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

Master in Aeronautical Engineering

Syllabus 2024-2025

- 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 specilizations: SYSTEMS (SYS) and VEHICLES (VEH)
- 6 majors - 3 for each specialization
    - SYSTEMS specialization : 3 majors
      - Embedded systems & Telecommunication (SET)
      - Mechatronic systems (SM)
      - Space, Launchers & Satellites (ELS)

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

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

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

Human Sciences and Languages common pole
Sh421 - Environmental ethics
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 - Gestion d'entreprise et analyse financière

Engineering Sciences common core
Au421 - Multiphysical systems graphical representation
Mi426 - Principes de base de Conception Avion et d'éco-conception - Industrialisation et Méthode de production
Aé421 - Flight mechanics

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 - Astronomy, Astrometry
For ELS students: Sp422 - General Astrophysics

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

SYSTEMS specialization
In421 - Complex Information Systems Modelling
In422 - Real Time Information Systems
In424 - Swarm Intelligent Systems
Ma422 - Introduction to Machine Learning
Au425 - Physical Approach to aeronautical automated systems

VEHICLES Major
Mf421 - Fluid Dynamics
En426 - Power generation and Hydrogen
Mé421 - Theory of plates & shells
Mé422 - Numerical calculations in mechanics and structures (FEM)

SYSTEMS specialization - Major Embedded systems & Telecommunication (SET)
El421 - Advanced Applications of RPGA Circuits
Té423 - Digital Signal Processor
Té421 - Telecommunications Principles
Té422 - Guided Propagation & Hyperfrequences

SYSTEMS specialization - Major Mechatronic systems (SM)
Au424 - Power Electronics & Actuators
Au422 - Guidance Principles of Autonomous Systems
In426 - Introduction to Robotics
In423 - Embedded networks

SYSTEMS or VEHICLES specialization - Major Space, Launchers & Satellites (ELS)
Sp423 - Space Mechanics
Sp424 - Mission design project 1 : Atmospheric Entry
Sp425 - Optics in aerospace engineering
Sp426 - Plasma physics : theory & applications in space
Sp427 - Numerical Methods for Space Applications (COMSOL) - *VEH only*

VEHICLES specialization - Major Energetics & Propulsion (EP)
En422 - Turbomachine Design
En423 - Thermal Engines for UAV
En424 - Nuclear energy and propulsion
En425 - Introduction to aeroacoustics

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

Grades are awarded to the students with an average of 10 or more, according to the following success scale:

- A: the top 10%
- B: the next 25%
- C: the next 30%
- D: the next 25%
- E: the remaining 10%
- FX corresponds to an average between 7 and 10
- F corresponds to an average of less than 7

The credits for a module are acquired:

- when the semester average grade is at least 10, if the module grade is at least 7
(10 for "French as a foreign language and intercultural seminars" and the cursus projects),
- when the semester average grade is less than 10, if the module grade is at least 10

Subject List and credits

(Academic Year 2024-2025)

AERO 4 - 1st year of Master (Promo 2026)

With some exceptions, modules are taught in English

MAJORS

AS FUNCTION OF "Filières"

SYS	Majors	
✓	SET	Embedded syst.and telecom.
✓	SM	Mechatronic Systems
✓	ELS	Space, Launchers, Satellites
	EP	Energetics and Propulsion
	MS	Mechanics and Structures

