INSTITUT POLYTECHNIQUE DES SCIENCES AVANCEES

IPSA
GRADUATE SCHOOL OF AERONAUTICS AND AEROSPACE ENGINEERING

MASTER OF AERONAUTICAL ENGINEERING 2018-2019

First year of Master (AERO4) curriculum

Spring semester

The second semester of Aéro4 is academic, the program being broken down into:

- A common core composed of Engineering sciences courses and elective modules open to all students
- A Human Sciences pole focusing on Labor law and Business Sociology open to French-speaking students
- A Corporate knowledge pole focusing on Management and Financial Management open to French-speaking students
- 2 majors : Vehicle (VEH) and Systems (SYS)
- 6 options : 3 for each majors

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

Systems major : 3 options
- Embedded systems & Telecommunication (SET)
- Mechatronic systems (SM)
- Space, Launchers & Satellites (ELS)

The student must choose one major and one option. They cannot mix courses from different majors and options.

Common core courses

Au411 - Graphic representation of Dynamic multilinear system

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

Prerequisites : Knowledge of automation, mechanics, hydraulics, electrical engineering

Mi411 - RAMS and FMECA Methodology

The objective of this module is to introduce students to the main methods of modelling systems and calculating their reliability and availability.

Aé411 - Flight Dynamics

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

Prerequisites : knowledge in aeronautics

Mo4xx - Elective Module

For EP, SET, MS and SM students: subjects will be given at the beginning of the semester

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

Mo4xx - Elective Module

For EP, SET, MS and SM students: subjects will be given at the beginning of the semester

For ELS students : 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.

Ci4xx - 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 (which is also in English).

Human Sciences pole

Sh411 - Responsabilité Sociétale des Entreprises

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.

Sh412 - Sociologie des Entreprises et 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.

Sh414 - Doit sociétal

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'œuvre, 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..).

Corporate knowledge pole

Mi415 - Management des grands projets

Connaître le fonctionnement en mode projet et son environnement
Apprendre les techniques de conduite de projets industriels ou de projets de systèmes d'information.
Apprendre à planifier et suivre la réalisation d'un projet
Savoir exprimer le besoin du client pour la conception d'un nouveau produit

Mi412 - 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.

Mi413 - 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.

Mi414 - Economie et Gestion Financière

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

Major "Systems"

Ma411 - Operations Research

The course is divided into two parts. We will start by studying linear programming (the geometric method and the simplex method). In the second part, in the context of integer linear optimization, we will present the Branch-and-Bound tree-search method and then some approximate type methods (the "metaheuristiques") such as the "variable depth" search methods of the "simulated annealing".

In this course we will not deal with the principle of dynamic programming, methods on graphs such as MPM or PERT methods, or methods based on flow optimization such as the Ford-Fulkerson algorithm.

In411 - 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.

Prerequisite: Object-Oriented programming

In412 - Real Time and Embedded 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.

Prerequisite: C/C++ skills, personal computer with gcc compiler

In413 - 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.

Prerequisite: 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

Au412- 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.

Prerequisite : Programming of microcontrollers

Major "Vehicle"

Aé412 - 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

Prerequisite: Fluid mechanics , Mechanics of continuous fluids

En413 - Energetics and Sustainable Design

Acquire notions in terms of national and international energy balances (who consumes what? In what proportions? How?)
Acquire knowledge on the reduction of energy reserves.
Become familiar with the concepts of global warming. Understand the implications of using new energies.
Understand the (simple) modelling of physical phenomena related to the greenhouse effect.
Acquire basic knowledge of the physical phenomena involved in renewable energy technologies.
Understand how this type of technology works.

Prerequisite: Thermodynamics, Physical Energy, Thermal Transfers

Mé417 - Advanced Continuum Mechanics

General introduction mechanics of materials – equations of elasticity – strain energy
Plane and axisymmetric problems:
- plane stress
- plane strain
Introduction to finite elements methods and experimental methods
Further developments – cracks propagation, notions of plasticity, introduction to design
Practical use of stress and strain tensors
Case study – design of a mechanical structure

Prerequisites:
- advance notions of mathematics (analysis, theory of distributions, statistics)
- Base notions of strength of materials – Theory of elastic beam, notions of elasticity, calculus of structures.
- Base notions of mechanics

Mé418 - Numerical Calculations in Mechanics and Structures (FEM)

This courses is intended to be an overview Finite Element Analysis using Patran and Nastran.
It is provided to be a supplement to a university course in FEA or to establish a foundation for a research project.

