SEMESTER 9
ENGINEERING FIELDS OF APPLICATION
PROGRAMME
MSO 2020-2021
MOS 2019-2020
## OPTIONS (2020-2021)

### AERONAUTICAL ENGINEERING
- Aircraft design project
- Conferences
- Elective project: Acoustics and Vibrations
- Elective project: Guidance and Control
- Elective project: Materials and Structures
- Elective project: Propulsion

### ENERGY

#### ON-BOARD ENERGY
- Alternative fuels
- Cogeneration
- Oil and gas
- Project EN

#### INFRASTRUCTURE ENERGY
- Energy Networks
- Nuclear Engineering
- Project
- Thermal Generation

#### BIO-ENGINEERING AND NANOTECHNOLOGY

#### BIO-ENGINEERING
- Bio-computing, bio-statistic and modelisation
- Bioproduction
- Conferences
- Living-material interactions
- Medical imaging
- Project

#### NANOTECHNOLOGIES
- Conferences
- Memories for Internet of Things
- Nano-optics
- Photonic guides
- Project
- Smarts surfaces

#### CIVIL AND ENVIRONMENTAL ENGINEERING

#### STRUCTURES AND WORKS
- Constructions
- Project
- Transportation facilities
ENVI RONMENTAL ENGINEERING
Advanced Building Physics .......................................................... 47
Bioresmediation ........................................................................... 51
ENV Project ................................................................................... 53
Geographical Information Systems ............................................. 49
Hydrogeology .............................................................................. 50
Water quality and water treatment .............................................. 48

ENERGY AND SUSTAINABLE BUILDING .................................. 54
Building Comfort ........................................................................ 55
Project ......................................................................................... 57
Renewable Energy Systems ....................................................... 56

SUSTAINABLE BUILDING ......................................................... 58
Building Comfort ........................................................................ 59
Project ......................................................................................... 61
Renewable Energy Systems ....................................................... 60

COMPUTER SCIENCE ................................................................. 62
Big-data Technologies .................................................................. 63
Computer Vision .......................................................................... 67
Deep structured learning ............................................................. 66
Geometric Calculation and Modeling for Computer Graphics ..... 68
Information systems in practice .................................................. 64
Internet of Things (IoT) ............................................................... 65
Real Time, Embedded and Mobile System .................................... 69
Technology Project ..................................................................... 70

MATHEMATICS AND DECISION MAKING .................................. 71

APPLIED MATHEMATICS, AND RISK ENGINEERING .................. 72
Advanced Tools for Learning : when Convexity meets Sparsity ..... 73
An introduction to Inverse Problems .......................................... 75
Introduction to financial mathematics ....................................... 74
Project MIR ................................................................................. 76

FIRM’S DECISION MAKING ......................................................... 77
Business game ............................................................................. 79
Decision support systems ........................................................... 80
Process simulation ..................................................................... 78
Project ......................................................................................... 81

TRAFFIC AND TRANSPORTATION ............................................... 82

TRAFFIC AND ENVIRONMENT .................................................... 83
Sites Visits .................................................................................. 89
Society and Transports ............................................................... 84
Transports Engineering ............................................................... 85
Transports Logistics ................................................................... 87
Transports Security ..................................................................... 86
TT Project ..................................................................................... 88
SUMMARY

VEHICLE TECHNOLOGY

Sites Visits ................................................................. 96
Society and Transports .................................................. 91
Transports Engineering .................................................. 92
TT Project ....................................................................... 95
Vehicle's Body and Architecture ...................................... 94
Vehicule Dynamics ........................................................... 93

ENGINEERING FIELDS OF APPLICATIONS (2019-2020) ........ 97

Active control of noise and vibrations ................................. 101
Advanced Foundation Engineering ...................................... 118
Atmospheric Pollution ...................................................... 114
Choice of materials and assemblies ...................................... 105
Civil engineering works ..................................................... 128
Coastal and Ocean Engineering ......................................... 113
Complex phenomena in structural dynamics ....................... 120
Computer Graphics .......................................................... 104
Decision support algorithms ............................................... 103
Dynamics of mechanisms .................................................. 107
Electromagnetic compatibility ............................................ 108
Energy and environmental impact ........................................ 129
Functionalized thin layers and surfaces ............................... 102
Hybrid electric vehicles : modelling and energy management 110
Information Technology .................................................... 116
Interactive Data Visualization ............................................ 121
Intrapreneur ................................................................... 130
Macro Energy ................................................................. 106
Managing business information systems ............................... 115
Microsystems, biosensors, microfluidics ............................... 124
Natural resources and their management ............................. 117
Physical problems in unbounded media : mathematical analysis and numerics ........................................... 119
Stability of rotating machines ............................................ 126
Startup creation ................................................................ 131
Strategic Management ...................................................... 123
Structural and system health monitoring ............................. 127
Structures for Power Generation ........................................ 109
Time series econometrics .................................................. 125
Tissue engineering and biomaterials .................................... 122
Traffic Flow Theory and Management .................................. 111
Transonic aerodynamics .................................................... 98
Transportation Noise ......................................................... 99
Unsteady flows in turbomachinery ...................................... 112
Vehicle Design ................................................................. 100
Semester 9 at Ecole Centrale de Lyon

During S9, students attend the following teaching units:
- UE Engineering Professions (September-November),
- UE Engineering Fields of Applications (January-March),
- UE General Engineering Modules (October-December),
- UE Languages and Cultures.

1. UE Engineering professions

Specific modules of the engineering profession (92h+30h project)
In this unit, the student must choose a module among 8:
- IBDE - Business Development Engineer
- ICS - Consultant Engineer
- ICO - Eco-Design and Innovation Engineer
- IGO - Industrial Operations Management Engineer
- IMR - Industrial and Environmental Risk Management Engineer
- IRD - Innovation, Research and development Engineer
- ISC - Supply Chain Engineer
- IE - Entrepreneur Engineer

The grade of the specific module is calculated from the weighted averages of the training actions taken in each module.

Open modules of the engineering profession (56h)
In addition to this specialization, students choose two courses among seven courses (MOM):

<table>
<thead>
<tr>
<th>Slot 1</th>
<th>Monday 14:00-16:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOM 1.1</td>
<td>Engineering Systems</td>
</tr>
<tr>
<td>MOM 2.1</td>
<td>Management of the Industrial Company</td>
</tr>
<tr>
<td>MOM 3.1</td>
<td>Company Law</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slot 2</th>
<th>Monday 16:00-18:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOM 1.2</td>
<td>Quality Management</td>
</tr>
<tr>
<td>MOM 2.2</td>
<td>Economic Intelligence and Information Protection</td>
</tr>
<tr>
<td>MOM 3.2</td>
<td>Human Resources Management and Organizations</td>
</tr>
<tr>
<td>MOM 4.2</td>
<td>Natural and Technological Risks</td>
</tr>
</tbody>
</table>

The grade of the open module is the average of the two MOM grades.

Assessment
The UE grade is the weighted sum of the specific module (80%) and the open module (20%). The UE is validated if the average is greater than 10 and if the grade of each course within each module is greater than 10.
2. UE (164h+50h project)

Specific modules of the Engineering fields of applications (80h+50h project)

In this unit, the student must choose a module among 7:

◊ AE - Aeronautics
◊ BIN - Bio-Engineering and Nanotechnologies
◊ EN - Energy
◊ GCE - Civil Engineering and Environment
◊ INFO - Computer
◊ MD - Mathematics and Decision
◊ TT - Transportation and Traffic

The grade of the specific module is calculated from the weighted averages of the courses taken in each module. The module is validated if the average is above 10.

Open modules of the Engineering fields of applications (84h)

In addition to this specialization, students choose three courses among 32 courses (MOS):

<table>
<thead>
<tr>
<th>Slot 1</th>
<th>Monday 8:00-12:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOS 1.1</td>
<td>Transonic Aerodynamics</td>
</tr>
<tr>
<td>MOS 2.1</td>
<td>Decision Support Algorithms</td>
</tr>
<tr>
<td>MOS 3.1</td>
<td>Electromagnetic compatibility</td>
</tr>
<tr>
<td>MOS 4.1</td>
<td><strong>Natural Ressources and their management (English)</strong></td>
</tr>
<tr>
<td>MOS 5.1</td>
<td>Advanced Foundation Engineering</td>
</tr>
<tr>
<td>MOS 6.1</td>
<td>Tissue Engineering and Biomaterials</td>
</tr>
<tr>
<td>MOS 7.1</td>
<td><strong>Stability of Rotating Machines (English)</strong></td>
</tr>
<tr>
<td><strong>Slot 2</strong></td>
<td><strong>Wednesday 8:00-12:00</strong></td>
</tr>
<tr>
<td>MOS 1.2</td>
<td><strong>Transportation Noise (English)</strong></td>
</tr>
<tr>
<td>MOS 2.2</td>
<td>Computer Graphics</td>
</tr>
<tr>
<td>MOS 3.2</td>
<td>Structures for Power Generation</td>
</tr>
<tr>
<td>MOS 4.2</td>
<td><strong>Atmospheric Pollution (English)</strong></td>
</tr>
<tr>
<td>MOS 6.2</td>
<td>Strategic Management</td>
</tr>
<tr>
<td>MOS 7.2</td>
<td><strong>Structural and System Health Monitoring (English)</strong></td>
</tr>
<tr>
<td><strong>Slot 3</strong></td>
<td><strong>Wednesday 14:00-18:00</strong></td>
</tr>
<tr>
<td>MOS 1.3</td>
<td>Vehicle Design</td>
</tr>
<tr>
<td>MOS 2.3</td>
<td>Choice of Materials and Assemblies</td>
</tr>
<tr>
<td>MOS 3.3</td>
<td>Hybrid Electric Vehicules: Modelling and Energy Management</td>
</tr>
<tr>
<td>MOS 4.3</td>
<td>Managing Business Information Systems</td>
</tr>
<tr>
<td>MOS 5.3</td>
<td><strong>Physical Problems in Unbounded Media: Mathematical Analysis and Numerics (English)</strong></td>
</tr>
<tr>
<td>MOS 6.3</td>
<td>Microsystems, Biosensors, Microfluidics</td>
</tr>
<tr>
<td>MOS 7.3</td>
<td>Civil Engineering Works</td>
</tr>
</tbody>
</table>
The grade of the open module is the average of the three MOM grades.

