IPSA
ÉCOLE D'INGÉNIEURS
DE L'AIR, DE L'ESPACE ET DE LA MOBILITÉ DURABLE

Undergraduate in Aeronautical Engineering

Syllabus 2022-2023

- Exchange students -

IONIS
EDUCATION GROUP

Fall semester

The Fall semester of the third year of undergraduate studies (Aéro 3) includes:

- Basic sciences 1
- Engineering sciences - core
- Aerospace
- Business knowledge 1
- Languages 1

Basic Sciences 1
AnMa312 - Elements of harmonic analysis for engineers
AnMa313 - Numerical linear algebra 1
AnMa314 - Engineering statistics and probabilities

Engineering sciences - Core
AnEn311 - Heat transfers 1
AnMé311 - General Mechanics 1
AnIn311 - Introduction to databases
AnAu311 - Automation of linear dynamical systems

Aerospace
AnMf311 - Aerodynamics 1
AnAé312 - Flight mechanics
AnEl311 - Electrotechnics & embedded power generation
AnSp311 - Introduction to space systems

Business knowledge 1
AnMi311 - Project management
AnMi314 - Decarbonising aeronautics : technological leveragings

Languages 1
FLEa - French as a foreign language and intercultural seminars
La311 - English
La312 - Preparation for English tests

Course description

Basic Sciences 1

AnMa312 - Elements of harmonic analysis for engineers

This course is an introduction to complex and harmonic analysis: two vast and fascinating fields of analysis with many ramifications, motivated by applications in various fields such as the analysis and control of dynamic systems (automatic), signal processing, aerodynamics or even electronics. At the end of this course, the student should be able to identify and apply the following basic concepts of complex and harmonic analysis:

- Holomorphy and the different versions of the Cauchy-Riemann theorem.
- Integral of functions of the complex variable (Riemann integral, curvilinear, Cauchy theorem and formula)
- Fourier series and transform (Dirichlet theorem and point convergence of Fourier series, Bessel inequality, Parseval equality).
- Convolution product and Dirac distribution.
- Laplace transform and inverse Laplace (analytic continuation)
- Properties of Laplace Transforms.

At the end of the Tutorials and Practical Tasks, the student must be able to apply the different mathematical concepts introduced at the level of the Magistral Courses in the following three areas:

- Aerodynamics: Complex potential of velocities, current function, Complex potential of flow, Potential of a dipole, bearing force, etc.
- Signal processing: Energy aspect, filtering (low-pass), radar, echo cancellation, speech processing, satellite positioning system.
- Automatic: Transfer function, block diagram, block diagram reduction.

AnMa313 - Numerical linear algebra 1

At the end of this course, the student must:

- Know how to describe the solutions of a linear system.
- Understand and manipulate matrix norms and matrix conditioning in the context of studying the sensitivity of the solution (of a square linear system) to perturbations of the matrix and/or second member.
- Understand the principle of pre-conditioning
- Understand and be able to apply the different direct methods presented in this course (Gauss pivot, Cholesky, QR factorization).
- Be able to evaluate for each of the direct methods the number of elementary operations.
- Be able to explain the principle of construction of iterative methods.
- Be able to present and apply the following iterative methods: Jacobi, Gauss-Seidel, relaxation (SOR), Richardson
- Know and be able to apply the main convergence results of the iterative methods of Jacobi, Gauss-Seidel, relaxation (SOR), Richardson.
- Be able to implement the different iterative methods.
- Be able to pose an approximation problem in the sense of least squares.
- Know and be able to use the main theoretical results concerning a least squares problem (normal equation, uniqueness of the solution, minimum norm solution).
- To be able to present and apply the following methods of numerical resolution of a least squares problem: normal equation method, QR factorization method.

AnMa314 - Engineering statistics and probabilities

This module aims first of all to provide a qualitative analysis of chance, that is to say to make mathematical modeling of phenomena in which chance intervenes. Then compare these mathematical models to reality, in particular to experience and observed data, in order to choose to adjust and validate the models. Finally, testing hypotheses to make decisions. The emphasis is mainly on new concepts. The examples of application have been chosen for the purpose of showing the variety, richness and topicality of the possible applications of probability and statistics. Rather, these situations aim to open avenues of work likely to be exploited by engineering students in their field of interest.

Engineering sciences - Core

AnEn311 - Heat transfers 1

Acquire the knowledge necessary for the engineer in terms of heat transfer.
To study the physical phenomena involving heat energy exchanges (thermal transfers and heat transfers). Know the laws of heat transfer and solve problems relating to convection, conduction and thermal radiation.
This knowledge is applied to practical case studies and in particular to issues related to radiation (thermal screens, solar collectors).

AnMé311 - General Mechanics 1

Acquire the theoretical methods necessary for the resolution by the general theorems and the Lagrange equations of a mechanical problem of rigid solids in order to find:

- Movements and trajectories
- Binding forces in the mechanism
- Balance and stability

AnIn311 - Introduction to databases

At the end of this course, students should :

- Understand and master the concepts of relational databases
- Apply the Merise method to obtain data modeling at the "conceptual" and "logical" level (MCD and MLD), respecting graphic conventions, the rules for transforming a conceptual model into a logical model and applying normal forms
- Approach relational algebra and SQL language, to design and write relevant database queries

They should be able to design an individual automated production tool

AnAu311 - Automation of linear dynamical systems

At the end of this course, the student must :

- Have understood the interest of automatic, the application fields and the issues of the system control.
- Have the basics of modeling of a mono-variable linear system.
- Have acquired analysis tools for feedback systems.
- Must also know how to design a PID type controller for physical systems (mechanical, hydraulic, electrical, ...) used in the aeronautical field.

Aerospace

AnMf311 - Aerodynamics 1

At the end of this course, the student:

- Master the flow dynamics modeling approach for Aerodynamic problems. Will be able to understand the different methods and tools used to solve the dimensioning problems encountered by the engineer.
- Acquire the knowledge of the elements from the scientific and technical field necessary for modeling for Aerodynamics by ensuring the prior mastery of basic knowledge and resources from the mechanics of continuums (more particularly, fluid mechanics) and mathematics.
- Will learn, in addition to the mastery of kinematics, the dynamics of flows, the description of the forces inside and at the border of a fluid as well as the study of the different laws of behavior (perfect fluid and Newtonian fluid) and their consequences on the models obtained.
- Will also be able to discern fluid-structure interface problems in perfect fluid and Newtonian viscous fluid flows and master the interface conditions to be used in modelling.
- Master the general methodology for calculating the aerodynamic forces exerted by a fluid on a profile and will be introduced to the study of the modeling of boundary layers and turbulence.

AnAé312 - Flight mechanics

At the end of this course, the student:

- Know the principles and physical constraints that govern the flight of an airplane.
- Will be able to take the Airplane Flying Qualities Course

AnEl311 - Electrotechnics & embedded power generation

At the end of this course, the student must :

- Will have acquired the basics of electrical engineering on DC and AC machines (synchronous and asynchronous).
- Know the principles of power electronics to its application to different forms of electrical energy conversion.
- Will be able to apply these bases and will have acquired the knowledge of the problems of the various types of energies, especially electric, as well as their specific management on board an aircraft.
- Will be particularly sensitive to developments towards "all-electric" aeronautics.

AnSp311 - Introduction to space systems

At the end of this course, the student:

- will know the history and challenges of the space conquest;
- will know the economic context, the political, industrial and scientific actors of the space sector;
- will know the particularities and problems of the space environment.

Business knowledge 1

AnMi311 - Project management

- Know how to operate in project mode and its environment
- Learn techniques for conducting industrial projects or information systems projects (including agile methods).
- Learn to plan and follow the realization of a project
- Know how to express the customer's need for the design of a new product

AnMi314 - Decarbonising aeronautics : technological leveragings

Languages 1

FLEa - French as a foreign language and intercultural seminars

This course will help students to learn the basics and more of French language in order to help them integrate into the IPSA student life as well as the daily life in Paris.

La311 - English

At the end of the 3rd year, the student must be able to:

- Reach the minimum level CEFRL B2 (understand a conference or a fairly long speech, follow a complex argument, read and understand articles, reports or contemporary literary texts, communicate spontaneously and easily with a native interlocutor, participate conversation, arguing and defending one's opinion, writing an essay, report or letter clearly on a wide range of topics).

The student must be able to:

- Easily understand an English speaker (in different accents)
- Understand a general or scientific course in English
- Express yourself in a way that is completely understandable to an English speaker
- Defend your point of view in a general or technical conversation
- Analyze and debate fluently a current topic, general or technical
- Master a technical vocabulary specific to the engineer - Carry out translations that do not require too specialized a vocabulary
- Write an essay or a report in correct and structured English
- Analyze a complex text on an academic or professional subject
- Make a reasoned presentation of a university or professional project.

La312 - Preparation for English tests

Reach the CECRL B2 level, i.e. a minimum score of 785 / 990 on the TOEIC L&R test or equivalent (IELTS 5.5 / 9 or TOEFL 87 / 120).

Spring semester

The Spring semester of the third year of undergraduate studies (Aéro 3) includes:

- Basic sciences 2
- Engineering sciences - Signal & systems
- Engineering sciences - Vehicles
- Business knowledge 2
- Languages 2

Students must choose between the Signals & sytems major and the Vehicle major

Basic Sciences 2
AnMa321 - Differentiable optimization 1
AnMa322 - EDO quadrature and digital resolution
AnMa323 - Finite difference method

Engineering sciences - Signals & systems
AnIn32 - Networks of smart devices
AnIn322 - Operating systems
AnIn323 - C++ programming
AnMa324 - Differentiable optimization 2
AnMa325 - Data and decision science
AnAu32 - Mini-project of automatic
AnAu322 - Microcontroller programming
AnEl321 - Digital electronics
AnEl322 - Introduction to programmable logic block (FPGA)
AnTé321 - Aeronautical telecommunications systems
AnTé322 - Digital signal processing

Engineering sciences - Vehicles
AnMé321 - General mechanics 2
AnMé322 - Introduction to FEM
AnMé323 - CAD (Catia)
AnMé324 - Continuum mechanics
AnMé325 - Materials science
AnEn321 - Introduction to turbomachinery
AnEn322 - Heat transfers 2
AnEn323 - Applied thermodynamics
AnMf321 - Aerodynamics 2
AnMf322 - Introduction to CFD

Business knowledge 2
AnSh325 - Management and conflict management
AnSh323 - Corporate social responsability

Languages 2
FLEb - French as a foreign language and intercultural seminars
La321 - English 2

Course description

Basic Sciences 2

AnMa321 - Differentiable optimization 1

At the end of this course, the student must be able for a quadratic function called positive definite (D.P.):

- To identify its analytic and matrix expressions and move from one to the other.
- To explain and demonstrate the following elementary properties: coercivity, strict convexity, strict global minimizer.
- To present and manipulate the different visualization modes: partial functions, level map, representative surface
- To present and manipulate
- To explain (give a graphical interpretation) and manipulate the local concepts of directional derivative, gradient, directional curvature, linear approximation.

At the end of this course, the student must be able to present and apply the main results resulting from the mathematical study of the quadratic optimization problem (D.P.) without constraint:

- Uniqueness of the solution and equivalence (in terms of the same solution) with the resolution of a symmetric linear system (D.P.).
- Conditioning of the problem: sensitivity of the solution after disturbance of the linear part of the objective function, geometric interpretation of the conditioning in terms of level lines.

At the end of this course, the student must be able to present in the context of the quadratic optimization problem the following concepts defining the methods with descent directions: Definition of a descent direction at a current point.

- Choice of the descent step (fixed step, optimal step).
- Choice of the stopping criterion (test of the residue).

At the end of this course, the student must be able to present and apply the following results from the study (theoretical and numerical) of methods with directions of descent of the gradient in the context of the quadratic optimization problem :

- Definitions of mathematical algorithms (sufficient condition on the fixed step, expression of the optimal step).
- Implementation under Python of the various methods.
- Theoretical (convergence results and convergence speed) and numerical (number of iterations, CPU time) comparison of the efficiency of the methods. At the end of this course, the student must be able to present and apply the results resulting from the study (theoretical and numerical) of the method of conjugate gradients:
- Definition of the mathematical algorithm (conjugate directions)
- Convergence of the method in the case of dimension 2
- Implementation in Python

Theoretical (convergence result and speed of convergence, complexity) and numerical (number of iterations, CPU time) comparison with the Cholesky method (case of large linear systems (D.P.)).

AnMa322 - EDO quadrature and digital resolution

This module aims to provide the basic knowledge necessary for the understanding and use of algorithms commonly used in engineering sciences, such as the main integral calculus schemes as well as the resolution of ordinary differential equations and systems. nonlinear (Euler, Runge-Kutta,...). A stability study will also be discussed. Several physical examples were discussed: pendulum, vehicle suspension, prey-predator, rocket equation, RLC.