SPRING SEMESTER = S8 = 1st year of Master

	Subjects	Teaching and knowledge test hours	ECTS Credits	Pilote(s)	Teaching Hours: Courses	Tutorial Work (TD)	Pratical Work (TP)	Projects	Graded Works: Grades works	Exams	*Unscheduled personal work*
Pole "Humain Sciences and languages" COMMON CORE FOR ALL STUDENTS											
Sh421	Environmental Ethics	**12**	**1,5**	**A. SORIYA**		12			TD Projet		20
Sh422	Corporate sociology (in French)	**12**	**1**	**JF. De JUNNEMANN**		10				2	12
Sh423	Social law (in French)	**11**	**1**	**F. BONNARD**		10				1	12
FLEb	French Language + Intercultural seminar - COMPULSORY	**30**	**6**		30						25
Pole "Professionnal Integration" COMMON CORE FOR ALL STUDENTS											
Corporate Knowledge and Employability											
Mi421	Quality - Regulation - Standards - Lean (in French)	**13**	**0,5**	**O. TERRIEN**	6	6				1	10
Mi422	Corporate strategy principles (in French)	**12**	**0,5**	**V. JEANNERET**		12			TD		10
Mi423	Economics: financial management (in French)	**26**	**2**	**JF. LEFEVRE**		24				2	20
Pole "Engineering Sciences" COMMON CORE FOR ALL STUDENTS											
Cours Sciences de l'Ingénieur											
Au421	Multiphysical systems graphical representation	**22**	**1,5**	**A. DEBIANE**	10		10		TP	2	15
Mi426	Basic principle of aircraft design and eco-design (in French)	**11**	**1**	**O. TERRIEN**	10					1	10
Aé421	Flight mechanics: flying qualities	**22**	**1,5**	**P. YAZIGI**	12	8			TD	2	25
Electives and Initiation to Resaerch											
Mo421a..i	All options except ELS : Electives 1 (among 8)	**22**	**1,5**	**selon module**	20					2	20
Sp421	ELS: Astronomy, Astrometry	**20**		**V. ROBERT**	20				Projet		22
Mo422a...i	All options except ELS : Electives 1 (among 8)	**22**	**1,5**	**selon module**	20					2	20
Sp422	ELS: General Astrophysics	**20**		**J. DESMARS**	20				Projet		22
Ci421a...r	Research and Innovation courses	**20**	**2**	**selon sujet**	20					TBD	24
Pole "Engineering Sciences - 1 specialization per student											
Specialization SYSTEMS (only for students with ELS, SET or SM options)											
In421	Complex Information systems modelling	**11**	**0,5**	**F. BONNEFOI**	4	6				1	10
In422	Real time information systems	**24**	**2**	**A. OZTURK**	7		16		TD	1	20
In424	Swarm intelligent Systems	**20**	**2**	**J. GUSTAVE J. ALVAREZ**	4			16	Projet		25
Ma422	Introduction to Machine Learning	**20**	**1,5**	**C. SALIBA**	10		10		TP-Projet		20
Au425	Physical approach to aeronautical automated systems	**25**	**1,5**	**Y. SELLAMI**	8		16		TP	1	16
Specialization VEHICLES (only for students with ELS, EP or MS options)											
Mf421	Fluid dynamics	**27**	**2**	**W. ABASSI**	8	8	9		TP	2	25
En426	Power generation and Hydrogen	**17**	**1,5**	**H. FRIHA**				17	Projet		20
Mé421	Theory of plates and shells	**22**	**2**	**M. GALIMBERTI**	8	12				2	20
Mé422	Numerical calculations in structural mechanics (FEM)	**17**	**2**	**W. LARBI**			16	1	TP-Projet		25

	Subjects	Teaching and knowledge test hours	Crédits ECTS UE	Pilote(s)	Courses	Tutorial Work (TD)	Pratical Work (TP)	Projects	Grades works	Exams	*Unscheduled personal work*
Pole "Aeronautics and Space " 1 major per student											
SET major "Embedded systems and telecommunications"											
El421	Advanced applications for RPGA circuits	**20**	**1,5**	**M. VASILEVSKI**	4	10	6		TD-TP		15
Té423	Digital Signal Processors	**20**	**2**	**M. BERRIOT**	8	10				2	25
Té421	Telecommunications principles	**22**	**2**		12	8				2	18
Té422	Guided propagation and hyperfrequences	**18**	**1,5**	**M. SMAIL**	10	6				2	15
SM major "Mechatronic systems"											
Au424	Power electronics and actuators	**16**	**1,5**	**A. DEBIANE**	8		8		TP		18
In425	Guidance principles of autonomous systems	**26**	**2**	**J. GUSTAVE J. ALVAREZ**	8	4	12		TP	2	20
In426	Robotics (introduction)	**20**	**1,5**	**J. GUSTAVE J. ALVAREZ**	8		12		TP		18
In423	Embedded networks	**20**	**2**	**F. BONNEFOI**	4		15		TP	1	25
EP major "Energetics and Propulsion"											
En422	Design of turbomachinery sizing of air inlets and nozzles	**42**	**2,5**	**C. DEVAUX**	20	20			TD	2	24
En423	Thermal engine for UAV	**24**	**2**	**R. BERTOSSI**	6			16	TP	2	18
En424	Nuclear energy and propulsion	**22**	**2**	**R PEREZ RAMOS**	10	10				2	20
En425	Aeroacoustics Initiation	**9**	**0,5**	**R PEREZ RAMOS**	4	4				1	10
MS major "Mechanics and Structures"											
Mé424	Advanced CAD (CATIA)	**19**	**2**	**P.GAUDIN P.VINTER**				19	Projet		25
Mé425	Metallic and composite materials	**34**	**2,5**	**JF.BEGUE A.BENELFELLAH**	12	8	12		TP	2	18
Mé427	Aeronauticals structures design	**13**	**0,5**	**JF. BEGUE**	6	6				1	12
Mé423	Advanced Materials	**29**	**2**	**A.BENELFELLAH**	10	8	9			2	18
ELS major "Space, Launchers and Satellites"											
Sp423	Space mechanics	**26**	**2**	**V. ROBERT**	12	12			Projet	2	20
Sp424	Mission Design Project I : Atmospheric Entry	**20**	**2**	**V. LAGO**	4			16	Projet		20
Sp425	Optics in aerospace enginering	**22**	**1,5**	**A. DORESSOUNDIRAM**	14	6				2	15
Sp426	Plasma physics : theory & applications in space	**20**	**1,5**	**A. LEKIC**	14	4				2	18
Sp427	Numerical methods for spatial applications (COMSOL) only for ELSV Students	**10**	**1**	**J.DESMARS**	6	4			Projet		15

