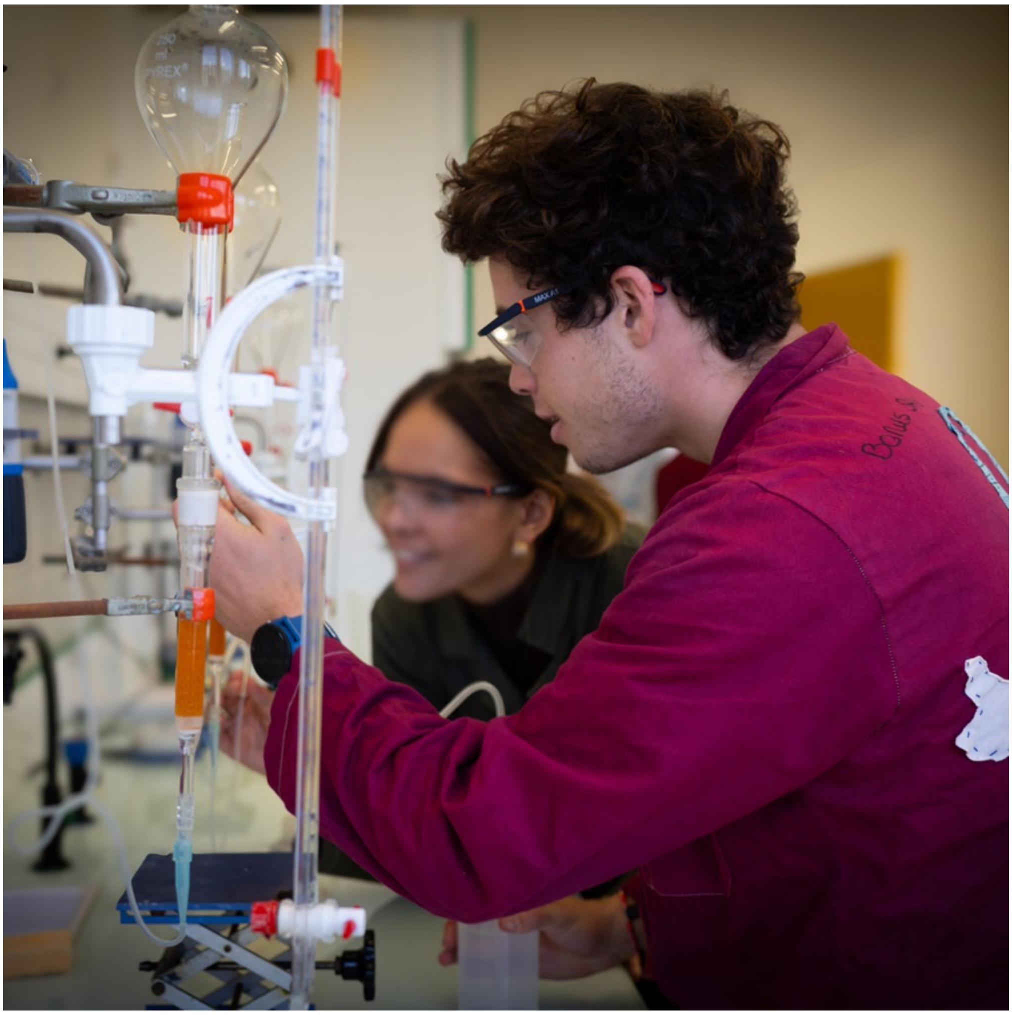
Contact : Joseph Shea

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I5DHUMPSE11-exc	Social Psychology and Ethics	FR	2		17.5		
I5DHUMME11-exc	Team Management	EN/FR	2	17.5			
I5DHUMAPS11-exc	Physical Education	EN/FR	1		21.5		
I5PEPE21-exc	Scientific project in English (*)	EN	3		30.0		

[1] If the language is FR or EN, the course and all materials are in French or English, respectively. If the language is EN/FR, the course is available in both languages.

Masters of Science Courses



Master Engineering for Durability - Rehabilitation and Innovation for Materials and Structures

Contacts : Sophie Claude

The built heritage is aging, and infrastructure maintenance has become a critical challenge in the field of Civil Engineering. Today, the upkeep of existing structures accounts for approximately half of the revenue in the construction and public works sectors. However, relatively few academic programs specifically train students for these professions, and companies are actively seeking qualified graduates in these areas. Moreover, infrastructure maintenance represents a significant environmental challenge.
It is from this observation that the Master's program ID-RIMS (Engineering for Durability – Research and Innovation in Materials and Structures) was created. Its objective is to train professionals capable of contributing to design, mastering implementation, and managing production systems in the construction and public works sector, while integrating the technical, economic, and human factors of the company.

Master 2, Semester 1, starting from end of September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
KGCD9LBU-exc	Binders and Concrete – Mix Design and Environmental Impact	FR	6	24.0	13.0	24.0	
KGCD9DMU-exc	Durability of Construction Materials	FR	3	15.0	11.0	12.0	
KGCD9MMU-exc	Mechanics of Materials and Structures	FR	6	20.0	36.0		
KGCD9TTU-exc	Thermal Conduction in the Building Envelope	FR	3	14.0		21.0	
KGCD9SSU-exc	Structural Health Monitoring of Civil Engineering Structures	FR	3	4.0	14.0	33.0	
KGCD9MOU-exc	Infrastructure maintenance	FR	6	6.0	54.0	15.0	
KGCD9ANU-exc	English	EN	3		24.0		

Master Industrial BioTechnology for a Bio-Based Economy

The courses of this Master of Science program will soon be open to exchange students. Thank you for your understanding and patience.

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Master Fluids Engineering for Industrial Processes

The courses of this Master of Science program will soon be open to exchange students. Thank you for your understanding and patience.

Cross-Disciplinary Courses

2^{nd} year Master's programme combining engineering courses from several departments

Urban Engineering

Contacts : Sophie Claude

The Urban Engineering Interdisciplinary Programme is a second-year Master's programme which combines engineering courses from two departments at INSA Toulouse: Civil Engineering and Process Engineering for Water, Energy and the Environment.

Contemporary urban challenges require action at various scales (building, neighbourhood, urban area and region) and demand a strong interdisciplinary approach. The Urban Engineering programm thus offers an integrated approach, combining a solid technical foundation in areas such as energy, microclimate, transport, water and waste management, and biodiversity, with the integration of users and the living environment in the broadest sense. Contributions from ecology, architecture, the humanities and social sciences, politics, law, economics and other fields enrich the INSA engineering programme.

The Urban Engineering programme's distinctive feature lies in its focus on the environmental and climate transition of cities, and its commitment to steering urban development towards sustainable, resilient, nature-based solutions.

Urban Engineering graduates are therefore key players in the transition, specialising in the management of water, energy, waste and transport, and capable of collaborating with urban planners, architects, landscape architects, sociologists, geographers and others on large-scale urban projects.

Semester 1, starting from September

Code	Course description	Lan.[1]	ECTS	L	T	LW	P
I5PTGU35-exc	Urban Workshop *	EN	10	20.0			80.0
I5PTGU25-01-exc	Cities and Energy	FR	3	13.75	21.25		
I5PTGU25-02-exc	Cities and Water	FR	3	27.5	6.25		
I5PTGU25-03-exc	Transport and Mobility	FR	3	16.25	17.5		
I5PTGU25-04-exc	Waste Manag. and Contaminated Sites	FR	1	11.25	3.75		
I5PTGU15-01-exc	Urban Expertise	FR	1	12.5	3.75		
I5PTGU15-02-exc	Modelling Cities *	EN/FR	3		40.0		
I5PTGU15-03-exc	Inter-programme Workshop **	EN/FR	3				35.0

(*) Although the majority of courses will be taught in English, a few courses may be taught in French, depending on the instructor. Please contact the International Relations Coordinator (S. Claude) for more details.

(**) As part of this course, students are required to meet and interact with French citizens, most of whom are French-speaking, during a one-day activity held prior to the five-day project, which may be fully supervised in either French or English.

Innovative Smart Systems

The courses of this Master of Science program will soon be open to exchange students. Thank you for your understanding and patience.

Energy

The courses of this Master of Science program will soon be open to exchange students. Thank you for your understanding and patience.

Course Syllabus

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Fluid mechanics

Module details

I3BEMF10-exc

5 ECTS EN/FR
20.0 h 22.5 h 9.0 h 0 h
DURUPT DOMINIQUE, LABORIE STEPHANIE, MOREL SANDRINE, SCHMITZ PHILIPPE
Revision date : May 18, 2026

Objectives

Learn the basics of fluid mechanics modeling in order to understand the operation and design of laboratory equipment and industrial facilities dealing with fluid flows

- Understand and apply global mass and momentum balances on a control domain
- Understand the concept of mechanical energy balance and apply Bernoulli's theorem
- Understand the concepts of dynamic and thermal boundary layers and apply the corresponding transfer coefficients
- Write a force balance on an inclusion selecting the appropriate drag law
- Write and apply the universal velocity profile in turbulent flow
- Estimate characteristic spatial and temporal scales of turbulence in reactors

Content

From the complete Navier–Stokes model, we will explore the usual restricted models for incompressible flows, including :

- Stokes (creeping flow)
- Euler (inviscid flow)
- Prandtl (laminar boundary layer)
- Reynolds (turbulent flow)

We will address and apply standard fluid mechanics concepts such as Euler's theorem, Bernoulli's principle, perfect fluid, irrotational flow, fluid-wall interaction (dynamic and thermal boundary layers) and drag coefficient. We will study turbulence through the notion of turbulent viscosity, the universal logarithmic profile, the k-epsilon model, and the different scales of turbulence.

Prerequisites

Prerequisite for this course include :

- I2BEMT10 Mathematics
- I2BEBT10 Transfer Fundamentals

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Heat transfer

Module details

I3BETT10-exc

4 ECTS EN/FR
12.5 h 13.75 h 10.5 h 0.0 h
LABORIE STEPHANIE, MOLINA CAROLE, MOREL SANDRINE, RUMPALA JOHANNE, SCHMITZ PHILIPPE
Revision date : May 18, 2026

Objectives

At the end of this common teaching section, the student should have understood and be able to explain (main concepts):

Common Section:

- The general equation of energy conservation
- The different modes of heat transfer and the associated laws into the phenomena of conduction (Fourier's law) and forced and natural convection (Newton's law),
- The expressions for heat flux by conduction and convection and temperature profiles within different systems in steady-state conditions (simple and composite walls, cylindrical and spherical layers, simple and composite).

Section "Chemical Engineering":

- Heat transfer in solids with and without heat production in steady-state
- Heat transfer in solids with and without heat production in transitional regime
- Heat transfer by radiation

Section "Industrial Biotechnology":

- Different technologies of heat exchangers (tubular, plate, coil, double-wall) implemented industrially
- Principles and operating theories of heat exchangers
- Sizing of heat exchangers

Content

Common Section :
The student should be able, for plan, cylindrical, and spherical systems in steady-state conditions, with or without heat generation, to:

- Establish and solve the energy balance equations in steady-state conditions to calculate heat fluxes and characterize temperature gradients,
- Calculate heat fluxes, thicknesses of materials composing walls, pipes, spherical tanks in steady-state conditions,
- Calculate temperatures at interfaces.

Section "Chemical Engineering":
The student should be able to:

- Explain the different heat fluxes
- Establish energy balances on reactive or non-reactive systems
- Integrate differential equations to determine temperature profiles and assess heat fluxes
- Know how to transmit a given amount of heat between two systems
- Know how to limit heat losses through a surface
- Study cases applicable to processes.

Section "Industrial Biotechnology":
The student should be able to:

- Choose a technology and configuration of heat exchanger according to its uses
- Calculate heat exchange between fluids within a heat exchanger based on steady-state configurations
- Calculate the efficiency of a heat exchanger based on steady-state configurations
- Size the heat exchange surface of a heat exchanger according to its steady-state configuration
- Calculate the performance of heat exchangers based on flow rates and inlet and outlet temperatures of fluids
- Solve, in transitional regime, the energy balance equations on a perfectly stirred tank to calculate heating and cooling times according to the implemented technologies (coil, double-wall, external heat exchanger) with or without thermal loss

Prerequisites

Prerequisite for this course include :

- Thermodynamics
- Differential equations and partial differential equations

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Hydraulic engineering

Module details

I3BEGH10-exc

3 ECTS EN/FR
7.5 h 16.25 h 9.0 h 10.0 h
DURUPT DOMINIQUE, LABORIE STEPHANIE, MARANGES CLAUDE, RUMPALA JOHANNE, SCHMITZ PHILIPPE
Revision date : May 18, 2026

Objectives

By the end of this module, the student should understand and be able to explain the hydraulic dimensioning of a complete system (processes, plants, hydropower turbine)

Content

The content of this course includes :

- Macroscopic mass, momentum and energy balance
- Fluid rheology
- Application of energy balance (Bernoulli)
- Conducted flow and free flow
- Linear and singular pressure losses
- Turbomachinery: Pumps and turbines
- Hydraulic networks
- Extension to total energy balance (EC thermodynamics)

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Process engineering

Module details

I3BEPT10-exc

3 ECTS EN/FR
0.0 h 25.0 h 0.0 h 0.0 h
DIETRICH NICOLAS, ENJALBERT BRICE, LABORIE STEPHANIE, MARANGES CLAUDE, MOREL SANDRINE, RUMPALA JOHANNE
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain the main concepts related to:

- The operating principles of transformation processes for raw materials (petroleum, coal, gas, ores, biomass), heavy organic and inorganic chemistry (refining and petrochemistry, NH−3, H−2SO−4, Na−2CO−3, NaOH, Cl−2, fertilizers, etc.), and energy production (thermal, nuclear, biomass).
- The schematic representation of a process (flowsheet) and associated graphical conventions.
- The basic principles of process cost estimation.
- The industrial context of the sector.

Students will also be able to:

- Describe an industrial production pathway.
- Read, interpret, and propose an installation flowsheet.
- Perform overall mass and energy balances for a process to calculate material and energy flows.
- Identify information flows.
- Conduct a critical analysis of an industrial process.
- Estimate the cost of a process.
- Work autonomously from a set of specifications.
- Find and analyze scientific and technical documentation.

Content

This course introduces the concept of industrial processes, their design principles, and the constraints inherent to industrial production. Students learn how to represent and estimate the cost of a process and study several major industrial production pathways. A group project involves the critical analysis of a material or energy transformation process.

Prerequisites

Prerequisite for this course include :

- Inorganic, organic, and biochemical chemistry
- Thermodynamics
- Chemical kinetics and reactors
- Unit operations in chemical engineering
- Control systems
- Metrology

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR
5.0 h 21.25 h 2.5 h 0.0 h
CARREY JULIAN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Microbiology

Module details

I3BEMI10-exc

2 ECTS EN/FR
10.0 h 2.5 h 1.25 h 0.0 h
ENJALBERT BRICE, MOREL SANDRINE, REMAUD MAGALI
Revision date : May 18, 2026

Objectives

Students will learn the rules of microorganism nomenclature, as well as the principles and methods of classification and identification of microorganisms.
They will understand the characteristics and procedures for identifying microorganisms based on traditional techniques (direct data collection, after culture, based on biochemical methods or antigenic characterization, etc.).
They will also need to understand and apply molecular methods based on nucleic acid analysis (use of nucleic probes, gene amplification, restriction or molecular profiling) or protein profiling.
In a second section, students will be able to independently investigate the reactions involved in the respiration and photosynthesis of microorganisms, acquiring the tools required to calculate average and specific growth rates.
A third section will focus on microbial viruses. Students will learn to describe their diversity, their ecological niche, and their role in regulating terrestrial and marine microbial biodiversity. They will also learn how to analyze and count them.
The final section will address examples of symbiosis, human gut microbiota and corals.

Content

The content of this course includes :

Microorganisms

- Review of nomenclature rules
- Principles and methods of classification and identification (principles of classification, identification characteristics and procedures, main characteristics and classification of some microorganisms)

Respiration, photosynthesis and microbial growth

Microbial viruses

- Definition and history
- Phage morphology and structural diversity
- Distribution in ecosystems
- Phage infection cycles
- Genetic material and replication/transcription/translatio
- T4 and Lambda phages

Symbioses

- Definition
- The human intestine
- Corals

Prerequisites

Prerequisite for this course include :

- I2BEBS10 Structural Biochemistry
- I2BEMI20 Microbiology

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Bacterial genetics

Module details

I3BEGB11-exc

3 ECTS EN/FR
18.75 h 11.25 h 7.5 h 0.0 h
ENJALBERT BRICE, MOREL SANDRINE
Revision date : May 18, 2026

Objectives

The aim of this course is to address the underlying mechanisms through which bacteria are able to evolve their genetic sequence and respond to environmental conditions.

Content

A review of mutagenic mechanisms, from point mutations to large-scale mutations (mutagens, horizontal transfer mechanisms, transposition). The course will address prokaryotic transcriptional and translational regulation. It will introduce the biotechnological applications of this knowledge, as well as existing tools for gene expression regulation, measurement and profiling.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Enzymology

Module details

I3BEEZ20-exc

4 ECTS EN/FR
23.75 h 10.0 h 22.5 h 0.0 h
MEYNIAL ISABELLE, MOREL SANDRINE, MOULIS CLAIRE
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain:

- the importance of studying enzymes and the use of these biocatalysts in biotechnology in the context of ecological transition, sustainable development related to the bioeconomy.
- the methods for measuring the velocity of an enzymatic reaction
- the equations applied to model the kinetics of enzymatic reactions
- the influence of the main physico-chemical parameters on the catalytic efficiency.
- the methods used to determine and analyze the enzyme three-dimensional structure

Students will also learn to use:

- databases of nucleic acids as well as databases of protein sequences and three-dimensional structures
- computational tools used for sequence alignments (nucleic acids or proteins), visualization of tertiary protein structures and for structure-function relationship studies.

Content

The content of this course includes :

- Classifications of enzymes, general and specialized databases
- Kinetic models: Michaelian enzymes, inhibition mechanisms, kinetic models of multi-substrate enzymes, allosteric enzymes and regulation
- Principles of nucleic acid and protein sequence alignment (local and global alignment)
- Biophysical methods used to determine 3D protein structure
- Visualization of catalytic site and analysis of catalytic mechanisms

Prerequisites

Prerequisite for this course include :

- I1ANETCH Chemistry
- I2BECH10 Organic Chemistry
- I2BEBS10 Structural Biochemistry
- I2BEAN20 Analytical Methods
- I2BEGR20 Reaction Engineering

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Biophysics

Module details

I3BEBP20-exc

3 ECTS EN/FR
16.25 h 10.0 h 1.25 h 0.0 h
DANELON CHRISTOPHE, GUIEYSSE DAVID, MOREL SANDRINE
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

Advanced methods in molecular and cellular biophysics:

- Fluorescence microscopy and correlation spectroscopy
- Flow cytometry and flow cytometry coupled with imaging and sorting
- Electrophysiology, nanopore-based detection and sequencing
- PyMol for protein visualization
- Surface measurement techniques

Key concepts in molecular and cellular biophysics:

- Macromolecular packing
- Noise as a general principle in biological organization and function (stochastic gene expression, random walk, protein conformational changes)
- Cell signaling in time and space

Students will be able to:

- Interpret data from biophysical experiments and link the results to the concepts studied
- Use biophysical data to solve novel problems in biology and bioengineering

Content

The content of this course includes :

- Introduction to biophysics
- Protein structure
- Ion channels and electrophysiology
- Random walk in biology
- Membrane organization and dynamics
- Fluorescence microscopy and spectroscopy
- Stochasticity in gene expression
- Cell signaling

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Organic chemistry

Module details

I3BECO20-exc

3 ECTS EN/FR
3.75 h 7.5 h 0.0 h 26.25 h
GUIEYSSE DAVID, MOREL SANDRINE
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- Reaction mechanisms encountered in chemistry and biology

Students will be able to:

- Understand and explain reaction mechanisms
- Carry out a multidisciplinary experimental mini-project in groups, including: designing an experiment on the basis of bibliographic research; devising an analytical follow-up approach; implementing an experimental approach with analytical techniques; generating data; interpreting, analyzing and evaluating experimental results; and making oral presentations

Content

The content of this course includes :

- Stereochemistry: prochirality, synthesis of enantiomerically pure compounds
- The carbonyl function (organic and related enzymatic reactions)
- Nucleophilic addition: main reaction of aldehydes and ketones
- Nucleophilic substitution at C(sp2): main reaction of derivatives
- Multidisciplinary experimental project bridging chemistry and biology.

Prerequisites

Prerequisite for this course include :

- I1ANETCH Chemistry
- I2BECH10 Organic Chemistry
- I2BEBS10 Structural Biochemistry
- I2BEAN20 Analytical Methods I

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Structural chemistry

Module details

I3BECS21-exc

3 ECTS EN/FR
12.5 h 13.75 h 4.0 h 0.0 h
GUIEYSSE DAVID, MOREL SANDRINE
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- The theory and practice of the main analytical methods used in chemistry and biochemistry

Students will be able to:

- Determine the structure of simple chemical and biological molecules using analytical methods (NMR, mass spectrometry, IR, UV)

Content

The content of this course includes :

- Training in spectroscopic methods applied to a rational approach to structural determinations. Students will deepen and broaden their theoretical knowledge on nuclear magnetic resonance, infrared spectroscopy, ultraviolet spectroscopy, and mass spectrometry.
- Students will leverage the complementary nature of the various techniques to determine the structure of molecules.
- Principles and applications of analytical methods (NMR, mass spectrometry, IR, UV) in chemistry and biochemistry.
- 1D and 2D NMR spectroscopy: ˆ1H, ˆ13C.
- Mass spectrometry: EI, CI, ESI, MALDI, SIMS.

Prerequisites

Prerequisites include :

- I1ANETCH Chemistry
- I2BECH10 Organic Chemistry
- I2BEBS10 Structural Biochemistry
- I2BEAN20 Analytical Methods I

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Bioseparation

Module details

I3BEBS20-exc

3 ECTS EN/FR
11.25 h 3.75 h 15.0 h 0.0 h
MEYNIAL ISABELLE, MOREL SANDRINE
Revision date : May 18, 2026

Objectives

Bioseparation: Upon completing this module, students will have gained an understanding of and be able to explain:

- The mechanisms of separation techniques usually used in biochemistry-biotechnology, more particularly in the case of biocatalysts
- Properties of biological molecules used in the application of separation techniques
- Techniques of precipitation (proteins, nucleic acids)
- Techniques of centrifugation and ultracentrifugation
- Membrane techniques (MF, UF, NF, dialysis, electrodialysis)
- Electrophoretic techniques

Students will also have learned how to:

- Select the most appropriate bioseparation method(s) for a specific situation on the basis of its mechanism
- Appropriately handle equipment and techniques for protein purification and verification of the purification process (tangential ultrafiltration, low- and medium-pressure chromatography, electrophoresis)
- Perform qualitative and quantitative assessments of the performance of one or more separation techniques

Content

The content of this course includes :

- Precipitation: definition, classification, salting-in, salting-out, precipitation by solvents, precipitation by polymers.
- Centrifugation and ultracentrifugation: definition, classification, sedimentation theory, equipment.
- Membrane techniques: microfiltration, ultrafiltration and nanofiltration, reverse osmosis, dialysis, electrodialysis (theory, mechanisms, equipment and use).
- Electrophoresis techniques: electrophoretic displacement, gel electrophoresis (agarose, PAGE, isoelectric focusing, 2-D electrophoresis), capillary electrophoresis.

Prerequisites

Prerequisites include :

- I1ANETCH Chemistry
- I2BECH10 Organic Chemistry
- I2BEBS10 Structural Biochemistry
- I2BEAN20 Analytical Methods
- I2BEGR20 Reaction Engineering

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Genetics engineering

Module details

I3BEGG20-exc

3 ECTS EN/FR

17.5 h 0.0 h 18.75 h 6.25 h

DANELON CHRISTOPHE, MEYNIAL ISABELLE, MOREL SANDRINE

Revision date : May 18, 2026

Objectives

By the end of this module, the student should understand and be able to explain (main concepts):

- The basic tools and methods used in genetic engineering (restriction enzymes, vectors, cloning, PCR, sequencing, DNA library construction, mutagenesis, analysis of gene expression and function, etc.)
- The main genetic engineering approaches used in synthetic biology
- The bioinformatics tools for analysis of primary protein sequences (large datasets) and identification of structural motifs as specificity signatures
- The bioinformatics tools for analysis of protein 1D, 2D, and 3D structures
- the methods for bibliographic research in scientific databases to produce a literature synthesis and presentation

The student should be able to:

- understand mechanisms of action and engineering of catalysts
- describe and/or summarize various molecular biology techniques and place them in a broader scientific and/or experimental context
- know and present different approaches and methods in the field of genetic engineering
- use in silico cloning software
- conduct molecular biology experiments in bacterial host systems
- describe bioinformatics methods for protein structure analysis (sequence alignment, graphic and molecular modeling software) and use these tools to understand structure–activity relationships and enzyme engineering
- know and use databases for scientific article research
- construct and write a bibliographic study

Content

The content of this course includes :

- Basic tools (enzymes, plasmids, oligonucleotides)
- Gene cloning techniques (with or without restriction enzymes)
- Protein expression in bacteria
- Gene and function analysis (Sanger sequencing, next-generation DNA sequencing, protein–protein interaction studies, gene expression analysis of one or several genes, site-directed mutagenesis, etc.)
- DNA library construction
- Completion of a bibliographic review within the thematic field of genetic engineering (genome editing, microorganism engineering, metagenomic techniques, gene expression, plant engineering, etc.). Oral presentation of one of the analyzed articles to the entire class.
- Rational and combinatorial protein engineering techniques
- Computer tools for sequence processing (analysis of genomic and proteomic databases, multiple protein sequence alignments, phylogenetic tree editing, and sequence clustering using SSN approaches) and for 3D protein structure and molecular docking (Pymol, AutoDock).
- Case study: oxidoreductases.

Prerequisites

Prerequisites include :

- Microbiology
- Structural Biochemistry
- Basic Molecular Biology

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS EN/FR

0.5 h 2.75 h 0.0 h 0.0 h

BOULIER THOMAS, CHAZEL FLORENT, DE GOURNAY FREDERIC, GUERMOUCHE NAWAL, GUIEYSSE DAVID, GUIGUI CHRISTELLE, HANTCHERLI MURIEL, LABORIE STEPHANIE, LAHANA YONI, MAHOUT VINCENT, MOREL SANDRINE, PLANTEC JEAN-YVES

Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Eukaryotic molecular biology and enzyme engineering

Module details

I4GBBM11-exc

7 ECTS EN
40.0 h 6.25 h 28.5 h 6.25 h
CAPP JEAN-PASCAL
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and will be able to explain (main concepts):

- The basic tools and methods used in genetic engineering (restriction enzymes, vectors, cloning, PCR, sequencing, construction of DNA banks, mutagenesis, analysis of gene expression and function, etc.)
- The main genetic engineering approaches used in synthetic biology
- Bioinformatics analysis tools for i) the analysis of protein primary sequences (on large datasets) and the search for structural pattern signatures of specificity ii) the analysis of 1D, 2D, 3D structures of proteins iii)) understanding the mechanisms of action and the engineering of catalysts.
- Literature research methods in scientific databases to produce a synthesis and a bibliographic presentation.

The student must be able to:

- Describe and/or summarize the different basic techniques and be able to place these techniques in a broader scientific and/or experimental context
- Know and present different approaches and methods in the field of genetic engineering
- Use 'in silico' cloning software
- Carry out molecular biology experiments in bacterial or yeast host systems
- Describe methods for bioinformatics analysis of protein structures (sequence alignment, graphics software and molecular modeling). Use these tools for understanding structure activity relationships and enzyme engineering.
- Know and use databases to search for scientific articles
- Construct and write a bibliographic study

Content

The content of this course includes :

- Basic tools (enzymes, oligonucleotides, plasmids)
- Gene cloning techniques (with or without restriction enzymes)
- Expression of proteins in bacteria or yeast.
- Analysis of a gene and its function (sequencing, protein-protein interaction studies, methods for studying the expression of one or more genes, site-directed mutagenesis, etc.)
- Completion of a bibliographic review in the thematic field of genetic engineering (genome editing, engineering of microorganisms, metagenomic techniques, gene expression, plant engineering, etc.). Oral presentation of one of the articles analyzed as part of the review to the entire class.
- Rational and combinatorial protein engineering techniques.
- Computer tools for sequence processing (analysis of genomic and protein databases, multiple alignments of protein sequences, editing of phylogenetic trees and clustering of sequences by SSN approach) and 3D structure of proteins and molecular docking (Pymol, AutoDock). Case study: oxidoreductases

Prerequisites

Prerequisites include :

- Microbiology
- Structural Biochemistry
- Basic Molecular Biology

Assessment

Assessement of this course includes :

- Written examination of knowledge restitutions
- Comprehensive exam on computer (restitution and case study).
- Bibliographic report and oral presentation

- Practical work report containing an analysis of results

Back to menu

Cellular metabolism and regulation

Module details

I4GBBC11-exc

6 ECTS EN/FR
42.5 h 2.5 h 18.0 h 0.0 h
GUILLOUET STEPHANE
Revision date : May 18, 2026

Objectives

Acquiring the basics in the cell metabolism and its regulation

Content

The content of this course includes :

- Acquiring the basics in the cell metabolism and its regulation
- Description of the main metabolic pathways.
- Thermodynamics and kinetics.
- Stoechiometric balances.
- Description of some pathway regulation.
- Interconnection between the different pathways within the carbon central metabolism.

Prerequisites

Under construction

Assessment

Assessement of this course includes :

- Written exam and Labwork

Back to menu

Biochemical kinetics and bioreactor

Module details

I4GBBC21-exc

5 ECTS FR
31.25 h 17.5 h 22.5 h 3.75 h
ACEVES LARA CESAR ARTURO
Revision date : May 18, 2026

Objectives

Understanding and implementing the biological reactions

- Elements in biochemical engineering.
- Description of the bioreactor and its instrumentation.
- Mass, elementary and energetic balances.
- Application to ethanolic fermentation.
- Numerical experimental data treatment

Content

The content of this course includes :

- Biochemical reactions, reactors and microbial engineering
- Reactors instrumentations
- Microbial kinetics
- Material Balances, stoichiometric and yield relationships
- Thermodynamic Balances
- Idealized reactors (Batch, Continuous Stirred Tank Reactor, Tubular Reactor), combinations of ideal reactors, recycling reactors and real reactors
- Distribution of residence times
- Modeling real reactors with combination of ideal reactors

Prerequisites

Prerequisites of this course include :

- Chemical and enzyme kinetics
- Matrix Differential Calculus

Assessment

Assessement of this course includes :

- Examination checking of basic knowledge
- Analysis of a case study

Back to menu

Mass transfer

Module details

I4GBTF11-exc

5 ECTS FR
30.0 h 7.5 h 4.0 h 0.0 h
MARANGES CLAUDE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- To understand mass transfer phenomena (diffusion, convection).

The student will be able to:

- read, interpret, propose an installation flowsheet
- to write global balances on a process in order to calculate matter and energy flows
- identify of information fluxes
- make an critical analysis of a process
- be able to design an optimal set of experiments

Content

The content of this course includes :

- Fundamental laws of mass transfer phenomena : conduction, convection.
- Steady state and transient state.
- Mass balance.
- Transfer in several phases.
- Reaction and transfer.
- Application to biotechnologies (oxygen transfer).
- Heterogeneous catalysis.
- Optimal design methodology and experimental strategy.
- Experimental designs.
- Factorial designs.
- Response surface.
- Optimal responses determination.
- Study of mixtures.

Prerequisites

Prequisites of this course include :

- Thermodynamics of solutes
- Differential and partial derivative operations.

Assessment

Assessement of this course includes :

- Answer to the written or oral questions
- Participation in Tutorial Classes and Labworks

Back to menu

Cell culture for biotherapies

Module details

I4GBBC41-exc

6 ECTS EN
30.0 h 2.5 h 45.0 h 3.75 h
CAPP JEAN-PASCAL
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- How to establish a cell line
- The specificities of mammalian cell culture in terms of culture conditions and media
- The basics of innate and adaptive immune responses
- The principles of vaccination and immunotherapy
- Production of proteins for therapeutic use
- Principles of innovative therapies (cell and gene therapy, RNA drugs)
- Basic elements of regulation and good practices for the bioproduction of biologics

The student should be able to :

- use the vocabulary specific to cell culture
- name the main characteristics of a mammalian cell
- implement and/or manipulate cell culture in dishes and roller bottle and cell spinner production systems
- understand and explain innovative therapies based on proteins, nucleic acids or cells
- analyse, comment on and criticize a scientific publication in the field of cell culture and biotherapies
- review the current state of knowledge in a field of application of cell culture
- address the social and environmental issues facing the pharmaceutical industry

Content

Courses and seminars :

- Basics of cell culture
- Immunology: innate and adaptive response, principle of vaccination, immunotherapies
- Virology: basics and production of whole viral vaccines
- Biotherapies and new drugs (cell and gene therapy / artificial organs, RNA drugs)
- Production of proteins for therapeutic use in animal or insect cells (including viral proteins for vaccination)
- Regulations and good practice, elements of life cycle analysis

Practical works :

- Culture of mammalian cell lines adherent or in suspension in culture dishes (lab work 1)
- Production of recombinant proteins in roller bottles and cell spinners (lab work 2).

Prerequisites

Under construction

Assessment

Assessement of this course includes :

- Written examination on course knowledge and/or analysis of bibliographical data
- Oral presentation
- Practical work reports containing an analysis of results

Main difficulties usually encountered by students:

- acquiring knowledge in a variety of health-related fields for the first time in their course.

Back to menu

Microbial cultures

Module details

I4GBBC31-exc

6 ECTS EN
31.25 h 15.0 h 31.5 h 0.0 h
GUILLOUET STEPHANE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- How to establish a cell line in culture
- Mammalian cell culture specificities in terms of conditions and media
- Major uses of mammalian cells
- Various kinetic behaviours of microbial growth and production
- Several strategies from implementation of the microbial cultures in the bio-reactor

The student will be able to:

- use a vocabulary specific to cell culture
- name major characteristics of a mammalian cell
- manipulate a cell line
- analyse, comment and criticize a scientific paper in the domain
- to calculate the various kinetic and stoechiometric parameters of microbial cultures
- to calculate the potentialities of productions for the various bio-reactors

Content

The content of this course include:

1. Theoretical and Methodological Foundations. This module aims to provide a general introduction to molecular modeling, methods for structure representation and analysis, as well as structural databases, and to present multi-scale molecular modeling approaches:
   - General introduction to structural biology
   - Theoretical calculation methods
   - Prediction of three-dimensional protein structures and molecular dynamics
2. Practical Application of Methods.Tthis module aims to apply several methods:
   - Analysis and modeling of 3D protein structures
   - Analysis and construction of 3D models of protein–ligand complexes
   - Molecular mechanics force fields and energy minimization
   - Molecular dynamics

Prerequisites

The prerequisites for this course includes:

- Basic knowledge of cellular Biology
- Basic concepts of molecular biology
- Courses of kinetics, microbiology, metabolism, reactor engineering

Assessment

Assessement of this course includes:

- general questions about the course
- exercises solving
- analysis of data from scientific papers
- group work on a subject and oral presentation of the work
- report on a one day and half labwork

Back to menu

Unit operations

Module details

I4GBTF21-exc

5 ECTS FR
20.0 h 7.5 h 54.0 h 0.0 h
MARANGES CLAUDE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- heat transfer phenomena: conduction, convection and radiation.
- Mass transfer : principles of distillation and absorption

The student will be able to:

- Size heat and mass exchangers

Content

The content of this course includes :

- Fundamental laws of heat transfer phenomena : conduction, convection and radiation.
- Thermal resistance.
- Conduction in solids : steady state and transient state.
- Natural and forced convection.
- Heat and mass exchanger: theory, calculations, technology.

Prerequisites

Under construction

Assessment

Assessement of this course includes :

- Answer to the written or oral questions
- Participation in Tutorial Classes and Labworks

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Pluridisciplinary projects

Module details

I4GBPJ11-exc

5 ECTS FR
18.75 h 15.0 h 0.0 h 35.0 h
MARANGES CLAUDE
Revision date : May 18, 2026

Objectives

At the end of this module, students should have understood and be able to explain:

- The methods for effective project management,
- The main quality-related concepts and tools,
- The requirements related to safety and environmental considerations during project implementation.

Students should be able to:

- Implement action projects independently and/or collaboratively,
- Manage the implementation and monitoring of a project as a specialist,
- Plan their own actions and anticipate those of others,
- Regulate activities during project implementation,
- Make appropriate decisions considering interactions between stakeholders in order to be effective,
- Communicate effectively to obtain the desired actions,
- Distribute roles while taking individual competencies into account,
- Act in response to constraints and challenging situations.

Content

The program includes four components:

- Project management methodology
- Principles of the "Quality, Safety and Environment" (QSE) approach
- The implementation of a multidisciplinary project involving knowledge in biochemical engineering, transport phenomena, bioreactor engineering, material balances and unit operations
- Participation in individual and team sports activities

Prerequisites

Prerequisites for this course include :

- Biochemical Engineering
- Transport Phenomena
- Bioreactor Engineering

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take various forms such as written examinations, oral presentations, reports, written assignments, or peer assessment. It enables students to evaluate their learning progress in problem-solving.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Systems and Synthetic Biology for biotech.

Module details

I5GBBM11-exc

12 ECTS EN
45.0 h 0.0 h 100.0 h 0.0 h
CAPP JEAN-PASCAL
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- how Systems Biology is changing the way biological systems are studied by allowing us to examine the cell and organism as a whole, especially Systems Biotechnology that allows optimal design and development of upstream to downstream bioprocesses by taking a systems-approach (with Escherichia coli as the main bacterial producer studied), and Systems Medicine that considers diseases as 'perturbations of networks', and transforms the way drugs are developed by targeting multiple components of networks and pathways perturbed in diseases ;
- why Synthetic Biology an emerging field is located at the intersection of life science and engineering and is the application of the principles of engineering to the construction of life with desired properties in a rational and systematic way ;
- what are the wide objectives of synthetic biology and their application for biomedicine, the cheaper synthesis of biopharmaceuticals, sustainable chemical synthesis by efficient biotransformation, environment and energy

The student will be able to:

- consider a biological question by applying a systems biology approach and study the mechanisms underlying complex biological processes as integrated systems of many interacting components. Systems biology involves (1) collection of large sets of experimental data, (2) proposal of mathematical models that might account for at least some significant aspects of this data set, (3) accurate computer solution of the mathematical equations to obtain numerical predictions, and (4) assessment of the quality of the model by comparing numerical simulations with the experimental data. Thus the student will acquire skills in network biology and genetic engineering, but also in mathematics (statistics, modelling), computer sciences and 'omics' technologies allowing acquisition of large-scale biological data.
- conceive of and purpose a synthetic biology approach to introduce novel functionality into engineered organisms for production purposes or for building new materials. The student should be able to develop the most appropriate strategy and choose the adapted technical methods to reach the goal of engineered biological systems with optimized biosynthetic pathways and develop efficient routes for producing pharmacologically active compounds, industrially important bulk chemicals, and liquid fuels for transportation

Content

The content of this course includes:

1. Generalities concerning Systems Biology:
   - Complexity of the cell (especially in terms of regulation) and of higher organisms, importance of network biology
   - Approaches and methods, genetic tools, modelling tools and statistics, -omics technologies, informatics tools.
2. Systems Biology for health :
   - Relevance for studying complex diseases
   - Focus on cancer which is archetypal (complexity of intra-cellular factors (genetic and epigenetic complexity) and extra-cellular factors (influence of other cell types, angiogenesis)) illustrated by examples.
3. Generalities, principles and field of application of synthetic biology
   - definition(s) and advantages of synthetic biology
   - methods of synthetic biology
   - identification and engineering of enzymes and metabolic pathways adapted to the final goal

- description of specific genetic tools developed for synthetic biology, presentation of host organisms to use, description of tools for optimization of metabolic fluxes to achieve high product titers

4. Synthetic biology for industrial biotechnologies

    - Interest for the biological production of existing bulk chemicals. Presentation of the challenges, the complexity but also the industrial success stories of this approach through several industrial examples.

Prerequisites

Assessment

Basic knowledge (50%) and ability to apply these concepts and methods on a concrete biological problem It checks the basic knowledge together with its use in biological studies using systems and/or synthetic approaches

Back to menu

Design project

Module details

I5GBPJ21-exc

12 ECTS EN
0.0 h 0.0 h 0.0 h 120.0 h
MARANGES CLAUDE
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- Enable students to apply their skills to the design of a biotechnological process.

The student should be able to:

- propose a process flowsheet,
- write overall balances for a process in order to calculate material and energy flows,
- carry out a critical analysis of a process,
- design a process by selecting appropriate unit operations,
- perform the economic evaluation of the process.

Content

With the support of a tutor, students are required to design a biotechnological process: literature review, selection of unit operations, coupled heat and mass transfer, economic evaluation

Prerequisites

Under construction

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take various forms: written exam, oral exam, report, written assignment, peer assessment, etc.

Back to menu

Microbiology *

Module details

I5GBBC1101-exc

12 ECTS   FR
35.0 h   0.0 h   100.0 h   0.0 h
GUILLOUET STEPHANE
Revision date : May 18, 2026

Objectives

Approach to microbial cultures under industrial production conditions, integrating physiology, modeling of biological reactions, and the implementation and operation of fermentation processes.

Content

The content of this course includes:

1. MICROBIAL PHYSIOLOGY
   - Physiological behavior for various industrial productions by bacteria, yeasts, and fungi
   - Cellular energetics and implementation constraints
2. MODELING
   - Methodology for modeling microbial reactions
   - Phenomenological modeling
   - Metabolic flux modeling
   - Structured modeling
3. BIOREACTOR OPERATION
   - Control through controlled substrate feeding strategies
   - Optimization strategies under non-limiting operating conditions
4. BIOREACTOR DESIGN
   - Aerated, mechanically stirred reactors (CSTR)
   - Non-CSTR aerated reactors: bubble columns, air-lift reactors, etc.

Prerequisites

The prerequisites for this course include:

- Microbial kinetics
- Microbial cultures
- Microbial metabolism

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take various forms: written exam, oral exam, report, written assignment, peer assessment, etc.

Back to menu

Biocatalyse *

Module details

I5GBBC1103-exc

12 ECTS EN
35.0 h 0.0 h 100.0 h 0.0 h
MOULIS CLAIRE
Revision date : May 18, 2026

Objectives

At the end of this course, the student should have understood the role of enzymes in the bioeconomy and in the development of sustainable bioprocesses that meet societal expectations. They will have become aware of the immense diversity of accessible sequences, derived from natural or synthetic diversity, and enabled by increasingly sensitive, miniaturized, and high-throughput analytical and screening techniques, as well as by an ever-growing range of powerful bioinformatics tools. The objective of this course is to deepen the knowledge and skills in enzymology and enzyme engineering introduced in the 3rd and 4th years, in order to specialize in mastering tools for the analysis, optimization, and in silico and in vitro design of enzymes. Their application to the development of enzymatic or chemo-enzymatic processes for the benefit of the circular bioeconomy and biotechnologies is also further explored.

Content

The content of this course includes:

- Deepening of knowledge and mastery of bioinformatics tools for sequence analysis, particularly those adapted to the analysis of very large datasets.
- Description of integrative structural biology techniques dedicated to determining the crystallographic structures of enzymes.
- Further development of knowledge and mastery of the latest advances in molecular modeling and analysis of enzyme–substrate interactions.
- Implementation of protein engineering tools through directed evolution and (semi-)rational design.
- Introduction to ultra-high-throughput screening techniques.
- Implementation of enzymes or enzymatic cascades in reactors, in homogeneous or heterogeneous media, with examples across various types of applications.

Prerequisites

Prerequisites fr this course include:

- Molecular Biology
- Organic Chemistry
- Structural Chemistry
- Enzymology
- Genetic Engineering and Enzyme Engineering

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take various forms: written exam, oral exam, report, written assignment, peer assessment, etc.

Back to menu

Design project

Module details

I5GBPJ21-exc

12 ECTS EN
0.0 h 0.0 h 0.0 h 120.0 h
MARANGES CLAUDE
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- Enable students to apply their skills to the design of a biotechnological process.

The student should be able to:

- propose a process flowsheet,
- write overall balances for a process in order to calculate material and energy flows,
- carry out a critical analysis of a process,
- design a process by selecting appropriate unit operations,
- perform the economic evaluation of the process.

Content

With the support of a tutor, students are required to design a biotechnological process: literature review, selection of unit operations, coupled heat and mass transfer, economic evaluation

Prerequisites

Under construction

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take various forms: written exam, oral exam, report, written assignment, peer assessment, etc.

Back to menu

Programming and Applications

Module details

I5GBioComp11-exc

10 ECTS FR
2.5 h 83.75 h 0.0 h 23.75 h
ACEVES LARA CESAR ARTURO
Revision date : May 18, 2026

Objectives

The objectives of this course include:

- Digital tools and fundamentals : The obective of this course involves revisiting (or introducing) fundamental concepts in computer science, statistics, and/or genomics, through multiple examples drawn in particular from high-throughput sequencing technologies.
- Bioinformatics Challenge Project: The student should be able to carry out, in the form of a collaborative project, a complex engineering task addressing a company's needs in the field of computational biology.
- RNA-SEQ Projet: The aim of this project-based course unit is to enable students to address a biological question related to gene expression in a living model through the implementation of a transcriptomics experiment. This course unit will provide all students with the prerequisites necessary to successfully carry out such an experiment, from its design to the interpretation of the results. More specifically, it will allow students to integrate concepts of experimental design and implementation with knowledge in computer science, statistics, and genomics required for the processing and analysis of RNA-Seq data.

Content

The content of this course includes:

- Digital tools and fundamentals: The student should be able to work in a Unix environment, manipulate files using Perl and Python, automate data processing tasks, and execute commands on a computing cluster. They should also be able to perform standard statistical analyses using the R software. The student should be familiar with second- and third-generation sequencing techniques, and be able to carry out sequence annotation using local alignment tools executed via the command line.
- Bioinformatics Challenge Project: The student will be able to approach a company, maintain professional communication, work effectively in a team, define specifications, plan and carry out a complex task, mobilize diverse technical knowledge, plan the organization of an event, and structure and present their results.
- RNA-SEQ Projet: design an experimental plan addressing a given biological question, perform RNA extractions for high-throughput sequencing on a platform, work in a Unix environment for file manipulation and execution of analyses on a computing cluster, automate these processes, carry out statistical analyses using R (differential expression, etc.), and answer the initial question based on the results obtained.

Prerequisites

Under construction

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take various forms: written exam, oral exam, report, written assignment, peer assessment, etc.

Back to menu

From Genome to Systems

Module details

I5GBioComp21-exc

14 ECTS EN/FR
0.0 h 185.0 h 0.0 h 0.0 h
ENJALBERT BRICE
Revision date : May 18, 2026

Objectives

The objectives of this course include:

1. Post-Genomics: To understand and be able to use the main "omics" approaches (genes, RNA, proteins, metabolites, and fluxes). Learn how to handle datasets and extract essential information from them.

2. Integrative Biology: Students should be able to analyze and model high-dimensional data and/or data from different levels of biological organization. To achieve this, students must be able to identify and appropriately use the relevant fields and methods presented in this course unit.

3. Structural and Computational Biology: the students should be able to

   - Be able to visualize, manipulate, and analyze three-dimensional structures of (macro)molecules. Understand the main computational methods used in 3D modeling, as well as their limitations in predicting protein structures and molecular assemblies, and in studying molecular reactivity, conformation, and dynamics.
   - Be able to select the most appropriate molecular modeling approaches depending on the biological question.

Content

The content of this course includes:

1. Post-Genomics

   - General Overview: Presentation of "omics" approaches, their objectives, relevance, and limitations. Introduction to genomic approaches.
   - Transcriptomics: This module aims to present approaches for quantifying RNA molecules, from early methods to RNA-Seq.
   - Proteomics: This module aims to present approaches for identifying and quantifying proteins at the genomic scale, from 2D gels to comparative proteomics.
   - Metabolomics and Fluxomics: This module aims to present approaches for identifying and quantifying metabolite pools and flux distributions in metabolic pathways.

2. Integrative Biology

   - Statistical data integration (with mixOmics)
   - Dynamic modeling of a biological system with regulation
   - Introduction to AI for genomics

3. Structural and Computational Biology

   - General introduction to structural biology
   - Theoretical calculation methods
   - Prediction of three-dimensional protein structures and molecular dynamics
   - Analysis and modeling of 3D protein structures
   - Analysis and construction of 3D models of protein–ligand complexes
   - Molecular mechanics force fields and energy minimization
   - Molecular dynamics

Prerequisites

Under construction

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take various forms: written exam, oral exam, report, written assignment, peer assessment, etc.

Back to menu

Design project

Module details

I5PEPR10-exc

12 ECTS EN
8.75 h 2.5 h 0.0 h 15.0 h
DURUPT DOMINIQUE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Energy and Value Creation

Module details

I5PEEM10-exc

? ECTS EN/FR
51.25 h 65.0 h 7.0 h 0.0 h
HEBRARD GILLES
Revision date : May 18, 2026

Objectives

The general objective of the Energy and Valorization course unit is to familiarize students with the current requirement to systematically seek solutions, across all production sectors, to valorize all materials involved in transformation processes and to maximize the use of the exergy invested in the system.
To achieve this, the course unit is structured around three components (EC) to provide the knowledge necessary for designing the following processes:

- Processes for waste valorization
- Processes for the valorization of effluents (N, C, P)
- Green processes for energy recovery from biomass

Content

The teaching content of each component is as follows:

- Processes for waste valorization: this component covers the design calculations of waste valorization systems, considering legislation, material and energy balances, and life cycle analysis. Concepts of the bioeconomy and green chemistry are introduced. Lectures on these topics are also given by industry professionals.
- Processes for the valorization of effluents (N, C, P): this component addresses the design calculations of valorization systems for liquid effluents from urban wastewater treatment plants and from the chemical and agri-food industries.
- Green processes for energy recovery from biomass: this component covers various aspects of the biogas sector, from its current context of rapid development to the operation of digesters, biogas treatment processes and their analytical monitoring, as well as the agronomic use of digestates. A visit to a methanization (anaerobic digestion) site is also included in this component.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Drive and operate efficiently

Module details

I5PEME10-exc
12 ECTS   EN
32.5 h   27.5 h   35.0 h   3.75 h
AHMADI ARAS
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Physical chemistry

Module details

I3BEPC10-exc
2 ECTS FR
12.5 h 2.5 h 3.0 h 0.0 h
DURUPT DOMINIQUE, GUIRAUD PASCAL, LABORIE STEPHANIE
Revision date : May 18, 2026

Objectives

The course aims to provide an understanding of the physical chemistry of surfaces and colloids: surface tension and energy, capillarity, wettability, adhesion, the role of surfactants, molecular interactions, and applications to colloids, emulsions, foams, and detergents.

Content

The content of this course includes :

- Definitions and properties of interfaces (liquid-gas, liquid-liquid, solid-liquid).
- Measurement and role of surface tensions.
- Capillarity and related laws (Jurin, Young-Laplace).
- Wettability and contact angle.
- Adhesion work and Young-Dupré laws.
- Surfactants: structure, classification, micelles, applications.
- Intermolecular and colloidal forces (Van der Waals, electrostatic, hydrophobic).
- Colloidal stabilization/destabilization (DLVO theory, polymers, flocculation).
- Applications: emulsions, foams, detergents.

Prerequisites

Prerequisites include :

- Fundamentals of thermodynamics and physical chemistry.
- Basic knowledge of molecular kinetics and intermolecular interactions.
- General understanding of solution chemistry (solubility, polarity, pH).

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Fluid mechanics

Module details

I3BEMF10-exc

5 ECTS EN/FR
20.0 h 22.5 h 9.0 h 0 h
DURUPT DOMINIQUE, LABORIE STEPHANIE, MOREL SANDRINE, SCHMITZ PHILIPPE
Revision date : May 18, 2026

Objectives

Learn the basics of fluid mechanics modeling in order to understand the operation and design of laboratory equipment and industrial facilities dealing with fluid flows

- Understand and apply global mass and momentum balances on a control domain
- Understand the concept of mechanical energy balance and apply Bernoulli's theorem
- Understand the concepts of dynamic and thermal boundary layers and apply the corresponding transfer coefficients
- Write a force balance on an inclusion selecting the appropriate drag law
- Write and apply the universal velocity profile in turbulent flow
- Estimate characteristic spatial and temporal scales of turbulence in reactors

Content

From the complete Navier–Stokes model, we will explore the usual restricted models for incompressible flows, including :

- Stokes (creeping flow)
- Euler (inviscid flow)
- Prandtl (laminar boundary layer)
- Reynolds (turbulent flow)

We will address and apply standard fluid mechanics concepts such as Euler's theorem, Bernoulli's principle, perfect fluid, irrotational flow, fluid-wall interaction (dynamic and thermal boundary layers) and drag coefficient. We will study turbulence through the notion of turbulent viscosity, the universal logarithmic profile, the k-epsilon model, and the different scales of turbulence.

Prerequisites

Prerequisite for this course include :

- I2BEMT10 Mathematics
- I2BEBT10 Transfer Fundamentals

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Heat transfer

Module details

I3BETT10-exc

4 ECTS EN/FR
12.5 h 13.75 h 10.5 h 0.0 h
LABORIE STEPHANIE, MOLINA CAROLE, MOREL SANDRINE, RUMPALA JOHANNE, SCHMITZ PHILIPPE
Revision date : May 18, 2026

Objectives

At the end of this common teaching section, the student should have understood and be able to explain (main concepts):

Common Section:

- The general equation of energy conservation
- The different modes of heat transfer and the associated laws into the phenomena of conduction (Fourier's law) and forced and natural convection (Newton's law),
- The expressions for heat flux by conduction and convection and temperature profiles within different systems in steady-state conditions (simple and composite walls, cylindrical and spherical layers, simple and composite).

Section "Chemical Engineering":

- Heat transfer in solids with and without heat production in steady-state
- Heat transfer in solids with and without heat production in transitional regime
- Heat transfer by radiation

Section "Industrial Biotechnology":

- Different technologies of heat exchangers (tubular, plate, coil, double-wall) implemented industrially
- Principles and operating theories of heat exchangers
- Sizing of heat exchangers

Content

Common Section :
The student should be able, for plan, cylindrical, and spherical systems in steady-state conditions, with or without heat generation, to:

- Establish and solve the energy balance equations in steady-state conditions to calculate heat fluxes and characterize temperature gradients,
- Calculate heat fluxes, thicknesses of materials composing walls, pipes, spherical tanks in steady-state conditions,
- Calculate temperatures at interfaces.

Section "Chemical Engineering":
The student should be able to:

- Explain the different heat fluxes
- Establish energy balances on reactive or non-reactive systems
- Integrate differential equations to determine temperature profiles and assess heat fluxes
- Know how to transmit a given amount of heat between two systems
- Know how to limit heat losses through a surface
- Study cases applicable to processes.

Section "Industrial Biotechnology":
The student should be able to:

- Choose a technology and configuration of heat exchanger according to its uses
- Calculate heat exchange between fluids within a heat exchanger based on steady-state configurations
- Calculate the efficiency of a heat exchanger based on steady-state configurations
- Size the heat exchange surface of a heat exchanger according to its steady-state configuration
- Calculate the performance of heat exchangers based on flow rates and inlet and outlet temperatures of fluids
- Solve, in transitional regime, the energy balance equations on a perfectly stirred tank to calculate heating and cooling times according to the implemented technologies (coil, double-wall, external heat exchanger) with or without thermal loss

Prerequisites

Prerequisite for this course include :

- Thermodynamics
- Differential equations and partial differential equations

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Hydraulic engineering

Module details

I3BEGH10-exc

3 ECTS   EN/FR
7.5 h   16.25 h   9.0 h   10.0 h
DURUPT DOMINIQUE, LABORIE STEPHANIE, MARANGES CLAUDE, RUMPALA JOHANNE, SCHMITZ PHILIPPE
Revision date : May 18, 2026

Objectives

By the end of this module, the student should understand and be able to explain the hydraulic dimensioning of a complete system (processes, plants, hydropower turbine)

Content

The content of this course includes :

- Macroscopic mass, momentum and energy balance
- Fluid rheology
- Application of energy balance (Bernoulli)
- Conducted flow and free flow
- Linear and singular pressure losses
- Turbomachinery: Pumps and turbines
- Hydraulic networks
- Extension to total energy balance (EC thermodynamics)

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Process engineering

Module details

I3BEPT10-exc

3 ECTS EN/FR
0.0 h 25.0 h 0.0 h 0.0 h
DIETRICH NICOLAS, ENJALBERT BRICE, LABORIE STEPHANIE, MARANGES CLAUDE, MOREL SANDRINE, RUMPALA JOHANNE
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain the main concepts related to:

- The operating principles of transformation processes for raw materials (petroleum, coal, gas, ores, biomass), heavy organic and inorganic chemistry (refining and petrochemistry, NH−3, H−2SO−4, Na−2CO−3, NaOH, Cl−2, fertilizers, etc.), and energy production (thermal, nuclear, biomass).
- The schematic representation of a process (flowsheet) and associated graphical conventions.
- The basic principles of process cost estimation.
- The industrial context of the sector.

Students will also be able to:

- Describe an industrial production pathway.
- Read, interpret, and propose an installation flowsheet.
- Perform overall mass and energy balances for a process to calculate material and energy flows.
- Identify information flows.
- Conduct a critical analysis of an industrial process.
- Estimate the cost of a process.
- Work autonomously from a set of specifications.
- Find and analyze scientific and technical documentation.

Content

This course introduces the concept of industrial processes, their design principles, and the constraints inherent to industrial production. Students learn how to represent and estimate the cost of a process and study several major industrial production pathways. A group project involves the critical analysis of a material or energy transformation process.

Prerequisites

Prerequisite for this course include :

- Inorganic, organic, and biochemical chemistry
- Thermodynamics
- Chemical kinetics and reactors
- Unit operations in chemical engineering
- Control systems
- Metrology

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR
5.0 h 21.25 h 2.5 h 0.0 h
CARREY JULIAN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Dispersed systems

Module details

I3BESD10-exc

3 ECTS EN/FR
10.0 h 16.25 h 12.0 h 0.0 h
DURUPT DOMINIQUE, LABORIE STEPHANIE
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain the main concepts related to:

- The fundamentals of unit operations involving momentum transfer of dispersed bubbles, droplets, and particles in a fluid.
- The basic principles governing fluid transport through porous media.
- The principles of dimensional analysis.
- The mass and energy balances applied to dispersed systems.

Students will be able to apply these fundamental concepts to:

- The design and sizing of different unit operations such as sedimentation and filtration on support.
- The calculation of hydrodynamic parameters in packed columns and fluidized beds.

Content

The content of this course includes : **Basic concepts:**

- Motion of bubbles, droplets, and particles in a fluid (various separation regimes, spherical and non-spherical particles, concentrated media).
- Flow through porous media (pressure drop, resistance).
- Hydrodynamics of packed columns.

Unit operations:

- Filtration with a solid support.
- Sedimentation in concentrated media.
- Fluidization.
- Dimensional analysis

Prerequisites

None

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Analytical methods 2

Module details

I3BEAN23-exc

3 ECTS FR
0.0 h 0.0 h 0.0 h 35.0 h
FERNANDEZ FERNANDEZ MARIA AURORA, LABORIE STEPHANIE, MATHE STEPHANE
Revision date : May 18, 2026

Objectives

Learning by experimental project: illustrate a scientific problem using various experiments involving analytical techniques. Forcing students to use all of their scientific knowledge in order to analyze the experimental results of their experiments and if necessary modify the protocols.

Content

The content of this course includes :

- formulate a scientific problem related to analysis methods in order to illustrate it by manipulations.
- Make a bibliography with the aim of proposing, adapting or creating experiments which will illustrate the chosen issue.
- Gather its theoretical and practical knowledge of the previous years and implement them to solve the chosen problem.
- Plan the experimental work of the group and organize the interactions with the other groups.
- Explain the principle and learn how to implement the experimental techniques for the analysis.
- Teach yourself on the new analysis techniques necessary to undertake the project when this methods haven't been taught previously.
- Carry out an experiment at the laboratory
- Analyze the experimental results.
- Share and debate the results in the scientific point of view with both your teachers and inside your students group. Suggest improvements or work lead.
- Verbally explain the objectives desired, the chosen scientific approach, and the results of the debate during an oral presentation.
- Give explanation on the scientific approach followed and the results reached in a written scientific report.

Prerequisites

Prerequisite for this course include :

- Molecular structure and reactivity.
- Thermodynamics, chemistry, electrochemistry.
- Techniques of separation, extraction.
- Analytical methods: chromatographic, UV-visible, electrochemical.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Thermodynamics and energy

Module details

I3BETH23-exc

4 ECTS FR
27.5 h 21.25 h 0.0 h 0.0 h
GUIGUI CHRISTELLE, LABORIE STEPHANIE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have acquired the theoretical concepts required to analyze the performance of thermodynamic systems in terms of energy (First Law) and exergy (simultaneous consideration of the First and Second Laws).
They should be able to explain the difference between energy and exergy (or available/mechanical energy).
They will be able to apply these concepts to analyze the performance (quantity and quality of energy used or produced) of complex industrial systems.
They will be able to explain the principles of pinch analysis and determine the minimum energy requirements of a system.
At the end of this module, the student will have a solid working knowledge of the equations required to determine volumetric properties (density) and thermodynamic properties (critical point, heat capacity, enthalpy, entropy) of real fluids.
They will also be able to predict physical properties (viscosity, thermal conductivity, diffusion coefficient).

Content

Principles of thermodynamics and their consequences :

- Physical meaning of irreversibility, degraded work, and entropy production.
- Energy balance of open systems and its implications.
- Saint-Venant (Barré de Saint-Venant) relation.
- Bernoulli's equation.
- Entropy balance of open systems.
- Exergy balance of open systems and the physical meaning of exergy.
- Gibbs free energy and the chemical component of exergy.
- Irreversible evolution of fluids.
- Isentropic and polytropic efficiencies.
- Analysis of compressors and turbines.