AnMa323 - Finite difference method

This course is part of the continuation of the Ma33 courses whose objective is the initiation to the numerical methods of Scientific Computing, i.e. the concrete calculation of exact or approximate solutions of problems from physics (linear or nonlinear systems, integrals , EDO, EDP, etc.).

We are going to approach in a concrete way the construction of approximate solutions of ordinary equations and partial differential equations. Unlike interpolation, it will be a question of calculating approximate values of the solution at certain points (nodes) without representing it by usual functions. We will content ourselves with fairly elementary examples (heat equation, advection-diffusion equation) because the problems become mathematically very complex quite quickly.

Engineering sciences - Signals & systems

AnIn321 - Networks of smart devices

- Master the basic concepts (OSI layers, TCP/IP layers, routing, addressing, fragmentation, error detection/correction, flow control, etc.) to understand the technical mechanisms providing services to network users. computers.
- Address emerging concepts (Internet of Things)
- Understand the issues and security mechanisms of distributed information systems.

AnIn322 - Operating systems

At the end of this course, the student must be able to master the concepts (Processes, Threads, scheduling, synchronization, execution time constraints) allowing them to understand the functioning of "generalist" multitasking operating systems. In addition, they will have knowledge of the Linux operating system.

AnIn323 - C++ programming

At the end of this course, the student must:
• Master the basic concepts of object-oriented design (OOP) and their transpositions into C++ language.
• be able to manipulate, in C++, files through streams
• be able to create, in C++, classes and instantiate them into objects
• be able to create data encapsulation mechanisms
• be able to create and manage simple and multiple inheritance between classes, in C++
• know how to translate a UML class and object diagram into C++ CODE, and vice versa.

AnMa324 - Differentiable optimization 2

This course aims to study in detail a certain number of basic methods of unconstrained differentiable optimization commonly used in engineering sciences. The methods will be illustrated on different examples from signal processing, automation, digital communications, etc.
Throughout this course we have tried to take into account a double imperative: on the one hand, to give the reader a certain number of tools (algorithms) that can be used directly, to solve optimization problems that may arise to him; on the other hand, to provide a sufficient theoretical and conceptual framework to understand and justify these algorithms. This is why the presentation of the theoretical results has been made with the aim of highlighting the links with the applications and the algorithmic implementation. With this in mind, emphasis will be placed on the critical analysis of the results provided by the numerical tools presented in order to identify the appropriate methods for a given problem, to understand the possible failures of such and such a method applied to a given problem, and possibly to design new ones. In particular, all IT developments will be done in Python.

AnMa325 - Data and decision science

At the end of this course, the student must:

- Know how to use basic statistical tools to exploit, interpret and criticize data,
- Be familiar with parameter estimation problems and classical statistical tests,
- Be able to set up a hypothesis test.

AnAu321 - Mini-project of automatic

The objective of this course is to know the different representations of physical systems, how to simulate their behavior, learn to develop under the textual environment of Matlab and graphics of Simulink.

The student must acquire the necessary knowledge according to a practical approach developed from work carried out in pairs. We would treat the simulation of continuous and discrete dynamic systems in different ways (without and with Simulink).

AnAu322 - Microcontroller programming

At the end of this course, the student must:

- Know the basics of programming and testing a microcontroller in Assembly and C languages on the Arduino platform
- To be able to apply this approach when designing simple circuits in electronics.

AnEl321 - Digital electronics

At the end of this course:

- The student must know the principles of Boolean logic, the operation of logic gates and flip-flops.
- They must have understood the operation of simple logic circuits whether they relate to combinatorial or sequential operation.
- They must know how to solve first-level problems in the field of logic and perform these functions from simple logic electronic components.

AnEl322 - Introduction to programmable logic block (FPGA)

At the end of this course, the student must:

- Know the different design stages of systems based on programmed digital circuits (combinatorial and sequential).
- Know the usual rules for using a language adapted to FPGA circuits (VHDL).
- Know how to program a programmable logic circuit (FPGA) in order to a simple logic function,
- Be able to simulate and test a programmable logic circuit (FPGA).

AnTé321 - Aeronautical telecommunications systems

At the end of this course, the student must know the main telecommunications equipment used in the aeronautical and space field.
They must have understood the main principles of antenna and radar theory, their characteristics and performance.
They must know how to make a simple assessment of a radio link and calculate the performance (range, measurements, etc.) of a radar system.

AnTé322 - Digital signal processing

At the end of this course, the student must:

- know the principles and laws of temporal and spectral representation of deterministic analog signals, and have understood the specific mathematical tools of Fourier analysis of continuous-time signals (Series and Fourier Transform).
- have understood the methodology for synthesizing an analog filter (template and analytical approximation)
- know how to use MATLAB for the spectral study of analog signals as well as for the synthesis and study of analog filters.
- Understand the consequences of signal sampling and coding in both the time domain and the spectral domain.
- Master the specific mathematical tools of Fourier analysis of digital signals (Discrete Fourier Transform and z Transform).
- Master the synthesis of digital filters.
- Know how to use MATLAB for filtering and spectral study of deterministic or random digital signals.

Engineering sciences - Vehicles

AnMé321 - General mechanics 2

Acquire the theoretical methods necessary for the resolution by: (i) the general theorems and (ii) the Lagrange equations, of a problem of mechanics of rigid solids in order to find:

- movements and trajectories,
- the connection forces in the mechanism,
- balance and stability.

AnMé322 - Introduction to FEM

Give the principle of solving partial derivative equations with the finite element method.
Solve an elastostatic problem of a one-dimensional bar, beam, truss type structure with the finite element method.

AnMé323 - CAD (Catia)

The objective of this training module is to acquire the skills and technical knowledge inherent in the use of computer-aided mechanical design software (Catia V5 software) useful for the 3D modeling of a product. comprising ten pieces. The constituent parts are modeled in solid, surface and/or hybrid mode.

AnMé324 - Continuum mechanics

At the end of this course, students should be able to:

- To understand the problems of continuous environments
- Define symmetric matrices (or tensors) of deformations and stresses
- To understand and use Hooke's law which connects them in a linear way by introducing the two Lamé coefficients. They will therefore be able to establish the basic equations of linearized elasticity around a state of natural equilibrium.

AnMé325 - Materials science

- To give students basic knowledge of the atomic and grain structure of materials.
- Introduce the atomic organization in the structure of materials.
- Illustrate changes in the microstructure
- Link the microstructure to macroscopic physical phenomena.

AnEn321 - Introduction to turbomachinery

This course concerns the description and operation of turbomachines. Its purpose is to provide general information and an overview of the subject and:

- to make the connection between the requirements of the mechanics of the flight and the calculations of cycles of the turbomachines,
- to explain the sizing of the thermodynamic cycles of turbomachines,
- present the fundamental principles of component sizing and some notions of turbomachinery technology

AnEn322 - Heat transfers 2

This module is a continuation of the En31 module. It constitutes a direct application of the elements taught previously. At the end of this course, students:

- Will be able to apprehend under a simple approach, the theory of fins.
- Have acquired the main principles of design and operation of heat exchangers.
- Will be able to apply the problems to concrete applications in connection with the main reasons for studying thermal engineering.

AnEn323 - Applied thermodynamics

At the end of this course, students will have:

- Deepened theoretical knowledge in thermodynamics.
- Acquired mastery of more complex physical phenomena.
- Studied complex thermodynamic cycles of the receiver type (heat pumps, refrigerating machines, air conditioning, etc.) and motors.
- Acquired basic knowledge of technologies.

They will then know:

- Apply theoretical knowledge to practical, sometimes complex examples (coupling between thermal machine and heat exchangers, etc.).
- Apply the issues to concrete applications related to the main study grounds of thermal and thermodynamic engineering.

AnMf321 - Aerodynamics 2

At the end of this course, the student will have an in-depth knowledge of the Aerodynamic modeling approach acquired in the Aé31TC course. They will discern the advantages and limitations of the different modeling methods and tools available to solve the dimensioning problems encountered by the engineer.

Thanks to the introductory reminder of the methodology for calculating the resultant of the forces exerted by a flow of fluid on a profile, they will master the framework of modeling for aerodynamics.

They will then improve his knowledge of the modeling techniques historically used in aerodynamics by deepening their mastery:

- the dynamics of perfect fluids and the particular properties of its flows (Bernouilli's theorems),
- the method of conformal transformations,
- the lifting line theory of Prandtl and the theory of thin profiles.
- Finally, they will benefit from a basic knowledge of the empirical notions related to the consequences of the compressible and viscous nature of the air on the resultant of the aerodynamic forces as well as the terms, concepts and quantities commonly used in aerodynamics and flight mechanics.

AnMf322 - Introduction to CFD

At the end of this course, the student must:

- Have had a first grip of the star ccm+ software
- Be able to follow and understand tutorials to model phenomena related to real fluid dynamics.
- Know the mathematical concepts behind the star ccm+ software

Business knowledge 2

AnSh325 - Management and conflict management

It aims to re-examine social dialogue, i.e. all the relationships and interactions that exist within the organization between management, staff representatives and employees. Quality social dialogue has every chance of strengthening overall cohesion and performance. Learning informal social dialogue - that which is established spontaneously or in the context of small working groups, outside of charters and codes of ethics - is essential. It is based, on a daily basis, on the expression and resolution of potential conflicts. Anticipating tensions, defusing conflicts and proposing constructive outcomes: the support of the future framework will define here both the regularity of these practices, through principles, standards, and an assumed professional identity.

AnSh323 - Corporate social responsability

Corporate Social Responsibility is a moral and intellectual obligation which, beyond the legal framework, puts into practice respect for the principles of sustainable development (eco-design, economic viability, well-being of society, protection of the environment). As such, the CSR approach questions the business model of the company and the very meaning of its competitiveness, its duty of vigilance linked to the environmental and social impacts of its activities. This course presents the benefits of CSR through a collective awareness combining the need to concretize ethics and the desire to prevent risks.
At the end of this course, students will have developed the following knowledge and skills
a) Understand the concepts contained in the CSR discourse (governance, stakeholders, legitimacy and legality, etc.)
b) Identify and take a critical look at managerial practices (in a context where the discourse on CSR has become essential for the company)
c) Identify and discuss the dilemmas that arise in day-to-day managerial practices

Languages 2

FLEb - French as a foreign language and intercultural seminars

This course will help students to learn the basics and more of French language in order to help them integrate into the IPSA student life as well as the daily life in Paris.

La321 - English 2

The student must be able to:

- Easily understand an English speaker (in different accents)
- Understand a general or scientific course in English
- Express yourself in a way that is completely understandable to an English speaker
- Defend your point of view in a general or technical conversation
- Analyze and debate fluently a current topic, general or technical
- Master a technical vocabulary specific to the engineer
- Carry out translations that do not require too specialized a vocabulary
- Write an essay or a report in correct and structured English
- Analyze a complex text on an academic or professional subject
- Make a reasoned presentation of a university or professional project.

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Subjects list and credits - 2022-2023

AERO 3: Undergraduate courses

FALL SEMESTER = "S5" = 3rd year

	Modules	Scheduled hours	ECTS	In-class hours*				Assessments			Out-of-class hours	Teaching Units
				Lectures	Tutorial classes	Practical work	Projects	Assignts	Mid-term exams*	Final exams*		
Basic Sciences 1												
AnMa312	Elements of harmonic analysis for engineers	**45**	3,5	14	20	6		PW	2	3	*40*	PSF 31
AnMa313	Numerical linear algebra 1	**35**	3	10	12	10	2	PW	1	Project	*35*	
AnMa314	Engineering statistics and probabilities	**30**	2		22		6	Project		2	*20*	
Engineering sciences - Core												
AnEn311	Heat transfers 1	**40**	3	18	8	10			2	2	*35*	PSITC 31
AnMé311	General mechanics 1	**45**	3,5	12	12	16		PW	2	3	*40*	
AnIn311	Introduction to databases	**17**	1,5	4	4	4	4	Project		1	*15*	
AnAu311	Automation of linear dynamical systems	**22**	2	10	10				MCQS	2	*20*	
Aerospace												
AnMf311	Aerodynamics 1	**22**	2	10	10			Continuous assess.		2	*25*	PAS 31
AnAé312	Flight mechanics (performances, static equilibrius)	**22**	2	10	10			Homework		2	*25*	
AnEl311	Electrotechnics & embedded power generation	**21**	2	10	8				1	2	*20*	
AnSp311	Introduction to space systems	**11**	1	10						1	*8*	
Business knowledge and occupational integration 1												
AnMi311	Project management	**18**	1,5	4			12	Projects		2	*20*	PCIP 31
AnMi314	Decarbonising aeronautics: technological leveragings	**11**	0,5	10						1	*5*	
Languages 1												
AnFLEa	French as a foreign language and intercultural seminars	**34**	6	32						2	*25*	
La311	English 1	**19,5**	1,5		12		6	Continuous assess.	Present.	1,5	*15*	
La312	Preparation for English tests	**14**	1		12			Continuous assess.		2	*14*	
* Hours		**406,5**	**36**								**362**	