**Assessment**

The UE score is the weighted sum of the specific module (50%) and the open module (50%). The UE is validated if the grade is greater than 10 and the score of each courses within each module is greater than 10.

### 3. UE General engineering modules (180h)

In this unit, the student must choose six courses (AF) among nearly fifty. In some conditions, a master course can be replaced by an AF (and vice-versa). The list of the courses is available in another booklet.

**Assessment**

The UE grade is the average of the 6 courses grades. The UE is validated if each grade is greater than 10.

**Semester 10: End of studies work (TFE)**

The End of Studies Work ends the engineering training with an internship of 5 to 6 months in a company or a laboratory. The student carries out a high-level scientific, technical and methodological work. The TFE ends with the writing of a dissertation and an oral defence in front of a jury.
OPTIONS (2020-2021)

DEAN

Grégory VIAL, Dean of Studies
Ségolène CALLARD, Vice Dean of Studies
**AERONAUTICAL ENGINEERING**

Directors: Jérôme Boudet, Olivier Dessombz

130h

**Introduction**

This option provides knowledge and know-how on aircraft design. Aeronautical engineering involves a great variety of disciplines. In the frame of this option, students define their specialization between the following disciplines: aerodynamics, acoustics, EEA, material engineering and structural mechanics. Teaching is organized essentially with tutored projects, with both transverse and specific aspects. Starting from the preliminary design of a business jet (common project), students choose between four different elective projects that focus on an element (turbojet engines, wings, fuselage...) or a discipline (acoustics, materials, control of aircraft...) in order to reach a more effective design (e.g. lower consumption or emissions...).

**Departments/Laboratories**

LMFA, LTDS, Ampère

**Programme**

AE 3.1: conferences.
AE 3.2: aircraft design project.
One elective project, to select between:
AE 3.31: acoustics and vibrations.
AE 3.32: control of aircraft.
AE 3.33: materials and structures.
AE 3.34: propulsion.

**Learning Outcomes**

◊ Formulate an engineering problem in aeronautical engineering.
◊ Model a complex system.
◊ Solve a multi-disciplinary problem.
◊ Use knowledge and know-how for the design of a complex system.

**Employment Sectors**

SAFRAN group (Safran Aircraft Engines, Safran Helicopter Engines, Safran Nacelles, ...), Airbus group (Airbus, Airbus Helicopters), Dassault Aviation, ONERA, CNES Toulouse, Hexcel composites...

**Requirements**

General engineering curriculum of ECL, or equivalent.
For the propulsion elective project (AE 3.34): MOS 1.1 or MOS 3.5, and MOS 5.4 or MOS 7.1.

**Assessment**

AE 3.1 : 15%, AE 3.2 : 25%, AE 3.3 (1,2 ou 3) : 60%
CONFERENCES

Lecturers: Olivier Dessombz

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 20 h | Project: 0 h | Language: 🇫🇷 |

Objectives

The conference cycle aims to provide a broader view of the different sectors and professions of aeronautics.

Keywords:

Programme

Cycle of 10 conferences of 2 hours, provided by engineers working in different sectors / aeronautics professions.

Learning outcomes

◊ to have a broader vision of the aeronautical field
◊ identify the challenges in the field of aeronautics
◊ to know the opportunities offered by the aeronautical option
**AIRCRAFT DESIGN PROJECT**

**Objectives**

This project concerns the preliminary design of a business jet, with given specifications (number of passengers, range, runway length...). The interactions of the global design choices are investigated with simplified models, using an iterative approach. This project is supported by Dassault Aviation.

**Keywords:** business jet, preliminary design

**Learning outcomes**

- Identify the influence of the aircraft design parameters on the performances.
- Elaborate and implement a multi-disciplinary design process.
- Propose and assess models for preliminary design.

**Core texts**


**Assessment**

Evaluation of the intermediate and final deliverables, including spreadsheets and oral presentation.
**Objectives**

The purpose of the project is to evaluate the vibratory and acoustic disturbances related to the aircraft, by distinguishing the nuisances produced by the aircraft around the airports, that is to say the external noise, and the nuisances suffered by the aircraft in terms of internal noise or mechanical strength. One of the objectives of this project is to obtain a dimensioning integrating several constraints related to the environment and/or safety, without neglecting the performance and robustness of the aircraft.

**Keywords:**

**Programme**

The proposed studies, which will be defined according to the sensitivity of the students, will use a strong interdisciplinarity in order to highlight the origin of the nuisances, and to examine realistic dimensioning solutions. Below are some project topics that have been realized in recent years:
- Impact studies near airports for take-off and landing.
- Optimization of traffic and trajectories to reduce the ground track of noise.
- Estimation of the noise and vibration levels induced by the flow in cruising flight for the internal noise.
- Location of surface acoustic sources from the knowledge of noise in the cabin.

**Assessment**

Participation, written report and defense
**Objectives**

The development of unmanned flights (aerospace) has led to the development of powerful control methods adapted to the strong constraints of this field: multi-actuators multi-sensors with important performance requirements. These methods were very quickly deployed in the military aeronautics (reactivity) before massively broadcast in the civil aeronautics. With the reinforcement of competition, it is crucial to manage energy as efficiently as possible in order to limit costs while ensuring the comfort and safety of passengers, which makes control systems indispensable. The objective of this project is to train in the methods of design and validation (robustness) powerful control systems, essential in the aerospace industry.

**Keywords:** Automatic, Multi-actuator multi-sensor control (multivariable), Flight mechanics, Robustness

**Programme**

- A first step of bibliographic study in which it will be necessary to become familiar with some notions of dynamics of flight, to understand the model of lateral movement, to formalize the specifications for the design of the laws of control. A series of lectures will be dedicated to flight mechanics.

- A second stage of actual design correctors. Depending on the specifications, students are asked to choose from a set of multivariable methods (placement of poles, H-infinity, LQG, ...), a suitable method for the calculation of the corrector.

- A third step of validation by application of robustness analysis methods.

**Learning outcomes**

- Know how to formalize the specifications of a control
- Know how to design a multivariable control algorithm answering a complete specification
- Know how to analyze the robustness of a control system
- Know how to apply the skills above on a civil transport plane

**Core texts**


**Assessment**

- Participation, written report and defense
**Objectives**

The project will focus on a particular system to carry out an in-depth study based on the functional specifications.

For example:
- Aircraft fuselage assembly (Mechanics of Structures + Materials).
- Damping of sandwich panels for aircraft floor (Mechanics of Structures + Materials).
- Bonding assembly of aerospace composites: non-destructive testing and characterization (Materials).

**Keywords:**

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**Assessment**

Participation, written report and defense
**Elective project : Propulsion**

**Objectives**
Design of a turbojet engine, with aerodynamic and mechanical specifications. Multi-disciplinary project organization.

**Keywords:** turbojet engine, compressor, turbine, aerodynamics, thermodynamics, structural mechanics, ensemble dynamics

**Programme**

To begin with, thermodynamic cycle calculations are used to define the overall architecture of the reactor to provide the thrust determined during the aircraft project. A one-dimensional analysis then leads to the definition of the number of components constituting this engine. ‘Zooms’ on particular components are finally made to address concrete and in-depth examples of expertise. For example:

- Detailed design of compressor stages, from 3D mechanical and aerodynamic simulations.
- Management of the combined constraints of aerodynamics and mechanics.
- Analysis of the overall dynamics (tree, disks, links ...).

Two series of courses support the realization of the project:

- Simulations in aerodynamics
- Overall dynamics

**Learning outcomes**

◊ formulate an engineering problem
◊ use knowledge and know-how for the detailed design of a system

**Core texts**


**Assessment**

Participation, report and oral presentation.
Introduction
The availability of an energy in sufficient amount and at a reasonable cost is fundamental for the current and future development of our modern societies. If the energy problem is identified as one of the major challenges that the next generations will have to face, it is already one in the essential concerns of the current world both at the industrial level and at the level of the society, generally speaking (energy transition, environmental impacts). Teachings of this option want to give the widest possible vision of the energy problem, on a long-term perspective and taking into account its current industrial and societal implications: to understand how are elaborated energy development policies, and how are structured energy supply and distribution pathways.

Departments/Laboratories
STMS, EEA

Programme
One pathway to choose: "Energy empowerment" EE (oil & gas, biofuels, hydrogen, or "Infrastructure energy" EI (energy networks, nuclear).
Course common to the 2 pathways: thermal production (cogeneration, methanisation, PV, wood, wind...)

Learning Outcomes
◊ Identify the possible ways of progress in the sector of energy
◊ Evaluate and quantify the energetic, the environmental and the economic impacts of different energy chains
◊ Comprehend an energy production project in its globality
◊ Manage a project in the field of energy.

Employment Sectors
-Industries of the energy sector (technical, commercial, trading)
-Industries of transportation and sectors with high consumption
-Territorial collectivities
-Consulting

Requirements
Depends on the chosen pathway. From a global point of view in engineering sciences : thermodynamics, energy mechanics, electrical engineering.

Assessment
Depends on the chosen pathway

Option Website
www.option-energie.ec-lyon.fr (en construction)

Additional Information
Les aspects sur la transition énergétique (énergies renouvelables, impacts environnementaux) sont abordés aussi bien dans les filières que dans les Modules Ouverts Sectoriels associés à l’option.
**Introduction**

"Energy Empowerment" master presents three topics:
1. Technological and technical developments from prospecting and extraction to processing operations and distribution of classical energy sources (oil, gas, coal). Regulatory and environmental constraints are included;
3. Cogeneration approaches

The notions are presented in a context of strong changes in energy production industrial pathways, and are related with environmental impacts and the question of energy mix. How to structure industrial and economical structures to increase renewable primary energy production (biomass, wind, solar...), based on the knowledge of current energy production systems, at the world scale?