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:
- Static calculation of elastic structures
- Eigenfrequencies problem

Prerequisite: Finite elements (theoretical part) - Strength of materials - Mechanics of continuous fluids - Mathematics

Major "Systems"
Option "Embedded Systems & Telecommunications"

El411 - 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.

Prerequisite: FPGA circuit basics, VHDL, digital electronics.

Te411 - Telecommunications: Principles and Liaison Balance

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

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

Te412 - Guided Propagation and Hyperfrequencies

In this lecture, we will describe the theoretical models for the analysis of wave propagation along different forms (coaxial, microstrip...) and classification (TEM, TE...) of transmission lines. The reflected waves and the standing waves will also descript. Smith chart and its performances in microwave circuit analysis and transmission lines adaptation.

Prerequisite: The students must have knowledge on: Mathematics for Engineers, Physics, Electromagnetic Field, Electric Circuits, Electrical Drives, and Transmission Lines.

In414 - 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.

Prerequisite: C/C++ skills, personal computer with Arduino + Gnuplot platform.

Major "Systems"
Option "Mechatronics Systems"

Au421 - Power Electronics and 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 electro-hydrostatic actuators (EHA) and electro-mechanical actuators (EMA).

Prerequisite: Applied control (AU412), Multidomain physical modelling (AU411)

Au422 - Guidance Principles of Autonomous Systems

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

Au423 - Introduction to Robotics

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

Prerequisite: Applied control (AU412), Matlab/Simulink

In414 - 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.

Prerequisite: C/C++ skills, personal computer with Arduino + Gnuplot platform.

Major "Vehicle" & "Systems"
Option "Space, Launchers & Satellite"

Sp411 - Spatial 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.

Prerequisite: Introduction to Space Systems, General Physics, General Mechanics, Digital Analysis

Sp412 - Atmospheric reentry and mission concept project

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.

Prerequisite : Programming in MatLab and thermodynamics.

Sp413 - Space Optics

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

Sp414 - Physics of Plasma, Electrical & Plasma Propulsion

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

Prerequisite : fluid mechanics, electromagnetism, thermodynamics and heat transfer, a little statistical physics and atomic and molecular physics, notions of quantum mechanics and wave physics.

Major "Vehicle"
Option "Energetics & Propulsion"

En411 - Turbomachine Design

TThe objective of this course is to:
To understand thermodynamic cycle calculations and performance in adaptation and non-adaptation 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.

Prerequisite: Thermodynamics applied to turbomachinery , Aerodynamics of flows and profiles, Beam mechanics - Vibration mechanics, Thermal exchanges, Mathematics associated with these modules.

En412 - Thermal engines for drones and light aircraft

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

Prerequisite: Thermodynamics, Thermal Transfers, Applied Thermodynamics.

Mé421- Behavior Law for 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.

Prerequisite: MMC, Computation on Structural materials.

Major "Vehicle"
Option "Mechanics & Structures"

Mé416 - 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.

Prerequisite: knowledge of CAD

Mé419 - Metallic and 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.

Prerequisite : Background in general mechanics and aeronautical context

Mé420- Aircraft Strcutures 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.

Prerequisite : Background in material sciences and beam and shell theory.

Mé421- Behavior Law for 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.

Prerequisite: MMC, Computation on Structural materials.

Second year of Master (AERO5) curriculum

Fall semester

The first semester of Aéro5 is academic, the program being broken down into:

- A Human Sciences pole focusing on Societal Issues and Ethics in Engineering
- A Corporate knowledge pole focusing on Contract Law and Corporate Strategy open to French-speaking students
- A Project Master IPSA (PMI) : a project intended to develop iniative, autonomy and the ability to manage priorities
- 3 majors : Vehicle (VEH),Systems (SYS) and Management (MLI)
- 7 options : 3 for each thechnical majors (VEH & SYS) and 2 for MLI

WARNING: the major Management and its options are fully taught in French.

Vehicle major:
- Airframe & Materials (CAE)
- Energetics & Motorization (EMO)
- Space, Launchers & Satellites (ELS)

Systems major :
- Autonomous Airborne Systems Control (SAA)
- Operation & Transmission of Embedded Information (TIE)
- Space, Launchers & Satellites (ELS)

Management Major:
- Management des projets industriels (MPI)
- Management de la production et du MCO (MPM)

The student must choose one major and one option. They cannot mix courses from different majors and options.

Human Sciences Pole

Sh501 - 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.. ?