The content of this course also includes:

- Methods for estimating missing data;
- critical properties of pure substances;
- thermodynamic properties of compounds in the ideal gas state;
- heat capacity of pure liquids;
- volumetric properties of pure real fluids;
- volumetric properties of fluid mixtures;
- thermodynamic properties of real fluids;
- saturated vapor pressure and enthalpy of vaporization;
- viscosity of pure fluids and mixtures;
- thermal conductivity of pure fluids and mixtures;
- diffusivity.

Prerequisites

Thermodynamics of Physicochemical Systems

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Water, environment and risks

Module details

I3BEER23-exc

4 ECTS FR

28.75 h 16.25 h 0.0 h 5.0 h

ALFENORE SANDRINE, GUIGUI CHRISTELLE, LABORIE STEPHANIE, SPERANDIO MATHIEU

Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to:

- Explain the principles of environmental law in France and be familiar with legal and regulatory information tools.
- Describe the main environmental problems, the principles of water and waste management and the main treatment processes.
- Know the main risks in the process industry and the mechanisms of accidents.

Content

The content of this course includes :

Environmental legislation and regulation

- Basics of law and regulatory instruments (TD)
- Design office project: Water in a region: from use to discharge

Environment

- Pollutant dispersion (mechanisms, consequences)
- Characterisation and typology of waste, waste management (treatment and storage methods), ordinary and radioactive waste, environmental impact of waste.

Process safety Definitions of the main types of risk in the field of processes: calculation of the probability of human impact, toxicity, different types of explosion, thermal runaway. Protection methods and devices.

Water: issues for actors and industries

- Environmental and health issues, indicators of pollution
- Main treatment stages and processes

Prerequisites

Prerequisite for this course include :

- Chemistry for solutions
- Unit operations
- Mass and Energy balances
- kinetics and thermodynamics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Mass transfer

Module details

I3BETM23-exc

3 ECTS EN/FR
15.0 h 12.5 h 7.0 h 5.0 h
FERNANDEZ FERNANDEZ MARIA AURORA, HEBRARD GILLES, LABORIE STEPHANIE
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have working knowledge of the equations required to determine the thermodynamic equilibrium properties (fugacity) of real fluids in multiphase systems. They will be able to apply this knowledge to the determination of exchange potentials and transfer properties (viscosity, diffusivity, etc.). Students will fully understand the notion of transfer coefficient and be able to estimate it for a given operation. They will be able to utilize these quantities in the generalized material balance equation applied to multiphase contactors. Students will be able to size industrial equipment such as packed, bubble and spray columns.

Content

Thermodynamic properties of gas/liquid equilibria in the perfect gas state, concepts of fugacity and Henry's equilibrium. Transfer properties (viscosity, thermal conductivity, diffusivity) and phase equilibria of multicomponent real fluids. Introduction to mass transfer: determining and solving the continuity equation in specific cases. Introduction to transfer coefficients, dimensional analysis, transfer models (film and double film), experimental determination of transfer coefficients, Height of Transfer Unit (HUT), and Number of Transfer Unit (NUT). Introduction to basic sizing of gas-to-liquid exchangers (packed column, bubble column, spray column).

Prerequisites

Prerequisite for this course include :

- I2BETH11 Thermodynamics of Physicochemical Systems

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Chemical reaction engineering II

Module details

I3BERR23-exc
4 ECTS EN/FR
11.25 h 30.0 h 3.5 h 0.0 h
FERNANDEZ FERNANDEZ MARIA AURORA, LABORIE STEPHANIE
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- Reaction systems with variable volume/flow rates
- Yield and selectivity in multiple stoichiometry reaction systems
- Reactor arrangements (series, parallel, plug flow with recycling)
- Mixing mechanisms and their relationship to the course of the reaction
- The effect of reactor non-ideality on conversion: Residence Time Distribution (notion of transfer function) and Concentration Distribution (mixing)
- Influence of temperature on reactor performance (notion of Optimal Temperature Progression)
- General equation for energy conservation in a reactor

Students will be able to:

- Calculate ideal open reactors under variable flow conditions
- Calculate the size, yield or selectivity of ideal open reactors in multiple stoichiometry systems, as well as the conversion rate attainable by arranging the reactors
- Determine the RTD of a reactor
- Apply a mixing or flow model to predict conversion in a non-uniform reactor
- Calculate the OTP for a given system
- Establish and solve enthalpy balances for reaction and non-reaction systems

Content

Material balances in ideal reactors:

- General balance form, application to different ideal reactors, application to complex reaction schemes, yields and selectivities.
- Combining ideal reactors to optimize conversion and yield.
- Influence of temperature on reactor performance.
- Notion of Optimal Temperature Progression (OTP).
- Energy balances for ideal reactors.
- Description of real reactor flows.
- Residence Time Distribution (RTD). Hydrodynamic interpretation and modeling.
- Application to a packed reactor.

Mixing/reaction interactions:

- Mixing mechanisms, methodology for identifying and solving a mixing/reaction problem, analysis/calculat of characteristic times, probability density function, micromixing models.
- Modeling/simulation of a case study.

Prerequisites

Prerequisite for this course include :

- Ideal reactors, reaction rates and reaction progress parameters
- Linear differential equations
- Basic understanding of Laplace transforms
- Fundamentals of transport phenomena
- Fundamentals of thermodynamics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL
DES SCIENCES
APPLIQUÉES
TOULOUSE

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS EN/FR
0.5 h 2.75 h 0.0 h 0.0 h
BOULIER THOMAS, CHAZEL FLORENT, DE GOURNAY FREDERIC, GUERMOUCHE NAWAL, GUIEYSSE DAVID, GUIGUI CHRISTELLE, HANTCHERLI MURIEL, LABORIE STEPHANIE, LAHANA YONI, MAHOUT VINCENT, MOREL SANDRINE, PLANTEC JEAN-YVES
Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Filtration and mixing operations

Module details

I4PEFM10-exc

ECTS FR
12.5 h 16.25 h 7.0 h 0.0 h
GUIGUI CHRISTELLE
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain:

- The different ways of implementing filtration and mixing operations
- The key parameters of depth filtration and membrane filtration
- The operating principles of industrial equipment used for mixing and filtration
- The dimensionless numbers used to characterize physical phenomena involved in mixing and separation processes
- The methods for sizing unit operations (UO) for separation by filtration and for mixing

Students should be able to:

- Identify the interactions between compounds or compound/interface involved in filtration and mixing operations, and measure their characteristic parameters
- Identify membrane fouling phenomena for a given operation
- Select the appropriate unit operation and technology for a given separation or mixing process
- Choose the appropriate mode of implementation for the separation process
- Establish mass balances
- Size a depth filter
- Size a membrane separation operation (MF, UF, NF)
- Size a static mixer and a stirred tank mixer

Content

The content of this course includes:

1. Membrane and depth filtration
   - Membrane filtration processes, membranes, and filter media. Pressure-driven processes: operating parameters, fouling mechanisms. Retention.
   - Effect of operating conditions on selectivity and productivity, mass balances, and sizing of depth filters and membrane processes.
   - Energy consumption.
2. Mixing
   - Macroscopic characterization of mixing
   - Mixing technologies: mechanical agitation, static mixers
   - Sizing of mixers

Prerequisites

Hydraulic Engineering and Dispersed Systems

Assessment

Under construction

Back to menu

Thermal separation operations

Module details

I4PESE10-exc

ECTS FR
10.0 h 11.25 h 22.75 h 0.0 h
LABORIE STEPHANIE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Phase equilibria and separation processes

Module details

I4PESQ10-exc
ECTS FR
12.5 h 8.75 h 7.0 h 12.5 h
TIRUTA LIGIA
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Heterogeneous reactions engineering

Module details

I4PERH12-exc

ECTS FR
10.0 h 25.0 h 7.0 h 0.0 h
PIC JEAN-STEPHANE
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain:

- the different types of chemical catalysts and their modes of operation
- the notion of limiting step in heterogeneous reactions
- the notion of apparent reaction rate
- the expression and meaning of dimensionless numbers used in heterogeneous reactions (Hatta, Thiele, Weiss, Biot)
- the concepts of effectiveness factors and enhancement factors

The student should be able to:

- establish a law for intrinsic kinetics
- determine the limiting process(es) in a heterogeneous chemical reaction
- express the apparent overall rate of a chemical reaction as a function of the operating conditions
- choose and design the most suitable reactor to implement a given reaction
- integrate and prioritize the mechanisms in order to model a homogeneous and heterogeneous reactor

Content

The content of this course includes :

- Interest and technologies of heterogeneous reactors.
- Gas-liquid reactors: gas/liquid mass transfer in the presence of a chemical reaction; Hatta modulus; Enhancement factor; Operating regimes; Modeling and design of gas/liquid reactors; Choice of reactor type.
- Catalytic reactors: Notions of catalysts and heterogeneous kinetics; Limitations by external or internal transport; Calculation of effectiveness factors; Thiele and Weisz moduli; Modeling and design of fixed bed reactors (material balance).

Prerequisites

Prerequisites of this course include :

- Homogeneous reactor enginering
- Fluid properties
- Equilibria thermodynamics
- Transport phenomena
- Mass transfer
- Heat transfer

Assessment

Assessement of this course includes :

- 2 written exams
- 1 Lab report
- 1 report for the synthesis design office

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Processes simulation

Module details

I4PESI10-exc

4 ECTS EN

15.0 h 0.0 h 51.0 h 0.0 h

MORCHAIN JEROME,PIC JEAN-STEPHANE

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- the principles and operation of process simulation tools at different scales
- the principles of life cycle assessment and carbon footprint analysis
- the basics of multi-criteria analysis
- the practical fundamentals of optimization

The student should be able to:

- implement a process simulation tool adapted to the scale of analysis (equipment, production unit, or process chain)
- connect their knowledge to analyze the results of a commercial simulation tool
- simulate an industrial chemical synthesis process (material and energy aspects)
- carry out a life cycle assessment (LCA) of a complete process and critically interpret the results
- use Ansys Fluent software to study coupled single-phase transport phenomena
- use ProSim software to study processes at the scale of equipment or a production unit
- use Umberto software for the global analysis of a process integrated into its environment
- perform an optimization calculation using ProSim

Content

The content of this course includes:

- Introductory lectures: Review of the Navier–Stokes equations and the main turbulence models; presentation of discretization and solution methods; main solution algorithms; fundamentals of turbulence modeling; forces, moments, and torques exerted by a fluid on an object.
- Training in the basic functions of FLUENT software : Tutorial sessions on 2D/3D hydrodynamic calculations using Fluent: meshing, discretization, finite volume method, numerical convergence, physical convergence, accuracy. Topics include: laminar and turbulent pipe flow, flow in a bundle of parallel tubes, numerical reactor vs. ideal reactor.
- Process simulation (mass and energy balances, preliminary equipment sizing elements) for various continuous processes, and simulation of a batch process such as a reactor or a distillation column.
- Methods for environmental impact assessment: Environmental analysis methods including Life Cycle Assessment (LCA), carbon footprint, and multi-criteria analysis. Use of databases and dedicated software (Umberto).

Prerequisites

The prerequisites for this course include:

- Numerical analysis, partial differential equations, ordinary differential equations, nonlinear systems
- Fluid mechanics
- Mass and energy balances, proficiency in unit operations of process engineering
- Thermodynamics (phase equilibria, physicochemical properties of mixtures)

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Electrochemical reactors for water, energy and environment

Module details

I4PERE10-exc

ECTS FR
8.75 h 8.75 h 3.0 h 0.0 h
PECHAUD YOAN,PIC JEAN-STEPHANE
Revision date : May 18, 2026

Objectives

The general aim of this course is to acquire a basic knowledge of electrochemical engineering, with particular emphasis on applications in the fields of energy, water and the environment. Specific skills:

- be able to describe the operation of an electrochemical process,
- acquire knowledge of the influence of operating and design parameters on the performance of an electrochemical process,
- be able to establish mass balances in ideal electrochemical processes or processes behaving as a combination of ideal processes,
- develop skills in sizing electrochemical reactors for applications related to energy storage or production and water treatment.

Content

The course is divided into three parts:

1. Basic principles:
   - Review the basic concepts of electrical phenomena and the notions of oxidant and reductant, understand and define the direction of spontaneous evolution of a reaction, understand the link between the direction of spontaneous evolution of a reaction and the potential applied to an electrode.
   - Review basic thermodynamic concepts (1A and 2A), Define tools for predicting the direction of evolution of an electrochemical reaction, Understand the distinction between faradaic and non-faradaic processes, Introduce the concepts of capacitive process and double layer.
2. Reaction kinetics and material transport:
   - Define electrochemical reaction rates
   - Understand the link between the voltage applied across a cell and reaction rates.
   - Identify and understand the parameters that govern reaction kinetics
   - Identify how to determine the reaction regime
   - Analyze the profile of current-potential curves
3. Water and energy engineering and applications
   - Analyze the problems associated with scaling up this type of process
   - Analyze the various components of an industrial process
   - Perform mass balances on ideal reactors and combinations of ideal electochemical reactors
   - Study several examples of electrochemical process applications
   - Study the anodic oxidation process
   - Study an industrial electrolyzer

Prerequisites

Basic knowledge of thermochemistry, reactor engineering, mass and momentum transport-transfer phenomena

Assessment

Under construction

Back to menu

Careers in Chemical Engineering (2)

Module details

I4PEBE12-exc

ECTS FR
6.0 h 6.0 h 0.0 h 0.0 h
DURUPT DOMINIQUE,PIC JEAN-STEPHANE
Revision date : May 18, 2026

Objectives

By the end of this course unit, students will be able to:

- Identify the activity sectors of GP3E engineers and the various career paths available (engineering consultancy, public sector engineering, environmental management, research and development, production, consulting, business engineering, etc.), along with their specific features and the requirements to access them
- Build a professional network based on interactions and information provided by guest speakers

Content

Presentation of various career paths in process engineering: design office engineer (preparation of tenders, responding to calls for tenders, project execution, public procurement and finance, etc.), project manager, RD engineer, lecturer-researcher, consulting and environmental management engineer, public sector engineer, etc.
The specific tools associated with these professions (which form part of their knowledge and skills), the pathways to access them, and typical career development are also discussed.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Heat exchangers

Module details

I4PEEC20-exc

3 ECTS EN
11.25 h 15.0 h 12.5 h 0.0 h
DURUPT DOMINIQUE
Revision date : May 18, 2026

Objectives

The student must be able to :

- select the appropriate device technology to meet specifications
- carry out material and energy balances on an exchanger operating continuously or discontinuously, with or without phase change,
- carry out balances involving coupled transfers of matter and heat,
- size all types of heat exchangers: determine local coefficients and the overall exchange coefficient, evaluate performance and predict the consequences of a change in operating conditions on operation
- use heat exchanger design software (e.g. ASPEN HTFS)
- design OPUs involving coupled heat and mass transfer, such as air coolers, dryers and dehumidifiers,
- explain the basic elements involved in furnace sizing

Content

The content of this course includes :

- various technological configurations of heat exchangers, condensers, evaporators and contactors involving coupled heat and mass transfer (air coolers, dehumidification towers, dryers)
- heat (and mass) transfer phenomena (mechanisms) involved in this type of equipment
- the notion of efficiency
- different condensation modes (film, drops), characteristics of pure vapor condensation, condensable vapor mixtures, vapor mixtures containing incondensables
- different boiling mechanisms
- the notion of specific, local and global heat transfer coefficients.
- the notion of coupled matter/heat transfers and their application in engineering, particularly in the management of Air/Liquid Water/Vapor Water systems.
- the phenomena (mechanisms) of heat (and mass) transfer taking place in this type of device
- the notion of efficiency
- the different modes of condensation (film, drops), the characteristics of the condensation of pure vapor, of mixtures of condensable vapors, of mixtures of vapors containing non-condensables
- the different boiling mechanisms
- the notion of particular, local, global heat transfer coefficient.
- the notion of coupled material/heat transfers and their application in engineering, particularly in the management of Air/Liquid Water/Ea systems

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Thermodynamic processes for energy systems

Module details

I4PEPT20-exc

ECTS FR
8.75 h 13.75 h 12.5 h 0.0 h
HEBRARD GILLES
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- Thermodynamic cycles associated with thermal power generation plants, refrigeration and air conditioning plants and gas liquefaction systems,
- the use of energy and exergy balances applied to the thermodynamic systems studied to optimize their operation.

Students should be able to :

- size a steam power plant of given capacity, including choice of working fluid, operating temperatures and pressures, choice of thermodynamic cycle (HIRN, RANKINE, Resurchauffe and extractions) as well as determination of flow rates and pre-sizing of compressors and turbines,
- sizing a thermodynamic generator of given capacity, including choice of working fluid, operating temperatures and pressures, choice of cycle and number of compression stages, as well as determining flow rates and pre-sizing compressors and expansion devices,
- dimensioning a gas liquefaction plant,

Content

The content of this course includes :

- steam power plants: from the Carnot cycle to the cycle with superheating, reheating and extractions (maximum theoretical efficiency cycle). Application to nuclear and biomass power plants. Cogeneration and fuel cell systems. Plant sizing and optimization (energy and exergy yields),
- Thermodynamic generators: from Carnot's inverse cycle with no change of state to the real cycle of refrigeration machines with change of state.
- absorption refrigeration machines. System sizing and optimization (energy and exergy yields),
- Gas liquefaction. Theoretical maximum efficiency cycle, Linde and Claude cycles. Presentation of air liquefaction plants and separation of components. Special plants for hydrogen and helium.

Prerequisites

The 3rd year course on energy thermodynamics and the introduction of energy balancing

Assessment

Under construction

Back to menu

Renewable energy production

Module details

I4PEPE20-exc

ECTS

13.75 h 8.75 h 0.0 h 2.5 h

HEBRARD GILLES

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- climate issues associated with the development of renewable energies
- the global, European and French context of the different renewable energy production sectors (Négawatt Scenario, Eco2Mix RTE)
- the technical and regulatory context of different forms of renewable energy (wind, solar photovoltaic, hydroelectric, etc.),

Students should be able to:

- Choose the forms of energy best suited to the projects they will be working on.
- participate in the implementation of a wind development zone
- help set up a photovoltaic site,
- participate in the implementation of a hydroelectric plant.

Content

The content of this course includes:

1. Wind power:
   - Stages in the development of a wind power project
   - Regulations and easements governing the establishment of a wind development zone
   - Wind power environmental impact assessment
   - Wind energy assessment and modeling,
   - Sizing of electrical generators and associated electrical network (turbines and connections)
2. Photovoltaics:
   - Climate issues
   - Solar potential
   - Solar compared with other energies
   - Analogies and differences between solar thermal and photovoltaics
   - Current market, players and outlets
   - Thermal / Photovoltaic: - system components: collection, transfer, storage - applications
   - Sizing stages for thermal and photovoltaic systems
   - Use of PVSyst sizing software
3. Hydroelectricity:
   - Current regulations
   - Assessing the energy potential of a reservoir
   - Turbine selection and sizing
   - Connections

Prerequisites

3A Hydraulic Engineering course

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Metrology for water and the environment

Module details

I4PEME20-exc

3 ECTS EN
3.75 h 6.25 h 24.0 h 0.0 h
ALFENORE SANDRINE
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- the concepts related to the quality and choice of metrologies whether for the analysis of environmental impacts and/or the dimensioning of processes
- the main environmental issues and the mechanisms involved in the treatment and recovery of organic materials by chemical and/or biological means

Content

The content of this course includes :

- measurement quality (accuracy, detection threshold, quantification threshold, robustness, repeatability, reproducibility of measurements)
- metrology(s) to measure environmental impacts and/or size treatment and recovery processes for complex organic matrices.

Prerequisites

The prerequisites of this course include :

- Chemistry
- Thermodynamics
- Kinetics and reaction
- Biological reactors

Assessment

Under construction

Back to menu

Biological reactors

Module details

I4PERB21-exc

4 ECTS FR
18.75 h 13.75 h 0.0 h 0.0 h
PAUL ETIENNE
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain (main concepts):

- the different microbial metabolisms according to energy source, electron acceptor and carbon source, and their application in different industrial fields
- stoichiometry, kinetic laws and their combination to represent the behavior of microbial cells in cell growth, in the production of various metabolites coupled or not to growth, and in depollution.
- description and modeling of homogeneous biological reactors, closed, semi-open or open to the liquid, single- or multi-stage, with or without cell recycling.

Students should be able to:

- identify the general metabolic functioning and kinetics of microbial growth and metabolite production.
- establish stoichiometric equations and rate laws for biological reactions as a function of environmental conditions
- choose a reactor type according to the type of production envisaged
- integrate and prioritize mechanisms to model homogeneous and heterogeneous biological reactors.
- size and optimize homogeneous biological reactors.

Content

The content of this course includes :

- Energetic metabolism according to electron donors and acceptors
- Calculation of culture media
- growth kinetics, yield limits and conversion observables, notion of cell maintenance, Monod's model, substrate or product inhibition, dependence on temperature, pH, etc.
- Determination of growth and product production stoichiometry
- Analyze the operation of batch, semi-continuous and continuous biological reactors, with or without recycling, for cell or product production or pollution control. Write balances on cells, substrates and use for reactor sizing and optimization.

Prerequisites

Prerequisites for this course include :

- Microbiology
- Biochimie structurale
- Microbiologie et statistique

Assessment

Under construction

Back to menu

Processes for water production and the circular water economy

Module details

I4PEEA20-exc

4 ECTS EN
18.75 h 11.25 h 10.5 h 0.0 h
GUIGUI CHRISTELLE
Revision date : May 18, 2026

Objectives

The objective of this module is to:

- Know and understand the challenges of the different resources that can be used for the production of drinking water (surface water, groundwater, sea water, brackish water, secondary effluents)
- Know the challenges of reusing treated wastewater (domestic or industrial) for the production of water for a given use
- the legislative elements associated with this problem
- typical fresh water purification sectors and the role of unit operations in these sectors
- modern technologies used in these sectors and their operating principle

The student must be able to:

- define a drinking water production sector from a given resource
- define a tertiary treatment sector for treated wastewater to produce water for a given use
- size the unit operations associated with these sectors

Content

Program (detailed content):

- sectors for producing drinking water from surface water
- sectors for producing drinking water from sea water
- treated wastewater reuse channels
- micropollutant treatment sectors (pharmaceutical residues
- regulations on drinking water (national and international level)
- the drinking water production sectors, the role of unit operations
- coagulation/flocculation, decantation, ultrafiltration, decarbonation, oxidation, disinfection and reverse osmosis operations for water treatment.
- nexus water-energy

Prerequisites

The prerequisites for this course include:

- Unit operation (basic)
- Chemistry
- Resolving equation

Assessment

Under construction

Back to menu

Introductory research project

Module details

I4PEPI20-exc

4 ECTS EN
3.75 h 2.5 h 0.0 h 15.0 h
LABORIE STEPHANIE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the approach and tools for a good literature and patent survey
- how to develop a scientific work
- the health and safety rules in a research laboratory
- the basic methods for project management

The student will be able to:

- to delimit and deepen a scientific research project
- to draw an up-to-date inventory of knowledge on this topic and to identify the international leading research teams
- to propose and to experimentally perform a scientific approach to address a problem based upon the previous literature survey with respect to health and safety rules
- to share and communicate the results with a common scientific formalism (paper, poster)
- to perform a project management approach

Content

Program:

- how to perform a relevant literature review on a subject
- identification of a problem and scientific approach to solve it
- participation to a current research project in a laboratory
- health and safety rules in a research laboratory

Project management: definition and organization:

- content (clearly define the limits and tasks)
- deadlines (with prioritization of tasks, Gantt chart)
- HR (assign tasks to people with skills, communication, team management)
- risk analysis, cost estimation.

Prerequisites

The prerequisites for this course include:

- Literature survey basic knowledge
- All scientific knowledge in relation with a research project

Assessment

Under construction

Back to menu

Design project

Module details

I5PEPR10-exc

12 ECTS EN
8.75 h 2.5 h 0.0 h 15.0 h
DURUPT DOMINIQUE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Energy and Value Creation

Module details

I5PEEM10-exc

? ECTS EN/FR
51.25 h 65.0 h 7.0 h 0.0 h
HEBRARD GILLES
Revision date : May 18, 2026

Objectives

The general objective of the Energy and Valorization course unit is to familiarize students with the current requirement to systematically seek solutions, across all production sectors, to valorize all materials involved in transformation processes and to maximize the use of the exergy invested in the system.
To achieve this, the course unit is structured around three components (EC) to provide the knowledge necessary for designing the following processes:

- Processes for waste valorization
- Processes for the valorization of effluents (N, C, P)
- Green processes for energy recovery from biomass

Content

The teaching content of each component is as follows:

- Processes for waste valorization: this component covers the design calculations of waste valorization systems, considering legislation, material and energy balances, and life cycle analysis. Concepts of the bioeconomy and green chemistry are introduced. Lectures on these topics are also given by industry professionals.
- Processes for the valorization of effluents (N, C, P): this component addresses the design calculations of valorization systems for liquid effluents from urban wastewater treatment plants and from the chemical and agri-food industries.
- Green processes for energy recovery from biomass: this component covers various aspects of the biogas sector, from its current context of rapid development to the operation of digesters, biogas treatment processes and their analytical monitoring, as well as the agronomic use of digestates. A visit to a methanization (anaerobic digestion) site is also included in this component.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Drive and operate efficiently

Module details

I5PEME10-exc

12 ECTS EN
32.5 h 27.5 h 35.0 h 3.75 h
AHMADI ARAS
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Hamiltonian mechanics

Module details

I3MAMH10-exc

1 ECTS FR
0.0 h 13.75 h 0.0 h 0.0 h
BOULIER THOMAS,GRZESKOWIAK MARJORIE,LAHANA YONI,LASSAGNE BENJAMIN
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts): D'Alembert's principle, principle of least action, Lagrangian and Hamiltonian formulation of mechanics, notion of generalized coordinates and generalized forces, canonical transformations, Poisson representation of Hamiltonian mechanics, notion of phase space. Students should be able to use the Euler-Lagrange and Hamiltonian equations to study the motion of an object.

Content

Newtonian mechanics, D'Alembert's principle and virtual work, Lagrangian formulation and Hamilton's principle of least action, Hamiltonian formulation, Canonical transformations and Poisson's bracket

Prerequisites

Newtonian mechanics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Numerical analysis

Module details

I3MAAN10-exc

2 ECTS FR
10.0 h 0.0 h 16.5 h 0.0 h
BOULIER THOMAS,DUBOSCQ ROMAIN,LAHANA YONI,VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts): Some notions of numerical analysis and scientific computing. The student should be able to: Choose an appropriate method for solving a mathematical problem. Use the Python language to implement numerical analysis methods.

Content

The course covers the following topics: numerical errors, solving non-linear equations, numerical integration, direct solutions of linear systems, matrix norms and conditioning, iterative methods for solving linear systems, least squares methods, and ordinary differential equations.

Prerequisites

Mathematical concepts are based on undergraduate linear algebra and analysis. Practical work is based on relatively simple programming.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Programming in C

Module details

I3MALC10-exc

2 ECTS EN/FR
6.25 h 6.25 h 5.5 h 0.0 h
BOULIER THOMAS,LAHANA YONI,MONTEIL THIERRY,VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain programming principles in one of the most widely used programming languages, C, particularly focusing on its low-level features and its proximity to hardware.

Content

This course covers both the conventional aspects of the C programming language — such as variables, data types, control structures, and loops — as well as more advanced features specific to C. These include bitwise operators, extensive use of pointers, parameter passing, and input/output operations.

Prerequisites

Basic knowledge of assembly language and experience in a high-level programming language are recommended.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Physical meas. and statistical modelling

Module details

I3MAPH10-exc

4 ECTS EN/FR
0.0 h 7.5 h 37.5 h 0.0 h
BOULIER THOMAS,LAHANA YONI,VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain the operating principles of the various sensors used during the lab sessions and know how to implement them within an experimental framework to address a specific problem. They should also have developed a critical perspective on experimental results. Students will be able to:

- Set up a measurement chain using different sensors, interpret the resulting data, and critically evaluate experimental outcomes.
- Analyze and quantify the various components of measurement error.
- Construct a statistical model from a set of collected observations to confirm or refute hypotheses about a studied phenomenon.
- Define a stochastic model of measurement, determine confidence intervals, and perform statistical tests.
- Design simple experimental plans optimally.
- Apply statistical reasoning to improve experimental reliability and precision.

Content

1. Experimental part:
   - Five 7.5-hour laboratory sessions selected among the following topics: Temperature Measurement, Vacuum Technology, Laser, Extensometry, Thin Films, and Optical Measurement. Each experiment introduces the physics underlying various sensors, their operating principles, and appropriate conditions of use. These sensors are then applied in different measurement contexts. The collected data are processed, analyzed, and critically discussed.
2. Statistical part:
   - Random modeling of measurements: systematic and random errors, confidence intervals.
   - Linear models: least-squares fitting, prediction intervals, model validation, model selection.
   - Introduction to experimental design: optimality criteria, estimation of main effects and interaction effects between factors.

Prerequisites

Probability and Statistics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

In-depth study of electronic circuits

Module details

I3MACE10-exc

4 ECTS EN/FR
13.75 h 15.0 h 5.5 h 0.0 h
BOULIER THOMAS,GRZESKOWIAK MARJORIE,LAHANA YONI
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain the main concepts related to:

- The electrical characteristics of diodes and transistors.
- The concept of operating point and linearization of characteristics around this point.
- The different classes of transistor-based amplification.
- The principles of LF and HF modeling for the design of advanced electronic functions.

Students will be able to:

- Implement appropriate biasing circuits according to the intended function.
- Derive equivalent circuits for low- or high-frequency operation.
- Recognize and implement fundamental circuits such as current mirrors and differential stages.
- Use electronic circuit simulation software and understand the limitations of the models employed.
- Design amplification and filtering chains for integration.
- Design circuits for the use of different types of sensors.
- Design power stages while considering power dissipation constraints.

Content

Study of the electrical characteristics of diodes and transistors (MOSFET, JFET, and bipolar types). The course covers biasing circuits and their corresponding classes, models of active components, and equivalent low-frequency (LF) and high-frequency (HF) schematics. It includes the design and analysis of functional circuits such as current regulators, current mirrors, and differential structures. The course also explores amplification and filtering chains with impedance matching and integrates sensor and signal-processing models within circuit simulation software.

Prerequisites

Fundamentals of electricity: Kirchhoff's laws, Thévenin, Norton, and superposition theorems; basic concepts of voltage and current sources; Fourier and Laplace transforms.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Semiconductors

Module details

I3MASC10-exc

4 ECTS EN/FR
22.5 h 12.5 h 0.0 h 7.0 h
BOULIER THOMAS,GRZESKOWIAK MARJORIE,HEBRAS XAVIER,LAHANA YONI
Revision date : May 18, 2026

Objectives

This course introduces the physics of materials and components involved in technologies associated with the transmission, processing, and storage of information. It focuses on timeless fundamental principles in a rapidly developing field. By the end of this course, the student will be able to:

- Clearly describe and express the various physical principles involved in the processing, transmission, and storage of information.
- Comprehend the overall technologies based on semiconductors, from the atomic level to the application of components.
- Enhance their understanding of the physical properties of semiconductors, particularly the PN junction, which serves as the basic technological building block present in all modern components, whether discrete (such as diodes or bipolar transistors) or integrated (such as field-effect transistors).

Content

This course aims to provide students with the fundamental knowledge and practical skills necessary to understand and apply the principles of materials physics and components in information technologies.

- Part 1: Fundamentals of Materials Physics
  1. Presentation of quantum mechanics concepts underlying the electronic structures of the atom.
  2. Introduction to chemical bonding and the organization of matter.
  3. Study of crystalline structures.
  4. Understanding band diagrams to distinguish insulators, semiconductors, and metals, as well as the concept of density of states within a material.
  5. Review of elementary statistical physics to explain how to modify charge densities in a semiconductor material through doping.
- Part 2: Doping and PN Junction
  1. Understanding different types of semiconductor doping.
  2. Construction of a simple component like the PN junction, introducing band diagrams of these structures at thermodynamic equilibrium and non-equilibrium (under bias or illumination).
  3. Study of charge carrier diffusion laws to establish the laws governing current levels observed in PN junctions under bias.
- Part 3: Bipolar Transistors
  1. Understanding the operation of the PN junction and its integration within a bipolar transistor.
  2. Explanation of various physical properties of bipolar transistors, particularly their role as amplifiers.
  3. Highlighting the links between the electronic properties of components and physical phenomena, such as the current gain parameters Alpha and Beta of bipolar transistors.
- Part 4: CMOS Technologies
  1. Emphasizing the physical links between materials and the electronic operation of MOS capacitors, MOS transistors, and their integration through CMOS technologies.
- Part 5: Practical Work
  1. 7 hours of practical work in a cleanroom. Students will construct and electrically characterize photovoltaic cells (Click here for details). These practical sessions are an excellent opportunity to enhance technical skills and understand the practical applications of the theoretical concepts covered in the course.

Prerequisites

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR

5.0 h 21.25 h 2.5 h 0.0 h

BOULIER THOMAS,CARREY JULIAN,CHAZEL FLORENT,ENJALBERT BRICE,GUERMOUCHE NAWAL,LABORIE STEPHANIE,LAHANA YONI,MOREL SANDRINE,RUMPALA JOHANNE,SANCHEZ DAVID,VIGNOLLES DAVID

Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Waves and propagation

Module details

I3MAOP10-exc

3 ECTS EN/FR
17.5 h 7.5 h 8.25 h 0.0 h
BALOCCHI ANDREA,BOULIER THOMAS,GRZESKOWIAK MARJORIE,LAHANA YONI
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- The fundamentals of electromagnetic wave propagation in simple media (linear, homogeneous, isotropic, dielectric, magnetic, and conductive)
- Reflection and refraction at the interface between two media, the functioning of metallic and dielectric waveguides (optical fibers), and the associated energy transfer Students will be able to:
- Use Maxwell's equations applied to different media to determine the nature of the electromagnetic waves present in a simple system (LHI medium, interface between two media, confined space between two plates of a good conductor) - Determine the conditions and characteristics of the modes that lead to the propagation of electromagnetic waves in various waveguides

Content

Detailed program:

- Electromagnetism in dielectric, conductive and magnetic media
- Propagation of electromagnetic waves in linear, homogeneous and isotropic media
- Continuity relations
- Applications to reflection and refraction
- Propagation in rectangular metallic waveguides and optical fibers

Prerequisites

Knowledge of electromagnetism in a vacuum.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Applied material physics

Module details

I3MAPAM20-exc

3 ECTS FR
1.25 h 0.0 h 37.5 h 0.0 h
BOULIER THOMAS,HANTCHERLI MURIEL,LAHANA YONI
Revision date : May 18, 2026

Objectives

This UF constitutes an experimental approach to the physics of materials. The educational objectives are:

- acquire scientific knowledge relating to the techniques

used in material science

- acquire practical skills on these techniques,
- acquire an experimental work method in physics (how

to choose the experimental parameters, carry out the experiment, analyze the results) The student should be able to:

- reproduce and apply techniques for the development

and characterization of materials among the techniques mentioned in the program.

Content

The experiments seen in practical work are: quantitative metallography, calorimetry, tensile tests, hardness, crystalline defects, crystallization and recrystallization, and anisotropic properties. The concepts covered are optical microscopy, phase diagrams, image processing, calorimetry, phase transitions, mechanical properties, structural hardening, defects and crystal growth, wave propagation in anisotropic medium.

Prerequisites

Thermodynamic prerequisite : The following notions must be seen before the practicals: enthalpy, heat capacity and phase diagram.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Dislocations and deformations

Module details

I3MADD20-exc

1 ECTS FR
6.25 h 5.0 h 0.0 h 0.0 h
BOULIER THOMAS,HANTCHERLI MURIEL,LAHANA YONI,RENUCCI PIERRE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts) the relations between defects and dislocations in the atomic structure and some macroscopic mechanical properties of crystals. The student will be able to describe from a geometric and energetic point of view the dislocations and their interactions, and put them in relations with mechanical properties of the crystalline material : fragility and ductility

Content

Plastic deformation and fracture of crystalline materials :

- Brittleness, ductility, plasticity of crystalline materials
- Dislocations : definition, theory of dislocations,

interaction, mobility and plasticity.

- Brittle fracture, cleavage.

Prerequisites

Know how to use tensor notation (seen during anisotropy lectures)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Scientific project

Module details

I3MAPJ20-exc

1 ECTS EN/FR

0.0 h 0.0 h 0.0 h 5.5 h

BOULIER THOMAS,HANTCHERLI MURIEL,LAHANA YONI

Revision date : May 18, 2026

Objectives

Students are faced with real-life situations and are introduced to concrete examples of materials physics. Students learn to conduct scientific research based on bibliographic data and to present their findings through an oral presentation.

Content

Students undertake a bibliographical research project to develop a better understanding of a theme defined by a tutor, usually a teacher from the Applied Physics department. The project complements the physics and materials courses that are taught in parallel.

Prerequisites

No specific prerequisites. The courses taught in parallel throughout the semester are sufficient.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Structure of solids

Module details

I3MASS20-exc

3 ECTS EN/FR
13.75 h 7.5 h 15.0 h 0.0 h
BOULIER THOMAS,HANTCHERLI MURIEL,LAHANA YONI,VIAU GUILLAUME
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- The structure and symmetry of crystalline solids
- X-ray diffraction by crystalline solids

Students will be able to:

- Characterize the structure of a crystal
- Classify crystalline solids by their symmetry
- Orient a crystal
- Apply basic X-ray diffraction techniques
- Analyze the results of a radiocrystallography experiment

Content

1. Description of crystalline solids
   - Perfect crystal: definition and description of typical ionic and covalent structures
   - Point lattices: unit cells, Miller indices, lattice planes, interplanar spacing
   - Crystallographic asymmetric unit
   - Reciprocal lattice: definition and properties
2. Crystal symmetry
   - Definitions of point symmetry elements, notions of group theory, crystal systems
   - Stereographic projection and point group representations
   - Description of translational symmetry elements, asymmetric unit, space groups and representations
3. X-ray crystallography
   - X-ray scattering and absorption
   - X-ray diffraction: diffraction conditions (Laue equations, Bragg's law, Ewald sphere); calculation of diffracted intensities (structure factor)
   - Main structural characterization methods for crystals, powders and thin films
   - Implementation and analysis of powder diffractograms and thin film diffractograms

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Thermodynamics

Module details

I3MATH20-exc

2 ECTS EN/FR
23.75 h 15.0 h 0.0 h 0.0 h
BOULIER THOMAS,LAHANA YONI,RENUCCI PIERRE,RESPAUD MARC
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The laws of thermodynamics, and the notions of work, heat, and energy associated with a transformation
- The application to heat engines, thermodynamic cycles, and efficiency calculations
- Phase changes and phase transitions
- Simple and binary material phase diagrams
- The concepts of diffusion and transport of matter/heat

The student should integrate these concepts, contextualize them, and be able to decontextualize them in order to project them into an adidactic situation.

Content

1. Introduction:
   The fundamental mathematical tools of thermodynamics: partial derivatives, Jacobian, exact and inexact total differentials, Legendre transformations, the notion of extensive and intensive quantities, integrating factor.
2. The formalism of equilibrium thermodynamics
   - Postulates for simple systems
   - State variables, equation of state for simple systems
   - Calorimetric coefficients of simple systems
   - Legendre transformations
   - Thermodynamic potentials, free energies of transformation, and their applications
   - Stability conditions of simple systems
   - Order parameter, first- and second-order phase transitions
3. Applications
   - Heat engines — balance and efficiency
   - Ideal gases, mixtures of ideal gases
   - Real gases, Van der Waals model
   - Solid–liquid–vapor transformations of a simple system
   - Phase changes & Phase diagram
4. Heat and mass transport phenomena
   - Diffusion phenomenon
   - Applications: thermoelectric effects (Peltier, Seebeck, etc.)
5. Thermodynamic model of the greenhouse effect : modeling and influence of atmospheric composition

Prerequisites

- Basics of mathematical analysis: functions of several variables, derivatives, integration, differential equations
- General notions of thermodynamics of physico-chemical systems

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Point defects and diffusion

Module details

I3MADI20-exc

1 ECTS EN/FR
8.75 h 6.25 h 0.0 h 0.0 h
BOULIER THOMAS,LAHANA YONI,RENUCCI PIERRE,RESPAUD MARC
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The laws governing mass diffusion in solid materials.
- The nomenclature of defects present in solid materials, the mechanisms of defect creation and annihilation, the induced electronic and optical properties, and their applications.

The student should integrate these concepts, contextualize them, and be able to decontextualize them to project them into an adidactic situation

Content

- Introduction:
  Role of diffusion mechanisms and defects in materials.
- Part I – Nature of defects:
  Volumetric, surface, line, and point defects in crystalline materials, ionic crystals, and amorphous solids.
- Part II – Thermodynamic aspects of point defects:
  Formation enthalpy, migration enthalpy, and equilibrium defect concentration.
- Part III – Fundamentals of diffusion:
  Flux equation, Fick's laws, macroscopic and microscopic aspects, calculation of the diffusion coefficient, influence of temperature.
- Part IV – Generation and annihilation of defects:
  Defect generation by exposure to radiation and by diffusion (vacancies, amorphization, doping), and defect annihilation by thermal treatment.
- Part V – Electronic and optical properties:
  Color centers in ionic crystals, doping effects in semiconductors.
- Part VI – Measurement techniques for defect concentration:
  Electrical measurements, geometric measurements, specific heat.
- Part VII – Applications.

Prerequisites

Basics of mathematical analysis: functions of several variables, derivatives, integration, differential equations. General notions of thermodynamics of physico-chemical systems.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Anisotropic physical properties of materials

Module details

I3MAAN20-exc

2 ECTS EN/FR
15.0 h 10.0 h 0.0 h 0.0 h
BOULIER THOMAS,FAZZINI PIER FRANCESCO,LAHANA YONI,RENUCCI PIERRE
Revision date : May 18, 2026

Objectives

This course introduces the fundamental principles of tensor theory and their use in describing the anisotropic properties of crystals. Through the study of static couplings (such as piezoelectricity and the acousto-optic effect) and anisotropic optics (wave plates, birefringence, etc.), several practical applications are presented to illustrate these concepts.

Content

Chapter 1: Tensors

- Definition of a tensor (use, order, transformation rules).
- Writing tensor relations: classical mathematical notation, Einstein summation convention, and matrix notation.
- Tensors and symmetries (symmetric tensors, system invariances and symmetries).

Chapter 2: Tensors and Mechanical Properties

- Definition of stress, strain, elasticity, and stiffness tensors.
- Different types of stress and strain (tensile, shear).
- Voigt or engineering notation (6-component representation).
- Isotropic elasticity tensor.
- Physical constants of isotropic elasticity (Young's, Poisson's, and Coulomb's moduli; Lamé coefficients).

Chapter 3: Static Couplings

- Direct and inverse piezoelectric effects.
- Piezoelectric tensor.
- Acousto-optic effect.
- Couplings between static properties: general concepts and definition of effects (pyroelectricity, thermal expansion, etc.).
- Statistical theory of couplings and matrix representation (Voigt notation).
- Primary and secondary effects (e.g. primary and secondary pyroelectricity).

Chapter 4: Anisotropic Optics

- Representation of a second-order tensor: the index ellipsoid and its geometric interpretation.
- Permittivity tensors and optical indices.
- Optical propagation along one of the principal axes of an anisotropic system; wave plates (quarter-wave and half-wave plates).
- Optical propagation in an arbitrary direction in an anisotropic system: birefringence and beam splitters.

Prerequisites

Linear algebra, multivariable calculus, solid mechanics, and wave optics.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Cohesion

Module details

I3MACO20-exc

1 ECTS EN/FR
6.25 h 1.25 h 0.0 h 0.0 h
BOULIER THOMAS,LAHANA YONI,RENUCCI PIERRE,VIAU GUILLAUME
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain physical models of cohesion of solid materials at atomic and molecular scales, as well as the relationship between these models and macroscopic physical quantities.

Content

Cohesion of solids:

- Describing models of solid-state cohesive energy
- Lennard-Jones potential
- Condon-Morse curve
- Properties and physical quantities relating to cohesion: compressibility, thermal expansion, melting point, allotropic transformations
- Applications to ionic crystals and crystals based on van der Waals interactions

Prerequisites

Bachelor-level (L2) knowledge in physics or materials science

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Quantum physics

Module details

I3MAPQ20-exc

2 ECTS EN/FR
13.75 h 7.5 h 0.0 h 0.0 h
BOULIER THOMAS,LAHANA YONI,RENUCCI PIERRE
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- Fundamental measurement postulates in quantum mechanics
- The time evolution of a quantum system
- The notion of plane waves and localized wave packets
- Harmonic oscillator theory and its applications
- Angular momentum theory and its applications

Students will be able to:

- Solve Schrödinger's equation (energy and eigenstates) in matrix formalism
- Apply the fundamental measurement postulates of a physical quantity
- Calculate the time evolution of a quantum state
- Manipulate the ladder operators of the harmonic oscillator and angular momentum

Content

- Brief review of the wave function and introduction to Dirac's formalism
- Fundamental measurement postulates in quantum mechanics
- Dynamics of quantum systems
- Harmonic oscillator theory
- Angular momentum theory

Students typically encounter mathematical difficulties (new formalisms and notations, solving the eigenvalue equation of a matrix, etc.).

Prerequisites

Knowledge in the fields of:

- Nanophysics (optics, photonics, nanotechnologies)
- Electrostatics
- Classical mechanics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Statistical physics

Module details

I3MAPS20-exc

3 ECTS EN/FR
0.0 h 31.25 h 0.0 h 0.0 h
BOULIER THOMAS,LAHANA YONI,LASSAGNE BENJAMIN,RENUCCI PIERRE
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- The fundamentals of statistical physics (origin of entropy)
- Microcanonical distribution, temperature, partition function and U, S functions
- Canonical and grand canonical distributions
- Fermi–Dirac and Bose–Einstein distributions

Students will be able to:

- Calculate the equilibrium properties of simple closed and open systems
- Employ the Fermi–Dirac or Bose–Einstein distributions in solid-state physics

Content

- Fundamental assumptions of statistical physics.
- Macrostates, microstates and density of states.
- Closed systems in equilibrium and the microcanonical distribution.
- Temperature and the Boltzmann distribution.
- Z, U and S functions.
- Thermodynamic link.
- Closed systems in contact with a thermostat and the canonical distribution.
- Systems in contact with a particle reservoir and the grand canonical distribution.
- Chemical potential.
- Fermions and bosons.
- Fermi–Dirac and Bose–Einstein distributions.
- Application examples.

Prerequisites

- Classical mechanics
- Hamiltonian mechanics
- Thermodynamics
- Electrostatics
- Electromagnetism

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS EN/FR

0.5 h 2.75 h 0.0 h 0.0 h

BOULIER THOMAS,CHAZEL FLORENT,DE GOURNAY FREDERIC,GUERMOUCHE NAWAL,GUIEYSSE DAVID,GUIGUI CHRISTELLE,HANTCHERLI MURIEL,LABORIE STEPHANIE,LAHANA YONI,MAHOUT VINCENT,MOREL SANDRINE,PLANTEC JEAN-YVES

Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Condensed Matter Physics I

Module details

I4GPPM11-exc

6 ECTS EN
37.5 h 25.0 h 0.0 h 0.0 h
BALOCCHI ANDREA
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain a number of notions of quantum mechanics and electronic structure of solids, associated with band engineering of modern devices.
In particular, with regard to quantum mechanics, he/she should be able to apply the following notions:

- quantized kinetic moments and their composition
- stationary and time-dependent perturbation theory applied to a quantum system of indistinguishable particles, to simple cases such as radiative recombination, multi-electron atom and two-state system.
- the student should be able to calculate energy spectra from model Hamiltonians, and argue the results.

In the field of solid-state electronics, students will need to be familiar with Drude and Sommerfeld's models for charge and heat transport in solids (Seebeck effect, Fourier law, Peltier effect). He will also need to master the following concepts, linked to a quantum approach to solids:

- first Brillouin zone
- Bloch's Theorem
- band structures in solids
- effective mass
- carrier dynamics under electric field (direct and reciprocal space acceleration theorem)
- electron-hole formalism
- phonons.

The student must be able to relate the electronic structure of materials to their physical properties (optics, transport) in order to understand the operation of semiconductor-based devices.

Content

Quantum mechanics:

- Orbital and spin kinetic moments and their composition.
- Stationary perturbation theory (non-degenerate and degenerate cases) and applications.
- Time-dependent perturbation theory (two-state systems, absorption, spontaneous and stimulated emission and selection rules).
- Indistinguishable particles (Pauli principle, helium atom).

Solid-state electronics:

- Free electron model (Drude and Sommerfeld models, Seebeck effect, Fourier's Law, Peltier effect).
- Crystal: direct and reciprocal lattices (primitive cell, first Brillouin zone).
- Electrons in a periodic potential (Bloch's theorem, band structure, LCAO method (graphene example), k.p method, DFT method).
- Electron dynamics (acceleration theorem in direct and reciprocal space, effective mass, electron-hole formalism).
- Phonons (dispersion curves, quantum model, role of phonons in transport, optical and thermal properties)

Prerequisites

Prerequisites for this course include :

- Nanophysics I and II
- Quantum physics
- Materials physics
- Mathematical tools: complex numbers, vector manipulation, matrix and differential calculus

Assessment

Tutorials, as direct applications of the lecture, enable the teacher to assess the overall understanding of the concepts introduced.
Students are invited to solve the various exercises. Corrections are discussed with interested students.

Two-hour final exams are held to test the knowledge acquired.
As the course progresses, students are asked to self-assess their understanding of the course during digital tutorials.
These sessions enable them to quickly become aware of any mistakes they have made and the additional work they need to do on certain points.

Back to menu

Laboratory Works Multiphysics Measurements I

Module details

I4GPLP11-exc

3 ECTS EN/FR
15.0 h 3.75 h 32.0 h 0.0 h
LASSAGNE BENJAMIN
Revision date : May 18, 2026

Objectives

The aim is to enable students to put their theoretical and technological knowledge into practice, using laboratory and industrial characterization and measurement techniques. These techniques are dedicated to :

- structural characterization of materials and devices
- characterization of electronic, optical and magnetic properties of materials and devices.

At the end of this module, students will be able to define, design and build a multi-physics measurement chain to characterize the structural, electronic, optical and magnetic properties of materials and devices at micro- and nanometric scales. He/she will also be able to exploit a set of experimental data, and evaluate their relevance. To do this, he or she must have understood and be able to explain the various concepts of solid state and device physics.

Content

Laboratory work (8h sessions):

- Optical microscope design and optical system simulation
- Electrical conduction properties of matter (hall effect, magneto-phonon effect)
- Optical properties of matter (electro- and photoluminescence, optical absorption)
- Magnetic properties of matter (electron paramagnetic resonance, Kerr effect)
- Structural characterization of matter (scanning and transmission electron microscopy, X-ray microanalysis)
- Diffusion in solids
- Non-destructive testing (eddy current, ultrasound, infrared thermography, X-ray)
- Atomic force microscopy.

Practical sessions emphasize autonomy and self-study.

Prerequisites

Prerequisites for this course include :

- Geometrical optics
- Electromagnetism 1A, 2A and 3A
- Classical and quantum mechanics
- Statistical physics
- Physical properties of matter 1 and 2
- Electro-kinetics 1A
- Electronics and signal processing 4A
- Instrumentation 4A
- Crystallography

Assessment

Under construction

Back to menu

Multidisciplinary project I

Module details

I4GPPJ11-exc

3 ECTS EN/FR
6.25 h 3.75 h 0.0 h 25.0 h
BLON THOMAS,CARREY JULIAN,GRISOLIA JEREMIE,LOHEZ SYLVAINE
Revision date : May 18, 2026

Assessment

Under construction

Back to menu

Objectives

The student, in pairs, will have to carry out a project drawing on knowledge and know-how in the fields of physics, electronics and measurement. The student must: Acquire autonomy in solving a complete technical problem Be able to apply their skills to establish technical specifications for requirements and resolve a given issue Implement project management techniques (consistently, etc.) over time Know how to communicate and interact in an engineering setting Be able to provide written and oral feedback

Content

The typical project involves designing, developing, and testing a complete measurement chain (sensor, amplification, acquisition, and signal processing).
These projects are carried out in partnership with companies (Continental, Thalesalineaspace, Astrium, Freescale, Laboratoire Fabre, etc.) and physics, chemistry, and mechanics research laboratories on the Toulouse campus.
In addition to supporting the project, students are also trained in project management, including drafting specifications and successfully completing their multidisciplinary project from a project management perspective, including scheduling, risk, cost, and quality management.

Prerequisites

Prerequisites for this course include :

- General physics
- Analog and digital electronics
- Instrumentation (data acquisition, instrument control)
- Computer language (C language, Labview, etc.)
- Signal processing

Electronic and signal processing

Module details

I4GPEL11-exc

5 ECTS FR
8.75 h 22.5 h 24.0 h 0.0 h
GERARD PASCAL
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Instrumentation

Module details

I4GPII11-exc

5 ECTS   EN
4.0 h   2.0 h   42.0 h   18.75 h
CARREY JULIAN
Revision date : May 18, 2026

Objectives

The general objectives are :

- Acquire knowledge in the field of measurement and data acquisition using computers.
- Determine the relevant parameters of a measurement chain.

Skills to be acquired :

- Choose the right equipment, method and language to solve a measurement problem.
- Develop instrumentation programs in LabVIEW and Labwindows-CVI environments.
- Communicate with a multifunction acquisition card or instrument via RS-232 or GPIB port
- Understand and implement important parameters when using multifunction DAQ instrument cards.

Content

Topics covered include :

- Different types of data transfer.
- Analog inputs/outputs, speed/resolution/price trade-offs.
- Serial and parallel digital I/O.
- Standardized instrumentation buses: RS232C, IEEE 488. 1 and 488. 2 standards, SCPI commands.
- Instrumentation languages: Labwindows-CVI, Labview. Analog signal acquisition and generation (DAQ card).

Prerequisites

Knowledge of C language required.

Assessment

Under construction

Back to menu

Physical properties of Condensed Matter II

Module details

I4GPPM21-exc

6 ECTS FR
20.0 h 27.5 h 0.0 h 0.0 h
LASSAGNE BENJAMIN
Revision date : May 18, 2026

Objectives

By the end of this module, students should have an understanding of both the macroscopic and microscopic aspects of dielectric and magnetic materials, as well as the methods used to produce these materials. They will be able to apply these concepts to design sensors and advanced microelectronic devices.
Students should be able to explain and apply:

- The main electronic properties of matter, as a continuation of the "Physics of Matter 1" course unit, with a particular focus on the dielectric and magnetic properties of materials.
- Methods for synthesizing nanostructured and bulk materials using chemical and physical approaches, and their implications in micro- and nanoelectronics processes as well as in metallurgy.

Content

The content for this course includes:

1. Dielectric properties of matter:
   Understanding the microscopic aspects of dielectric materials. Being able to calculate:
   - the electric field and electric polarization in a linear, homogeneous, and isotropic (LHI) dielectric material with simple geometry,
   - the different microscopic contributions to polarization,
   - the propagation modes of an electromagnetic wave in an LHI dielectric material,
   - the response of piezoelectric, pyroelectric, or ferroelectric sensors to an external electrical stimulus.
2. Magnetic properties of matter:
   Understanding the origin of magnetism and the different magnetic behaviors of materials. Being able to calculate:
   - the field generated by electromagnets,
   - the magnetic moment of isolated atoms,
   - the equilibrium positions of magnetization within the Stoner–Wohlfarth model.
3. From molecule to material:
   - Knowledge of forces and bonding in molecular chemistry. Understanding phase transformations, nucleation, and growth at interfaces. Applying these principles to the synthesis of nanoparticles and the control of their properties, as well as to the processing and heat treatment of bulk materials.
   - Practical work: analysis of high-resolution electron microscopy images of nanoparticles and thin films – determination of structure and zone axis – epitaxial relationships.

Prerequisites

The prerequisites for this course include:

- Electrostatics (1st year)
- Electromagnetism (2nd and 3rd year)
- Classical and quantum mechanics
- Statistical physics
- Physical properties of matter 1
- Crystallography

Assessment

Continuous assessment of learning during tutorial sessions (TD). Student self-assessment during tutorials and based on additional exercises not covered in class to go further. Summative assessments in the different parts. Group work.

Back to menu

Laboratory Works Multiphysics Measurements II

Module details

I4GPLP21-exc

3 ECTS   EN
0.0 h   0.0 h   35.0 h   0.0 h
HANTCHERLI MURIEL
Revision date : May 18, 2026

Objectives

The aim is to enable students to put their theoretical and technological knowledge into practice, using laboratory and industrial characterization and measurement techniques. These techniques are dedicated to :

- structural characterization of materials and devices
- characterization of electronic, optical and magnetic properties of materials and devices.

At the end of this module, students will be able to define, design and build a multi-physics measurement chain to characterize the structural, electronic, optical and magnetic properties of materials and devices at micro- and nanometric scales. He/she will also be able to exploit a set of experimental data, and evaluate their relevance. To do this, he or she must have understood and be able to explain the various concepts of solid state and device physics.

Content

Laboratory work (8h sessions):

- Optical microscope design and optical system simulation
- Electrical conduction properties of matter (hall effect, magneto-phonon effect)
- Optical properties of matter (electro- and photoluminescence, optical absorption)
- Magnetic properties of matter (electron paramagnetic resonance, Kerr effect)
- Structural characterization of matter (scanning and transmission electron microscopy, X-ray microanalysis)
- Diffusion in solids
- Non-destructive testing (eddy current, ultrasound, infrared thermography, X-ray)
- Atomic force microscopy.

Practical sessions emphasize autonomy and self-study.

Prerequisites

Prerequisites for this course include :

- Geometrical optics
- Electromagnetism 1A, 2A and 3A
- Classical and quantum mechanics
- Statistical physics
- Physical properties of matter 1 and 2
- Electro-kinetics 1A
- Electronics and signal processing 4A
- Instrumentation 4A
- Crystallography

Assessment

Under construction

Back to menu

Ecological transition scenarios

Module details

I4GPSE21-exc

3 ECTS EN/FR
11.25 h 0.0 h 0.0 h 16.25 h
CARREY JULIAN
Revision date : May 18, 2026

Objectives

By the end of this module, students should be able to:

- Understand methods of both low-carbon and carbon-based energy production: main characteristics (efficiency, costs, emissions), limitations, and environmental and social impacts
- Understand the main methods of energy storage (efficiency, cost), their limitations, and environmental and social impacts
- Understand the main characteristics of nuclear electricity generation
- Perform simple energy production calculations (required surface area, cost, efficiency)
- Search the scientific literature for information needed for analysis
- Understand, interpret, and critically assess an energy transition scenario: realism of the models used, underlying assumptions, unspoken human values, conflicts of interest and lobbying, chosen trade-offs, unexplored pathways, and potential errors. Understand and illustrate that no model is neutral: every scenario is inherently political.

Content

Theoretical lectures on energy production, energy–climate challenges, renewable and nuclear electricity. Study of various transition scenarios: French, European, and international. Pair work on a mini-review of the scientific literature.

Prerequisites

Basic knowledge of energy and climate change is required.

Assessment

Under construction

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

From the sensor to the test bench in open source hardware

Module details

I4GPMH21-exc

3 ECTS EN
6.25 h 40.0 h 0.0 h 0.0 h
GRISOLIA JEREMIE
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain the main concepts related to:

1. FABRICATION OF "LOW-TECH" GRAPHITE-BASED SENSORS:
   - Including elements of physics (electronic transport) enabling the understanding of the electrical characteristics of a sensor based on a granular system (graphite nanoparticles)
2. SENSORS AND DATA ACQUISITION CHAIN:
   - The elements required for the design and use of such a sensor and an appropriate measurement chain

Students will be able to work with:

- The physical principles underlying sensor operation
- Concepts used in metrology
- Implementation procedures
- Electrical conditioning circuits
- The design of a measurement chain

1. DESIGN OF AN ANALOG ELECTRONIC CIRCUIT:
   - Students will be able to design and simulate an amplification stage dedicated to measuring the fabricated sensor
2. MICROCONTROLLERS AND OPEN-SOURCE HARDWARE:
   - Students will be able to program microcontrollers required for the design and implementation of practical Open Source Hardware applications
3. DEVELOPMENT OF AN ANDROID APPLICATION:
   - Students will be able to develop a smartphone (Android) application to collect and display data from the graphite sensor
4. DEVELOPMENT OF A SENSOR-SPECIFIC TEST BENCH:
   - Students will be able to build a test bench to optimally and reproducibly characterize the electrical properties of the sensor
5. PREPARATION OF THE SENSOR DATASHEET:
   - Finally, students will produce the technical datasheet for the sensor they have developed

Content

Fabrication of a graphite-based sensor using a "low-tech" approach with nanoparticles
SENSORS AND DATA ACQUISITION CHAIN:

1. FUNDAMENTAL PRINCIPLES:
   - definitions and general characteristics, measurement chain, definition of a sensor, types of sensors, conversion of physical quantities, influence quantities, integrated sensors, smart sensors ("smart devices")
2. METROLOGICAL CHARACTERISTICS:
   - sensor calibration, limits of sensor use, sensitivity, linearity, repeatability – accuracy – precision, response time, resolution
3. DETECTION PRINCIPLES USED IN SENSORS:
   - analog sensors, digital sensors
4. GENERAL CHARACTERISTICS OF SENSOR CONDITIONING CIRCUITS:
   - main types of conditioners for passive sensors, quality of a conditioner, potentiometric circuits, bridge circuits
5. SIGNAL CONDITIONING:

- adaptation of the signal source to the measurement chain, linearization, signal amplification and reduction of common-mode voltage

6. AUTOMATED SYSTEMS
7. APPLICATIONS:
   - optical sensors, gas sensors
8. MICROCONTROLLERS AND OPEN SOURCE HARDWARE:
   - Architecture and operation of ATMEL AVR microcontrollers
   - Programming Arduino boards in C and C++, and use of their IDE development environment
   - Development of custom libraries and programs
   - Creation of human–machine interfaces: Arduino/Processing, Android, and Python
   - Design of custom electronic boards (Eagle, PCB, etc.)
   - Interfacing boards with various devices (displays, motors, sensors, Nunchuk, touchscreens, I2C bus, Wi-Fi, Bluetooth LE)
   - Intellectual property in open source hardware
9. DEVELOPMENT OF AN ANDROID APPLICATION:
   - Programming with MIT App Inventor to create a smartphone application for collecting sensor data
   - Design of an Android interface
10. DESIGN OF AN ELECTRONIC CIRCUIT:
    - Creation of electronic circuits using KiCad (schematics, routing, PCB design)
11. DEVELOPMENT OF A SENSOR TEST BENCH
12. DEVELOPMENT OF A DEMONSTRATOR

Prerequisites

Prerequisites for this course include:

- Knowledge of a programming language such as Fortran, C, or preferably C++
- Knowledge of algorithms

Assessment

Assessment method: project + oral presentation, with submission of documents on the GitHub platform.