SPRING SEMESTER = "S6" = 3rd year												
				Heures encadrées				Evaluations			Out-of-class hours	
Modules		Scheduled hours	ECTS	Lectures	Tutorial classes	Practical work	Projects	Assignts	Mid-term exams*	Final exams*		Teaching Units
Basic Sciences 2												
Ma321	Differentiable optimization 1	**26**	2,5	8	8		8		2	Project	*30*	PSF 32
Ma322	EDO quadrature and digital resolution	**25**	2	8	8	6	2	PW	1	Project	*25*	
Ma323	Finite difference method	**18**	1,5	6	4	4	4	PW		Project	*25*	
Engineering sciences - Signal and Systems												
In321	Networks of smart devices	**18**	1,5	12		4		PW		2	*15*	PSIS 31
In322	Operating systems	**18**	1,5	12		4		PW		2	*15*	
In323	C++ programming	**24**	2	E-Learning		24		PW		PW	*30*	
Ma324	Differentiable optimization 2	**26**	2	6	8		10		2	Project	*25*	PSIS 32
Ma325	Data and decision science	**20**	2	6	4	6	4			Project	*20*	
Au321	Mini-project of automatic	**17**	1,5	8			8		1	Project	*20*	
Au322	Microcontroller programming	**17**	1,5	6		10		PW		1	*20*	
El321	Digital electronics	**27**	2	14	10				1	2	*20*	PSIS 33
El322	Introduction to programmable logic blocks (FPGA)	**24**	2	5		17		PW		2	*20*	
Té321	Aeronautical telecommunication systems	**20**	1,5	12	6			MCQS		2	*15*	
Té322	Digital signal processing	**39**	3	14	14	8		PW	1	2	*30*	
Engineering sciences - Vehicles												
Mé321	General mechanics 2	**29**	2	12	12				2	3	*25*	PSIV 31
Mé322	Introduction to FEM	**18**	1,5	8	8					2	*20*	
Mé323	CAD (Catia)	**19**	2				18	Project		1	*35*	
Mé324	Continuum mechanics	**44**	4	20	20				2	2	*35*	
Mé325	Materials science	**20**	1,5	10	8			Continuous assess.		2	*15*	
En321	Introduction to turbomachinery	**26**	2	12	8		4	Project		2	*25*	PSIV 32
En322	Heat transfers 2	**23**	2	6	6	9		PW		2	*20*	
En323	Applied thermodynamics	**32**	2,5	8	8	6	8	Continuous assess.		2	*25*	
Mf321	Aerodynamics 2	**24**	2	10	8	4		PW		2	*22*	
Mf322	Introduction to CFD	**14**	1	2	4	8				PW	*8*	
Business knowledge and occupational integration 2												
Sh325	Management and conflict management	**12**	1	4	8					Present.	*10*	PCIP 32
Sh323	Corporate social responsibility	**16**	1	4	12					Report + present.	*15*	
Languages 2												
FLEb	French as a foreign language and intercultural seminars	**34**	6	32						2	*25*	
La321	English 2	**19**	1,5		12		6	Continuous assess.	1	Present.	*15*	
* Hours		**SYS**	**400**	**36**							**375**	

IPSA
ÉCOLE D'INGÉNIEURS
DE L'AIR, DE L'ESPACE ET DE LA MOBILITÉ DURABLE

Master in Aeronautical Engineering

Syllabus 2022-2023

- Exchange students -

IONIS
EDUCATION GROUP

Spring semester

The spring semester of the first year of master (Aero 4) includes:

- Human Sciences and Languages common pole focusing on Labor law and Business Sociology
- Corporate knwoledge common pole focusing on Management and Financial Management
- Engineering Sciences common core and Elective Modules
- 2 majors: SYSTEMS (SYS) and VEHICLES (VEH)
- 6 options - 3 for each major
    - SYSTEMS major : 3 options
      - Embedded systems & Telecommunication (SET)
      - Mechatronic systems (SM)
      - Space, Launchers & Satellites (ELS)

    - VEHICLES major: 3 options
      - Energetics & Propulsion (EP)
      - Mechanics & Structures (MS)
      - Space, Launchers & Satellites (ELS)

NOTE: Students must choose one option according to their major. They cannot mix courses from different majors and options.

NOTE: Some courses are taught in French, their description is accordingly.

Human Sciences and Languages common pole
Sh421 - Ethics for Engineers & Sustainable development
Sh422 - Sociologie des Entreprises & des Organisations
Sh423 - Droit social
Fleb - French language courses and intercultural seminar

Corporate knowledge common pole
Mi421 - Qualité, Réglementation, Normes, Lean
Mi422 - Principes de Stratégies d'Entreprises
Mi423 - Economie : Gestion Financière

Engineering Sciences common core
Au421 - Graphic representation of Dynamic multilinear system
Mi426 - Principes de base de Conception Avion et d'éco-conception - Industrialisation et Méthode de production
Aé421 - Flight Dynamics

Elective modules and Initiation to Research and Innovation
For EP, MS, SET, and SM students: subjects will be given at the beginning of the semester
For ELS students: Sp 421 - Fundamental astronomy, Astrometry
For ELS students: Sp422 - Astrophysics - General Astrophysics
Ci421a...r - Introducing Project to Research or Innovation (CIRI)

SYSTEMS Major
In421 - Complex Information Systems Modelling
In422 - Real Time Information Systems
In423 - Embedded Networks
Ma422 - Introduction to Machine Learning
Au425 - Physical Approach to aeronautical automated systems

VEHICLES Major
Mf421 - Fluid Dynamics
En426 - Electric and hydrogen production
Mé421 - Theory of plates & shells
Mé422 - Numerical calculations in mechanics and structures (FEM)

SYSTEMS Major - OPTION Embedded systems & Telecommunication (SET)
El421 - Advanced Applications of RPGA Circuits
In424 - Swarm Intelligent Systems
Té421 - Telecommunications: Principles & Bond Balance
Té422 - Guided Propagation & Hyperfrequencies

SYSTEMS Major - OPTION Mechatronic systems (SM)
Au424 - Power Electronics & Actuators in Aeronautics
Au422 - Guidance Pr inciples of Autonomous Systems
Au423 - Introduction to Robotics
In424 - Swarm Intelligent Systems

SYSTEMS or VEHICLES Major - OPTION Space, Launchers & Satellites (ELS)
Sp423 - Space Mechanics
Sp424 - Project: Atmospheric Reentry & Mission Concept
Sp425 - Space Optics
Sp426 - Plasma physics, Electrical & Plasma Propulsion
Sp427 - Numerical Methods for Space Applications (COMSOL) - *VEH major only*

VEHICLES Major - OPTION Energetics & Propulsion (EP)
En422 - Turbomachine Design
En423 - Thermal Engines for Drone & Light Aircraft
En424 - Nuclear physics and nuclear rocket propulsion
En425 - Introduction to aeroacoustics

VEHICLES Major - OPTION Mechatronic & Structures (MS)
Mé424 - CAD: CATIA
Mé425 - Metallic & Composite Materials
Mé427 - Aircraft Structures Design
Mé423 - Advanced Materials

2-month internship at the end of the spring semester

Course description

Human Sciences and Languages common pole

Sh421 - Ethics for Engineers & Sustainable development

La Responsabilité Sociétale des Entreprises est une obligation morale et intellectuelle qui, au-delà du cadre légal, met en pratique le respect des principes du développement durable (viabilité économique, bien-être de la société, protection de l'environnement). A ce titre, la démarche RSE interroge le business model de l'entreprise et le sens même de sa compétitivité, son devoir de vigilance lié aux impacts environnementaux et sociaux de ses activités. Ce cours expose les bénéfices de la RSE par une prise de conscience collective alliant nécessité de concrétiser l'éthique et volonté de prévenir les risques.

Sh422 - Sociologie des Entreprises & des Organisations

L'ensemble de ce cours doit permettre de comprendre le fonctionnement général d'une entreprise ou de toute autre forme d'organisation, en intégrant deux principes fondamentaux que sont la prise en compte des impératifs économiques actuels et le respect de l'éthique. L'accent est mis sur la notion de transversalité et d'interaction tant en ce qui concerne l'environnement que les contraintes propres à chaque organisation.
A l'issu de ce cours, les étudiants seront capables :
- de s'intégrer dans une organisation, de l'animer et de la faire évoluer ;
- de comprendre les enjeux industriels, économiques et professionnels du domaine aérospatial ;
- de travailler dans un contexte international ;
- de respecter les valeurs de la société.

Sh423 - Droit social

Ce cours doit permettre aux élèves ingénieurs de comprendre les fondements et les bases du droit social pour leur activité professionnelle : des éléments de droit constitutionnel, d'organisation des institutions juridictionnelles (droit public et privé). Droits et devoirs (temps de travail, accident de travail...). Recours à l'intérim, au prêt de main-d'oeuvre, à la sous-traitance. Mode de calcul des salaires et des incidences diverses : déplacements, trajets, transports... Organisation du travail : temps de travail, heures normales et supplémentaires, différents congés, chômage. Contrôle du travail, rôle des principaux acteurs (formation continue, principes de la délégation de responsabilité, notions de responsabilité civile et pénale, sous-traitance, etc..).

Fleb - French language courses for engineers

This course will help students to learn the basics and more of French language in order to help them integrate into the IPSA student life as well as the daily life in Paris.

Corporate knowledge common pole

Mi421 - Qualité, Réglementation, Normes, Lean

Initier les étudiants à la connaissance des différents concepts et notions de base du management de la qualité rencontrés dans les principales branches professionnelles de l'industrie et des services.
Mieux comprendre ce qu'est une démarche qualité, de diffuser la culture, l'esprit Qualité. Initier les étudiants à la réglementation aéronautique.

Mi422 - Principes de Stratégies d'Entreprises

Analyser la typologie des objectifs stratégiques des entreprises afin de comprendre leur diversité et leur cohérence.
Analyser les modèles d'analyse stratégique des entreprises.
Etre en mesure d'analyser les choix stratégiques des entreprises par des études de cas

Mi423 - Economie : Gestion Financière

Etre en mesure d'effectuer un diagnostic financier afin de distinguer les forces et faiblesses d'une entreprise
Analyser les différentes notions de rentabilité d'une entreprise et leurs déterminants. Etre en mesure de relier ceux-ci aux choix stratégiques effectués par une entreprise.
Analyser et appliquer les critères de sélection des projets d'investissement.

Engineering Sciences common core

Au421 - Graphic representation of Dynamic multilinear system

At the end of this course, the student must:
- have effectively acquired the method that allows him to understand, through "bond graph" modeling, the functioning and optimization of mechatronic and therefore multi-physical systems
- have acquired autonomy in the analysis of multi-domain systems (mechanical, hydraulic, electrical, pneumatic, etc.)
- Be able to make complete and multi-physical system models
Prerequisites: Knowledge of automation, mechanics, hydraulics, electrical engineering

Mi426 - Principes de base de Conception Avion et d'éco-conception - Industrialisation et Méthode de production

At the end of this course, students must be able to:
- Understand the basic principles of aircraft design.
- Integrate the objectives and constraints of eco-design.
- Master the main principles of industrialization and the main production methods.

Aé421 - Flight Dynamics

The main objective of this course is to understand aircraft configuration aerodynamics, performance, stability and control. This course allows student to estimate an aircraft's aerodynamic characteristics from
geometric and inertial properties. At the end of this course, the student should be able to analyze linear and nonlinear dynamic systems, recognize airplane modes of longitudinal and lateral motion and their significance, and knowing what to do for making the airplane more stable, and answering to flying qualities criteria.
Prerequisites: knowledge in aeronautics

Elective modules and Initiation to Research and Innovation

Sp 421 - Fundamental astronomy, Astrometry

The students will learn all thematics of the fundamental astronomy: observation, space-time reference systems, and reference frames. They will see the different mechanisms of observation and positioning in space.

Sp422 - Astrophysics - General Astrophysics

The students will see all thematics and sciences of the Universe. They will learn details of its components, and the formation processes of the big objects : stars, planetary systems, galaxies, nebula, and dark holes.

Ci421a...r - Introducing Project to Research or Innovation (CIRI)

The objective of this course is to introduce engineering students to research and train them in innovation through research by offering a range of Master's level courses that cover the different disciplines covered during the IPSA curriculum, such as automation, optimization and its applications, energetics, aerodynamics, structural and fluid mechanics, engineering ethics and applied mathematics. The skills targeted are in the order of the methodology of scientific research work (including motivation, inductive approach, bibliographic research, rigour and autonomy), teamwork, the development of a critical and innovative spirit, and the exercise of oral communication on technical work.