A significant part of the courses of EE is common with pathway "Energy & Infrastructure", because it is important to relate problems of energy sources and energy networks.

<table>
<thead>
<tr>
<th>Departments/Laboratories</th>
<th>Programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>STMS</td>
<td>EE 3.1 - Oil and gas</td>
</tr>
<tr>
<td></td>
<td>EE 3.2 - Alternative energy sources</td>
</tr>
<tr>
<td></td>
<td>EE 3.3 - Cogeneration</td>
</tr>
<tr>
<td></td>
<td>One project</td>
</tr>
</tbody>
</table>

**Learning Outcomes**
- Comprehend all the scientific and technical dimensions of a problem in the field of energy
- Understand and communicate in English in the energy sectors.
- Integrate rules and quality / security / environmental standards in the industries related to production and transportation of energy
- Take into account the societal, legal, financial, economic stakes of energy sectors

**Employment Sectors**
Example of partner companies and recruiters:
IFPEN, TOTAL, ENGIE, Technip, Subsea...

**Requirements**
Mandatory MOD: "Energy, storage and conversion"
Mandatory MOS: "Macro energy"
Recommended MOS: "Energy and impact on environment".

**Option Website**
www.option-energie.ec-lyon.fr (en construction!)

**Additional Information**
Autres modules ouverts conseillés: "Système électrique", "Eoliennes", "Turbines pour la production d'énergie", "Gestion de l'énergie dans le transport"
Objectives

Oil and Gas play an important role since the sixties in energy consumption and development of countries. Diversity of problem technic, scientific is focused and presented in each step of life cycling of fossils fuels. A particular interest is given to oil transformation and product in the second part of this course.

Keywords: Oil; gas; fossil fuels;

Programme

Part 1: Prospection, Extraction
  - What to look for
  - A Natural Underground Storage: concept of traps, concept of seals
  - Hydrocarbons
  - Seismic survey
  - Exploration drilling
  - Data acquisition in an exploration well
  - Development project
  - Economically Recoverable Quantities

Part 2: Refining and petroleum products
  - Petroleum products
  - Refinery treatment processes
  - CO2 Capture: Methods and processes, Geological storage
Objectives

Countries want to develop energetic alternatives to reduce their environmental impact. In particular in transport, the aim is to find a credible industrial vector to take a significant place in a market dominated by petrol and diesel. In this course, biofuels and hydrogen is focused as realistic alternatives. A large panel of technologies (wood energy, fuel cells) is also presented beyond transport industry.

Keywords: Fuels; alternative; environment

Programme

Part 1: Biofuels
- Context and standard for 1st and 2nd generation: Context, resource and availability, greenhouse gas emissions, politics of biofuels development
- Biofuels today: ethanol, ethers, biodiesel, hydroprocessing of vegetable oils
- 2nd generation of biofuels: ligno-cellulosic biomass, Chemical processes: bioethanol production, thermochemical processes: direct and indirect operation, focus on BTL
- Alternative solutions and 3rd generation: Microalgae

Part 2: Hydrogen
- Sources and production processes:
- Purification of hydrogen
- Transport, storage and distribution;
- Energetic conversion of hydrogen
- Fuel Cells: properties and applications, principle, thermodynamic aspect, kinetic aspect, electrocatalyst approach, different types & applications

Part 3: Wood
Objectives

The course "cogeneration" is common to pathways EE & EI. It introduces various approaches for improving overall yields. This course introduces various approaches for energy production improvements. It also introduces renewable energies. And their optimization depends on many factors: technical, economic, and legislative. In this context, some answers will be given on:
- place of coal and gas in cogeneration context?
- wood, hydrogen, and biofuels?
- photovoltaics, wind energy
- How to choose and design the right technology such as to increase efficiency and to reduce environmental impact?
- How to evaluate economic value of a project?

Keywords:

Programme

Part 1: Coals combustion
- Coal: An heterogeneous solid Fuel
- HELE: Industrial Combustion Challenges: pulverized coal, fluidized bed plants
- Gasification Plant IGCC
- CO2 Emission Drawback: reduction, capture
- Coal-fired Plant perspectives

Part 2: Wood and others biomass
- Resource
- Solid bio-fuels
- Criterion of choices
- The supply of boiler rooms
- Combustion an emissions
- Market and prediction

Part 3: Gaz and technology of cogeneration
- Gas turbine and steam turbine
- Heat Recovery Steam Generator
- Evaporative desalination processes →MED, MSF
- Case study: Taweelah installation

Part 4: Economic evaluation
**Project EN**

**Lecturers:**

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

**Objectives**

**Keywords:**
Introduction

Departments/Laboratories

E.E.A.

Programme

Learning Outcomes

Employment Sectors

Requirements

Assessment

Option Website

Additional Information

MOD conseillés : « Énergie Nucléaire », "Turbines pour la production d’énergie", "Eoliennes"
RÉSEAUX D’ÉNERGIE

ENERGY NETWORKS

Lecturers: D. VOYER

| Lectures: 14 h | TC: 0 h | PW: 8 h | Autonomy: 0 h | Study: 4 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
PRODUCTION THERMIQUE

THERMAL GENERATION

Lecturers: D. VOYER

| Lectures: 28 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: ❓ |

Objectives

Keywords:
AF EI 3.3

INGÉNIERIE NUCLÉAIRE
NUCLEAR ENGINEERING

Lecturers: Yves ROBACH

| Lectures: 27 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
AF EI 3.4

**PROJET EN**

**PROJECT**

**Lecturers:**

| Lectures: 0 h | TC: 0 h | PW: 50 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

**Objectives**

**Keywords:**
**Introduction**

The aim of this option is to provide multidisciplinary chemistry-biology-physics training to engineering students, enabling them to apprehend recent and future applications of high technologies in the fields of bioengineering (or engineering for living things) and nanotechnologies. The general engineering skills acquired during the first two years will be supplemented by fundamental knowledge in micro- and opto-electronics, photonics, nanosciences and biology. The interactions between these different disciplines will be illustrated through different examples: microsensors, functional materials, systems on chips, medical imaging, biomaterials, Big data, ...

The engineering students from this training will be privileged interlocutors to lead projects at the interface of these different disciplines.

**Departments/Laboratories**

STMS, EEA INL, LTDS, Ampère, LMFA

**Programme**

BIN3.1 - Lecture Series
BIN3.2 - Option project
1 sector of your choice:
Bio-Engineering (BIO)
Nanotechnology (NANO)

**Learning Outcomes**

◊ Understanding the challenges of health and nanotechnology
◊ Acquire knowledge in biology and nanotechnology
◊ Understand the issues of miniaturization
◊ Apply knowledge to solve multidisciplinary problems
◊ Implement multidisciplinary projects

**Employment Sectors**

Research and Development, Quality, Production, Consulting. Business sectors: microelectronics and information technologies, energy, medical imaging, pharmaceutical and cosmetics industry, agro-food and the environment.

**Requirements**

2 compulsory MOS from:
MOS 1.5 "Thin films and functionalized surfaces"
MOS 6.1 "Tissue engineering and biomaterials"
MOS 6.3 "Microsensor, Microsystem, Microfluidics"
MOD: depends on the chosen course, some MOD are in equivalence of courses of Master

**Additional Information**

Masters Recherche co-acrédités:
Energie Electrique, Electronique, Automatique (3EA)
Ingénierie de la Santé (IdS)
Matériaux
NanoScale Engineering (NSE)
**Introduction**

Bioengineering is about technologies to develop diagnostic tools and more efficient treatments, to model and simulate biological processes and the evolution of life, to design new materials and devices miniaturized and communicating to develop a personalized medicine. It is based on advanced concepts and tools in physics, optics, chemistry and chemical engineering, electrical engineering, mechanics and mechanical engineering. The aim of this sector is to enable general engineers to acquire both technical and scientific knowledge enabling them to manage transversal projects and technology transfer. Combining sciences for the engineer and life sciences, this sector offers high level training in strong interactions with industrial and societal expectations in the fields of health and life.

**Departments/Laboratories**

- STMS, MFAE, MI / INL, LTDS, Ampère, LMFA, ICJ

**Programme**

- BIO3.1 - Medical Imaging
- BIO3.2 - Material-living interactions
- BIO3.3 - Bioproduction
- BIO3.4 - Bio-informatics, bio-statistics and modeling

**Learning Outcomes**

- Understanding the challenges and issues related to health
- Acquire knowledge in biology and nanobiotechnology
- Apply knowledge to solve multidisciplinary problems
- Implement multidisciplinary projects

**Additional Information**

MOD fortement recommandés : MOD 9.4 - Comportement des matériaux ; MOD 6.2 - Matière molle : nanosystèmes et interfaces biologiques ; MOD 6.6 - Dynamique des systèmes biologiques humains

MOS recommandés : MOS 6.3 - Microsystèmes, microcapteurs, microflui
Objectives

Through this AF, 3 main techniques of imaging and image processing will be discussed: electronic cryo-tomography, X-ray imaging and ultra-sound imaging. Concrete examples of image reconstruction and modeling as well as device manipulations (RX, US) will help to understand the complete chain of image formation and its interpretation.

Keywords:

Programme

Course (6h):
- Principle of electronic cryo-tomography
- Principle of X-ray imaging
- Principle of Ultra-sound imaging

TP (9h): 1 workshop proposed each year on one of the 3 imaging techniques

Learning outcomes

◊ Understanding the scientific issues of medical imaging in terms of information extraction
◊ Understand the difficulties of reconstructing images from physical measurements and know the methods to overcome them
◊ Know the signal processing techniques used in ultrasound imaging
**Objectives**

Through this AF, the fundamental aspects related to the biological, physicochemical and mechanical phenomena involved in the contact between a surface and a biological environment will be treated. The link with the bioengineering of the interfaces and its application will be approached in various forms: article analysis, device realization, design office.