Back to menu

Multidisciplinary project II (*)

Module details

I4GPPJ21-exc

2 ECTS EN/FR
0.0 h 0.0 h 0.0 h 25.0 h
MARIE XAVIER
Revision date : May 18, 2026

Objectives

The student, in pairs, will have to carry out a project drawing on knowledge and know-how in the fields of physics, electronics and measurement. The student must: Acquire autonomy in solving a complete technical problem Be able to apply their skills to establish technical specifications for requirements and resolve a given issue Implement project management techniques (consistently, etc.) over time Know how to communicate and interact in an engineering setting Be able to provide written and oral feedback

Content

The typical project involves designing, developing, and testing a complete measurement chain (sensor, amplification, acquisition, and signal processing).
These projects are carried out in partnership with companies (Continental, Thalesalineaspace, Astrium, Freescale, Laboratoire Fabre, etc.) and physics, chemistry, and mechanics research laboratories on the Toulouse campus.
In addition to supporting the project, students are also trained in project management, including drafting specifications and successfully completing their multidisciplinary project from a project management perspective, including scheduling, risk, cost, and quality management.

Prerequisites

Prerequisites for this course include :

- General physics
- Analog and digital electronics
- Instrumentation (data acquisition, instrument control)
- Computer language (C language, Labview, etc.)
- Signal processing

Assessment

Under construction

Back to menu

Safety, quality and applications to measurement

Module details

I4GPSQ21-exc

7 ECTS FR
26.75 h 22.5 h 26.0 h 0.0 h
GRISOLIA JEREMIE
Revision date : May 18, 2026

Objectives

This module provides a theoretical and experimental approach to the main concepts involved in the fields of quality, safety, environment, measurement, and microtechnologies.
The following topics are covered:

- Design of experiments
- Metrology and experimentation
- Decision-making and risk analysis
- Physics of advanced devices
- Micro- and nanotechnologies

This set of courses is designed to motivate students by placing them in practical situations related to the kinds of problems they may encounter in their future careers as engineers.
Within this framework, the guiding principle of the program is to emphasize, on the one hand, group work centered around unifying and highly application-oriented themes, and on the other hand, to strengthen the connection between theoretical coursework and the concepts students will need during practical internships in laboratories and/or industry.
In particular, the program presents the techniques used in the microelectronics industry for the fabrication of integrated circuits (photolithography, thin film growth and deposition, doping, etching), as well as various optical and electrical characterization techniques. Students study the physicochemical processes involved in these techniques.
This presentation is based on the example of complete fabrication processes for NMOS and CMOS circuits.
Students are also introduced to the design and simulation of integrated circuits.
The physics of advanced semiconductor devices focuses on heterojunction devices.
At the end of this course unit, students should be able to:

- Define, design, and analyze an experimental plan for a complex physics problem, and critically assess the obtained results.
- Master advanced concepts in device physics.
- Understand and apply semiconductor device fabrication processes in a cleanroom environment.
- Be aware of issues related to safety, quality, decision-making, environmental risks, and risk analysis.

Content

This module is divided into two main parts: one focused on quality, safety, and environmental theory, and the other on experimentation.
The “theoretical” part emphasizes:

- A general introduction to quality, safety, and the environment
- A course on safety
- An introductory course on decision-making and risk analysis
- A course on Design of Experiments (DOE): definition, history, objectives, scientific foundations, plan selection, construction, and model validation
- A course on environmental risks applied to nanotechnologies
- A course on the physics of advanced devices
- A course on the physicochemistry of processes used in microelectronics

The “experimental” part emphasizes group-based experimental work centered around the core theme of this module:

- A debriefing on Design of Experiments (DOE) through the construction of paper helicopters.
- Practical work in a cleanroom, during which students fabricate integrated circuits based on NMOS transistors. This includes specific circuits implementing various logic functions, as well as components to be studied and characterized. Students carry out all fabrication steps and characterize them progressively to ensure the proper execution of the process. At the end of the training

period, they test the functionality of the logic circuits and conduct a study of the electrical characteristics of certain components (NMOS transistors with different gate lengths, MOS capacitors).

- Practical sessions using professional microelectronics software for an introduction to the design and simulation of integrated circuits.

Prerequisites

Prerequisites for this course include:

- Semiconductor physics (electrons, holes, doping, band structure).
- Structure and operating principles of basic electronic components (PN junction, MOS transistor).
- Statistical modeling.

Assessment

Assessment of the learning objectives is carried out through an exam and an experimental exercise followed by a written report (for the Design of Experiments part).
The evaluation of the micro- and nanotechnologies component is based on a written exam covering the knowledge and skills acquired during lectures and practical sessions.
The assessment is designed to ensure that students engage in regular preparation for lectures and tutorial sessions. The experimental exercise places them in an autonomous working situation, allowing for a better understanding of their difficulties.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Applied physics and Scientific Communication

Module details

I5GPAP11-exc

3 ECTS   EN
38.75 h   1.25 h   0.0 h   0.0 h
CARRERE HELENE
Revision date : May 18, 2026

Objectives

By the end of this module (taught entirely in English), students should understand and be able to explain:

- the basic operating principles of lasers, associated techniques and optoelectronics
- the differences in the principles of written and oral expression in scientific English.

Students should be able to:

- apply laser-related technologies to his or her job as an engineer, and train technicians in this field (including safety aspects)
- follow a scientific course in English
- select relevant information adapted to their interlocutor or audience
- develop, reformulate and synthesize specific scientific knowledge in English
- present project work orally and in writing in English
- translate scientific knowledge for a non-specialist audience
- adapt expression to formal and informal situations

Content

Laser and optoelectronics education:

- Light-matter interactions
- Pumping principles / Gain
- Resonant cavity
- Operating modes: cw, Q-switching, mode-locking
- Laser beam characteristics: coherence, divergence
- Applications: machining, metrology, medicine
- On-line optics
- Specificities of semiconductor-based lasers and gain media
- Integration challenges in micro-optoelectronics

English teaching:

- Collaboration with the Laser science course taught in English
- Informal individual/team presentations
- Individual filmed presentation, analyzed in group
- Team presentations of project milestones to specialized audiences
- Individual and group written exercises

Writing of a technical report on a technical topic related to laser techniques + presentation monitored by both English teachers and the laser course teacher

Prerequisites

English: Intermediate level B2
Laser and optoelectronics:

- Quantum mechanics
- Statistical physics
- Geometric and wave optics
- Materials physics
- Semiconductor and device physics
- Solid-state physics

Assessment

Back to menu

Physics Engineering and knowledge Transfer

Module details

I5GPPV11-exc

7 ECTS EN/FR
66.25 h 0.0 h 0.0 h 0.0 h
CHRISTOPHE THIBAULT
Revision date : May 18, 2026

Objectives

The multiple objectives are as follows:

- To be able to describe the basic architecture of a telecom payload, including the functional description of a bent-pipe transponder.
- Acquire in-depth knowledge of each RF device making up the payload of a telecom satellite (specifications, drivers, technologies and associated key points).
- Understand and be able to explain new microelectronics technologies and materials (SiGe, SiC, III-V, SOI, OLED...)
- acquire basic knowledge of plasmas and their use
- Acquire notions of electromagnetic compatibility and failure analysis
- Develop a personal reflection on the impact of science on society in relation to environmental change
- Analyze and criticize the nature of science and technology
- Build a research project that makes sense in terms of personal values and major societal challenges.

Content

The content of this course includes:

1. Microwave / EMC / Failure Analysis Course:
    - Description of the electromagnetic compatibility of equipment, hardening of systems against aggression (lightning, strong fields, nuclear electromagnetic pulse, etc.), threats, coupling phenomena, protection techniques.
    - Fundamentals (propagation) / Main microwave functions (planar lines and couplers, amplifiers, attenuators, phase shifters, oscillators, mixers) / Active microwave components (semiconductors, transistors, MMICs, oscillators) / Satellite applications
    - CultureS nano course: The "Culture(S) Nano" course is a pedagogical experiment designed to engage engineering students in analyzing the challenges of Nanotechnologies and beyond, the challenges of science in the 21st century. The aim is to identify the existence of a dominant "Nano Culture" and to perceive its specific features. Beyond the initial example of nanotechnologies, the aim is to reflect on the scientific culture at work in today's world. A series of individual and group activities are set up to engage students in the discovery of alternative scientific cultures. The work is put into practice in the design of a scientific project that makes sense for the students. Through this approach, engineering students develop critical thinking skills and articulate their future profession and ethical values in the search for personal coherence.
2. Plasma course
    - Overview of cold plasma-assisted processes
    - Concept of electrical discharge in a gas
    - Continuous discharge
    - Radiofrequency discharge
    - Reaction mechanisms in plasmas
    - Plasma-assisted deposition processes (PECVD)
    - Dry etching
3. Tech. New materials
    - Si-Ge-C alloys: structure, electrical pps, applications, component integration
    - SiC: structure, electrical pps, applications, component integration
    - SOI: manufacturing, applications
    - Si nanocrystals: memories and optoelectronics
4. Technology transfer
    - Patent policy and entrepreneurship.

Prerequisites

Prerequisites for this course include:

- Courses on "semiconductors".
- Manipulation of decibel quantities
- Practical knowledge of solid-state thermodynamics and physical metallurgy
- Notions of RF (noise, gain) and electromagnetism

Assessment

Written exams, report and oral presentation

Back to menu

Advanced intrumentation 1

Module details

I5GPII11-exc

5 ECTS   FR
40.0 h   0.0 h   22.5 h   0.0 h
VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

The objectives of this course includes:

- VXI: Be able to implement the main component of VXI system (slave, masger, register'), to develop communication protocols.
- VISA: Being able to develop a high-level VISA driver instrument To be able to develop a high lever instrument driver.
- Definition and Qualification of Industrial Measurement System: being able to write a technical and financial proposal in response to a call for tenders on an instrumentation project

Content

The content of this course includes:

- Overview of VXI Specifications: Interrupt request, bus request, devices (slave, master, register based, message based, extended commander, servant), register map for devices, communication protocols, system resources.
- Description of VISA specifications: VISA software model and the VISA Application Programming Interface (API).
- Description of SCPI (Standard Commands for Programmable Instruments) language
- Practical work : VXI et VISA
- Implementation with a practical case of the different aspects of project management (technical, economic, human, environmental, ...) and preparation of engineering students for the realization of projects, the major part of which is not or insufficient defined by the requester. Highlighting the plurality of solutions corresponding to a given problem

Prerequisites

Prerequisites for this course include:

- Knowledge of Fortran, C and even C++
- Knowledge of algorithmic

Assessment

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Advanced intrumentation 2

Module details

I5GPII12-exc

5 ECTS FR
18.75 h 7.5 h 23.5 h 0.0 h
LOHEZ SYLVAINE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Real Time : Real time concept, scheduling, rules to develop a real time application, determinism and jitter concepts
- Can Bus : General CAN concept, from concept to protocol
- Advanced virtual instrumentation : architecture template, state machine architecture, VI Server functionnalities, using configuration file in LabVIEW, event structure

The student will be able to:

- Real Time : Develop a real time application running on National Instruments Compact RIO
- Can Bus : Manage communication between two CAN nodes
- Advanced virtual instrumentation : Develop a complex application using the best architecture

Content

the content of this course includes:

- Real Time : Real time presentation
- Scheduling : on line and off line scheduling, static and dynamic scheduling, static and dynamic priorities
- Classic systems limits for real time
- System constraints for real time
- CAN bus: CAN nodes, frames format, acknowledgement, synchronisation, error handling, electronics, automotive dedicated protocol, National Instruments board main software functions
- Advanced virtual instrumentation : architecture template, state machine architecture, VI Server functionnalities, using configuration file in LabVIEW, event structure

Prerequisites

The prerequisites for this course include:

- General computing
- LabVIEW programming
- Labwindows/CVI programming

Assessment

Written exam

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

NanoPhysics and Nanochemistry

Module details

I5GPNN11-exc

5 ECTS EN
37.5 h 0.0 h 12.0 h 0.0 h
VIAU GUILLAUME
Revision date : May 18, 2026

Objectives

This course provides theoretical and experimental approaches to the main concepts of nanoelectronics, spintronics and quantum technologies.
It also includes an introduction to nanoparticle growth and X-ray scattering analysis methods.
The pedagogical objectives are:

- Acquire scientific knowledge of the physics and chemistry of nanostructured and low-dimensional solids;
- Enable students to link these teachings to develop, observe and understand the properties of nano-objects and nanostructures, and use them for purposes as diverse as nanoelectronics, quantum sensors and bottom-up approaches to nanomaterials.

Content

Nanoelectronics and Spintronics:

- Characteristic lengths of electronic transport ;
- Transport regimes (diffusive, ballistic, mesoscopic)
- Basics of spin-polarized transport ;
- Magnetic properties of multilayers;
- Spintronics applications.

Quantum technologies:

- Demonstration of the corpuscular aspect of photons;
- Quantum key distribution protocol;
- Handling twin photons;
- Generating entangled photons;
- Observation of the quantum states of nitrogen defects in diamond ;
- Optical pumping;
- Zeeman effect for magnetometry;
- Comparative study of classical and quantum sensors.

Nanochemistry:

- Chemical synthesis of nanoparticles - metals, semiconductors, oxides - nucleation/growth in liquid phase - morphological control;
- X-ray scattering at small and wide angles (SAXS-WAXS);
- Physical chemistry of colloids; self-assembly; surface functionalization
- Biological and medical applications;
- Nanoparticle integration: nanoelectronic devices - sensors.

Prerequisites

Master 1 in General Physics or Applied Physics or equivalent

Assessment

Back to menu

Innovative technologies, devices and materials

Module details

I5GPTI11-exc

5 ECTS EN/FR
15.0 h 0.0 h 33.0 h 0.0 h
GERBER IANN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain:

- quantum phenomena such as diffusion, electron paramagnetic resonance, and quantum cryptography
- entangled states, single-photon and pairs of entangled states source based on semiconductors quantum dots.

The student will be able to apply the quantum mechanics formalism to describe innovative devices at the nano-scale and apply his/her theoretical knowledge of the electronic transport and optoelectronic properties of semiconductor devices.
The student will also be able to:

- choose the kind of scanning probe microscopy well adapted to a specific application/characterization
- analyze and interpret basic images of scanning probe microscopy.

Content

Light-matter interaction:

- Diffusion process (cross-section of an embedded component)
- OLED working process
- Electronic paramagnetic resonance phenomenon
- Single photon nano-emitter.

Advanced Physics practical lessons :

- Measurement of the electronic properties of a graphene-based nanodevice using a sub-tip tester and a set of high-performance measurement devices
- Measurement of the optical properties of a semiconductor based device (quantum wells) using an optical spectrometer.

Near field Theory:

- electronic, electrostatic and optical near fields
- Application to scanning probe microscopy : STM, AFM, SNOM
- Principle, architecture, performances, modes of imaging, spectroscopy and lithography

Prerequisites

The prerequisites for this course include:

- Electromagnetism
- Quantum Mechanics
- Mathematics: matrix calculus and differential equations
- Basic knowledge of numerical and symbolic computational tool (Python).
- Statistical physics
- Solid state electronics
- Electronic transport

Assessment

End-of-course exams with open questions. Continuous assessment through practical exercises

Back to menu

Nano-bioengineering

Module details

I5GPNB11-exc

2 ECTS EN
0.0 h 18.0 h 11.5 h 0.0 h
THIBAULT CHRISTOPHE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Nanotechnological processes for the investigation, the sensing and the quantification of biomolecular specific interactions, basis of all biosensing technologies.
- The principle of some of these technologies: Fluorescence, soft lithography, surface biofunctionalization, single molecule assays, biochips, 3D lithography, microfluidic.

The student will be able to:

- Formulate nanoscale mechanisms and give precise examples of biomolecular specific interactions
- Master nanoscale technics for transducing a molecular event into a measurable signal
- Analyze any kind of biosensor
- Implement a scientific experimental investigation
- Implement these nanotechnological and fluidic processes
- Discuss results, give interpretations and set the l advantages as well as limitations,
- Gather different concepts; assimilate them for being able to extract them from their context in order to face adidactical situations.

Content

A 10-hour introductory training course on technologies of interest in biology will be provided to students.
Following this, the students will simulate microfluidic chips using Comsol software, implement it through fabrication and measurements on microfluidics chips. Three workshops will be proposed in a research environment combining labrooms and a nanofabrication clean room:

- Multiphysics simulation of microfluidic systems (Comsol)
- 2D/3D fabrication of fluidic systems.
- Measurments of velocit and diffusion profiles on microfuidic systems.

Prerequisites

The prerequisites for this course include:

- Initiation to micro/nano-biotechnologies
- Scientific M1 in Chemistry, Biology or Physics

Assessment

Oral presentation of the work

Back to menu

Charged particle optics

Module details

I5GPPC11-exc

2 ECTS EN
0.0 h 17.5 h 12.5 h 0.0 h
HOUDELLIER FLORENT
Revision date : May 18, 2026

Objectives

Charged particle optics (CPO) is a science that compiles under a common theoretical base all the laws governing the transport, focusing, mass/energy dispersion, etc. of charged particles that can be electrons, positrons, ions or molecules. It allows the description of the optical properties of all the usual individual optical elements (lenses, energy filter, magnetic sector, etc.) and thanks to the multiple combinations of these elements, it allows the creation of a wide range of tools for the characterisation of innovative materials. For years, applications in this field have been considerable: development of increasingly powerful electron microscopes, focused ion beams that have opened the way to nano-manufacturing, secondary ion mass spectrometers (SIMS), an essential tool for characterising dopants in semiconductors, and also large instruments such as synchrotrons and particle accelerators.For several years, the demand for engineers with solid skills in this field has been significant and has been increasing regularly. Indeed, the companies providing state-of-the-art analysis instruments are in a permanent race to innovate, on the one hand to meet the needs of the original market of increasingly small and complex semiconductor devices, but also to meet new markets such as the characterisation of chemical materials (pharmaceutical molecules, etc.) or biological materials (viruses, etc.) and the development of medical instruments (proton therapy for example). The development in the early 2000s of spherical aberration correctors for electron microscopes, whose innovative optics are based on the symmetry properties of magnetic multipoles, is an emblematic example that has revolutionised the use of these instruments. In order to respond to this craze and to the demand for innovation that will enable the instruments of the future to be imagined, the industrial world is looking for engineering schools that can offer a modern approach to OPC adapted to their needs. This module will aim to develop the theoretical foundations of OPC by insisting on the practical aspects useful for the development of new innovative optical instruments. The course will insist in particular on the strength of the general formalism of the OPC which gathers under the same logic all the elements which can transport, focus or disperse charged particles. The tutorials around simulations using the SIMION software (https://simion.com/docs/simion8brochure.pdf) and practical work will allow the engineering students to put this knowledge into practice around a design project of a concrete optical system such as, for example

- the manufacture of an electrostatic electron microscope whose elements, previously dimensioned with SIMION, can be manufactured with a 3D printer.

We would like to focus this module on aspects of the OPC that are of interest to industry and we will be in contact with Orsayphysics, a French manufacturer of focused ion beams. A visit to the company may even be considered, depending on requests and availability.

Content

Structure of the module :

- Theoretical basis: Formalism and applications
- TDs SIMION: Handling and practice on known examples
- TPs: Design of a simple optical system and realization of a prototype (electron or ion optics)
- Oral presentation in the presence of teachers and industrialists
- Free work planned in groups or personally: Bibliography, simulations, electrical/vacuum tests/on the prototype...

Prerequisites

The prerequisites for this course include:

- Electromagnetism
- Advanced Geometrical Optics
- Fourier optics
- quantum mechanics
- an approach to point mechanics problems using Lagrange's variational principle would be a plus.

Assessment

Grand oral restitution in January

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Gas Sensor

Module details

I5GPNC11-exc

2 ECTS FR

0.0 h 3.0 h 25.0 h 0.0 h

LACHAIZE SEBASTIEN

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the approach and the different steps for the conception and realization of a micro- and nano-electronic by integration of nano-objects synthesized as a colloidal solution;
- the operating model of a nano-sensor

the student will have understood and be able to explain:

- the main concepts and the experimental practices about nano-object synthesis and stabilization of colloidal solutions;
- the main concepts and the experimental practices about deposition of nano-objects from a solution into 2D and 3D arrays on a surface;
- the physical principles of nanoparticles based sensors (gaz sensor, strain sensor ').

The student will be able to:

- produce a sensor relying on nanoparticle arrays with particles synthesized and assembled during the project;
- measure the sensor properties and describe how it works;
- discuss the results obtained and suggest improvements

The student will be able to:

- suggest a reasonable solution for the realization of a sensor gathering the different concepts described above;
- produce an expertise on the conception and the practical realization on a novel sensor.

Content

Programme (detailed contents):

- This project begins with a bibliographic work in the framework of sensors and an oral presentation of this work.
- It follows with an experimental work et a report on the experiments.

The experimental realization of a sensors includes:

- chemical synthesis of nanoparticles; characterization by dynamic light scattering (DLS), electron microscopy, atomic force microscopy (AFM);
- Assembly of the nanoparticles by convective deposition, nanoxerography, and/or dielectrophoresis;
- Electrical measurements of the nanoparticles based sensors; characterization of gas sensors under pcontrroled partial pressure of different gas; study of the temperature effect; sensibility and selectivity.

Prerequisites

Master 1 in Physics, Applied Physics, Chemistry or Material Science or equivalent

Assessment

Assessement of this course includes:

- Oral presentation of the bibliographic report
- Report of the experimental works
- Oral presentation in front of a board with industrial partners

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Digital filtering

Module details

I3MAFI10-exc

2 ECTS FR
7.5 h 7.5 h 8.25 h 0.0 h
ACCO PASCAL,BOULIER THOMAS,GRZESKOWIAK MARJORIE,LAHANA YONI
Revision date : May 18, 2026

Objectives

Understanding of discrete time signals and discrete systems, principles of signal theory and methods of signal processing, with emphasize on spectral analysis and digital filter design

Content

The content of this course includes :

- Signal conversion and processing (Analog / Digital, Digital / Analog, Difference equation)
- Discrete-Time linear systems (Z-transform, transfer, function, impulse response)
- Filter structure and Design. (FIR and IIR Filters, stability, Bilinear transform)

Prerequisites

Prerequisites include :

- Fourier transform and series
- Laplace transform and transfer functions
- Bode diagrams

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Numerical analysis

Module details

I3MAAN10-exc

2 ECTS FR
10.0 h 0.0 h 16.5 h 0.0 h
BOULIER THOMAS,DUBOSCQ ROMAIN,LAHANA YONI,VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts): Some notions of numerical analysis and scientific computing. The student should be able to: Choose an appropriate method for solving a mathematical problem. Use the Python language to implement numerical analysis methods.

Content

The course covers the following topics: numerical errors, solving non-linear equations, numerical integration, direct solutions of linear systems, matrix norms and conditioning, iterative methods for solving linear systems, least squares methods, and ordinary differential equations.

Prerequisites

Mathematical concepts are based on undergraduate linear algebra and analysis. Practical work is based on relatively simple programming.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Programming in C

Module details

I3MALC10-exc

2 ECTS   EN/FR

6.25 h   6.25 h   5.5 h   0.0 h

BOULIER THOMAS,LAHANA YONI,MONTEIL THIERRY,VIGNOLLES DAVID

Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain programming principles in one of the most widely used programming languages, C, particularly focusing on its low-level features and its proximity to hardware.

Content

This course covers both the conventional aspects of the C programming language — such as variables, data types, control structures, and loops — as well as more advanced features specific to C. These include bitwise operators, extensive use of pointers, parameter passing, and input/output operations.

Prerequisites

Basic knowledge of assembly language and experience in a high-level programming language are recommended.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Physical meas. and statistical modelling

Module details

I3MAPH10-exc

4 ECTS EN/FR
0.0 h 7.5 h 37.5 h 0.0 h
BOULIER THOMAS,LAHANA YONI,VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain the operating principles of the various sensors used during the lab sessions and know how to implement them within an experimental framework to address a specific problem. They should also have developed a critical perspective on experimental results. Students will be able to:

- Set up a measurement chain using different sensors, interpret the resulting data, and critically evaluate experimental outcomes.
- Analyze and quantify the various components of measurement error.
- Construct a statistical model from a set of collected observations to confirm or refute hypotheses about a studied phenomenon.
- Define a stochastic model of measurement, determine confidence intervals, and perform statistical tests.
- Design simple experimental plans optimally.
- Apply statistical reasoning to improve experimental reliability and precision.

Content

1. Experimental part:
   - Five 7.5-hour laboratory sessions selected among the following topics: Temperature Measurement, Vacuum Technology, Laser, Extensometry, Thin Films, and Optical Measurement. Each experiment introduces the physics underlying various sensors, their operating principles, and appropriate conditions of use. These sensors are then applied in different measurement contexts. The collected data are processed, analyzed, and critically discussed.
2. Statistical part:
   - Random modeling of measurements: systematic and random errors, confidence intervals.
   - Linear models: least-squares fitting, prediction intervals, model validation, model selection.
   - Introduction to experimental design: optimality criteria, estimation of main effects and interaction effects between factors.

Prerequisites

Probability and Statistics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

In-depth study of electronic circuits

Module details

I3MACE10-exc

4 ECTS EN/FR
13.75 h 15.0 h 5.5 h 0.0 h
BOULIER THOMAS,GRZESKOWIAK MARJORIE,LAIFA YONI
Revision date : May 18, 2026

Objectives

At the end of this module, students should understand and be able to explain the main concepts related to:

- The electrical characteristics of diodes and transistors.
- The concept of operating point and linearization of characteristics around this point.
- The different classes of transistor-based amplification.
- The principles of LF and HF modeling for the design of advanced electronic functions.

Students will be able to:

- Implement appropriate biasing circuits according to the intended function.
- Derive equivalent circuits for low- or high-frequency operation.
- Recognize and implement fundamental circuits such as current mirrors and differential stages.
- Use electronic circuit simulation software and understand the limitations of the models employed.
- Design amplification and filtering chains for integration.
- Design circuits for the use of different types of sensors.
- Design power stages while considering power dissipation constraints.

Content

Study of the electrical characteristics of diodes and transistors (MOSFET, JFET, and bipolar types). The course covers biasing circuits and their corresponding classes, models of active components, and equivalent low-frequency (LF) and high-frequency (HF) schematics. It includes the design and analysis of functional circuits such as current regulators, current mirrors, and differential structures. The course also explores amplification and filtering chains with impedance matching and integrates sensor and signal-processing models within circuit simulation software.

Prerequisites

Fundamentals of electricity: Kirchhoff's laws, Thévenin, Norton, and superposition theorems; basic concepts of voltage and current sources; Fourier and Laplace transforms.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Semiconductors

Module details

I3MASC10-exc

4 ECTS   EN/FR
22.5 h   12.5 h   0.0 h   7.0 h
BOULIER THOMAS,GRZESKOWIAK MARJORIE,HEBRAS XAVIER,LAHANA YONI
Revision date : May 18, 2026

Objectives

This course introduces the physics of materials and components involved in technologies associated with the transmission, processing, and storage of information. It focuses on timeless fundamental principles in a rapidly developing field. By the end of this course, the student will be able to:

- Clearly describe and express the various physical principles involved in the processing, transmission, and storage of information.
- Comprehend the overall technologies based on semiconductors, from the atomic level to the application of components.
- Enhance their understanding of the physical properties of semiconductors, particularly the PN junction, which serves as the basic technological building block present in all modern components, whether discrete (such as diodes or bipolar transistors) or integrated (such as field-effect transistors).

Content

This course aims to provide students with the fundamental knowledge and practical skills necessary to understand and apply the principles of materials physics and components in information technologies.

- Part 1: Fundamentals of Materials Physics
  1. Presentation of quantum mechanics concepts underlying the electronic structures of the atom.
  2. Introduction to chemical bonding and the organization of matter.
  3. Study of crystalline structures.
  4. Understanding band diagrams to distinguish insulators, semiconductors, and metals, as well as the concept of density of states within a material.
  5. Review of elementary statistical physics to explain how to modify charge densities in a semiconductor material through doping.
- Part 2: Doping and PN Junction
  1. Understanding different types of semiconductor doping.
  2. Construction of a simple component like the PN junction, introducing band diagrams of these structures at thermodynamic equilibrium and non-equilibrium (under bias or illumination).
  3. Study of charge carrier diffusion laws to establish the laws governing current levels observed in PN junctions under bias.
- Part 3: Bipolar Transistors
  1. Understanding the operation of the PN junction and its integration within a bipolar transistor.
  2. Explanation of various physical properties of bipolar transistors, particularly their role as amplifiers.
  3. Highlighting the links between the electronic properties of components and physical phenomena, such as the current gain parameters Alpha and Beta of bipolar transistors.
- Part 4: CMOS Technologies
  1. Emphasizing the physical links between materials and the electronic operation of MOS capacitors, MOS transistors, and their integration through CMOS technologies.
- Part 5: Practical Work
  1. 7 hours of practical work in a cleanroom. Students will construct and electrically characterize photovoltaic cells (Click here for details). These practical sessions are an excellent opportunity to enhance technical skills and understand the practical applications of the theoretical concepts covered in the course.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL
DES SCIENCES
APPLIQUÉES
TOULOUSE

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR
5.0 h 21.25 h 2.5 h 0.0 h
BOULIER THOMAS,CARREY JULIAN,CHAZEL FLORENT,ENJALBERT BRICE,GUERMOUCHE NAWAL,LABORIE STEPHANIE,LAHANA YONI,MOREL SANDRINE,RUMPALA JOHANNE,SANCHEZ DAVID,VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Modeling and analysis of cont. linear sys.

Module details

I3MAAU10-exc

2 ECTS EN/FR
13.75 h 8.75 h 0.0 h 0.0 h
BOULIER THOMAS,GRZESKOWIAK MARJORIE,LAHANA YONI
Revision date : May 18, 2026

Objectives

This module focuses on the representation and analysis of continuous linear dynamic systems by means of the state-space formalism. Students will learn how to modify the representation basis, analyze the stability, and calculate the time response of a linear time-invariant system.

Content

In this course, students will be introduced to the notion of state-space representation of dynamic systems. The relationship with other models (transfer function, differential equations) and the generation of a model by linearization will be discussed in detail. The content of the course covers several representation bases (modal forms, control and observation) and the analysis of linear time-invariant systems in terms of time response and stability properties.

Prerequisites

I2MAAU11 Feedback Systems

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Introduction to networks

Module details

I3MAIR20-exc

2 ECTS FR
12.5 h 6.25 h 2.75 h 0.0 h
BOULIER THOMAS,CHASSOT CHRISTOPHE,LAHANA YONI,MAHOUT VINCENT
Revision date : May 18, 2026

Objectives

This course focuses on computer networks (local area networks, wide area networks and the Internet) from the perspective of their main concepts: connectivity, addressing, resource sharing + loss models, switching / routing + desequencing models, quality of service, architecture / service / protocol, basic protocol mechanisms.

Content

The course introduction provides a general overview of network applications and their communication needs, followed by an overview of networks and their interconnection within the Internet. The central part of the course presents and illustrates the fundamental concepts associated with network design: connectivity, resource sharing, switching, quality of service and architecture (including the concepts of service and protocol). These concepts are illustrated and explored in depth within the framework of standardized local area networks and their connection to the TCP/IP Internet. A case study on Ethernet local area networks connected to the Internet (networks used in the practical work rooms) punctuates the course. The concepts are illustrated in tutorials and practical work.

Prerequisites

C Language, Operating System, Algorithms and Programming Courses

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

C language and networks

Module details

I3MACR20-exc

1 ECTS FR

2.5 h 2.5 h 13.75 h 0.0 h

BOULIER THOMAS,CHASSOT CHRISTOPHE,LAHANA YONI,MAHOUT VINCENT

Revision date : May 18, 2026

Objectives

At the end of this module:

- The student should have understood and be able to

explain the fundamental concepts associated with programming distributed applications on the Internet via the Socket API

- The student should be able to use the Socket API to

develop (in C language) a distributed client/server application on the Internet

Content

The course is structured in two parts : The first part presents the Socket Programming Interface (Socket API), the basic technology for coding a distributed application (particularly on) the Internet. The second part consists of a programming project for a distributed client/server application on the Internet.

Prerequisites

Prerequisites include :

- Introduction to Operating Systems
- Introduction to Computer Networks (3rd year IMACS)
- C Language (3rd year IMACS)

Assessment

The objectives are assessed based on a project report and an assessment of student engagement during the practical sessions. An individual written exam may complete the validation of theoretical skills.

Back to menu

Databases

Module details

I3MABD20-exc

1 ECTS FR
3.75 h 8.75 h 0.0 h 0.0 h
BOULIER THOMAS,GUERMOUCHE NAWAL,LAHANA YONI,MAHOUT VINCENT
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The different data models, their advantages and limits
- What is DBMS (Database management system)
- The different concepts of the relational model
- Data integrity constraints
- Relational algebra and SQL languages

Content

The aim of this course is to study relational databases. The fundamental concepts of the relational model are studied. The emphasis is then placed on relational algebra and the SQL language for manipulating and querying databases.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Assembly language

Module details

I3MALA20-exc

3 ECTS FR

10.0 h 5.0 h 16.5 h 0.0 h

BOULIER THOMAS,LAHANA YONI,MAHOUT VINCENT

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- Von Neuman model
- Computation, storage, input-output circuits, control unit, interrupt mechanism, instruction-level pipeline execution
- Instruction set and assembly language programming
- Elements of a development chain : compiler, assembler, linker, loader, debugger

The student should be able to:

- Understand the principles of instruction set creation
- Develop an assembly language program on a microcontroller
- Use cross-development tools

Content

Definition and role of assembly language among programming tools. Generic assembly language notions: data operations (arithmetic, logic), memory access (addressing modes), execution control (conditional processing). Application to ARM architecture. Subroutine calls and returns, role of the stack, interrupts, special case of ARM architecture. Conventions for calling functions, passing arguments, return values, context preservation. Development of mixed C-language and ARM-language applications

Prerequisites

1st year Algorithms and Programming.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Hardware architecture

Module details

I3MAAM20-exc

1 ECTS FR
6.25 h 0.0 h 11.0 h 0.0 h
BOULIER THOMAS,LAHANA YONI,MAHOUT VINCENT,MIGLIORE VINCENT
Revision date : May 18, 2026

Objectives

At the end of this module, students will be able to program in assembly language, identify and correct software problems (resource under-utilization, bugs) in C and assembly language, and identify potential hardware vulnerabilities.

Content

The content of this course includes :

- Description and programming in Arm and x86 assembly languages.
- Description and use of a standardized C compilation chain via scripts, as well as the use of associated debugging tools.
- Description and analysis of the main aspects of the software's lower layers (function calls, data storage, associated security aspects) at C and assembly language level.
- Description and optimization of the use of hardware resources, particularly memory.
- Description and analysis of hardware vulnerabilities.

Prerequisites

Prerequisites include :

- Knowledge of computer architecture and internal functional description (processor, memory, caches).
- C language.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Random signals

Module details

I3MASA20-exc

1 ECTS EN/FR
6.25 h 5.0 h 2.75 h 0.0 h
BOYER ALEXANDRE
Revision date : May 18, 2026

Objectives

Introduce the main concepts allowing a characterization of random signals. In particular, the main properties : stationarity, ergodicity, needed for a spectral characterization useful in electronics and automatic control, are specifically developed. The linear filtering of random signals concludes the course

Content

The content of this course includes :

- Introduction : deterministic signals and spectral chraracterization
- Probability theory and random signal
- Stochastic processes and random signals : first and second order characteristics, stationarity, ergodicity, discrete-time random signals
- Spectral analysis: Wiener-Kintchine Theorem
- Linear filtering

Prerequisites

Probability theory, random variable, Fourier Series, Fourier Transform, Linear invariant systems (Transfer function)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Electronics project

Module details

I3MABE20-exc

3 ECTS EN/FR
0.0 h 0.0 h 35.75 h 0.0 h
BOULIER THOMAS,DRAGOMIRESCU DANIELA,LAHANA YONI,ROCACHER THIERRY
Revision date : May 18, 2026

Objectives

The aim of this project is to design and build an audio amplifier using discrete transistors, with a power of around 20W, on a test plate. The power stages are studied (push-pull Darlington,etc...) as well as all the classic architecture of an operational amplifier (differential, active load...). The problem of output dynamics is clearly defined (blocking/saturation limit). The technology used is the bipolar transistor.

Content

The content of this course includes :

- LTspice training (OP, AC, DC, Step, Sweep)
- study of differential stage
- common emitter stage study, active load, current sources
- output stage design
- transistor heating, heat sink sizing
- optional routing, PCB construction of the Hifi amplifier studied and designed.

Prerequisites

Prerequisites include :

- essential: good understanding of basic electical laws
- strongly recommended prerequisites: bipolar transistor, polarization, dynamic small signal circuits

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Telecommunication systems

Module details

I3MAST20-exc

2 ECTS EN/FR
8.75 h 6.25 h 11.0 h 0.0 h
BOULIER THOMAS,DRAGOMIRESCU DANIELA,LAHANA YONI
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain the operating principles of telecommunication systems. Students will be able to design the architecture of a telecommunication system (choice of modulation, channel access, etc.).

Content

- Telecommunication systems: data transfer rates, eye diagrams, transmission lines, baseband coding, analog and digital modulation, constellation diagrams, frames, multiplexing, channel access (FDMA, TDMA, CDMA), spread spectrum.
- Introduction to space communications.
- Tutorials will help students gain a deeper understanding of the concepts seen in class by focusing on well-known applications of telecommunication systems (USB, Bluetooth, FM radio, etc.).
- Lab classes will address the design of analog and digital modulations.

Prerequisites

Signal Processing Analog Electronics Digital Electronics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Control of continuous linear systems

Module details

I3MASC20-exc

4 ECTS EN/FR
13.75 h 8.75 h 22.0 h 0.0 h
BOULIER THOMAS,DRAGOMIRESCU DANIELA,LAHANA YONI,TOLEDO ZUCCO JESUS PABLO
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- The main methods for synthesizing state-space control laws for linear time-invariant systems
- The basic principles of observer synthesis for linear time-invariant systems
- How to incorporate integral actions to the state feedback control

Students will be able to:

- Define the major characteristics of the control law from the desired specifications
- Design control laws using pole placement

Content

Control in state space representation: specifications of performances, observability-controllability, state feedback control by pole placement, observers design, state feedback with integral action.

Prerequisites

Linear algebra

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Modeling and control of discrete-event sys.

Module details

I3MASD20-exc

1 ECTS EN/FR
6.25 h 3.75 h 8.25 h 0.0 h
BOULIER THOMAS,CHANTHERY ELODIE,DRAGOMIRESCU DANIELA,LAHANA YONI
Revision date : May 18, 2026

Objectives

Upon completing this module, students will have gained an understanding of and be able to explain:

- The basic principles of modeling discrete-event systems using various tools (finite-state machines, Petri nets, statecharts)
- Different techniques for controlling discrete-event systems (PLC, FPGA, real-time target)

Students will be able to:

- Model and implement the control of a discrete-event system

Content

Modeling and control of discrete-event systems: modeling tools (finite-state machines, Petri nets, statecharts) and related implementation techniques (PLC, FPGA, real-time target).

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS EN/FR

0.5 h 2.75 h 0.0 h 0.0 h

BOULIER THOMAS,CHAZEL FLORENT,DE GOURNAY FREDERIC,GUERMOUCHE NAWAL,GUIEYSSE DAVID,GUIGUI CHRISTELLE,HANTCHERLI MURIEL,LABORIE STEPHANIE,LAHANA YONI,MAHOUT VINCENT,MOREL SANDRINE,PLANTEC JEAN-YVES

Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Analog electronic system architecture

Module details

I4AESE31-exc

5 ECTS FR
18.75 h 12.5 h 19.25 h 0.0 h
FOURNIOLS JEAN-YVES
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Dimension and design of analog electronic functions of information processing (filtering, amplification, automatic gain control, voltage controlled oscillators, modulators / demodulators AM and FM)
- Optimize the signal to noise ratio in each subset of an embedded system
- Modeling architectures for robust usage constraints (consumption, temperature to dissipate), the thermal variations of the environment and dispersions characteristics of components

Content

Lecture is divided in four main parts :

1. Active filtering and modeling of noise sources:
   - Identify sources of noise and maximize signal to noise ratio on each floor of a chain of analog signal processing.
   - Build filters from the specification to the electronic choice with the constraints and drift components.
   - Transcribe a transfer function of biquadratic filter functions and the decline in active analog filter architecture based on feedback montages (Sallen Key, Rauch, UAF, ...) or synthesis of switched capacitor filter.
   - Optimize the order of a filter based on criteria of cost, integration, stability and sensitivity.
2. Architectures for analog information transmission :
   - In many electronic systems, such as telecommunication or measurement systems, oscillations play an essential role in the information processing.
   - Each electronic system poses different requirements on these oscillations, depending on the type and performance level of that specific system. It is the designer's challenge to find the specifications for the desired oscillation and to implement an electronic circuit meeting these specifications.
   - As the desired oscillations have to fulfill many requirements, the design process can become very complex. To find an optimal solution, the designer requires a design methodology that is preferably completely top-down oriented.
   - To achieve such a methodology, it must be assured that each property of the system can be optimized independently of all other properties.
3. Oscillators and Oscillator Systems:
   - Classification, Analysis and Synthesis takes a systematic approach to the design of high-performance filters and oscillator systems.
   - A fundamental classification of oscillators, based on their internal timing references, forms the basis of this approach.
4. Establish a system prototype design of programmable analog circuits such FPAA.

Prerequisites

Under construction

Assessment

The skills are validated by combining written exam(s) with a practical project which can be orally, in writing or by rendering a report

Back to menu

Device modeling and digital circuits architectures (reconfigurable computing)

Module details

I4AESE41-exc

4 ECTS EN/FR
20.0 h 6.25 h 24.75 h 0.0 h
DRAGOMIRESCU DANIELA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the electronic device and digital electronic systems modelling
- the issue of the integration of electronic circuits
- the design and performance optimisation of digital architectures especially in frequency and power consumption. Ultra low power architectures will be studied for sustainable development.
- the technologies for green computing
- reconfigurable computing using FPGAs
- digital architectures dedicated to embedded Artificial Intelligence (AI)

The student will be able to understand the models of main electronics active devices and digital complex architectures and their optimisation for sustainable development. The student will be prepared for the future technological breakout in their professional life.

Content

The following concepts will be taught in detail during courses and laboratory work:

- the electronic phenomena in semiconductor devices and circuits
- the structure of MOS, MOS,CMOS and logical gates
- the modeling of transistors (MOS, bipolaire) and their environment sensitive parameters
- Power switches MOS and IGBT
- the CMOS implementation of logical functions. The high-speed, low power and gate clocking issues for CMOS gates will be presented
- the VHDL language and model for digital systems
- the synthesis and FPGA implementation of digital architectures
- the performance optimization, especially in power consumption and frequency for digital architectures. Ultra-low power optimization techniques will be detailed to achieve digital circuits for sustainable development.
- the technologies for green computing
- the importance of reconfigurable computing for a high number of applications nowadays (ex: mobile networks)
- the digital architectures dedicated to embedded AI (Artificial Intelligence)

Prerequisites

Prerequisites for this course include :

- Aanalog and Digital electronics
- Computer engineering
- Computer architectures

Assessment

A written exam will be proposed to the students on the devices modelling and on the digital architectures. The lab work will also be evaluated.

Back to menu

Embedded Computing -µcontroller

Module details

I4AEIM11-exc
3 ECTS FR
1.25 h 0.0 h 30.25 h 0.0 h
MAHOUT VINCENT
Revision date : May 18, 2026

Back to menu

Objectives

At the end of this module, the student will have understood and be able to explain:

- Programming specificities of the peripheral units for microcontroller.
- The different peripherals of a microcontroller and their behaviour.
- How to take into account hardware constraints for the design of embedded system.

The student will be able to:

- To select an architecture processor adapted to the software application and to the process configuration.
- To conceive and test the techniques of the programming by hardware interruption.
- To use debug tools o and test in the context of cross- development.
- To find information into datasheet

Content

The functions and the programming of the STM32 (based on an ARM/CortexM3 core) is studied essentially in lab. Half of time is devoted to a project. This project consists with the software development of an embedded system embarked

Prerequisites

Under construction

Assessment

The assessement for this course includes:

- 1 written exam
- 1 evaluation of the practical work and realization of a project by team

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Machine Learning

Module details

I4AEML11-exc

1 ECTS FR

7.5 h 0.0 h 8.25 h 0.0 h

LELEUX PHILIPPE

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the characteristics of supervised learning problems (data sets, classification / regression, learning process, evaluation of learning models)
- the main basic methods and algorithms to deal with these problems (interpretable models and neural networks)

The student will be able to:

- set up a learning process
- use the algorithms implemented in existing libraries
- adapt and develop his/her own algorithms
- present and explain the results of learning algorithms
- program in Python

Content

The course is divided in three parts:

- Introduction to supervised learning (learning process and assessment) - 2 lectures
- Learning using interpretable models - 2 lectures
- Learning using neural networks - 2 lectures

3 practical sessions allow to implement the two families of learning models for classification or regression tasks. The labs are in Python with the scikit-learn library.

Prerequisites

Prerequisites for this course include :

- Algorithmics
- Optimization
- Statistics
- Python

Assessment

The evaluation is based on a knowledge test (MCQ) and a report on the practical sessions.

Back to menu

Analysis of complex systems

Module details

I4AESY11-exc

4 ECTS FR
27.5 h 17.5 h 5.5 h 0.0 h
ARIBA YASSINE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Principles, difficulties and limits of the modelling of systems with multiple inputs and multiple outputs.
- Design and implementation of control of systems with multiple inputs and multiple outputs.
- Main possible and observable behaviors which can occur in the nonlinear systems (equilibrium states, limit cycles, complex behaviors) and their evolution by variation of the parameters.
- Basis of the theory of Lyapunov

The student will be able to:

- To apprehend the implementation of the control of a process with multiple inputs and multiple outputs.
- To begin the analysis of a nonlinear system by various techniques (qualitative, geometrical, and simulations)
- To lean on numerical analysis (Matlab©) to establish, confirm, validate, simulate and implement the theoretical results discussed during the courses.

Content

This course is composed of two distinct and autonomous parts:

- Multivariable systems
- Nonlinear systems analysis

Prerequisites

The prerequisites for this course include:

- Closed-loop systems
- Modeling and analysis of linear systems
- Control of systems

Assessment

The written exam is based on some exercises allow verifying that the main concepts introduced in the lectures are fully understood.

Back to menu

Software engineering

Module details

I4AEIL11-exc

4 ECTS FR
12.5 h 12.5 h 22.0 h 0.0 h
MONTEIL THIERRY
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

1. Object-Oriented Programming part:
   - The principles of object-oriented programming: method call, classes.
   - The application of those notions for programming connected objects
2. Networks part:
   - The basic concepts and techniques allowing interconnecting local area networks in the Internet: repeater, bridge, router
   - the basic concepts and techniques allowing interconnecting LAN in the Internet : subnetting, CIDR, VLAN, VPN, applicative proxy, NAT
   - the main protocols of the TCP/IP Internet architecture : UDP, TCP, IP, ARP/proxy ARP, ICMP, DHCP, RIP, OSPF, BGP
3. Real-Time part:
   - Designing real time applications.
   - Understand and manipulate a real time kernel.

The student will be able to:

1. Oject-Oriented Programming part:
   - Develop java applications, using a modular object-oriented style.
2. Networks part:
   - Do architecture choices allowing to take into account requirements and constraints associated to a LAN interconnection.
   - Do basic or complex addressing and routing schemas.
   - Set up (administrate) Ethernet and IP networks in the basic and advanced interconnection contexts considered in the course.
3. Real-Time part
   - Set up a design methodology to respond to a specification.
   - Design software architectures for real time applications.
   - Ajust the tasks parameters to reach the expected performances.
4. Simulate and analyze real-time applications performance

Content

The content of this course includes:

1. Object-otiented programming part:
   - Classes, inheritance, method call, exceptions, data structures, static attributes, operators overloaded.
2. Networks part:
   - Network part: In a first part, the course presents the main local area networks interconnection technologies in the Internet (repeater, bridge, router), and details the routing in the Internet (algorithm and protocols RIP, OSPF, BGP) and its evolutions (subnetting and classless routing - CIDR).
   - The ARP, proxy ARP, ICMP and DHCP protocols are also introduced. In a second part, the course presents the concepts and techniques associated with the management of virtual LAN (VLAN) and virtual private networks (VPN), and the management of private IP addresses in the Internet (applicative proxy, NAT). The two major Transport protocols of the Internet (TCP, UDP) are presented in a third part. Finally, the Internet evolutions towards the management of multicast, QoS and mobility requirements are finally introduced and the basic multicast management is detailed. Practical manipulation (labs) of Ethernet and IP networks administration on Linux PC and CISCO equipments are associated to the course.

3. Reall-Time part:
   - Specification and design of real time systems (AADL language), introduction to basic vx-works routines,
   - programming and testing of en application.

Prerequisites

The prerequisites for this course include:

- Software Engineering,
- introduction to networking,
- C programming

Assessment

Written theoretical exam and programming exam

Back to menu

Quality, safety and environment

Module details

I4AEQSE11-exc

1 ECTS FR
10.0 h 0.0 h 8.25 h 0.0 h
BOYER ALEXANDRE
Revision date : May 18, 2026

Objectives

Many companies and organizations have a QSE (Quality, Safety, Environment) department or division. From a professional point of view, a QSE manager ensures product quality to satisfy customers, and the safety of installations and working conditions for employees on the production site, usually a company; he or she also makes sure that they work in a certain level of comfort for greater efficiency. At the same time, they work to reduce the impact of the site's activity on the environment, in waste management and sorting for example. From an engineer's point of view, the stakes of QSE are high, in terms of working methods and responsibilities, including criminal liability. Understanding these multifaceted issues is at the heart of this course, which aims to help students position themselves as professionals in all the areas covered.

Content

QSE issues are addressed through a range of topics specific to the Electrical and Computer Engineering department's specialties, such as:

- Electrical safety (risks, standards, protection)
- Risks associated with electromagnetic interference, obligations for manufacturers of electronic equipment and the basis for compliance,
- System hardware and software security

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Digital signal acquisition architectures and computed controlled systems

Module details

I4AEAU11-exc

3 ECTS FR
8.75 h 8.75 h 19.25 h 0.0 h
FOURNIOLS JEAN-YVES
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

1. Object-Oriented Programming part:
   - The principles of object-oriented programming: method call, classes.
   - The application of those notions for programming connected objects
2. Networks part:
   - The basic concepts and techniques allowing interconnecting local area networks in the Internet: repeater, bridge, router
   - the basic concepts and techniques allowing interconnecting LAN in the Internet : subnetting, CIDR, VLAN, VPN, applicative proxy, NAT
   - the main protocols of the TCP/IP Internet architecture : UDP, TCP, IP, ARP/proxy ARP, ICMP, DHCP, RIP, OSPF, BGP
3. Real-Time part:
   - Designing real time applications.
   - Understand and manipulate a real time kernel.

The student will be able to:

1. Oject-Oriented Programming part:
   - Develop java applications, using a modular object-oriented style.
2. Networks part:
   - Do architecture choices allowing to take into account requirements and constraints associated to a LAN interconnection.
   - Do basic or complex addressing and routing schemas.
   - Set up (administrate) Ethernet and IP networks in the basic and advanced interconnection contexts considered in the course.
3. Real-Time part
   - Set up a design methodology to respond to a specification.
   - Design software architectures for real time applications.
   - Ajust the tasks parameters to reach the expected performances.
4. Simulate and analyze real-time applications performance

Content

Content of this course includes :

- Object-otiented programming part : Classes, inheritance, method call, exceptions, data structures, static attributes, operators overloaded.
- Networks part : Network part: In a first part, the course presents the main local area networks interconnection technologies in the Internet (repeater, bridge, router), and details the routing in the Internet (algorithm and protocols RIP, OSPF, BGP) and its evolutions (subnetting and classless routing - CIDR).

The ARP, proxy ARP, ICMP and DHCP protocols are also introduced. In a second part, the course presents the concepts and techniques associated with the management of virtual LAN (VLAN) and virtual private networks (VPN), and the management of private IP addresses in the Internet (applicative proxy, NAT). The two major Transport protocols of the Internet (TCP, UDP) are presented in a third part. Finally, the Internet evolutions towards the management of multicast, QoS and mobility requirements are finally introduced and the basic multicast management is detailed. Practical manipulation (labs) of Ethernet and IP networks administration on Linux PC and CISCO equipments are associated to the course.

- Real-Time part : Specification and design of real time systems (AADL language), introduction to basic vxworks routines,

programming and testing of en application.

Prerequisites

Prerequisites for this course include :

- Software Engineering
- introduction to networking
- C programming

Assessment

Written theoretical exam and programming exam Written formalization of the solutions and practical implementation

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Energy management for embedded systems

Module details

I4AESE51-exc

3 ECTS FR
1.25 h 20.0 h 13.75 h 0.0 h
AIME MARTIN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The characteristics of the energy sources that can be used on embedded systems,
- The characteristics of quantities in electrical distribution networks
- Power converter architectures,
- The modeling of an electric motor/generator based on its coupled electrical and mechanical values.
- The operation of a transformer and its model.
- The structures and main characteristics of single-phase and three-phase AC-DC converters.
- The main chopper structures, their properties, reversibilities and their control.
- The principle of torque and/or speed regulation of a DC machine using a chopper.

The student should be able to:

- Analyze the energy needs of an on-board system and propose and size a solution,
- Use coupled electrical and mechanical equations to model an electro-mechanical system
- Analyze a mechanical system and identify the drive requirements, the type of converter that must be associated with the machine.
- Dimension the elements of an electrical energy conversion chain which allows to drive a given actuator.

Content

the content of this course includes :

- Ragone diagram, energy and power densities of various energy sources.
- Photovoltaic panels,
- Principle of the MPPT circuit,
- Model of a DC electric motor/generator; relationships between electrical and mechanical values; torque-speed characteristics; transient electrical and mechanical equations; block diagram of the machine.
- Single phase transformer; operating equations and models; equivalent diagrams.
- Single-phase and three-phase diode rectifiers; ripple rate; diode sizing; power factor.
- Step-down, step-up, current-reversible and H-bridge choppers; continuous and discontinuous conduction mode; PWM command; power components for hard switching, conduction and switching loss calculations

Prerequisites

General knowledge of electricity, alternating current, electrical circuits, analog and digital electronics as well as mathematical tools (Fourier and Laplace transforms) and the basics of automatic control (transfer functions and block diagrams)

Assessment

A final summary and certification exam lasting at least 2 hours gives rise to a grade.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Networks and real time

Module details

I4AERT21-exc

4 ECTS FR
22.5 h 3.75 h 19.25 h 0.0 h
CHASSOT CHRISTOPHE
Revision date : May 18, 2026

Objectives

This teaching module consists of two parts:

1. The real-time systems section** introduces real-time systems, key concepts, applications, and constraints, and teaches how to program these systems using real-time operating system services. At the end of the course, students should be able to:
   - Establish a design methodology to meet specifications with timing constraints
   - Design software architectures for real-time applications
   - Properly size task parameters as well as synchronization and communication mechanisms
   - Program the system using real-time operating system services and an object-oriented language
   - Develop, simulate, and analyze application performance
2. The networking section** aims to provide knowledge and practical skills related to:
   - Basic concepts and techniques for interconnecting local networks within the Internet: repeater, bridge, router
   - Advanced concepts and techniques for interconnecting LANs within the Internet: routing, subnetting, VLAN, VPN, application proxy, NAT, etc.
   - The main protocols of the TCP/IP Internet architecture: UDP, TCP, IP, ARP, ICMP, DHCP, RIP, etc.

   At the end of the course, students should be able to:

   - Make appropriate hardware architecture choices to meet the needs and constraints of local network interconnection
   - Design simple addressing and routing schemes
   - Implement (administer) Ethernet and IP networks in the basic interconnection contexts covered in the course

Content

The content of this course includes:

1. Real-time systems part:
   - The module covers the mechanisms of real-time kernels and the design of applications running on these operating systems.
2. Networking part:
   - The course first presents the classical technologies for interconnecting local networks within the Internet (repeater, bridge, router), and provides a detailed study of Internet routing (algorithms implemented at the IP level and protocols such as RIP, OSPF, BGP) and its evolution (subnetting and classless routing – CIDR). The ARP, proxy ARP, ICMP, and DHCP protocols are also introduced.
   - The course then presents the concepts and techniques related to the management of virtual local area networks (VLAN) and virtual private networks (VPN), as well as the management of private IP addresses on the Internet (application proxy, NAT).
   - The two main Internet transport protocols (TCP, UDP) are covered in detail in a third part.
   - Finally, developments in the Internet to support multicast, quality of service (QoS), and mobility are introduced, and basic multicast management is explained.
   - Practical lab sessions on administering Ethernet and IP networks using Linux PCs and Cisco equipment complement the course.
   - The course is assessed through a written exam.

Prerequisites

The prerequisites for this course include:

1. Algorithms :
   - C programming (beginner level)
2. Networking:

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

- Knowledge of basic networking concepts
- Basic skills in distributed programming in networks (socket API)

Assessment

Under construction

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Discrete systems optimisation

Module details

I4AESY21-exc

4 ECTS FR

26.25 h 18.75 h 2.75 h 0.0 h

CHANTHERY ELODIE

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understoodand be able to explain (main concepts):

- different approaches to analyse, evaluate the performance of discrete event systems through different models (deterministic or stochastic, graphs) and to optimise them (linear programming)

The student will be able to:

- to analyse, model and solve an optimization problem ofdiscrete systems by a linear programming or a graph, byapplying relevant algorithms (simplex, usual graphs andnetworks algorithms, combinatorial optimization)
- to model and to characterize: stationary Makovian processes with discrete state space (chains) and continuous or discrete time, queuing systems, to analyse their transient and stationary behaviours, to evaluate their performances
- to model a discrete event systems by Petri nets and to analyse the properties by enumerative and structural approaches.

Content

Linear programming basic concepts :

- Graph modelling and algorithms for paths search, trees and maximal flows.
- Branch and bounds methods.
- Application areas: allocation, transportation, production planning and scheduling.
- Markov chains with continuous and discrete time.
- Basic queuing systems.
- Performance evaluation.
- Applications: computer and industrial systems.
- Basic concepts of Petri Nets
- Analysis by marking enumeration (marking graph and coverability graph)
- Structural analysis (Place and transition invariants)
- Petri nets composition

Prerequisites

Prerequisites for this course include :

- Linear algebra
- Probabilities
- Dynamic systems (state concept)
- Basic elements in logic systems and Petri nets.

Assessment

Written examinations Guided exercises help students in assimilating concepts and force them to model concrete problems.

Back to menu

Research project

Module details

I4AEPJ11-exc

3 ECTS   EN/FR
0.0 h   5.0 h   0.0 h   22.0 h
CHANTHERY ELODIE
Revision date : May 18, 2026

Objectives

These projects are backed up by training in documentary research (FRD) to help develop a state of the art in the field. A project management course completes the training. At the end of this module, students will have had a practical introduction to the following activities:

- carry out a bibliographical search relevant to a given subject, in compliance with IEEE presentation standards
- write a state-of-the-art section of a scientific article
- refine the forecast scope of intervention for the project realization phase.
- apply project management and collaborative work techniques in project mode.
- write a scientific article and prepare a project presentation in English.

Content

The work to be carried out comprises two parts:

- a bibliographical study on a research topic relevant to the project. This study leads to the writing of the state-of-the-art part of a scientific article (IEEE article standard).
- a technical phase lasting a whole semester. This phase leads to the writing of the final part of the scientific article, and a presentation in English.

Prerequisites

Under construction

Assessment

Assesseement merges several forms of evaluation: written and oral synthesis and demonstration of the work performed.
Deliverables :

- a state of the art note (with IEEE bibliography)
- a project report

Oral project defense with a eventually a demonstrator show.

Back to menu

Advanced control

Module details

I4AECA21-exc

5 ECTS FR
25.0 h 15.0 h 19.25 h 0.0 h
ARIBA YASSINE
Revision date : May 18, 2026

Objectives

At the end of this module, students will be able to :

- model and analyze a discrete or sampled linear dynamic system, represented by recursive equations or a state-space form or a Z transfer function
- switch from one representation to another
- analyze its stability
- calculate the sampled system of a continuous system
- implement a Z transfer function controller on a digital computer
- synthesize an RST controller
- synthesize an LQ optimal control
- calculate the optimal solution to an optimization problem

Content

This course is divided into three parts:

- digital control, which focuses on the control of dynamic systems for implementation on digital computers. We study the modeling and analysis of discrete linear systems, the discretization of a continuous system by sampling, and the synthesis of control laws by state-space feedback or RST from Z transfer functions.
- Optimal control, which focuses on the synthesis of control laws, generally by state feedback, based on the resolution of an optimization problem.
- mini-projects, which aim to put into practice the theoretical methods learned in class and on various models

Prerequisites

The prerequisites for this course include:

- Feedback Systems
- Modeling and Analysis of Linear Systems
- Control of Systems

Assessment

Digital control and optimal control courses are assessed by a final written exam. Mini-projects are assessed both during the session, depending on student involvement and progress, and a report.