SYSTEMS Major

In421 - Complex Information Systems Modelling

Model Based Engineering (MBE) is an engineering method dedicated to complex systems. This course introduces students on how to produce and use models on the different steps of a system life cycle. Students will learn different kind of models used to represent static and dynamic behaviours, global and detailled aspects of a system with UML.
Prerequisites: Object-Oriented programming

In422 - Real Time Information Systems

The focus of this course is to familiarize students with real time systems. Several real time algorithms will be studied and compared with each other. During the practical work, students will need to program in C/C++ to manage real time algorithms.
Prerequisites: C/C++ skills, personal computer with gcc compiler

In423 - Embedded Networks

This course is dedicated to the study and production of applications for digital communications. Students will learn how to produce client and server applications to exchange data or data stream using different network protocols. This course is mainly based on practical works using berkley api and python programming language.
Prerequisites: Basic concepts of digital networks (i.e. the OSI architecture) – Basic concept of programming – nb: knowledge of the python programming language is not required but recommended

Ma422 - Introduction to Machine Learning

This class yields a general introduction to machine learning, statistical pattern recognition and data mining Some of the subjects covered in the course include: supervised learning (linear and logistic regression, neural networks and support vector machines), good practices for model selection and unsupervised learning (clustering, dimensionality reduction). The course will also examine numerous case studies and applications, so that you will also learn how to apply and implement theselearning algorithms.
Prerequisites : Elementary statistics, basic notions in probabilities, good programming skills.

Au425 - Physical Approach to aeronaut ical automated systems

At the end of this course, the student must :
- know the practical aspect of the control and its implementation on ECUs
- be able to synthesize while respecting the stability and precision performances imposed by a set of specifications.

Prerequisites : Programming of microcontrollers

VEHICLES Major

Mf421 - Fluid Dynamics

Objectives of the course:
- Understand the phenomena related to fluid dynamics
- Master the fundamental equations
- Solve fluid dynamics problems
- Build and interpret digital models

Prerequisites: Fluid mechanics , Mechanics of continuous fluids

Mé421 - Theory of plates & shells

At the end of this course, students:
- Will have a detailed knowledge of the mechanics of continuous media in the elastic field for plates and shells,
- Master the determination of the different characteristics of the latter and the consequences in design.
- Will be able to exercise judgment in making choices to meet a need.

Prerequisites: Aeronautics - General mechanics - Material resistance

Mé422 - Numerical calculations in mechanics and structures (FEM)

This courses is intended to be an overview Finite Element Analysis using Patran and Nastran. The three types of elements below will be studied:
- One dimensional elements: 1D beam elements are used to model long, slender structural members...
- Two dimensional elements: 2D plate elements are used to model thin structural members such as aircraft fuselage skin or car body
- Three dimensional elements: 3D solid elements are used to model thick components such as the piston head

The problems studied are are: Static calculation of elastic structures: Eigenfrequencies problem
Prerequisites: Finite elements (theoretical part) - Strength of materials - Mechanics of continuous fluids - Mathematics

SYSTEMS Major - OPTION Embedded systems & Telecommunication (SET)

El421 - Advanced Applications of RPGA Circuits

The aim of this course is to implement a sequential circuits (Flip-flop, clock divider) using VHDL language. In addition, the students will learn how to design a state machine (i.e. traffic light) and a VGA controller to display something on a monitor using FPGA Board.
Prerequisites: FPGA circuit basics, VHDL, digital electronics.

In424 - Swarm Intelligent Systems

This course introduces some basic notions of artificial intelligence. It mainly focus on the notion of task planning and how the machine is reasoning to produce a plan dealing with temporal constraints. At the end of the course, we will implement a planning system into a wheeled robot.
Prerequisites: C/C++ skills, Arduino + Gnuplot platform.

Té421 - Telecommunications: Principles & Bond Balance

At the end of this course, the student must:
- Know the mathematical tools used in signal expression and the different types of modulations commonly used.
- Have an understanding of the basic models used to characterize the architecture and performance of a telecommunications system.
- Be able to characterize a transmission by these different parameters in terms of transmission link..

Prerequisites: Fourier Transform, electromagnetism, and general aeronautical telecommunication systems

Té422 - Guided Propagation & Hyperfrequencies

In this lecture, we will describe the theoretical models for the analysis of wave propagation along different forms (coaxial, microstrip...) and classification (TEM, TE...) of transmission lines. The reflected waves and the standing waves will also descript. Smith chart and its performances in microwave circuit analysis and transmission lines adaptation.
Prerequisites: The students must have knowledge on: Mathematics for Engineers, Physics, Electromagnetic Field, Electric Circuits, Electrical Drives, and Transmission Lines**.**

SYSTEMS Major - OPTION Mechatronic systems (SM)

Au424 - Power Electronics & Actuators in Aeronautics

Contents of the course: Aircraft electrical system. Electrical actuators. Aircraft hydraulic and pneumatic systems. Hydraulic actuators. Lab session on modelling and control of electrohydrostatic actuators (EHA) and electro-mechanical actuators (EMA).
Prerequisites: Applied control (AU412), Multidomain physical modelling (AU411)

Au422 - Guidance Principles of Autonomous Systems

The aim of the course focuses on poviding theoretical (and partially experimental) background to address navigation and guidance (N&G) strategies used for autonomous systems. In this course we will study different navigation strategies for aerial and terrestrial vehicles. The principles discussed in the actual course and especially the passage from theory to practice will be implemented on a demonstrator designed by IPSA.

Au423 - Introduction to Robotics

At the end of this course, the student must:
- be familiar with the principles of robotics and the organization of a robotics system from the point of view of its control and also from the point of view of its architecture.
- have understood the technological principles of the main components of industrial robots.
- be able to carry out the geometric and kinematic modelling of an industrial robot (openchain series).

Prerequisites: Applied control (AU412), Matlab/Simulink

In424 - Swarm Intelligent Systems

This course introduces some basic notions of artificial intelligence. It mainly focus on the notion of task planning and how the machine is reasoning to produce a plan dealing with temporal constraints. At the end of the course, we will implement a planning system into a wheeled robot.
Prerequisites: C/C++ skills, personal computer with Arduino + Gnuplot platform.

SYSTEMS or VEHICLES Major - OPTION Space, Launchers & Satellites (ELS)

Sp423 - Space Mechanics

The students will see all aspects of the spatial mechanics, from the non-disturbed keplerian motion to the disturbed one. They will be able to use all informations for orbital applications and spacecraft missions.
Prerequisites: Introduction to Space Systems, General Physics, General Mechanics, Digital Analysis

Sp424 - Project: Atmospheric Reentry & Mission Concept

At the end of this course, the student must:
- Master the basic concepts (trajectography, rapid assessment of hypersonic aerodynamic coefficients for complex vehicles, hypersonic aerodynamic constraints, thermal response of protective materials, etc.) to design a feasibility analysis of the atmospheric re-entry/entry component of a space mission.
- Know how to evaluate orders of magnitude.
- Design and produce a feasibility report on the atmospheric re-entry/entry component of a space mission.
Prerequisites : Programming in MatLab and thermodynamics.

Sp425 - Space Optics

At the end of this course, students:
Know the basics of passive optronic sensors that combine optics and detection.
Know the different techniques used.
Have an understanding of the operating procedures and technical characteristics of this equipment.
Will be able, at the technical level, to interpret the results of observations.

Sp426 - Plasma physics, Electrical & Plasma Propulsion

The first part concerning the plasma theory and in particular: the characteristic parameters of a plasma, the industrial and natural plasmas and their differences, the different descriptions of a plasma (particulate, kinetic and fluid), the phenomena of transport and confinement of plasmas, the generation of discharge plasmas, used for electric propulsion for space, some notions in propagations of waves in a plasma. The second part concerns the study of plasma flows during the phenomenon of atmospheric reentry of probes for example, study of radiation phenomena and ablation.
Prerequisites : fluid mechanics, electromagnetism, thermodynamics and heat transfer, a little statistical physics and atomic and molecular physics, notions of quantum mechanics and wave physics.

Sp427 - Numerical Methods for Space Applications (COMSOL) - *VEH major only*

Complex systems are governed by physical and mathematical laws. Their modelling requires complex equations to be solved by numerical methods. The course proposes to give an overview of numerical methods for space applications. We will see in particular methods of numerical integration, inversion, least squares, etc.

VEHICLES Major - OPTION Energetics & Propulsion (EP)

En422 - Turbomachine Design

The objective of this course is to:
To understand thermodynamic cycle calculations and performance in adaptation and nonadaptation as well as the laws of regulation of turbomachines.
To understand the physical phenomena and design criteria of the compressor and turbine components of a turbomachine.
Present the main types of tests carried out to develop and qualify an aeronautical turbomachinery.
To train students in critical thinking through guided design work using simplified tools.
Prerequisites: Thermodynamics applied to turbomachinery , Aerodynamics of flows and profiles, Beam mechanics - Vibration mechanics, Thermal exchanges, Mathematics associated with these modules.

En423 - Thermal Engines for Drone & Light Aircraft

This class allows students to be familiar with thermal engines. They will particularly work on engines design and energetic performances optimization (concerning efficiency, effective mechanical work...). They will perform their studies in team projects.
Prerequisites: Thermodynamics, Thermal Transfers, Applied Thermodynamics.

En424 - Nuclear physics and nuclear rocket propulsion

Chemical rockets are already approaching their theoretical limits. Various ways of utilizing nuclear reactions for rocket propulsion have been suggested, some of which have been tested on earth. The aim of these lectures is to provide the main knowledges of nuclear physics and their advantages on thermal nuclear propulsion. We start from the basics of nuclear physics to more speci c aspects of nuclear engineering and thermal rocket propulsion.
Prerequisites: General physics, electromagnetism, thermodynamics, basics of quantum or nuclear physics (not required)

En425 - Introduction to aeroacoustics

Through these lectures, students will be introduced to the main basics of acoustics and aeroacoustics starting from the sound wave equation in free field and the expression of the speed of sound in different fluids. We derive the wave equation from linearised Navier-Stokes equations and introduce the Lighthill's tensor for the first time in this frame. Helmholtz resonators will be studied along with other applications on aircraft sound insulation.

VEHICLES Major - OPTION Mechatronic & Structures (MS)

Mé424 - CAD: CATIA

At the end of this course, the student :
- will be able to model in 3D a family of parts in solid or surface mode;
- will be able to model in 3D a family of assemblies composed of about ten parts;
- will be able to structure and share tasks related to the 3D modeling of a simple generic product, in the case of a small work team.
Prerequisites: knowledge of CAD

Mé425 - Metallic & Composite Materials

The objective of this course is to give knowledge about aeronautical materials.
This course presents metallic and composite materials used in aeronautical structures.
It gives their main characteristics and behaviours: Static strength, Fatigue Testing aspects and airworthiness requirements are introduced and detailed continuously through the course.
Prerequisites: Background in general mechanics and aeronautical context

Mé427 - Aircraft Structures Design

The objective of this course is to give an initiation to aircraft structural design.
This course provides with methods for stress analysis and sizing.
The main topics are:
Wing Box Structural Design : architectures – stress analysis and sizing
Fuselage Structural Design: architectures – stress analysis and sizing
Testing aspects and airworthiness requirements are introduced and detailed continuously through the course.
Prerequisites: Background in material sciences and beam and shell theory.

Mé423 - Advanced Materials

The study of the mechanical behaviour of materials aims to know their response to a given solicitation. The state variables involved in this domain are stress tensor and strain tensor. The objective of this course is to give a general overview of the mechanical behaviour of materials, and its modelling. Indeed, while linear elasticity currently represents the framework for the majority of continuous-cycle mechanical calculations carried out in industry, other types of behaviour are increasingly used because they are closer to reality, and thus allow a more strict dimensioning of structures or certain processes.
Prerequisites: MMC, Computation on Structural materials.

Second year of Master
(Aero 5)

Fall semester

The fall semester of the second year of master (Aero 5) includes:

- Human Sciences and Languages common pole focusing on Societal Issues and Ethics in Engineering
- Corporate knowledge common pole focusing on Contract Law and Corporate Strategy
- IPSA Project Master (PMI) : a project intended to develop initiative, autonomy and the ability to manage priorities
- 3 majors: VEHICLES (VEH), SYSTEMS (SYS) and MANAGEMENT (MLI)
- 9 options - 4 for SYSTEMS, 3 for VEHICLES and 2 for MANAGEMENT
    - SYSTEMS major : 4 options
      - Autonomous Airborne Systems Control (SAA)
      - Operation & Transmission of Embedded Information (TIE)
      - Space, Launchers & Satellites (ELS)
      - Cybersecurity, Data & AI (CDI)

    - VEHICLES major: 3 options
      - Airframe & Materials (CAE)
      - Energetics & Engines (EMO)
      - Space, Launchers & Satellites (ELS)

    - MANAGEMENT major: 2 options - fully taught in French
      - Management des projets industriels (MPI)
      - Management de la production et du MCO (MPM)

NOTE: Students must choose one option according to their major. They cannot mix courses from different majors and options.

NOTE: Some courses are taught in French, their description is accordingly.