Sh502 - Ethics of Engineering

Beyond the laws, codes and charters of ethics, this course aims to to make future engineers aware of the plurality of morals by confronting them with concrete professional situations with dilemmas. By deliberation around of these situations, a critique of organizations, procedures and values is emerging, to better understand the concepts of transparency, accountability and emancipation (empowerment).

Sh503 - Human Factors and Man-Machine Interaction

At the end of this course, students will have understood through the analysis of air accidents, their causes, and the risks specific to the different phases of flight:
- The importance of taking into account the human factor in risk control, and its general consequences on design;
- More specifically, the importance of taking into account the human factor in the design of the human-machine interface

Sh508 - Environmental dimension of CSR

RMeeting the needs of the present without compromising the needs of future generations is the sustainable development approach that is the responsibility of the engineer. This course aims to raise awareness of the environmental impact of technical achievements and industrial programmes (particularly in aeronautics and space). Based on real cases, it invites us to question the principles of solidarity, precaution, participation and responsibility in the exercise of the engineering profession.
The objective is to integrate social equity and ecological prudence into long-term economic development models.

Corporate knowledge Pole

Sh504 - Droits des contrats et Droit du travail

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'œuvre, à la sous-traitance. Mode de calcul des salaires et des incidences diverses : déplacements, trajets, transports... Organisation du travail : temps de travail, heures nor**mal**es 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..).

Sh507 - Connaissance et Insertion milieu industriel

Cette matière doit permettre aux étudiants de :
- Se préparer à l'insertion professionnelle
- S'approprier les outils de candidatures
- Préparer les entretiens adaptés à un premier emploi
- Définir et Préparer son projet professionnel

Mi502 - 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.

Mi503 - Code de la Commande Publique

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.

Pf531 - Projet Master IPSA

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.

Major "Systems"

Au561 - Aicraft Modelling & 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

Au541 - Systems deterministic & Stochastic observers

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)

Te521 - EM compatibility and 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.

Au521 - 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

Major "Vehicle"

Aé501 - Hypersonic Aerodynamics Introduction

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.

Prerequisite: Subsonic and supersonic aerodynamics course. 'Mechanics of flight' course.

Mé512 - Reliability Approach in Mechanics

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

Mé515 - Computational Fluid Dynamics (CFD)

At the end of this course 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.

Prerequisite: Course in 'Fluid Mechanics'.

Mé531 - Airborne and Ground Payload

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.

Prerequisite: Background in aerodynamics and flight mechanics..

Mé534 - Vibration Dynamics of Plates and 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

Major "Management"

Mi511 - Achats et 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

Mi513 - Management des coûts

Ce module de Management des coûts doit permettre aux étudiants de comprendre et maîtriser les principales méthodes de détermination et d'analyse des coûts.

Mi514 - Conduite de projets - Intro SAP

Ce module doit permettre à l'étudiant futur maître d'ouvrage dans une grande entreprise de Piloter un projet de mise en œuvre d'un système d'information de gestion, et en particulier un système qui sera développé avec SAP.

Mi515 - 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.

Mi516 - Supply chain

A l'issue de ce cours, l'étudiant doit avoir :
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)
une connaissance des principaux outils numériques (ERP, SGM, IA, ...)

Major "Systems" Option "Autonomous Airborne Systems Control"

In531 - Artificial Intelligent Control

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

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

In541 - Distributed Intelligent Systems

This course, which is part of the embedded intelligence field, allows to approach the various learning algorithms (algorithms allowing to memorize a situation to reproduce an adapted command) and their applications in Distributed systems (e.g., a swarm of drones).

Prerequisite: Knowledge of artificial intelligence

Au571 - Drones and Visual Servoing

At the end of this course, the student:
1. will know the basics in image processing
2. will be able to manipulate images and apply basic image processing algorithms (contour detection, image enhancement, noise reduction)
Will be able to follow the courses of processing of images of higher levels, Mathematical morphology, image compression)

Au581 - Control of Linear Systems

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.

Au501 - Project: Dynamic Palnning of Autonomous navigation

Major "Systems"
Option "Operation & Transmission of Embedded Information"

In511 - 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.

Prerequisite: 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.

Te541 - Airborne Sensors and Data Transmission

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

Te511 - Aeronautical Telecommunications Systems

At the end of this course, the student should:
- Know the main elements of a digital telecommunication chain as well as the architecture of the current principal telecommunication systems.
- Understand the principles governing the implementation of the various technologies and the possible uses of each.
Be able to apprehend their respective contribution to overall performance (example of complex system) and to mobilize resources from the field of basic sciences to calculate the performance of a telecommunication system.

Prerequisites: Fundamentals of analog signal processing and analog modulations.