Back to menu

Multiphysical modeling

Module details

I4ISME71-MP-exc

7 ECTS FR
21.25 h 50.0 h 9.0 h 0.0 h
BUDINGER MARC
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The main concepts of modelling multiphysics systems with localised/lumped (0D/1D) or distributed (3D) parameters.
- Network approaches in multi-domain modelling (electrical, mechanical, hydraulic, thermal), acausal/causal modelling, bond graphs, and finite element calculation methods in electromagnetics and mechanics.

The student should be able to:

- Set up 0D/1D (electrical, mechanical, hydraulic, thermal), 2D/2D multibody or 3D (electromagnetic, mechanical) models for mechatronic systems.
- Use programming software such as Python and OD/1D platforms such as Dymola/Modelica, AMESim, Simulink and 3D such as FEMM, Patran-Nastran or Abaqus.

Content

The content of this course includes :

- Introduction to the implementation of localised parameter models (0D/1D): network approach to multi-domain modelling (electricity, mechanics, hydraulics, heat), Modelica language, incremental modelling and choice of model level, calculation of parameters using energy approaches.
- Implementation and analysis of localised parameter models (0D/1D): Modelica models, Simulink block diagram models, causal and acausal approaches, bond graph, numerical resolution in Python.
- Modelling electromagnetic actuators: calculating magnetic fields (analytical and FEM) and inductances, calculating forces, modelling mechatronic actuators.
- Modelling of mechanical structures and 3D systems: introduction, multi-body mechanical systems, modelling and finite elements in Python and Abaqus.

Prerequisites

The prerequisites for this course include:

- Kirchhoff's laws and electrokinetics
- concept of work/energy and power
- concept of pressure in fluid hydrostatics
- conduction and convection in heat transfer.

Assessment

Assessment takes the form of written tests, project reports and oral presentations.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Architectures of power transmission systems

Module details

I4ISME71-EI-exc

4 ECTS FR
12.5 h 20.0 h 5.5 h 0.0 h
REYSSET AURELIEN
Revision date : May 18, 2026

Objectives

The module consists of 6 components:

- Power Transmission Architecture
- Mechanism Analysis (AE only)
- CAD and Digital Twin
- Industrial Networks Introduction
- Embedded Computing and Electronics
- Research Documentation Training and Research Project

The objectives are specific to each component:

- Power Transmission Architecture
  - analyze a mechanical/hydraulic/electrical power diagram from an architectural and functional perspective,
  - synthesize a mechanical/hydraulic/electrical power architecture based on functional requirements.
- Mechanism Analysis
  - The student will be able to read part and assembly drawings and analyze the kinematics required for the realization of a mechanism.
- CAD and Digital Twin
  - The student will implement co-simulation between a multi-body CAD model and a 0D/1D multiphysics environment for preliminary validation.
- Industrial Networks Introduction
  - The student will have acquired the fundamental knowledge of industrial networks and protocols.
- Embedded Computing and Electronics
  The student will understand:
  - the fundamental concepts related to a digital transmission chain, from capturing physical information, processing it, to transmitting it over a wireless network,
  - the different parameters to consider when shaping an analog signal,
  - the various parameters to consider when choosing a wireless transmission technology,
  - basic programming techniques for STM32 microcontrollers.

  The student will also be able to:
  - analyze a problem and design a hardware and software architecture for data transmission based on a specification study,
  - choose the appropriate technologies for transmission from basic or more advanced equipment such as XBee or GSM modules,
  - read a datasheet to understand the operation of simple electronic sensors,
  - build the electronic circuit to shape the signal from the sensor.
- Research Documentation Training
  The student will be able to:
  - collect relevant and reliable academic/research documents using various sources,
  - present their bibliographic synthesis in a structured and standardized format.

Content

The content of this course includes:

1. Power Transmission Architecture
   - Teaching focused on power systems with mechanical applications (actuators, drives, propulsion chains, etc.).
   - Divided into three areas: hydraulics, electrical engineering, and mechanics, with an analysis of the technological components that fulfill functions such as: dosing, distribution, transformation, conditioning, and management.

- Practical examples covering mobility/construction sectors (electric vehicles, aerospace, construction machinery).

2. CAD and Digital Twin

   - Work on a CAD model of a recumbent electric bike, where the driving behavior is co-simulated (suspension/propulsion).

3. Embedded Computing and Electronics

   - Sensor analysis (e.g., temperature probe),
   - Building a circuit integrating an operational amplifier,
   - Hands-on experience with STM32 microcontroller family,
   - Hands-on experience with various RF transmission modules,
   - Setting up a complete hardware and software architecture to enable wireless temperature communication.

4. Research Documentation Training

   - Training will be provided on scientific dissemination channels (documentary databases, journals), research methodologies, and associated tools. There will also be an introduction to copyright and the analysis of information quality.

Prerequisites

The prerequisites for this course include:

- Power Transmission Architecture: Basic technological knowledge in mechanics is required, as the leveling course (I4ISEI11-2 Mechanism Analysis) is brief. Self-training materials will be available online.
- Embedded Computing and Electronics: First-year computer science course.

Assessment

Assessement of this course includes:

- Power Transmission Architecture: 1 Multiple Choice Quiz + 1 Written Evaluation
- Mechanism Analysis: No Evaluation
- CAD and Digital Twin: Evaluation based on the TD (Tutorial) sessions
- Introduction to Industrial Networks: No Evaluation
- Embedded Computing and Electronics: Multiple Choice Quiz and Evaluation of Programs and/or Written Evaluation.
- Training in Document Research: Evaluation based on 2 reports: 1 bibliographic, 1 progress report

Back to menu

Automatic control

Module details

I4ISTI71-AU-exc

5 ECTS FR
18.75 h 21.25 h 19.25 h 0.0 h
LE CORRE GWENDOLINE
Revision date : May 18, 2026

Objectives

The objectives of this course are to gain knowledge of digital control techniques and methods:

- be able to identify and model a discrete system and a sampled system
- be able to evaluate the performance criteria of a discrete system and a sampled system
- know how to set up and validate a corrector for a discrete or sampled system

Content

The content of this course includes:

- Discrete-time linear models: input/output models and state-space models.
- Sampling with zero-order blocker.
- Stability criteria.
- Switching from an analogue to a digital control law.
- RST corrector: Regulation and tracking.
- Link with state-space methods.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Architectures of information system chains

Module details

I4ISTI71-EI-exc

2 ECTS FR
2.5 h 6.25 h 16.5 h 0.0 h
ROCHACHER THIERRY
Revision date : May 18, 2026

Objectives

The module consists of 6 components:

- Power Transmission Architecture
- Mechanism Analysis (AE only)
- CAD and Digital Twin
- Industrial Networks Introduction
- Embedded Computing and Electronics
- Research Documentation Training and Research Project

The objectives are specific to each component:

1. Power Transmission Architecture: the student will be able to:
   - analyze a mechanical/hydraulic/electrical power diagram from an architectural and functional perspective,
   - synthesize a mechanical/hydraulic/electrical power architecture based on functional requirements.
2. Mechanism Analysis: the student will be able to read part and assembly drawings and analyze the kinematics required for the realization of a mechanism.
3. CAD and Digital Twin: the student will implement co-simulation between a multi-body CAD model and a 0D/1D multiphysics environment for preliminary validation.
4. Industrial Networks Introduction: the student will have acquired the fundamental knowledge of industrial networks and protocols.
5. Embedded Computing and Electronics: the student will understand:
   - the fundamental concepts related to a digital transmission chain, from capturing physical information, processing it, to transmitting it over a wireless network,
   - the different parameters to consider when shaping an analog signal,
   - the various parameters to consider when choosing a wireless transmission technology,
   - basic programming techniques for STM32 microcontrollers.

   The student will also be able to:

   - analyze a problem and design a hardware and software architecture for data transmission based on a specification study,
   - choose the appropriate technologies for transmission from basic or more advanced equipment such as XBee or GSM modules,
   - read a datasheet to understand the operation of simple electronic sensors,
   - build the electronic circuit to shape the signal from the sensor.
6. Research Documentation Training: the student will be able to:
   - collect relevant and reliable academic/research documents using various sources,
   - present their bibliographic synthesis in a structured and standardized format.

Content

The content for this course includes:

1. Power Transmission Architecture
   - Teaching focused on power systems with mechanical applications (actuators, drives, propulsion chains, etc.).
   - Divided into three areas: hydraulics, electrical engineering, and mechanics, with an analysis of the technological components that fulfill functions such as: dosing, distribution, transformation, conditioning, and management.
   - Practical examples covering mobility/construction sectors (electric vehicles, aerospace, construction machinery).

2. CAD and Digital Twin
    - Work on a CAD model of a recumbent electric bike, where the driving behavior is co-simulated (suspension/propulsion).
3. Embedded Computing and Electronics
    - Sensor analysis (e.g., temperature probe),
    - Building a circuit integrating an operational amplifier,
    - Hands-on experience with STM32 microcontroller family,
    - Hands-on experience with various RF transmission modules,
    - Setting up a complete hardware and software architecture to enable wireless temperature communication.
4. Research Documentation Training
    - Training will be provided on scientific dissemination channels (documentary databases, journals), research methodologies, and associated tools.
    - There will also be an introduction to copyright and the analysis of information quality.

Prerequisites

The prerequisites for this course include:

- Power Transmission Architecture: Basic technological knowledge in mechanics is required, as the leveling course is brief. Self-training materials will be available online.
- Embedded Computing and Electronics: first-year computer science course.

Assessment

Assessement for this course includes:

- Power Transmission Architecture: 1 Multiple Choice Quiz + 1 Written Evaluation
- Mechanism Analysis: No Evaluation
- CAD and Digital Twin: Evaluation based on the TD (Tutorial) sessions
- Introduction to Industrial Networks: No Evaluation
- Embedded Computing and Electronics: Multiple Choice Quiz and Evaluation of Programs and/or Written Evaluation.
- Training in Document Research : Evaluation based on 2 reports: 1 bibliographic, 1 progress report and projection for S8

Back to menu

Modeling tools and systems engineering process

Module details

I4ISTI71-IE-exc

4 ECTS FR
28.75 h 12.5 h 11.0 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

The module consists of 3 components with their specific objectives:

1. Industrial Networks Introduction
   - The student will have acquired the fundamental knowledge of industrial networks and protocols.
2. Embedded Computing and Electronics: The student will understand:
   - the fundamental concepts related to a digital transmission chain, from capturing physical information, processing it, to transmitting it over a wireless network,
   - the different parameters to consider when shaping an analog signal,
   - the various parameters to consider when choosing a wireless transmission technology,
   - basic programming techniques for STM32 microcontrollers.

   The student will also be able to:
   - analyze a problem and design a hardware and software architecture for data transmission based on a specification study,
   - choose the appropriate technologies for transmission from basic or more advanced equipment such as XBee or GSM modules,
   - read a datasheet to understand the operation of simple electronic sensors,
   - build the electronic circuit to shape the signal from the sensor.
3. Research Documentation Training The student will be able to:
   - collect relevant and reliable academic/research documents using various sources,
   - present their bibliographic synthesis in a structured and standardized format.

Content

The content of this course includes:

1. Industrial Networks Introduction
   - General introduction to industrial networks and protocols.
2. Embedded Computing and Electronics
   - Sensor analysis (e.g., temperature probe),
   - Building a circuit integrating an operational amplifier,
   - Hands-on experience with STM32 microcontroller family,
   - Hands-on experience with various RF transmission modules,
   - Setting up a complete hardware and software architecture to enable wireless temperature communication.
3. Research Documentation Training
   - Training will be provided on scientific dissemination channels (documentary databases, journals), research methodologies, and associated tools. There will also be an introduction to copyright and the analysis of information quality.

Prerequisites

Embedded Computing and Electronics and first-year computer science course.

Assessment

Assessement for this course includes:

1. Introduction to Industrial Networks
   - No Evaluation
2. Embedded Computing and Electronics

- Multiple Choice Quiz and Evaluation of Programs and/or Written Evaluation.

3. Training in Document Research

    - Evaluation based on 2 reports: 1 bibliographic, 1 progress report

Back to menu

Remedial course on automatics and electronics*

Module details

I4ISME71-RAE-exc

1 ECTS FR
0.0 h 10.0 h 2.75 h 0.0 h
GUIGNARD LUDOVIC
Revision date : May 18, 2026

Objectives

At the end of the module, the student should know :

- Model a planar system for a static or dynamic study
- Solve a dynamic problem by choosing and applying the right method
- Analyse a kinematic mechanism.

Content

The content of this course includes:

- 3 Newton's laws, types of force, principle of virtual work, potential and kinetic energy.
- Modeling of simple systems, external mechanical actions, resolution method.
- Kinematic connections

Prerequisites

Point mechanics

Assessment

Under construction

Back to menu

Remedial course on mechanical engineering*

Module details

I4ISTI71-RGM-exc

1 ECTS FR
0.0 h 7.5 h 0.0 h 0.0 h
ABDELLATIF SLIM
Revision date : May 18, 2026

Objectives

At the end of this course, students will be able to explain :

- the operating principles of computer networks and their data routing function
- how the Internet is organised and how data is routed on the Internet
- addressing and naming in computer networks and the Internet
- the concepts of protocol, service, communication layer and communication architecture
- the TCP/IP architecture of the Internet and describe the services of the main protocols (IP, TCP, UDP)

Content

The course is a mixture of lectures and tutorials and is structured as follows:

- Chapter 1: Introduction to computer networks and the Internet
- Chapter 2: Addressing in computer networks and the Internet
- Tutorial 1: addressing in computer networks
- Tutorial 2: communication architecture
- chapter3 : Internet Communication Architecture
- Tutorial 3: TCP/IP Architecture of the Internet

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Mechatronics project

Module details

I4ISMM81-PM-exc

4 ECTS EN/FR
2.5 h 7.5 h 23.75 h 12.5 h
REYSSET AURELIEN
Revision date : May 18, 2026

Objectives

The main objective of the domain is to develop the ability to size, prototype, and validate, as well as integrate significant issues such as the strong vibratory-control coupling from the early design phase of a mechatronic system.

Content

The domain of mechanical engineering, mechatronics, and powertrains 2 integrates several components with content covering various aspects:

- Mechatronic project: prototyping, integration, and validation of a mechatronic system in a process combining real-time simulation and test bench.
- Mechatronic design: methodology/tools and models for the sizing of multiphysical power architectures.
- Structural dynamics: vibratory analysis of mechanical structures and associated control.
- Specialization: specific teaching is provided depending on the AE/GM background, complementing structural dynamics with a focus either on control or vibratory analysis.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Mechatronics design

Module details

I4ISMM81-CM-exc

2 ECTS FR

6.25 h 10.0 h 5.5 h 0.0 h

BUDINGER MARC

Revision date : May 18, 2026

Objectives

In a context of rapid technological change and increasingly complex industrial organizations, developing a new system from scratch represents a major challenge. The preliminary design and sizing phase is one of the most crucial stages in the overall product development process, during which the key characteristics and performance of a system are defined for the first time. This early stage is critical, as it lays the foundation for the system's main features and directly influences the final performance, feasibility, and cost of the product.

Content

The content of this course includes:

- Sizing scenarios for a technical system
- Estimation and simulation models for components or assemblies of technological components
- Sizing and optimization procedures
- Implementation of calculations in a digital environment (Python, Excel)

Prerequisites

Prerequisites for this course include:

- Basic knowledge of 0D/1D multiphysics modeling
- Basic knowledge of optimization

Assessment

Under construction

Back to menu

Advanced lectures for mechnaical engineering

Module details

I4ISMM81-AGM-exc

1 ECTS FR
0.0 h 11.25 h 0.0 h 0.0 h
SEGUY SEBASTIEN
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Advanced lecture for automatic and eletronics

Module details

I4ISMM81-AAE-exc

1 ECTS

0.0 h 12.5 h 0.0 h 0.0 h

TONDU BERTRAND

Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain the basic principles of data acquisition using a computer.
Students should be able to:

- Size the different components of a simple data acquisition system
- Use a graphical programming language dedicated to data acquisition and processing (LabVIEW)

Content

Study of the different components making up a data acquisition system (from the sensor to the computer):

- Sensors
- Signal conditioning
- Data acquisition card
- Development of a data acquisition program and a user interface

Prerequisites

Prerequisites for this course include:

- Basic concepts of algorithms
- Fundamentals of electrical circuit theory (electrokinetics)

Assessment

Written report and oral presentation on both projects + practical exam.

Back to menu

Modeling and control of structures

Module details

I4ISMM81-CS-exc

2 ECTS FR
6.25 h 10.0 h 11.0 h 0.0 h
PASSIEUX JEAN-CHARLES
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Instrumentation

Module details

I4ISTI81-CM-exc

2 ECTS   FR
2.5 h   13.75 h   5.5 h   0.0 h
VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain the basic principles of data acquisition using a computer.
Students should be able to:

- Size the different components of a simple data acquisition system
- Use a graphical programming language dedicated to data acquisition and processing (LabVIEW)

Content

Study of the different components that make up a data acquisition system (from the sensor to the computer):

- Sensors
- Signal conditioning
- Data acquisition card
- Development of a data acquisition program and a user interface

Prerequisites

Prerequisites for this course include:

- Basic concepts of algorithms
- Fundamentals of electrical circuit theory (electrokinetics)

Assessment

Written report and oral presentation on both projects + practical exam.

Back to menu

Object oriented programming and real-time

Module details

I4ISTI81-IL-exc

4 ECTS FR
12.5 h 13.75 h 22.0 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

This module consists of two components:

- The part on real-time systems presents real-time systems, key concepts, applications, constraints, and teaches the programming of these systems using the services of real-time operating systems.
- At the end of the object programming part, students will be able to produce C++ code from a UML class diagram with relationships, inheritance and polymorphism.

Content

Real-time section :
The module covers the mechanisms of real-time kernels and the design of applications on these executables. The student should be able to :

- set up a design methodology to meet a specification with time constraints
- Design software architectures for real-time applications
- correctly size the various task parameters and synchronization and communication means
- Program the system using the services of a real-time operating system and an object-oriented language
- Develop, simulate and analyze application performance

Object-oriented programming section:
At the end of the course, students will be able to explain what is (in the object-oriented paradigm).

- A class (attributes, methods, encapsulation)
- An object,
- A relationship between classes (association, composition, aggregation, inheritance),
- The polymorphism property and how to obtain it (overloading, overriding).

Prerequisites

Prerequisites for this course include :

- Algotihmics
- C programming (beginner)

Assessment

Exam and project report

Back to menu

Remedial course on mechanical engineering

Module details

I4ISTI81-RGM-exc

0 ECTS FR

0.0 h 5.0 h 0.0 h 0.0 h

BARON CLAUDE

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Modeling tools

Module details

I4ISTI81-OM-exc

4 ECTS FR
25.0 h 12.5 h 16.5 h 0.0 h
LELEUX PHILIPPE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Model Based System Engineering

Module details

I4ISTI81-AC-exc

3 ECTS FR
2.5 h 6.25 h 27.5 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Electronic architecture for energy

Module details

I5AEEE11-exc
4 ECTS FR
25.0 h 0.0 h 22.0 h 0.0 h
ESCRIBA CHRISTOPHE
Revision date : May 18, 2026

Objectives

The aim of this course unit is to be able to determine, design, and implement the electronic architecture of an embedded system, select components, and operate under energy constraints such as battery limitations, autonomy, and availability of energy sources.
The course therefore covers topics related to the architecture of electrical energy converters, the implementation of charging systems and battery management, and architectures with multiple energy sources (intermittent renewable energy). The measurement of physical quantities (current, voltage, temperature, etc.) is essential in an energy conversion chain or in controlling an electromechanical actuator. The course also addresses different sensor technologies and the associated instrumentation electronics.
By the end of this module, the student should be able to:

- Design the electronic architecture of an embedded system under energy constraints
- Size the electronics of an energy conversion chain
- Choose electrical energy storage solutions according to the associated constraints
- Manage battery charging/discharging and balancing
- Implement an ambient energy harvesting solution to make embedded systems energy-autonomous
- Carry out hardware/software co-design

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Energy autonomy for connected objects

Module details

I5AEAOC11-exc

2 ECTS FR/EN
5.0 h 0.0 h 35.75 h 0.0 h

Revision date : May 18, 2026

Objectives

Low energy consumption is an essential requirement in the design of battery-powered, energy-autonomous applications. IoT nodes are part of this class of applications. To ensure long battery life, they use low-power circuits (e.g., ultra-low-power microcontrollers, radio transceivers that support low-energy protocols, power management circuits). A detailed understanding of the hardware and software specificities of these circuits is required to make the best use of them and optimize energy autonomy. Energy autonomy can also be extended through the use of ambient energy recovery techniques (e.g., photovoltaics, thermogeneration). This module also addresses this topic, focusing on the evaluation of energy resources and the sizing of extraction circuits, with the aim of powering an IoT node.
Expected Competences:

- Understanding existing low-power hardware and software techniques in integrated circuits
- Development of an embedded software reducing the energy consumption of the programable platform
- Implement an ambient energy harvesting solution to design embedded systems energy self-sufficient
- Experimenting and measuring the reduction in energy consumption achieved through the implementation of “low energy” solutions

Content

The content of this course includes:

- Management and recovery of electrical energy
- Low Energy programming for the IOT: the aim of this course is to teach techniques for optimizing and measuring the energy consumption of a programmable platform by adjusting the embedded software. During the practical part, students will implement these different techniques on a hardware target (STM32L476RG microcontroller and nRF24L01 radio transceiver) in order to compare different operating modes (Run, Sleep, Stop0/1/2, Standby, etc.), the influence of voltage scaling, clock gating, oscillators, etc. They will implement wake-up solutions based on the use of the RTC and backup registers
- Energy characterization of an IOT module

Prerequisites

The prerequisites for this course include:

- Embedded Computing, Microcontroller
- Study and Modeling of Active Components

Assessment

The assessment is based on some practical or numerical works illustrating the different parts of the course giving rise to a synthesis report and an oral presentation

Back to menu

Embedded AI

Module details

I5AEIA11-exc

3 ECTS FR
7.5 h 0.0 h 24.75 h 0.0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Project I

Module details

I5AEPRJ11-exc

4 ECTS EN
0.0 h 30.0 h 0.0 h 13.75 h
GRZESKOWIAK MARJORIE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Industrialisation and assembly

Module details

I5AEINA11-exc
2 ECTS FR
17.5 h 0.0 h 16.5 h 0.0 h
ESCRIBA CHRISTOPHE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Reliability and robustness for energy conversion

Module details

I5AEFCE11-exc

2 ECTS EN/FR
21.25 h 0.0 h 13.75 h 0.0 h
TOUNSI PATRICK
Revision date : May 18, 2026

Objectives

As power components are subjected to high electrical and thermal stresses, reliability and robustness issues are essential to ensure nominal operation and sufficient lifetime. Furthermore, power converters are a major source of electromagnetic disturbances that may compromise the electromagnetic compatibility (EMC) of the systems in which they are embedded. Controlling conducted emissions is one of the most frequent causes of EMC non-compliance.
At the end of this module, students should have understood and be able to explain the following main concepts:

- The reliability and robustness challenges of new power components
- The challenges related to chip integration within power modules
- The origin of conducted emission issues in power converters and EMC compliance techniques

Students should be able to:

- Test the electromagnetic emissions of a power converter
- Develop a simplified equivalent electrical model of conducted emissions in power converters
- Describe the main EMC filter structures (common-mode and differential-mode) and their design methods (through measurement and simulation)
- Implement several low-emission design rules

Content

This module is composed of three courses:

1. Reliability / robustness new power components
This course will begin with a general introduction to the robustness and reliability of power components. The main aging processes and their impact on power equipment will be addressed by including the notion of mission profile. The various drifts and their causes will be approached (RdsOn, Vce, leakage current…) illustrated by concrete examples. The concept of lifetime (MTBF, MTTF, MDT ...) and the laws used for its estimation will then be discussed. The contribution of multiphysics and circuit modeling will be demonstrated on concrete case examples. The methods of "monitoring" aging will then be approached through current research. Then comes the interest of switching to new large gap components. Comparisons with current power components will be made based on all static and dynamic characteristics. A variation of components in SiC then in GaN will be given. The adaptations and difficulties to integrate these new components into power equipment will be studied through existing converters. The specific drivers for driving these new switches will also be discussed. Finally, specific applications in the automotive, rail and space fields (hardened components)... will be addressed by calling on external stakeholders (CEA-TECH, EXAGAN, ALSTOM, CNES, 3DPHI ...).

2. High performance packaging and cooling
This course will begin by reminding you of the importance of limiting the junction temperature of components in general. Notions of thermal conduction and convection will be discussed and then, with the use of 3D simulations, they will be demonstrated through the use of thermal 3D software. The thermal-electrical analogy will be studied through exercises, and examples of dynamic models will be covered. Then concrete cases of "confined" equipment will be given and calculations will show the great difficulty of the cooling process. Mechatronic integration will be introduced and the constraints on packaging (reduction of parasitic inductances, etc.) will be mentioned. All the technologies to aid cooling efficiency will be discussed (heat transfer fluid, phase change, LHP, micro channels, etc.). The specificity of space and aeronautics will be explained. Some innovative packaging will be described by the manufacturers involved (CIRTEM, APSI-3D ..).

3. EMC of power converters
   Conducted emissions are one of the most common causes of EMC non-compliance in power converters. EMC compliance requires the proper sizing of input and output EMC filters, as well as good placement and routing practices. However, these choices can only be made based on a detailed understanding of the mechanisms involved in the generation and propagation of high-frequency conducted disturbances. The purpose of this introductory course is multifold:

   - Define the concept of conducted emissions and present the context
   - Briefly present standard measurement techniques for conducted emissions (e.g., EN55022, CISPR25)
   - Identify the sources and modes of propagation of conducted noise produced by a power converter
   - Describe the main EMC filter structures (common mode and differential mode) and their sizing
   - Present and illustrate several rules for low-emission design of switching power supplies.

Prerequisites

The prerequisites for this course include:

- Energy Management for Embedded Systems
- QSE, Electromagnetic Risks
- High-Frequency Issues in Electronic Control

Assessment

Under construction

Back to menu

Techniques for optimising electronic control

Module details

I5AETO11-exc

2 ECTS EN/FR
5.0 h 0.0 h 19.25 h 0.0 h
BOYER ALEXANDRE
Revision date : May 18, 2026

Objectives

At the end of this module, students should have understood and be able to explain the following main concepts:

- The challenges and trends related to accelerating and enabling the use of data in numerical simulation and Electronic Design Automation (EDA)
- The main artificial intelligence / machine learning algorithms used to optimize the design of electronic components or systems

Students should be able to:

- Develop a Python script jointly controlling a numerical simulation tool and a machine learning algorithm, and configure a machine learning algorithm according to the complexity of the problem
- Compare different methods
- Analyze and critically assess the proposed solutions

Learning Objectives:

- Formulate an optimization problem in electronic design (define the problem constraints, prioritize them, and define the objective function)
- Develop an electronic design workflow combining simulation tools from different domains (e.g., electrical/electromagnetic, electrical/thermal, etc.)
- Understand, implement, and compare different machine learning methods suited to electronic design needs (e.g., depending on the laboratory problem studied: genetic algorithms, Bayesian optimization, reinforcement learning, neural networks)
- Analyze the results, evaluate the relevance of the solutions (industrial realism), compare different technological choices, and assess the robustness of the solution (e.g., with respect to tolerance sensitivity and uncertainties)
- Present and summarize simulation and optimization results

Content

This teaching unit is divided into two courses:

1. High-Frequency Issues in Electronic Control
   Under construction
2. Machine Learning for Electronic Design
   For several decades, the design process of electronic systems has relied heavily on Electronic Design Automation (EDA) tools and numerical simulation. Regardless of the field (microelectronics, HF/RF electronics, power electronics, signal integrity, EMC, etc.), these software tools have become essential for designers to efficiently optimize the performance of electronic systems and ensure both their reliability (design for reliability) and manufacturability (design for manufacturability). However, the complexity of electronic systems is growing exponentially, making their modeling and optimization increasingly challenging.
   In recent years, artificial intelligence and machine learning techniques have experienced unprecedented growth and are revolutionizing all fields of engineering. These techniques provide efficient algorithms and methods to:
   - Efficiently develop electronic system models based on measurement or simulation data (surrogate modeling)
   - Automate design workflows capable of rapidly identifying optimal design parameters with minimal human intervention

   This course is part of this context and has a twofold objective:
   - To provide an overview of modern EDA tools used in the electronics industry, familiarize students with the required simulations (e.g., electrical, electromagnetic, electrothermal simulations), and present the latest trends
   - To present the most common artificial intelligence and machine learning algorithms for electronic design through the implementation of a concrete example during laboratory sessions

Depending on the problem studied during the lab sessions, the methods illustrated and implemented include metaheuristics (genetic algorithms, particle swarm optimization), supervised learning based on neural networks, Bayesian optimization, and reinforcement learning.

Prerequisites

Machine learning

Assessment

Under construction

Back to menu

Electronics and control for power conversion

Module details

I5AEECD11-exc

3 ECTS FR
22.5 h 0.0 h 16.5 h 0.0 h

Revision date : May 18, 2026

Objectives

The evolution of electrical energy management in embedded systems (e.g. for chargers or inverters in automotive, aerospace, industrial or general-purpose applications) requires the development of more compact, more efficient, more robust and less noisy power converters. These last years, new semiconductor technologies based on wide bandgap transistors (SiC, GaN) have emerged in order to meet these requirements. Advanced converters topologies (e.g. resonant, multilevel) have also enhanced the potential provided by these new technologies. This module introduces several aspects of power converters based on these new technologies.
The electrical efficiency of electronic systems can also be drastically improved by an appropriate selection of controls. The modeling of processing energy systems is central to evaluate their stability properties but also their dynamic performances which are key properties for the design of adequate control laws. One of the main difficulties is due to the nonlinear behavior and the commuting nature of all the processing energy systems which impose an important adaption of the control design methods. In this module, control law design methods considering efficiency constraints are presented for static power electronics converters and for electrical motors.
Expected Competences:

- Modeling of static power electronic converters (Linearization around an equilibrium state, Nonlinear model, Switched model)
- Design and implementation of a control law for a static converter (linear and nonlinear control)
- Understand the benefits of wide bandgap transistors in energy conversion
- Present characterization techniques for wide bandgap transistors
- Clarify the properties and constraints of wide bandgap transistor driving
- Using simulation tool dedicated for switching-mode power electronics (Simba)
- Dimension a resonant power converter

Content

The content of this course includes:

- Control of static power electronic converters:
  - The objective is to present the models of power electronic converters used to design control laws guaranteeing the stability, the robustness and the performances.
- New generation power converters: the module deals with the following points.
  - Properties and characteristics of wide bandgap transistors (SiC, GaN, diamant)
  - Dynamic and static characterization techniques
  - Electronic implementation of wide bandgap transistors
  - Realization of advanced topologies of power converters based on wide bandgap transistors

Prerequisites

The prerequisites for this course include:

- Energy management for embedded systems
- Basic concepts of power electronics

Assessment

Under construction

Back to menu

Project II

Module details

I5AEPRJ12-exc
2 ECTS EN
0.0 h 0.0 h 11.0 h 0.0 h
GRZESKOWIAK MARJORIE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Operating safety

Module details

I5AISF11-exc

6 ECTS FR
32.5 h 5.0 h 38.5 h 0.0 h
VERNADAT FRANCOIS
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain (main concepts):

- The fundamental concepts of dependability and the main methods and techniques for achieving and validating the dependability of a system.

The student should be able to:

- Apply this general knowledge to electronic and software-based technological systems
- Explain the different approaches and choose the appropriate type of approach for a given application

Content

An initial lecture provides a general introduction to dependability, specifying the terminology, attributes, and means.
More specialized lectures go further into this overview, mainly illustrating methods such as:

- Fault prevention through modeling, following synchronous and asynchronous timed paradigms
- Fault elimination through static verification of sequential programs and diagnosis

Prerequisites

The prerequisites for this course include:

- Discrete event systems
- Propositional logic

Assessment

Assessement for this course includes:

- Written tests
- Practical sessions to become familiar with tools and to implement the approaches covered in class
- Presentations in front of the entire cohort
- Reports

The required personal work allows students to assess their progress with respect to the learning objectives.
Practical sessions help students assimilate the concepts covered in class and place them in situations where they apply them to concrete problems.
Preparing the oral presentation and writing a dissertation require synthesis work on the discipline.

Back to menu

Engineering processes

Module details

I5AIMI11-exc

6 ECTS FR
32.5 h 11.25 h 24.75 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

Present the main principles of systems engineering and software engineering: concepts, methods and tools, to define and control the process development of a critical embedded system.
The student will be able to apply these general competences to computer based embedded systems explain different methods and chose the best adapted to develop a specific application.

Content

The goal of this course is to introduce the main principles of systems engineering and software engineering.

- A first course introduces the concepts, methods and tools, to define and control the process development of a critical embedded system.
- A second course introduces agile management of engineering processes in an embedded system development project.
- A MOOC allows the student to synthetize all the notions of this UF and to reinforce some.
- Another course introduces the principles of machine learning.
- A final course, specific to the students specialization, allows them to deepen their knowledge of model checking or the Kalman filter.

All method, tools and good practices presented in the UF will be used in a transversal project of development of a critical embedded system.

Prerequisites

Under construction

Assessment

Assessement for this course includes:

- Exams
- Lab works
- Project

Back to menu

Embedded Computer Architecture

Module details

I5AISE51-exc

3 ECTS FR
18.75 h 2.5 h 16.5 h 0.0 h

Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain:

- The principles and specific features of networks used in embedded systems in the automotive, avionics, and IoT sectors
- The specific characteristics of operating systems and their main services (scheduling, memory, privileges, etc.) for embedded systems
- The advantages and disadvantages of different computing architectures used in embedded systems
- The factors affecting performance (computation, energy consumption, etc.) of a computing architecture and methods for optimizing them

The student should be able to:

- Choose a network technology that meets the needs of an embedded system
- Set up the network supporting an embedded system
- Deploy an operating system on an embedded architecture
- Develop a driver within an operating system
- Compare two embedded computing architectures in terms of performance
- Choose a computing architecture suited to the needs of an application

Content

Under construction

Prerequisites

Prerequisites for this course include:

- C programming
- Computer architecture
- Networks
- Operating systems

Assessment

Under construction

Back to menu

Interdisciplinary Project

Module details

I5AIPI11-exc

7 ECTS EN
0.0 h 30.0 h 41.25 h 0.0 h
CHANTHERY ELODIE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Implement and apply agile management according to the agile method in order to create a product,
- Select and interweave a set of interdisciplinary technical skills in order to develop a critical embedded system,
- Search autonomously and be able to critique technical solutions for which he/she does not have prior knowledge in order to meet requirements specific to critical embedded systems,
- Design and build a product deployed on a heterogeneous and communicating embedded architecture guaranteeing performance properties,
- Define needs, requirements and architecture when designing a product
- Communicate in an interdisciplinary context and to work together with actors with heterogeneous skills,
- Adapt the writing and presentation of scientific results according to the audience (client, decision maker, evaluator, general public) and through various media (presentation, website, report, synthesis, poster).

To express themselves correctly in English, using a concise and precise style respecting the conventions of genre in writing as well as orally

Content

Methods, practices and tools presented in the dependability, engineering methods and embedded computer architecture UFs will be implemented in this transversal project for the development of a critical embedded system, including courses in English

Prerequisites

Prerequisites for this course includes dependability, engineering methods and embedded computer architecture Ues

Assessment

Assessement for this course includes:

- Project plan 0: written report on the needs, risks and project management
- Web page
- Oral presentation during weekly meetings and reviews every two weeks
- Final review
- Poster
- Final abstract

Very regular and personalized follow-up and feedback allows students to improve throughout the semester.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Service Robotics

Module details

I5IRRS41-exc

4 ECTS FR
10.0 h 5.0 h 35.75 h 0.0 h
TONDU BERTRAND
Revision date : May 18, 2026

Objectives

At the end of this module, the student would be able to explain the main components of a robot service and to say in which way it differs from industrial robotics; he/she will know the main concepts in humanoid robotics and why it is difficult to control a walking robot.
His/her knowledge will include the main notions in jointed robotics: direct and inverse kinematic models, dynamic model of the robot, trajectory generation and stability of a bipedal robot.
The student is supposed to be able to model a jointed robot, to understand its technical components and to analyse the functioning of a service robot in its domestic or professional environment.

Content

The content of this course includes:

- Introduction to service robotics: this lecture introduces the specificity of the service robot and aims to specify its field of application both at home and at the hospital; both simple mobile robots and more complex jointed robots will be modeled; direct and inverse kinematic models will be considered as also simple methods in trajectory generation; the choice of a relevant actuator will be discussed and how its position can be controlled by means of classic linear control methods; the special case of hybrid position-force control will be briefly discussed.
- Labwork in service robotics: students must select one concept or method they will try to study in some advanced way in the framework of a problem encountered inside the robot club of the department or peculiar labwork project proposed by a teacher.
- Labwork in humanoid robotics: the labwork is a true introduction to humanoid robotics, considered as a multidegrees of freedom tree chain structure whose modelling requires a direct kinematic approach based on the robot Jacobian matrix and an inverse approach based on the pseudo-inverse of this Jacobian matrix. Theoretical notions are illustrated by means a graphical simulator of the Japanese humanoid robot HRP2.

Prerequisites

Prerequisites for this course include:

- Matrix theory
- Linear control

Assessment

Assessement is taking place during labworks

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Industrialization and Logistics

Module details

I5ISPR22-exc

5 ECTS EN/FR
36.25 h 16.25 h 13.75 h 0.0 h
MONTEIRO DE ARAUJO ANNA CARLA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The systems of industrialization and its interfaces.
- The challenges of production management (PM) and supply chain (SCM) as well as issues of scheduling.
- What is configuration management, what are the enablers and what is the purpose

The student will be able to:

- Have an overview on manufacturing processes
- Understand the historical context of Industrialization
- Have a critical view on global manufacturing strategy
- Understand the elements on Smart Manufacturing and Industry 4.0
- Use the information of the different types of Industrial Management Tools
- Roughly describe airbus world (A/Cs family, industrial sharing across the Europe)
- Define a hierarchical and appropriated breakdown of a complex product
- Apply the change process and identify required data to allow decision
- Identify mechanisms that enable management of product offer and its customisation
- Demonstrate that final product manufactured is conform to expectations

Content

Industrialization :

- Overview of manufacturing processes
- Historical context on global manufacturing
- Smart manufacturing and Industry 4.0
- Tools for industrial management
- Production of a CNC code using CAD/CAM Software
- Analysis of a CNC code and CNC trace of servo position data from machine
- Virtual design by digital scanning

Production management, planning, scheduling :

- Production management and logistics
- Linear programming applied to planning
- Graphs and scheduling application
- Scheduling and combinatorial optimization
- Production Planning
- Labwork : Introduction to AMPL and Excel

Configuration Management :

- Configuration management generalities (first look and presentation of modules that will be detailed afterwards)
- Product structure (What is product structure, how it is built and what are the main rules)
- The change process (all different steps of a change request during the full process, data and deliverables requiered pending on progress in the process)
- Offer management (what is offer management and what are the associated deliverables)
- Attestation and control of conformity (Delta managements)
- Conclusion (links between Configuration Management modules and synthesis)

Prerequisites

Prerequisites for this course includes:

- Reading of plans, current metallic materials, various types of machining.

Basic elements on:

- Probabilities
- Linear programming

Assessment

This course is assessed:

- By interaction with students during courses
- By practising with different use cases
- By concluding with a written exam

Assessement also includes:

- Use cases allow students to apply a complex process and understand all its mechanisms.
- During this practice, the interaction between student/teacher is promoted, thus students can ask relevant questions and teachers can insist on important notions.
- Last but not least, written exam allows to ensure that information has been assimilated properly

Back to menu

Mechatronic/Technological systems for sustainable mobility

Module details

I5ISMD11-exc

4 ECTS FR
10.0 h 17.5 h 19.25 h 0.0 h
BUDINGER MARC
Revision date : May 18, 2026

Objectives

At the end of this module the student should be able to:

- Set up a dynamic vehicle model to calculate power requirements and energy consumption and optimize a mission profile to minimize energy consumption
- Sizing an energy storage assembly (supercapacitor, batteries) and a static DC/DC converter
- Carry out an LCA assessment (Life Cycle Analysis)
- Analyze the architectures of static converters applied to electric vehicles
- Control a set of converters to manage the overall energy needs of a vehicle

Content

The module has 4 parts:

- Needs, scenarios and requirements
- Ecodesign, Analysis and CV
- Control of converters and actuators
- Technologies of converters and energy storage systems

The common thread study concerns means of electric public transport (buses, electric trams).

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Reliable systems

Module details

I5ISGR22-exc

4 ECTS EN/FR
26.25 h 16.25 h 2.75 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain the notions associated with dependability, reliability, maintenance and risk, as well as the organizations, trades, methods and activities useful to implement these notions.
The student will be able

- to identify the hindrances to the availability and to the reliability of systems,
- to make an assessment for choosing the most suitable architectures,
- to choose among the available methods the most appropriate to obtain the expected service of a system, when designing and maintaining, and to provide its insurance.

Content

The content of this course includes:

1. Dependability
   - Needs and obstacles
   - Techniques for preventing, detecting and removing, and tolerating faults.
2. Reliability
   - General and mathematics for reliability.Methods for reliability (Functional Block Diagrams): Fault-Tree analysis (FTA) and Minimum Cut set (MCS), Reliability block diagram (RBD) for non-repairable components, Markov Diagram and models for complex systems, including coverage and repair processes.
   - Fail-safe design and application to current industrial examples.
   - General and mathematics for reliability.
3. Maintenance
   - Introduction to the maintenance function. Maintenance strategies. Failure rate and concept concerning the status of a device.
   - Industrial maintenance by vibration analysis, mechanical defects and associated vibration signals, signal processing methods, diagnosis of industrial cases.
4. Safety assessment
   - Presentation of the issues related to safety in critical systems. Illustration in aeronautics.
   - Model-based approaches to safety assessment
   - Methods and tools to assess the safety of complex systems (Altarica, Cecila-OCCAS)

Prerequisites

The prerequistes for this course include:

- System life cycle.
- Basic knowledge on probabilities.
- Statistics.
- Signal processing.

Assessment

Assessement for this course includes:

- Dependability: the student must be able to choose the means appropriate to each development step to insure the expected service of a system.
- Reliability: the student shall be able to select and apply the various methods and tools enabling the candidate system architectures to be assessed and decisions to be made regarding main contributors to unreliability.
- Maintenance): the student must be able to identify and select a maintenance policy. It must be able to implement vibratory maintenance tools.
- Risk Management: student must be able to identify risks of a system, to assess its significance, and to choose efficient and effective risk controls to insure users' safety.

Project defended as a response to a call for tender with feedback on weakness.

Back to menu

Research project and industrial property

Module details

I5ISPJ21-exc

8 ECTS EN/FR
7.5 h 40.0 h 44.0 h 0.0 h
BUDINGER MARC
Revision date : May 18, 2026

Objectives

Under construction

Content

Part 1: This educational unit aims to have students work in project groups on the following types of projects:

- Addressing Societal Challenges:** In cooperation with associations (e.g., Formula Student, TIM, ...) and vocational campuses (such as CMQe MTI).
- Innovative Projects: Focusing on new products.
- Interdisciplinary Projects: Involving at least two subjects from the 4th and 5th years.

Students will be required to work autonomously and will be evaluated on their ability to work as a team and propose concrete solutions.
Part 2: Intellectual and Industrial Property Module
This module aims to achieve five major objectives:

1. Understand and Explain Key Concepts:
   - Distinguish the major differences between intellectual and industrial properties.
   - Autonomously initiate protection procedures by addressing the appropriate interlocutors, based on one's inventive activity and protection needs.
   - Know the costs and limitations associated with these procedures.
2. Describe and Define:
   - The different types of protections available.
   - The legal framework of each protection and the modalities of application.
3. Understand Protection Strategies:
   - Strategies associated with patents, disclosure, or secrecy.
   - Corporate strategies related to the defense and exploitation of industrial property, such as the "Patent Pool" strategy, Licensing strategy, monopolistic strategy, and the "false route" strategy.
   - Explain the advantages and disadvantages of each strategy.
4. Identify Protection Organizations:
   - Know the major protection organizations and their respective roles to effectively navigate one's protection needs.
5. Initiate Protection Procedures:
   - Start the procedures to protect an invention, a trademark, a design, a model, a domain name, a work, a musical composition, a software program, or any other discovery.
   - Know the deadlines, costs, as well as the temporal and geographical limitations associated with these procedures.

This module aims to equip students with the skills necessary to navigate the complex field of intellectual and industrial property, providing them with the tools and knowledge to effectively protect their innovations and creations.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Systems on chip *

Module details

I5ISEC11-exc

4 ECTS EN
20.0 h 0.0 h 30.25 h 0.0 h
DRAGOMIRESCU DANIELA
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain:

- the design and performance optimisation of advanced digital systems (e.g. microprocessors)
- notions of hardware security for digital systems
- hardware embedded AI techniques
- co-design: the joint hardware-software design of a complex system depending on the chosen application.

The student should be able to :

- design and implement advanced digital systems using the VHDL language on FPGAs and optimise their performance in terms of power consumption and operating frequency according to the specifications of the application.
- design and implement neural networks on FPGAs

Content

This course is organised around the methodology of designing digital hardware systems.
In the first part, the design, implementation and performance optimisation (frequency, power consumption, etc.) of complex digital systems on FPGA/ASIC are taught.
Notions of hardware security for digital systems, typically processors, will also be presented. Next, the life cycle of Systems on Chip

- SoC or Systems on Programmable Chip
- SoPC (specifications, design, implementation) is discussed in the context of joint hardware/software development, followed by a presentation of co-design and hardware/software co-verification techniques.
- The chiplet-based approach to designing complex analogue and digital systems will also be presented.

Part 3 will cover the concepts of embedded AI, presenting the different types of neural networks and their hardware implementation on FPGAs, with a focus on the new types of processors that include neural components: neural engine, neural processor unit (NPU), tensor processor unit (TPU).
Practical work will focus on VHDL design and implementation:

- a RISC microprocessor on an FPGA
- a perceptron and a neural network (MLP) on FPGA

Prerequisites

Prerequisites for this course includes:

- Digital electronics
- Microprocessor hardware architecture
- Requirements engineering

Assessment

Under construction

Back to menu

Thermal engines and systems *

Module details

I5ISTH12-exc

4 ECTS FR

13.75 h 12.5 h 22.0 h 0.0 h

HAZYUK ION

Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to analyze thermal and mechanical energy production systems and their associated components.

The student should be able to:

- Analyze the thermodynamic cycle associated with a power plant.
- Size a thermal engine to meet specifications in terms of requested power.
- Specify the components of a thermal engine or system.
- Calculate the air conditioning flow requirements to perform various functions (pressurization, fresh air renewal, heating, cooling) in an aircraft and adjust the recirculation and the flow distribution between the different cabin zones.

Content

Thermal engines:

- reminder of the principles of thermodynamics, fluid modeling, thermodynamic transformations (isobar, isoenthalp, adiabatic, etc.).
- analysis of the thermodynamic cycles of steam engines, gas turbines and heat pumps.

Thermal systems:

- Lumped parameter modeling of components involved in thermal engines and systems such as heat exchangers, compressors, turbines, valves.
- Case study on an air conditioning and pressurization system for an aircraft.

Computational fluid mechanics:

- Initiation to the CFD code Fluent.
- Numerical simulation of one of the components of a thermal system, in the framework of a project done by groups of 2 students.

Prerequisites

Basics of thermodynamics and heat transfer.

Assessment

Assessement for this course includes:

- Thermal engines: exam.
- Thermal systems: exam, and a lab-work report.
- Computational fluid mechanics: project

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Partial diff. equations and Fourier series

Module details

I3ICMT51-exc

3 ECTS FR
12.5 h 13.75 h 7.5 h 0.0 h
BAUDOUIN LUCIE
Revision date : May 18, 2026

Objectives

This course aims to master some basic mathematical concepts for the study of partial differential equations (PDE) by the future engineer in Civil Engineering or Mechanical Engineering.
This UE is naturally composed of academic knowledge presented in lectures, and computational know-how (studied in tutorials) and numerical know-how (implemented in practical work).
Students will learn to identify and classify PDEs according to their nature (elliptic, parabolic, hyperbolic). They will approach the basic concepts, properties and theorems concerning Fourier series and Fourier transforms, which are powerful tools for solving PDEs, particularly in areas related to periodic phenomena and vibrations.
Finally, the separation of variables, a classic and effective technique for solving certain classes of PDEs, will be formalized and studied.
This method will be illustrated through several concrete examples linked to wave-type equations (vibration phenomenon) or heat (diffusion phenomenon).

Content

The content of this course includes:

1. Introduction to PDEs and classification
   - Prerequisites in linear algebra, integration, resolution of ordinary differential equations, functions of several variables;
   - Terminology and Examples of PDEs;
   - Classification of linear PDEs of order 2.
2. Fourier Series
   - Physical motivation
   - Space of periodic functions of square integrable
   - Trigonometric series
   - Fourier coefficient
   - Fourier series in L^1 (Dirichlet Thm) then in L^2 (Parseval Identity).
3. Fourier Transform
   - Analysis and Synthesis of the Fourier transform on L^1, algebraic and derivation properties, inverse Fourier Transform and Plancherel Formula, Convolution;
   - Fourier Transform on L^2 and illustrative examples.
4. Sturm Liouville Problem
   - Definition, examples and properties of the solutions.
5. Solving PDEs by Separation of Variables
   - Well-posed problem and Boundary conditions;
   - Homogeneous 1D heat equation; Homogeneous 1D wave equation
   - Generalities on the method of separation of variables (homogeneous Eq, then with source term, then with non-homogeneous boundary conditions, and interest in knowing the associated Sturm Liouville problem)

Students will be provided with a course handout, tutorial statements (then their corrections) and laboratory work.
The laboratory work will be carried out under Python

Prerequisites

Mathematics UE for years 1 and 2. More specifically:

- linear algebra (Diagonalization of matrices)
- integration (change of variable, Integrations by parts)
- resolution of ordinary differential equations (characteristic polynomial, solution of the homogeneous equation and particular solution...)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Continuum mechanics

Module details

I3ICMS51-exc

4 ECTS FR
1.25 h 30.0 h 6.0 h 0.0 h
PASSIEUX JEAN-CHARLES
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have a comprehensive understanding of solid deformation mechanics, stresses, linearized strains, displacement fields and the constitutive relationship in elasticity.
The student should be able to:

- Analyze the state of stress and strain of a solid under loading.
- Calculate the stress state based on the strain state and vice versa.
- Calculate the strain state based on the displacement field.
- Establish equations for the local equilibrium of the solid at every point.
- Propose a relevant modeling of a real problem, particularly in terms of boundary conditions.
- Calculate the stresses from the diagrams of internal solicitations obtained from beam theory.

Content

Theory of stresses, theory of strains, displacement strain relationship, linear elasticity constitutive law, formulation of the elasticity problem, analytical methods for solving the general problem of linear elasticity. Applications in practical exercises using Python programming language.

Prerequisites

Mathematics (analysis, linear algebra, numerical analysis), general mechanics (statics and kinematics), beam theory (internal solicitations, stresses in beams. . .), basics in Python programming.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Fluid mechanics I

Module details

I3ICMF51-exc

3 ECTS EN/FR
12.5 h 15.0 h 6.0 h 0.0 h
ROJAS CARDENAS MARCOS JAVIER
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The concept of a fluid and the forces acting on a fluid particle.
- The distribution of static pressure within a fluid and the forces exerted by the fluid on a solid surface.
- The ideal fluid in motion: kinematics and dynamics.

The student should be able to:

- Calculate the forces exerted by a fluid on flat and curved solid surfaces.
- Use Bernoulli's equation (energy conservation) and Euler's theorem (momentum conservation) in a wide range of practical applications.

Content

Introductory definitions and general properties of a fluid, forces acting on a fluid particle. Fluid statics for incompressible and compressible fluids, manometry, buoyant force, forces and moments exerted by a fluid on flat and curved surfaces, and pressure distribution in rigid body motion. Fluid dynamics and kinematics, Euler's equation, Bernoulli's equation, mass conservation, control volume and Reynolds transport theorem, linear momentum equation.

Prerequisites

Basic thermodynamics concepts facilitate a better understanding of the fundamental principles.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Dynamic systems

Module details

I3ICSD51-exc

4 ECTS EN/FR

15.0 h 17.5 h 6.0 h 0.0 h

HAZYUK ION

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood the basics on signals and linear systems as well as the dynamical and frequency performances of the systems.
The student should be able to:

- Build in Matlab/Simulink a dynamic model of a system out of its algebro-differential equations
- Determine and analyze the dynamic and frequency performances of a system of intermediate complexity (1ˆ*st* or 2ˆ*nd* order) based on its dynamic model
- Carry out the preliminary sizing of a system of intermediate complexity (1ˆ*st* or 2ˆ*nd* order) to fulfill the dynamic specifications.

Content

Fundamentals of signals and systems. Transfer functions of linear time-invariant systems. Systems of 1st order, generalized 1st order, 2nd order, system delay. Frequency response in Bode diagram and its asymptotic plot. Introduction to state space representation.

Prerequisites

Laplace transform. Basic notions to model mechanical, electrical, thermal and hydraulic systems

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR
5.0 h 21.25 h 2.5 h 0.0 h
CARREY JULIAN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Mechanical design I

Module details

I3ICCM51-exc

3 ECTS FR
1.25 h 30.0 h 0.0 h 0.0 h
LOUBET THIERRY
Revision date : May 18, 2026

Objectives

The objective of this teaching unit is to increase skills in the design and manufacture of mechanical products.

Content

The EU is divided into 3 parts:

1. Mechanical Design:
   - Modeling of mechanisms
   - Design of complete removable links
   - Design of the pivot links: friction and bearing
2. Tolerancing:
   - Geometric: ISO method
3. Manufacturing Analysis

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Introd. manufacturing and tolerancing

Module details

I3ICFA51-exc

3 ECTS FR
3.75 h 22.5 h 5.0 h 0.0 h
COUTOULY DAMIEN
Revision date : May 18, 2026

Objectives

At the end of the Tolerancing-Manufacturing Analysis (TMA) module, the student should be able to develop a process plan for a simple part using appropriate methods, after decoding, interpreting, and/or creating the definition drawing.

Content

The content of this course includes:

- Tolerancing
- Manufacturing Analysis

Prerequisites

Industrial Drawing, Design

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Digital Logic systems

Module details

I3ICSL61-exc

2 ECTS FR
6.25 h 13.75 h 9.0 h 0.0 h
BALDAS LUCIEN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to use the main tools and methods for the specification and sequential control of automated production systems.
The student will have to be able to:

- Design the sequential control of an automated production system;
- Implement on a Programmable Logic Controller the various operating modes of a sequential automated system of medium complexity.

Content

The content of this course includes:

1. Combinatorial logic: basic notions, Boole algebra, representation of logical functions.
2. Sequential logic: design of sequential production systems – detailed study of a specification language: Grafcet – study of the Statechart language – how to define operating modes using both language.
3. Realization of sequential control systems using Programmable Logic Controller.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Introduction to systems engineering

Module details

I3ICIS61-exc

1 ECTS FR

5.0 h 7.5 h 6.25 h 0.0 h

BUDINGER MARC

Revision date : May 18, 2026

Objectives

Mechatronic and aerospace systems are complex systems that often need to meet specific and rigorous requirements depending on the application. They require the joint development of technological systems and control software. This course provides an introduction to the concepts and development of such systems.

Content

Main concepts introduced:

- Requirements analysis and preliminary design.
- Dynamic modeling and identification of multiphysics technological systems.
- PID control and digital implementation.

Case studies:

- This course will use thermal control and attitude control of CubeSats as case studies.

For pedagogical reasons, the approaches will be deliberately simplified, and the digital implementation of the controllers will be carried out on Arduino boards.

Prerequisites

Dynamical systems

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Mechanical design II

Module details

I3ICCM61-exc

6 ECTS FR
0.0 h 43.25 h 10.0 h 25.0 h
GUIGNARD LUDOVIC
Revision date : May 18, 2026

Objectives

Student must be able to :

- Valid a simulation model and exploit results.
- Analyze a technological system from the real object (behavior during different phases of use, identify components ensuring the different functions, etc.), design its kinematic and architectural diagram in 3D, calculate and possibly modify its degree of hyperstatism.
- Choose an actuator (technology and sizing)
- Design and size a pivot connection with radial contact bearings (all types of external loads)
- Create a dimension chain

Content

The content of this course includes :

- First on the modeling of a mechanical architecture using multiphysics simulation software: Making the model/real link, parameters, validation of the model and exploitation of the results
- A second on kinematic modeling of a complex system (kinematic diagram, hyperstatism, equivalent connections)
- A final part on design and sizing of mechanical systems. We will focus on actuators (cylinders and motors) and pivot connections.
- A project, carried out in small groups over the entire semester, will complete and reinforce knowledges acquired in previous parts.

- Disassembly of gearboxes and differentials during practical work sessions

Prerequisites

Prerequisites for this course include:

- Mechanical drawings
- Mechanic (Kinematic connections, PFS, PFD)
- Mechanical technology

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

CNC and computer-aided manufact.

Module details

I3ICCN61-exc

2 ECTS EN/FR
0.0 h 2.5 h 16.0 h 0.0 h
GILLES PATRICK
Revision date : May 18, 2026

Objectives

This course introduces the techniques used for the manufacturing and inspection of mechanical parts.
By the end of the course, students should understand and be able to explain the main concepts of Computer-Aided Manufacturing (CAM) and the Numerical Control (CNC) of turning and milling machine tools, as well as the main principles of digitization for reverse engineering.

Content

The content of this course includes:

- Computer-Aided Manufacturing
- Numerical Control
- Digital Manufacturing

Prerequisites

Prerequisites for this course includes:

- Engineering Design Office
- Tolerancing and Functional Analysis

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Metrology

Module details

I3ICME61-exc

2 ECTS   FR
8.75 h   10.0 h   8.0 h   0.0 h
COUTOULY DAMIEN
Revision date : May 18, 2026

Objectives

At the end of this course, the student should be able to:

- Adopt a methodology that enables the successful development of a product within a quality-driven approach,
- Understand the stakeholders involved and identify the documentation generated,
- Interpret the implementation of production and assembly methods, as well as the means and methods for product inspection and improvement.

Regarding inspection methods and techniques, the student should be able to:

- Have a basic understanding of cost/quality/time controls at all stages of the development and manufacturing cycle, with the objective of mastering the geometric quality of a product,
- Be familiar with the main technical tools used for dimensional and geometric inspection of mechanical parts,
- Be able to establish an inspection plan for a specification by zone or template, using a surface plate or a Coordinate Measuring Machine (CMM),
- Understand the main surface association criteria (Least Squares, Least Squares Tangent, Mini-Max),
- Be capable of characterizing a measuring device (calibration, interpretation of measurement uncertainties, etc.),
- Have some knowledge of arithmetic and statistical functional tolerancing.

Content

Under construction

Prerequisites

Mechanical Design, Dimensional and Geometrical Tolerancing and Manufacturing Analysis

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Heat treatment and welding

Module details

I3ICTH61-exc

1 ECTS FR
0.0 h 0.0 h 4.0 h 8.0 h
CHAUSSUMIER MICHEL
Revision date : May 18, 2026

Objectives

The student should be able to:

1. In Heat Treatment
   - Distinguish between special steels for mechanical engineering suitable for heat treatments
   - Know how to select heat treatment conditions adapted to the expected performance of mechanical parts
   - Be able to identify the different phases present in the alloy after heat treatment
2. In Welding Techniques
   - Know how to choose a welding technique for a given design
   - Know how to select welding parameters for Electric Arc welding techniques: EE (Covered Electrode), MIG (Metal Inert Gas) and TIG (Tungsten Inert Gas)

Content

The content of this course includes:

1. in Heat Treatment
   - Special Steels for Mechanical Engineering
   - Concepts of heat treatment of steels: Quenching
   - Tempering
   - Implementation of a method for selecting heat treatment conditions: IRSID-OTUA method
   - Implementation of heat treatments
   - Mechanical characterization of heat-treated mechanical parts: Hardness tests and tensile test
2. in Welding
   - Concepts of electric arc welding
   - Implementation of EE, MIG and TIG techniques on steel

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Heat transfer I

Module details

I3ICTTGM61-exc

3 ECTS EN/FR
11.25 h 13.75 h 9.0 h 0.0 h
COLIN STEPHANE
Revision date : May 18, 2026

Objectives

The purpose of this course is to provide the necessary foundations for understanding and modeling heat transfer.

Content

The course is structured into three main parts, which cover conduction, convection, and radiation, the three modes of heat transfer. These three parts are developed across six chapters:

- Chapter 1 – Introduction to heat transfer
- Chapter 2 – Fundamental principles of conduction
- Chapter 3 – Steady one-dimensional conduction
- Chapter 4 – Fundamental principles of convection
- Chapter 5 – Forced convection in external flow (over a flat plate, around a cylinder, or around a sphere)
- Chapter 6 – Fundamental principles of radiation

Prerequisites

This course does not require any particular prerequisites, apart from basic knowledge in mathematics.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Control systems

Module details

I3ICCS61-exc

2 ECTS EN/FR
10.0 h 11.25 h 8.0 h 0.0 h
HAZYUK ION
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain the fundamentals of control engineering for linear systems in time and frequency domains.
The student will have to be able to design a controller to fulfil a set of required dynamic performance, by using Matlab.

Content

- Frequency analysis of closed-loop systems; rapiditytyprecision dilemma, stability.
- Controller design: series, parallel, feed-forward and state feedback.