Course description

Human Sciences and Languages common pole

Sh421 - Environmental ethics

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 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.

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 - Gestion d'entreprise et analyse 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 - Multiphysical systems graphical representation

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 mechanics

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 - 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 - 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 specialization

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

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.

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 aeronautical 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 specialization

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

En426 - Power generation and hydrogen

Understand the benefits of hydrogen in many areas of human activity.
In particular, understand the importance of green hydrogen as the energy carrier of the future for land and air transport, in order to make an effective contribution to the fight against CO2 emissions.
Finally, to understand the interest of hydrogen and the concept of nuclear thermal propulsion (NTP) for a manned Earth-Mars flight in the next decade.

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 specialization - major 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.

Té423 - Digital Signal Processor

- Understand the fundamental concepts of digital signal processing and its advantages for embedded systems.
- Acquire the skills to design and implement digital filters and real-time processing systems on FPGAs and microcontrollers.
- Be able to interact with the real world using sensors and actuators for practical applications.

Té421 - Telecommunications Principles

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 & Hyperfrequences

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 specialization - major 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)

In425 - 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.

In426 - 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

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

SYSTEMS or VEHICLES specialization - major 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 - Mission design project 1 : Atmospheric Entry

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 - Optics in aerospace engineering

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 : theroy & applications in space

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 specialization - major 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 UAV

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 energy and 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 specialization - major Mechatronic & Structures (MS)

Mé424 - Advanced 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 specializations: VEHICLES (VEH), SYSTEMS (SYS) and MANAGEMENT (MLI)
- 9 majors - 3 for SYSTEMS, 3 for VEHICLES and 2 for MANAGEMENT
    - SYSTEMS specialization : 3 majors
      - Autonomous Airborne Systems Control (SAA)
      - Operation & Transmission of Embedded Information (TIE)
      - Space, Launchers & Satellites (ELS)

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

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

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

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 &Intercultural seminar

Corporate knowledge common pole

Sh515 - Droit des contrats et droit du travail
Mi519 - Cycle de vie et éco-conception
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 specialization
Au511 - Aircraft Modeling & Autopilot
Au512 - Identification & Observation of systems
Ma512 - Deep Neural Network & Deep Learning
Au513 - Systems Design & Fast Prototyping

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

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

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

VEHICLES specialization - Major Energetics & Engines (EMO)
En511 - Cursus project: Turbomachinery enhancement and design projet for a turbojet engine
En512 - Combustion
En513 - Space Propulsion Systems
En517 - Introduction to Electrical propulsion
En514 - Analytical & numerical calculations in heat transfer
Mf514 - Aeroacoustics
Mf515 - Turbulence

MANAGEMENT specialization - Major 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 specialization - Major 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 - Stratégie de maintenance
Mi515g - Gestion de production
Mi515h - Projet compagnie aérienne

Grades are awarded to the students with an average of 10 or more, according to the following success scale:

- A: the top 10%
- B: the next 25%
- C: the next 30%
- D: the next 25%
- E: the remaining 10%
- FX corresponds to an average between 7 and 10
- F corresponds to an average of less than 7

The credits for a module are acquired:

- when the semester average grade is at least 10, if the module grade is at least 7
(10 for "French as a foreign language and intercultural seminars" and the cursus projects),
- when the semester average grade is less than 10, if the module grade is at least 10

Institut Polytechnique des Sciences Avancées
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94200 Ivry sur Seine

Subjects list and credits
(Academic year 2024-2025)
AERO 5 (Promo 2025)