**Keywords:**

- Course (3h):
  - Physico-chemistry of interfaces
  - Biomechanics of interfaces

- BE (4h): Tribo-mechanics of living tissue

- TP (6h): Realization of a glucose biosensor

- TD (2h): Restitution of the analysis of scientific articles

**Learning outcomes**

- Understand the biomechanical stakes of aging and prosthetic medicine.
- To know some techniques of characterization of living tissues.
- Establishment of an experimental protocol.
- Write a complete technical report correctly referenced.
**Objectives**

This AF will enable engineering students to identify the steps involved in the production of a recombinant protein as well as the various purification methods, their roles and interests in biomanufacturing processes. The production of recombinant proteins by genetic engineering methods is a common process in most areas of biotechnology. By using perfectly controlled methods, this process makes it possible to obtain specific proteins, in particular of therapeutic interest, with a very high yield.

**Keywords:**

-. Know the techniques of bio-production and characterization of biomolecules
-. Set up an experimental protocol.
-. Present results in a relevant, rigorous and critical way for analysis.
-. Write a complete technical report correctly referenced
AF BIO 3.4

BIO-INFORMATIQUE, BIO-STATISTIQUE ET MODÉLISATION

BIO-COMPUTING, BIO-STATISTIC AND MODELISATION

Lecturers: Christelle Yéromonahos, Romain Rieger

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

Objectives

Through this AF, basic statistical tools as well as concepts and modeling techniques will be addressed to enable student engineers to analyze and model data in life sciences. From concrete examples, analysis and modeling strategies will be studied, and the development of a complete model will be developed.

Keywords:

Programme

BE 1 (4h): Living tissue modeling
BE 2 (4h): Cellular membrane modeling in molecular dynamics
BE 3 (4h): Epidemiology and vaccination
BE 4 (3h): Statistical tools for life sciences

Learning outcomes

◊ Understand modeling
◊ Being able to simulate and analyze a model
◊ Recognize contexts of application of statistical methods and implement them on datasets
◊ Understand the principle of molecular dynamics simulations
**Objectives**

The goal of this AF is to introduce engineering students to the many business opportunities related to the fields of bioengineering and nanotechnology. The different themes will be presented in the form of seminars and conferences by researchers and professionals in these fields. Visits to industrial sites (STMicroelectronic, Sanofi-Pasteur, Becton-Dickinson) and research centers (CEA-LETI, CEA-INES, Synchrotron ESRF) are also organized.

**Keywords:**

- Challenges of medical imaging techniques (by a physician-radiologist)
- Damage to prostheses (by Surgeon St-Etienne, Bertrand Boyer)
- Big data and genomics (Sébastien Cécillon)
- Large data processing (Céline Helbert, Delphine Maucort Boulch)
- The AURA industrial fabric in bioengineering and nanotechnologies (Sébastien Cécillon, Minalogic, Lyon Biopôle)
- Clinical trials in silico (Novadiscovery)

**Learning outcomes**

- Identify / analyze the socio-economic needs and constraints related to health and nanotechnologies
- Adopt a global vision and apprehend the domain in its complexity
- Take into account the international dimension of research in bio- and nano-technologies
- Extend scientific and technical knowledge
**Objectives**

Through projects (transdisciplinary or not) proposed by industrial partners or research laboratories, student engineers will identify technological barriers, propose solutions and implement them. It will also involve learning to present the results (in written and oral form).

**Keywords:**

- Develop and apprehend a scientific and technical project
- Identify technological barriers and implement technological solutions
- Integrate rules and standards quality / safety / environmental
- Conduct a synthesis of information and a presentation of the results
**Introduction**

Nanotechnologies receive huge investment budgets each year in research and development. It is therefore a sector in strong growth. Nanoscience and nanotechnology are at the crossroads of several scientific disciplines such as electronics, mechanics, chemistry, optics, biology that handle objects of a size of nanometer. The aim of this sector is to enable general engineers to acquire both technical and scientific knowledge enabling them to manage transversal projects and technology transfer. Combining sciences for the engineer and life sciences, this sector offers high level training in strong interactions with the industrial expectations of the field of information and communication technologies.

**Programme**

- NANO3.1 – Memories for Internet of Things
- NANO3.2 – Smart surfaces
- NANO3.3 – Photonic guide
- NANO3.4 – Nano-optics

**Departments/Laboratories**

- STMS, EEA / INL, LTDS

**Additional Information**

MOD fortement recommandés : MOD 1.3 « Photonique »; MOD 8.5 « Physique pour les technologies de l’information »; MOD 7.6 « Caractérisation des surfaces et des nanostructures »

MOS recommandés : MOS 4.4 « Nouvelles Technologies de l’Information et de la Communication »
Objectives

The students will be led to understand the operation of these different physical properties of the same ferroelectric material with great potential for innovative applications and to manufacture, characterize and use even smaller and faster digital memories useful for the Internet of Things. The greatest electronic mobility will be one of tomorrow's big challenges, just like the Internet of Things. In the future, the interaction with objects will no longer be only by means of electronic chips or specific orders transmitted by a touch screen, but also between the objects themselves.

Keywords:
Objectives

The students will be required to develop bioinspired surfaces with specific functionality (superhydrophobia, super-adherent, ...) thanks to nano / microtexturation. These surfaces will be characterized and analyzed with regard to two specific properties, their wettability and adhering power.

Keywords:
Objectives

The students will take in hand the different aspects of the design and the realization of nano-photonic components in guided optics, on Silicon substrate.
After an introduction (context of the integrated photonics on Si, stakes), the student-engineers design with the help of dedicated simulation tools the different basic photonic bricks necessary for the fabrication of complex routing / light guiding systems. on Si. They work on different aspects of manufacturing in clean room (optical and electronic lithography, plasma-assisted engraving, …). The fabricated structures are then characterized by optical and electronic microscopy.

Keywords:
Nano-optics

Lecturers: Christelle Monat & Virginie Monnier

Objectives

The students will be led to develop, using nanotechnologies, optical devices with special diffraction / reflection properties from their periodic pattern at the wavelength scale. Different types of periodic systems will be studied, developed both physically from thin films (clean room technology) and chemically (from colloidal dispersions). Their structural properties as well as their optical properties will be simulated and characterized.

Keywords:
Objectives

The goal is to introduce engineering students to the many business opportunities related to the fields of bioengineering and nanotechnology. The different themes will be presented in the form of seminars and conferences by researchers and professionals in these fields. Visits to industrial sites (STMicroelectronic, Sanofi-Pasteur, Becton-Dickinson) and research centers (CEA-LETI, CEA-INES, Synchrotron ESRF) are also organized.

Keywords:
**PROJECT**

Lecturers: Bertrand Vilquin & Emmanuelle Laurenceau

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: ❗️ |

**Objectives**

Through projects (transdisciplinary or not) proposed by industrial partners or research laboratories, student engineers will identify technological barriers, propose solutions and implement them. It will also involve learning to present the results (in written and oral form).

**Keywords:**
**Introduction**

The aim of this option is to provide students with the scientific and technological knowledge and skills needed to embark on a career in civil engineering design and construction, urban planning, or environmental management. The work is focused on the interactions between constructions and the environment on which they are located, the management of associated hazards and uncertainties, and the importance of long-term considerations in the technical choices that have to be made. A student who has followed the courses in this option should have the knowledge and the tools to model complex constructions and their multiple interactions with the environment, taking account of the requirements for sustainable development.

**Departments/Laboratories**

MSGMGC, MFAE, LTDS, LMFA, Ampère

**Programme**

Students must choose one of three themes:
- Design and Construction
- Sustainable buildings - Civil Engineering
- Sustainable buildings - Energy
- Environment

**Learning Outcomes**

◊ Know how to model a complex engineering problem
◊ Be capable of developing technical solutions which respect the relevant legislation

**Employment Sectors**

Consulting engineers, contractors, government agencies, environmental organisations and agencies, local planning authorities

**Requirements**

See the details for each theme

**Assessment**

See the details for each theme

**Additional Information**

Le contrat Pro n’est pas compatible avec les filières Ouvrages (OUV), Bâtiment durable- Energie (EBD) et Bâtiment durable - Génie Civil (GBD).
STRUCTURES AND WORKS
Directors: Eric VINCENS

Introduction

Departments/Laboratories
MSGMGC

Programme

Additional Information
MOD fortement recommandés : "Matériaux de construction" / "Reconnaissance et comportement des sols"

!!! : le MOS "Géotechnique" oblige à avoir suivi soit le cours ELC C6 "Mécanique des sols" soit le MOD "Reconnaissance et comportement des sols"

MOS recommandé : "Procédés généraux de construction"
CONSTRUCTIONS

Lecturers: Francesco Froio

| Lectures: 24 h | TC: 0 h  | PW: 0 h   | Autonomy: 0 h | Study: 16 h | Project: 0 h | Language: 

Objectives

Keywords:

Core texts


OUVRAGES DE TRANSPORT
TRANSPORTATION FACILITIES

Lecturers: Eric VINCENS

| Lectures: 28 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 12 h | Project: 0 h | Language: FR |

Objectives

Keywords:

Core texts


PROJET GCE
PROJECT

Lecturers: Eric VINCENS

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
Introduction
The aim of this set of courses is to provide the engineer with an understanding of the impact of human activities on the environment, and of the ways of managing that impact. Two modules - Hydrogeology and Water Quality and Treatment - are devoted to different aspects of the natural environment, their characteristics, ways of limiting their degradation, and of possible remedial measures. The Bioremediation module is more directly concerned with biological approaches to depollution, whilst the module ‘Advanced Building Physics’ explores ways of designing heating and ventilation systems to limit energy consumption. The module on Graphical Information Systems provides an introduction to these techniques, in the context of modelling environmental problems.

Departments/Laboratories
MFAE, LMFA, Ampère

Programme
Graphical Information Systems
Hydrogeology
Bioremediation
Water quality and water treatment
Advanced Building Physics
Project

Learning Outcomes
◊ Know and understand the key parameters for characterising the natural environment.
◊ Know how to evaluate the impact of a pollutant on the natural environment
◊ Be able to suggest suitable techniques for the depollution of a contaminated environment.