Prerequisites

Systems Engineering

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS EN/FR
0.5 h 2.75 h 0.0 h 0.0 h
PLANTEC JEAN-YVES
Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Multiphysical modeling

Module details

I4ISME71-MP-exc

7 ECTS FR
21.25 h 50.0 h 9.0 h 0.0 h
BUDINGER MARC
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The main concepts of modelling multiphysics systems with localised/lumped (0D/1D) or distributed (3D) parameters.
- Network approaches in multi-domain modelling (electrical, mechanical, hydraulic, thermal), acausal/causal modelling, bond graphs, and finite element calculation methods in electromagnetics and mechanics.

The student should be able to:

- Set up 0D/1D (electrical, mechanical, hydraulic, thermal), 2D/2D multibody or 3D (electromagnetic, mechanical) models for mechatronic systems.
- Use programming software such as Python and OD/1D platforms such as Dymola/Modelica, AMESim, Simulink and 3D such as FEMM, Patran-Nastran or Abaqus.

Content

The content of this course includes :

- Introduction to the implementation of localised parameter models (0D/1D): network approach to multi-domain modelling (electricity, mechanics, hydraulics, heat), Modelica language, incremental modelling and choice of model level, calculation of parameters using energy approaches.
- Implementation and analysis of localised parameter models (0D/1D): Modelica models, Simulink block diagram models, causal and acausal approaches, bond graph, numerical resolution in Python.
- Modelling electromagnetic actuators: calculating magnetic fields (analytical and FEM) and inductances, calculating forces, modelling mechatronic actuators.
- Modelling of mechanical structures and 3D systems: introduction, multi-body mechanical systems, modelling and finite elements in Python and Abaqus.

Prerequisites

The prerequisites for this course include:

- Kirchhoff's laws and electrokinetics
- concept of work/energy and power
- concept of pressure in fluid hydrostatics
- conduction and convection in heat transfer.

Assessment

Assessment takes the form of written tests, project reports and oral presentations.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Architectures of power transmission systems

Module details

I4ISME71-EI-exc

4 ECTS FR

12.5 h 20.0 h 5.5 h 0.0 h

REYSSET AURELIEN

Revision date : May 18, 2026

Objectives

The module consists of 6 components:

- Power Transmission Architecture
- Mechanism Analysis (AE only)
- CAD and Digital Twin
- Industrial Networks Introduction
- Embedded Computing and Electronics
- Research Documentation Training and Research Project

The objectives are specific to each component:

- Power Transmission Architecture
  - analyze a mechanical/hydraulic/electrical power diagram from an architectural and functional perspective,
  - synthesize a mechanical/hydraulic/electrical power architecture based on functional requirements.
- Mechanism Analysis
  - The student will be able to read part and assembly drawings and analyze the kinematics required for the realization of a mechanism.
- CAD and Digital Twin
  - The student will implement co-simulation between a multi-body CAD model and a 0D/1D multiphysics environment for preliminary validation.
- Industrial Networks Introduction
  - The student will have acquired the fundamental knowledge of industrial networks and protocols.
- Embedded Computing and Electronics
  The student will understand:
  - the fundamental concepts related to a digital transmission chain, from capturing physical information, processing it, to transmitting it over a wireless network,
  - the different parameters to consider when shaping an analog signal,
  - the various parameters to consider when choosing a wireless transmission technology,
  - basic programming techniques for STM32 microcontrollers.

  The student will also be able to:
  - analyze a problem and design a hardware and software architecture for data transmission based on a specification study,
  - choose the appropriate technologies for transmission from basic or more advanced equipment such as XBee or GSM modules,
  - read a datasheet to understand the operation of simple electronic sensors,
  - build the electronic circuit to shape the signal from the sensor.
- Research Documentation Training
  The student will be able to:
  - collect relevant and reliable academic/research documents using various sources,
  - present their bibliographic synthesis in a structured and standardized format.

Content

The content of this course includes:

1. Power Transmission Architecture
   - Teaching focused on power systems with mechanical applications (actuators, drives, propulsion chains, etc.).
   - Divided into three areas: hydraulics, electrical engineering, and mechanics, with an analysis of the technological components that fulfill functions such as: dosing, distribution, transformation, conditioning, and management.

- Practical examples covering mobility/construction sectors (electric vehicles, aerospace, construction machinery).

2. CAD and Digital Twin

   - Work on a CAD model of a recumbent electric bike, where the driving behavior is co-simulated (suspension/propulsion).

3. Embedded Computing and Electronics

   - Sensor analysis (e.g., temperature probe),
   - Building a circuit integrating an operational amplifier,
   - Hands-on experience with STM32 microcontroller family,
   - Hands-on experience with various RF transmission modules,
   - Setting up a complete hardware and software architecture to enable wireless temperature communication.

4. Research Documentation Training

   - Training will be provided on scientific dissemination channels (documentary databases, journals), research methodologies, and associated tools. There will also be an introduction to copyright and the analysis of information quality.

Prerequisites

The prerequisites for this course include:

- Power Transmission Architecture: Basic technological knowledge in mechanics is required, as the leveling course (I4ISEI11-2 Mechanism Analysis) is brief. Self-training materials will be available online.
- Embedded Computing and Electronics: First-year computer science course.

Assessment

Assessement of this course includes:

- Power Transmission Architecture: 1 Multiple Choice Quiz + 1 Written Evaluation
- Mechanism Analysis: No Evaluation
- CAD and Digital Twin: Evaluation based on the TD (Tutorial) sessions
- Introduction to Industrial Networks: No Evaluation
- Embedded Computing and Electronics: Multiple Choice Quiz and Evaluation of Programs and/or Written Evaluation.
- Training in Document Research: Evaluation based on 2 reports: 1 bibliographic, 1 progress report

Back to menu

Automatic control

Module details

I4ISTI71-AU-exc

5 ECTS FR

18.75 h 21.25 h 19.25 h 0.0 h

LE CORRE GWENDOLINE

Revision date : May 18, 2026

Objectives

The objectives of this course are to gain knowledge of digital control techniques and methods:

- be able to identify and model a discrete system and a sampled system
- be able to evaluate the performance criteria of a discrete system and a sampled system
- know how to set up and validate a corrector for a discrete or sampled system

Content

The content of this course includes:

- Discrete-time linear models: input/output models and state-space models.
- Sampling with zero-order blocker.
- Stability criteria.
- Switching from an analogue to a digital control law.
- RST corrector: Regulation and tracking.
- Link with state-space methods.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Architectures of information system chains

Module details

I4ISTI71-EI-exc

2 ECTS FR
2.5 h 6.25 h 16.5 h 0.0 h
ROCHACHER THIERRY
Revision date : May 18, 2026

Objectives

The module consists of 6 components:

- Power Transmission Architecture
- Mechanism Analysis (AE only)
- CAD and Digital Twin
- Industrial Networks Introduction
- Embedded Computing and Electronics
- Research Documentation Training and Research Project

The objectives are specific to each component:

1. Power Transmission Architecture: the student will be able to:
    - analyze a mechanical/hydraulic/electrical power diagram from an architectural and functional perspective,
    - synthesize a mechanical/hydraulic/electrical power architecture based on functional requirements.
2. Mechanism Analysis: the student will be able to read part and assembly drawings and analyze the kinematics required for the realization of a mechanism.
3. CAD and Digital Twin: the student will implement co-simulation between a multi-body CAD model and a 0D/1D multiphysics environment for preliminary validation.
4. Industrial Networks Introduction: the student will have acquired the fundamental knowledge of industrial networks and protocols.
5. Embedded Computing and Electronics: the student will understand:
    - the fundamental concepts related to a digital transmission chain, from capturing physical information, processing it, to transmitting it over a wireless network,
    - the different parameters to consider when shaping an analog signal,
    - the various parameters to consider when choosing a wireless transmission technology,
    - basic programming techniques for STM32 microcontrollers.

    The student will also be able to:

    - analyze a problem and design a hardware and software architecture for data transmission based on a specification study,
    - choose the appropriate technologies for transmission from basic or more advanced equipment such as XBee or GSM modules,
    - read a datasheet to understand the operation of simple electronic sensors,
    - build the electronic circuit to shape the signal from the sensor.
6. Research Documentation Training: the student will be able to:
    - collect relevant and reliable academic/research documents using various sources,
    - present their bibliographic synthesis in a structured and standardized format.

Content

The content for this course includes:

1. Power Transmission Architecture
    - Teaching focused on power systems with mechanical applications (actuators, drives, propulsion chains, etc.).
    - Divided into three areas: hydraulics, electrical engineering, and mechanics, with an analysis of the technological components that fulfill functions such as: dosing, distribution, transformation, conditioning, and management.
    - Practical examples covering mobility/construction sectors (electric vehicles, aerospace, construction machinery).

2. CAD and Digital Twin
    - Work on a CAD model of a recumbent electric bike, where the driving behavior is co-simulated (suspension/propulsion).
3. Embedded Computing and Electronics
    - Sensor analysis (e.g., temperature probe),
    - Building a circuit integrating an operational amplifier,
    - Hands-on experience with STM32 microcontroller family,
    - Hands-on experience with various RF transmission modules,
    - Setting up a complete hardware and software architecture to enable wireless temperature communication.
4. Research Documentation Training
    - Training will be provided on scientific dissemination channels (documentary databases, journals), research methodologies, and associated tools.
    - There will also be an introduction to copyright and the analysis of information quality.

Prerequisites

The prerequisites for this course include:

- Power Transmission Architecture: Basic technological knowledge in mechanics is required, as the leveling course is brief. Self-training materials will be available online.
- Embedded Computing and Electronics: first-year computer science course.

Assessment

Assessement for this course includes:

- Power Transmission Architecture: 1 Multiple Choice Quiz + 1 Written Evaluation
- Mechanism Analysis: No Evaluation
- CAD and Digital Twin: Evaluation based on the TD (Tutorial) sessions
- Introduction to Industrial Networks: No Evaluation
- Embedded Computing and Electronics: Multiple Choice Quiz and Evaluation of Programs and/or Written Evaluation.
- Training in Document Research : Evaluation based on 2 reports: 1 bibliographic, 1 progress report and projection for S8

Back to menu

Modeling tools and systems engineering process

Module details

I4ISTI71-IE-exc

4 ECTS FR
28.75 h 12.5 h 11.0 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

The module consists of 3 components with their specific objectives:

1. Industrial Networks Introduction
   - The student will have acquired the fundamental knowledge of industrial networks and protocols.
2. Embedded Computing and Electronics: The student will understand:
   - the fundamental concepts related to a digital transmission chain, from capturing physical information, processing it, to transmitting it over a wireless network,
   - the different parameters to consider when shaping an analog signal,
   - the various parameters to consider when choosing a wireless transmission technology,
   - basic programming techniques for STM32 microcontrollers.

   The student will also be able to:
   - analyze a problem and design a hardware and software architecture for data transmission based on a specification study,
   - choose the appropriate technologies for transmission from basic or more advanced equipment such as XBee or GSM modules,
   - read a datasheet to understand the operation of simple electronic sensors,
   - build the electronic circuit to shape the signal from the sensor.
3. Research Documentation Training The student will be able to:
   - collect relevant and reliable academic/research documents using various sources,
   - present their bibliographic synthesis in a structured and standardized format.

Content

The content of this course includes:

1. Industrial Networks Introduction
   - General introduction to industrial networks and protocols.
2. Embedded Computing and Electronics
   - Sensor analysis (e.g., temperature probe),
   - Building a circuit integrating an operational amplifier,
   - Hands-on experience with STM32 microcontroller family,
   - Hands-on experience with various RF transmission modules,
   - Setting up a complete hardware and software architecture to enable wireless temperature communication.
3. Research Documentation Training
   - Training will be provided on scientific dissemination channels (documentary databases, journals), research methodologies, and associated tools. There will also be an introduction to copyright and the analysis of information quality.

Prerequisites

Embedded Computing and Electronics and first-year computer science course.

Assessment

Assessement for this course includes:

1. Introduction to Industrial Networks
   - No Evaluation
2. Embedded Computing and Electronics

- Multiple Choice Quiz and Evaluation of Programs and/or Written Evaluation.

3. Training in Document Research

    - Evaluation based on 2 reports: 1 bibliographic, 1 progress report

Back to menu

Remedial course on automatics and electronics*

Module details

I4ISME71-RAE-exc

1 ECTS FR
0.0 h 10.0 h 2.75 h 0.0 h
GUIGNARD LUDOVIC
Revision date : May 18, 2026

Objectives

At the end of the module, the student should know :

- Model a planar system for a static or dynamic study
- Solve a dynamic problem by choosing and applying the right method
- Analyse a kinematic mechanism.

Content

The content of this course includes:

- 3 Newton's laws, types of force, principle of virtual work, potential and kinetic energy.
- Modeling of simple systems, external mechanical actions, resolution method.
- Kinematic connections

Prerequisites

Point mechanics

Assessment

Under construction

Back to menu

Remedial course on mechanical engineering*

Module details

I4ISTI71-RGM-exc

1 ECTS FR
0.0 h 7.5 h 0.0 h 0.0 h
ABDELLATIF SLIM
Revision date : May 18, 2026

Objectives

At the end of this course, students will be able to explain :

- the operating principles of computer networks and their data routing function
- how the Internet is organised and how data is routed on the Internet
- addressing and naming in computer networks and the Internet
- the concepts of protocol, service, communication layer and communication architecture
- the TCP/IP architecture of the Internet and describe the services of the main protocols (IP, TCP, UDP)

Content

The course is a mixture of lectures and tutorials and is structured as follows:

- Chapter 1: Introduction to computer networks and the Internet
- Chapter 2: Addressing in computer networks and the Internet
- Tutorial 1: addressing in computer networks
- Tutorial 2: communication architecture
- chapter3 : Internet Communication Architecture
- Tutorial 3: TCP/IP Architecture of the Internet

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Mechatronics project

Module details

I4ISMM81-PM-exc

4 ECTS EN/FR
2.5 h 7.5 h 23.75 h 12.5 h
REYSSET AURELIEN
Revision date : May 18, 2026

Objectives

The main objective of the domain is to develop the ability to size, prototype, and validate, as well as integrate significant issues such as the strong vibratory-control coupling from the early design phase of a mechatronic system.

Content

The domain of mechanical engineering, mechatronics, and powertrains 2 integrates several components with content covering various aspects:

- Mechatronic project: prototyping, integration, and validation of a mechatronic system in a process combining real-time simulation and test bench.
- Mechatronic design: methodology/tools and models for the sizing of multiphysical power architectures.
- Structural dynamics: vibratory analysis of mechanical structures and associated control.
- Specialization: specific teaching is provided depending on the AE/GM background, complementing structural dynamics with a focus either on control or vibratory analysis.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Mechatronics design

Module details

I4ISMM81-CM-exc

2 ECTS FR
6.25 h 10.0 h 5.5 h 0.0 h
BUDINGER MARC
Revision date : May 18, 2026

Objectives

In a context of rapid technological change and increasingly complex industrial organizations, developing a new system from scratch represents a major challenge. The preliminary design and sizing phase is one of the most crucial stages in the overall product development process, during which the key characteristics and performance of a system are defined for the first time. This early stage is critical, as it lays the foundation for the system's main features and directly influences the final performance, feasibility, and cost of the product.

Content

The content of this course includes:

- Sizing scenarios for a technical system
- Estimation and simulation models for components or assemblies of technological components
- Sizing and optimization procedures
- Implementation of calculations in a digital environment (Python, Excel)

Prerequisites

Prerequisites for this course include:

- Basic knowledge of 0D/1D multiphysics modeling
- Basic knowledge of optimization

Assessment

Under construction

Back to menu

Advanced lectures for mechnaical engineering

Module details

I4ISMM81-AGM-exc

1 ECTS FR

0.0 h 11.25 h 0.0 h 0.0 h

SEGUY SEBASTIEN

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Advanced lecture for automatic and eletronics

Module details

I4ISMM81-AAE-exc

1 ECTS FR
0.0 h 12.5 h 0.0 h 0.0 h
TONDU BERTRAND
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain the basic principles of data acquisition using a computer.
Students should be able to:

- Size the different components of a simple data acquisition system
- Use a graphical programming language dedicated to data acquisition and processing (LabVIEW)

Content

Study of the different components making up a data acquisition system (from the sensor to the computer):

- Sensors
- Signal conditioning
- Data acquisition card
- Development of a data acquisition program and a user interface

Prerequisites

Prerequisites for this course include:

- Basic concepts of algorithms
- Fundamentals of electrical circuit theory (electrokinetics)

Assessment

Written report and oral presentation on both projects + practical exam.

Back to menu

Modeling and control of structures

Module details

I4ISMM81-CS-exc

2 ECTS FR

6.25 h 10.0 h 11.0 h 0.0 h

PASSIEUX JEAN-CHARLES

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Instrumentation

Module details

I4ISTI81-CM-exc

2 ECTS FR
2.5 h 13.75 h 5.5 h 0.0 h
VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain the basic principles of data acquisition using a computer.
Students should be able to:

- Size the different components of a simple data acquisition system
- Use a graphical programming language dedicated to data acquisition and processing (LabVIEW)

Content

Study of the different components that make up a data acquisition system (from the sensor to the computer):

- Sensors
- Signal conditioning
- Data acquisition card
- Development of a data acquisition program and a user interface

Prerequisites

Prerequisites for this course include:

- Basic concepts of algorithms
- Fundamentals of electrical circuit theory (electrokinetics)

Assessment

Written report and oral presentation on both projects + practical exam.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Object oriented programming and real-time

Module details

I4ISTI81-IL-exc

4 ECTS FR

12.5 h 13.75 h 22.0 h 0.0 h

BARON CLAUDE

Revision date : May 18, 2026

Objectives

This module consists of two components:

- The part on real-time systems presents real-time systems, key concepts, applications, constraints, and teaches the programming of these systems using the services of real-time operating systems.
- At the end of the object programming part, students will be able to produce C++ code from a UML class diagram with relationships, inheritance and polymorphism.

Content

Real-time section :
The module covers the mechanisms of real-time kernels and the design of applications on these executables. The student should be able to :

- set up a design methodology to meet a specification with time constraints
- Design software architectures for real-time applications
- correctly size the various task parameters and synchronization and communication means
- Program the system using the services of a real-time operating system and an object-oriented language
- Develop, simulate and analyze application performance

Object-oriented programming section:
At the end of the course, students will be able to explain what is (in the object-oriented paradigm).

- A class (attributes, methods, encapsulation)
- An object,
- A relationship between classes (association, composition, aggregation, inheritance),
- The polymorphism property and how to obtain it (overloading, overriding).

Prerequisites

Prerequisites for this course include :

- Algotihmics
- C programming (beginner)

Assessment

Exam and project report

Back to menu

Remedial course on mechanical engineering

Module details

I4ISTI81-RGM-exc

0 ECTS FR
0.0 h 5.0 h 0.0 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Modeling tools

Module details

I4ISTI81-OM-exc

4 ECTS FR
25.0 h 12.5 h 16.5 h 0.0 h
LELEUX PHILIPPE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Model Based System Engineering

Module details

I4ISTI81-AC-exc

3 ECTS FR
2.5 h 6.25 h 27.5 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Thermal machines

Module details

I4GMFS71-MT-exc

2 ECTS FR
6.25 h 13.75 h 9.0 h 0.0 h
COLIN STEPHANE
Revision date : May 18, 2026

Objectives

With this course, the goal is to understand the operation of conventional thermal machines, learn how to design them, and optimize their performance.

Content

Building on appropriate thermodynamic reviews and extensions, the course covers the operation of various thermal machines:

- continuous mass flow machines (compressors, turbines, etc.),
- machines with condensable vapors (steam engines, refrigeration machines, etc.), with a focus on designing and optimizing them, particularly in terms of energy efficiency.

All resources are available on the course's Moodle page: https://moodle.insa-toulouse.fr/course/view.php?id=1996.

Prerequisites

Basic knowledge of thermodynamics is helpful, but all the necessary concepts are provided in the course.

Assessment

The assessment includes multiple-choice questionnaires to verify a solid understanding of the course, a written exam focused on a practical problem, and reports on the practical sessions.

Back to menu

Materials and Non-Destructive Testing

Module details

I4GMFS71-MA-exc

4 ECTS   FR
15.0 h   13.75 h   11.5 h   0.0 h
DUFOUR JOHN ERIC
Revision date : May 18, 2026

Objectives

Materials: Students should be able to explain the basics of the failure mechanics and discuss about the associated problematics with a with a metallurgist.
Non Destructive Tests: Students should know the main techniques used in NDT associated with their pros and cons to be able to choose the right method to control a given industrial problem and use it in compliance with the standards.

Content

Materials: Presentation of the mechanisms of plastic deformation and damage of metallic materials by showing phenomenological aspect of plasticity, fatigue, creep, corrosion and failure mechanic.
Non Destructive Tests: Liquid penetrant testing and magnetoscopie, Eddy currents, Ultrasound testing, Radiology

Prerequisites

The students should already know the basic physical concept regarding electricity, electromagnetism, thermodynamics, optics and material science

Assessment

Written final exam and laboratory works

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Structural Analysis I

Module details

I4GMFS71-CS-exc

5 ECTS FR
25.0 h 23.75 h 12.0 h 0.0 h
PASSIEUX JEAN-CHARLES
Revision date : May 18, 2026

Objectives

The Structural Design 1 component groups together the Finite Elements and Vibration components. The objectives of these two components are described below.
Finite Elements :

- After completing this module, the student should be able to master the theoretical foundations of the finite element method applied to the sizing of structures in the field of linear (thermo)elasticity.
- He/she will also be capable of analyzing and designing models with precision using the finite element method, using mesh generation techniques (free and regular) and applying boundary conditions representative of the real loading on the studied part.
- The student will also be able to analyze the quality of the solution in a critical manner considering numerical phenomena that may alter it.
- Finally, he/she will be able to program and automate the finite element method using a computer language such as Python.

Vibrations :

- identify mass-spring model parameters (stiffness, mass, etc.)
- determine the characteristic parameters of 1-degree-of-freedom mass-spring models (natural frequency, damping factor)
- determine the free response and harmonic response of mass-spring models
- use frequency response functions to determine harmonic response
- use analytical formulas to determine the natural frequencies of continuous models (beam...)

Content

Finite Elements :

- Recall of direct problem in structural analysis, along with its strong and energetic formulations
- We will then address the Ritz method before introducing the concept of the finite element, which will be gradually illustrated with bars (normal force), beams (bending moment) and plane elasticity elements.
- Additionally, we will explore technical aspects such as Gaussian quadrature and parent element, as well as conditions on unknowns like symmetries and periodicities.
- We will also address post-processing (calculation of link reactions and stresses within the elements) and the effect of thermal expansion.
- Hands-on : The practical sessions will focus on practicing mesh generation techniques (free and regular), along with considering boundary conditions. Students will be expected to compare element types, evaluate model precision and analyze results critically.
- Furthermore, we propose an optional project that involves automating and programming the finite element method in Python for a simple case.

In the component Vibrations we cover the following concepts concerning the vibration of mass-spring systems and the vibration of continuous structures:

- Equating mass-spring systems by writing down the fundamental principle of dynamics
- Free response and harmonic response of a one-degree-of-freedom model
- Free response and harmonic response of multi-degree-of-freedom models
- Frequency response functions
- Vibrations of analytical structures (beams, strings, etc.)

Prerequisites

Finite Elements :

- Mathematical tools : linear algebra, numerical analysis (Python).

- Continuum mechanics: stresses, deformation, constitutive relation, potential energy theorem, Neumann and Dirichlet boundary conditions.
- Beam theory : normal force, bending moment, Euler-Bernoulli theory, moment of inertia, deformation energy, stresses in beams.

Vibrations :

- Ability to apply the Fundamental Principle of Dynamics
- Solving eigenvalue problems
- Complex numbers: modulus, argument
- Writing simple Python scripts

Assessment

Vibrations : Assessment takes the form of a final exam and one or more interim exams.

Back to menu

Manufacturing Processes I

Module details

I4GMCF71-FA-exc

5 ECTS FR
18.75 h 18.75 h 18.0 h 0.0 h
SEGUY SEBASTIEN
Revision date : May 18, 2026

Objectives

The student will be able to:

- Classify groups of manufacturing processes and understand the relationship between process and mechanical properties
- Define the influencing parameter on cutting material
- Optimize a machining operation in HSM
- Design parts by casting
- Argument the choice of a process for obtaining raw parts by casting
- Discuss critically and objectively with a professional in obtaining raw parts by casting
- Define the advantages and limitations of additive manufacturing processes
- Design and produce plastic parts using an additive manufacturing process

Content

Program (detailed contents):

- Theory of cutting
- Cutting tools
- Optimization of cutting conditions
- High speed machining
- Chatter
- Shaping of plastics and composites
- Casting
- Presentation of Additive Manufacturing processes and intervention of specialized industrialists
- Method of implementing a 3D printing process

Prerequisites

Prerequisites for this course include:

- CAM manufacturing technology
- Tolerance Manufacturing analysis
- Mechanical characteristics of materials
- Resistance of materials: elasticity
- Know how to read a technical drawing
- Digital production chain: CAD, CAM, Post-processing, use of means of production, control

Assessment

Written exam in the different subjects
The subjects of the written exam are based on studies of industrial parts, aeronautics or automotive.
Written examen, Report and Labwork

Back to menu

Mechanical Transmission and Introduction to Research Project

Module details

I4GMCF71-TM-exc

7 ECTS EN/FR
0.0 h 80.0 h 0.0 h 6.25 h
LERAY DIMITRI
Revision date : May 18, 2026

Objectives

Mechanical Power Transmissions

- analyze the specifications for a gear reducer
- design the reducer and write the associated calculation instructions
- communicate a solution with a 2D drawing and a digital mock-up.

Bibliographic research

- carry out, synthesize and cite bibliographical research on a given scientific subject

Content

Mechanical Power Transmissions

1. Part I - CAD
   - elements for efficient use of CAD tools (data organization; top-down modeling using skeletons)
   - training in 3DX software
2. Part II - Tutorial
   - planetary gears (basic reasoning, transmission ratio, stress analysis, energy efficiency)
   - detailed geometry of involute gears (addendum offset, helical gears, interference)
   - dimensioning of involute gears (surface pressure, bending stress)
   - technology and sizing of angular contact bearing pivot connections
3. Part III - Project

In groups of 2 or 3 students, using the following data:

- context of use, geometry
- input and output data
- desired lifetime

Each group draws up:

- a complete design brief for the entire mechanism (gears, shafts, connections, pivot links)
- a digital model of the project
- a cross-sectional drawing of the mechanism

Bibliographic research :

- This forms the first part of the "Research Project".
- The "Bibliographic Research" part is supervised by Bib'INSA staff.

Prerequisites

Solid mechanics:

- equilibrium equations
- calculation of connexion forces

RdM:

- beam-type calculations

Mechanical technology :

- connections: classic designs
- radial bearing pivot connections: design and sizing
- basics of metal parts manufacturing

Assessment

Under construction

Back to menu

Fluid Mechanics and Heat Transfer II

Module details

I4GMFS81-FT-exc

5 ECTS FR
25.0 h 25.0 h 15.0 h 0.0 h
ROJAS CARDENAS MARCOS JAVIER
Revision date : May 18, 2026

Objectives

This course is an advanced course that builds on the foundational concepts of heat transfer acquired in the Ideal Fluid Mechanics 1 (I3ICFT01) and Transferts Thermiques 1 (A3GMCM51-TT) course. At the end of this course, the student should have understood and will be able to explain the basics allowing to approach a phenomenon involving real (viscous) fluids. He will be able to tackle situations involving more or less complex heat and mass transfers. The student will also be able to conduct a numerical simulation with Ansys Fluent code.

Content

Viscous Fluid Flows :

- Intro: viscosity, fluid particle, deformation, Eulerian and Lagrangian reference system
- Fundamental eqs : Conservation of Mass, Linear Momentum (Navier-Stokes eq) and Energy, dimensional analysis and similarity
- Internal flows: Analytical solution of the fundamental equations, friction factor, head losses, hydraulic circuits
- Labwork: Rheology, pumps characterization, hot-wire anemometry

Heat transfer 2:

- Unsteady-state conduction
- Additional external convection topics
- Heat exchangers using tube bundles
- Impinging jets
- Convection with mass transfer (evaporation, sublimation)
- Internal convection

Prerequisites

It is essential to have a solid understanding of the foundational concepts taught in :

- Thermodynamics
- Introduction to fluid mechanics (I3ICFT01 Fluid Mechanics 1)
- Transferts Thermiques 1

Assessment

The assessment is based on a written exam consisting of 3 practical exercises and a project, which is reported as part of the numerical practical sessions.

Back to menu

Composite materials

Module details

I4GMFS81-MC-exc

3 ECTS FR
17.5 h 5.0 h 6.0 h 12.0 h
CASTANIE BRUNO
Revision date : May 18, 2026

Objectives

The objectives of this course includes:

- Know the materials and different technologies for manufacturing composite structures.
- Know the classical theory of laminates to perform simple static sizing at first ply rupture.

Content

The content of this course includes:

- Fibers and matrices.
- Eco composites and wood.
- Manufacturing methods in or out of autoclave and automated.
- Case of thermoplastic matrices.
- 2D1/2, 3D, 4D composite architectures and sandwich structures.
- Aeronautical, energy, automotive, naval and space applications.
- Orthotropic ply behavior.
- Laminate theory.
- Static pre-sizing using the Hill or Yamada-Sun criterion.
- Nonlinear behavior of laminates under impact and after impact. Damage tolerance.

Prerequisites

Continuum Mechanics

Assessment

Assessement of this course includes:

- Examen terminal
- BE Composite
- Report of LabWork "Fabrication"

Back to menu

Structural Analysis II

Module details

I4GMFS81-CS-exc

4 ECTS EN/FR
7.5 h 6.25 h 15.0 h 12.0 h
OUMAZIZ PAUL
Revision date : May 18, 2026

Objectives

Structural Design 2 is structured around 3 components: Finite element project, vibration practical work and reliability. The main objective of the component is to reinforce mastery of the theoretical concepts acquired in the first semester, by applying them to specific concrete contexts and applications. More specifically, the objectives of each component are described below.
Students should be able to:

1. Finite element project
   - Understand the methods and principles of finite element analysis using a reference finite element code.
   - Identify the functionalities offered by these digital tools and the associated potentialities.
   - Create relevant analysis models
   - Exploit results
   - Analyze the impact of modeling assumptions.
   - Evaluate the risks associated with misuse of results.
2. Vibration practical work:
   - The aim of the course is to introduce the concepts of experimental vibration, in particular the handling of impact hammer tests, and vibration monitoring of machine tools.
   - It also involves comparing analytical and numerical models with experimental results.
3. Reliability:
   - Introduction to uncertainty propagation and reliability in structural mechanics
   - First Order Reliability Method (FORM) for estimating failure probability
   - Mastering the Monte-Carlo method
   - Awareness of uncertainty management in the design process

Content

The content of this course includes:

1. Finite element projects:
   - Students develop the various phases of a finite element analysis using a modern calculation tool: geometric modeling of a structure, meshing, boundary conditions, resolution, critical analysis of results. It covers the various functionalities offered by the codes: mastery of meshing techniques, assembly of different structures, use of specific elements and algorithms dedicated to non-linear problems (contact, plasticity), error estimation, etc.
   - The course is divided into two periods. The first period is devoted to understanding and getting to grips with the calculation code that serves as the teaching support tool. This period is very closely supervised. In the second phase, students are required to carry out a partially autonomous analysis in the form of a project. The student is provided with a pre-defined support and study framework.
2. Vibration practical work :
   - Impact hammer tests and identification of modal properties of a free structure
   - Comparison of analytical and numerical (finite element) models with experimental results
   - Use of vibration measurements to monitor the condition of a machine tool
   - Modeling and manufacturing a small piezoelectric motor
   - Simulation of gyroscopic effects for rotating shafts
3. Reliability :
   - Introduction to probabilistic formalism (reminder of modeling using random variables)
   - Resistance - stress case
   - Iso-probabilistic transformation and Hasofer-Lind index
   - FORM method
   - Monte-Carlo method
   - Conclusions and outlook (variance reduction method, importance drawing and meta-model).

Prerequisites

The prerequisites for this course include:

1. Finite element project : Geometric modeling (CAD) and finite element foundation, in particular having taken the Finite Element component of EC Calcul de Structures 1 (I4GMFS71-CS) or equivalent at an external institution. Beam theory, continuum mechanics, material behavior.

2. Vibration practical work: Completion of the Vibrations component of EC Calcul de Structures 1 (I4GMFS71-CS) or equivalent at an external institution.

3. Reliability :

   - Course in probability and statistics (in particular absolutely continuous random variables)
   - Calculation of integrals
   - Python programming

Assessment

The assessement for this course includes:

- Finite element project : marking at the end of the practical work and the final project report.
- Vibration practical work : Assessment will be based on the PT reports due at the end of each session.
- Reliability: A table-top examination will be used to assess the Reliability component.

Back to menu

Advanced Mechanical Modeling

Module details

I4GMCF81-MM-exc

6 ECTS FR
0.0 h 65.0 h 15.0 h 0.0 h
PAREDES MANUEL
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain how works a pre-stressed (or preloaded) mechanical system

Content

The basis of behavior under preload is highlighted through the study of fatigue life of shafts, angular contact bearings, fasteners, interference shaft assemblies and mechanical springs.
The design office is broken down into 3 parts:

- Study 1: Study of a hydrostatic transmission
- Study 2: Study of an automatic gearbox
- Project: Design of a braked hydraulic winch

Prerequisites

Understanding of mechanical systems, physics of material and strength of materials

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Manufacturing processes II and Research Project

Module details

I4GMCF81-FP-exc

4 ECTS EN/FR
6.25 h 10.0 h 0.0 h 18.75 h
MONTEIRO DE ARAUJO ANNA CARLA
Revision date : May 18, 2026

Objectives

Production Planning : The Manufacturing Management course aims to provide students with an understanding of the key principles of industrial production. It covers the history of industrial revolutions, the organization of the production floor, lean manufacturing concepts, and innovations linked to the industry of the future. A practical industrial organization project enables students to apply this knowledge to optimize a production unit. Metallic Forming (Plastic deformation) : At the end of the Plastic Deformation module, the student should be able to define the raw material and the manufacturing sequence for parts produced using plastic deformation processes (forging, bending, stamping, etc.). Research Project : The module aims at giving the students a first experience with research through a tutored project in teasm (2 to 4 students). At the end of the module, the student will :

- know how to conduct a bibliography search, synthesise and cite it, for a given scientific topic;
- communicate with rigor in English, orally of through written documents to highlight the research activity performed;
- perform a simple research action in a team organization to generate scientific propositions, then implement and finally assess them."

Content

Production Planning :

- The Manufacturing Management course aims to provide students with an understanding of the key principles of industrial production.
- It covers the history of industrial revolutions, the organization of the production floor, lean manufacturing concepts, and innovations linked to the industry of the future.
- A practical industrial organization project enables students to apply this knowledge to optimize a production unit.

Metallic Forming (Plastic deformation) :

- At the end of the Plastic Deformation module, the student should be able to define the raw material and the manufacturing sequence for parts produced using plastic deformation processes (forging, bending, stamping, etc.).

Research Project :

- The module aims at giving the students a first experience with research through a tutored project in teasm (2 to 4 students).

At the end of the module, the student will :

- know how to conduct a bibliography search, synthesise and cite it, for a given scientific topic;
- communicate with rigor in English, orally of through written documents to highlight the research activity performed;
- perform a simple research action in a team organization to generate scientific propositions, then implement and finally assess them.

Prerequisites

Production Planning : Prerequisites for the Manufacturing Management course include a basic understanding of manufacturing principles (Fab Additive, Machining. Molding).
Metallic Forming : Industrial Drawing, Constructive solutions associated with kinematic joints, Basic principles of manufacturing processes
Research Project :This course is a continuation of the work done in semester 7. It is highly recommended that the student does both semesters.

Assessment

Production Planning : A practical industrial projet is graded.
Metallic Forming (Plastic deformation) : Final Exam
Research Project : scientific report assessed by the scientific tutor and Oral Presentation in a Mini-Conference

organised by DGM.
The oral and written deliverables are targeted to each step of the project, with close link to other courses.

Back to menu

Industrialization and Logistics

Module details

I5ISPR22-exc

5 ECTS EN/FR
36.25 h 16.25 h 13.75 h 0.0 h
MONTEIRO DE ARAUJO ANNA CARLA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The systems of industrialization and its interfaces.
- The challenges of production management (PM) and supply chain (SCM) as well as issues of scheduling.
- What is configuration management, what are the enablers and what is the purpose

The student will be able to:

- Have an overview on manufacturing processes
- Understand the historical context of Industrialization
- Have a critical view on global manufacturing strategy
- Understand the elements on Smart Manufacturing and Industry 4.0
- Use the information of the different types of Industrial Management Tools
- Roughly describe airbus world (A/Cs family, industrial sharing across the Europe)
- Define a hierarchical and appropriated breakdown of a complex product
- Apply the change process and identify required data to allow decision
- Identify mechanisms that enable management of product offer and its customisation
- Demonstrate that final product manufactured is conform to expectations

Content

Industrialization :

- Overview of manufacturing processes
- Historical context on global manufacturing
- Smart manufacturing and Industry 4.0
- Tools for industrial management
- Production of a CNC code using CAD/CAM Software
- Analysis of a CNC code and CNC trace of servo position data from machine
- Virtual design by digital scanning

Production management, planning, scheduling :

- Production management and logistics
- Linear programming applied to planning
- Graphs and scheduling application
- Scheduling and combinatorial optimization
- Production Planning
- Labwork : Introduction to AMPL and Excel

Configuration Management :

- Configuration management generalities (first look and presentation of modules that will be detailed afterwards)
- Product structure (What is product structure, how it is built and what are the main rules)
- The change process (all different steps of a change request during the full process, data and deliverables requiered pending on progress in the process)
- Offer management (what is offer management and what are the associated deliverables)
- Attestation and control of conformity (Delta managements)
- Conclusion (links between Configuration Management modules and synthesis)

Prerequisites

Prerequisites for this course includes:

- Reading of plans, current metallic materials, various types of machining.

Basic elements on:

- Probabilities
- Linear programming

Assessment

This course is assessed:

- By interaction with students during courses
- By practising with different use cases
- By concluding with a written exam

Assessement also includes:

- Use cases allow students to apply a complex process and understand all its mechanisms.
- During this practice, the interaction between student/teacher is promoted, thus students can ask relevant questions and teachers can insist on important notions.
- Last but not least, written exam allows to ensure that information has been assimilated properly

Back to menu

Mechatronic/Technological systems for sustainable mobility

Module details

I5ISMD11-exc

4 ECTS FR
10.0 h 17.5 h 19.25 h 0.0 h
BUDINGER MARC
Revision date : May 18, 2026

Objectives

At the end of this module the student should be able to:

- Set up a dynamic vehicle model to calculate power requirements and energy consumption and optimize a mission profile to minimize energy consumption
- Sizing an energy storage assembly (supercapacitor, batteries) and a static DC/DC converter
- Carry out an LCA assessment (Life Cycle Analysis)
- Analyze the architectures of static converters applied to electric vehicles
- Control a set of converters to manage the overall energy needs of a vehicle

Content

The module has 4 parts:

- Needs, scenarios and requirements
- Ecodesign, Analysis and CV
- Control of converters and actuators
- Technologies of converters and energy storage systems

The common thread study concerns means of electric public transport (buses, electric trams).

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Reliable systems

Module details

I5ISGR22-exc

4 ECTS EN/FR
26.25 h 16.25 h 2.75 h 0.0 h
BARON CLAUDE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain the notions associated with dependability, reliability, maintenance and risk, as well as the organizations, trades, methods and activities useful to implement these notions.
The student will be able

- to identify the hindrances to the availability and to the reliability of systems,
- to make an assessment for choosing the most suitable architectures,
- to choose among the available methods the most appropriate to obtain the expected service of a system, when designing and maintaining, and to provide its insurance.

Content

The content of this course includes:

1. Dependability
   - Needs and obstacles
   - Techniques for preventing, detecting and removing, and tolerating faults.
2. Reliability
   - General and mathematics for reliability.Methods for reliability (Functional Block Diagrams): Fault-Tree analysis (FTA) and Minimum Cut set (MCS), Reliability block diagram (RBD) for non-repairable components, Markov Diagram and models for complex systems, including coverage and repair processes.
   - Fail-safe design and application to current industrial examples.
   - General and mathematics for reliability.
3. Maintenance
   - Introduction to the maintenance function. Maintenance strategies. Failure rate and concept concerning the status of a device.
   - Industrial maintenance by vibration analysis, mechanical defects and associated vibration signals, signal processing methods, diagnosis of industrial cases.
4. Safety assessment
   - Presentation of the issues related to safety in critical systems. Illustration in aeronautics.
   - Model-based approaches to safety assessment
   - Methods and tools to assess the safety of complex systems (Altarica, Cecila-OCCAS)

Prerequisites

The prerequistes for this course include:

- System life cycle.
- Basic knowledge on probabilities.
- Statistics.
- Signal processing.

Assessment

Assessement for this course includes:

- Dependability: the student must be able to choose the means appropriate to each development step to insure the expected service of a system.
- Reliability: the student shall be able to select and apply the various methods and tools enabling the candidate system architectures to be assessed and decisions to be made regarding main contributors to unreliability.
- Maintenance): the student must be able to identify and select a maintenance policy. It must be able to implement vibratory maintenance tools.
- Risk Management: student must be able to identify risks of a system, to assess its significance, and to choose efficient and effective risk controls to insure users' safety.

Project defended as a response to a call for tender with feedback on weakness.

Back to menu

Research project and industrial property

Module details

I5ISPJ21-exc

8 ECTS EN/FR
7.5 h 40.0 h 44.0 h 0.0 h
BUDINGER MARC
Revision date : May 18, 2026

Objectives

Under construction

Content

Part 1: This educational unit aims to have students work in project groups on the following types of projects:

- Addressing Societal Challenges:** In cooperation with associations (e.g., Formula Student, TIM, ...) and vocational campuses (such as CMQe MTI).
- Innovative Projects: Focusing on new products.
- Interdisciplinary Projects: Involving at least two subjects from the 4th and 5th years.

Students will be required to work autonomously and will be evaluated on their ability to work as a team and propose concrete solutions.
Part 2: Intellectual and Industrial Property Module
This module aims to achieve five major objectives:

1. Understand and Explain Key Concepts:
   - Distinguish the major differences between intellectual and industrial properties.
   - Autonomously initiate protection procedures by addressing the appropriate interlocutors, based on one's inventive activity and protection needs.
   - Know the costs and limitations associated with these procedures.
2. Describe and Define:
   - The different types of protections available.
   - The legal framework of each protection and the modalities of application.
3. Understand Protection Strategies:
   - Strategies associated with patents, disclosure, or secrecy.
   - Corporate strategies related to the defense and exploitation of industrial property, such as the "Patent Pool" strategy, Licensing strategy, monopolistic strategy, and the "false route" strategy.
   - Explain the advantages and disadvantages of each strategy.
4. Identify Protection Organizations:
   - Know the major protection organizations and their respective roles to effectively navigate one's protection needs.
5. Initiate Protection Procedures:
   - Start the procedures to protect an invention, a trademark, a design, a model, a domain name, a work, a musical composition, a software program, or any other discovery.
   - Know the deadlines, costs, as well as the temporal and geographical limitations associated with these procedures.

This module aims to equip students with the skills necessary to navigate the complex field of intellectual and industrial property, providing them with the tools and knowledge to effectively protect their innovations and creations.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Systems on chip *

Module details

I5ISEC11-exc

4 ECTS EN
20.0 h 0.0 h 30.25 h 0.0 h
DRAGOMIRESCU DANIELA
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain:

- the design and performance optimisation of advanced digital systems (e.g. microprocessors)
- notions of hardware security for digital systems
- hardware embedded AI techniques
- co-design: the joint hardware-software design of a complex system depending on the chosen application.

The student should be able to :

- design and implement advanced digital systems using the VHDL language on FPGAs and optimise their performance in terms of power consumption and operating frequency according to the specifications of the application.
- design and implement neural networks on FPGAs

Content

This course is organised around the methodology of designing digital hardware systems.
In the first part, the design, implementation and performance optimisation (frequency, power consumption, etc.) of complex digital systems on FPGA/ASIC are taught.
Notions of hardware security for digital systems, typically processors, will also be presented. Next, the life cycle of Systems on Chip

- SoC or Systems on Programmable Chip
- SoPC (specifications, design, implementation) is discussed in the context of joint hardware/software development, followed by a presentation of co-design and hardware/software co-verification techniques.
- The chiplet-based approach to designing complex analogue and digital systems will also be presented.

Part 3 will cover the concepts of embedded AI, presenting the different types of neural networks and their hardware implementation on FPGAs, with a focus on the new types of processors that include neural components: neural engine, neural processor unit (NPU), tensor processor unit (TPU).
Practical work will focus on VHDL design and implementation:

- a RISC microprocessor on an FPGA
- a perceptron and a neural network (MLP) on FPGA

Prerequisites

Prerequisites for this course includes:

- Digital electronics
- Microprocessor hardware architecture
- Requirements engineering

Assessment

Under construction

Back to menu

Thermal engines and systems *

Module details

I5ISTH12-exc

4 ECTS FR
13.75 h 12.5 h 22.0 h 0.0 h
HAZYUK ION
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to analyze thermal and mechanical energy production systems and their associated components.
The student should be able to:

- Analyze the thermodynamic cycle associated with a power plant.
- Size a thermal engine to meet specifications in terms of requested power.
- Specify the components of a thermal engine or system.
- Calculate the air conditioning flow requirements to perform various functions (pressurization, fresh air renewal, heating, cooling) in an aircraft and adjust the recirculation and the flow distribution between the different cabin zones.

Content

Thermal engines:

- reminder of the principles of thermodynamics, fluid modeling, thermodynamic transformations (isobar, isoenthalp, adiabatic, etc.).
- analysis of the thermodynamic cycles of steam engines, gas turbines and heat pumps.

Thermal systems:

- Lumped parameter modeling of components involved in thermal engines and systems such as heat exchangers, compressors, turbines, valves.
- Case study on an air conditioning and pressurization system for an aircraft.

Computational fluid mechanics:

- Initiation to the CFD code Fluent.
- Numerical simulation of one of the components of a thermal system, in the framework of a project done by groups of 2 students.

Prerequisites

Basics of thermodynamics and heat transfer.

Assessment

Assessement for this course includes:

- Thermal engines: exam.
- Thermal systems: exam, and a lab-work report.
- Computational fluid mechanics: project

Back to menu

Modeling and Sim. of multi-domain systems

Module details

I5GMPP91-MS-exc

2 ECTS FR
8.75 h 5.0 h 15.0 h 0.0 h
REYSSET AURELIEN
Revision date : May 18, 2026

Objectives

The student will be able to model, simulate and analyse multi-domain power systems

Content

This course is dedicated to the lumped parameters modeling and simulation of power systems. The methodology and the analysis is supported by the Bond-Graph formalism.
A progressive approach leads the student to acquire knowledge and practical know-how in muti-domain modelling (models structures, adaptation to simulation software, link with distributed models and inverse problems).
Practicals are based on up-to-date industrial examples that are simulated within both Matlab/Simulink, AMESim and Dymola.

Prerequisites

Dynamic systems, fluid mechanics, solid rigid mechanics.

Assessment

Mixing background work (practicals) by pairs and individual work in limited time.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Multidisciplinary Project

Module details

I5GMPP91-PJ-exc

10 ECTS EN
0 h 0 h 0 h 0 h
MARENIC EDUARD
Revision date : May 18, 2026

Objectives

Intellectual and Industrial Property Module aims to achieve five major objectives:

1. Understand and Explain Key Concepts:
   - Distinguish the major differences between intellectual and industrial properties.
   - Autonomously initiate protection procedures by addressing the appropriate interlocutors, based on one's inventive activity and protection needs.
   - Know the costs and limitations associated with these procedures.
2. Describe and Define:
   - The different types of protections available.
   - The legal framework of each protection and the modalities of application.
3. Understand Protection Strategies:
   - Strategies associated with patents, disclosure, or secrecy.
   - Corporate strategies related to the defense and exploitation of industrial property, such as the "Patent Pool" strategy, Licensing strategy, monopolistic strategy, and the "false route" strategy.
   - Explain the advantages and disadvantages of each strategy.
4. Identify Protection Organizations:
   - Know the major protection organizations and their respective roles to effectively navigate one's protection needs.
5. Initiate Protection Procedures:
   - Start the procedures to protect an invention, a trademark, a design, a model, a domain name, a work, a musical composition, a software program, or any other discovery.
   - Know the deadlines, costs, as well as the temporal and geographical limitations associated with these procedures.

This module aims to equip students with the skills necessary to navigate the complex field of intellectual and industrial property, providing them with the tools and knowledge to effectively protect their innovations and creations.

Content

Course Content:

1. Discovery of Various Types of Protection:
   - Patents
   - Trademarks
   - Designs and Models
   - Copyright
   - Related Rights
   - Discoverers' Rights
   - Protected Designations of Origin (AOP), etc.
2. Practical Applications through Case Studies:
   - Brand Creation and Protection: Establishing and protecting a trademark or domain name within an association or startup, tailored to the students' needs.
   - Inventive Activity: Engaging in inventive activities within the RD department of a company like Decathlon.
   - Patent Research Techniques: Conducting thorough and practical searches in the international patent database (prior art search). Implementing a search protocol using the IPC (International Patent Classification) on the European Patent Office (EPO) website.

This course aims to provide students with a comprehensive understanding of various types of intellectual and industrial property protections, along with practical skills to apply these concepts in real-world scenarios.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Computational Mechanics

Module details

I5GMMAJ91-CM-exc

10 ECTS EN
0 h 0 h 0 h 0 h
PASSIEUX JEAN-CHARLES
Revision date : May 18, 2026

Objectives

The Major in Computational Mechanics aims to:

- Provide students with advanced knowledge and skills in computational modeling and analysis of complex mechanical systems.
- Equip students to address challenges involving material nonlinearity, dynamic behaviors, and multiscale interactions in modern engineering contexts.
- Foster expertise in cutting-edge methodologies, including Artificial Intelligence and data-driven approaches, to revolutionize problem-solving in mechanics.
- Prepare students for careers in industries such as aerospace, biomechanics, and materials science by combining theoretical knowledge with practical applications.

Content

The Major is composed of the following specialized courses:

1. Materials:
   - Study of material nonlinearity in mechanical behavior.
   - Experimental characterization techniques for advanced materials.
2. Aerospace Composites:
   - Design and sizing of aerospace composite structures.
   - Investigation of geometrical nonlinearities in composite materials.
3. Dynamics:
   - Analysis of nonlinear and transient vibration phenomena.
   - Modeling dynamic responses in complex mechanical systems.
4. Multiscale Mechanics:
   - Introduction to multiscale mechanical analysis and coupled computational methods.
   - Applications in biomechanics, architected materials, and the development of innovative mechanical systems.
5. Artificial Intelligence in Mechanics:
   - Use of AI techniques, including topological optimization and data-driven approaches.
   - Development and application of digital twins for mechanical systems.

Prerequisites

The reprequisites for this course include:

- Strong foundation in mechanical engineering principles and mathematics.
- Basic knowledge of computational mechanics and numerical methods.
- Proficiency in programming (e.g., Python, MATLAB) and familiarity with simulation tools is advantageous.
- Interest in integrating emerging technologies such as Artificial Intelligence into traditional engineering practices.

Assessment

The evaluation is based on a combination of:

- Coursework and Assignments: Regular assessments on course topics, including problem-solving and computational analysis.
- Project Work: Group or individual projects addressing complex problems, with emphasis on innovation and application of advanced methods.
- Final Examination: Comprehensive exams assessing understanding of theoretical principles and computational techniques.
- Presentation and Reports: Oral presentations and detailed reports on projects and case studies.
- Continuous Evaluation: Participation in workshops, engagement in discussions, and performance in hands-on activities throughout the module.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Smart Manufacturing

Module details

I5GMMAJ91-SM-exc

10 ECTS EN/FR
0 h 0 h 0 h 0 h
MONTEIRO DE ARAUJO ANNA CARLA
Revision date : May 18, 2026

Objectives

the objectives of this course includes:

1. Advanced machining:
   - Discovering machine tool data acquisition.
   - Controlling vibration problems in machining.
   - Wear analysis on twin-spindle lathes, trajectory analysis on 5-axis CNC.
2. Industrial production:
   - Mastery of production management methods.
   - Method of deploying different methods on concrete cases.
3. Process control:
   - Control of mechanical production processes using statistical indicators and compliance with product specifications.
4. Special Techniques :
   - Discover special production techniques and innovative processes.
   - Identify the technical and economic potential of these special processes. 3) Discovering virtual reality; 4) Practising additive manufacturing.

   Energy efficiency in production: understanding the energy consumption required by industrial processes and the importance of real-time monitoring in proposing energy-saving solutions.

Content

The content of this course incldes:

1. Advanced machining:
   - application of cutting forces and cutting power,
   - wear analysis,
   - analysis of monitoring data,
   - use of 5-axis NC,
   - NC supervision and communication,
   - machining dynamics.
2. Industrial production:
   - lectures,
   - flipped classroom and practical exercises using production management software.
3. Process control:
   - process statistics (MSP) and tolerancing.
4. Special techniques:
   - water-jet machining,
   - metal and polymer additive manufacturing,
   - virtual reality,
   - mixed reality and augmented reality,
   - emerging manufacturing processes.
5. Energy efficiency in production:
   - course on the environmental impact of processes,
   - process-material-property relationships,
   - international cooperation project on monitoring energy and monitoring with data analysis.

Prerequisites

The prerequisites for this course include:

1. Advanced machining:
   - Knowledge of structural dynamics.
   - Knowledge of machining.
   - Mastery of rotation matrices (linear algebra).
2. Industrial Production:
   - Knowledge of the organisation of mechanical production and the concept of the production process.
   - Specific mechanical manufacturing terminology is also required.
3. Process control:
   - Basic statistical indicators (mean, standard deviation, median) and normal distribution.

- Knowledge of dimensioning and decoding of geometric and surface finish specifications assigned to the surfaces of mechanical parts.

4. Special techniques :

   - Knowledge of machining, mechanical production machinery and production management.
   - It will also be necessary to master the specific terminology of mechanical manufacturing.

5. Energy efficiency in production:

   - Knowledge of manufacturing processes and the behaviour of materials.

Assessment

Assessement of this course includes:

1. Advanced Machining :

   - TP assessment and assessment of a mini-project report.
   - In-class exercises.

2. Industrial production:

   - assessment of inverted classroom reports
   - assessment of practical work and written or oral final exam.

3. Process Control :

   - assessment on mini projects.

4. Special Manuf. Processes :

   - assessment of each subject in the form of an examination
   - assessment of practical work or assessment of a mini-project report.

5. Energy efficiency:

   - assessment of mini-projects and a final project for on-site energy measurement.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Fluids Engineering

Module details

I5GMMAJ91-FE-exc

10 ECTS

0 h 0 h 0 h 0 h

BALDAS LUCIEN

Revision date : May 18, 2026

Objectives

The major in Fluids Engineering aims to provide advanced knowledge and skills in the design of systems and microsystems involving heat and mass transfer, in particular using Computational Fluid Dynamics (CFD) approaches. It consists of the following 4 modules:

- An introduction course to Microfluidics, a recent and highly active field of research that is now well-developed and present across all industrial sectors. The objective of this course is to raise students' awareness of the specificities of micro-flows and the numerous applications of microfluidics in various industries (aerospace, environment, healthcare, biochemistry, process engineering, computing, etc.).
- A course in Compressible Fluid Mechanics whose aim is to introduce the tools for modelling tools for subsonic and supersonic compressible fluid flows.
- A course in Turbomachinery whose aim is to familiarize students with the different types of turbomachinery, such as pumps, fans and compressors, as well as steam and water turbines.
- A course in Advanced Computational Fluid Dynamics (CFD) whose aim is to train students in the advanced use of a CFD code for the local analysis of conjugate heat and mass transfers.

Content

Microfluidics module:

1. A brief introduction to the fabrication techniques of fluid microsystems is provided to highlight their advantages and uniqueness. The course then details the specifics of micro-flows, focusing on the micro-effects that require consideration of physical phenomena not encountered in classical fluid mechanics. The course demonstrates that the challenges differ significantly for gases (rarefied flows), liquids (electrokinetic flows), and multiphase flows (discrete microfluidics), using concrete examples illustrated by the latest breakthroughs in research and development. The course consists of the following chapters:
   - Chapter 1: Introduction to Microfluidics
   - Chapter 2: Specificities of Micro-flows
   - Chapter 3: Gas Micro-flows
   - Chapter 4: Liquid Micro-flows
   - Chapter 5: Multiphase Aspects
   - Chapter 6: Experimental Techniques for Analyzing Gas Micro-flows
2. Compressible Fluid Mechanics module: Particular attention will be paid to one-dimensional perfect fluid flows and their application to the study of nozzles, shock and expansion phenomena and flows with heat input and their application to the study of turbojet engines. The course consists of the following parts:
   - Part 1: Main characteristics of compressible flows
   - Part 2: One-dimensional inviscid compressible fluid flows
   - Part 3: Shock and expansion phenomena
   - Part 4: Nozzle thrust
   - Part 5: One-dimensional flows with heat addition
3. Turbomachinery module: Concepts of fluid mechanics and thermodynamics are applied to establish the modelling and understanding of flow in a turbomachine, and to develop basic elements for the design and selection of these machines. This course is a continuation of the incompressible and compressible fluid mechanics and thermal machines courses. The course consists of the following chapters:
   - Chapter 1: General definitions
   - Chapter 2: Positive displacement machines
   - Chapter 3: Description of a turbomachine
   - Chapter 4: Power balance
   - Chapter 5: Similarity laws
   - Chapter 6: Flow representation
   - Chapter 7: Turbopumps
   - Chapter 8: Pumping networks

- Chapter 9: Hydraulic turbines
- Chapter 10: gas and steam turbine

4. Advanced CFD module: The projects developed using the Ansys-Fluent code will focus on modelling turbulent compressible flows (flow around a turbine blade - supersonic jet at the outlet of a turbojet nozzle), simulating unsteady gas flows and studying problems involving heat transfer in turbulent flow.

Prerequisites

A basic background in fluid mechanics, thermodynamics and heat transfer is required.*

Assessment

Assessement of this course includes:

- Microfluidics module: The knowledge is assessed through a written exam consisting of course-related questions and application exercises. The assessment is complemented by an oral presentation on a topic related to microfluidics, chosen by the student and prepared in pairs.
- Compressible Fluid Mechanics module: The knowledge acquired is assessed by a written exam based on application exercises.
- Turbomachinery module: The knowledge acquired is assessed by a written exam based on application exercises.
- Advanced CFD module: Students are assessed on the basis of 3 project reports, the first of which they must complete individually and the next 2 in pairs.

Back to menu

Configuration Management

Module details

I5GMMAJ91-MO-GC-exc

2 ECTS

0 h 30.0 h 0 h 0 h

NDIAYE ASSANE

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Biomechanics

Module details

I5GMMAJ91-MO-BM-exc

2 ECTS

0 h 30.0 h 0 h 0 h

WATIER BRUNO

Revision date : May 18, 2026

Objectives

The objectives of this course include:

- Characterize the position and orientation of a rigid body in space from the coordinates of its constituent points
- Identify 3D angles used to describe the angular position of a rigid body
- Define anatomical reference frames
- Calculate forces and torques at the joints (in 2D)
- Compute Euler angles from data obtained from inertial measurement units (IMUs)
- Define an appropriate protocol for human motion capture
- Critically analyze studies from the literature related to human motion analysis

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Hydraulic Systems

Module details

I5GMMAJ91-MO-SH-exc

2 ECTS
0 h 30.0 h 0 h 0 h
GUIGNARD LUDOVIC
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Tolerancing

Module details

I5GMMAJ91-MO-TO-exc

2 ECTS

0 h 30.0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Partial diff. equations and Fourier series

Module details

I3ICMT51-exc

3 ECTS FR
12.5 h 13.75 h 7.5 h 0.0 h
BAUDOUIN LUCIE
Revision date : May 18, 2026

Objectives

This course aims to master some basic mathematical concepts for the study of partial differential equations (PDE) by the future engineer in Civil Engineering or Mechanical Engineering.
This UE is naturally composed of academic knowledge presented in lectures, and computational know-how (studied in tutorials) and numerical know-how (implemented in practical work).
Students will learn to identify and classify PDEs according to their nature (elliptic, parabolic, hyperbolic). They will approach the basic concepts, properties and theorems concerning Fourier series and Fourier transforms, which are powerful tools for solving PDEs, particularly in areas related to periodic phenomena and vibrations.
Finally, the separation of variables, a classic and effective technique for solving certain classes of PDEs, will be formalized and studied.
This method will be illustrated through several concrete examples linked to wave-type equations (vibration phenomenon) or heat (diffusion phenomenon).

Content

The content of this course includes:

1. Introduction to PDEs and classification
   - Prerequisites in linear algebra, integration, resolution of ordinary differential equations, functions of several variables;
   - Terminology and Examples of PDEs;
   - Classification of linear PDEs of order 2.
2. Fourier Series
   - Physical motivation
   - Space of periodic functions of square integrable
   - Trigonometric series
   - Fourier coefficient
   - Fourier series in L^1 (Dirichlet Thm) then in L^2 (Parseval Identity).
3. Fourier Transform
   - Analysis and Synthesis of the Fourier transform on L^1, algebraic and derivation properties, inverse Fourier Transform and Plancherel Formula, Convolution;
   - Fourier Transform on L^2 and illustrative examples.
4. Sturm Liouville Problem
   - Definition, examples and properties of the solutions.
5. Solving PDEs by Separation of Variables
   - Well-posed problem and Boundary conditions;
   - Homogeneous 1D heat equation; Homogeneous 1D wave equation
   - Generalities on the method of separation of variables (homogeneous Eq, then with source term, then with non-homogeneous boundary conditions, and interest in knowing the associated Sturm Liouville problem)

Students will be provided with a course handout, tutorial statements (then their corrections) and laboratory work.
The laboratory work will be carried out under Python

Prerequisites

Mathematics UE for years 1 and 2. More specifically:

- linear algebra (Diagonalization of matrices)
- integration (change of variable, Integrations by parts)
- resolution of ordinary differential equations (characteristic polynomial, solution of the homogeneous equation and particular solution...)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Continuum mechanics

Module details

I3ICMS51-exc

4 ECTS FR
1.25 h 30.0 h 6.0 h 0.0 h
PASSIEUX JEAN-CHARLES
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have a comprehensive understanding of solid deformation mechanics, stresses, linearized strains, displacement fields and the constitutive relationship in elasticity.
The student should be able to:

- Analyze the state of stress and strain of a solid under loading.
- Calculate the stress state based on the strain state and vice versa.
- Calculate the strain state based on the displacement field.
- Establish equations for the local equilibrium of the solid at every point.
- Propose a relevant modeling of a real problem, particularly in terms of boundary conditions.
- Calculate the stresses from the diagrams of internal solicitations obtained from beam theory.