Human Sciences and Languages common pole
Sh511 - Enjeux sociétaux
Sh512 - Facteurs humains et Interaction Homme-Machine Analyse Sécurité des vols
Flea - French as a foreign language (FLE) and Intercultural seminar

Corporate knowledge common pole
Sh515 - Droit social
Mi516 - Sûreté de fonctionnement : Méthodologie AMDEC
Mi518 - Techniques de conduite de projet
In519 - Initiation à la Cybersécurité
Mi511 - Stratégie d'entreprise - Etude de cas
Mi517 - Outil de gestion-certification (Excel- TOSA et VBA)

Pm 511 - IPSA Project Master

SYSTEMS Major
Au511 - Aircraft Modeling & Autopilot
Au512 - Identification & Observation of systems
Ma512 - Deep Neural Network & Deep Learning
Au513 - Systems Design & Fast Prototyping

VEHICLES Major
Mf511 - Introduction to Hypersonic Aerodynamics
Mé511 - Vibration Dynamics of Plates & Shells
Mé512 - Reliability & fatigue of structures
Mé513 - Calculation of ground and flight loads
Mf512 - Computational Fluid Dynamics (CFD)

MANAGEMENT Major
Mi513a - Achats & relations fournisseurs
Mi513b - Management des coûts
Mi512 - Code de la commande publique
Mi513d - Outil de gestion de projet (MS Project)
Mi513e - Gestion financière
Mi513f - Finance appliquée au secteur aéronautique - étude de cas
Mi513g - Integrated Logistic Support & Integrated In service Support (MCO)

SYSTEMS Major - OPTION Autonomous Airborne Systems Control (SAA)
In511 - Intelligent Controls
Au514 - Nonlinear systems control
In512 - Distributed Intelligent Systems
Au515 - Drones & Visual Servoing
Au516 - Project : Dynamic Planning of Autonomous navigation

SYSTEMS Major - OPTION Operation & Transmission of Embedded Information (TIE)
In513 - Embedded Real-time Operating Systems
El511 - Embedded systems: Image processing with FPGA
In518 - High Performance Computing on GPU
Te511 - EM Compatibility & Antennas
Te513 - Cursus project: Programming of advanced neural networks on FPGA or GPU
Te514 - Object Localization through Wireless Sensors Networks

SYSTEMS Major - OPTION Cybersecurity, Data & AI (CDI)
In514 - Cybersecurity (Software "Driver" Hardware)
In515 - Cryptography and network security
In517 - Fundamentals and techniques in Cybersecurity
In512 - Distributed intelligent systems
Ma511 - Application of Deep Learning for Image Processing
Ma513 - Hands-on Machine Learning for Cybersecurity
In516 - Cursus project: S2D and Cyber or IA and S2D

SYSTEMS or VEHICLES Major - OPTION Space, Launchers & Satellites (ELS)
En513 - Space Propulsion Systems
En515 - Electric & nuclear Propulsion for aircraft
Sp517 - Launchers and Satellites Design
Sp518 - Satellites Prototyping
Sp513 - Payload Integration & Launchers
Sp514 - Cursus Project : Conception of a Space Mission II
Sp515 - Space telecommunications - ELSS
Sp516 - Space telecommunications - ELSS applications

VEHICLES Major - OPTION Airframe & Materials (CAE)
Aé513 - Vertical Flight
Mé514 - Multi-body Mechanical Simulation
Mé515 - Calculation in Structural Materials
Mé516 - Durability of Advanced Materials
Mé517 - Nonlinear Numerical Simulation in Structural Mechanics
Mé518 - Cursus project: Finite Element Method for Structures Calculation

VEHICLES Major - OPTION Energetics & Engines (EMO)
En511 - Cursus project: Turbomachinery enhancement and design projet for a turbojet engine
En512 - Combustion
En513 - Space Propulsion Systems
En514 - Analytical & numerical calculations in heat transfer
Mf514 - Aeroacoustics
Mf515 - Turbulence

MANAGEMENT Major - OPTION Management des projets industriels (MPI)
Mi514a - Négociations internationales
Mi514b - Contrôle de gestion
Mi514c - Evaluation financière des projets
Mi514d - Analyse de la performance commerciale
Mi514i - Challenge "négociations commerciales"
Mi514e - Analyse et gestion des risques des projets industriels
Mi514f - Financement des projets industriels
Mi514g - Réponse à appel d'offres
Mi514h - Simulation informatisée à la gestion d'entreprise

MANAGEMENT Major - OPTION Management de la production et du MCO (MPM)
Mi515a - Journée Etude de cas SLI
Mi515b - Approvisionnement et gestion des stocks
Mi515c - Techniques de gestion de la Qualité
Mi515d - Supply chain (approfondissement)
Mi515e - Contrôle de gestion de la production
Mi515f - Cycle de vie des produits - Gestion de configuration
Mi515g - Après-vente - Maintenance : Navigabilité et MCO
Mi515h - Projet compagnie aérienne

Course description

Human Sciences and Languages common pole

Sh511 - Enjeux sociétaux

Par la connaissance des réflexions les plus récentes en sciences humaines, les élèves ingénieurs sont invités à prendre part à des controverses et à des débats mettant en jeu le lien entre leur futur métier et la société dans laquelle ils évolueront.
La mise en commun des projets industriels actuels doit permettre de dresser un panorama des biens et services imaginés par les ingénieurs (ou attendus par leurs bénéficiaires). Devant ces perspectives techniques et scientifiques, une vision de la société de demain s'esquisse et nous interroge : quels seront les effets produits par l'introduction de nouvelles technologies sur les rythmes de vie, la cohésion sociale, la culture d'un peuple, etc.. ?

Sh512 - Facteurs humains et Interaction Homme-Machine Analyse Sécurité des vols

A l'issu de cet enseignement, les étudiants auront compris au travers de l'analyse d'accidents aériens, de leurs causes, et des risques spécifiques aux différentes phases du vol :
- L'importance de la prise en compte du facteur humain dans la maîtrise des risques, et de ses conséquences générales sur la conception ;
- Plus spécifiquement l'importance de la prise en compte du facteur humain dans la conception de l'interface Homme-Machine.

Flea - French as a foreign language (FLE)

This course will help students to learn the basics and more of French language in order to help them integrate into the IPSA student life as well as the daily life in Paris.

Corporate knowledge common pole

Sh515 - Droit social

Ce cours doit permettre aux élèves ingénieurs de comprendre les fondements et les bases du droit social pour leur activité professionnelle : des éléments de droit constitutionnel, d'organisation des institutions juridictionnelles (droit public et privé). Droits et devoirs (temps de travail, accident de travail...). Recours à l'intérim, au prêt de maind'oeuvre, à la sous-traitance. Mode de calcul des salaires et des incidences diverses : déplacements, trajets, transports... Organisation du travail : temps de travail, heures normales et supplémentaires, différents congés, chômage. Contrôle du travail, rôle des principaux acteurs (formation continue, principes de la délégation de responsabilité, notions de responsabilité civile et pénale, sous-traitance, etc..).

Mi516 - Sûreté de fonctionnement : Méthodologie AMDEC

Connaissance générale des domaines de la sureté de fonctionnement.

In519 - Initiation à la Cybersécurité

The objective of this cours is to acquire the basics of cybersecurity and understand how it works through demonstrations. Several vocabulary and concepts of the field will be introduced. Then, the students will have an introduction to different types of cyber attacks

Mi511 - Stratégie d'entreprise - Etude de cas

Ce cours vise à permettre aux étudiants de maîtriser les différents outils de l'analyse stratégique.
La maîtrise de ceux-ci permet d'analyser les choix stratégiques des entreprises en fonction de leurs objectifs et environnement.

Mi517 - Outil de gestion-certification (Excel- TOSA et VBA)

Approfondir ses connaissances des nombreuses utilisations du tableur Excel
- Mieux maitriser les différentes fonctionnalités d'Excel
- Savoir manipuler les graphiques et les tableaux croisés dynamiques et les fonctions de recherche afin d'analyser des bases de données. Maitriser les fonctions financières et matricielles. Appréhender le langage Visual Basic et créer des macros et fonctions.

Pm 511 - IPSA Project Master

At the end of this project, the student must be able to:
- conduct research work in teams of two or three people using a rational project management approach;
- search for references on the subject (in a library, on the Internet or on any other media);
- conduct a thorough general theoretical study based on the knowledge acquired
- prepare a report presenting the objectives of the project, the approach followed, the theoretical study, the implementation and the results obtained
- present the subject orally before a jury

SYSTEMS Major

Au511 - Aircraft Modeling & Autopilot

At the end of this course, the students:
Will be able to apply the theoretical concepts developed in the course on 'fundamental automation' to formalize the behaviour of an aerospace vehicle.
Will be able to find the roots of performance through the examination of the results through time.
They will be able to use the MATLAB / SIMULINK analysis and synthesis tools for system design and analysis.
They will have understood the methods and requirements for the sequencing of a complex project.
Prerequisites: Automotion courses and Mechanics of flight courses

Au512 - Identification & Obeservation of systems

Identification and Observers, particularly Kalman filters, are major topics for engineers. The aim is to estimate the parameters or the internal variables (states) of a physical system by only using experimental input and output measurements. Attitude estimation of an aerial object with Extended Kalman Filter is taken as a case study.
Prerequisites: Matlab/Simulink, Introduction de control systems (AU41), Digital control systems, Introduction to state space control (AU43), preferably Applied control (AU412)

Ma512 - Deep Neural Network & Deep Learning

At the end of this course, the student must:
- Know the most common methods in deep neural networks.
- Understand the mechanisms underlying the performance of deep learning approaches,
-Approach many case studies and applications, so that it also learns to apply and implement these learning algorithms.

Au513 - Systems Design & Fast Prototyping

The course focuses on the design of the embedded part of a mechatronic system; At the end of the course, the student:
• Will have understood the principle of designing and building a mechatronic system.
• Will be familiar with the concepts of Model-Based-Design and the Cycle V design approach
• Will be able to develop, based on specifications, control laws and embedded codes using multi-domain physical modelling tools and rapid prototyping.
Prerequisites: Automation modules, mechatronics, electronics modules, embedded systems, programmable logic.

VEHICLES Major

Mf511 - Introduction to Hypersonic Aerodynamics

At the end of this course, the student will:
- have learned the generalities on high speed flows
- know the effects of large MACH numbers on flows of the moving fluid.
- be able to determine the characteristics of a normal shock, oblique shock and curvilinear shock
- be able to analyze the characteristics of a hypersonic flow behind thin partitions.
Prerequisites: Subsonic and supersonic aerodynamics course. ‘Mechanics of flight’ course.

Mé511 - Vibration Dynamics of Plates & Shells

At the end of this course, students:
- We know perfectly the basic principles of vibration mechanics and the vibrational behaviour of solids and structures
- Master the determination of the different characteristics of these and the consequences in design.
- Will be able to exercise judgment in making choices to meet a need.
Prerequisites : Aeronautics - General mechanics - Material resistance

Mé512 - Reliability & fatigue of structures

The purpose of this course is to provide with methods and tools to take into account uncertainties in aircraft structures, especially in aircraft fatigue.
Structural analysis require the consideration of several sources of uncertainties [material and load uncertainties for instance].
Basic approaches, generally deterministic, are often applied because of their simplicity, but sometime criticized when the results are found unrealistically severe. Actually these deterministic approaches are often not adapted to take into account uncertainties with accuracy.
Reliability approaches enable to take into account uncertainties with an adequate accuracy and provide with and optimized and acceptable level of safety. The reliability methods are applied to Aircraft Fatigue domain.
Prerequisites : Background in probability and statistic methods. Background in material sciences.

Mé513 - Calculation of ground and flight loads

The objective of this course is to give an initiation to aircraft loads.
This course provides with fundamental knowledge about aircraft load analysis.
The 3 mains topics are: Flight loads, Ground loads and Crash loads.
Testing aspects and airworthiness requirements are introduced and detailed continuously through the course.
Prerequisites: Background in aerodynamics and flight mechanics..

Mf512- Computational Fluid Dynamics (CFD)

At the end of this project the student will:
- be familiar with the interface and logic of a digital tool for solving a fluid mechanics problem: Starccm +
- be able to analyze an aerodynamic problem and to model it with 'Starccm +'software
- be able to construct the geometry of its problem, to define the boundary conditions, the mesh as well as the various other physical parameters of the problem to be processed
- be able to represent the numerical results and to analyze them. - Will be able to carry out more complex aerodynamic modelling problems.

Prerequisites: Course in 'Fluid Mechanics'. Knowledge of the Starccm+ software

MANAGEMENT Major

Mi513a - Achats & relations fournisseurs

A l'issue de ce cours, l'étudiant doit :
- Être capable de réaliser une analyse de besoin d'achats,
- Être capable de réaliser une analyse de marché fournisseurs,
- Être capable de réaliser des analyses de coûts d'achats et définir des objectifs de prix d'achats.
- Être capable de construire et déployer des stratégies d'achats,
- Etre capable de préparer et réaliser des négociations d'achats avec des fournisseurs

Mi513b - Management des coûts

Initier les étudiants aux procédures de la commande publique :
- Présentation des sources internationales, européennes et nationales du droit de la commande publique,
- Les procédures de passation des marchés publics,
- Sélection des candidatures et des offres dans les marchés publics,
- Modifications des marchés publics,
- Les aspects financiers et comptables des marchés publics,
- Le contentieux de la passation et l'exécution des marchés publics (voies de recours),
- Les délits associés à la commande publique.