SYS	VEH	MLI	
✓			SAA
✓			TIE
✓	✓		ELS
	✓		CAE
	✓		EMO
		✓	MPI
		✓	MPM

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	*12*	***1***	D. MARICOURT	12						**15**
Sh 512	Facteurs humains et Intéraction Homme-Machine (16h)	*17*	***1,5***	F. REYNAUD	16					1	**15**
	Analyse Sécurité des Vols (4h)			B.DANIEL							
FLEa	French as a foreign language - 1st semester (26h) **COMPULSORY**	*34*	**6**	T. MINOT	32					2	**30**
	Intercultural seminar (6h) **COMPULSORY**			S. DESCAVES							
Pole "Corporate knowledge & Professional skills" COMMON CORE FOR ALL STUDENTS											
Cours dispensés en langue française											
Sh 515	Droit des contrats et droit du travail	*15*	***1***	F. BONNARD	10	4				1	**12**
Mi 519	Cycle de vie et éco-conception	*11*	***1***	V. PERRARD	6	4				1	**8**
In 519	Inititation to Cybersecurity	*10*	***1***	T. GREMION	10				TD		**10**
Mi518	Techniques de conduite de projet	*13*	***1***	O. TERRIEN	4	8				1	**10**
Mi 516	Sûreté de Fonctionnement - Méthodologie AMDEC	*11*	***1***	B. HERFRAY	6	4				1	**10**
Mi 517	Outil de gestion-certification (Excel- TOSA et VBA)	*16*	***1***	S. BOUTELOUP		16			TD		**15**
Project											
Pm 511	Master Project IPSA PMI (*)	*20*	***6***	W. ABASSI				20			**100**
Pole "Engineering sciences" - Major Students must choose 1 major											
Major SYSTEMS (only for students wtih ELS/S, SAA and TIE options)											
Au 511	Aircraft Modeling - Autopilot	*24*	***2***	J-P. NOUAILLE	8		16		TP		**17**
Au 512	Identification & observation of systems (deterministic & stochastic observers, Kalman filters)	*34*	***2***	S.DIOP	16		16		TP	2	**20**
Ma 512	Deep Neural Network & Deep Learning	*18*	***1***	O. AL HAMMAL	8	10			TP - Project		**15**
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/V and EMO options)											
Mf 511	Introduction to Hypersonic Aerodynamics	*26*	***2***	P-E. WEISS	12	12				2	**25**
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		**20**
UE OPTIONNELLE Filière MANAGEMENT (uniquement étudiants MPI et MPM)											
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***	TBD	10	6			TD	2	**12**
Mi 513d	Outil de gestion de projet (MS Project)	*12*	***0,5***	G. LATOUCHENT		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***	L. DEBENEY - J. NAVARATNAM		12				2	**15**
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)											
In 511	Intelligent Controls	*28*	***1,5***	J. ALVAREZ	10		16		TP	2	**15**
Au 514	Nonlinear systems control	*32*	***1,5***	J. MAURICIO ROSARIO	10	12	8			2	**18**
In 512	Distributed intelligent systems	*26*	***2,5***	A. OZTURK	10	16			Project		**30**
Au 515	Drones & visual servoing	*34*	***2,5***	J. ALVAREZ	12	8	12		TP	2	**25**
Au 516	Cursus project: Dynamic planning of autonomous navigation	*24*	***3***	J. GUSTAVE	4			20	Project		**40**
Embedded information management & processing (TIE option)											
In 513	Embedded Real-time operating systems	*32*	***2***	F. BONNEFOI	8		24		TP		**18**
El 511	Embedded systems: image processing with FPGA	*18*	***1***	M.VASILEVSKI	8	10			Project		**15**
In 518	High Performance Computing	*20*	***1***	TBD	8	10				2	**15**
Te 511	EM compatibility & antennas	*28*	***2***	M. SMAIL	16	10				2	**25**
Te 513	Cursus project	*24*	***3***	M. SMAIL - O. EL HAMMAL	4			20	Project		**35**
Te514	Object localization through wireless sensors networks	*28*	***2***	TBD	16	10			TD	2	**25**
Airframe and materials (CAE option)											
Aé 513	Vertical flight	*28*	***1,5***	C. MARTINAND	6	12	8			2	**8**
Mé 514	Multi-body mechanical simulation	*21*	***1,5***	J. DUBOC			21		TP		**18**
Mé 515	Calculation in structural materials	*24*	***2***	A. BENELFELLAH	10	12				2	**20**
Mé 516	Advanced materials sustainability	*18*	***1,5***	A. BENELFELLAH	8	8				2	**18**
Mé 517	Nonlinear numerical simulation in structural mechanics	*18*	***1,5***	A. BENELFELLAH			18		BE		**22**
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)											
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	**12**
En 513	Space propulsion systems	*26*	***2***	DUFOUR-COLLINET-MAGNIANT	16	8				2	**20**
En517	Introduction to Electrical propulsion	*9*	***1***	S. MAZOUFFRE	8					1	**10**
En 514	Analytical and numerical calculations in heat transfer	*13*	***1***	R.BERTOSSI	4			9	TP		**12**
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)											
En 513	Space propulsion systems	*26*	***2***	DUFOUR-COLLINET-MAGNIANT	16	8				2	**20**
En 515	Electric and nuclear propulsion for space	*34*	***1***	S.MAZOUFFRE - R. PEREZ RAMOS	32					2	**25**
Sp 517	Launchers and Satellites design	*44*	***3***	V. ROBERT et J.DESMARS		44			Project		**30**
Sp 518	Satellites prototypes	*7*	***1***	T. GARNIER				7			**7**
Sp 515	Space telecommunications (for ELSS students)	*22*	***1***	TBD	16	4			TD	2	**20**
Sp 516	Space telecommunications - Applications (for ELSS students)	*20*	***3***	TBD				20	Project		**30**
Sp 513	Payload integration and launchers (for ELSV students)	*22*	***1***	S.DUPRE	16	4				2	**15**
Sp 514	Cursus project: Conception of a space mission II (for ELSV students)	*20*	***3***	S. MAZOUFFRE				20	Project		**25**
UE OPTIONNELLE MPI (management des projets industriels)											
Mi 514a	Négociations internationales	*14*	***1***	F. PELOSSE		14			TD		**10**
Mi 514b	Contrôle de gestion	*14*	***1***	V. JEANNERET		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	**12**