Content

Theory of stresses, theory of strains, displacement strain relationship, linear elasticity constitutive law, formulation of the elasticity problem, analytical methods for solving the general problem of linear elasticity. Applications in practical exercises using Python programming language.

Prerequisites

Mathematics (analysis, linear algebra, numerical analysis), general mechanics (statics and kinematics), beam theory (internal solicitations, stresses in beams...), basics in Python programming.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Fluid mechanics I

Module details

I3ICMF51-exc

3 ECTS EN/FR
12.5 h 15.0 h 6.0 h 0.0 h
ROJAS CARDENAS MARCOS JAVIER
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The concept of a fluid and the forces acting on a fluid particle.
- The distribution of static pressure within a fluid and the forces exerted by the fluid on a solid surface.
- The ideal fluid in motion: kinematics and dynamics.

The student should be able to:

- Calculate the forces exerted by a fluid on flat and curved solid surfaces.
- Use Bernoulli's equation (energy conservation) and Euler's theorem (momentum conservation) in a wide range of practical applications.

Content

Introductory definitions and general properties of a fluid, forces acting on a fluid particle. Fluid statics for incompressible and compressible fluids, manometry, buoyant force, forces and moments exerted by a fluid on flat and curved surfaces, and pressure distribution in rigid body motion. Fluid dynamics and kinematics, Euler's equation, Bernoulli's equation, mass conservation, control volume and Reynolds transport theorem, linear momentum equation.

Prerequisites

Basic thermodynamics concepts facilitate a better understanding of the fundamental principles.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Dynamic systems

Module details

I3ICSD51-exc

4 ECTS EN/FR
15.0 h 17.5 h 6.0 h 0.0 h
HAZYUK ION
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood the basics on signals and linear systems as well as the dynamical and frequency performances of the systems.
The student should be able to:

- Build in Matlab/Simulink a dynamic model of a system out of its algebro-differential equations
- Determine and analyze the dynamic and frequency performances of a system of intermediate complexity (1ˆ*st* or 2ˆ*nd* order) based on its dynamic model
- Carry out the preliminary sizing of a system of intermediate complexity (1ˆ*st* or 2ˆ*nd* order) to fulfill the dynamic specifications.

Content

Fundamentals of signals and systems. Transfer functions of linear time-invariant systems. Systems of 1st order, generalized 1st order, 2nd order, system delay. Frequency response in Bode diagram and its asymptotic plot. Introduction to state space representation.

Prerequisites

Laplace transform. Basic notions to model mechanical, electrical, thermal and hydraulic systems

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR
5.0 h 21.25 h 2.5 h 0.0 h
CARREY JULIAN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Cementitious materials

Module details

I3ICMC51-exc

4 ECTS FR

12.5 h 11.25 h 6.0 h 0.0 h

DE LARRARD-COUDERC DE FONLONGUE THOMAS,POUHET-GOUDEAU RAPHAELLE

Revision date : May 18, 2026

Objectives

This course develops a materials science culture concerning cementitious materials.

Content

The course covers the following topics:

- history of cementitious materials
- cement manufacture and composition
- structure and texture of cement paste
- hydration, setting and hardening
- behavior of hardened concrete
- deferred behavior of concrete
- concrete durability
- fire resistance and freeze/thaw cycles
- formulation optimization

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Concrete mix design

Module details

I3ICCO51-IB-exc

2 ECTS   FR
10.0 h   5.0 h   5.0 h   4.0 h
SAMSON GABRIEL
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Ecodesign

Module details

I3ICCO51-EC-exc

1 ECTS FR

3.75 h 18.75 h 0.0 h 0.0 h

CLAUDE SOPHIE

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Building technology

Module details

I3ICCO51-TC-exc

3 ECTS FR

10.0 h 3.75 h 10.0 h 0.0 h

MASSON PHILIPPE

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Fluid mechanics

Module details

I3ICMF61-exc

2 ECTS FR
10.0 h 16.25 h 7.5 h 0.0 h
OMS CLAIRE
Revision date : May 18, 2026

Objectives

Fluid Mechanics of Real Fluids
By the end of the session, the student will be able to:

- Apply the generalized Bernoulli equation and perform head loss calculations;
- Design gravity-driven and pressurized flow networks;
- Select an appropriate pump;
- Estimate flow rates for uniform open-channel flows.

Content

Fluid mechanics for Civil Engineers :

- Properties of real fluids
- Pressurized flows in cylindrical pipes (gravity networks; pump-network coupling)
- Open-channel flows in uniform flow conditions

Prerequisites

Fluid statics. Real fluid flow.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Heat transfer

Module details

I3ICTTGC61-exc

3 ECTS FR
10.0 h 12.5 h 7.5 h 0.0 h
MOISSON MARC
Revision date : May 18, 2026

Objectives

At the end of this course, the student should have understood and be able to explain:

- Heat transfer in solids, fluids, and at a distance by radiation.
- The operation of a fin.
- The operation of a radiator-type heat exchanger.

The student should be able to:

- Calculate heat flux and determine temperatures in typical building cases.
- Design a fin.
- Size a radiator and calculate the heat output of an existing radiator.

Content

The content of this course includes:

- General concepts.
- Conduction, with applications to walls, cylinders, and spheres.
- Convection, method for calculating the convective heat transfer coefficient.
- Radiation, view factor, calculation of heat exchange between two surfaces, linearized radiative heat transfer coefficient.
- Fin calculations.
- Radiator-type heat exchanger, LMTD and NTU methods.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Analysis of static structures

Module details

I3ICAS61-exc

3 ECTS FR
12.5 h 13.75 h 0.0 h 8.5 h
DE LARRARD-COUDERC DE FONLONGUE THOMAS
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain :

- the distribution of internal forces in structures under static mechanical loads (continuous beams, trusses, frameworks, etc.) and the associated fields of stress, strain and displacement;
- the essential elements of a calculation note.

Students should be able to :

- formulate and justify relevant hypotheses for the static resolution of a structure;
- determine the degree of hyperstaticity of a structure;
- solve a hyperstatic structure using the force method;
- solve a hyperstatic structure using the displacement method;
- argue the choice of resolution method;
- calculate the support reactions of the structure;
- draw internal force diagrams (bending moment, shear force, normal force);
- calculate structural deformations (displacements, rotations);
- write a clear, accurate and concise calculation note.

Content

The content of this course inclides:

1. Notion of hyperstaticity
2. Force method
   - Associated system: static equivalence and kinematic equivalence
   - Energetic method
   - Special cases: articulated trusses
   - Special cases: continuous beams
3. Displacement method
   - Kinematic analysis
   - Locking and embedding moments
   - Principle of virtual work for Rigid Body Motion

Prerequisites

Solving isostatic systems and determining internal forces.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Civil engineering in-depth study

Module details

I3ICAPPRO61-exc
0 ECTS FR
0.0 h 0.0 h 0.0 h 0.0 h
DE LARRARD-COUDERC DE FONLONGUE THOMAS
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Deepening in structures

Module details

I3ICAD61-exc

2 ECTS FR
17.5 h 12.5 h 0.0 h 0.0 h
DE LARRARD-COUDERC DE FONLONGUE THOMAS
Revision date : May 18, 2026

Objectives

By the end of the course, the student will have acquired basic skills related to:

- the dynamic behavior of Civil Engineering structures;
- their aging over their service life;
- structural mechanics (strength of materials) modeling based on a real system.

Content

This module is composed of three independent parts.

- A Structural Dynamics Analysis module introduces the fundamentals of modeling systems subjected to dynamic loading in order to determine their natural vibration modes. The modeling may involve both continuous and discrete systems. The natural modes are studied through exact solutions as well as approximate methods (Rayleigh–Ritz method).
- A Structural Aging module focuses on the long-term behavior of civil engineering structures and their interaction with the environment. Physico-chemical deterioration and the viscoelastic behavior of civil engineering materials are examined.
- An Existing Structure Modeling module consists of selecting a real structure, proposing a structural mechanics (strength of materials) model, and preparing a calculation report to determine the distribution of internal forces.

Prerequisites

The prerequisistes for this course include:

- Strength of Materials (Mechanics of Materials)
- Behavior of Cementitious Materials
- Fundamental Principles of Dynamics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Climatics - Aerolitics - Fluid Mechanics

Module details

I3ICAC61-exc

2 ECTS FR
0.0 h 20.0 h 0.0 h 9.0 h
OMS CLAIRE
Revision date : May 18, 2026

Objectives

By the end of the session, the student will be able to:

- Design a cold water and wastewater system for a building.
- Design emergency response systems for a publicaccess building (ERP).

Content

The content of this course includes:

- Building Hydraulics (Cold water, wastewater)
- Introduction to fire safety for public-access buildings (ERP): basics of fire safety regulations and fundamentals of emergency system design.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Reinforced concrete

Module details

I3ICBA61-exc

5 ECTS FR
25.0 h 20.0 h 6.0 h 15.0 h
GUERY ARIANE
Revision date : May 18, 2026

Objectives

The objectives of this course include:

- Master the fundamental concepts of reinforced concrete behavior under various loads.
- Apply safety and durability requirements in structural design.
- Be able to calculate and verify cross-sections of elements under compression, tension, and simple or combined bending at serviceability (SLS) and ultimate (ULS) limit states.
- Develop autonomy in solving practical reinforced concrete design problems.

Content

This course aims to provide students with the theoretical and practical knowledge required to design and size reinforced concrete elements in accordance with current standards. It covers the entire calculation process, from load analysis to section design. The main topics studied are:

1. Load combinations: Study of different types of loads (permanent, variable, accidental) and application of combinations according to Serviceability Limit States (SLS) and Ultimate Limit States (ULS).
2. Cover and anchorage: Rules related to minimum concrete cover for reinforcement, anchorage devices, and lap splices to ensure durability and structural safety.
3. Section design: Dimensioning of elements subjected to:
   - Axial compression
   - Axial tension
   - Simple bending
   - Combined bending

   according to Serviceability Limit State (SLS) and Ultimate Limit State (ULS) criteria.

The course combines theory, calculation methods, and practical exercises, enabling students to develop a rigorous and critical approach to reinforced concrete design.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Prestressed Concrete

Module details

I3ICBPC61-exc

1 ECTS FR
7.5 h 5.0 h 0.0 h 0.0 h
DUPRAT FREDERIC
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- Technology and simplified calculation of a prestressed concrete beam;

The student should be able to:

- Determine the minimum prestressing force for an isostatic beam,
- Calculate and verify the stresses on the extreme fibers of a concrete cross-section.

Content

The content of this course includes:

- Technology of prestressed concrete: tendons, anchorages, jacks, fields of application.
- Main systems used: post-tensioning, pre-tensioning, internal prestressing, external prestressing.
- Stresses induced by prestressing.
- Principles for determining the minimum prestressing force.
- Principles of phase-by-phase verification.

Prerequisites

The prerequisites for this course include:

- Continuum Mechanics
- Beam Mechanics, Concrete Material

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Geotechnic I

Module details

I3ICMS61-exc

3 ECTS EN/FR
16.25 h 15.0 h 12.0 h 0.0 h
GIROUDON MARIE
Revision date : May 18, 2026

Objectives

On completion of this course, students will be able to:

- Quote and measure the physical properties of a soil
- Calculate the stresses in a soil
- Calculate soil settlement
- Calculate soil resistance

Content

Geotechnical engineering covers all activities relating to the application of soil mechanics, rock mechanics and engineering geology. Geotechnics plays an essential role in all building, civil engineering and development projects.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS EN/FR
0.5 h 2.75 h 0.0 h 0.0 h
PLANTEC JEAN-YVES
Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Concrete and timber structures

Module details

I4GCBA12-exc

6 ECTS FR
21.25 h 42.5 h 0.0 h 0.0 h
GUERY ARIANE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Prominent design parts (bearing frames, foundations, bracing systems)
- calculation of reinforced concrete buildings, calculation of reinforced concrete buildings submitted to vertical loads according to Eurocode 2.
- Understand the principles of design and calculation of timber structures according to Eurocodes.

The student will be able to:

- To identify actions on the structures and environmental conditions, to understand and predict the mechanical behaviour of a structure;
- To argue its technological choices
- To design the various structural elements of a common construction;
- To analyse the structural behaviour of a timber structure

Content

The content of this course includes :

- Basic rules of structural design for concrete structures according to Eurocdes.
- Actions and combinations of actions on structures.
- Foundations: actions on foundations, pad footings, pile caps.
- Choice of materials according to mechanical and environmental performance criteria.
- Effects of horizontal actions on bracing walls.
- Design and verification of simple elements:

- Vertical load-carrying components: columns and walls.
- Horizontal load-carrying components: continuous concrete beams, floors (continuous supported slabs).
- Bracing wall with or without windows.

Prerequisites

The prerequisites for this course include fundamentals in material resistance and reinforced concrete

Assessment

The assessement of this course includes written exams and project presentation

Back to menu

Comfort Engineering

Module details

I4GCTF11-exc

5 ECTS FR
40.0 h 21.25 h 0.0 h 0.0 h
LABAT MATTHIEU
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Relevant criteria to quality comfort;
- The behaviour of HVAC systems;
- Heat and mass balances applied to HVAC systems;
- Efficient technics to decrease the primary energy consumption for HVAC systems;
- The main objectives of the current regulation code;
- Acoustic treatments of the building

The student will be able to:

- To describe the operation of an existing HVAC system;
- To design a basic HVAC system;
- To calculate the sound insulation of a wall and the time of reverberation of a room

Content

The content of this course includes :

- Thermal and acoustic comfort;
- Sensitizing with RE2020, the practice of the thermal insulation, bioclimatic concepts
- HVAC: Heating only: heat production, distribution and emission;
- HVAC: Air conditioning: humid air diagram, heat and mass balances, sizing of an HVAC system, technical description of HVAC devices;
- Acoustics: physical acoustics, sound insulation of buildings, acoustics of the rooms, regulation code.

Prerequisites

The prerequisites for this course include fundamentals of heat transfer

Assessment

The assessement of this course includes written exams

Back to menu

Geotechnics 2

Module details

I4GCMS21-exc

5 ECTS FR
26.25 h 22.5 h 0.0 h 0.0 h
SAMSON GABRIEL
Revision date : May 18, 2026

Objectives

The objective of this course is to design and to verify foundations and earth retaining wall with Eurocode 7. The student will be able to:

- To determinate the active and passive soil pressure;
- To determinate forces of earth pressure;
- To design a retaining wall;
- To analyse famous in-situ testing;
- To design shallow and deep foundations

Content

The content of this course includes:

- Active and passive soil pressure.
- Verification of gravity and sheet pile walls.
- Principal in situ testing.
- Shallows foundations.
- Deeps foundations.

Prerequisites

The prerequisites for this course include fundamentals in geotechnics

Assessment

The assessement of this course includes a written exam and a mini-project

Back to menu

Advanced Mechanics and Finite Elements

Module details

I4GCRM11-exc

7 ECTS FR
27.5 h 13.75 h 9.0 h 36.0 h
LACARRIERE LAURIE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The limits of the use of linear mechanics and the interest of advanced mechanics in the context of environmental and numerical transitions
- The mechanical formulations of the plate type
- Visco-elastic behaviour, and principles for formulating creep models
- Plastic behaviour of materials (criteria) and elastoplastic calculation of wire structures
- The different instability phenomena of structures
- Modelling by the finite element method

The student will be able to:

- To express linear viscoelastic behaviour laws from rheological models
- To determine the global instability load of a structure
- To determine the plastic failure load of a structure
- To perform the calculation of a structure using a finite element code

Content

The content of this course includes:

1. Advanced linear mechanics and the Finite Element Method
   - Elementary laws of linear mechanics and overview of beam theory
   - Plate theory
   - Finite element method
2. Non-linear mechanics at the material level
   - Demonstration of nonlinearities
   - Plasticity and damage
   - Induced nonlinearities
   - Linear viscoelasticity
3. Nonlinear structural design
   - Plasticity at section scale
   - Elastoplastic design of steel structures
   - Instabilities (buckling of elements and structures)

Prerequisites

The prerequisites for this course include fundamentals in solid mechanics, linear structures and material resistance

Assessment

The assessement of this course includes written reports and oral presentations

Back to menu

Building facilities

Module details

I4GCTF71-exc

6 ECTS   FR
22.0 h   18.25 h   16.0 h   0.0 h
LABAT MATTHIEU
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The behavior and the design of classical thermodynamic devices used in buildings. (Applied thermodynamic)
- Protection and security techniques used in houses, collective housing or industrial buildings (Electricity)
- How to determine experimentally the energy balance of heating and cooling units (Metrology)

The student will be able to:

- Name and explain the protection and security techniques used in classical buildings
- Calculate thermodynamic devices efficiency (refrigeration, cogeneration') and draw the corresponding cycles on thermodynamic charts
- Analyse experimental data and calculate the related uncertainty

Content

The content of this course includes :

1. Applied thermodynamic
   - Reminder of thermodynamic basics (1st and 2nd principles)
   - study of the devices through their cycle: vapor turbine, thermal motors, cogeneration
   - Power and efficiency calculations
2. Electricity
   - Study of the C15-100 of the UTE C 15-105 guide.
   - Analyze of various protections relating to the safety of electrical installations:
     - protection of the circuits (choice of the protection apparatus adapted to a drain);
     - protections of the people (modes of neutral, differential protection);
3. Metrology
   - Metrology fundamentals, basics of uncertainty calculation, calibration
   - Practical application to real HVAC systems.

Prerequisites

The prerequisites for this course include:

- fluid mechanics (viscous flows)
- basic notions in electricity,
- thermodynamic principles and charts

Assessment

The assessement of this course includes written exams and laboratory works

Back to menu

Building networks

Module details

I4GCTF31-exc

6 ECTS FR
18.0 h 51.0 h 0.0 h 0.0 h
OMS CLAIRE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The hydro-thermal characteristics of a heating system;
- The pressure distribution in a network;
- The control strategies applied to heating systems used in buildings;
- How to design air devices: transport, supply
- Transient heat transfer, heat exchanger theory

The student will be able to:

- To design hydraulic and air networks by using the methods exposed during the seminars;
- To design heat exchangers

Content

The content of this course includes:

1. Hot water networks
   - In-depth presentation of the heating system (heat production, emission, distribution, operation)
   - Hydro-thermal performance of a heating system
2. Hydraulics
   - Based on the Technical Document 60-11: sizing of indoor hot and sanitary water devices, study of Legionella problem, sizing of storage systems, of pressure maintain devices.
   - Sizing of sewage disposal.
3. Aeraulics
   - Raising awareness of ventilation issues.
   - Design and sizing of an aeraulic network.

Prerequisites

Assessement for this course includes:

- Basics of heat transfer (conductive, convective and irradiative heat transfer) and heat exchangers.
- Fluid mechanics

Assessment

The assessement of this course includes written reports and a written exam

Back to menu

Building project

Module details

I4GCPJ22-exc

7 ECTS FR
8.0 h 0.0 h 0.0 h 84.0 h
MERCADIER SEBASTIEN
Revision date : May 18, 2026

Objectives

The objectives of this course is to understand and be able to explain the main stages of design of a concrete building for the frame as well as for the air conditioning and heating systems. The students will apply what they learned during the previous semesters in structural design.
The student will be able to:

- To identify and calculate actions on structure;
- To determine the energetic demands;
- To understand the mechanical behaviour of a frame as a whole design;
- To calculate the main structural members and heating or air conditioning circuits;
- To use and enrich a numerical model

Content

The students apply what they have learned during the previous semester in structural design.
The project is divided in three parts:

1. Technical equipments
   - Acoustic and thermal insulation, choice and design of air conditioning and heating equipments.
   - Installation plan.
2. Structural design
   - Foundations: actions on foundations, pad footings, pile caps.
   - Vertical load carrying components: columns, concrete walls, timber walls.
   - Horizontal load carrying components: continuous beams, concrete floors (continuous supported slabs), timber floors
3. Environmental impacts
   - Mass and energy management and their environmental impacts, both during the construction process and the use period of the project

Main difficulties for students: Teamwork problems, Own work

Prerequisites

Prerequisites for this course include:

- Concrete Engineering
- Strength of Materials (ou Mechanics of Materials)
- Behavior of Concrete Structures

Assessment

The assessement of this course is a project

Back to menu

Existing structures and buildings

Module details

I4GCOE11-exc

2 ECTS FR
12.5 h 0.0 h 0.0 h 15.0 h
DOMEDE NATHALIE
Revision date : May 18, 2026

Objectives

The objectives of this course are to introduce students to the challenges of evaluating and recalculating existing structures and buildings, from a structural or energy point of view, or circular economy.
Students must choose one of the following options.

- Calculation of old masonry works: to discover the heritage of bridges in France and Europe. To learn the evolution of construction methods, materials, loads applied to structures and calculation methods.
- Aging of major energy and transport structures: to discover the causes of aging of concrete structures and reassessment techniques.
- Energy rehabilitation: to diagnose a building and its energy consumption, to define solutions to improve comfort, to calculate the carbon impact of the solutions envisaged.
- Circular economy: to discover the circular economy in the construction sector: principles, issues, legislative context, the resources in favour of circular economy.

Content

The content of this course includes:

1. Large Concrete Structures
   - The stock of concrete civil engineering structures in France (bridges, dams, nuclear power plants) is aging. The condition of these structures must be regularly monitored to ensure their safety, and maintaining them in service is a major sustainable development challenge. The objective of this course is to review the causes of aging in concrete structures and the techniques used for their reassessment. The project addresses the issue of numerical evaluation of concrete aging within structures and its mechanical consequences.
2. Energy Retrofit
   - The topic of energy retrofit is approached through a dual perspective, combining the study and improvement of both the building envelope and its systems. Through a project, students analyze the energy retrofit of a building by first establishing a diagnosis of the structure and its energy consumption, then defining solutions to improve winter and summer comfort, as well as an Energy Performance Action Plan aimed at significantly reducing energy costs. Finally, the carbon impact of the proposed solutions (systems and building) is also assessed.
3. Option: Circular Economy
   - Through this topic, students discover the circular economy applied to the construction sector (BTP), through both theoretical and practical approaches. This includes learning key principles, challenges, the legislative context, specific definitions, the obligations of stakeholders in the construction process, and available resources supporting the circular economy. In several stages, each group carries out a circular economy approach applied to a building scheduled for deconstruction. A partial PEMD (Products, Equipment, Materials, Waste) diagnosis is produced, complemented by a specific resource study.
4. Option: Masonry Structures
   - The module begins with an introduction to the heritage of masonry bridges in France. The objective is to learn how to implement a diagnostic approach for an old stone bridge through structural recalculation. The course covers the evolution of construction methods, materials, loads applied to structures, and calculation methods up to the present day. A case study involves the analysis of a project to widen a real bridge in Toulouse, using two calculation methods: one from the 19th century (Méry's method) and one from the 21st century (limit analysis using the RING software).

Prerequisites

Under construction

Assessment

The assessement of this course inludes a project report

Back to menu

Introduction to research

Module details

I4GCRE11-exc

2 ECTS FR
1.25 h 2.5 h 0.0 h 21.0 h
POUHET-GOUDEAU RAPHAELLE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The scientific approach of researchers;
- The operation differences of scientific expression principles

The student will be able to:

- To conduct bibliographic research;
- To propose a work plan;
- To put results in perspective;
- To report orally and in writing on the results obtained and discuss the key elements of the project

Content

The module is carried out in small groups of students and the research topic is chosen at the beginning of the module.
This introductory research training includes

- Bibliographic training
- Numerical and/or experimental research work in the field of Civil Engineering supervised by a researcher

The validation of this module justifies a research experience allowing engineering students to be able to apply for a doctoral contract at the end of their course.

Prerequisites

Under construction

Assessment

The assessement of this course includes writting of an article in English and oral presentation in English

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Bracing and steel structures

Module details

I4GCCO21-exc

5 ECTS FR
32.5 h 22.5 h 0.0 h 0.0 h
MERCADIER SEBASTIEN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The principles of design and calculation of steel structures and timber structures according to Eurocodes.

The student will be able to:

- Analyse the structural behaviour of a timber or steel structure
- justify the technological structural choices and materials
- design the structural bearing and bracing members.

Content

The content of this course includes:

- Review of industrial branches timber and steel.
- Properties of used materials (timber, wood products, steel).
- Influence of environmental conditions on timber and wood products properties.
- Classification and geometrical features of cross-sections.
- Construction systems and frames (horizontal and vertical bearing members).
- Structural behavior and effect of connections between members.
- Actions and action combinations, principles of verification.
- Consideration of structural imperfections.
- Verification of resistance ultimate limit states of cross-sections.
- Verification of stability ultimate limit states of members and shells.
- Verification of serviceability limit states.
- Principles and calculation of bracing systems and members.
- Technology and calculation of main types of connection.
- Verification of fire resistance.

Prerequisites

Prerequisites for this course include:

- Fundamentals of Building Engineering
- Strength of Materials
- Static and Dynamic Structural Analysis

Assessment

Written exam (design and calculation) Work in groups in aided works

Back to menu

Prestressed concrete structures and bridges

Module details

I4GCBA32-exc

6 ECTS FR

35.0 h 15.0 h 0.0 h 16.0 h

DUPRAT FREDERIC

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The technology, design and calculations of a prestressed concrete structure with Eurocode 2;
- The technology and design of metallic, concrete or composite bridges

The student will be able to:

- To state the required assumptions;
- To calculate a prestressed concrete structure;
- To define the technical choices for designing a bridge

Content

The content of this course includes:

1. Prestressed concrete structures
    - Design rules (EC2): minimum requirements towards cracking, stress limitation, minimum reinforcement and various layouts, calculation of the minimum prestress force, calculation of the prestress losses
    - Tensioning stages
    - Stress control
    - Calculation of the stresses in cracked cross-section under serviceability limit state
    - Calculation of the reinforcement areas.
2. Bridges
    - Terminology, bridge classification
    - Data for the project, design procedure
    - Technical regulation
    - Foundations: design and execution
    - Supports: piers and abutments
    - Superstructures: wearing surfaces, barrier walls, bearings, pavement join, drainage, sidewalks
    - Concrete bridges: materials, field of use, pre-design, execution
    - Steel bridges: materials, field of use, joints, classification, pre-design, execution.

Prerequisites

The prerequisites for this course include fundamentals of prestressed concrete and material resistance

Assessment

The assessement of this course includes written exams and roject

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Air Conditioning

Module details

I4GCTF51-exc

6 ECTS FR
16.25 h 10.25 h 16.0 h 32.0 h
FOURTANET DORIAN
Revision date : May 18, 2026

Objectives

Main goal of this teaching is to allow student to learn conception elements and also best practices rules of air conditioning installations (HVAC).
Expected skills :

- Analyze an air conditioning installation (HVAC) from the schematic drawing and determined specifications;
- Design main elements of an HVAC installation;
- Identify and prioritize main elements of the control system from an installation;
- Analyze thermal qualities of a building with STD modelling and RE2020

Content

The content of this course includes:

- Calculation of thermal balances of rooms and buildings;
- Principal air conditioning systems (HVAC);
- Air filtration;
- Regulation of air conditioning installations

Prerequisites

The prerequisites for this course include fundamentals on air conditionning

Assessment

The assessement of this course includes an individual written exam and a project

Back to menu

Acoustics

Module details

I4GCAC22-exc

5 ECTS FR
20.0 h 11.25 h 12.0 h 8.0 h
MOISSON MARC
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Diffusion of sound waves inside and outside rooms
- Transfer of acoustic waves along ductworks
- Transfer of vibrations generated by building services

The student will be able to:

- Calculate walls absorption to restrict noise dose absorption by workers
- Reduce noise propagation in ducts
- Define noise proof walls to protect the surrounding
- Size vibration pads

Content

The content of this course includes:

- Diffuse field, direct field
- Different sound absorbers
- Determination of absorption coefficient
- Auditorium acoustics
- Acoustic power of building services
- Design methods

Prerequisites

The prerequisites for this course include fundamentals of acoutics

Assessment

The assessement of this course includes Individual written examination, project and labworks

Back to menu

Eco Construction*

Module details

A4GCEC21-exc

ECTS EN
20.0 h 20.0 h 0.0 h 0.0 h

Revision date : May 18, 2026

Objectives

The objectives of this course include:

- Acquire civil engineering skills at an international level based on a case study
- Be able to identify, explain, and apply electrical protection techniques in buildings
- This course covers the main principles of construction and operation of future buildings

Content

The content of this course inludes:

1. International Civil Engineering
   - Procurement procedures in an English-speaking country. Exploration of technologies and best practices in another European country through a large-scale international construction project. This module is taught in English.
2. Renewable Energies
   - Renewable energy sources mainly used in buildings: solar thermal energy, wind energy, and photovoltaics. These teaching modules are delivered through lectures and projects and are complemented by site visits.
3. Sustainable Materials (module taught in English)
   - This module begins with four lectures followed by a group project. The objective is to explore eco-materials (raw earth, hemp, straw, etc.) and understand their specific properties in order to be able to design a simple wall structure.
4. Electricity
   - New requirements in the field of electrical certification. Obligations of the new NFC 18-510 standard, the structure of the new regulations applicable to E.R.T (workplaces) and E.R.P (public buildings). Electrical hazards, structure of matter, flow of electric current, components of an electrical installation, basic electrical quantities, resistance in direct current, demonstration of Ohm's law, series connection of resistors, Joule effect, magnetic field, induced current, single-phase generator, alternating current.

Prerequisites

Prerequisites for this course include:

- English
- Thermal Engineering
- Building Equipment

Assessment

Quiz, exam, installation analysis

Back to menu

Project Management Assistance (PMA)

Module details

I5GCPJ12-exc

5 ECTS FR
27.5 h 27.5 h 0.0 h 0.0 h
OMS CLAIRE
Revision date : May 18, 2026

Objectives

The student should be able to:

- AMO part: acquire the regulatory and technical approaches to the act of building in public buildings, public markets, relations between stakeholders (MOP law), local town planning.
- English part: acquire the vocabulary specific to tenders; report on the project carried out in writing and orally as well as discuss the key elements of the project.

Content

Three aspects are covered:

- Responsibilities and contractual relationships between the various actors in the act of building; in particular project management and project management, companies.
- Regulation of public contracts for supplies, works and services' private contracts
- Local planning law (scot plus)

A project illustrates this teaching which is mainly carried out by temporary workers from the professional world.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

BIM Environnement

Module details

I5GCMOBE01-exc

5 ECTS FR
27.5 h 27.5 h 0.0 h 0.0 h
MERCADIER SEBASTIEN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Organisation of a collaborative work thanks to the numerical model
- Role, limit and responsibilities of the stakeholders in a BIM project

The student will be able to:

- Give principles of the process for elaborating the numerical model as function of the invitation to tender
- Participate to a BIM construction project
- Know how to interact with the participants of a BIM construction project

Content

The content of this course includes:

- Principles and elaboration of a BIM project
- Responsibilities of the stakeholders
- Making of the numerical model
- BIM design / BIM project / BIM works
- Work on a real multisite collaborative project.

Prerequisites

The prerequisites for this course include:

- Engineering Sciences / CAD (Computer-Aided Design)
- Construction Environment 1
- Eco-design and Engineering
- Building Project

Assessment

The assessement for this course includes:

- Writing a project report.
- Synthesis detailed work.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Eco building and Environmental impact

Module details

I5GCTF11-exc

5 ECTS FR
27.5 h 27.5 h 0.0 h 0.0 h
FOURTANET DORIAN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Interest and principles being used to establish a diagnosis of energetic performance (DPE).
- Interest and the principle of a thermal dynamic simulation for buildings to help with the design - renovating of the buildings in a bioclimatic approach
- Interest and principles of methods to evaluate global environmental impacts in a project of new or renovated building: life cycle analysis (LCA), Bilan Carbone and other methods.

The student will be able to:

- carry out the DPE and the thermal dynamic simulation of a project of building, analyze results obtained and propose improvements with the studied project
- analyze and take into account a study report on the environmental impacts of a project
- carry out a simplified LCA to study a building

Expected skills :

- To optimize a building according to bioclimatic principles, using a dynamic thermal simulation software
- To assess the environmental impact of a building (or part of a building) via LCA and / or a Carbon Footprint analyze.

Content

The content of this course includes:

- Thermal dynamic simulation of buildings: bioclimatic design; heat transfer in unsteady state; use of a software to carry out a thermal dynamic simulation of a buildings and a sensitivity factor analysis (PLEIADES+COMFIE)
- Environmental Indicators for life cycle analysis (LCA); application to buildings and their integration in a district ; use of a LCA software dedicated to building (NovaEQUER)
- Principles of the Bilan Carbon method and application on an example;
- Diagnosis of energy performance (DPE): principles and application to a study project.

Main difficulties for students:

- unsteady state thermal equations

Prerequisites

The prerequisites for this course include:

- Heat Transfer and Fluid Mechanics 1, 2
- Indoor Environmental Physics (or "Environmental Building Physics" depending on context)
- Concrete, Timber, and Steel Structures

Assessment

Assessement for this course includes:

- By the analysis of reports and oral examination on the projects
- The projects make it possible to the students to look further into the topics seen during the meetings or the conferences.
- The direct practical application allows a fast assimilation of the concepts.

Back to menu

Construction Methods*

Module details

A5GCMA11-exc

ECTS FR
35.0 h 45.0 h 0.0 h 15.0 h
OMS CLAIRE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Elaborating means, planning and budget of a construction operation
- Main techniques and methods in various sectors (building, bridges and roads)

The student will be able to:

- Elaborate methods.
- Estimate a budget and establish a planning of works.
- Present LEAN principles applied to Construction context

Content

The content of this course includes:

1. Methods:
   - Preparing sites and roadworks
   - Defining missions and assignments
   - Site facilities: basics, constraints due to localization, access, resupplying
   - Temporary works
   - Special formworks (piles, deck)
   - Lifting apparatus
   - Production means
   - Special road equipments
   - Operating methods chosen from architect drawings.
2. Planning:
   - Cycles and phases study
   - Equipment and workforce saturation
   - Implementation.
3. Budget and site management:
   - Type a call for tenders in public works
   - Project manager approach
   - Enterprise approach
   - Establishing selling price from cost price
   - Price study (quantities, sub-details, organization, cost prices, selling prices)
   - Budget and financial margin.

Prerequisites

Assessment

The assessement for this course includes:

- Writing a project report.
- Put into practice in a quasi-professional situation.

Back to menu

Bridge

Module details

I5GCBP11-exc

ECTS FR
25.0 h 0.0 h 0.0 h 75.0 h
DUPRAT FREDERIC
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Main steps in design and calculation of a prestressed concrete bridge.

The student will be able to:

- Define and calculate the main structural components of a concrete bridge.

Content

The content of this course include:

1. Lecture
    - Technical regulations
    - Loading: Eurocode 1 part 2
    - Foundations: volume 61 part V of the general technical clauses notebook
    - Soil-structure interaction modelling
    - Concrete-steel composed and steel bridge decks: French regulation and Eurocodes
    - Concrete bridge decks: transversal load distribution and transversal flexure of girder and slab bridges
    - Special verification and provisions for bridges constructed by incremental launching or segmental cantilever.
2. Project:
    - Defining the main components from the programme (spans and footings type), topographical map and ground tests
    - Calculation of applied loads
    - Calculation of the minimum prestress force according to Fauchart method
    - Minimum reinforcement
    - Verification of the deck under SLS and ULS
    - Designing bearing pads
    - Calculating forces on piers
    - Design and calculation of foundations
    - Cost estimate

Prerequisites

Prestressed Concrete Structures and Bridges

Assessment

The assessement for this course includes:

- Writing a project report.
- Put into practice in a quasi-professional situation.

Back to menu

Roads and methods PW

Module details

I5GCGE42-exc

5 ECTS FR
43.0 h 15.0 h 0.0 h 5.0 h
DUPRAT FREDERIC
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Elaborating methods, planning and budget for the construction of a road and a bridge.
- Main road techniques.

The student will be able to:

- Design of a structural pavement.
- Elaborate methods.
- Estimate a budget and establish a planning of works.

Content

The content of this course includes:

1. Road techniques:
    - Mechanical behaviour of pavements
    - Basic components, requirements and quality control (gravels, binding and fines)
    - Laboratory study (composition, mechanical performances, durability)
    - Production and processing (roles, tender spots and normalization request)
    - Quality tests of pavements
    - Work compliance and receipt control
    - Maintenance of pavements: inspection, design, specific techniques.
2. Methods:
    - Preparing sites and roadworks
    - Defining missions and assignments
    - Site facilities: basics, constraints due to localization, access, resupplying
    - Temporary works
    - Special formworks (piles, deck)
    - Lifting apparatus
    - Production means
    - Special road equipments.
3. Planning:
    - Cycles and phases study
    - Equipment and workforce saturation
    - Implementation.
4. Budget:
    - Type a call for tenders in public works
    - Project manager approach
    - Enterprise approach
    - Establishing selling price from cost price.

Prerequisites

Civil engineering materials lecture.

Assessment

Assessement for this course includes:

- Written examination, writing a project report.
- Put into practice in a quasi-professional situation.

Back to menu

Advanced algorithmics

Module details

I3MIAA10-exc

2 ECTS FR
8.75 h 10.0 h 0.0 h 0.0 h
SIALA MOHAMED
Revision date : May 18, 2026

Objectives

The objective of this course is to introduce the foundations of computational thinking, including complexity theory, proofs of correctness, advanced algorithmic design, and more. Throughout the course, students will learn to analyze the tractability of problems as well as the correctness and complexity of algorithms. They will be taught advanced algorithmic design techniques, such as divide and conquer, greedy algorithms, dynamic programming, and branch and bound.

Content

- Correction proofs
- Asymptotic analysis
- Devide and conquer
- Greedy algorithms
- Dynamic Programming
- Branch and Bound
- Problems tractability

Prerequisites

Algorithms and Programming (1ˆ*st* & 2ˆ*nd* year)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Databases I

Module details

I3MIBD11-exc

2 ECTS FR
7.5 h 10.0 h 0.0 h 0.0 h
GUERMOUCHE NAWAL
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Databases II

Module details

I3MIBD10-exc

2 ECTS FR
3.75 h 7.5 h 8.25 h 0.0 h
GUERMOUCHE NAWAL
Revision date : May 18, 2026

Objectives

At the end of this module, students should be able to understand and explain the main concepts.

- The relational model
- Data integrity constraints
- Languages for manipulating and querying relational databases, in particular relational algebra and the SQL language.

In practice, students should be able to :

- Implement a designed database while guaranteeing integrity constraints
- Write queries in relational algebra, then implement them in SQL for manipulating and querying relational databases

Content

The content of this course includes:

- The relational model
- Data integrity constraints
- Languages for manipulating and querying relational databases, in particular relational algebra and the SQL language

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Data analysis

Module details

I3MIAD10-exc

3 ECTS FR
12.5 h 3.75 h 13.75 h 4.0 h
MAUGIS CATHY
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the main definitions for the unidimensional and bidimensional descriptive statistics
- the main concepts and the interpretation of graphical results of the principal component analysis
- the main concepts of clustering (hierarchical clustering, kmeans method and DBSCAN) and the interpretation of graphical results

The student will be able to:

- develop a descriptive statistical analysis with the R software
- manipulate the concepts of the principal component analysis, know the main properties and comment the graphical results

Content

- Unidimensional descriptive statistics
- Bidimensional descriptive statistics
- Principal component analysis
- Clustering: principle, hierarchical clustering, Kmean and DBSCAN
- Introduction to programming in R and Rmarkdown

Prerequisites

Probability and Statistic course

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Optimization and linear programming

Module details

I3MIOP10-exc

3 ECTS EN/FR
13.75 h 12.5 h 11.0 h 0.0 h
ESCANDE PAUL
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The notions of local extremum and convexity
- Characterization of a local extremum by optimality conditions: first and second order conditions in unconstrained differentiable optimization, Karush-Kuhn-Tucker (KKT) conditions in constrained differentiable optimization
- The first algorithms for unconstrained optimization: gradient algorithm (fixed step, optimal step), Newton's algorithm, linear and nonlinear least squares problems
- Optimization under linear constraints (Linear Programming/PL): modeling in PL, characterization of the search space, geometric interpretation, solution principle, simplex algorithm, dictionary methods, complexity, duality.

The student will be able to:

- Choose and implement a relevant and numerically efficient optimization method for an unconstrained differentiable optimization problem or for a linear programming problem.

Content

- Introduction to constrained optimization: definitions and generalities, existence of solutions, convexity and uniqueness
- Optimality conditions: first and second order conditions in unconstrained differentiable optimization, Karush-Kuhn-Tucker (KKT) conditions in constrained differentiable optimization, Lagrangian notion
- Algorithms for unconstrained optimization: gradient algorithm (fixed step, optimal step), Newton's algorithm, linear and nonlinear least squares problems
- Introduction to linear constrained optimization: modeling formalisms, characterization of the search space, geometric interpretation, graphical resolution, link with KKT conditions, simplex algorithm, method of dictionaries, complexity, duality of a PL problem, strong and weak duality theorems, complementary deviations theorems, Farkas lemma, alternatives theorem.

Keywords : differentiable optimization, first and second order optimality conditions, gradient algorithms, Newton, least squares problems, linear programming and simplex algorithm.

Prerequisites

Differential calculus: know how to calculate a gradient and a hessian. Link with differential. Linear algebra: know how to diagonalize a matrix, calculate the eigenvalues, notion of semi-definite positivity.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Operating system

Module details

I3MISE10-exc
2 ECTS EN/FR
7.5 h 3.75 h 0.0 h 0.0 h
MONTEIL THIERRY
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain the operating system problems with a global overview of its functions and architecture.

Content

The operating system is considered as resources managers: processors management (processes, scheduling) memory management (virtual memory, allocation), access to resources (synchronisation, mutual exclusion) and file system.

Prerequisites

Notions in computer's structure.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Markov chains

Module details

I3MICM10-exc

2 ECTS EN/FR
7.5 h 8.75 h 2.75 h 0.0 h
PEDECHES LAURE
Revision date : May 18, 2026

Objectives

Time-homogenous Markov chain over discrete state space, classification of states, stationary measure, reversible Markov chain, convergence to stationary distribution, ergodic theorem. The description of a Markovian model to its formalization by a Markov chain develop a analysis of Markov chains (description of its communication classes, conclusion on the existence of a stationary distribution and on the convergence of the chain distribution)

Content

Markov chains and their classification: definition and class properties (irreducibility, recurrence, transience, aperiodicity), convergence to the stationary distribution, reversible Markov chain, absorbing time.

Prerequisites

Basic notions in discrete probability theory

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Web progamming

Module details

I3MIPW10-exc
1 ECTS FR
5.0 h 7.5 h 8.25 h 0.0 h
BEN HADDI THOURIA
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Networks

Module details

I3MIRE10-exc

2 ECTS FR
17.5 h 5.0 h 2.75 h 0.0 h
CHASSOT CHRISTOPHE
Revision date : May 18, 2026

Objectives

At the end of this module:
The student will understand and be able to explain the main concepts associated with computer networks (personal, local, and wide-area networks) and their interconnection within the Internet (TCP/IP).
They will thus be able to identify: the characteristics of the main distributed applications in networks, the different types of connectivity and addressing schemes within networks, resource sharing solutions and their impact on transfer quality (loss, de-sequencing, delay, throughput), and finally, the concepts of service, protocol, architecture, and quality of service.
More specifically, the services, functionalities, and main mechanisms of the protocols involved in the architecture of Ethernet local area networks and the TCP/IP Internet will be mastered theoretically by the end of the course.

Content

The content of this course includes:

- The first part of the course introduces the characteristics of the main network applications.
- The second part details the fundamental concepts associated with network design: connectivity, resource sharing, switching, quality of service, and architecture.
- The third part describes the architecture of local area networks, using case studies, and Ethernet networks.

Illustrations of these concepts are explored in tutorials and labs.

Prerequisites

Notions on operating systems and C programming.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Theory of information and coding

Module details

I3MIIC10-exc

1 ECTS FR
10.0 h 6.25 h 0.0 h 0.0 h
MIGLIORE VINCENT
Revision date : May 18, 2026

Objectives

The aim of the course is to introduce the founding principles of information theory with its applications in data compression, corrective codes and cryptography.
At the end of the course, students will be able to:

- apply the principles of information theory to evaluate, quantify and size algorithms for data compression and error detection and correction.
- apply standard cryptographic encryption algorithms for confidential information transfer.

Content

The content of this course includes:

- Shannon paradigm, quantity of information, entropy
- Data compression with and without loss of information
- Linear error-correcting codes
- Classical, contemporary and post-quantum cryptography

Prerequisites

Basic mathematics in algorithms, information representation, linear algebra, probability and modular arithmetic.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR
5.0 h 21.25 h 2.5 h 0.0 h
BOULIER THOMAS,CARREY JULIAN,CHAZEL FLORENT,ENJALBERT BRICE,GUERMOUCHE NAWAL,LABORIE STEPHANIE,LAHANA YONI,MOREL SANDRINE,RUMPALA JOHANNE,SANCHEZ DAVID,VIGNOLLES DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

System programming and multithreading

Module details

I3MIPS20-exc

3 ECTS FR
11.25 h 6.25 h 11.0 h 0.0 h
MONTEIL THIERRY
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Internet app. and socket programming

Module details

I3MIAI20-exc
2 ECTS FR
6.25 h 3.75 h 19.25 h 0.0 h
CHASSOT CHRISTOPHE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Digital filtering

Module details

I3MIFN20-exc
1 ECTS FR
8.75 h 7.5 h 0.0 h 0.0 h
GRZESKOWIAK MARJORIE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL
DES SCIENCES
APPLIQUÉES
TOULOUSE

Random signal

Module details

I3MISA20-exc

1 ECTS FR
6.25 h 5.0 h 0.0 h 0.0 h
GRZESKOWIAK MARJORIE
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Concepts and hardware for data trans.

Module details

I3MICH20-exc

2 ECTS FR
0.0 h 0.0 h 30.25 h 0.0 h
ROCACHER THIERRY
Revision date : May 18, 2026

Objectives

The objectives of this course includes:

- Description and programming in Arm and x86 assembly languages.
- Description and use of a standardized C compilation chain via scripts, as well as the use of associated debugging tools.
- Description and analysis of the main aspects of the software's lower layers (function calls, data storage, associated security aspects) at C and assembly language level.
- Description and optimization of the use of hardware resources, particularly memory.
- Description and analysis of hardware vulnerabilities.
- Study of DFT, setup DFT parameters (window, number of points) according to a given application, (MATLAB)
- Study of spectrum aliasing phenomena, then design of an anti-aliasing filter
- programming on STM32 controller for the laser shooting game in ASM and C.

Content

The module is divided into two parts, one dealing with assembler language and associated hardware architectures, the other based on numerous practical sessions, combining signal, electronics and embedded programming in assembler and C on STM32 controller.
At the end of the module assembly language and hardware architectures, students will be able to program in assembly language, identify and correct software problems (resource under-utilization, bugs) in C and assembly language, and identify potential hardware vulnerabilities.
The aim of the second part composed of 11 practical sessions is to study a telecommunication-type transmission system (optical link) at all levels, from signal aspects to on-board programming in ASM and C, including a small-scale electronic implementation on a test plate.
The supporting application is a multi-player laser shooting game with use of DFT to identify players

Prerequisites

Prerequisites for this course include:

- Knowledge of computer architecture and internal functional description (processor, memory, caches).
- C language.
- electronics and signal basics strongly recommended

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Graphs

Module details

I3MIGR20-exc

3 ECTS FR
8.75 h 8.75 h 16.5 h 0.0 h
HUGUET MARIE-JOSE
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- how to use the formalism of graphs for modeling various classical problems in computer science
- The principles of several graph-based problemsolving algorithms.

The student should be able to :

- develop a classical graph algorithm to solve a known problem, but with large datasets,
- develop and compare different implementations of a known algorithm, in order to understand the notions of algorithm complexity,
- propose adaptations of classic algorithms to solve a new problem,
- conduct relevant test campaigns to evaluate the performance of different algorithms.

Content

Outline :

- General definitions of graphs
- Some classic graph problems (traversal, connectedness, shortest path, spanning tree, flow) and various associated solving methods.

Practical Labs in Graphs :

- In this lab, the concepts and algorithms of graph theory will be used to solve a standard problem requiring the development of known algorithms.
- Secondly, we will be asked to design a new algorithm to solve a more innovative problem.
- The programming language is Java.

Prerequisites

The prerequisites for this course include:

- Programming (Ada, C, Python, Java, ...)
- Advanced Algorithms and Complexity (3rd year MIC)
- Algorithms and Data Structures (2nd year MIC and 1st year)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Hardware architecture

Module details

I3MIAM20-exc

3 ECTS EN/FR
15.0 h 5.0 h 22.0 h 0.0 h
BIT ARTHUR
Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Object oriented programming

Module details

I3MIPO20-exc

1 ECTS EN/FR
6.25 h 8.75 h 0.0 h 0.0 h
GUERMOUCHE NAWAL
Revision date : May 18, 2026

Objectives

The student will be able to:

- design class diagrams of an application
- design and program in JAVA a simple application,
- to develop a classical graph algorithm aimed at solving a well-known problem whose specificity is to manipulate great amount of data,
- to develop and compare different implementation of a well-known algorithm with the aim to apprehend the notion of algorithm complexity,
- to propose and adapt classical algorithms aimed at solving a new problem,
- to perform relevant measurements tests aimed at evaluating performances of different algorithms.

Content

Introduction to the object oriented programming. A first part introduces the fundamental concepts of object oriented design and programming. Then, the application of those concepts using an object-oriented language (JAVA) is studied. A second part is dedicated to the introduction of UML (Unified Modeling Languages). Class diagrams are particularly used. Finally, tutorials allow practical implementation of the objects concepts.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Telecommunication systems

Module details

I3MIST21-exc

3 ECTS EN/FR
12.5 h 12.5 h 11.0 h 0.0 h
DRAGOMIRESCU DANIELA
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- Definitions related to random signals
- Basics of spectral analysis
- Structures and design modes of digital filters
- Operating principles of telecommunication systems

The student will be able to design a simple digital filter and the architecture of a telecommunication system: choice of the modulation, choice of the media access type, etc.

Content

- Random signals: random process, stationarity, correlation, ergodicity, covariance, spectral density.
- Digital filters: fast Fourier transform, discrete signals and systems, structure and properties of recursive and non-recursive filters, design methods.
- Telecommunications systems: data rates, eye diagrams, transmission lines, baseband coding, analog and digital modulation, constellation diagrams, frames, multiplexing, channel access (FDMA, TDMA, CDMA), spread spectrum.
- Introduction to mobile networks, space communications and securing wireless communications.

The tutorials will go into greater depth on the concepts seen in class, and will focus on well-known applications of telecommunications systems (e.g. USB, Bluetooth, FM radio, etc.). Lab classes will address the design of analog and digital modulations using Software Defined Radio (SDR) tools and an implementation on Universal Software Radio Peripherals (USRP) to develop a wireless telecommunication system. An introduction to the topic of communications security will also be illustrated.

Prerequisites

Signal Process Course

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS   EN/FR
0.5 h   2.75 h   0.0 h   0.0 h
BOULIER THOMAS,CHAZEL FLORENT,DE GOURNAY FREDERIC,GUERMOUCHE NAWAL,GUIEYSSE DAVID,GUIGUI CHRISTELLE,HANTCHERLI MURIEL,LABORIE STEPHANIE,LAHANA YONI,MAHOUT VINCENT,MOREL SANDRINE,PLANTEC JEAN-YVES
Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Object Oriented Design and Object Oriented Programming

Module details

I4IRIL11-exc

8 ECTS FR
18.75 h 43.75 h 27.5 h 0.0 h
YANGUI SAMI
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to:

- Master object-oriented theory and the UML modeling language
- Master a software design methodology driven by use cases, including analysis and detailed design phases
- Apply object-oriented concepts and a design methodology using the Java programming language
- Understand the benefits of best design practices based on design patterns (Observer, MVC, etc.)
- Configure and use configuration management tools (Git) as well as dependency management tools (Maven)
- Become familiar with standard documentation used in project management, requirements specification, design, and testing
- Configure, implement, and use collaborative environments for the software development process
- Gain an introduction to the challenges of managing a software development project
- Plan and take on the different roles of designer and developer within a software development process

Content

A first part introduces the fundamental concepts of the object-oriented model, as well as the notation used to describe design models through the UML language.
A second part focuses on the implementation of these concepts using an object-oriented programming language: Java. During this part, students will have the opportunity to work with advanced Java frameworks such as threads, sockets, JDBC, and Swing.
In addition, students are required to set up an automated development process by implementing an end-to-end pipeline.

Prerequisites

Prerequisites for this course include:

- Knowledge of structured programming (e.g. Ada, C, Pascal, etc.)
- Basic knowledge of object-oriented programming (e.g. encapsulation, instantiation, inheritance, overloading, etc.)

Assessment

The module is assessed through two exams (UML design and Java programming) as well as an integrative project.

Back to menu

Internet and Security

Module details

I4IRRS11-exc

6 ECTS FR
42.5 h 3.75 h 16.5 h 0.0 h
NICOMETTE VINCENT
Revision date : May 18, 2026

Objectives

By the end of this module, students should have understood and be able to explain the main concepts related to:

1. Network and Internet Interconnection:
   - Basic concepts and techniques for interconnecting local networks within the Internet: repeater, bridge, router
   - Advanced concepts and techniques for interconnecting LANs within the Internet: routing, subnetting, CIDR, VLAN, VPN, application proxy, NAT
   - The main protocols of the TCP/IP Internet architecture: UDP, TCP, IP, ARP/proxy ARP, ICMP, DHCP (Note: routing protocols such as RIP, OSPF, and BGP are only briefly introduced)
2. Distributed Algorithms:
   - Main characteristics of distributed systems (asynchrony, distribution of control and data, lack of global knowledge, dynamism, etc.)
   - Problems specific to such systems and the difficulty of solving them in a distributed context (mutual exclusion, shared data management, distributed decision-making, broadcasting, termination detection, etc.)
   - Some generic algorithmic tools to address these problems: causality, distributed recursion and iteration, specific topological structures
3. Security:
   - Principles of computer security through its defining properties, as well as the classification of major threats and defense mechanisms
   - Main vulnerabilities of computer networks, particularly the Internet, and associated defense mechanisms
   - Main application-level vulnerabilities and some associated defense mechanisms

Students should be able to:

1. Network and Internet Interconnection:
   - Make hardware architecture choices that take into account the requirements and constraints of interconnecting local networks
   - Design simple addressing and routing schemes
   - Implement (administer) Ethernet and IP networks in basic interconnection contexts covered in the course
2. Distributed Algorithms:
   - Solve generic problems related to the implementation of distributed systems
   - Use the most general tools to address them
3. Security:
   - Analyze a corporate network and its applications to identify major vulnerabilities, both at the application and network levels, and propose appropriate solutions to improve overall security

Content

The content of this course includes:

1. Network Interconnection:
   - The course first presents the classical technologies for interconnecting local networks within the Internet (repeater, bridge, router), and provides a detailed study of Internet routing (algorithms implemented at the IP level and protocols such as RIP, OSPF, BGP), as well as its evolution (subnetting and classless routing – CIDR). The ARP, proxy ARP, ICMP, and DHCP protocols are also introduced.
   - The course then covers the concepts and techniques related to the management of virtual local area networks (VLANs) and virtual private networks (VPNs), as well as the management of private IP addresses on the Internet (application proxy, NAT).

- The two main Internet transport protocols (TCP, UDP) are detailed in a third part.
- Developments in the Internet to address multicast, quality of service (QoS), and mobility are finally introduced, with a detailed study of basic multicast management.
- Practical sessions on Ethernet and IP network administration using Linux PCs and Cisco equipment illustrate the course.

2. Distributed Algorithms:

- Causal time (logical and vector clocks)
- Phase-based synchronization (applied to optimal routing) and wave-based synchronization (distributed construction of a spanning tree)
- Distributed decision-making (applied to the election problem)
- Distributed mutual exclusion
- Termination detection
- Management of distributed data (illustration of quorum theory)

3. Security:

- Principles of computer security: properties (confidentiality, integrity, availability), authentication, authorization, security policies, auditing, intrusion detection, evaluation
- Classification of attacks: viruses, worms, Trojan horses, etc.
- Network vulnerabilities: study of major vulnerabilities in OSI layers 2, 3, and 4 (ARP spoofing, ARP flooding, IP spoofing, IP fragmentation attacks, TCP hijacking, etc.)
- Application vulnerabilities: focus on memory buffer overflows

Prerequisites

Prerequisites for this course include:

- Introduction to computer networks
- Distributed programming in networks (socket API)

Assessment

Assessement for this course includes:

- Network Interconnection: Written exam and practical (lab) grade
- Distributed Algorithms: Written exam
- Security: Written exam
- Network Interconnection: Written formalization of solutions and practical implementation
- Distributed Algorithms: Written formalization of solutions and implementation
- Security: Written formalization of solutions and implementation

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Mobiles networks and wireless networks

Module details

I4IRRS21-exc

5 ECTS FR
27.5 h 7.5 h 19.25 h 0.0 h
DRAGOMIRESCU DANIELA
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain the principles of deployment and operation as well as the communication architectures of mobile and wireless networks:

- Design, plan and deploy a mobile cellular network
- Understand the cellular architecture of mobile and wireless networks
- Master mobile network architectures, macro-mobility and micro-mobility (handover, paging)
- Master radio interfaces (radio access network) and their impact on network architecture and deployment
- Understanding the transmission of information (voice, data, multimedia) over end-to-end wireless mobile networks
- Understand energy management and transmission power adaptation in mobile wireless networks
- Understand the general operating principles of wireless local area networks
- Design and deploy a wireless enterprise LAN

Content

This module is divided into two complementary lessons: mobile networks and wireless local area networks.

1. Mobile networks
   - the design, planning and deployment of a cellular mobile network
   - mobile network architecture
   - the radio interface - Radio Access Network
   - energy management and transmission power adaptation
   - the different generations of mobile networks and their specific features
2. Wireless local area networks
   - general concepts and terminology of wireless networks
   - the characteristics of wireless transmissions and their impact on the protocol architectures of wireless networks
   - detailed study of 802.11 wireless local area networks (better known by the acronym Wi-Fi), including performance and security aspects
   - the design, analysis and implementation of 802.11 enterprise networks as part of practical work and tutorials

Prerequisites

3rd year Telecommunication and Network Introductory classes

Assessment

A written exam refers to mobile networks and a second written exam refers to wireless networks. The lab work will be also evaluated and the students has to prepare a report

Back to menu

Transmission systems and techniques

Module details

I4IRTC11-exc

5 ECTS EN/FR
21.25 h 3.75 h 33.0 h 0.0 h
BOYER ALEXANDRE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- How the properties and limitations of channelsinfluence transmission
- The different perturbation sources
- The properties of most antennas
- Modulation and demodulation techniques
- Coding and error-correction techniques.

The student will be able to:

- Identify the limitations of a channel and how they alter the signal
- Build a model of a transmission channel, so as to conceive an adapted and optimized transmission link
- Dimension an antenna, taking into account the propagation setting
- Use a software-defined radio module to carry out numerical modulations (ASK, FSK, PSK, APSK, QAM).

Content

The content of this course includes:

- Noisy transmission channels: impact of the physical channel on the transmission and reception of a (mostly, digital) information-carrying signal; signal degradation by the channel; Evaluation of the effect of radio interferences; primary means to enhance transmission reliability.
- Modulation / demodulation: concepts and technique of analog and (de)modulation (ASK, FSK, PSK, APSK, QAM), introduction to softwaredefined radio.
- Antennas and models for RF transmission: essential characteristics, choosing an antenna given the expected radio coverage; conceiving and basic testingof common types of antennas; RF signal transmission to the antenna; main radio propagation models for terrestrial environments.

Prerequisites

Prerequisites for this course include:

- Electromagnetism
- Electronics
- Linear algebra
- Telecommunications and related hardware (basic notions).

Assessment

Written exam for Noisy transmission channels, Error-correcting codes, Antennas
End-of-project report for Modulation/Demodulation

Back to menu

Fundamentals in Computer Science

Module details

I4IRIF11-exc

7 ECTS FR
28.75 h 21.25 h 22.0 h 0.0 h
LE BOTLAN DIDIER
Revision date : May 18, 2026

Objectives

This course is heterogeneous course and groups 3 parts :

- Functionnal Programming : Ocaml
- Formal Logic and Logic Programming in Prolog
- Advanced Algorithmics : AA

At the end of this module, students are expected to :

1. Ocaml Part
   - understand and write pure functional programs,
   - design recursive functions to iterate over recursive data types,
   - define variants or parameterized types,
   - more generally think in terms of higher-order functions in order to write reusable codes.
   - describe the semantics of simple lambda terms
   - have a basic theoretical understanding of the type systems theory
2. Prolog part
   - translate natural language statements into formulas of propositional logic and of 1st order predicate calculus
   - apply several methods in order to check the validity and the consistency of a formula
   - explain the fundamentals of logic programming and of Prolog.
   - express problem solving as a demonstration (proof) based on axioms and theorems describing the particular properties of the problem.
   - design a Prolog program and trace its execution
3. AA Part Some paradigms in algorithmics for discrete optimization :
   - Exhaustive enumeration
   - Divide and Conquer
   - Dynamic Programming
   - Greedy Algorithms

Content

The content of this course includes:

1. Ocaml
   The students undergo practical work and assessments dedicated to basic concepts used in functional programming (curried functions, closures, pattern matching, recursion, variant data types, parametric polymorphism, ...) before working on a small programming project.
2. Prolog part
   - Propositionnal logic
     - Syntax and semantics
     - Truth table method
     - Method of analytic tableaux
     - Hilbert deduction system, derivations and proofs
     - SAT problem- DPLL algorithms
     - Binary Decisions Diagrams
     - Reduced and Ordered Binary Decision Diagrams
   - First order predicate calculus
     - Resolution principle and refutation based demonstration
     - Derivation trees
     - Prenex normal form, skolemization, most general unifiers
     - Herbrand Base, Herbrand universe
   - Logic programming in Prolog
     - Linear resolution for definite clauses
     - Negation by failure
     - Recursive clauses
     - Built-in predicates
     - Applications and extensions
3. AA part
   Main principles of generic algorithms are presented. Their features are compared, taking into account classes of problems, optimization strategies and complexity.