Mi512 - Code de la Commande Publique

Ce module de Management des coûts doit permettre aux étudiants de comprendre et maîtriser les principales méthodes de détermination et d'analyse des coûts (Coûts complets et partiels). Ce module de Management des coûts doit permettre aux étudiants doit permettre aux étudiants de comprendre l'élaboration de devis et de réponses à des appels d'offre.

Mi513d - Outil de gestion de projet (MS Project)

Ce module doit permettre la maîtrise du logiciel MS Project dans la cadre de la conduite de projets.

Mi513e - Gestion financière

Ce module de Gestion Financière doit permettre à l'étudiant de savoir analyser les principaux enjeux de l'analyse financière : La rentabilité, le financement de l'activité, les choix de projets d'investissement.

Mi513f - Finance appliquée au secteur aéronautique-étude de cas

Ce module de Finance Appliquée au secteur aéronautique doit permettre de mettre en application différentes techniques et concepts présentés en cours de Gestion Financière. Il doit permettre la maîtrise certaines techniques financières fréquemment utilisées par les constructeurs aéronautiques et/ou les compagnies aériennes.

Mi513g - Integrated Logistic Support & Integrated In service support (MCO)

Objectifs:
- Une vision des activités de support et de soutien d'un aéronef et de ses équipements tout au long du cycle de vie.
- Une connaissance des principaux leviers d'optimisation pour chacun des grands processus (SLI, gestion de flotte, maintenance et supply chain)
- La connaissance des principaux outils numériques (ERP, SGM, IA, ...)

SYSTEMS Major - OPTION Autonomous Airborne Systems Control (SAA)

In511 - Intelligent Controls

At the end of this course, the student must:
1. Master the concepts of learning in computer systems.
2. Master the command of a robot.
3. Be able to design and implement, a learning approach on the control of a mobile robot in a stable environment

Prerequisites: Good knowledge of the programming language, for practical work.

In512 - Distributed Intelligent Systems

Manipulate the concepts of modelling with multi-agents systems. Understand the notion of Artificial Intelligence and why do we need distributed systems. Be able to implement an autonomous robot for obstacle avoidance. Learn how to program all the major systems of a robotic system for autonomous driving cars. This class will teach you basic methods in Artificial Intelligence, including: probabilistic inference, planning and search, localization, tracking and control, all with a focus on robotics. Extensive programming examples and assignments will apply these methods in the context of building self-driving cars

Prerequisites: Knowledge about Artificial intelligence

Au514 - Nonlinear systems control

The objective of the course is to provide an overview on the techniques of analysis and control of non-linear systems. Most systems (mechanical, aeronautical, chemical, etc.) involve phenomena of the non-linear type, therefore its analysis is based on different control techniques. The course will provide an introduction on the most classical analytical tools to determine the behaviour of a nonlinear system using a description in terms of
differential equations.

Au515 - Drones & Visual Servoing

At the end of this course, the student:
1. Know the basics of image processing
2. Will be able to manipulate images and apply basic image processing algorithms (edge detection, image enhancement, noise reduction)
3. Will be able to follow the courses of image processing of higher levels (Fourier transform, mathematical morphology, image compression)

Au516 - Project: Dynamic Planning of Autonomous navigation

During this project students will study and understand the control and the use of some techniques of AI into a robotic platform.

SYSTEMS Major - OPTION Operation & Transmission of Embedded Information (TIE)

In513 - Embedded Real-time Operating Systems

After an introduction to hard, soft, strict and certificable real-time systems, students will learn how to use linux for real-time application. The course will explore the linux operating system, how it could be setup for real-time and how to produce real-time applications using C/C++ programming language.
Prerequisites: Basic concepts of system programming : processes, threads, signals, etc...

El511 - Embedded systems: Image processing with FPGA

Image processing is a growing field with tremendous potential and scope for development. With the advent of advanced visual technologies, there is a need to have an ultra high speed processing devices to match the quality of the high definition domain. An optimum architecture can be developed by prototyping it on a reconfigurable device (FPGA). This course deals with the design and implementation of an image processing using an FPGA Board. The expected and achieved outputs will be compared to standard MATLAB outputs.

In518 - High Performance Computing

During this course, the student need to:
- Understand the fundamental programming techniques for high performance computer architectures
- Be able to design, implement and benchmark parallel programs on shared-memory and distributed-memory systems.
Prerequisites: Good knowledge of programming languages (Python, Java, C, or C++).

Te511 - EM Compatibility & Antennas

The course is divided in two parts, the first consist to study the Antennas. The Antennas are basic components of any electric system and are connecting links between the transmitter and free space or free space and the receiver. Thus antennas play very important role in finding the characteristics of the system in which antennas are employed. Antennas are employed in different systems in different forms.
The second part of the course provides basic understanding of how electromagnetic disturbances appear in, propagate and influence electromagnetic components and systems.
Also the methods and strategies that reduce the influence of disturbances will be studied.
Prerequisites: Mathematics for Engineers, Physics, Electromagnetic Field, Electric Circuits, Analog and Digital Electronics, Electrical Drives and Transmission Lines.

Te513 - Cursus project

During this project students will study and understand the concept of communication between two or several systems using different types of telecommunication technics.

Te514 - Object Localization through Wireless Sensors Networks

After this course, the student will:
1. master mathematical tools and basic models to characterize and define the architecture and performance of a wireless sensor network (WSN) system.
2.understand the different routing protocols and synchronization of sensors
3. be able to evaluate the performance and relevance of the use of different architecture

SYSTEMS Major - OPTION Cybersecurity, Data & AI (CDI)

In514 - Cybersecurity (Software "Driver" Hardware)

At the end of this course, the student must:
- Master the principles of security and pentest.
- Understand the attacker's cycle and associated methodology.
- Be able to conduct a security audit on a LAN environment.
- Know how to write an audit report and propose safety recommendations

In515 - Cryptography and network security

At the end of this course, the student must:
1.Master the security principles related to embedded architectures and IOT.
2.Understand the main threats related to these environments.
3.Be able to conduct a security audit on an IOT environment
4.Know how to write an audit report and propose safety recommendations

In517 - Fundamentals and techniques in Cybersecurity

At the end of this course, the student must:
- Understand the security principles related to embedded architectures and IOT, and Big Data
- Understand the main threats related to these environments.
- Be able to conduct a security audit on an IOT environment
- Understand security principles for big data
- Understand machine learning to security assessment with IOT

In512 - Distributed intelligent systems

Manipulate the concepts of modelling with multi-agents systems. Understand the notion of Artificial Intelligence and why do we need distributed systems. Be able to implement an autonomous robot for obstacle avoidance.
Learn how to program all the major systems of a robotic system for autonomous driving cars. This class will teach you basic methods in Artificial Intelligence, including: probabilistic inference, planning and search, localization, tracking and control, all with a focus on robotics. Extensive programming examples and assignments will apply these methods in the context of building self-driving cars

Ma511 - Application of Deep Learning for Image Processing

At the end of this course, the student must:
1. Know the most common methods in deep neural networks.
2. Understand the mechanisms underlying the performance of deep learning approaches,
3. Address numerous case studies and applications, so that he also learns to apply and implement these learning algorithms.

Ma513 - Hands-on Machine Learning for Cybersecurity

At the end of this course the student must:
- Know the challenges of cybersecurity and its itnerest in strengthening the defense arsenal available to professionals in the security of information systems,
- Know the different supervised and unsupervised learning methods used for cybersecurity service,
- Know to evaluate the performance and relevance of the use of each method
- Adress numerous case studies and applications, so that he also learns to apply and implement these learning algorithms.

In516 - Cursus project: S2D and Cyber or IA and S2D

In this project and based on specifications and a description of a fictitious company, a study is to be carried out in order to conduct: A business risk analysis and a proposal for an evolution of architecture in order to better secure it.

SYSTEMS or VEHICLES Major - OPTION Space, Launchers & Satellites (ELS)

En513 - Space Propulsion Systems

To introduce students to the architecture of propulsion systems for space launchers, Master the important parameters of these systems, To be able to dimension this type of propulsion system using simple methods and to estimate the performances. To know the basics of the technology of these engines.
Prerequisites: Thermodynamics (In 21a and b) - Thermal Transfers (in 31), Applied Thermodynamics In 32b)

En515 - Electric & Nuclear Propulsion for Aircraft

This module allows students to familiarize themselves with plasma physics and its fundamental concepts while emphasizing those that will be useful to the understanding of electric propulsion. In the first part of the module, after comparing with chemical propulsion, the principle of electrical propulsion and the fundamental laws that describe the plasma state and its physics are presented. The second part of the module focuses on electrical propulsion and its advantages over chemical propulsion. This module stimulates reflexion in students in the face of tomorrow's major challenges by proposing a model of propulsion that already works and trying to question the future of this technology.
Prerequisites: Electromagnetism,Wave Physics, Fluid Mechanics.

Sp513 - Payload Integration & Launchers

At the end of this course, the student must:
- To know the constraints related to mechanical, thermal and electromagnetic environments applicable to a satellite during a launch on Ariane 5, Soyuz and Vega
-To know the different methods of demonstrating the qualification of a satellite for these environments
- To know the processes applied by the sector's industrialists in the management of derogations and anomalies
- To know the competitive environment facing European launchers

Sp514 - Project: Conception of a Space Mission II

At this end of this course, the student:
- Should know the different elements of a spatial mission
- Should be familiar wiht the preparation and the development of a mission
- Should know how to elaborate the mission scenario and identify critical steps
- Should know the specificities of a mission base on nano and micro satellites
- Should have basic knowledge on economic and strategic issues about spatial missions.

Prerequisites: Space mechanics, Satellite design (Sp 551), Space propulsion systems (In 504), Launcher design (Sp552)

Sp515 - Space telecommunications - (only for ELSS)

At the end of this course, the student must
- Know the main components of a digital telecommunications chain as well as the architectures of the main current telecommunications systems.
- Understand the principles governing the implementation of different technologies and the perspectives in which each one fits.
- To be able to understand their respective contribution to overall performance (example of a complex system) and to mobilize resources from the field of fundamental sciences to calculate the performance of a telecommunications system.

VEHICLES Major - OPTION Airframe & Materials (CAE)

Aé513 - Vertical Flight

To understand vertical flights and acquire knowledges on helicopters' technologies, aerodynamic principles, rotor's mechanic, etc.

Prerequisites : Aerodynamics

Mé514 - Multi-body Mechanical Simulation

To use a software of multi-body mechanical simulation and apply it to SimDesigner Motion (and CATIA V5).

Prerequisites: vibrational dynamics, CAD, solid mechanics.

Mé515 - Calculation in Structural Materials

At this end of this course, the student:
- Should have general knowledge about composite materials and on their performances
- Should have the basis and tools used for composite structures sizing
- Should have basic knowledge about anisotrop linear elasticity for composite materials
- Should know prediction and modelling methodology of a mechanical behaviour for a 1D mechanical ply
- Should have basic knowledge about analytical or numerical pre-dimensioning of simple composite
- Should have basic knowledge about the thermo-mechanical of a ply

Prerequisites: Mechanics of continuous fluids, linear algebra, implementation of composite materials.

Mé516 - Durability of Advanced Materials

At this end of this course, the student:
- Should know how to analyse microstructure and the physical phenmomena linked to advanced material durability
- Should know mechanics of advanced sustainibility of materials
- Should know notions about breakage mechanics

Prerequisites: MMC, Laws of behaviour, Composite materials

Mé517 - Nonlinear Numerical Simulation in Structural Mechanics

At this end of this course, the student:
- Should have basic knowledge on non-linear numerical simulation (non-linear mechanical behavior ...)
- Should know how to model a structure behavior and to be able to compare the model with experimental tests
- Should be able to make comparisons between numerical modellings and experimental results about general mechanical tests

Prerequisites: Aeronautics - General mechanics - Material resistance

Mé518 - Cursus project: Finite Element Method for Structures Calculation

The European Ariane 5 launcher is able of putting two satellites in orbit per flight. The satellites are located under the cap. Each satellite is fixed on a support: the payload adapter (ACU). Different phases of flight cause vibration in the satellites. The primary cause of those vibrations is the engine noise transmitted by the structure and through the air. The second cause is the shock wave caused by the separation of the different stages of the launcher.
The aim of this project is the design and numerical study of the ACU, the satellite and the ties between the two structures. We can define 3 mainly parts of this study:
1) Study of the dynamic behavior of the ACU
2) Design and vibration study of the satellite
3) Design of ties connecting the ACU to the satellite.