Te501 - Cursus project

Major "Systems" & "Vehicle" Option "Space, Launchers & Satellites"

En504 - Space Propulsion System

To introduce students to the architecture of propulsion systems for space launchers, Master the important parameters of these systems, To be able to dimension this type of propulsion system using simple methods and to estimate the performances.
To know the basics of the technology of these engines.

Prerequisites: Thermodynamics (In 21a and b) - Thermal Transfers (in 31), Applied Thermodynamics In 32b)

En506 - Alternative Energy Propulsion

This 5th year 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. In this second part, we focus on several electric motor concepts by detailing their performances and particularities, finishing on the innovative concepts, the issues at stake for society and commercial aspects of electric propulsion. An update on the status of research is presented at the end of the module. 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 (PH22),Wave Physics 1 & 2 (PH23a and PH23b), Fluid Mechanics (aero 2)

Sp551 - Satellites Design

Provide students with basic elements of satellite design.
Know all the subsystems that make up a satellite
To know the orders of magnitude and to know how to make a preliminary dimensioning of some subsystems.

Prerequisite : space mechanic, thermic, electricity, automatic

Sp552 - Lauchers Design

At the end of this course, the student will:
- be able to understand the problems of the design of the launchers
- know the basic principles of space mechanics
- know the different technical fields that come into play in the Calculation of trajectories.
Will be able to put into practice the theoretical principles to design a launcher

Prerequisite: Space mechanics course

Sp554 - Payload Integration and 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

Sp555 - 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)

Major "Vehicle"
Option "Aiframe & Materials"

Aé533 - Vertical Flight

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

Prerequisite : Aerodynamics

Mé532 - Multi-body Mechanical Simulation

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

Prerequisite : vibrational dynamics, CAD, solid mechanics.

Mé533 - Calculations about 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.

Mé534 - 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

Mé535 - Advanced Sustainability of 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

Prerequisite : MMC, Laws of behaviour, Composite materials

Mé514 - 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, Patran/Nastran, Continuum mechanics

Major "Vehicle"
Option "Energetics & Motorization"

En501 - Turbine Engines

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.

Prerequisite : 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.

En502 - Desing of a Propulsion System

At the end of this module, students will be able to conduct a critical reflection on a propulsion system project through practical dimensioning work on a component using simplified tools. (application of modules En33, En 411 and En501).

Prerequisite : 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.

En503 - 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.

Prerequisite: Thermal engines for drones and light aviation.

En504 - Space Propulsion Systems

To introduce students to the architecture of propulsion systems for space launchers, Master the important parameters of these systems, To be able to dimension this type of propulsion system using simple methods and to estimate the performances.
To know the basics of the technology of these engines.

Prerequisites: Thermodynamics (In 21a and b) - Thermal Transfers (in 31), Applied Thermodynamics In 32b)

En506 - Alternative Energies Propulsion

This 5th year 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.
In this second part, we focus on several electric motor concepts by detailing their performances and particularities, finishing on the innovative concepts, the issues at stake for society and commercial aspects of electric propulsion. An update on the status of research is presented at the end of the module.
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 (PH22),Wave Physics 1 & 2 (PH23a and PH23b), Fluid Mechanics (aero 2)

Aé536 - Turbulences

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

Major "Management"
Option "Management des projets industriels"

Mi521 - 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.

Mi522 - 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.

Mi523 - 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 indus-triels en situation complexe.

Mi524 - 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.

Mi525 - Analyse et 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.

Mi526 - 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.

Mi527 - 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.

Mi528 - Simulation informatisée à la gestion d'entreprise

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.

Major "Management"
Option "Management de la production"

Mi532 - Journée Etude de cas Supply Chain

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.

Mi533 - 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.

Mi534 - 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.

Mi535 - Supply Chain (approfondissement)

A l'issue de ce cours, l'étudiant doit :

o Être capable de tenir un poste à responsabilité au sein de la supply chain d'une grande entreprise,

o 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.

Mi536 - 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

Mi537 - Industrialisation - Méthodes de production- Cycle de vie des produits - Gestion de configuration

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

Mi538 - Navigabilité et MCO

A l'issu de ce cours, l'étudiant devra :

o connaitre l'historique et les exigences de la maintenance avion

o comprendre les raison de la maintenance aéronautique

o connaitre les processus de mise en place de la maintenance par l'intermédiaire des programmes de maintenance

o Etre capable de prendre en compte les contraintes liées à l'utilisation de l'avion et le maintien en condition opérationnelle nécessitant le respect des règles de sécurité

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