Prerequisites

Assessment

Assessement of this course includes:

- 1 written exam on each part (FP, FL-Prolog, AA)
- 1 practical work assessment
- Self-assessment exercices, Annals and solutions

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Hardware Computing µcontrollers

Module details

I4IRIF31-exc

3 ECTS FR
1.25 h 0.0 h 30.25 h 0.0 h
MAHOUT VINCENT
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Programming specificities of the peripheral units for microcontroller.
- How to take into account hardware constraints for the design of embedded system.

The student will be able to:

- To select an architecture processor adapted to the software application and to the process configuration.
- To conceive and test the techniques of the programming by hardware interruption.
- To use debug tools and test in the context of cross-development.
- To find information into datasheet.

Content

The functions and the programming of the STM32 (based on an ARM/CortexM3 core) is studied essentially in labwork. Half of time is devoted to a project. This project consists with the software development of an embedded system embarked

Prerequisites

Prerequisites for this course include:

- Informatique matérielle Electronique numérique
- Langage dassemblag

Assessment

Assessement of this course includes:

- 1 written exam
- 1 evaluation of the practical work and realization of a projectby team

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Concurrent and real time system

Module details

I4IRTR11-exc

6 ECTS FR
23.75 h 2.5 h 27.5 h 0.0 h
KLODA TOMASZ
Revision date : May 18, 2026

Objectives

This module deals with the specification, modeling, and implementation of parallel, communicating, synchronized, and time-constrained systems.

Content

The course presents the fundamental formalisms used to describe such systems—Petri nets and communicating automata—their main characteristics and specific issues, as well as the associated analysis methods (state-space enumeration, structural analysis, verification using observers, and a brief introduction to temporal logic), providing an initial overview of the analysis techniques applied to them.
Illustrative examples of concurrent systems from communication systems and real-time systems are modeled and analyzed using both formalisms.
Practical sessions use the software tools TINA (for the Petri net part) and UPPAAL (for the communicating automata part).
The course also presents the theoretical foundations and practical solutions for developing multitasking applications under real-time constraints. For example, in a robotic or avionics system, an excessively long response time can lead to failure or accidents. This course covers several aspects necessary to guarantee the deterministic execution of real-time systems, such as worst-case execution time analysis, the main scheduling algorithms used in industry, and protocols for accessing shared resources.
Students should be able to:

- Program a real-time application, build its timing model, and analyze its feasibility.

Prerequisites

Prerequisites for this course include:

- MSC: Graph theory
- PRT: C programming language

Assessment

Assessement for this course includes:

- MSC: Written exam
- PRT: Assessment based on practical work (labs); a formative project allows verification of the understanding of fundamental concepts, and the final report (in the form of a standard document to be completed) highlights the acquisition of technical skills

Back to menu

Quality, Security and the environment

Module details

I4GEIQSEAPS2-exc

1 ECTS   FR
7.5 h   0.0 h   5.5 h   0.0 h
BOYER ALEXANDRE
Revision date : May 18, 2026

Objectives

In many companies and organizations, there is a QSE (Quality, Safety, Environment) department or division. From a professional standpoint, a QSE manager ensures product quality to satisfy customers, as well as the safety of facilities and working conditions for employees at the production site—most often a company. They also make sure that employees work in a certain level of comfort to improve efficiency. At the same time, they work to reduce the environmental impact of the site's activities, for example through waste management and sorting.
From an engineering perspective, QSE issues are significant in terms of working methods and responsibilities, including legal liability. Understanding these multifaceted challenges is at the heart of this course, whose objective is to encourage each individual to position themselves as a professional across all the areas covered.

Content

This course addresses QSE issues through various topics specific to the electrical engineering and computer science department, such as:

- Electrical safety (risks, standards, protections)
- Risks related to electromagnetic interference, manufacturers' obligations for electronic equipment, and the basics of compliance restoration
- Software and hardware security of systems

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Machine learning

Module details

I4IRML21-exc

2 ECTS FR
7.5 h 0.0 h 8.25 h 0.0 h
SIALA MOHAMED
Revision date : May 18, 2026

Objectives

The objective of this course is to master the basic concepts of supervised machine learning. The two types of supervised learning—classification and regression—are covered in detail, along with the different evaluation methods. Students are required to implement, use, and evaluate standard prediction models, such as neural networks and decision trees.

Content

The content of this course includes:

- General introduction to machine learning (applications, supervised learning, unsupervised learning, reinforcement learning)
- Supervised learning: classification vs. regression
- Evaluation
- Neural networks
- Interpretability (decision trees and rule-based prediction models)

Prerequisites

Prerequisites for this course include:

- Linear algebra
- advanced algorithms course
- Python

Assessment

Assessement for this course includes:

- Multiple-choice questionnaire
- lab reports

Back to menu

Research Initiating Project

Module details

I4IRPJ11-exc

3 ECTS EN/FR
0.0 h 5.0 h 0.0 h 22.0 h
CHANTHERY ELODIE
Revision date : May 18, 2026

Objectives

This course unit aims to introduce students to research activities through group projects carried out under the supervision of a tutor (a faculty member, with or without an industrial mentor).
These projects are supported by training in literature review (FRD) to facilitate the development of a state of the art in the field. A project management course complements this training.
By the end of this module, students will have gained practical experience in the following activities:

- Conducting a relevant literature review on a given topic while adhering to presentation standards (IEEE)
- Writing a state-of-the-art section of a scientific paper
- Refining the projected scope of work for the project implementation phase
- Applying project management techniques and collaborative work methods in a project-based setting
- Writing a scientific paper and preparing a project presentation in English

Content

The work to be carried out consists of two parts:

- A literature review on a research topic related to the project subject. This study leads to the writing of the state-of-the-art section of a scientific paper (IEEE article format).
- A technical implementation carried out over an entire semester. This phase leads to the writing of the remainder of the scientific paper and to an oral presentation in English.

Prerequisites

Under construction

Assessment

Assessed materials:

- A written state of the art (with an IEEE-format bibliography)
- A project report

An oral project presentation, possibly including a demonstration.
It combines several forms of assessment: written and oral summaries, as well as a demonstration of the work carried out.

Back to menu

Advanced interconnection and long distance networks

Module details

I4IRRS31-exc

6 ECTS FR
48.75 h 11.25 h 41.25 h 0.0 h
ABDELLATIF SLIM
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain the:

- network architectures and protocols used in operator networks. More precisely, those related to Quality of Service, IPv6, SNMP, inter-domain and intra-domain routing, MPLS and traffic engineering
- wide area data network services that are in use in business, namely VPN (Virtual Private Network) services (Layer 2 and IP) and Carrier Ethernet services
- basics of network optimization, network planning and traffic engineering as well as the accompanying models and algorithms
- main concepts and formalisms used for the description and verification of communication protocols.

The student will be able to:

- Apprehend and master the functioning of Internet core networks (that may conform to the DiffServ framework, with IPv6 and/or MPLS enabled portions, etc.) and manage them
- Design and deploy VPN services for business
- Manage network devices via SNMP
- Apply the appropriate algorithms to network planning and network optimization problems
- Apply formal modelling and verification techniques to communication protocols

Content

This module is composed of 7 complementary courses (each with a set of lectures and lab sessions) and a common project (associated to all the courses). The courses are:

- Quality of Service (QoS) in IP based networks
- IPv6
- Network management with SNMP
- Routing in the Internet
- Wide area networks and services
- Models and algorithms for network traffic engineering
- Communication protocols verification

The project is composed of two parts. In the first part, students are asked to set up an operator network that satisfies the following requirements:

- Capable of providing to its business customers common wide area network services with QoS to connect their remote sites;
- Implementation of a predefined network traffic engineering policy.

The second part deals with development (in software) of a network resource reservation system that allows end customers to provide different classes of services (telephony, transactional data service, best-effort service) to its applications (typically, those that are distributed on different sites).

Prerequisites

Assessment

Assessement for this course includes:

- written exam for each course and homeworks
- For the project: oral presentation and end-of-project report

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Architecture of telecommunication systems

Module details

I4IRTC21-exc

4 ECTS EN/FR
18.75 h 0.0 h 30.25 h 0.0 h
GRZESKOWIAK MARJORIE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the particularities of different types of networks (optical, wireless, spatial networks) and their transmission channel.
- The specification, dimensioning, implementing and/or deployment process of equipments of telecommunication systems in order to optimize parameters such as quality of service, throughput, coverage

Content

The module is organized in three parts :

1. Lab Dimensionning of the radio interface for mobile network (20 hours):
   - implement the dimensioning and planning process of the radio interface of a IoT network, e.g. the LoRa radio.
   - The main properties of radioelectric channel and their effects on coverage and the quality of service, and the most common propagation models are presented in this lab.
2. Lab Medium access control:
   - Design and dimensioning of the Medium Access Control (MAC) layer of a telecommunication system in a wireless network, based on real specifications.
   - Presentation of the mechanisms in the access management of MAC layer in wireless systems (medium access control protocol, collision management, error control, RTS/CTS)
3. Access network and optical communications:
   - Learn how to choose the type of access network or integrate to an architecture the particularities of a given access network.
   - Basics of numerical synchronous hierarchies.
   - Introduction to optical communications: topologies, devices and tests.

Prerequisites

Prerequisites for this course include:

- Signals and telecommunications
- Transmission Systems and Techniques

Assessment

Assessement for this course includes:

- Written exam for Access network and optical communications
- End of project report for Lab Dimensioning of the radio interface for mobile network and Access network and optical communications

Back to menu

Logic and problem solving artificial intelligence

Module details

I4IRSD11-exc

4 ECTS FR
22.5 h 0.0 h 35.75 h 0.0 h
BIT ARTHUR
Revision date : May 18, 2026

Objectives

This course is composed of 3 parts :

- Artificial Intelligence search algorithms for Problem Solving (AI-PS)
- Semantic Web (SW)
- Meta-heuristics (MH)

At the end of this module, students are expected to:

1. AI-PS : Develop programs that implement
   - A* algorithm for searching the best action plan in a problem-state space
   - Algorithms for games with multiple players and non-determinism : minmax, negamax, alphabeta, MCTS
2. SW part : Explain the major issues of the semantic web
   - Implement the RDF graph model and its use for describing web resources and their metadata.
   - Design ontologies for knowledge representation, with the OWL language.
   - Develop an application that access to some ontologies and infers new knowledge through a reasoning.
3. MH Part : Be familiar with he main classes of discrete decision problems and optimization problems and implement three main classes of metaheuristics :
   - Local search methods
   - Evolutionary methods
   - Hybrid methods

Content

The content of this course include:

- Heuristic search in state-problem graphs: A* algorithm
- Heuristic search in AND-OR graphs and hypergraphs: AO* algorithm
- Perfectly informed 2-players games: minmax, negamax, alpha-beta algorithms,
- Monte-Carlo simulation-based approach: MCTS algorithm
- RDF modeling
- Designing ontologies using the OWL language.
- Exploitation of an ontology and knowledge inference.
- Local search algorithms : Hill-Climbing, Simulated annealing, Taboo search
- Evolutionary algorithms : genetic algorithms, ant colony algorithms
- Hybrid metaheuristics

Prerequisites

Prerequisites for this course include:

- Algorithmics and programming: Logic for knowledge representation (1st order predicate calculus)
- Tree search algorithms: Exact and approached methods (heuristics) for combinatorial optimization

Assessment

Each part has two assessments :

- 1 exam
- 1 or several reports of practical works

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Software and hardware architecture for computer systems

Module details

I4IRIM11-exc

6 ECTS   EN/FR
25.0 h   10.0 h   30.25 h   0.0 h
DRAGOMIRESCU DANIELA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Manipulation of with various type automata, language theory, parsers, compilers;
- Development of a compiler, management and allocation of a program memory;
- Introduction to quantic computing
- Specification of hardware components and architectures in a high-level language;
- Taking Into account the specific material constraints for embedded systems with limited resources.
- Architectures and technologies for green computing, green software for sustainable development

The student will be able to:

- Create parsers and compilers while considering constraints from the environment (embedded or not).
- Understand and design processor architectures
- Select a processor architecture adapted to the software application and the environment.
- Specify a hardware system in a concurrent language used widely in industry, VHDL and implement this system on an FPGA.

Content

The content of this course includes:

- The Automata Theory and Languages, the design of parsers and compilers. Automatic code generation concepts will be also introduced.
- Basis of quantic computing will be presented.
- Hardware architecture for computer systems (processor architecture, pipeline, branch hazards, branch prediction unit, DMA, MMU (paging and segmentation), data hazards, multi-core), VHDL language for hardware description, the FPGAs, the concepts of reconfigurable computing, GPU will be studied in detail.
- The technologies for green computing and green software will be resented for the sustainable development of future computing systems
- During Computer Systems Project, the students will develop a compiler and its associated processor architecture. They will optimize their computer system upon different criteria : low power architectures for sustainable development or security architectures.

Prerequisites

C programming, computer architecture

Assessment

Resolution of particular case in a project and written examinations, covering the main points of the courses. The assessment provides to the student an estimation of his/her knowledge compared to the fundamental points.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Cloud native computing and networking

Module details

I5IRIL12-exc

6 ECTS FR
18.75 h 17.5 h 41.25 h 0.0 h
GUERMOUCHE NAWAL
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain (main concepts):

- The software project lifecycle
- The challenges of software development
- DevOps
- Service-oriented architecture
- Resource-oriented architecture (RESTful)
- Microservices architecture
- The concept of Cloud

The student should be able to:

- Manage a software development project carried out in a team, particularly by following the Agile Scrum methodology
- Apply the Agile Scrum methodology in practice, from requirements analysis based on specifications, to defining user stories, tasks, sprint planning, etc.
- Design and develop a service-based architecture
- Develop SOAP and REST web services
- Develop microservices
- Understand and implement a REST API
- Understand the concept of cloud computing
- Use a cloud infrastructure in an Infrastructure as a Service (IaaS) model
- Set up continuous integration and continuous deployment (CI/CD) pipelines

Content

The content of this course includes:

- Automation of the software lifecycle (DevOps)
- Web services (SOAP, REST)
- Design and execution of business processes (BPEL)
- Microservices architecture
- Virtualization and cloud computing
- Network softwarization (SDN)

Prerequisites

The prerequisites for this course include:

- algorithms
- object-oriented programming in Java
- object-oriented design using UML, XML and XML Schema

Assessment

Assessment is based on continuous lab (practical) work as well as a real software project carried out in groups. Working on a real project allows students to apply and consolidate their knowledge, and to face the challenges related to software development. Students are required to submit a report, the source code, and to present their work during an oral defense.

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Frameworks for Big Data

Module details

I5IRBD12-exc

2 ECTS FR
8.75 h 0.0 h 16.5 h 0.0 h
YANGUI SAMI
Revision date : May 18, 2026

Objectives

At the end of this module, the student will understand and be able to explain the concepts and techniques related to the main pillars that have to be managed by an IT service provider, in terms of:

- physical infrastructure (network, storage , computing) ;
- organizational and data management (allocation of storage , ...);
- computation services of such data (based on calculation models like map reduce, etc.).

The student will be able to:

1. With regard to physical infrastructures
   - design and deploy a network architecture adapted to a big data oriented service, using advanced network technology (network virtualization, optimization protocols, etc.);
   - dimension and deploy a physical storage infrastructure aimed at receiving massive amounts of data;
   - assess and deploy the computing power required to process massive data, based on the latest technologies for processors, such as virtualization.
2. With regard to the organization and data management
   - design and implement tools to organize data within the physical infrastructure;
   - provide appropriate interfaces for access to such data;
   - choose a data organization adapted to the constraints of treatment (offline versus real-time processing);
3. With regard to the data processing services
   - provide facilities for analyzing data and extract value added information (e.g., learning, trends).

Content

Organization and Data Management:

- Databases (SQL and NoSQL)
- Concept of distributed and efficient files systems (focus on Hadoop Distributed File System)
- Indexing techniques Data
- File formats

Data processing:

- Models of data distributed processing (Map-Reduce)
- Hadoop platform
- Spark platform
- Cassandra platform
- Neo4j platform

Prerequisites

Prerequisites for this course include:

- Networking
- Operating systems
- Algorithmics and programming (Python, Java)
- Databases
- Algorithmic and programing

Assessment

Practical manipulation of the theoretical concepts and techniques introduced in the lectures.

Back to menu

Reliability and model-checking

Module details

I5IRSF11-exc

4 ECTS FR

26.25 h 0.0 h 16.5 h 0.0 h

BARON CLAUDE

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain the main principles of systems engineering and software engineering:

- concepts, methods and tools
- to define and control the process development of a critical embedded system.

The student will be able to:

- apply these general competences to computer based systems
- explain different methods and chose the best adapted to develop a specific application.

Content

The goal of this UF is to introduce the main principles of dependability.
A first course introduces the concepts, methods and tools, to define and control the process development of a computer based system. Specific courses allow you to go a step further by focusing on two aspects:

- Modeling of timed systems with an introduction to the formalisms of time Petri nets and timed automata and an introduction to the associated verification techniques.
- Model verification allows to ensure the satisfaction of the required properties. An introduction to temporal logics is given for the formal expression of required properties.
- The main algorithms for model checking are presented.

Prerequisites

Petri Nets, Communicating Automata, formal Logic, Graph theory

Assessment

Assessement for this course includes:

- Exams
- Lab works
- Personal reports
- Presentations

Personal work allows students to position themselves in relation to the learning objectives. Lab works allow students to assimilate the concepts and put them in a position of application on concrete problems. The preparation of the oral presentation and the writing of a memory require synthesis work.

Back to menu

Descriptive and predictive analysis

Module details

I5IRAD12-exc

4 ECTS FR
23.75 h 0.0 h 33.0 h 0.0 h
HUGUET MARIE-JOSE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the different problems associated with data study (in exploratory data analysis and in machine learning)
- the main concepts and algorithms allowing to solve those problems
- the main existing libraries

The student will be able to:

- analyze the requirements of the data processing
- set up the most efficient algorithms
- use the algorithms that are implemented in the main existing libraries
- adapt and develop his/her own algorithms
- analyze and explain the results of those algorithms
- program in Python and R languages

Content

The content of this course includes:

1. Exploratory analysis and visualization
   - Exploratory analysis aims at describing data sets in order to improve their understanding and extract information.
   - The goal of this section is to present the concepts and tools of exploratory analysis (probabilities, statistics, dimension reduction) and data visualization.
2. Machine learning
   - This part focuses on obtaining a model of a data set.
   - In a first sequence, we focus on supervised learning methods to deepen the notions seen in the 4th year IR course (complement on standard methods, ensemble methods, deep learning, bias and fairness issues, explicability, robustness, privacy, hybrid models).
   - In a second sequence, we study unsupervised learning with a focus on clustering problems and methods (hierarchical, k-means, density-based).

The goal of these two parts is also to know the main existing libraries in Python (Scikit-learn) or in R.

Prerequisites

Prerequisites for this course include:

- Algorithms
- data structures
- computational complexity
- programming
- optimization
- supervised machine learning (basic knowledge)
- statistics and probability (basic knowledge)

Assessment

Assessement for this course include:

- Mini projects
- Labworks reports
- Oral presentation

Back to menu

Distributed Systems and Big Data Project

Module details

I5IRPR12-exc

4 ECTS EN
0.0 h 30.0 h 22.0 h 0.0 h
HUGUET MARIE-JOSE
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and will be able to explain:

- The objectives of an Artificial Intelligence and Big Data project
- The methodological and technological choices retained and developed to respond to a specific project

The student should be able:

- To create a software chain for the collection, storage and processing of massive data,
- to argue about the choices made,
- to evaluate the proposed solution.

Content

The content of this course includes:

- The project involves teams of 5 or 6 students.
- Several subjects are proposed, potentially in conjunction with an industrial partner.
- The project is associated with English courses for the presentation and report parts.
- The project is also linked to the labs of the "Service-Oriented Architecture" course.
- The aim of these lab sessions is to produce a software application based on the project topic.

Prerequisites

Descriptive and Predictive Analysis, Big Data Infrastructures

Assessment

project report and presentation

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Prescriptive Analytics *

Module details

I5IRSD12-exc

4 ECTS FR
22.5 h 0.0 h 27.5 h 0.0 h
SIALA MOHAMED
Revision date : May 18, 2026

Objectives

This course addresses models for efficient data processing encountered in industrial problems of a combinatorial nature. The models are based on logical reasoning and optimization: constraint satisfaction problems (CSP), Boolean satisfiability problems (SAT/SMT), and integer linear programming (ILP).
For the CSP part, students must be familiar with the main propagation and solving techniques, and, through practical sessions, learn to use programming tools that integrate constraint propagation algorithms, branching strategies, and other advanced solving techniques (e.g., tools such as CPLEX, CPMpy).
In the SAT section, students implement a SAT solver based on the Conflict-Driven Clause Learning (CDCL) algorithm and explore satisfiability modulo theories (SMT) models. Various classical combinatorial problems (graph coloring, resource allocation, scheduling) are used as practical case studies to practice SAT encoding.
For the ILP part, students are required to model industrial problems as integer linear programs and solve them using branching algorithms or decomposition methods with programming tools (CPLEX).

Content

The content of this course includes:

- Constraint satisfaction problems: satisfiability and consistency.
- Constraint formulation in intension and extension.
- Constraint networks: node, arc, and path consistency algorithms.
- Generalized arc consistency.
- Bounds consistency.
- Global constraints: Alldiff, Sum, Cardinality, Disjunctive, Cumulative.
- SAT modeling: Boolean satisfiability, DPLL algorithm, implication graphs, conflict analysis, Two-Watched Literals (TWL) algorithm.
- SAT solvers based on Conflict-Driven Clause Learning (CDCL). Satisfiability Modulo Theories (SMT).
- Integer Linear Programming: modeling and solving.
- Modeling industrial problems using ILP.
- Standard solving algorithms: branch and bound, branch and cut.
- Decomposition methods: column generation, Benders decomposition.

Prerequisites

Prerequisites for this course include:

- Algorithmics and Programming
- Fundamentals of Computer Science
- Intelligent Systems

Assessment

The written exam is based on exercises designed to test whether the different concepts presented in the course have been understood.

Back to menu

Software Defined Comm. Infrastructure *

Module details

I5IRRS12-exc

4 ECTS   FR
5.0 h   6.25 h   38.5 h   0.0 h
YANGUI SAMI
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain:

- Concepts related to Network Function Virtualization (NFV)
- Concepts related to network programmability (Software-Defined Networking, SDN)
- The autonomic computing model defined (among others) by IBM
- The perspectives of real-world stakeholders involved in large-scale projects (application developer, middleware operator, network operator)

The student should be able to:

- Use an SDN network emulator (ContainerNET)
- Use an SDN controller (Ryu)
- Use a standardized NFV MANO (SON-EMU)
- Develop a standardized VNF
- Design and implement solutions leveraging network function virtualization and programmable networking concepts, in the context of building an SDCI
- Apply and implement the autonomic computing model to a QoS management problem in an SDCI

Content

The content of this course includes:

1. Network function virtualization:
   - Software-defined networking (SDN)
   - Forms of network function virtualization
   - Network Function Virtualization (ETSI NFV)
   - VNF orchestration
   - Use of a Southbound API: OpenFlow
2. SDCI Project Two objectives in the project:
   1/ Dynamic and transparent deployment, for applications, of virtual network functions (VNFs):
   - To meet the functional and/or non-functional requirements of distributed applications, for example in the context of IoT activities
   - By applying concepts and techniques related to network function virtualization (NFV) and software-defined networking (SDN)

   2/ Development of an autonomous management approach for deploying the targeted VNFs using the concept of Autonomic Computing (AC) introduced at the beginning of the project

Prerequisites

The prerequisites for this course include:

- Network Interconnection – TCP/IP
- Object-Oriented Design – UML
- Object-Oriented Programming – Java
- Concepts and techniques related to virtualization
- Service-Oriented Architectures

Assessment

Assessement of this course includes:

- Project, report, oral presentation
- Application of knowledge through the development of a group project

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Operating safety

Module details

I5AISF11-exc

ECTS

32.5 h 5.0 h 38.5 h 0.0 h

VERNADAT FRANCOIS

Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain (main concepts):

- The fundamental concepts of dependability and the main methods and techniques for achieving and validating the dependability of a system.

The student should be able to:

- Apply this general knowledge to electronic and software-based technological systems
- Explain the different approaches and choose the appropriate type of approach for a given application

Content

An initial lecture provides a general introduction to dependability, specifying the terminology, attributes, and means.
More specialized lectures go further into this overview, mainly illustrating methods such as:

- Fault prevention through modeling, following synchronous and asynchronous timed paradigms
- Fault elimination through static verification of sequential programs and diagnosis

Prerequisites

The prerequisites for this course include:

- Discrete event systems
- Propositional logic

Assessment

Assessement for this course includes:

- Written tests
- Practical sessions to become familiar with tools and to implement the approaches covered in class
- Presentations in front of the entire cohort
- Reports

The required personal work allows students to assess their progress with respect to the learning objectives.
Practical sessions help students assimilate the concepts covered in class and place them in situations where they apply them to concrete problems.
Preparing the oral presentation and writing a dissertation require synthesis work on the discipline.

Back to menu

Engineering processes

Module details

I5AIMI11-exc

ECTS

32.5 h 11.25 h 24.75 h 0.0 h

BARON CLAUDE

Revision date : May 18, 2026

Objectives

Present the main principles of systems engineering and software engineering: concepts, methods and tools, to define and control the process development of a critical embedded system.

The student will be able to apply these general competences to computer based embedded systems explain different methods and chose the best adapted to develop a specific application.

Content

The goal of this course is to introduce the main principles of systems engineering and software engineering.

- A first course introduces the concepts, methods and tools, to define and control the process development of a critical embedded system.
- A second course introduces agile management of engineering processes in an embedded system development project.
- A MOOC allows the student to synthetize all the notions of this UF and to reinforce some.
- Another course introduces the principles of machine learning.
- A final course, specific to the students specialization, allows them to deepen their knowledge of model checking or the Kalman filter.

All method, tools and good practices presented in the UF will be used in a transversal project of development of a critical embedded system.

Prerequisites

Under construction

Assessment

Assessement for this course includes:

- Exams
- Lab works
- Project

Back to menu

Embedded Computer Architecture

Module details

I5AISE51-exc

ECTS
18.75 h 2.5 h 16.5 h 0.0 h

Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain:

- The principles and specific features of networks used in embedded systems in the automotive, avionics, and IoT sectors
- The specific characteristics of operating systems and their main services (scheduling, memory, privileges, etc.) for embedded systems
- The advantages and disadvantages of different computing architectures used in embedded systems
- The factors affecting performance (computation, energy consumption, etc.) of a computing architecture and methods for optimizing them

The student should be able to:

- Choose a network technology that meets the needs of an embedded system
- Set up the network supporting an embedded system
- Deploy an operating system on an embedded architecture
- Develop a driver within an operating system
- Compare two embedded computing architectures in terms of performance
- Choose a computing architecture suited to the needs of an application

Content

Under construction

Prerequisites

Prerequisites for this course include:

- C programming
- Computer architecture
- Networks
- Operating systems

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Interdisciplinary Project

Module details

I5AIPI11-exc

ECTS

0.0 h 30.0 h 41.25 h 0.0 h

CHANTHERY ELODIE

Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Implement and apply agile management according to the agile method in order to create a product,
- Select and interweave a set of interdisciplinary technical skills in order to develop a critical embedded system,
- Search autonomously and be able to critique technical solutions for which he/she does not have prior knowledge in order to meet requirements specific to critical embedded systems,
- Design and build a product deployed on a heterogeneous and communicating embedded architecture guaranteeing performance properties,
- Define needs, requirements and architecture when designing a product
- Communicate in an interdisciplinary context and to work together with actors with heterogeneous skills,
- Adapt the writing and presentation of scientific results according to the audience (client, decision maker, evaluator, general public) and through various media (presentation, website, report, synthesis, poster).

To express themselves correctly in English, using a concise and precise style respecting the conventions of genre in writing as well as orally

Content

Methods, practices and tools presented in the dependability, engineering methods and embedded computer architecture UFs will be implemented in this transversal project for the development of a critical embedded system, including courses in English

Prerequisites

Prerequisites for this course includes dependability, engineering methods and embedded computer architecture Ues

Assessment

Assessement for this course includes:

- Project plan 0: written report on the needs, risks and project management
- Web page
- Oral presentation during weekly meetings and reviews every two weeks
- Final review
- Poster
- Final abstract

Very regular and personalized follow-up and feedback allows students to improve throughout the semester.

Back to menu

Service Robotics

Module details

I5IRRS41-exc

ECTS

10.0 h 5.0 h 35.75 h 0.0 h

TONDU BERTRAND

Revision date : May 18, 2026

Objectives

At the end of this module, the student would be able to explain the main components of a robot service and to say in which way it differs from industrial robotics; he/she will know the main concepts in humanoid robotics and why it is difficult to control a walking robot.
His/her knowledge will include the main notions in jointed robotics: direct and inverse kinematic models, dynamic model of the robot, trajectory generation and stability of a bipedal robot.
The student is supposed to be able to model a jointed robot, to understand its technical components and to analyse the functioning of a service robot in its domestic or professional environment.

Content

The content of this course includes:

- Introduction to service robotics: this lecture introduces the specificity of the service robot and aims to specify its field of application both at home and at the hospital; both simple mobile robots and more complex jointed robots will be modeled; direct and inverse kinematic models will be considered as also simple methods in trajectory generation; the choice of a relevant actuator will be discussed and how its position can be controlled by means of classic linear control methods; the special case of hybrid position-force control will be briefly discussed.
- Labwork in service robotics: students must select one concept or method they will try to study in some advanced way in the framework of a problem encountered inside the robot club of the department or peculiar labwork project proposed by a teacher.
- Labwork in humanoid robotics: the labwork is a true introduction to humanoid robotics, considered as a multidegrees of freedom tree chain structure whose modelling requires a direct kinematic approach based on the robot Jacobian matrix and an inverse approach based on the pseudo-inverse of this Jacobian matrix. Theoretical notions are illustrated by means a graphical simulator of the Japanese humanoid robot HRP2.

Prerequisites

Prerequisites for this course include:

- Matrix theory
- Linear control

Assessment

Assessement is taking place during labworks

Back to menu

Advanced algorithmics

Module details

I3MIAA10-exc

2 ECTS FR
8.75 h 10.0 h 0.0 h 0.0 h
SIALA MOHAMED
Revision date : May 18, 2026

Objectives

The objective of this course is to introduce the foundations of computational thinking, including complexity theory, proofs of correctness, advanced algorithmic design, and more. Throughout the course, students will learn to analyze the tractability of problems as well as the correctness and complexity of algorithms. They will be taught advanced algorithmic design techniques, such as divide and conquer, greedy algorithms, dynamic programming, and branch and bound.

Content

- Correction proofs
- Asymptotic analysis
- Devide and conquer
- Greedy algorithms
- Dynamic Programming
- Branch and Bound
- Problems tractability

Prerequisites

Algorithms and Programming (1ˆ*st* & 2ˆ*nd* year)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Databases II

Module details

I3MIBD10-exc

2 ECTS FR
3.75 h 7.5 h 8.25 h 0.0 h
GUERMOUCHE NAWAL
Revision date : May 18, 2026

Objectives

At the end of this module, students should be able to understand and explain the main concepts.

- The relational model
- Data integrity constraints
- Languages for manipulating and querying relational databases, in particular relational algebra and the SQL language.

In practice, students should be able to :

- Implement a designed database while guaranteeing integrity constraints
- Write queries in relational algebra, then implement them in SQL for manipulating and querying relational databases

Content

The content of this course includes:

- The relational model
- Data integrity constraints
- Languages for manipulating and querying relational databases, in particular relational algebra and the SQL language

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Data analysis

Module details

I3MIAD10-exc

3 ECTS FR
12.5 h 3.75 h 13.75 h 4.0 h
MAUGIS CATHY
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- the main definitions for the unidimensional and bidimensional descriptive statistics
- the main concepts and the interpretation of graphical results of the principal component analysis
- the main concepts of clustering (hierarchical clustering, kmeans method and DBSCAN) and the interpretation of graphical results

The student will be able to:

- develop a descriptive statistical analysis with the R software
- manipulate the concepts of the principal component analysis, know the main properties and comment the graphical results

Content

- Unidimensional descriptive statistics
- Bidimensional descriptive statistics
- Principal component analysis
- Clustering: principle, hierarchical clustering, Kmean and DBSCAN
- Introduction to programming in R and Rmarkdown

Prerequisites

Probability and Statistic course

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Optimization and linear programming

Module details

I3MIOP10-exc

3 ECTS EN/FR
13.75 h 12.5 h 11.0 h 0.0 h
ESCANDE PAUL
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The notions of local extremum and convexity
- Characterization of a local extremum by optimality conditions: first and second order conditions in unconstrained differentiable optimization, Karush-Kuhn-Tucker (KKT) conditions in constrained differentiable optimization
- The first algorithms for unconstrained optimization: gradient algorithm (fixed step, optimal step), Newton's algorithm, linear and nonlinear least squares problems
- Optimization under linear constraints (Linear Programming/PL): modeling in PL, characterization of the search space, geometric interpretation, solution principle, simplex algorithm, dictionary methods, complexity, duality.

The student will be able to:

- Choose and implement a relevant and numerically efficient optimization method for an unconstrained differentiable optimization problem or for a linear programming problem.

Content

- Introduction to constrained optimization: definitions and generalities, existence of solutions, convexity and uniqueness
- Optimality conditions: first and second order conditions in unconstrained differentiable optimization, Karush-Kuhn-Tucker (KKT) conditions in constrained differentiable optimization, Lagrangian notion
- Algorithms for unconstrained optimization: gradient algorithm (fixed step, optimal step), Newton's algorithm, linear and nonlinear least squares problems
- Introduction to linear constrained optimization: modeling formalisms, characterization of the search space, geometric interpretation, graphical resolution, link with KKT conditions, simplex algorithm, method of dictionaries, complexity, duality of a PL problem, strong and weak duality theorems, complementary deviations theorems, Farkas lemma, alternatives theorem.

Keywords : differentiable optimization, first and second order optimality conditions, gradient algorithms, Newton, least squares problems, linear programming and simplex algorithm.

Prerequisites

Differential calculus: know how to calculate a gradient and a hessian. Link with differential. Linear algebra: know how to diagonalize a matrix, calculate the eigenvalues, notion of semi-definite positivity.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Operating system

Module details

I3MISE10-exc

2 ECTS   EN/FR

7.5 h   3.75 h   0.0 h   0.0 h

MONTEIL THIERRY

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain the operating system problems with a global overview of its functions and architecture.

Content

The operating system is considered as resources managers: processors management (processes, scheduling) memory management (virtual memory, allocation), access to resources (synchronisation, mutual exclusion) and file system.

Prerequisites

Notions in computer's structure.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Markov chains

Module details

I3MICM10-exc

2 ECTS EN/FR
7.5 h 8.75 h 2.75 h 0.0 h
PEDECHES LAURE
Revision date : May 18, 2026

Objectives

Time-homogenous Markov chain over discrete state space, classification of states, stationary measure, reversible Markov chain, convergence to stationary distribution, ergodic theorem. The description of a Markovian model to its formalization by a Markov chain develop a analysis of Markov chains (description of its communication classes, conclusion on the existence of a stationary distribution and on the convergence of the chain distribution)

Content

Markov chains and their classification: definition and class properties (irreducibility, recurrence, transience, aperiodicity), convergence to the stationary distribution, reversible Markov chain, absorbing time.

Prerequisites

Basic notions in discrete probability theory

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Complements of probabilities

Module details

I3MICP10-exc

3 ECTS FR
18.75 h 18.75 h 0.0 h 0.0 h
JOULIN ALDERIC
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The notion of sigma-algebra generated by one or many random variables.
- The definition and main properties of a conditional expectation.
- The definition and main properties of a Gaussian vector.
- The various modes of convergence in probability theory and the links between them.

The student will be able to:

- Compute a conditional expectation with respect to a given sigma-algebra.
- Prove that a random vector is a Gaussian random vector and give the underlying parameters (expectation and covariance matrix); use the specific properties of Gaussian random vectors.
- Use classical inequalities appearing in probability theory.
- Prove that a given sequence of random variables converges (or not) almost surely, in probability, in distribution or in Lebesgue spaces (Lp spaces).

Content

- Sigma-algebra, sigma-algebra generated by one or many random variables.
- Conditional expectation with respect to a sigmaalgebra generated by a partition and then with respect to a general sigma-algebra. Main properties of conditional expectation.
- Gaussian random vectors. Main properties, Gaussian miracle for the independence of coordinates, projection theorem for Gaussian random vectors, multidimensional central limit theorem.
- Classical inequalities arising in probability theory: Markov, Chebyshev, Cauchy-Schwarz and Hölder.
- Modes of convergence of random variables: almost sure, in probability, in distribution, in the Lp spaces, and links between them.

Prerequisites

Probability and Statistics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Dynamical systems

Module details

I3MISD10-exc

3 ECTS FR
13.75 h 11.25 h 11.0 h 0.0 h
SANCHEZ DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to :

- Define a Cauchy problem and prove the wellposedness of an autonomous ordinary differential equation
- Obtain qualitative properties of the solution of an autonomous ordinary differential equation (maximal solution, maximum domain, stability)
- Draw the phase portrait of an autonomous ordinary differential equation in dimension 1 and 2
- Solve using numerical integration an autonomous ordinary differential equation
- Apply these notions to analyze a dynamical system used in physics, biology or population dynamics

Content

- Definition of a maximal solution and the maximum domain, analysis of the stability
- Qualitative properties: conservative systems, Lyapunov functions, introduction to bifurcations (+ limit cycles)
- Construction of the phase portrait of an ODE in dimension 1 and 2
- Numerical integration of an autonomous ODE (Euler, RK, Crank-Nicholson)
- Analysis of a numerical scheme: stability, consistency and convergence

The above-mentioned concepts will be introduced and applied to 4 dynamical systems used all along this class

Prerequisites

Differential and integral calculus, linear algebra

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Ecological transition and greenhouse gases

Module details

I3CCIE11-exc

3 ECTS FR

5.0 h 21.25 h 2.5 h 0.0 h

BOULIER THOMAS,CARREY JULIAN,CHAZEL FLORENT,ENJALBERT BRICE,GUERMOUCHE NAWAL,LABORIE STEPHANIE,LAHANA YONI,MOREL SANDRINE,RUMPALA JOHANNE,SANCHEZ DAVID,VIGNOLLES DAVID

Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to:

- Be comfortable with the fundamental concepts related to greenhouse gas emissions, and be able to make simple calculations on this subject.
- Know the order of magnitude of important quantities.
- Be able to fetch emission values from the ADEME database and use them appropriately.
- Think about ecological issues in all their complexity and study a specific problem
- Have an understanding of life cycle analysis and how to apply it
- Be able to research scientific literature
- Be able to understand and analyse figures/data
- Draw political conclusions from scientific facts and one's own values
- Debate, discuss and confront points of view.

Content

The teaching includes a "2 tonnes" workshop, which provides a fun way of understanding the orders of magnitude linked to the objectives of carbon neutrality in 2050. It also includes assignments on the following topics: housing; electricity production; inequalities and responsibilities; mobility; the climate inaction debate; agriculture and food; and aeronautics.
Students also work on a complex problem linked to ecological issues, starting their reflections from an everyday object or service.

Prerequisites

Basic knowledge on energy.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Partial Derivative Equations I

Module details

I3MIDP20-exc

3 ECTS FR
11.25 h 13.75 h 11.0 h 0.0 h
SANCHEZ DAVID
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Classical linear one dimensional PDE (heat, transport, wave...), their exact resolution and the qualitative behavior of their solutions
- The Finite Difference method in one dimension space to solve PDE

The student will be able to:

- Solve linear PDE in one dimension space (characteristic method, variable splitting, superposition principle, Fourier transform)
- Implement Finite Difference method in one dimension space, coupled with numerical solving method for ODE in order to solve PDE.

Content

Modeling with PDE (linear PDEs in one dimension space)

- Transport and wave equation
- Heat equation
- Schrödinger's equation

Exact resolution of PDE in one dimension space

- Characteristic method (transport, wave)
- Variable separation (heat, wave, Schrödinger equation), use of the linearity (superposition principle) and link with Fourier series
- Fourier transform
- Dissipative and dispersive phenomenon

Finie Difference Method in one dimension space

- Consistancy, order, stability, scheme convergence
- Courant-Friedrichs-Levy condition (CFL)

Prerequisites

- Linear Algebra: matrix manipulation, eigenvalues and eigenelements, solving of linear differential equations.
- Ordinary differential equations: modeling, existence of solutions, qualitative study, numerical simulation (convergence, stability, order)

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Inferential statistics

Module details

I3MISI20-exc

3 ECTS   FR
16.25 h   15.0 h   5.5 h   0.0 h
MELISANDE ALBERT
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- defining a parametric model using usual distributions, such as normal, exponential, Bernoulli, Poisson, etc
- parameter estimation in a parametric model
- confidence interval construction
- hypothesis testing

The student will be able to:

- Model a situation using usual probability distributions, and manipulate them
- Estimate parameters in a parametric model and study the properties of these estimators
- Construct a parametric confidence interval
- Construct a parametric hypothesis testing

Content

- Review of the definitions and properties of the usual distributions (normal, Chi-square, Student's, Fisher's, Gaussian vectors, etc.) and probabilistic tools (law of large numbers, central limit theorem, Slutsky's lemma)
- Estimation in a parametric model: method of moments, maximum likelihood
- Cramer-Rao bound, and efficiency of an estimator
- Confidence interval for the mean and the variance of a Gaussian or a non-Gaussian sample
- Parametric hypothesis testing: concept, tests on the mean and the variance of a Gaussian sample, tests on a proportion, p-value, test for comparing two independent Gaussian samples, Neyman Pearson's lemma, maximum likelihood ratio tests

Prerequisites

Probability and Statistics

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Project

Module details

I3MIBE20-exc

3 ECTS FR

0.0 h 5.0 h 0.0 h 25.0 h

CHAZEL FLORENT

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Principles of mathematical modeling of an application problem in relation to another discipline or a particular industrial sector
- Self-evaluation of the results obtained in relation to the objectives.

The student will be able to:

- Interact with a specialist or engineer from another discipline
- Organize collaborative work in small groups
- Define the framework and specifications of an original mathematical modeling problem
- Conduct the necessary bibliographic research to solve the problem
- Develop the deterministic and/or stochastic model adapted to its resolution
- Implement its numerical resolution
- Report in writing and orally on the results obtained

Content

Elements of Scientific Communication:

- Introduction to Latex
- Introduction to Beamer
- Communication in applied mathematics: document structure (reports, slides), key points: modeling, analysis, simulation, tests

Mathematical modelling project : to be chosen in a list of possible projects.

Prerequisites

Dynamical systems, advanced probabilities, data analysis.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

MCMC methods

Module details

I3MIMC20-exc

3 ECTS FR
15.0 h 15.0 h 8.25 h 0.0 h
JOULIN ALDERIC
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The fundamental principles of simulating random variables and vectors.
- The classical methods for variance reduction when approximating numerically integrals by means of the Monte Carlo method.
- The approximation of integrals by means of the Monte Carlo method using Markov chains.

The student will be able to:

- Generate a real random variable by the inversion method.
- Simulate a random vector by the acceptancerejection method.
- Choose appropriate techniques for variance reduction (control variate, importance sampling, antithetic variates method).
- Use the Metropolis-Hastings algorithm generating a reversible ergodic Markov chain with prescribed stationary distribution.

Content

- Simulation of random variables and vectors: pseudorandom numbers, simulation by the inversion method of the probability distribution function, by the acceptancerejection method and by specific simulation methods.
- Classical Monte Carlo methods: implementation, variance reduction by different methods (control variate, importance sampling, antithetic variates method).
- Markov chain Monte Carlo methods: reminders on Markov chains, Markovian law of large numbers, Metropolis-Hastings algorithm.
- Application with the Python software

Prerequisites

- Probability and Statistics
- Probability and Data Analysis
- Complements of Probability

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Object oriented programming

Module details

I3MIPO20-exc

1 ECTS EN/FR
6.25 h 8.75 h 0.0 h 0.0 h
GUERMOUCHE NAWAL
Revision date : May 18, 2026

Objectives

The student will be able to:

- design class diagrams of an application
- design and program in JAVA a simple application,
- to develop a classical graph algorithm aimed at solving a well-known problem whose specificity is to manipulate great amount of data,
- to develop and compare different implementation of a well-known algorithm with the aim to apprehend the notion of algorithm complexity,
- to propose and adapt classical algorithms aimed at solving a new problem,
- to perform relevant measurements tests aimed at evaluating performances of different algorithms.

Content

Introduction to the object oriented programming. A first part introduces the fundamental concepts of object oriented design and programming. Then, the application of those concepts using an object-oriented language (JAVA) is studied. A second part is dedicated to the introduction of UML (Unified Modeling Languages). Class diagrams are particularly used. Finally, tutorials allow practical implementation of the objects concepts.

Prerequisites

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Signal II

Module details

I3MISG20-exc

3 ECTS EN/FR
12.5 h 11.25 h 13.75 h 0.0 h
NOBLE PASCAL
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Fourier transform of integrable functions.
- Fourier transform of sequences
- Short time Fourier trasnform
- Sampling Shannon's Theorem
- Modelisation of random signals.
- ARMA process
- Signal denoising

Content

The content of this course includes:

- Continuous Signal Processing: Fourier Transform in L1(IR) and L2(IR): Definitions and properties, Inversion, derivability and convolution, Plancherel Theorem
- Discrete Signal Processing: Shannon Theorem, Definition, properties of Fourier Series, Convolution
- Short time Fourier transform: Definition, Windowing and application to sound processing.
- Random Signals Processing: Definition, ARMA processes, Denoising in an orthogonal basis.

Prerequisites

Undergraduate Analysis: integration, Fourier Series, Gaussian Vectors

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Functions approximation

Module details

I3MIAF20-exc

3 ECTS EN/FR
10.0 h 10.0 h 16.5 h 0.0 h
DE GOURNAY FREDERIC
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The approximation of data using splines, either through interpolation or smoothing.
- The link with geometry generation in CAD and the capabilities for image processing.
- Automatic differentiation and the structure of a neural network.
- Object-oriented programming in Python.

The student should be able to:

- Determine and calculate the interpolation spline, the smoothing spline, and the least squares spline for n points.
- Construct a B-Spline curve for nn points and a BSpline surface.
- Interpolate and filter an image using splines.
- Design a basic neural network.
- Develop an automatic differentiation library in Python.

Content

The content of this course includes:

1. Data Representation Using Splines
   - Interpolation splines
   - Smoothing splines
   - B-splines and least squares splines
2. Data Representation Using Neural Networks
   - Adjunction
   - Neural networks as an approximation method and automatic differentiation

Prerequisites

Multivariable function differentiation, unconstrained optimization (existence, first-order Euler equations, gradient algorithms), linear algebra (matrix systems, scalar product, adjunction). Strong knowledge of Python.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Numerical culture and skills II

Module details

I3CCNU21-exc

1 ECTS EN/FR
0.5 h 2.75 h 0.0 h 0.0 h
BOULIER THOMAS,CHAZEL FLORENT,DE GOURNAY FREDERIC,GUERMOUCHE NAWAL,GUIEYSSE DAVID,GUIGUI CHRISTELLE,HANTCHERLI MURIEL,LABORIE STEPHANIE,LAHANA YONI,MAHOUT VINCENT,MOREL SANDRINE,PLANTEC JEAN-YVES
Revision date : May 18, 2026

Objectives

At the end of this module, which follows the 2A module, the student will have consolidated his knowledge of the field of AI: accuracy, loss function, overfitting, batch size, visualization techniques... He will also have prepared and passed a PIX certification.

Content

The content of this course includes :

- The flow of Machine Learning
- Data preparation
- Machine Learning Terminology
- Data types
- Data visualization, quality and size
- Reliability
- Some activation functions
- Model performance
- Environmental impact

Prerequisites

Basics of Python programming

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Statistical modelling

Module details

I4MATCEMS11-exc

5 ECTS FR
21.25 h 21.25 h 13.75 h 0.0 h
CHEVALLIER JULIETTE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The use of statistical tests for goodness-of-fit, independence, populations comparisons
- The characteristics of a linear model and a generalized linear model, and their use for statistical modelling

At the end of this module, the student should be able to:

- Choose a test procedure suited to a given problem
- Build nonparametric test procedures to compare two populations
- Build goodness-of-fit tests for a single distribution or a family of distributions
- Choose a linear model or a generalized linear model suited to a given problem
- Estimate the parameters in a linear model and a generalized linear model
- Use statistical tests to validate or invalidate hypotheses on these linear models and generalized linear models.
- Implement a variable selection strategy
- Perform a complete statistical analysis on a real data set using a linear model or a generalized linear model

Content

Programme (detailed contents):

- Nonparametric tests: empirical distribution function, goodness-of-fit test of Kolmogorov, tests of comparison of two populations, (Kolmogorov-Smirnov and Wilcoxon tests), normality tests (Kolmogorov and Shapiro-Wilk)
- Chi-square test of goodness-of-fit, of independence, of homogeneity
- Linear models: estimation of the parameters, confidence intervals, prediction intervals, Fisher test for a sub-model, variable selection
- Linear regression, ANOVA, ANCOVA
- Generalized linear model: statistical inference, variable selection.
- Logistic regression, loglinear model

Prerequisites

Prerequisites for this lecture include:

- Probability and Statistics (I2MIMT31)
- Statistics (I3MIMT15)

Assessment

Written exams Exams encourage students to acquire the basic knowledge necessary for developing deeper understanding. Lab-work enables them to determine their level of skills and possibly indicate which parts need more work. For each skill, an evaluation will be given on top of the overall grade which will be both expressed using the A, B, C, D system already used at INSA Toulouse, and which enables one to appraise his understanding of the skill under interest.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Optimisation

Module details

I4MATCOP11-exc

5 ECTS EN
22.5 h 20.0 h 13.75 h 0.0 h
RONDEPIERRE AUDE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Existence and uniqueness conditions for solutions of an optimization problem (constrained differentiable optimization, non-differentiable convex optimization)
- Optimality conditions: Karush Kuhn Tucker points in the constrained differentiable case, optimality NHA in unconstrained convex optimization.
- The duality principle: Lagrangian duality, Fenchel-Rockafellar duality
- Gradient and Newton type algorithms, and their convergence results, classical algorithms of constrained optimization:
- The general principle of inertial algorithms: acceleration of gradient algorithms, generalization to the composite case.

The student will be able to:

- Interpret the behavior of an algorithm as a discretization of a dynamic system
- Identify classes of optimization problems and propose algorithms adapted to the geometry of the functions to be minimized.
- Implement and numerically calibrate these algorithms.

Content

The content of this course includes:

- Elements of convex analysis: convexity, lower semicontinuity, notion of subdifferential, elements of analysis for algorithmic purposes (Lipschitz gradient functions, strong convexity, conditioning)
- Optimality conditions (Karush Kuhn Tucker conditions, second order sufficient conditions)
- Lagrangian duality
- Algorithms for unconstrained differentiable optimization and link with ODEs: generalities on descent methods, gradient algorithms, Newton and quasi-Newton algorithms. Convergence study and convergence speed depending on the geometry of the functions to be minimized.
- Algorithms for constrained differentiable optimization: SQP, penalization methods, augmented Lagrangian.
- Convex optimization: how convexity can improve the convergence speed of algorithms.
- Inertial algorithms, Nesterov acceleration. Subgradient algorithms. Notion of proximal operator, Moreau regularization, proximal algorithms. Splitting methods: Forward Backward algorithm and Nesterov acceleration (FISTA). Study of convergence and convergence rate on the class of convex functions.

Prerequisites

Prerequisites for this course include:

- Basics of differential calculus and linear algebra.
- 3rd year MIC optimization course

Assessment

3 written exams and one oral examination on practical work Written exmas help in verifying the assimilation of theoritical knowledge, whereas labwork reports verify the understanding of the knowledge.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Quality, security, environment (QSE)

Module details

I4MATCQSE11-exc

2 ECTS FR
22.5 h 0.0 h 0.0 h 0.0 h
JOULIN ALDERIC
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Mains concepts and tools for quality control
- The principles and stakes in the health and in the safety at work.
- The main concepts of the IT security.

The student will be able to:

- Integrate the aspects of Quality, Security, Environment into the analysis of problems and the development of solutions.

Content

The content of this course includes:

- Specific QSE: Statistical process control (SPC); notions of metrology; capability of a process; control cards; the SPC system in a company.
- Health and Safety at work: notions of risks, evaluation, prevention, protection.
- Notions of IT security: bases of cryptography; electronic certificates; protocol https; digital signature.

Prerequisites

Prerequisites for this course includes:

- Probability and Statistics
- Inferential Statistics

Assessment

Assessement of this course includes:

- A written exam of 1h on the specific QSE part (statistical process control)
- A written exam of 30 min for each of the three parts Cryptography, IT security and Health and safety at work.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Reading seminar

Module details

I4MATCRS11-exc

3 ECTS EN/FR
0.0 h 5.0 h 0.0 h 30.0 h
GRUSEA SIMONA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Principles and operation of a collaborative work environment
- Project management (PERT, GANTT, WBS)
- Self-evaluation of the results obtained in relation to the objectives.

The student will be able to:

- Produce a synthesis of the results of a research article
- Carry out relevant bibliographic research to deepen the understanding of a mathematical result (theoretical or numerical)
- Work collaboratively in a small group
- Use bibliographic and digital collaborative tools

Content

During the Reading Seminar, students will work on different bibliographic resources (research articles, books, digital resources) in order to prepare the S8 Research Innovation project. Their objective will be to understand in depth certain mathematical results or to reproduce certain numerical experiments proposed in the articles. They will produce a summary explaining their work in an educational manner and according to precise specifications (summary, citations, elements of evidence, statement of results, production of graphs).

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Advanced probability

Module details

I4MAOPPA11-exc

3 ECTS   EN
18.75 h   13.75 h   5.5 h   0.0 h
HUANG LORICK
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The notion of conditional expectation, the main properties of martingales and their classical use in modelling,
- Stochastic algorithms of Robbins-Monro type.

The student will be able to:

- To compute a conditional expectation, to show that a random process is a martingale, to use the various theorems (Doob, optional stopping and convergences), in particular for the maximum likelihood estimation.
- Build and study the convergence of stochastic optimization algorithms, apply these methods to different problems (quantile, quantization)
- To compute a conditional expectation, to show that a random process is a martingale, to use the various theorems (Doob, optional stopping and convergences), in particular for the maximum likelihood estimation.
- Build and study the convergence of stochastic optimization algorithms, apply these methods to different problems (quantile, quantization)
- Simulate a random variable by different methods, use probabilistic, choose appropriate techniques for variance reduction and error estimation

Content

The content of this course includes:

- Conditional expectation, filtration, martingale, submartingale and supermartingale, Doob's theorem, optional stopping theorem, convergence theorems
- law of large numbers and central limit theorem for martingales.
- Parametric estimation through maximum likelihood estimation in Markovian models.
- Background on deterministic gradient descent
- Introduction to Robbins-Monro algorithms and links with classical results (Law of Large Numbers)
- Robbins-Siegmund Lemma and Robbins-Monro Convergence Theorems
- Applications (Two-Armed Bandit, quantile, quantization, Linear Regression in high dimension).

Prerequisites

A basic course on probabilities.

Assessment

1 written exam

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Partial derivative equations

Module details

I4MAOPEDP11-exc

3 ECTS EN
18.75 h 6.25 h 11.0 h 0.0 h
NOBLE PASCAL
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Main PDE models found in the literature in biology, ecology, physics and engineering.
- Notions of weak derivatives, weak solutions and variational formulations
- Finite elements and finite volume methods: formulation, implementation and convergence.

The student will be able to:

- Derive a variational formulation of an elliptic problem
- Implement finite elements method in 1d for elliptic equations.
- Solve nonlinear scalar hyperbolic equations with method of characteristic
- Implement finite volume method in 1d for hyperbolic equations.

Content

The content of this course includes:

1. Modeling with PDE (nonlinear PDEs in one dimension space)
   - Ecology, Population Dynamics, Epidemiology (reaction-diffusion equations)
   - Traffic, Ecology (forest fire): nonlinear advection equations
   - Wave propagation phenomena (elliptic equations)
2. Elliptic equations : analysis and simulation
   - Variational formulation: weak derivatives, weak solutions, Sobolev spaces
   - Finite element methods (in one dimension space): Galerkin methods, P1 and P2 elements, convergence and error estimates, qualitative properties
3. Hyperbolic equations: analysis and simulation
   - Method of characteristics, weak solutions, formation of shocks in finite time, maximum principle
   - Finite volume methods (in one dimension space): centered and upwind schemes, discrete maximum principle, order 1 and 2 methods.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Machine learning

Module details

I4MATCML21-exc

5 ECTS EN
21.25 h 3.75 h 27.5 h 0.0 h
LAURENT BEATRICE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The properties of the main learning methods and their limitations.
- The principle of bias-variance trade-off, model selection
- Algorithms and methods for estimating a risk (cross validation, bootstrap..)
- Optimization and implementation of the main methods in R and Python (Scikit-learn).
- Ethical and legal principles of Artificial Intelligence.

The student will be able to:

- Analyze datasets from various domains (meteorology, marketing, industry, ...) with R and Python libraries.
- Implement the main methods and run the following learning algorithms: discriminant analysis, k-nearest neighbors, classification and regression trees, random forests, neural networks, SVM, boosting.
- Optimize the values of the hyper-parameters, automate the processing chain.
- Optimize the management of missing data.
- Detect legal or ethical flaws (bias, discrimination, opacity) in machine learning algorithms.

Content

Program (detailed contents):

- Introduction to machine learning
- Risk estimation (or generalization error), Optimization of the bias/variance trade-off
- Model selection and variable selection via penalized criteria: Mallows CP, BIC, Ridge, Lasso
- Linear and quadratic discriminant analysis, k nearest neighbors.
- Binary classification and regression trees (CART)
- Tree aggregation, random forests
- Support Vector Machine and Support Vector Regression
- Neural networks, multilayer perceptron, gradient backpropagation algorithm, optimization algorithms, introduction to deep learning.
- Boosting algorithms
- Missing data imputation.
- Bias of algorithms
- Legal framework and societal impacts of AI.

Prerequisites

Prerequisites for this course include:

- Statistical modelling
- Introduction to R and Python languages

Assessment

Written exam (2,5h) and report on a project on real data sets

Back to menu

Signal processing

Module details

I4MATCSI21-exc

3 ECTS EN
11.25 h 12.5 h 13.75 h 0.0 h
DOSSAL CHARLES
Revision date : May 18, 2026

Objectives

Students must understand what the wavelet transform of a signal and an image is. They should be able to implement such transforms in Python and apply them to simple image processing problems such as denoising and inpainting. They must understand the Mallat–Meyer theorem, the definition of the moment of a wavelet, and be able to use a wavelet basis suited to the problem they need to solve.

Content

The content of this course includes:

- Wavelet transforms.
- Basis of wavelets: definition and properties.
- Multiresolution analysis.
- Discrete wavelets: Haar basis, filter banks with exact reconstruction, 1d bi-orthogonal wavelets, wavelet decomposition, spatial and frequency localization, 2d wavelets.
- Introduction to jpeg, denoising.
- Greedy algorithms such that Matching Pursuit and Orthogonal Matching Pursuit.

Prerequisites

Prerequisites for this course include:

- Fourier transform and Fourier series
- Hilbert space analysis.

Assessment

Under construction

Back to menu

Research and innovation project

Module details

I4MATCPRO21-exc

4 ECTS EN/FR
0.0 h 0.0 h 0.0 h 43.0 h
GRUSEA SIMONA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Principles of mathematical modeling of an application problem in relation to another discipline or a particular industrial sector
- Self-evaluation of the results obtained in relation to the objectives.

The student will be able to:

- Interact with a specialist or engineer from another discipline
- Organize collaborative work in small groups
- Define the framework and specifications of an original mathematical modeling problem
- Conduct the necessary bibliographic research to solve the problem
- Develop the deterministic and/or stochastic model adapted to its resolution
- Implement its numerical resolution
- Report in writing and orally on the results obtained

Content

The student will work on an open problem in applied science and will implement the four major skills of the engineer in applied mathematics:

- Reformulate a user need to produce a problem that can be treated mathematically
- Analyze and design a digitally implementable solution to the mathematical problem posed
- Implement the digital solution to make it a demonstrator
- Use the technical and digital solution to produce a decision support tool (a study or a calculation code) meeting user needs

Prerequisites

Under construction

Assessment

Written report and a short talk

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Finite element methods

Module details

I4MAOPEF21-exc

5 ECTS EN
18.75 h 10.0 h 27.5 h 0.0 h
CANTIN PIERRE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- How to build up a FE scheme.
- How to elaborate an off-online strategy of resolution.