Prerequisites: Finite Elements Method, level 1 of the software Patran/Nastran, Continuum mechanics

VEHICLES Major - OPTION Energetics & Engines (EMO)

En511 - Cursus project: Turbomachinery enhancement and design projet for a turbojet engine

This module will focus on the design of inlet, exhaust nozzle, main combustor and aferburner modules. The overall design process is finalised by the presentation of engine tests, maintenance and manufacturing aspects and life cycle cost consideration.
Prerequisites : Thermodynamics applied to turbomachines (En33). Design of turbomachines - module 1 (En411) Aerodynamics of flows and profiles. Mechanics of beams - Mechanics of vibratory. Thermal exchanges. Mathematics associated with these modules.

En512 - Combustion

Objective:
Give students basic elements of combustion theory.
Have them write a combustion equation.
Calculate the various corresponding energy potentials.
Apply this knowledge to the case of the internal combustion engine.
Solve complex problems in groups (design office) related to energy potentials.
Prerequisites: Thermal engines for drones and light aviation.

En513 - Space Propulsion Systems

To introduce students to the architecture of propulsion systems for space launchers, Master the important parameters of these systems, To be able to dimension this type of propulsion system using simple methods and to estimate the performances.
To know the basics of the technology of these engines.
Prerequisites: Thermodynamics (In 21a and b) - Heat Transfers (En31), Applied Thermodynamics In 32b)

En514 - Analytical & numerical calculations in heat transfer

After a brief introduction which will remind basic elements on unsteady conductive heat transfer, original analytical methods for solving such equations will be exposed (separation of variables, Laplace transform, method of complex temperatures...). Exercices will also be proposed.
The second part of this course will focus on the numerical resolution of heat equation using finite dfference method. Students will achieve a Matlab program to solve an unsteady heat transfer problem. A preliminary version of the code will be provided to students.
Prerequisites: HeatTransfers (En31), Numerical resolution of partial differential equations by the finite differences (Ma32c)

Mf514 - Aeroacoustics

At the end of this course, students:
- will be familiar with the general concepts of acoustics and sound waves
- will be able to analyze the nature of a sound and determine its propagation
- will be able to determine a total sound level of a given environment
- will be able to discuss the acoustic qualité of a room and propose improvements in terms of sound insulation.
- will be able to use the basic concepts of aeroacoustics.
- will have an idea of how to reduce noise at source.

Prerequisites: Thermodynamics, Fluids Dynamics

Mf515 - Turbulence

At the end of this course, the student:
- Should be able to analyse the turbulence phenomenology
- Should know the notions of averaged equations
- Will be able to apprehend the fundamental equations of turbulence
- Should be able to write the different models of turbulence.

Prerequisites: Fluid Dynamics Course Aé412

MANAGEMENT Major - OPTION Management des projets industriels

Mi514a - Négociations Internationales

A l'issue de ce cours, l'étudiant sera en mesure :
- de diagnostiquer les difficultés rencontrées dans le cadre de négociation internationales.
- d'établir une stratégie dans le cadre de la négociation internationale.
- d'apprécier l'efficacité d'une stratégie de négociation internationale.

Mi514b - Contrôle de gestion

Ce module à pour objectif de permettre aux étudiants de maîtriser et d'appliquer les différentes méthodes d'analyse du seuil de rentabilité de l'activité des entreprises ainsi que les conséquences de différentes décisions de gestion.

Mi514c - Évaluation financière des projets

Ce module à pour objectif de permettre aux étudiants de maîtriser et d'appliquer les différents critères financiers d'analyse des projets industriels en situation complexe.

Mi514d - Analyse de la performance commerciale

A l'issue de ce cours, l'étudiant saura utiliser les méthodes, outils et indicateurs attachés à l'analyse de la performance commerciale, en tirer un diagnostic, décliner ce diagnostic en termes de management tactique et opérationnel de la force de vente. Il sera capable de resituer l'analyse de la performance commerciale dans le cadre plus général de du marketing management.

Mi514i - Challenge "négociations commerciales"

Cette simulation doit permettre aux étudiants d'appliquer les différentes techniques travaillées lors des cours de Négociations Commerciales Inyternationales (Mi-514-a), d'Analyse de la performence commerciale (Mi-514-d), d'Achats et relations fournisseurs (MI-513-a).

Mi514e - Analyse & gestion des risques des projets industriels

Ce module d'analyse et de gestion des risques des projets industriels à pour objectif de permettre aux étudiants de maîtriser la typologie des risques liés aux projets industriels et aux différentes techniques d'assurance possibles.

Mi514f - Financement des projets industriels

Ce module à pour objectif de permettre aux étudiants de maîtriser et d'appliquer les différentes techniques de financements des projets industriels.

Mi514g - Réponse à appel d'offres

A l'issu de ce cours, l'étudiant sera capable de :
- de gérer une réponse à appel d'offre technique par la maîtrise des procédures et outils disponibles.
- maîtriser l'ensemble des problématiques financières d'une réponse à appel d'offre.

Mi514h - Simulation informatisée à la gestion d'entreprise

Cette simulation a pour objectif de permettre aux étudiants d'appliquer l'ensemble de leurs apprentissages relatifs à lastratégie d'entreprise, la gestion d'entreprise et le management d'équipes. Celle-ci permet une synthèse de l'ensemble des cours travaillés en AERO5-MLI-MPI

MANAGEMENT Major - OPTION Management de la production et du MCO

Mi515a - Journée Etude de cas SLI

Ce module a pour objectif de permettre aux étudiants de maîtriser et d'appliquer les différentes méthodes d'analyse de la gestion des stocks, de la gestion de flux, de la gestion des risques, par des études de cas réels au sein de l'entreprise Matra-Electronics.

Mi515b - Approvisionnement et gestion des stocks

Ce module à pour objectif de permettre aux étudiants de maîtriser et d'appliquer les différentes techniques de gestion des stocks et des approvisionnements dans des configurations de complexité variée.

Mi515c - Techniques de gestion de la Qualité

Ce cours permet aux étudiants de connaitre les multiples outils et méthodes mettant en oeuvre les concepts et les principes d'une démarche Qualité appliquée au sein d'une entreprise (à vocation industrielle et/ou aéronautique). Au travers de plusieurs exemples concrets, ils découvriront toutes les facettes de ce domaine.

Mi515d - Supply chain (approfondissement)

A l'issue de ce cours, l'étudiant doit :
- Être capable de tenir un poste à responsabilité au sein de la supply chain d'une grande entreprise,
- Être capable, en tant que cadre au sein d'une enti-té de production, de prescrire ses besoins et ses contraintes aux différents responsables de supply chain qui l'approvisionnent et lui livrent ses produits.

Mi515e - Contrôle de gestion de la production

Ce module a tout d'abord pour objectif de permettre aux étudiants de maîtriser et d'appliquer les différentes techniques d'analyse des écarts sur coûts d'un produit. Ce module a ensuite pour objectif de permettre aux étudiants d'appliquer les techniques d'optimisation à la gestion de la production et à la logistique.

Mi515f - Cycle de vie des produits - Gestion de configuration

A l'issu de ce cours, les étudiants connaitront toutes les étapes de la conception des PRODUITS ET PROCESS depuis l'initiation du projet jusqu'à la production (étudier, concevoir et faire réaliser un ouvrage).

Mi515g - Après-vente - Maintenance : Navigabilité et MCO

A l'issu de ce cours, l'étudiant devra :
- connaitre l'historique et les exigences de la maintenance avion
- comprendre les raison de la maintenance aéronautique
- connaitre les processus de mise en place de la maintenance par l'intermédiaire des programmes de maintenance
- Etre capable de prendre en compte les contraintes liées à l'utilisation de l'avion
et le maintien en condition opérationnelle nécessitant le respect des règles de sécurité

Mi515h - Projet compagnie aérienne

Ce projet vise à permettre aux étudiants d'analyser la stratégie d'une compagnie aériennepar l'analyse de son environnement et de ses choix stratégiques.
Il doit permettre également l'analyse de différents outils et techniques de gestion appliqués.

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BIENVENUE EN FRANCE

flə QUALITÉ FRANÇAIS LANGUE ÉTRANGÈRE

Subjects list and credits
(Academic year 2022-2023)
AERO 5 (Fall)

Fall semester = "S9" = 2nd year of Master											
Code	Subjects	Teaching hours & exams	ECTS credits	Teachers	Lectures	Tutorials (TD)	Practical work (TP)	Projects	Marked Assignments	Exams	Personal work
Pole "Human Sciences & Languages" COMMON CORE FOR ALL STUDENTS											
Sh 511	Enjeux sociétaux (cours dispensés en langue française) (in French)	*13*	***1,5***	D. MARICOURT	12					1	**20**
Sh 512	Facteurs humains et Intéraction Homme-Machine (in French) Analyse Sécurité des Vols (in French)	*21*	***1***	F. REYNAUD B.DANIEL	20					1	**10**
FLEa	French & Intercultural seminar - COMPULSORY	*34*	**6**	T. MINOT S. DESCAVES	32					2	**30**
Pole "Corporate knowledge & Professional skills" COMMON CORE FOR ALL STUDENTS											
Cours dispensés en langue française											
Sh 515	Droit des contrats et droit du travail (in French)	*17*	***1***	F. BONNARD	10	6				1	**12**
Mi 516	Sûreté de fonctionnement : Méthodologie AMDEC (in French)	*11*	***1***	R. ZANDERIGO	6	4				1	**12**
In 519	Initiation à la Cybersécurité (in French)	*10*	***1***	A. MOITTEAUX et C. SAGAZ	10				TD		**12**
Mi518	Techniques de conduite de projet (in French)	*13*	***0,5***	O. TERRIEN	4	8				1	**10**
Mi 511	Stratégie d'entreprise - Etude de cas (in French)	*12*	***1***	J-F. DE JUNNEMANN		12			TD		**12**
Mi 517	Outil de gestion-certification (Excel- TOSA et VBA) (in French)	*16*	***1***	S. BOUTELOUP		16			TD		**12**
Project											
Pm 511	Master Project IPSA PMI (*)	*20*	***6***	W. ABASSI				20			**100**

(*) only supervised hours are counted

Pole "Engineering sciences" - Major (Students must choose 1 major)											
Major SYSTEMS (only for students with ELS, SAA and TIE options)											
Au 511	Aircraft Modeling - Autopilot	*24*	***2***	J-P. NOUAILLE	8		16		TP		**20**
Au 512	Identification & observation of systems (deterministic & stochastic observers, Kalman filters)	*34*	***2***	S.DIOP - Y.SELLAMI	16		16		TP	2	**15**
Ma 512	Deep Neural Network & Deep Learning	*18*	***1***		8	10			Project		**12**
Au 513	Systems design - Fast prototyping	*24*	***2***	A. DEBIANE - Y. SELLAMI	6		16		TP	2	**20**
Major VEHICLES (only for students with CAE, ELS and EMO options)											
Mf 511	Introduction to Hypersonic Aerodynamics	*26*	***2***	P-E. WEISS	12	12				2	**20**
Mé 511	Vibration Dynamics of Plates and Shells	*22*	***1,5***	M. GALIMBERTI	12	8				2	**20**
Mé 512	Reliabilty & fatigue of structures	*13*	***1***	J-F. BEGUE	8	4				1	**10**
Mé 513	Calculation of ground and flight loads	*21*	***1***	J-F. BEGUE	12	8				1	**10**
Mf 512	Computational Fluid Dynamics (CFD)	*18*	***1,5***	W. ABASSI			18		TP		**25**
UE OPTIONNELLE Filière MANAGEMENT (uniquement étudiants MPI et MPM) (in French)											
Mi 513a	Achats et relations fournisseurs	*20*	***1***	P. GOLDSTEIN		20			TD		**10**
Mi 513b	Management des coûts	*22*	***1***	J-F. LEFEVRE		20				2	**12**
Mi 512	Code de la commande publique	*18*	***1***	J-P. DEVAUX	10	6			TD	2	**12**
Mi 513d	Outil de gestion de projet (MS Project)	*12*	***0,5***	S. GRENAT - K. RASSAY		12			TD		**10**
Mi 513e	Gestion financière	*22*	***1,5***	J-F. LEFEVRE		20				2	**15**
Mi 513f	Finance appliquée au secteur aéronautique - étude de cas	*14*	***1***	J-F. LEFEVRE		12				2	**10**
Mi 513g	Integrated Logistic Support & Integrated In service Support (MCO)	*26*	***2***	A. PIZEL	24					2	**15**