Employment Sectors
Consulting Engineers, Urban planning, Environmental impact and assessment

Assessment
ENV 3.1 : 20%, ENV 3.2 : 20%, ENV 3.3 : 20%, ENV 3.4 : 10%, ENV 3.5 : 30%,

Objectives

The aim of this course is to provide students with an in-depth knowledge of the different elements involved in the characterisation and the treatment of water resources. The course therefore covers both the analysis and modelling of water quality, and the different physical, chemical and biological processes employed in its treatment. The course will also cover regulatory aspects of water quality.

Keywords: Water quality, water treatment, depollution, drinking water, modelling

Programme

Natural water courses: physical, chemical and ecological aspects

Biological activity in water courses: the different species - micro-organisms, plants, invertebrates, vertebrates. Adaptation to life in water, Movement in water, nutrients and energy.

Water quality: the principal pollutants; the advection-diffusion equation and its application to streams and rivers; the concept of Biochemical Oxygen Demand, modelling dissolved Oxygen concentration.

Water treatment and supply; urban drainage, water treatment (mechanical, chemical and biological processes); water supply networks.

Learning outcomes

◊ Students will be familiar with the criteria for defining water quality, the principal pollutants and their impact on water quality
◊ Students will know how to measure and evaluate water quality
◊ Students will be able to develop and run a simple model to predict water quality in a river.
◊ Students will be familiar with the different approaches for treating polluted water.

Core texts


Assessment

Reports on activities carried out during the design classes.
Objectives

This course provides a general introduction to Graphical Information Systems, and their use in managing environmental issues. Students will become familiar with the different systems of georeferencing data, and the range of techniques used to acquire data for GIS databases. The course will then introduce some of the more widely-used GIS software (ArcGIS, MapINFO, QGIS, GRASS) and the rest of the course will then be devoted to practical applications of these tools.

Keywords: Graphical Information Systems, Spatial Analysis, Geodesy, Digital Terrain Mapping, Remote sensing

Programme

General presentation of GIS and their applications; an introduction to geodesy, including the different systems for georeferencing geographical data, and associated spatial projections.

The different types of data, the techniques used to acquire data (remote sensing and others) and the underlying physical principles; digital terrain models.

GIS software; the main programs, and their use in analysing environmental processes. Methods of interrogating, combining and processing geographical data. Ways of presenting the results of GIS analysis.

Practical application of GIS to analyse sample problems, using the QGIS software.

Learning outcomes

◊ Students will be familiar with the different standards for the storage and representation of geographical data, and the possible ways of processing them
◊ Students will be familiar with the different techniques for acquiring geographical data, and the physical principles on which they are based.
◊ Students will be capable of using GIS software to analyse a problem and present the results of that analysis.

Core texts


Assessment

Report based on the practical activity using QGIS to analyse an environmental problem.
HYDROGÉOLOGIE
HYDROGEOLOGY

Lecturers: Pietro Salizzoni, Jean-Sébastien Beaulne, Richard Perkins

| Lectures: 16 h | TC: 0 h | PW: 4 h | Autonomy: 0 h | Study: 4 h | Project: 0 h | Language: | |

Objectives

The aim of this course is to provide students with the scientific and technical knowledge and skills necessary to treat problems in which the movement of water in the soil or the rocks plays an important role. The students will learn the basics of modelling the flow of water and pollutants in the ground.

Keywords: Porous media, hydraulic head, hydraulic conductivity, piezometers, streamlines, hydrodynamic dispersion

Programme

Groundwater and its role in the hydrological cycle
Water in porous media and fractured rock
The water table, physical characteristics of underground reservoirs, piezometric mapping and flow nets.
Analytic solutions of the governing equations; the diffusion equation
The Dupuit assumptions, the Thiem, Theis and Jacob equations.
Interpreting well tests to determine the hydraulic characteristics of underground media.
Well boring technology, well tests
Transport of pollutants in porous media, physical and chemical aspects
Numerical modelling of flow in porous media

Learning outcomes

◊ Understand and master the basic concepts in hydrogeology
◊ Students will be able to apply simple analytical models to real problems
◊ Students will be able to perform a numerical simulation of a practical situation

Core texts


Assessment

Reports on the modelling activities performed as part of the course.
Advanced Building Physics

Lecturers: Gary Hunt (Cambridge University), Pietro Salizzoni, Lionel Soulhac

| Lectures: 4 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 4 h | Project: 0 h | Language:  |

Objectives

The focus is on exposing the students to the available analytical, experimental and computational techniques for the analysis of efficient low-energy ventilation of modern buildings.

Keywords: Buoyancy-driven flows; low-energy building ventilation; architectural fluid mechanics.

Programme

Natural ventilation of buildings
Bulk ventilation – airflow rates, temperatures
Modelling techniques – laboratory & flow visualisation, simplified theoretical
Stack (buoyancy-driven flows) – displacement ventilation, mixing ventilation
Airflow through vents – flow contraction
Transient flows – purging heat at night
Sources of heat / cool – dynamics, distribution
Steady flows – daytime scenario
Effect of wind flow – assisting, opposing
Sizing ventilation openings – desired flow direction

Learning outcomes

◊ Simplified mathematical modelling
◊ low-energy building design
◊ rapid design calculations

Core texts


Assessment

Oral presentation/discussion based on a natural ventilation design coursework.
PROJECT ENV

ENV PROJECT

Lecturers:

| Lectures: 0 h | TC: 0 h | PW: 50 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |
**Objectives**

The aims of this course are to provide an introduction to the main classes of pollutants and their sources, and then to present the different techniques (Phytoremediation, Mycoremediation and bacterial Bioremediation) that can be employed to eliminate them. The course will also discuss the ecologic and economic aspects of the management of industrial emissions and waste products.

**Keywords:** Pollution, Phytoremediation, Mycoremediation, Bacterial remediation, soils, water
Introduction

Departments/Laboratories
MSGMGC

Programme

Additional Information
MOD recommandé : "Matériaux de construction"

MOS recommandés : "Ouvrages de production d'énergie" / "Procédés généraux de construction"
AF EBD 3.1

CONFORT DU BÂTIMENT
BUILDING COMFORT

Lecturers:

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
Renewable Energy Systems

Lecturers:
Lectures: 20 h  |  TC: 0 h  |  PW: 0 h  |  Autonomy: 0 h  |  Study: 0 h  |  Project: 0 h  |  Language:  

Objectives

Keywords:
PROJET D'OPTION GCE

PROJECT

Lecturers: Eric Vincens

| Lectures: 0 h | TC: 0 h | PW: 50 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

Objectives

Keywords:
Bâtiment Durable
SUSTAINABLE BUILDING
Directors: Eric VINCENS

Introduction

Departments/Laboratories
MSGMGC

Programme

Additional Information
MOD fortement recommandés: "Matériaux pour la construction" / "Reconnaissance des sols"

MOS recommandés: "Ouvrages de production d'énergie" / "Géotechnique"
AF GBD 3.1

CONFORT DU BÂTIMENT
BUILDING COMFORT

Lecturers:
| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
Objectives

Keywords:
PROJET D’OPTION GCE

PROJECT

Lecturers:
| Lectures: 0 h | TC: 0 h | PW: 50 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
**Introduction**

The Information Technology is increasingly ubiquitous and transparent. Computer systems are everywhere: in companies of course (information systems, industrial computer), but also in everyday life (mobility, leisure, social life), even in the most banal objects (car, connected objects).

The Computer Science Curriculum responds to the challenges posed by the rapid evolution of digital solutions and uses by offering targeted formation on the key elements of the field to train general engineers, able to specify, design and supervise innovative projects in the context of increasingly complex systems. The fields of application are numerous, including the IT and digital sector of course, but also the sectors that depend on it: aeronautics, automotive, banking and insurance, (bio) medical, energy, retail, entertainment, media, production.

Each student has the possibility to build a "à la carte" course, adapted to their professional project, by choosing training actions proposed by the option within the EU Sector and MODs that deal with different topics of the computer science: is made mandatory to choose a MOD in the list of computer science MODs, the MOS 4.4, and to choose 4 MSO among the 7 proposed, as well as the MSO project. The option has identified some relevant career paths in terms of career opportunities, indicating for each a coherent choice of courses.

**Departments/Laboratories**

Dép. MI, EEA; Lab. LIRIS

**Programme**

- INFO3.1 Big-data Technologies
- INFO3.2 Info. Sys. in practice
- INFO3.3 Internet of Things
- INFO3.4 Machine Learning
- INFO3.5 Computer Vision
- INFO3.6 Geo. Calculation & Modeling for Computer Graph
- INFO3.7 Real Time, Embedded and Mobile Sys
- INFO3.8 Project

**Learning Outcomes**

- Specify, design and supervise innovative projects in the digital world, in the context of increasingly complex systems.
- Master the key element,
- Master the IT project process.
- Allow engineering students, wishing it, to move towards a thesis in Computer Science.

**Employment Sectors**

Digital-related job families are numerous and varied (design and project management, programming and development, data production and management, interfaces and digital creation, infrastructures, communication and networks, e-commerce, e-learning), as well as the sectors that depend on it. At the time of the defense of TFE, 80% of the students are definitely hired in the digital sectors, or intend to continue their formation.

**Requirements**

Students wishing to follow the course of the Computer Option must have followed the first two years at Ecole Centrale de Lyon, or any other equivalent formation.

**Additional Information**

Pour des informations sur les parcours suggérés, les étudiants sont priés de consulter la fiche proposée sur le site de scolarité et/ou contacter les responsables de l’option.

Des aménagements sont prévus pour le double diplôme master Informatique de Lyon.
Responsable : Liming.Chen@ec-lyon.fr.
AF INFO 3.1

TECHNOLOGIES INFORMATIQUES DU BIG DATA

Big-data Technologies

Lecturers: Stéphane Derrode

| Lectures: 10 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 10 h | Project: 0 h | Language: |

Objectives

The quantitative explosion of digital data has created new orders of magnitude that impact the capture, storage, analysis and visualization of digital data. The potential for processing big data are still partly unsuspected; prospective analysis (climate, commercial, socio-political), risk management (insurance, industrial, natural) or medical (genomics, epidemiology) and security (fight against crime).