The student will be able to:

- Write weak forms of PDEs (and energy minimization in symmetric cases).
- Write and implement Finite Element schemes for linear and nonlinear scalar PDEs
- Employ Finite Element libraries: FEniCS - Python and FreeFem++.
- Set up an offline ' online strategy (real time computations):
- POD reduction for linear PDEs,
- Hybrid POD-ANN (Neural Networks) for non-linear PDEs.
- Simulate classical phenomena : linear/nonlinear advection-diffusion equations

Content

The content of this course includes:

1. FE BASES
   - Recalls. Analysis of elliptic PDEs : weak solution vs classical solution, Sobolev spaces, Lax-Milgram theory, a-priori estimations. Boundary conditions. Energy minimization.
   - Modelling with a FE software (FreeFEM++): classical models, one real-like problem.
   - 1 Lab Work with FreeFEM++
   - Finite Element Method (FEM) principles in multi-D: discretisation, approximation, Error analysis (a-priori).
   - In practice: data structures, implementation (assembly algorithm). Convergence curves (code validation from exact solutions).
2. DISCONTINUOUS GALERKIN (DG) METHODS
   - Discontinuous Galerkin Method for Diffusive and transport problem: Broken spaces, jumps and interior penalty techniques, stability, introduction to non-conforming analysis.
3. ADVANCED FE METHODS
   - The advection-diffusion equation: analysis and naïve discretization, transport term: FE stabilisation (SD, SUPG).
   - Non-linear models: linearization, including: differential calculus / Riez-Frechet theorem and help to the marked practical.
   - Unsteady models: semi-discretisation.
4. PDE MODEL REDUCTIONS
   - Model Reduction for parametrized PDEs, offline-online strategies.
   - Linear PDEs: POD method.
   - Non-linear PDEs: Hybrid approaches POD - Neural Networks.

Prerequisites

Prerequisites for this course includes:

- Fundamentals of PDE models and math. analysis,
- Numerical analysis.

Assessment

Under construction

Back to menu

Models and numerical methods for solid and fluid mechanics

Module details

I4MAOPMECA21-exc

5 ECTS FR
22.5 h 12.5 h 22.0 h 0.0 h
VILLEDIEU PHILIPPE
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The fundamentals of Mechanics for fluid and deformable solids, from a physical, mathematical and numerical point of view.

The student will be able to:

- Know the main models used in continuum mechanics for fluids and solids
- Calculate exact solutions of simple problems and know how to interpret them physically
- Evaluate orders of magnitude
- Formulate and solve the dynamics of an incompressible flow using the finite volume method.
- Formulate and solve the problem of elasticity using the finite element method.
- Use an industrial software to model and compute the elasticity problem in both static and dynamic modes, and some fluid mechanics problems, for incompressible and compressible flows
- Write and implement a mixed formulation to couple different elastic domains and different numerical codes used as black-boxes.
- Apprehend the data-driven (model-free) paradigm in computational mechanics.

Content

Program (detailed contents):

1. Fundamental concepts of continuum mechanics:
   - Physical properties of fluids and solids.
   - Lagrangian and Eulerian formulations
   - Tensor of deformations, strain rates and stresses
   - Derivation of the general equations of continuum mechanics
2. Modeling and scientific computing in fluid mechanics:
   - Dynamics of viscous incompressible fluids
   - Dynamics of incompressible perfect fluids, potential flows
   - Introduction to the finite volume method (FVM) for incompressible viscous fluids
   - Implementation in PYTHON of the FVM on a simple problem
   - Use of the industrial software FLUENT to model and compute the solution of some 2D problems (driven cavity, flow around a wing profile)
3. Modeling and scientific computing in structural mechanics
   - Variational formulation and relation with the energy minimization for the elasticity problem.
   - Numerical solution of elasticity with the finite element method.
   - Modeling and computation of static as well as dynamic elastic problems through the use of an industrial software (ABAQUS)
   - Multiscale model and code coupling.
   - Development of python routines for the computation of stress concentration and local propagation of cracks within solids
   - Data-Driven Computational Mechanics
   - Introduction of the concept and application on a 2D example of lattice.

Prerequisites

Fundamentals in:

- Mechanics (forces, Newton's laws, kinetic energy, potential energy)
- PDE course (finite element method in 1D, finite volume method in 1D)
- Analysis and electrostatic courses: Differential and integral calculus for functions of several variables (gradient, Jacobian, Ostrogradsky's theorem ...)

Assessment

Class work (labwork) and a final written exam.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Stochastic processes

Module details

I4MAOPPS21-exc

5 ECTS EN
25.0 h 15.0 h 8.25 h 8.0 h

Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

1. Time series
   - Trend and seasonality of a time series
   - Definitions and properties of stationary processes
   - The autocovariogram and autocorrelograms (total and partial) of a stationary process
   - The ARMA and ARIMA models
2. Poisson processes and application to reliability and actuarial science
   - Homogeneous and inhomogeneous Poisson processes
   - Statistical inference for homogeneous Poisson processes

The student will be able to:

1. Time series
   - Estimate or eliminate the trend and/or the seasonality of a time series.
   - Study the stationnarity of a time series.
   - Calculate and estimate the autocorrelogram and the autocorrelograms (total and partial) of a stationary process.
   - Study and/or adjust an ARMA (or ARIMA) model on a stationary time series.
   - Carry an optimal linear forecast of an ARMA process.
   - Apply these concepts using R software
2. Poisson processes and application to reliability and actuarial science
   - Know and understand the (homogeneous and inhomogeneous) Poisson process theory fundamentals.
   - Estimate the rate of a homogeneous Poisson process and construct confidence intervals and statistical tests for such rate (theoretically and in practice with the R software)
   - Draw at random (homogeneous and inhomogeneous) Poisson processes using different methods
   - Model the recursive occurrences of the failures on a system, or the claim times in Insurance by Poisson processes

Content

Program (detailed contents):

1. Time series
   - Introduction and Descriptive Analysis: Time series decomposition, Estimation and Elimination of Trend and Seasonal Components
   - Random Modeling of Time Series: Stochastic process, stationnarity, Autocovariance Function
   - Statistical Inference of Stationary processes of order 2: Moment Estimation, Best linear predictor, Partial autocorrelation, statistical tests
   - ARMA and ARIMA Models: AR process, MA process, ARMA et ARIMA processes
2. The practical labworks will be performed with R software.
3. Poisson processes and application to reliability and actuarial science
   - 1st part: Theoretical foundations
     - Probability distributions in reliability theory, hazard rate, memoryless distributions
     - Introduction to homogeneous Poisson processes: definitions, fundamental properties, and simulation methods
     - Inferential statistics for the homogeneous Poisson process (likelihood, estimation of the rate, confidence intervals, statistical tests)
     - Introduction to inhomogeneous Poisson processes: definition, fundamental properties, simulation methods, and likelihood
   - 2nd part: Mini projects

- Application and illustration of different aspects of the Poisson process on real and/or simulated data in reliability theory or actuarial science (e.g. Cramér-Lundberg model)

The practical labwork and the projects will also be performed with the R software.

Prerequisites

Prerequisites for this course includes:

- Probability and Statistics
- Probability and Data Analysis
- Inferential Statistics
- Statistics Modelling

Assessment

Two written exams for Time series part and 1 project (with report and oral defence) for the Poisson porcess part.

Back to menu

High Dimensional and Deep Learning

Module details

I5MATCHDDL11-exc

3 ECTS   FR
8.75 h   10.0 h   16.5 h   4.0 h
DALMAU CHERINO JOSEBA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- The use of deep learning algorithms (convolutional neural networks) for the classification of complex data (signals, images) in high dimension with estimation of the prediction error
- The main algorithms for signal or image classification
- Dimension reduction methods for complex data
- Anomaly detection algorithms
- Recurrent neural networks for the study of sequential data
- The use of convolutional networks for object detection in images

The student will be able to:

- Adjust deep neural networks for signal or image classification.
- Apply anomaly detection algorithms.
- Use recurrent neural networks for time series prediction
- Implement and optimize deep learning algorithms on real data using Python libraries.

Content

This course is dedicated to deep learning methods for processing complex data such as signals, images or sequential data (time series or textual data). It also covers methods for anomaly detection, especially in functional data.

- Convolutional neural networks: convolutional layer, pooling, dropout, architecture of convolutional networks (ResNet, Inception), transfer learning, applications to signal and image classification and object detection.
- Encoder-decoder, variational auto-encoder, generative adversarial networks.
- Functional decomposition on Spline, Fourier, wavelet or functional PCA bases: cubic splines, penalized least squares criterion, Fourier bases, wavelet bases, application in non-parametric regression, linear and non-linear estimators by thresholding, links with the LASSO method.
- Anomaly detection, Main algorithms: One Class SVM, Random Forest, Isolation Forest, Local Outlier Factor. Applications to anomaly detection for functional data.
- Recurrent networks (RNN, LSTM) for the analysis of sequential data.

Prerequisites

The prerequisites for this course include:

- Elements of Statistical Modeling (4MA)
- Machine Learning (4MA)
- Introduction to Python
- Software for statistics (R,Python)

Assessment

A written exam and a group project The written exam allows students to deepen their understanding of the different algorithms studied in class and in lab. The project allows students to work in groups on the reading of an article presenting a new algorithm. The aim is to understand the algorithm and to explain it during an oral presentation, as well as to implement it on a new data set.

Back to menu

Metamodeling

Module details

I5MATCMETA11-exc

3 ECTS EN
8.75 h 8.75 h 11.0 h 1.0 h
ROUSTANT OLIVIER
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Metamodeling for optimization / uncertainty quantification of a computer code, with a limited computational budget
- Gaussian processes
- Kernel customization to account for external knowledge
- Design of computer experiments
- Global sensitivity analysis

The student will be able to:

1. At a theoretical level, to do computations for:
   - covariance kernels and Gaussian process
   - ANOVA decomposition, Sobol indices
2. At a practical level, to perform the complete methodology for analyzing a computer code
   - design of experiments
   - metamodel construction / evaluation
   - application to optimization / uncertainty quantification

Content

The content of this course includes:

- Introduction: computer experiments and metamodeling. Examples.
- Metamodeling with Gaussian process (GP) and kriging. Probabilistic and functional (RKHS) interpretation of the approximation problem. Simulation of GPs. Customization of covariance models. Physically informed GPs.
- Design of computer experiments. a) Initial designs: focus on space-filling designs. b) Adaptive methods. Example of Bayesian optimisation.
- Uncertainty quantification. Uncertainty propagation. Global sensitivity analysis: focus on the ANOVA decomposition (Sobol-Hoeffding decomposition).
- Case study.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Rsearch and innovation project

Module details

I5MATCPT11-exc

9 ECTS EN/FR
0.0 h 30.0 h 0.0 h 48.0 h
SANCHEZ DAVID
Revision date : May 18, 2026

Objectives

The student will be able to:

- Interact with a specialist or engineer from another discipline.
- Organize collaborative work in small groups.
- Define the framework and specifications of an original mathematical modeling problem.
- Conduct the necessary bibliographic research to solve the problem.
- Develop the deterministic and/or stochastic model adapted to its resolution.
- Implement its numerical resolution.
- Report in writing and orally on the results obtained.

Content

After a call for tenders from the corporate sector (aeronautics, spatial, pharmaceutical sectors. . .) or scientific laboratories (IMT, LISBP, LAAS, IMFT, LPNO, CEMES, . . .), students have to solve a mathematical modelling problem, supervised by specialists in the concerned domain (physics, mechanics, biology, finance, reliability...).
The essential point is the confrontation with a complex problem, whose solution is not known, even by the supervisor. This is the typical situation faced in research or innovation in industry and is a key factor in learning both autonomy and collaborative teamwork.
Through targeted activities (presentations in context, written accounts of experience...) the students will develop a working knowledge of the specificities of scientific English and be able to adapt their language strategies to specialists and non-specialists.

Prerequisites

Applied Mathematics

Assessment

Assessement of this course includes:

- Written Report in English
- Oral defense in English with slides in English

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Image processing

Module details

I5MAOPIM11-exc

3 ECTS EN
11.25 h 3.75 h 22.0 h 9.0 h
DOSSAL CHARLES
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- Modeling an image processing problem as an optimization problem.
- The notions of proximal operators, Fenchel conjugate, algorithm convergence rate.

The student will be able to:

- Understand and know how to use the different convex optimization algorithms.
- Know how to use neural networks to perform different image processing tasks.

Content

Program (detailed contents):

1. Differentiable optimization.
   - Optimality conditions.
   - Gradient descent.
   - Link with ODEs
2. Non differentiable optimization.
   - Sub-gradient.
   - Proximal operator
   - Forward-Backward algorithm.
3. Advanced algorithms
   - FISTA
   - Douglas-Rachford
   - Fenchel conjugate
   - Primal Dual Algorithms

Prerequisites

Convex Optimization, Fourier Analysis, wavelets and Python

Assessment

Assessement for this course includes:

- A small quizz at the half of the semester.
- An applicaition project (6 to 8 students by project)
- A written exam : 2h

These various ways to evaluate the students allow to check the theoretical and the numerical skills of the studuents.

Back to menu

Data Assimilation

Module details

I5MAOPAD11-exc

3 ECTS EN
13.75 h 3.75 h 16.5 h 0.0 h
MONNIER JEROME
Revision date : May 18, 2026

Objectives

The objectives for this course include:

- Standard basic tools to analyze and solve inverse problems.
- How to fuse measurements (datasets) and PDE-based models.
- Set up the optimal control of a system (ODEs and PDEs).
- Compute the gradient of a model output (cost function) in large dimensional cases by the adjoint method.
- Set up a control-like algorithm to identify uncertain parameters and/or calibrate the model (Variational Data Assimilation, 4D-Var).
- Explain the links and differences between VDA, filters (Kalman etc) and Bayesian estimations.
- Explain what is a Physics Informed Neural Network (PINN).
- Carry out the non dimensionalization of a system of PDE, use correctly physical units in a PDE system.
- Carry out the analysis of the dynamics around equilibrium of PDE system with dispersion relations.

Content

The content for this course includes:

1. Basics tools to solve inverse problems (including examples)
   - Least-squares (linear, non-linear)
   - Regularization.
2. Data Assimilation principles (variational, sequential).
   - Bayesian analysis.
   - Equivalences between the BLUE:Kalman filter, the MAP and VDA in the Linear-Quadratic-Gaussian case.
   - A first application to model identification in experimental mechanics: (i) computation of the measures from image registration and (ii) data assimilation to calibrate constitutive laws.
   - Optimal control of ODEs. Linear-Quadratic case, maximum principle, Hamiltonian.
   - Small practical: optimal control of a vehicle trajectory.
3. Optimal control of PDEs. Gradient computation, adjoint model, optimality system.
   - Variational Data Assimilation (steady-state case, unsteady case). Algorithms (3D-VAR, 4D-Var, variants).
   - Examples, practical aspects.
   - DA by Physics Informed Neural Networks (PINNs).
   - Practical (marked): estimation of river bathymetry from water surface measurements (problem arising in spatial hydrology).
4. Ocean circulation modelling
   - Fluid mechanics at the planetary scale, Equilibrium solutions
   - Shallow water equations: derivation and description of wave propagation. Applications: Gravity waves, Poincaré Waves, Kelvin Waves
   - Quasi-Geostrophic equations: derivation and description of wave propagation. Applications: Rossby Waves, Gulf Stream.

Prerequisites

The prerequisites for this course include:

- Differential calculus
- Numerical optimisation
- Bases of functional analysis and mechanical models
- The few classical PDE models (weak forms and FE schemes is a plus)
- Python programming.

Assessment

Assessement for this course include:

- A few intermediate examinations.
- Exercises with answers in Quiz form.
- Two programming practicals (with short written report + source code). Provided Python codes to be completed
- (Ocean Modelling): one written exam based on a series of exercices provided before the exam.

Back to menu

Advanced modeling for fluids and structural mechanics

Module details

I5MAOPMDFS11-exc

3 ECTS FR
15.0 h 7.5 h 11.0 h 0.0 h
BOUCLIER ROBIN
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain a few advanced modelling methods in structural mechanics to tackle current challenging applications such as:

- Describe the dynamics of compressible fluids
- Understand what is a shock wave, an expansion wave, an acoustic wave in a fluid
- computation of shell-type structures.
- use of CAD data for the computation of structures.

The student will be able to:

- solve a Riemann problem approximately.
- Know and know how to apply the finite volume method to calculate the numerical solution of the compressible fluid dynamics equation system.
- Formulate and solve by the FEM beam models.
- Apprehend a computational technique based on the exact geometric representation in CAD (NURBS-based isogeometric analysis).

Content

The content of this course includes:

1. Fluid mechanics
   - Equations of perfect compressible fluid dynamics: establishment of equations, acoustic waves, shock waves, Rankine-Hugoniot relations, boundary conditions, total pressure and temperature, shock tube...
   - Oblique shock on a wedge: Application to supersonic vehicle air inlets
   - Laval nozzle: Application to rocket propulsion
   - General principles of the finite volume method for compressible fluid mechanics. Riemann problem (linear case, perfect gas dynamics case). Approximate Riemann solvers
   - Preparation for the Finite Volume Labwork. Programming in PYTHON of the finite volume method applied to the equations of the dynamics of perfect gases
2. Structural mechanics
   Numerical modeling of thin structures:
   - Construction of a beam model from standard 3D solid elasticity
   - Variational formulation, connection with energy minimization and numerical resolution by the finite element method.

   CAD-analysis relation:
   - Fundamentals for describing geometries in CAD.
   - Isogeometric analysis: spline finite elements
   - Application for the computation of beam models.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Stochastic Calculus

Module details

I5MAOPCSTO11-exc

3 ECTS FR
13.75 h 11.25 h 8.25 h 0.0 h
DUBOSCQ ROMAIN
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The Brownian motion, as well as the Wiener integral and Itô's formula.
- The relationship between a stochastic differential equation and its Fokker-Planck equation.
- The formulation of a solution to a parabolic or elliptic PDE using a suitably chosen stochastic process.
- The maximum likelihood estimation of parameters in a stochastic differential equation.

The student should be able to:

- Perform stochastic calculus by applying Itô's formula.
- Implement numerical methods for solving a parabolic or elliptic equation using a probabilistic approach based on solutions of stochastic differential equations.
- Use Girsanov's theorem combined with the ergodicity results of Markov processes to estimate parameters via maximum likelihood in stochastic differential equations.

Content

The content of this course includes:

- Continuous-time stochastic processes and martingales. Introduction to stopping times.
- Construction of Brownian motion and the stochastic integral, followed by the derivation of Itô's formula.
- Introduction to stochastic differential equations (SDEs) and derivation of the Fokker-Planck equations.
- Solving a parabolic equation using a solution of an SDE.
- Solving a Dirichlet problem using Brownian motion.
- Girsanov's theorem.
- Ergodicity of Markov processes.
- Maximum likelihood estimation of parameters in an SDE.

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Reliability and lifetime analysis

Module details

I5MAOPFDV11-exc

3 ECTS EN
13.75 h 5.0 h 11.0 h 0.0 h
ROUSTANT OLIVIER
Revision date : May 18, 2026

Objectives

By the end of this module, the student should have understood and be able to explain (main concepts):

- the usual probability laws for modeling survival data
- the notion of censoring and truncation in data
- parametric, non-parametric, and semi-parametric estimation of a survival function

The student will be able to:

- statistically analyze right-censored data with the R software
- estimate a survival function through parametric, non-parametric, and semi-parametric approaches
- test the adequacy to a law or the equality of two survival distributions for censored data
- model and test the effect of covariates on lifespan

Content

Program (detailed contents):

- Survival distributions: specific functions, usual laws for durations
- The notion of censoring and truncation
- Parametric estimation
- Non-parametric estimation of the survival function and the hazard function (Kaplan-Meier, Nelson-Aalen)
- Adequacy to a probability law and study of the heterogeneity between subgroups
- Parametric regression models
- The semi-parametric Cox model: estimation and model validation
- Applications in the field of reliability or survival analysis

Prerequisites

The prerequisites for this course include:

- Inferential Statistics
- Elements of Statistical Modeling

Assessment

Assessement for this course include:

- A multiple-choice exam (MCQ) aimed at direct assessment of knowledge
- A project involving the analysis of a real dataset

The MCQ allows students to verify their acquisition of the basic knowledge necessary for the concepts presented in this course. The project enables them to evaluate the quality of their practical reappropriation and implementation of these concepts.

Back to menu

Cultural module and presentation skills *

Module details

I2DHUMLV111-exc

2 ECTS EN
0.0 h 27.5 h 0.0 h 0.0 h
MOORE BARBARA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will have understood and be able to explain (main concepts):

- give a Powerpoint oral presentation in front of a group and orally interact with the audience
- demonstrate creativity, initiative and open mindedness in teamwork
- develop a thorough knowledge and a critical mind about different English-speaking socio-cultural contexts, taking into account historical, geographical and/or geopolitical considerations

Content

The content of this course includes :

- Oral presentation : general skills in English
- Use of language skills for the oral presentation in English
- Study of pronunciation and intonation (English)

Prerequisites

B1/B2 level in English

Assessment

Team oral presentations in English

Back to menu

Contemporary Econ. and Eco. Transition *

Module details

I2DHUMECO11-exc

2 ECTS FR
0.0 h 18.75 h 0.0 h 0.0 h
LECLERC LUCIE
Revision date : May 18, 2026

Objectives

The aim of this course is to provide students with the fundamental concepts necessary to better understand their current and future environment and to identify its main challenges.
Students will be expected to be able to hold a conversation and debate using arguments based on knowledge of fundamental economic mechanisms and some theories of economic thought.

Content

The main areas of study are as follows:

- The market
- Economic stakeholders
- Income and distribution
- Economic growth
- Unemployment
- Financing the economy
- Money and inflation
- Economic policies
- New economic models

Prerequisites

B2 level in French, no previous study of economics needed.

Assessment

Formative assessment throughout the e-learning sessions in Moodle
Summative assessment at the end of the course: a one-hour multiple-choice quiz

Back to menu

Elective course **

Module details

I3DHUMCE11-exc

2 ECTS   EN/FR
0.0 h   22.5 h   0.0 h   0 h
JALENQUES BEATRICE
Revision date : May 18, 2026

Objectives

Here is the list of courses offered in English:

- Intercultural negotiation
- Starting Drama! (Theatre in English)

Content

As part of the missions of the Centre for Human Sciences, various courses are offered to students within the Humanities (I3DHUMCE11, semester 5). The main objective is to encourage them to broaden their horizons on subjects covered in the humanities or other cultures: numerous language courses, but also courses on science communication, anthropology or Intercultural negotiation.

Prerequisites

None

Assessment

Each course has its own specific assessment methods.

Back to menu

French as a foreign language (FLE)

Module details

ERASLF21-exc

3 ECTS FR
0.0 h 25.0 h 0.0 h 0.0 h
SHEA JOSEPH
Revision date : May 18, 2026

Objectives

To reinforce and develop the language skills of the student in order to achieve a greater autonomy in its everyday and scientific activities. The student will mainly be able to:

- Apprehend and describe more thouroughly the world he evolves in: sounds, objects, physical or psychological characteristics or movements.
- Express his opinion on objects, persons, or actions (compare, suggest, forbid...)
- Synthesize information to express his opinions orally on in a written form. (debates, scientific presentations, resumes..)
- Achieve a better understanding of the french sociocultural system.

Content

The content of this course includes :

- From a varied portfolio of real life documents (articles, videos...), the student will observe and discover given grammar structures and vocabulary. He/she will later be made to use those structures in different situations of communication such as debates or presentations with a particular attention drawn on scientific use.
- Individual correction of the accent.

Prerequisites

Assessment

Depending on his starting level, the student will be evaluated through different types of oral and written presentations such as:

- presenting an object in a 2d and 3d environment,
- presenting an invention or a project,
- roleplaying games involving different situations.

An evaluation of his comprehension skills will be held through note taking exercises, written or oral reports, or controversial group debates. Those latter activities will serve also as a preparation of the DELF B2 exam. The functionning of grammar structures will be punctually validated through structural exercises in various situations of communication. Those different modes of evaluation will help the student to test his language skills in situations close to reality and thus help him pinpoint what he may lack.

Back to menu

Physical education

Module details

I3DHUMAPS11-exc

2 ECTS EN/FR
0.0 h 20.0 h 0.0 h 0.0 h
MAYRAND MATHIS
Revision date : May 18, 2026

Objectives

The objective of this module is to support students' physical, mental, and social development. Regular sports practice helps improve fitness, stress management, and teamwork skills, while fostering a balanced lifestyle compatible with the demands of higher education.

Content

This module offers students the opportunity to regularly participate in various sports as part of their studies (2 hours per week). Activities include soccer, volleyball, badminton, orienteering, circuit training, and contemporary dance, among others. Adapted activities are offered to students with temporary or total disabilities, such as Pilates or adapted bodybuilding. Specific courses are also offered to learn to swim and learn to ride a bike. The course aims to promote physical activity, team spirit, and overall well-being.

Prerequisites

All students are accepted. No particular skill level is required, but active and consistent participation in the sessions is expected.

Assessment

Assessments are competency-based, with continuous assessment based on participation and progress, and a final assessment at the end of the cycle. Adapted assessments are offered within adapted activities. Specific competencies for each year of study must be achieved to validate the program.

Back to menu

Job search

Module details

I3DHUMJS11-exc

2 ECTS EN
0.0 h 20.0 h 0.0 h 0.0 h
SCANLAN PAUL
Revision date : May 18, 2026

Objectives

At the end of the modules, the student is expected to understand the necessary steps for seeking a internship and a job and will grasp the differences between the job search in France and English-speaking countries.
The student will be able to:

- make a personal statement, and start elaborating a professional project use current research tools (web, online networks, company websites) to conduct a documentary survey on recruitment.
- seek work placements matching his/her objectives and profile.
- find and analyze an English advert in his/her future field.
- adapt his/her CV and cover letter to a specific application.
- write a CV in English following various country-relevant templates.
- ensure his/her application meets the company's requirements.
- prepare for an interview (self-knowledge, company awareness, preparation of adequate questions)
- show adequate degree of proficiency in job search related technical English to be able to take a professional job interview.

Content

The content of this course includes:

- Personal statement and project
- CV and cover letter writing in English
- Search for information about companies and the job market
- New recruitment techniques
- Building up professional and internet networks
- Job interview practice and simulation
- Introduction to recruitment techniques in English-speaking countries
- Analysis of English job ads

Prerequisites

B1/B2 level in English

Assessment

Assessement for this course includes:

- CV and cover letter for a engineering internship in an English-speaking country, wherethe job ad is chosen by the student (graded)
- Job interview based on the previously written CV and cover letter (graded)

Back to menu

French job hunting techniques

Module details

I3DHUMTRE11-exc

1 ECTS FR
0.0 h 13.75 h 0.0 h 0.0 h
JALENQUES BEATRICE
Revision date : May 18, 2026

Objectives

Development of skills for searching for internships or jobs (self-assessment, job search tools, tailored CVs and cover letters, analysis of job offers in French, interview preparation, intercultural communication).

Content

Students will carry out a personal assessment, improve their CV and cover letter in both French and English, and learn how to research information about companies and the job market. They will explore modern recruitment techniques, professional networks, and the Internet, and create a LinkedIn profile. Interview simulations for internships will be offered, and job postings in both French and English will be analyzed. An introduction to Anglo-Saxon recruitment methods will also be covered.

Prerequisites

Minimum C1 level in French required. Course open to exchange students only if they are seeking job in France.

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Structuring an argument and Debating *

Module details

I2DHUMLV121-exc

2 ECTS EN
0.0 h 22.5 h 0.0 h 0.0 h
MOORE BARBARA
Revision date : May 18, 2026

Objectives

At the end of this module, the student will be able to :

- research, organize and synthesize relevant information drawn from resources in English.
- structure an argument in a convincing way
- take part in a debate and interact with other participants
- write a report in English

Content

The content of this course includes:

- Practice of language skills for debating and oral interaction
- Methodology of report writing
- Practice of language skills for report writing
- Work on pronunciation and intonation

Prerequisites

B1/B2 level in English

Assessment

Skills-based assessment, subdivided into 7 sub-skills:

- Final Report (= 4 sub-skills)
- Final Debate (= 2 sub-skills)
- Participation en class (= 1 sub-skill)

Back to menu

Elective course addressing societal issues **

Module details

I3DHUMMO21-exc

2 ECTS EN/FR
0.0 h 30.0 h 0.0 h 0.0 h
NEGREL NATHALIE
Revision date : May 18, 2026

Objectives

The Societal Awareness Modules are courses addressing the five key societal challenges identified by INSA Toulouse. They are designed to help students approach complex real-world situations and explore topics not usually covered in the standard INSA curricula. Here is the list of courses offered in English :

- Public Speaking and Debating

Content

The content of this course includes :

- Focus on major societal challenges such as Energy Transition, Ecological Transition, Digital Society, Global Health, Mobility, and Infrastructure.
- Interdisciplinary themes combining Science and Engineering with Humanities and Social Sciences, or topics within the Human and Social Sciences that complement the INSA Toulouse core curriculum.

Prerequisites

None

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

French as a Foreign Language (FLE)

Module details

ERASLF31-exc

3 ECTS FR
0.0 h 25.0 h 0.0 h 0.0 h
SHEA Joseph
Revision date : May 18, 2026

Objectives

To reinforce and develop the language skills of the student in order to achieve a greater autonomy in its everyday and scientific activities The student will mainly be able to:

- Apprehend and describe more thouroughly the world he evolves in: sounds, objects, physical or psychological characteristics or movements.
- Express his opinion on objects, persons, or actions (compare, suggest, forbid...)
- Synthesize information to express his opinions orally on in a written form. (debates, scientific presentations, resumes..)
- Achieve a better understanding of the french sociocultural system.

Content

The content of this course includes :

- From a varied portfolio of real life documents (articles, videos...), the student will observe and discover given grammar structures and vocabulary . He/she will later be made to use those structures in different situations of communication such as debates or presentations with a particular attention drawn on scientific use.
- Individual correction of the accent.

Prerequisites

Assessment

Depending on his starting level, the student will be evaluated through different types of oral and written presentations such as:

- presenting an object in a 2d and 3d environment,
- presenting an invention or a project,
- roleplaying games involving different situations.

An evaluation of his comprehension skills will be held through note taking exercises, written or oral reports, or controversial group debates. Those latter activities will serve also as a preparation of the DELF B2 or C1 exam. The functionning of grammar structures will be punctually validated through structural exercises in various situations of communication. Those different modes of evaluation will help the student to test his language skills in situations close to reality and thus help him pinpoint what he may lack.

Back to menu

Physical education

Module details

I3DHUMAPS21-exc

2 ECTS EN/FR
0.0 h 23.0 h 0.0 h 0.0 h
MAYRAND MATHIS
Revision date : May 18, 2026

Objectives

The objective of this module is to support students' physical, mental, and social development. Regular sports practice helps improve fitness, stress management, and teamwork skills, while fostering a balanced lifestyle compatible with the demands of higher education.

Content

This module offers students the opportunity to regularly participate in various sports as part of their studies (2 hours per week). Activities include soccer, volleyball, badminton, orienteering, circuit training, and contemporary dance, among others. Adapted activities are offered to students with temporary or total disabilities, such as Pilates or adapted bodybuilding. Specific courses are also offered to learn to swim and learn to ride a bike. The course aims to promote physical activity, team spirit, and overall well-being.

Prerequisites

All students are accepted. No particular skill level is required, but active and consistent participation in the sessions is expected.

Assessment

Assessments are competency-based, with continuous assessment based on participation and progress, and a final assessment at the end of the cycle. Adapted assessments are offered within adapted activities. Specific competencies for each year of study must be achieved to validate the program.

Back to menu

English business communication

Module details

I3DHUMBE21-exc

2 ECTS EN
0.0 h 20.0 h 0.0 h 0.0 h
SCANLAN PAUL
Revision date : May 18, 2026

Objectives

This course aims to develop essential skills in business communication. Students will learn to understand a simple business plan and market study, to lead meetings, and to use key professional vocabulary. They will also acquire skills to describe charts and deliver impactful presentations. In addition, students will learn how to pitch to investors, present a company effectively, and address issues of social and environmental responsibility in the workplace.

Content

Students will create a fictitious start-up in a market of their choice, conduct a market analysis, and identify competitors. They will produce a GoFundMe-style video and take part in meetings conducted in English to address business challenges. The final presentation will take the form of a "Shark Tank" competition, where students will pitch their project to a panel of investors.

Prerequisites

None

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Business game

Module details

I3DHUMBG21-exc

2 ECTS FR
0.0 h 19.25 h 0.0 h 0.0 h
LOMI MICHEL
Revision date : May 18, 2026

Objectives

The student must have understood and be able to explainthe interdependence of the company's functions (production, sales, finance, human resources) through decision-making and the analysis of the company's economic and financial results.
They must understand how a company operates, prepare financial statements, calculate costs, create simple management tools, optimize resources to improve profitability, and present an oral report on activities (in English).

Content

Simulation of five years of the company's operations (decision-making in production, finance, and marketing) using the SIMGEST business simulation game.

Prerequisites

Third-year Financial Management course

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Company finance

Module details

I3DHUMGF21-exc

1 ECTS FR
15.0 h 0.0 h 0.0 h 0.0 h
LOMI MICHEL
Revision date : May 18, 2026

Objectives

The student must have understood and be able to explain the company's summary financial statements, as well as the basics of cost calculation in an industrial company.

Content

Income statement, cash flow, balance sheet. Cost elements. Break-even point. Consideration of inventories in financial statements. Debt financing. Company profitability.

Prerequisites

No prerequisite

Assessment

Learning outcomes are continuously assessed throughout the semester. Depending on the module, these may comprise written and oral examinations, written reports, peer reviews, etc.

Back to menu

Finance*

Module details

I4DHUMFI11-exc

2 ECTS FR
18.75 h 0.0 h 0.0 h 0.0 h
LOMI MICHEL
Revision date : May 18, 2026

Objectives

Be able to critically assess a company's financial health and evaluate the profitability of an investment.

Content

The content of this course includes:

1. Financial diagnosis:
   - Balance sheet analysis.
   - Financial equilibrium.
   - Income statement analysis.
   - Self-financing capacity.
   - Ratios.
2. Investment decision:
   - Net cash flows and selection criteria, with or without discounting, based on the economic profitability of an investment.

Prerequisites

Third-year financial management course (knowledge of a company's financial statements, balance sheet, and income statement).

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take different forms: written exam, oral exam, report, written assignment, or peer assessment.

Back to menu

Strategies for Responsible Companies*

Module details

I4DHUMSTRAT11-exc

2 ECTS FR
18.75 h 0.0 h 0.0 h 0.0 h
LECLERT LUCIE
Revision date : May 18, 2026

Objectives

By the end of this course, students will be able to:

- Carry out a market and company diagnosis in order to make decisions and set strategic objectives
- Mobilize market knowledge to implement a responsible strategic action plan, taking into account ecological, economic, and societal challenges

Content

The main topics covered are:

- Reflection on the engineer of tomorrow
- Definitions, challenges, and limits of conventional business strategy
- Market knowledge
- Designing and developing a sustainable offering
- Building a fair pricing policy
- Developing responsible and effective communication strategies

Prerequisites

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take different forms: written exam, oral exam, report, written assignment, or peer assessment.

Back to menu

Law*

Module details

I4DHUMDRT11-exc

2 ECTS FR
0 h 0 h 0 h 0 h
LECLERT LUCIE
Revision date : May 18, 2026

Objectives

By the end of this course, students will understand the legal context and the legal implications of a company's activities.

Content

The main topics covered are:

- The legal structures of a company
- The main contracts and institutions in business life
- Risk and liability

Prerequisites

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take different forms: written exam, oral exam, report, written assignment, or peer assessment.

Back to menu

Foreign Language

Module details

I4DHUMLV211-exc

2 ECTS
0.0 h 20.0 h 0.0 h 0.0 h
AUFFRET KATJA
Revision date : May 18, 2026

Objectives

The objectives, defined in reference to the CEFRL for the 5 language activities, are specific for the language studied Chinese, German, Spanish – and the level of the student.
They can be consulted on : here

Content

The programme and activities depend on the level of the group and the objectives for each language activity.

Prerequisites

none

Assessment

Continual assessment (50%) including Spoken interaction and production and Final examination (50%) on Listening, reading and writing

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Physical Education

Module details

I4DHUMAPS11-exc

2 ECTS EN/FR
0.0 h 22.0 h 0.0 h 0.0 h
GUY CLAIRE
Revision date : May 18, 2026

Objectives

Physical and Sports Activities aim to promote the development of health (physical, mental, and social) and autonomy for all within a sustainable framework.
At the end of this module, the student should be able to define and implement a project collectively:

- By designing the project's objective
- By selecting and planning actions over time
- By regulating their actions and adapting when necessary
- By engaging in the group and the project

Content

2 activities chosen from: tennis, Pilates/circuit training, football (soccer), judo, weight training, outdoor physical activities, badminton, volleyball, climbing, rugby, and golf.
Adapted activities are offered for students with total or partial incapacity: Pilates/relaxation, adapted weight training, and sophrology.

Prerequisites

No prerequisites are required as part of the implementation of differentiated instruction.

Assessment

Assessment based on competencies related to the design and implementation of a collective project (continuous assessment and final assessment).

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Scientific English (**)

Module details

I4DHUMLV121-exc

3 ECTS EN
0.0 h 30.0 h 0.0 h 0.0 h
SHEA JOSEPH
Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood:

- scientific research publications in English in their field

The student should be able to:

- identify and master the specific linguistic features in English related to scientific presentations and publications
- write an abstract and a scientific article or report in English in their field of specialization, respecting the appropriate conventions
- communicate effectively in spoken scientific English to both specialist and non-specialist audiences

Content

The courses consist of practical exercises based on the PIR (Research Project) in each department. The various aspects of scientific publications are addressed, as well as the differences between oral and written communication. Emphasis is placed on the specific needs of students according to their specialization.

Prerequisites

B1/B2 level in English. Students must register for Research project in scientific department.

Assessment

Assessement for this course includes:

- Scientific article and abstract (group mark) 25%
- Oral presentation of research results (individual mark) 35%
- Presentation slides/poster (group mark) 20%
- Active participation and group member (individual mark) 20%

Back to menu

Future/Prospective Method

Module details

I4DHUMPIF21-exc

2 ECTS EN/FR
0.0 h 30.25 h 0.0 h 0.0 h
NEGREL NATHALIE
Revision date : May 18, 2026

Objectives

By the end of this module, the student will be able to:

- Engage in a forward-looking approach using a complex and systemic perspective
- Conduct ethical, critical, and reflective thinking adapted to a prospective approach
- Develop professional communication skills

Content

The program is built around a group project carried out by the students. Based on a foresight topic, students organize and take part in foresight workshops. They then produce several scenarios, which they present for discussion during a foresight forum. The resulting debates support them in formulating their recommendations. Additional tutorials (TDs) further enrich students' thinking, with contributions on narratives and imaginaries, ethics and philosophy, as well as geopolitics and intercultural issues.

Prerequisites

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take different forms: written exam, oral exam, report, written assignment, or peer assessment.

Back to menu

Physical Education

Module details

I4DHUMAPS21-exc

2 ECTS EN/FR
0.0 h 24.0 h 0.0 h 0.0 h
GUY CLAIRE
Revision date : May 18, 2026

Objectives

Physical and Sports Activities aim to promote the development of health (physical, mental, and social) and autonomy for all within a sustainable framework.
At the end of this module, the student should be able to define and implement a project collectively:

- By designing the project's objective
- By selecting and planning actions over time
- By regulating their actions and adapting when necessary
- By engaging in the group and the project

Content

2 activities chosen from: tennis, Pilates/circuit training, football (soccer), judo, weight training, outdoor physical activities, badminton, volleyball, climbing, rugby, and golf.
Adapted activities are offered for students with total or partial incapacity: Pilates/relaxation, adapted weight training, and sophrology.

Prerequisites

No prerequisites are required as part of the implementation of differentiated instruction.

Assessment

Assessment based on competencies related to the design and implementation of a collective project (continuous assessment and final assessment).

Back to menu

Social Psychology and Ethics

Module details

I5DHUMPSE11-exc

2 ECTS FR
0.0 h 17.5 h 0.0 h 0.0 h
ERIKSSON ANDREAS
Revision date : May 18, 2026

Objectives

The objectives of this course include:

- Analyzing group situations using concepts from social psychology
- Understanding interpersonal relationships in professional and intercultural contexts
- Deepening reflection on socio-ecological issues within one's professional path
- Identifying the ethical dimensions of these situations and being able to argue one's position
- Sharpening critical thinking, perspective-taking, and self-reflection: metacognition

Content

The psychosocial perspective: key concepts in social psychology, including group dynamics, decision-making processes, conflict management, social influence, stereotypes, conditions of obedience to authority, active minorities, psychosocial risks (PSR), and quality of life at work (QWL). Overall, these concepts will be explored through concrete examples and professional and intercultural scenarios, within an ethical approach to 21st-century engineering and socio-ecological challenges.

Prerequisites

No prerequisite

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take different forms: written exam, oral exam, report, written assignment, or peer assessment.

Back to menu

Team Management

Module details

I5DHUMME11-exc

2 ECTS EN/FR
17.5 h 0.0 h 0.0 h 0.0 h
HERENG HELENE
Revision date : May 18, 2026

Objectives

The student will be able to:

- Identify and understand information related to human resources within a company
- Analyze a team management situation with reference to a theoretical framework
- Formulate and justify managerial solutions

Content

All topics related to team management: recruitment, work motivation, total compensation, employee appraisal, management styles (leadership), conflict management, professional relations (social dialogue), human resources flexibility and employment contracts, training, job and skills management, and career management.

Prerequisites

Assessment

Assessment of learning outcomes is carried out continuously throughout the semester. Depending on the course components, it may take different forms: written exam, oral exam, report, written assignment, or peer assessment.

Back to menu

Physical Education

Module details

I5DHUMAPS11-exc

1 ECTS EN/FR
0.0 h 21.5 h 0.0 h 0.0 h
REY FRANCOISE
Revision date : May 18, 2026

Objectives

Physical and Sports Activities aim to promote the development of health (physical, mental, and social) and autonomy for all within a sustainable framework.
At the end of this module, the student should be able to:

- Act in a natural environment after analyzing and deciding on their action plan safely, using specific equipment and discovering a site
- Respect and integrate into an environment different from their usual one
- Develop their environmental awareness
- Commit consistently to the activity project
- Take an active part in the group by integrating into it

Content

3-day Outdoor Physical Activities course
Canoeing, mountain biking, biathlon, archery, climbing, orienteering
Adapted activities are offered for students with total or partial incapacity: adapted outdoor activities or low-intensity activities such as Pilates, relaxation, and yoga.

Prerequisites

No prerequisites are required as part of the implementation of differentiated instruction.

Assessment

Competency-based assessment through continuous assessment.

Back to menu

Scientific project in English (*)

Module details

I5PEPE21-exc

3 ECTS EN
0.0 h 30.0 h 0.0 h 0.0 h
SHEA JOSEPH
Revision date : May 18, 2026

Objectives

In both written and oral communication, students are expected to structure their ideas clearly, express themselves in accurate language and in a concise and precise style while respecting genre conventions; master specialized vocabulary; use an appropriate register; and cite their sources in compliance with international standards.
With regard to the innovative project, students will be able to successfully carry out a large-scale innovative project implementing a range of topics covered during the semester. The project will encompass specification, design, implementation, and presentation before an academic and industrial panel.

Content

English courses are organized as workshops during which students work on the written and oral deliverables related to their project. Emphasis is placed on autonomous work and on the constructive feedback provided by the instructors. Regular, individual, and detailed feedback is therefore intended to help students produce documents and deliver presentations that meet the professional standards of their field.
The technical aspects of the project are supervised by instructors according to the subjects emphasized in each project, with further in-depth guidance provided whenever necessary.

Prerequisites

Proficiency in general English and in the skills required for the rigorous written and oral presentation of scientific material.

Assessment

Under construction

Back to menu

Binders and Concrete – Mix Design and Environmental Impact

Module details

KGCD9LBU-exc

6 ECTS FR
24.0 h 13.0 h 24.0 h 0.0 h

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The mechanisms governing the microstructural evolution of cementitious and alternative materials from the fresh state to the hardened state.
- The main physicochemical characterization techniques used for cementitious materials.
- The microstructural characteristics of cementitious materials that control their long-term behavior and durability.

The student should be able to:

- Select appropriate cementitious matrices according to civil engineering construction requirements and service conditions.
- Formulate and characterize construction materials using suitable experimental methods and analytical tools.
- Analyze the relationships between microstructure, processing conditions, and material performance.

Content

The content of this course includes:

- Formulation and Hydration
- Cements and Concretes
- Industrial Mix Design
- Low-Carbon Concretes
- Alternative Binders
- Life Cycle Assessment (LCA)

Prerequisites

Master 1 (or equivalent) in civil engineering

Assessment

The assessement of this course includes:

- Written examination
- Laboratory report

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Durability of Construction Materials

Module details

KGCD9DMU-exc

3 ECTS FR
15.0 h 11.0 h 12.0 h 0.0 h

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The reaction mechanisms associated with the main endogenous and exogenous chemical attacks affecting reinforced and non-reinforced cementitious materials, and their consequences on material properties and structural performance.
- The influence of intrinsic material parameters and environmental conditions on the severity of degradation mechanisms and the durability of cement-based materials.
- The principles of durability assessment, including laboratory testing methods, numerical modeling of degradation processes, probabilistic approaches to durability analysis, and performance-based concrete design methodologies.

The student should be able to:

- Analyze durability issues in cementitious materials and structures by identifying degradation mechanisms and the governing physicochemical parameters.
- Develop and apply numerical and probabilistic approaches for durability assessment, including finite element multiphysics modeling, sensitivity analysis, and surrogate modeling techniques.
- Design and formulate concrete mixtures for ordinary and exceptional structures using performance-based durability indicators and relevant standards.

Content

The content of this course includes:

- Durability Phenomenology
- Degradation of Cementitious Materials: Mechanisms and Standardization Issues
- Modeling Tools
- Porous Media Transport Project
- Characterization Testing and Performance Indicators

Prerequisites

Master 1 (or equivalent) in civil engineering

Assessment

The assessement of this course includes:

- Written examination
- Laboratory report
- Oral presentation (project)

Back to menu

Mechanics of Materials and Structures

Module details

KGCD9MMU-exc

6 ECTS FR
20.0 h 36.0 h 0.0 h 0.0 h

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The mechanisms of cracking, creep, plasticity, and damage in materials and structures subjected to static and cyclic loading conditions.
- The influence of inclusions within elastic matrices, homogenization approaches, and the mechanical behavior of heterogeneous materials.
- The principles of nonlinear mechanical modeling and numerical analysis, including finite element formulations and reliability assessment under uncertainty.

The student should be able to:

- Formulate appropriate mechanical assumptions and select suitable nonlinear constitutive models for the analysis of structural elements.
- Calibrate the parameters of nonlinear mechanical models and implement numerical approaches for structural analysis.
- Interpret the results of nonlinear finite element simulations and reliability analyses in order to optimize engineering and technological solutions.

Content

The content of this course includes:

- Nonlinear Mechanics
- Fracture Mechanics
- Time-Dependent Behavior of Concrete
- Numerical Formulations and Chemo-Mechanical Coupling
- Finite Element Modeling of the Chemo-Mechanical Behavior of Structures

Prerequisites

Master 1 (or equivalent) in civil engineering

Assessment

The assessement of this course includes:

- Written examination
- Oral presentation (project)

Back to menu

Thermal Conduction in the Building Envelope

Module details

KGCD9TTU-exc

3 ECTS FR
14.0 h 0.0 h 21.0 h 0.0 h

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The principles governing heat transfer in buildings, including heat losses through walls, thermal bridges, and air leakage.
- The fundamental difference between thermal insulation and thermal inertia, as well as the impact of building mass on thermal response and summer comfort.
- The principles of heat conduction modeling, including one-dimensional finite difference methods and modal approaches for thermal analysis.

The student should be able to:

- Perform a complete thermal assessment of a building, including walls, thermal bridges, and air transfer phenomena.
- Identify and characterize condensation risks in building envelopes and propose appropriate mitigation solutions.
- Apply numerical simulation methods to solve heat conduction problems and analyze the thermal behavior of buildings.

Content

The content of this course includes:

- Heat Conduction and Thermal Bridges
- Transient Heat Conduction

Prerequisites

Master 1 (or equivalent) in civil engineering

Assessment

The assessement of this course includes:

- Written examination
- Oral presentation (project)

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Structural Health Monitoring of Civil Engineering Structures

Module details

KGCD9SSU-exc

3 ECTS FR
4.0 h 14.0 h 33.0 h 0.0 h

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The principles and applications of the main non-destructive testing (NDT) techniques used in civil engineering.
- The theoretical foundations of electrochemical, electromagnetic, and ultrasonic methods for material characterization and structural assessment.
- The physical mechanisms governing wave propagation, electrochemical responses, and signal interpretation in construction materials and structures.

The student should be able to:

- Analyze and explain the operation of ultrasonic, electromagnetic, and electrochemical non-destructive testing methods.
- Perform standard non-destructive measurements and process the associated experimental data and signals.
- Interpret NDT results in order to assess the condition, durability, and integrity of civil engineering materials and structures.

Content

The content of this course includes:

- Non-Destructive Evaluation of Civil Engineering Structures
- Electrochemical Methods
- Ultrasonic Methods
- Electromagnetic Methods
- Structural Health Monitoring of Civil Engineering Structures
- Digital Image Correlation and Optical Fiber Sensors

Prerequisites

Master 1 (or equivalent) in civil engineering

Assessment

The assessement of this course includes:

- Laboratory Report

Back to menu

Infrastructure maintenance

Module details

KGCD9MOU-exc

6 ECTS FR
6.0 h 54.0 h 15.0 h 0.0 h

Revision date : May 18, 2026

Objectives

At the end of this module, the student should have understood and be able to explain (main concepts):

- The main degradation mechanisms affecting civil engineering structures and the methods used to assess their condition while ensuring operational safety.
- The principles and techniques of structural repair and rehabilitation for deteriorated structures.
- The principles, implementation, and performance of cathodic protection systems applied to civil engineering structures.

The student should be able to:

- Diagnose deterioration issues and evaluate the condition and safety of civil engineering structures.
- Propose appropriate rehabilitation and structural repair solutions for degraded structures.
- Design and define electrochemical maintenance strategies, including cathodic protection systems, for the long-term durability of structures.

Content

The content of this course includes:

- Assessment, Reassessment and Pathologies of Structures
- Structural Pathologies
- Repair Techniques
- Risk Assessment and Rehabilitation
- Assessment of Masonry Structures
- Structural Reassessment Project
- Electrochemical Maintenance
- Corrosion Theory
- Design of an Electrochemical System: Engineering Consultancy Perspective
- Theory and Practice of Electrochemical Maintenance
- Cathodic Protection Project

Prerequisites

Master 1 (or equivalent) in civil engineering

Assessment

The assessement of this course includes:

- Written examination
- Laboratory Report
- Oral presentation (project)

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Synthetic biology

Module details

M1BIBC11-exc

2 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

System biology

Module details

M1BIBC21-exc

2 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Enzyme System

Module details

M1BIBC31-exc

2 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Biochemical engineering

Module details

M1BIBC41-exc

2,5 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Upstream and Downstream Processing

Module details

M1BITF11-exc

2,5 ECTS EN

0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Ethical Issues

Module details

M1BIET11-exc

2 ECTS EN

0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Bioeconomy

Module details

M1BIEC11-exc

2 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Practical training in research laboratory

Module details

M1BIPJ11-exc

15 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Life Cycle Assessment

Module details

M2BITF11-exc
2,5 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Ethical Issues

Module details

M2BIET11-exc

2,5 ECTS EN

0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Biochemical engineering

Module details

M2BIBC11-exc

2,5 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Enzyme System

Module details

M2BIBC21-exc

2,5 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Entrepreneurial skills and leadership

Module details

M2BILE11-exc
2 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Bioprocess design / Project management

Module details

M2BITF21-exc

8 ECTS EN

0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Practical courses

Module details

M2BIPJ11-exc

10 ECTS EN
0 h 0 h 0 h 0 h

Revision date : May 18, 2026

Objectives

Under construction

Content

Under construction

Prerequisites

Under construction

Assessment

Under construction

Back to menu

Urban Workshop *

Module details

I5PTGU35-exc
10 ECTS EN
20.0 h 0.0 h 0.0 h 80.0 h
BONHOMME MARION
Revision date : May 18, 2026

Objectives

The Urban Project is an innovative approach that puts into perspective all the strategic actions for the City.
This course allows crossing advanced technical knowledge on various key areas addressed in the other classes, in an urban project linked to the development of a neighborhood in the urban area of Toulouse.
This course is designed to be able to integrate the various problems linked to a neighborhood, and to make a comprehensive diagnosis from heterogeneous data; to define territorial and interdisciplinary issues; to make structured proposals, on an urban project, an open space or a district in a transversal approach putting into perspective technical performances and qualities of use.

Content

This workshop focuses on a neighborhood of the Toulouse urban area, with high stakes and a potential for mutations.
This workshop begins with a diagnosis divided into various themes: urban identity and landscape / transportation and mobility / social context of the neighborhood / economics context of the neighborhood and activities). Using SWOT approaches, territorial issues are ranked. Design proposals are proposed for the neighborhood.

Prerequisites

Students may have difficulty adapting to the working methods of the urban project and to the necessary iterative approach. Open-mindedness and adaptability are necessary.

Assessment

An English course is linked to the urban workshop, and the intermediate and final evaluations are to be presented both in French and in English.

Back to menu

Cities and Energy

Module details

I5PTGU25-01-exc

3 ECTS   FR
13.75 h   21.25 h   0.0 h   0.0 h

Revision date : May 18, 2026

Objectives

Cities are places of high density of people, of goods and of services but also places of high resources consumption. This course particularly focuses on energy. At the end of the course, the student should be able:

- to develop comprehensive approaches to take into account the complexity of the city and urban networks,
- to evaluate the energy consumption of a neighbourhood,

Knowledge on energy will focus on energy management in the city, eco-districts, and the link between urban form and energy consumption; on urban water management; on management of urban processes and key characteristics of urban waste.

Content

This course focuses on the analysis of the energy footprint of cities, by crossing physical approaches (thermal building and urban microclimate), urban approaches (morphological, rehabilitation), technical approaches (heating networks, renewable energies, energy storage, etc.) and Life Cycle Assessment Method. Theoretical contributions and tutorials will be combined to carry out an analysis of the neighborhood studied in the Urban Workshop.

Prerequisites

Under Construction

Assessment

The evaluation of the objectives of this course will focus on presentations of work by group of students.
This rating system will help students to enroll in the practice of collaborative project work.

Back to menu

Cities and Water

Module details

I5PTGU25-02-exc

3 ECTS FR
27.5 h 6.25 h 0.0 h 0.0 h

Revision date : May 18, 2026

Objectives

Cities are places of high density of people, of goods and of services but also places of high resources consumption. This course particularly focuses on water. At the end of the course, the student should be able:

- to develop comprehensive approaches to take into account the complexity of the city and urban networks,
- to scale various water networks, and systems management of storm water,

Content

This course focuses on water, which will present the challenges of the various techniques used today: water supply, sanitation of waste water and rainwater, as well as the alternatives that can be offered, particularly in terms of sanitation, and which make water a component of urban planning. Theoretical contributions and project will be associated to carry out an analysis of the district studied in the Urban workshop.

Prerequisites

Under Construction

Assessment

The evaluation of the objectives of this course will focus on presentations of work by group of students.
This rating system will help students to enroll in the practice of collaborative project work.

Back to menu

Transport and Mobility

Module details

I5PTGU25-03-exc

3 ECTS FR
16.25 h 17.5 h 0.0 h 0.0 h

Revision date : May 18, 2026

Objectives

Cities are places of high density of people, of goods and of services but also places of high resources consumption. This course particularly focuses on transport and mobility. At the end of the course, the student should be able:

- to develop comprehensive approaches to take into account the complexity of the city and urban networks,
- to design strategies of urban mobilities

Content

This course focuses on transport and mobility, which will be presented from historical, geographical, ecological, urban planning, political and technical perspectives. The main modeling techniques for traffic and infrastructure dimensioning will be presented. A small project on the Toulouse metropolis will be carried out in groups.

Prerequisites

Under Construction

Assessment

The evaluation of the objectives of this course will focus on presentations of work by group of students.
This rating system will help students to enroll in the practice of collaborative project work.

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Waste Manag. and Contaminated Sites

Module details

I5PTGU25-04-exc

1 ECTS FR
11.25 h 3.75 h 0.0 h 0.0 h

Revision date : May 18, 2026

Objectives

Cities are places of high density of people, of goods and of services but also places of high resources consumption. This course particularly focuses on wastes and contamonated sites. At the end of the course, the student should be able:

- to develop comprehensive approaches to take into account the complexity of the city and urban networks,
- or to be able to participate in the organization of waste management for communities, knowing the key recovery and treatment processes.

Content

This course focuses on urban waste and polluted soils, which will present the main methods of waste management (sorting and recovery, incineration and storage), on the technical, economic and regulatory aspects. The risk assessment methodology will make it possible to introduce the notion of polluted or potentially polluted soil, in particular through the identification of the possible impacts of pollution. Theoretical contributions and project will be associated to carry out an analysis of the district studied in the Urban workshop.

Prerequisites

Under Construction

Assessment

The evaluation of the objectives of this course will focus on presentations of work by group of students.
This rating system will help students to enroll in the practice of collaborative project work.

Back to menu

Urban Expertise

Module details

I5PTGU15-01-exc

1 ECTS FR

12.5 h 3.75 h 0.0 h 0.0 h

Revision date : May 18, 2026

Objectives

The expected scientific skills are as follows:

- awareness of the diversity of urban, architectural, landscape, economic, social, environmental and regulatory approaches
- ability to integrate a multidisciplinary teams (understand the interplay of actors and the underlying issues)
- set up a project method on an urban scale (multi-criteria and multi-scale diagnosis, positioning, iterative design approach)
- use GIS software for urban projects, use image processing software to make sense of project information

Content

The course "Urban Expertise" will focus on the actors of the urban project both in their missions and in their coordination. Will also be discussed: the role of sociology in urban planning, the regulatory framework, the economics of urban development.

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Modelling Cities *

Module details

I5PTGU15-02-exc

3 ECTS EN/FR
0.0 h 40.0 h 0.0 h 0.0 h

Revision date : May 18, 2026

Objectives

The expected scientific skills are as follows:

- awareness of the diversity of urban, architectural, landscape, economic, social, environmental and regulatory approaches
- ability to integrate a multidisciplinary teams (understand the interplay of actors and the underlying issues)
- set up a project method on an urban scale (multi-criteria and multi-scale diagnosis, positioning, iterative design approach)
- use GIS software for urban projects, use image processing software to make sense of project information

Content

The course "Modeling the City" will aim to understand the structuring of data, the representation of knowledge for forecasting and evaluation, decision support, design or management of a development. Some representation tools for Urban Engineering will be used. The use of Geographic Information Systems (GIS) will be central in this level. Thematic approaches to modeling will complete the program: energy-climate, mobility, water management, architecture.

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Inter-programme Workshop **

Module details

I5PTGU15-03-exc

3 ECTS EN/FR
0.0 h 0.0 h 0.0 h 35.0 h

Revision date : May 18, 2026

Objectives

The expected scientific skills are as follows:

- awareness of the diversity of urban, architectural, landscape, economic, social, environmental and regulatory approaches
- ability to integrate a multidisciplinary teams (understand the interplay of actors and the underlying issues)
- set up a project method on an urban scale (multi-criteria and multi-scale diagnosis, positioning, iterative design approach)
- use GIS software for urban projects, use image processing software to make sense of project information

Content

The course "Inter-universities workshop" will allow students to come into contact with other cultures/logics of urban projects. This course is an inter-universities workshop in the form of a 5-day intensive program to compare knowledge related to various universities (engineering, architecture, geography, visual arts, political sciences, economics, communication) on a joint urban project with Toulouse Métropole.
This co-design work will lead to the publication of a book, Les Carnets de Ville, in collaboration with the services of Toulouse Métropole.

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Smart Devices

Module details

I5SSSD11-exc

4 ECTS EN
10.0 h 26.25 h 16.5 h 0.0 h
J. Grisolia
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Wireless Sensors Network

Module details

I5SSWN11-exc

1 ECTS EN
10.0 h 0.0 h 8.25 h 0.0 h
D. Dragomirescu
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Embedded IA for IoT

Module details

I5SSIA11-exc

1 ECTS   EN
7.5 h   0.0 h   8.25 h   0.0 h
P. Leleux
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Security for IoT

Module details

I5SSSE11-exc

2 ECTS   EN
12.5 h   0.0 h   22.0 h   0.0 h
R. Cayre
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Energy for connected objects

Module details

I5SSEC11-exc
1 ECTS EN
5.0 h 0.0 h 5.5 h 0.0 h
G. Loubet
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Innovative Project 1

Module details

I5SSIP11-exc
2 ECTS EN
0.0 h 0.0 h 19.25 h 0.0 h
T. Monteil
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Portfolio 1

Module details

I5SSPO11-exc

1 ECTS EN
0.0 h 1.25 h 2.75 h 0.0 h
G. Loubet
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Wireless Communications

Module details

I5SSWC12-exc

2 ECTS EN
8.75 h 3.75 h 5.5 h 0.0 h
S. Abdellatif
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

5G Technologies

Module details

I5SSFG12-exc

1 ECTS EN
7.5 h 0.0 h 11.0 h 0.0 h
E. Sicard
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Innovative Project 2

Module details

I5SSIP12-exc

2 ECTS EN

0.0 h 0.0 h 19.25 h 0.0 h

T. Monteil

Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

Portfolio 2

Module details

I5SSPO12-exc

1 ECTS EN
0.0 h 0.0 h 2.75 h 0.0 h
G. Loubet
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

English

Module details

I5SSEN12-exc

1 ECTS EN
0.0 h 30.0 h 0.0 h 0.0 h
J. Shea
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu

Middleware and Services

Module details

I5SSMS12-exc

5 ECTS EN
16.25 h 15.0 h 38.5 h 0.0 h
N. Guermouche
Revision date : May 18, 2026

Objectives

Under Construction

Content

Under Construction

Prerequisites

Under Construction

Assessment

Under Construction

Back to menu