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

Undergraduate in Aeronautical Engineering

Syllabus 2023-2024

- 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
AnMa315 - Data and decision science 1

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
AnLa311 - English
AnLa312 - Preparation for English tests

List of modules and coefficients per teaching unit - 2023-2024

AERO 3: Undergraduate courses

Incomings

AUTUMN 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	**36**	3	10	12	10	2	PW	Project	2	*35*	
AnMa315	Data and decision science 1	**30**	2,5		24		4	Project		2	*30*	
Engineering sciences - Core												
AnEn311	Heat transfers 1	**40**	3	18	8	10			2	2	*30*	PSITC 31
AnMé311	General mechanics 1	**45**	3	12	12	16		PW	2	3	*30*	
AnIn311	Introduction to databases	**17**	1,5	4	4	4	4	Project		1	*20*	
AnAu311	Automation of linear dynamical systems	**22**	2	10	10				MCQ	2	*25*	
Aerospace												
AnMf311	Aerodynamics 1	**22**	2	10	10			Contin. assess.		2	*25*	PAS 31
AnAé312	Flight mechanics (performances, static equilibrius)	**22**	2	10	10			Homework		2	*25*	
AnEl311	Electrotechnics & embedded power generation	**21**	1,5	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**	1	8		2				1	*5*	
Languages 1												
FLEa	French as a foreign language and intercultural seminars	**32**	6	30				Contin. assess.	Project	2	*25*	
AnLa311	English 1	**19,5**	1,5		12		6	Contin. assess.	Present.	1,5	*15*	
AnLa312	Preparation for English tests	**14**	1		12			Contin. assess.		2	*12*	
* Hours		**405,5**	**36**								**365**	

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.

AnMa315 - Data and decision science 1

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

This course focuses on the measures taken to adapt aviation to climate change.
The objectives are to
- To explain the causes of global warming,
- To explain the impact of aviation on the climate,
- To describe the main levers for reducing the carbon and non-carbon effects of aviation on the climate,
- Describe the main possible scenarios for change.

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 - Numerical solving of integrals and ODE
AnMa323 - Finite difference method

Engineering sciences - Signals & systems
AnIn321 - Networks of smart devices
AnIn322 - Operating systems
AnIn323 - C++ programming
AnMa324 - Differentiable optimization 2
AnMa325 - Data and decision science 2
AnAu323 - Linear state space control
AnAu322 - Microcontroller programming
AnEl321 - Digital electronics
AnEl322 - Introduction to programmable logic blocks (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
AnAu324 - Modeling and dynamical analysis of aircrafts
AnMf321 - Aerodynamics 2
AnMf322 - Introduction to CFD

Business knowledge 2
AnSh322 - Prospective
AnSh323 - Corporate social responsability
AnSh326 - The Digital Collage (Fresque Numérique)

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

List of modules and coefficients per teaching unit - 2023-2024

AERO 3: Undergraduate courses

Incomings

SPRING SEMESTER = "S6" = 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 2												
AnMa321	Differentiable optimization 1	**26**	2,5	6	10		8		Project	2	*30*	PSF 32
AnMa322	Numerical solving of integrals and ODE	**25**	2	8	8	6	2	PW	Project	1	*25*	
AnMa323	Finite difference method	**18**	1,5	6	4	4	4	PW		Project	*20*	
Engineering sciences - Signal and Systems												
AnIn321	Networks of smart devices	**24**	1,5	14		8		PW		2	*15*	PSIS 31
AnIn322	Operating systems	**18**	1,5	12		4		PW		2	*15*	
AnIn323	C++ programming	**24**	2			20		PW		4	*30*	
AnMa324	Differentiable optimization 2	**26**	2	6	8		10		Project	2	*25*	PSIS 32
AnMa325	Data and decision science 2	**19**	1,5	6	4	4	4		Project	1	*20*	
AnAu323	Linear state space control	**23**	1,5	8	6		8		Project	1	*20*	
AnAu322	Microcontroller programming	**17**	1,5	6		10		PW		1	*15*	
AnEl321	Digital electronics	**23**	2	10	10				1	2	*20*	PSIS 33
AnEl322	Introduction to programmable logic blocks (FPGA)	**24**	2	5		17		PW		2	*20*	
AnTé321	Aeronautical telecommunication systems	**20**	1,5	12	6			MCQ		2	*15*	
AnTé322	Digital signal processing	**39**	3	14	14	8		PW	1	2	*30*	
Engineering sciences - Vehicles												
AnMé321	General mechanics 2	**29**	2	12	12				2	3	*20*	PSIV 31
AnMé322	Introduction to FEM	**18**	1,5	8	8					2	*15*	
AnMé323	CAD (Catia)	**19**	2				18	Project		1	*30*	
AnMé324	Continuum mechanics	**40**	3	18	18				2	2	*35*	
AnMé325	Materials science	**18**	1,5	8	8			Contin. assess.		2	*15*	
AnEn321	Introduction to turbomachinery	**26**	2	12	8		4	Project		2	*25*	PSIV 32
AnEn322	Heat transfers 2	**23**	1,5	6	6	9		PW		2	*15*	
AnEn323	Applied thermodynamics	**32**	2,5	8	8	6	8	Contin. assess.		2	*25*	
AnAu324	Modeling and dynamical analysis of aircrafts	**15**	1	6	4		4	Project		1	*15*	PSIV 33
AnMf321	Aerodynamics 2	**24**	2	10	8	4		PW		2	*25*	
AnMf322	Introduction to CFD	**14**	1	2	4	8				PW	*8*	
Business knowledge and occupational integration 2												
AnSh322	Prospective	**12**	1	2	10			Contin. assess.		Present.	*10*	PCIP 32
AnSh323	Corporate social responsibility	**16**	1	4	12					Present.	*15*	
AnSh326	The Digital Collage	**3**	0,5				3			Attendance		
Languages 2												
FLEb	French as a foreign language and intercultural seminars	**32**	6	30				Contin. assess.	Project	2	*25*	
AnLa321	English 2	**19**	1,5		12		6	Contin. assess.	1	Present.	*15*	

* Hours

SYS	**408**	**36**	**365**
VEH	**409**	**36**	**368**

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 - Numerical solving of integrals and ODE

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 2

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.

AnAu323 - Linear state space control

Firstly, students acquire an in-depth understanding of the fundamental concepts involved in state representation, including the mathematical modelling of dynamic systems. Secondly, they develop practical modelling and simulation skills using tools such as Matlab/Simulink, enabling them to apply their theoretical knowledge in a practical way. Finally, students are able to analyse and design linear systems using state representation, preparing them to solve complex engineering problems in a variety of application areas.

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 blocks (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.

AnAu324 - Modeling and dynamical analysis of aircrafts

new course

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

AnSh322 - Prospective

Identify contemporary issues at the heart of design offices and research laboratories, Imagine the world of tomorrow. Based on presentations of industrial projects under development or research programmes developed in laboratories around the world and in all sectors of activity, students are invited to give an account of tomorrow's society, in the light of what is being conceived today. The aim of these short presentations (20 minutes) is to reflect on the prospects opened up by the choice of technical solutions, innovative projects or research programmes.

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

AuSh326 - The Digital collage

A workshop to understand, as a team and in a fun way, the impact of digital technologies on the environment.
https://digitalcollage.org/

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.

IPSA

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