An economic ecosystem is being created around the phenomenon, which involves the largest players in the IT sector, industrials, and many new start-ups. This module aims to provide skills in current computer technologies that allow these large volumes to be managed, interrogated and exploited.

Keywords: Big Data, NoSQL, Hadoop, MapReduce, Storm, Spark, Mahout, MongoDB, Cassandra

Programme
- The program is built on the achievements of MOD 2.1 "Big Data IT Challenges".
- Advanced database: NoSQL, New SQL (MongoDB, Cassandra)
- Hadoop framework & ecosystem (Map-Reduce, Hive, Storm)
- Apache Spark & scalable Machine Learning Library MLIB

Learning outcomes
◊ Operating of a system for managing a large document base (Cassandra)
◊ Use of a system for managing large amounts of data, with distributed storage and processors.
◊ Implementation of massive data processing algorithms by MapReduce programming.
◊ Design of machine learning algorithms and implementation under Spark, with MLib.

Core texts


SRINATH PERERA. Hadoop MapReduce cookbook : recipes for analyzing large and complex datasets with Hadoop MapReduce. PACKT Books, 2013.

Assessment
The final evaluation and the score of the BE
AF INFO 3.2

LES SYSTÈMES D’INFORMATION PAR LA PRATIQUE
INFORMATION SYSTEMS IN PRACTICE

Lecturers: Daniel Muller

| Lectures: 10 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 10 h | Project: 0 h | Language:  |

Objectives

In the job market, the information systems (IT or IT) professions are facing a shortage of talent. Possessing these specific technological skills is a headache for companies around the world. The latter seek engineers capable of understanding the complexity of business operations at the business, organizational and social levels, and possessing advanced technical skills. This training action aims to present with a practical approach the information systems present in companies.

Keywords: IS/IT (information system), ERP, IMSP (integrated management software package), ISS (security), governance, process, IS/IT architecture

Programme

This training action completes the MOD of Business Information Systems.
- Security aspects of information systems (6h): different types of security, main protections, crisis management, etc.
- The ERP (integrated management software packages) and their operation (6h).
ERP are complex tools, practice in 8 hours of design offices will familiarize with them.

Learning outcomes

◊ Analyze the functioning of an ERP (ERP)
◊ Know how to use and develop an ERP
◊ Know the basic principles of information systems security

Core texts


Assessment

The final evaluation, MCQ, and the score of the BE
INTERNET DES OBJETS
INTERNET OF THINGS (IoT)

Lecturers: Daniel Muller, René Chalon

Objectives

The Internet of Things builds on the ongoing advances in microelectronics and network technologies that enable the deployment of distributed services over interconnected networks of communicating objects. Among the sectors already concerned we can mention the connected car (accident reduction, vehicle sharing, taxis, fleet management), the health sector (individualized medical monitoring), domotics (home automation), or logistics (optimization of transport and storage). This formation provides an overview of the Internet of Things, from the standards, standards and technologies on which it is based, to the applications. Not forgetting the societal problems (legal aspects, privacy, security, operational safety).

Keywords: Internet of Things, Web of Things, Connected Objects, Smart Cities, Ambient Intelligence, Domotics, Geolocation, Big Data, IoT, WoT, RFID, Bluetooth, Zigbee, 6LoWPAN, CPL, PoE, Linky

Programme

Context, uses and fields of application (history, web of objects, environment, infrastructures, medical, home automation, transport, smart cities, ambient intelligence, Big Data)
Technologies of connected objects (hardware, power supply, sensors, processors, geolocation, computing power vs. consumption, examples of connected objects)
Unique identification, communication and programming (RFID, Bluetooth, Zigbee, 6LoWPAN, PLC, PoE, middlewares, frameworks)
Societal aspects (safety, physical safety of actuators, legal aspects, privacy)
Examples of applications - interventions by experts in companies (EDF companies, Sopra Steria, Sigfox, Wistiki)
BE programming a communicating object equipped with sensors

Learning outcomes

◊ To understand the field of connected objects, their technologies and their applications,
◊ To design an application based on the exploitation of data from distributed sensors,
◊ To understand the societal implications of such an application.

Core texts


Assessment

Final Test and scores of BE
Deep structured learning

Lecturers: Liming Chen, Emmanuel Dellandrea

Objectives

Deep learning has revolutionized an increasing number of domains, e.g., computer vision, natural language processing, games, etc. Structured learning is machine learning which aims to output data, e.g., sequences, matrix, graphs, which have components under some dependencies, e.g., words in a sentence. In this course, we aim to introduce fundamental concepts, theories and advanced techniques in deep structured learning, covering in particular sequence to sequence learning and Generative Adversarial Network (GAN). A number of practical works will be scheduled, including for instance image generation, image to text generation, text-to-image generation, style transfer, etc.

Keywords: Structured learning, recursive networks, LSTM, Attention-based models, Transformer, Bert, GAN

Programme

Sequence to sequence learning
- Recursive Network, LSTM, GRU
- Attention-based Model
- Transformer
- Language models, ELMO, BERT, GPT

Generative Adversarial Network (GAN)
- Basics
- Conditional GAN
- Unsupervised cGAN
- Theory and General framework of GANs
- WGAN, EBGAN, InfoGAN, VAE-GAN, BiGAN
- Evaluation of GAN
- Applications: face editing, speech generation

Learning outcomes

◊ Understand the basic principles of deep structured learning
◊ Know how to implement state of the art techniques and methods, e.g., LSTM, Transformer, and GANs, for practical structured learning problems
◊ Know how to evaluate the quality of an implemented deep structured learning method

Core texts


Assessment

Final exam and assignments
Objectives

Computer vision aims to model and automate the visual recognition process by the machine and has many applications (e.g., industrial inspection, robotic navigation, human-machine interaction, etc.). This course introduces the key concepts and techniques of the field and covers the following topics: image formation and filtering, contour detection and segmentation, local descriptors and their matching, stereovision, movement and structure estimation, detection and recognition of objects.

Keywords: Image Filtering and processing, edge detection and segmentation, local descriptors, motion tracking, stereovision, object detection and recognition

Programme

Introduction to Computer Vision
Reminders on image formation and filtering, contour detection by variational techniques
Reminders on homogeneous coordinates and geometric transformation
Projective Geometry
Segmentation of images and objects
Local Feature's Descriptors and Matching
Movement tracking and structure estimation
Camera Calibration and Stereo Vision
Object detection and recognition

Learning outcomes

◊ Understand the process of image formation and stereovision
◊ To be able to implement fundamental techniques to improve and process images
◊ Develop vision applications for the detection of simple objects

Core texts


Assessment

The final test and scores of BE
GEOMETRIC CALCULATION AND MODELING FOR COMPUTER GRAPHICS

Lecturers: Raphaëlle Chaine

| Lectures: 10 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 10 h | Project: 0 h | Language: | |

Objectives

The popularization of 3D digitization techniques has led to the development of complex digital object models. It is indeed essential to benefit from efficient and fast treatments to obtain, transmit, edit and deform quality models that are produced from raw data that may be very noisy and redundant. The purpose of this course is to introduce the notion of Geometry Processing useful for shape modeling.

In particular, we will examine the problem of generating a surface mesh as a discretization of the geometry of a 2D or 3D shape, and we will present the approaches of Computational Geometry to generate, simplify, refine and manipulate them, by relying on geometric structures, with particular properties.

Keywords: Geometry processing, mesh generation, 3D reconstruction, mesh simplification and refinement, Techniques based on Delaunay triangulation and Voronoi diagram, virtual sculpture

Programme

Mesures:
- Definitions
- Generation of meshes, 3D reconstruction and virtual sculpture
- Simplification and refinement of meshes
- Meshes improvement, coding

Geometry Processing and Computational Geometry (CG):
- Elementary notions of CG in 2D (planar maps, graphs, triangulation, convex hull)
- Construction of convex hull in 2D: optimal algorithm (divide and conquer)
- Incremental algorithms
- Triangulation of Delaunay in 2D (and its dual: Voronoi diagram): general definitions, properties
- Power diagrams
- Algorithm for optimal construction of Delaunay triangulation (divide and conquer), and incremental algorithms

Core texts


Assessment

Final evaluation and score of the BE
The aim is to raise the student's awareness of the notions of concurrent programming (Process, Threads) and implement them. Also notions about real-time and embedded systems are discussed. Some important diagrams and examples (Producer / Consumer, Reader / Writer, 5-phi, barber, ...) will illustrate the point. Finally, in relation with a professional in the field, this course will present the specificities of the development of mobile applications (iOS, Android, ...), in terms of technology and project management.

**Keywords:** Concurrent Programming, Real-Time Computing, Embedded Computing, Mobile Computing
**PROJECT INFORMATIQUE**

**TECHNOLOGY PROJECT**

Lecturers: Moshen Ardabilian, Daniel Muller

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 40 h | Language: 🇫🇷 |

**Objectives**

Transverse projects are offered by industrial Partners, academic and LIRIS Research members. These projects cover all the topics proposed by the option and allow students to work in project team configuration.

**Keywords:**

**Programme**

From January to the end of March, students work in teams of four on a project of their choice. Working sessions are scheduled every Thursday morning to work on these projects. Two reporting-sessions in January and February and a final presentation of deliverables in March are planned to assess students work.

**Learning outcomes**

◊ To be able to specify, design and officer innovative projects in the digital world, in the context of increasingly complex systems.

**Assessment**

Two reporting-sessions and a final presentation of the deliverables, appreciated by the sponsors, tutors and pedagogical team.
Mathématiques et Décision

MATHEMATICS AND DECISION
Directors: Sylvie Mira-Bonnardel et Christophette Blanchet
130h

Introduction
Each engineer has to take decisions in its professional environment when solving scientific or technical problems, when optimizing industrial processes or when dealing with strategic management. Engineering approach consists in building a model with mathematical or managerial tools, to analyse its inherent risk level, and then in using it for decision-making.

The specialization « Mathematics and Decision » (option MD) gives to students tools for apprehending either of those models. They will learn modelling, mathematical analysis, as well as risk analysis of complex problems arising in companies, finance, ecology, biology or physics.