Mi 514i	Challenge "négociations commerciales"	*2*	***0,5***	F.PELOSSE ; P.GOLDSTEIN			2		Oral defence		**8**
Mi 514e	Analyse et gestion des risques des projets industriels	*18*	***1***	R. DERBEL		16			TD	2	**12**
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	**12**
Mi 514h	Simulation informatisée à la gestion d'entreprise	*18*	***1,5***	J-F LEFEVRE				18	Project		**25**
UE OPTIONNELLE MPM (management de la production et du MCO)											
Mi 515a	Journée Etude de cas SLI	*12*	***0,5***	E. LE DONNE				12	Etude de cas		**8**
Mi 515b	Approvisionnement et gestion des stocks	*14*	***1***	J. MAITREL			12			2	**8**
Mi 515c	Techniques de gestion de la Qualité	*22*	***1,5***	O. TERRIEN	12	8				2	**12**
Mi 515d	Supply chain (approfondissement)	*17*	***1***	A. PIZEL	16					1	**12**
Mi 515e	Contrôle de gestion de la production	*22*	***1***	V. PERRARD		20				2	**15**
Mi 515h	Projet compagnie aérienne	*6*	***2***	V. PERRARD				6	Project		**35**
Mi 515f	Stratégie de maintenance	*12*	***1***	V. PERRARD - J. NAVARATNAM	6	6			Project		**12**
Mi 515g	Gestion de production	*20*	***1***	V. PERRARD - J. NAVARATNAM	20				Project		**15**

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 Specialization

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 Specialization

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 Specialization

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 Specialization - Major 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 Specialization - Major 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 or VEHICLES Specialization - Major 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 - Thermal Transfers, Applied Thermodynamics

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 Specialization - Major 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 Specialization - Major 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 Specialization - Major 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 Specialization - Major 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 - Stratégie de maintenance

Expliquer le fonctionnement d'une entreprise avec les contraintes auxquelles elle peut avoir à faire face concernant la production quand on considère celle-ci dans l'environnement global de l'entreprise avec toutes ses fonctions. 2. Expliquer les méthodes de la gestion de production telles que les outils comme le MRP (Material Requirement Planning) le JAT (Juste à Temps) ou encore l'OPT (Optimized Production Technology)

Mi515g - Gestion de production

To provide students with knowledge of the various concepts and basic notions of quality management encountered in the main professional branches of industry and services. Gain a better understanding of what a quality approach is, and spread the culture and spirit of quality. mastery and application of the tools of a quality approach.

Mi515h - Projet compagnie aérienne

Ce projet vise à permettre aux étudiants d'analyser la stratégie d'une compagnie aérienne par 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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