Code	Subjects	Teaching hours & exams	ECTS credits	Professors	Lectures	Tutorials (TD)	Practical work (TP)	Projects	Marked Assignments	Exams	Personal work
Pole "Aeronautics & Space" (Students must choose 1 option according to their major)											
Autonomous airborne systems (SAA option) - for students majoring in systems											
In 511	Intelligent Controls	*28*	***1,5***	A. BELBACHIR	10		16		TP	2	**15**
Au 514	Nonlinear systems control	*32*	***2***	J. MAURICIO ROSARIO	10	12	8			2	**20**
In 512	Distributed intelligent systems	*26*	***2,5***	A. BELBACHIR	10	16			Project		**30**
Au 515	Drones & visual servoing	*34*	***2***	J.CHAHAL	12	8	12		TP	2	**20**
Au 516	Cursus project: Dynamic planning of autonomous navigation	*24*	***3***	A. BELBACHIR	4			20	Project		**40**
Embedded information management & processing (TIE option) - for students majoring in systems											
In 513	Embedded Real-time operating systems	*28*	***2***	F. BONNEFOI	8		20		TP		**20**
El 511	Embedded systems: image processing with FPGA	*18*	***1***	M.VASILEVSKI	8	10			Project		**20**
In 518	High Performance Computing	*20*	***1***	A. CASALS	8	10				2	**20**
Te 511	EM compatibility & antennas	*26*	***2***	M. SMAIL	16	8				2	**20**
Te 513	Cursus project	*24*	***3***	M. SMAIL - EL HAMMAL	4			20	Project		**30**
Te514	Object localization through wireless sensors networks	*28*	***2***	S. FORTUNATI	16	10			TD	2	**20**
Airframe and materials (CAE option) - for students majoring in vehicles											
Aé 513	Vertical flight	*28*	***1,5***	C. MARTINAND	6	12	8			2	**12**

Mé 514	Multi-body mechanical simulation	*21*	***1,5***	P. SERRE			21		TP		**15**
Mé 515	Calculation in structural materials	*24*	***1,5***	A. BENELFELLAH	10	12				2	**15**
Mé 516	Advanced materials sustainability	*18*	***1,5***	A. BENELFELLAH	8	8				2	**15**
Mé 517	Nonlinear numerical simulation in structural mechanics	*18*	***2***	A. BENELFELLAH			18		BE		**25**
Mé 518	Cursus project: Finite Element Method for structures calculation (FEM)	*38*	***3***	W. LARBI			20	18	TP Project		**40**
Energy and engines (EMO option) - for students majoring in vehicles											
En 511	Cursus project: Turbomachinery and design project for a turbojet engine	*44*	***3***	C. DEVAUX	14			28	Project	2	**40**
En 512	Combustion	*16*	***1***	R. BERTOSSI	3	11			TD	2	**15**
En 513	Space propulsion systems	*26*	***2***	DUFOUR-COLLINET-MAGNIANT	16	8				2	**15**
En 514	Analytical and numerical calculations in heat transfer	*24*	***2***	R.BERTOSSI	6	12		4	TD	2	**15**
Mf 514	Aeroacoustics	*22*	***1,5***	R. PEREZ RAMOS	8	8		4	TD	2	**15**
Mf 515	Turbulence	*16*	***1,5***	W. ABASSI	8	6				2	**20**
Space, launchers and satellites (ELS option) - for students majoring in vehicles or systems											
En 513	Space propulsion systems	*26*	***2***	DUFOUR-COLLINET-MAGNIANT	16	8				2	**15**
En 515	Electric and nuclear propulsion for space	*30*	***1***	S.MAZOUFFRE - R. PEREZ RAMOS	28					2	**15**
Sp 517	Launchers and Satellites design	*44*	***3***	V. ROBERT et J.DESMARS		44			Project		**40**
Sp 518	Satellites prototypes	*7*	***1***	T. GARNIER				7			**7**
Sp 515	Space telecommunications (for systems students)	*22*	***1***	S. FORTUNATI	16	4			TD	2	**15**
Sp 516	Space telecommunications - Applications (for systems students)	*20*	***3***	S. FORTUNATI	16	4			Project		**25**
Sp 513	Payload integration and launchers (for vehicles students)	*22*	***1***	S.DUPRE	16	4				2	**15**
Sp 514	Cursus project: Conception of a space mission II (for vehicles students)	*20*	***3***	S. MAZOUFFRE				20	Project		**25**
UE OPTIONNELLE MPI (management des projets industriels) (in French) - for students majoring in management											
Mi 514a	Négociations internationales	*14*	***1***	F. PELOSSE		14			TD		**10**
Mi 514b	Contrôle de gestion	*14*	***1***	J-F. LEFEVRE		12				2	**12**
Mi 514c	Evaluation financière des projets	*14*	***1***	J-F. LEFEVRE		12				2	**12**
Mi 514d	Analyse de la performance commerciale	*17*	***1***	F. PELOSSE		16				1	**15**
Mi 514i	Challenge "négociations commerciales"	*2*	***0,5***	EVRE ; F.PELOSSE ; P.GOLDSTEIN			2		Oral defence		**4**
Mi 514e	Analyse et gestion des risques des projets industriels	*18*	***1***	TBD		16			TD	2	**15**
Mi 514f	Financement des projets industriels	*14*	***1***	J-F. LEFEVRE		12				2	**12**
Mi 514g	Réponse à appel d'offres	*13*	***1***	F. RICCI	12				IC	1	**15**
Mi 514h	Simulation informatisée à la gestion d'entreprise	*18*	***1,5***	J-F LEFEVRE				20	Project		**25**
UE OPTIONNELLE MPM (management de la production et du MCO) (in French) - for students majoring in management											
Mi 515a	Journée Etude de cas SLI	*12*	***0,5***	M. BREUIL ; JF LEFEVRE				12	Etude de cas		**3**
Mi 515b	Approvisionnement et gestion des stocks	*14*	***1***	J-F. LEFEVRE			12			2	**15**
Mi 515c	Techniques de gestion de la Qualité	*22*	***1,5***	O. TERRIEN	12	8				2	**10**
Mi 515d	Supply chain (approfondissement)	*17*	***1***	A. PIZEL	16					1	**15**
Mi 515e	Contrôle de gestion de la production	*22*	***1***	J-F.LEFEVRE		20				2	**20**
Mi 515h	Projet compagnie aérienne	*6*	***2***	J-F.LEFEVRE				6	Projevt		**35**
Mi 515f	Cycle de vie des produits - Gestion de configuration	*12*	***1***	R. ZANDERIGO	6	6			TD		**12**
Mi 515g	Après-vente - Maintenance : Navigabilité et MCO	*20*	***1***	R. ZANDERIGO	18					2	**12**

Subjects list and credits
(Academic year 2022-2023)
AERO 4 (Spring)

IPSA ÉCOLE D'INGÉNIEURS DE L'AIR, DE L'ESPACE ET DE LA MOBILITÉ DURABLE

Spring semester = "S8" = 1st year of Master											
Code	**Subjects**	Teaching hours & exams	ECTS credits	Teachers	Lectures	Tutorials (TD)	Practical work (TP)	Projects	Marked Assignments	Exams	Personal work
Pole "Human Sciences & Languages" COMMON CORE FOR ALL STUDENTS											
Sh 421	Environmental Ethics	*12*	***1,5***	A. SORIYA		12			TD Project		**20**
Sh 422	Sociologie des entreprises et des organisations (in French)	*12*	***1***	JF. De JUNNEMANN		10				2	**12**
Sh 423	Droit social (in French)	*11*	***1***	F. BONNARD		10				1	**12**
FLEb	French & Intercultural seminar - COMPULSORY	*34*	***6***	T. MINOT S. DESCAVES	32					2	**25**
Pole "Corporate knowledge & Professional skills" COMMON CORE FOR ALL STUDENTS											
Cours Sciences de l'entreprise											
Mi 421	Qualité - Règlementation - Normes - Lean (in French)	*13*	***1***	O. TERRIEN	6	6				1	**10**
Mi 422	Principes de stratégie d'entreprise (in French)	*12*	***0,5***	TBD		12			TD		**10**
Mi 423	Gestion d'entreprise et Analyse financière (in French)	*26*	***1,5***	JF. LEFEVRE		24				2	**20**
Pole "Engineering Sciences" - COMMON CORE FOR ALL STUDENTS											
Engineering Sciences											
Au 421	Graphic representation of dynamic multilinear systems	*22*	***1,5***	A. DEBIANE - Y. SELLAMI	10		10		TP	2	**15**
Mi 426	Principes de base de Conception Avion et d'éco-conception - Industrialisation et Méthode de production	*11*	***1***	R. ZANDERIGO	10					1	**10**
Aé 421	Flight dynamics: aircraft flying qualities	*22*	***1,5***	P. YAZIGI	12	8			TD	2	**25**
Electives and Initiation to Research											
Mo 421a..i	All options except ELS : Elective module 1 (8 choices)	*22*	***1,5***	depends of the module	20					2	**20**
Sp 421	ELS option : Astronomy, Astrometry	*20*		V. ROBERT	20				Project		**22**
Mo 422a...i	All options except ELS : Elective module 2 (8 choices)	*22*	***1,5***	depends of the module	20					2	**20**
Sp 422	ELS option : Astrophysics	*20*		J. DESMARD	20				Project		**22**
Ci 421a...r	Introducing Project to Research or Innovation PIRI	*20*	***2***	depends of the project	20					TBD	**24**
Pole "Engineering Sciences" - 1 major/student											
Major SYSTEMS (only for students with ELS, SET or SM options)											
In 421	Complex information systems modelling	*11*	***1***	F. BONNEFOI	4	6				1	**10**
In 422	Real Time Information Systems	*24*	***2***	A. BELBACHIR	7		16		TD	1	**20**
In 423	Embedded networks	*17*	***1***	F. BONNEFOI	4		12		TP	1	**15**
Ma 422	Introduction to Machine Learning	*20*	***1,5***	TBD	10		10		project		**20**
Au 425	Physical approach to aeronautical automated systems	*25*	***2***	Y. SELLAMI	8		16		TP	2	**16**
Major VEHICLES (only for students with ELS, EP or MS options)											
Mf 421	Fluid Dynamics	*27*	***2***	W. ABASSI	8	8	9		TD / TP	2	**22**
En 426	Electrical and hydrogen production	*17*	***2,5***	B. WIESENFELD				17	Project		**30**
Mé 421	Theory of plates and shells	*22*	***2***	M. GALIMBERTI	8	12				2	**18**
Mé 422	Numerical calculations in mechanics and structures (FEM)	*17*	***1***	W. LARBI			16	1	Project		**20**

Code	**Subjects**	Teaching hours & exams	ECTS credits	**Teachers**	Lectures	Tutorials (TD)	Practcial work (TP)	Projects	Marked Assignments	Exams	Personal work
Pole "Aeronautics and Space" - 1option/student											
SET option "Embedded systems and telecommunications" - for students majoring in systems											
El 421	Advanced applications of RPGA circuits	*20*	***1,5***	S. BENABID	4	10	6		TD-TP		15
In 424	Swarm intelligent systems	*22*	***2,5***	A. BELBACHIR	6			16	Project		25
Té 421	Telecommunications: principles and liaison balance	*22*	***2***	S. FORTUNATI	12	8				2	18
Té 422	Guided propagation and hyperfrequencies	*18*	***1***	M. SMAIL	10	6				2	15
SM option "Mechatronic systems" - for students majoring in systems											
Au 424	Power electronics and actuators in aeronautics	*16*	***1***	A. DEBIANE	8		8		TP		18
Au 422	Guidance principles of autonomous systems	*26*	***2***	J. CHAHAL	8	4	12		TP	2	20
Au 423	Introduction to robotics	*20*	***1,5***	A. CASALS J. GUSTAVE	8		12		TP		18
In 424	Swarm intelligent systems	*22*	***2,5***	A. BELBACHIR	6			16	Project		25
EP option "Energetics and Propulsion" - for students majoring in vehicles											
En 422	Turbomachines design	*42*	***2,5***	C. DEVAUX	20	20			TD	2	24
En 423	Thermal engines for drone & light aircraft	*24*	***2***	R. BERTOSSI T. KASRAOUI	6			16	Project	2	18
En 424	Nuclear Energy and Propulsion	*22*	***1,5***	R PEREZ RAMOS	10	10				2	20
En 425	Initiation to aeroacoustics	*9*	***1***	R PEREZ RAMOS	4	4				1	10
MS option "Mechanics and Structures" - for students majoring in vehicles											
Mé 424	CAD: CATIA	*19*	***2***	P.GAUDIN P.VINTER				19	Project		25

Mé 425	Metallic and composite materials	*34*	***2,5***	JF.BEGUE A.BENELFELLAH	12	8	12		TP	2	18
Mé 427	Aircraft structures design	*13*	***1***	JF. BEGUE	6	6				1	12
Mé 423	Advanced Materials	*29*	***1,5***	A.BENELFELLAH	10	8	9			2	18
ELS option "Space, Launchers and Satellites" - for students majoring in systems or vehicles											
Sp 423	Space mechanics	*26*	***1,5***	V. ROBERT	12	12			Project	2	20
Sp 424	Project : Atmospheric reentry and mission concept	*20*	***2,5***	V. LAGO	4			16	Project		20
Sp 425	Space optics	*22*	***1,5***	R. LEGOFF	12	8				2	15
Sp 426	Plasma physics, electrical and plasma propulsion	*20*	***1,5***	A. LEKIC S. MAZOUFFRE	10	8				2	18
Sp 427	Numerical methods for space applications (COMSOL) (for vehicles students only)	*10*	***1***	J. DESMARS	6	4			Project		15