Departments/Laboratories
Mathématiques-Informatique / Communication - Langages - Entreprise - Sports

Programme
see specialization MIR and ADE

Learning Outcomes
◊ Decision-Making
◊ Mathematical and managerial tools for modelling
◊ Abstraction capabilities

Employment Sectors
see specialization MIR and ADE

Requirements
1st and 2nd year at ECL or equivalent curriculum.

Option Website
http://option-md.ec-lyon.fr/
**Mathématiques et Ingénierie du Risque**

**APPLIED MATHEMATICS, AND RISK ENGINEERING**

Directors: Elisabeth Mironescu

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**Introduction**

The third year specialization « Applied mathematics and risk engineering » is devoted to mathematical modeling and numerical simulation of problems arising in engineering.

Students study a wide range of stochastic and deterministic methods concerning ordinary and partial differential equations, optimization problems, discrete and time-continuous stochastic processes, statistics, together with the associated numerical methods.

Opportunity is given to the best students to complete their formation with a master degree in one of the three following fields: applied mathematics, finance / insurance, biomathematics / biostatistics.

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**Departments/Laboratories**

Département Mathématiques-Informatique, Institut Camille Jordan

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**Programme**

MD fo IM3.5 - Project
2 modules to choose among:
- MD fo IM3.2 - An introduction to financial mathematics
- MD fo IM3.4 - Advanced Tools for Learning: when Convexity meets Sparsity
- MD fo IM3.3 - An introduction to Inverse Problems and imaging

---

**Learning Outcomes**

◊ Up to date mathematical technics
◊ Tools for scientific monitoring
◊ Necessary background for an applied mathematics PhD.

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**Employment Sectors**

Job opportunities are given mostly by R&D in industrial firms, risk management in finance or insurance, data science, pharmaceutical industry, academic research.

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**Requirements**

1 MOD (1st semester) among "Applied statistics for engineers" and "Numerical Methods for PDEs" (it is advised to choose both)

2 MOS among "Decision support algorithms", "Time series econometrics" and "Physical problems in unbounded media: mathematical analysis and numerics"

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**Assessment**

Mean of the 4 courses

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**Option Website**

http://option-md.ec-lyon.fr/MIR.php

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**Additional Information**

Parcours de master liés:
- Mathématiques en Action (MeA) du master Mathématiques appliquées, statistique
- Gestion des Risques en Assurance et en Finance (GRAF) du master Économétrie, Statistique
- Biostatistique Biomathématique Bioinformatique et Santé (B3S) du master Santé publique
**Advanced Tools for Learning: when Convexity Meets Sparsity**

**Lecturers:** Yohann De Castro

| Lectures: 15 h | TC: 15 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇬🇧 |

**Objectives**

A powerful tool in Machine Learning is to optimize a convex function to solve a learning problem. This makes it possible to offer a solution to intrinsically complex problems (clustering on graphs, detection of communities on networks) and/or structured (completion of matrices, medical imaging).

The objective of this course will be to study these tools and to know how to deploy them in practical cases.

**Keywords:** Machine Learning; Convex Optimisation; High-Dimensional Statistics

---

**Programme**

Lectures, hands-on sessions, projects

Detailed Program would be announced on the first Lecture

**Learning outcomes**

- Python (SciKitLearn)
- Optimisation
- High-dimensional Probability
- Advanced Linear Algebra

**Core texts**


**Assessment**

Exam + Projet
**AF IM 3.2**

**INTRODUCTION AUX MATHÉMATIQUES FINANCIÈRES**

**INTRODUCTION TO FINANCIAL MATHEMATICS**

**Lecturers:** Elisabeth Mironescu, Christophette Blanchet

| Lectures: 14 h | TC: 4 h | PW: 0 h | Autonomy: 0 h | Study: 12 h | Project: 0 h | Language: 🇫🇷 |

**Objectives**

This course presents in detail the classical models used in mathematical finance in discret and continuous times. It includes two sessions of numerical implementation. It is based on the Stochastics Processes course (MOD) given during the first part of the year.

**Keywords:** Mathematical finance, Cox-Ross-Rubinstein model, Black-Scholes model, stochastic calculus, pricing and hedging options.

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**Programme**

- Cox-Ross-Rubinstein model
- Black-Scholes model and some extensions

**Learning outcomes**

◊

**Independent study**

**Objectives:**

**Methods:**

**Core texts**


**Assessment**

- 2 BE on computer
- 1 final exam
Objectives

Is it possible to reconstruct the geometry of a vibrating membrane from its own frequencies? Detecting cracks in a piecework by measuring at its boundary (or part of its boundary) simultaneously the temperature and/or fluxes. Or to determine the parameters of a system, knowing its evolution. These questions give rise to the so-called "Inverse Problems". Unlike direct problems, which are generally well posed, the inverse problems are often "ill-posed" (non existence, non uniqueness or non stability with respect to the data). In this course, we discuss basic mathematical and numerical tools concerning the inversion of poorly conditioned problems and their use through applications in some engineering fields.

Keywords: Ill posed problems, Generalized solutions, Least squares, Singular Value Decomposition (SVD), Regularization, Parameter estimation.

Programme

1- Introduction
2- Examples of some inverse problems
3- Integral equations and their numerical treatment
4- Linear inverse problems : least squares, quasi-solutions and SVD.
5- Regularization of ill-posed inverse problems
6- Non Linear inverse problems : parameter identification, the adjoint-state method.

Learning outcomes

◊ Identify inverse problems,
◊ Know and use mathematical tools for linear inverse problems
◊ Use the SVD to solve ill-conditionned problems
◊ Know and use some regularisation techniques

Independent study

Objectives:
Methods:

Core texts


Assessment

Written Exam 2hours,
Practical work
**PROJET MIR**

**PROJECT MIR**

**Lecturers:** Elisabeth MIRONESCU, Christophe Blanchet

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 8 h | Project: 50 h | Language: |

**Objectives**

Through this project, students will identify mathematical problems/barriers, propose solutions and implement them. They will also improve their communication skills to present the results (in written and oral forms).

**Keywords:** Modelization, Analysis, Simulations.

**Learning outcomes**

◇ Build a model
◇ Analysis of a deterministic or random model
◇ Use of an appropriated software to perform simulations
Write a report, build a presentation. Group Work, pair work.

**Assessment**

Report and defense.
Introduction

Departments/Laboratories

CLES

Programme

Learning Outcomes

◊
◊
◊
◊

Employment Sectors

Requirements

Assessment

Option Website

Additional Information
AF ADE 3.1

SIMULATION DE DÉCISIONS OPÉRATIONNELLES

PROCESS SIMULATION

Lecturers: Emmanuel Boutleux

| Lectures: 23 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 31 h | Project: 0 h | Language: French |

Objectives

Keywords:
SIMULATION DE DÉCISIONS STRATÉGIQUES ET FINANCIÈRES

BUSINESS GAME

Lecturers: Sylvie Mira Bonnardel

| Lectures: 21 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:

Core texts

Selmer C. Concevoir le tableau de bord. DUNOD, 2015.


**SYSTÈMES ET OUTILS D’AIDE À LA DÉCISION**

**DECISION SUPPORT SYSTEMS**

**Lecturers:** Sylvie Mira Bonnardel

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

**Objectives**

**Keywords:**

**Core texts**


PROJECT

Lecturers: Sylvie Mira Boonnardel

| Lectures: 0 h | TC: 50 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
**Introduction**
Traffic and Transportation speciality is a comprehensive program to the transportation industry. Two main topics are addressed: vehicle and mobility.
A general education and knowledge is offered to the student in order to facilitate their integration in all the fields of this industry.
The coordinated choice of the Sector Opened Courses is in coherence with the activities of the Specialized Specific Courses.

**Programme**
Two common courses
- "Transport et society"
- "Mobility and infrastructures"
Two choices of training tracks: Traffic and Environment or Vehicle Technology
One project: study of an industrial test-case

**Employment Sectors**
Transportation infrastructures, Logistics, R &D services, Design, Product industrialisation

**Additional Information**
Les thèmes abordés au cours de cette formation permettent de mettre en place des parcours coordonnés avec certains masters afin de permettre l'accès à deux diplômes simultanément : les masters de l'école doctorale MEGA, le master Matériaux, le master Génie Electrique, Génie des Procédés.
**Introduction**

This training track is more focused on: traffic, logistics, road safety and environment. The following subject can be addressed:
- Transportation infrastructures and systems
- Environment and disturbance
- Traffic safety
- Logistics
- ...

**Departments/Laboratories**

**Programme**

**Employment Sectors**

Transportation infrastructures, Logistics, R &D services, Design, Product industrialisation
TRANSPORTS ET SOCIÉTÉ
SOCIETY AND TRANSPORTS

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
Objectives

Keywords:
SÉCURITÉ DES TRANSPORTS
TRANSPORTS SECURITY

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
LOGISTIQUE DE TRANSPORTS
TRANSPORTS LOGISTICS

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: FR |

Objectives

Keywords:
AF TE 3.5

PROJET TT
TT PROJECT

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: FR |

Objectives

Keywords:
AF TE 3.6

VISITES DE SITES
SITES VISITS

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 法语 |

Objectives

Keywords:
Introduction
This training track is more focused on the following topics
- Alternative vehicles: hybrid and electrical power
- Component technologies
- Technological innovations

Learning Outcomes
◊
◊
◊
◊

Employment Sectors
Transportation infrastructures, Logistics, R &D services, Design, Product industrialisation

Requirements

Assessment

Option Website

Additional Information
**Objectives**

**Keywords:**
INGÉNIERIE DES TRANSPORTS
TRANSPORTS ENGINEERING

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Keywords:
Objectives

Keywords:
ORGANES ET ARCHITECTURE VÉHICULE

VEHICLE’S BODY AND ARCHITECTURE

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

Objectives

Keywords:
TT Project

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

Objectives

Keywords:
VISITES DE SITES
SITES VISITS

Lecturers: Olivier BAREILLE, Benjamin CHOUVION

Objectives

Keywords:
ENGINEERING FIELDS OF APPLICATIONS (2019-2020)

DEAN
Grégory VIAL, Dean of Studies
Ségolène CALLARD, Vice Dean of Studies
AF MOS 1.1

AÉRODYNAMIQUE TRANSSONIQUE
TRANSONIC AERODYNAMICS

Lecturers: Stéphane AUBERT

| Lectures: 20 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 8 h | Project: 0 h | Language: |  

Objectives

Keywords:

Core texts

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<th>Core texts</th>
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BRUIT DES TRANSPORTS
TRANSPORTATION NOISE

Lecturers: Mohamed Ichchou, Didier Dragna

| Lectures: 16 h | TC: 0 h | PW: 12 h | Autonomy: 0 h | Study: 4 h | Project: 0 h | Language:  |

Objectives

Sound pressure level, both for the interior of transportation systems and the surrounding environment, is an important element to take into account from the design phase: regulatory constraints are increasingly severe; acoustic and vibratory comfort is often a key element in the choice of customers. These noises have a multiple origin: propulsion and engine systems, ventilation and air conditioning, unsteady flow around vehicles. This course deals with sound sources due to the different transport modes, with particular attention to aircraft transportation, and their consequences for the perceived noise levels inside and outside the vehicle. Lectures related to air transportation are given by speakers from SAFRAN Aircraft Engines.

Keywords: Acoustics, noise, vibration, comfort, nuisances, transportation systems, car, train, aeronautics

Programme

II - Noise sources in air transportation. Legislation and certification. (SAFRAN AE)
III - Noise reduction methods for transportation noise. (SAFRAN AE)
IV - Localization and identification of sources. Advanced measurement techniques (SAFRAN AE).

Learning outcomes

◊ understand noise and vibration issues in transport
◊ know and be able to analyze noise sources in transport
◊ solve typical problems in transportation noise

Options/Masters

Option ECL: Aeronautical engineering and Transport and traffic (suggested MOS).
Master: Acoustics (suggested MOS) and Aeronautics.

Core texts


Assessment

Written exam
Reports on TP/BE
AF MOS 1.3

CALCULS AVANCÉS EN DYNAMIQUE DES VÉHICULES

VEHICLE DESIGN

Lecturers: Olivier Bareille et Mohamed Ichchou

| Lectures: 0 h  | TC: 28 h  | PW: 0 h  | Autonomy: 0 h  | Study: 0 h  | Project: 0 h  | Language: ⓧ |

Objectives

Keywords:

◊ Dynamic confort
◊ Dynamic behavior
◊ Driven suspension

Core texts


CONTRÔLE ACTIF DU BRUIT ET DES VIBRATIONS
ACTIVE CONTROL OF NOISE AND VIBRATIONS

Lecturers: Marie-Annick Galland, Mohamed Ichchou

| Lectures: 8 h | TC: 0 h | PW: 12 h | Autonomy: 0 h | Study: 8 h | Project: 0 h | Language: |

Objectives

Active control systems have been widely developed in the last 20 years. The basic principle is well known: a secondary wave, 180° out of phase, is synthesized to interfere with the primary one. Active noise or vibration control therefore aims to reduce an existing noise or vibration, especially at low frequencies, where passive means are inefficient. The objective of this course is to introduce the basic principles and the main realizations in mechanics. Other topics are also investigated: active absorption, semi-active control, smart materials...

Keywords: active control, acoustics, vibration, fluid mechanics, adaptive filters, real time, analog filters

Programme

1- active noise control
2- adaptive algorithms
3- energy in active systems. Local control/ global control
4- semi-active and active control of vibrations
5- LQG control - MIMSC control
6- smart structures
7- vibro-acoustic control
8- active control of flow instabilities

Practical Works (12h):
- active headset
- real time systems for noise control
- active control of vibrations in a structure

Learning outcomes

◊ to identify potential applications of active control systems
◊ to select the suited active control technologies
◊ to design an active control system
◊ to discuss about active systems' limitations

Options/Masters

Option : aeronautical engineering, transport and traffic, civil and environmental engineering
Master : aeronautics, acoustics, mechanics

Core texts


Assessment

- reports on practical works
- MCQ
- oral presentation of a recent scientific paper (by groups of 2 or 3 students)
COUCHES ULTRAMINCES ET SURFACES FONCTIONNALISÉES
FUNCTIONALIZED THIN LAYERS AND SURFACES

Lecturers: Stéphane Benayoun, Bertrand Vilquin

Objectives

Keywords:
**Objectives**

In this course, we’ll show how to modelize some complex problems which arise in biology, politics, economy using game theory tools. And, how to solve them in the simplest cases. Solving explicitly these problems are in general not possible. We'll introduce some powerfull optimization tools (heuristics, meta-heuristics).

**Keywords:** optimization, heuristics, game theory

**Programme**

- Introduction to optimization via heuristics
- Introduction to game theory

**Learning outcomes**

- modelization
- optimization

**Core texts**


**Assessment**

- Exam 2h / BEs
Objectives

Computer Graphics is a growing scientific and technical field with multiple applications and opportunities in industries that use scientific visualization, simulation, planning, digital archiving, virtual reality and digital entertainment. Despite the ever-increasing performance of hardware, algorithmic, scientific and technical problems persist. In particular, the management of data masses for the modeling, editing and visualization of very large models. The objective of this course is to present the algorithms and fundamental data structures in computer graphics from several complementary angles: 3D modeling, visualization and image synthesis, interactive editing.

Keywords: Computer Graphics, 3D modeling, Image synthesis, Algorithms, Data structures.

Programme

- Algorithmic geometry: fundamental algorithms, intersection and separation calculations, spatial data structures.
- Modeling: state of the art representations of objects, modeling using implicit surfaces, meshes and treatments on the meshes, compression, spatial enumeration.
- Realistic rendering: state-of-the-art image synthesis techniques, stochastic ray tracing, photon tracing, radiosity.

Learning outcomes

◊ To be able to master the models, algorithms and tools introduced as well as their applications.

Options/Masters


Core texts


Assessment

Final exam, continuous monitoring
CHOIX DES MATÉRIAUX ET DES ASSEMBLAGES

CHOICE OF MATERIALS AND ASSEMBLIES

Lecturers: Stéphane Benayoun, Michelle Salvia

Objectives

Keywords:

Core texts


MACRO ENERGY

Objectives

The current development model of societies is based on an energy consumption that is not sustainable in the long term. This course aims to enable a general engineer to acquire a global vision of the energy system which is essential for understanding the current context and the challenges that future generations will face.

Keywords: primary, secondary and final energy; energy balance; energy systems; energy and climate; energy and development; energy geopolitics; international, national & local scales;

Programme

Introduction: primary secondary and final energy, energy vectors; The order of magnitude of global energy: production, consumption and reserves.
- Coal industry.
- Oil and gas industry
- Smart Cities: Illustration of the economic, technological and social challenges which are underlying a concept to reduce energy demand by the integration of multiple technologies.
- Management of energy systems: illustration of different levels of decision.

The program may change depending on the availability of speakers from the world of business.

Learning outcomes

◊ to know the orders of magnitude which characterize the global energy and to know how to handle them
◊ to understand and analyze a balance sheet at a country level
◊ to know the technical and political features of the main energy pathways
◊ to understand the systemic aspects of the energy consumption

Options/Masters

Required for the cursus of the option "Energy"

Core texts


Assessment

knowledge: 2 h final test (70%)
know-how: literature studies (30%)
DYNAMIQUE DES MÉCANISMES
DYNAMICS OF MECHANISMS

Lecturers: Joël Perret-Liaudet, Alain Le Bot

| Lectures: 12 h | TC: 6 h | PW: 0 h | Autonomy: 0 h | Study: 10 h | Project: 0 h | Language: |  

Objectives

Structural architecture of mechanisms are diversified and often complex. This requires specific approaches. Design is more and more reliant on dynamic analysis in order to optimize the performance/cost ratio. The performance can concern the mass power gain as well as the sound annoyance (NVH approach). The goals of this course is to introduce methods to model, simulate and analyze the main dynamic phenomena. Several examples are presented to illustrate the various concepts.

Keywords: Mechanisms, Transmission errors, Dynamics, Vibrations, Contacts, Nonlinear and parametric behaviours.

Programme

Ideal transmission law: geometric, kinematic, dynamic.
Transmission errors, definition, origins, characteristics and consequences.
Performance variability: origins, tolerances, statistical description
Contact dynamics: hertz and clearance nonlinearity, impact laws, rattle.
Friction instabilities: friction laws, self-excited vibrations, squeal noise.
Parametric behaviours: sources, instability and parametric resonances.
Local and global modelling.
Industrial examples

Learning outcomes

◊ Derivation of the governing equations of multi body dynamics
◊ Knowledge and identification of the main vibratory behaviour of mechanisms
◊ Description of self-excited responses, nonlinear and parametric resonances
◊ Global approach to describe elastodynamic behaviour (FEM, Specific methods)

Options/Masters

Mechanical engineering / Vibration / Vibroacoustic
Master - Mechanical Engineering
Transportation and Energy fields

Assessment

Final test (100% knowledge mark)
Practical work (100% Know-how)
COMPATIBILITÉ ÉLECTROMAGNÉTIQUE DES SYSTÈMES DE PUISSANCE ET INTERACTION AVEC LEUR ENVIRONNEMENT

ELECTROMAGNETIC COMPATIBILITY

Lecturers: Christian Vollaire

| Lectures: 0 h | TC: 28 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: FR |

Objectives

The current generalization of telecommunications as well as that of digital systems leads to take into consideration the ambient "electromagnetic pollution", with the objective of ensuring the safety of these complex systems. These phenomena of electromagnetic disturbances are today of considerable importance with the development of power electronics devices that can interact with low-level systems in areas such as transport or energy. The purpose of the course is to raise awareness of electromagnetic compatibility (EMC) problems, to present the main sources of disturbances, to understand coupling methods, to specify the main remedies, as well as the evolution of standards.

Keywords: Electromagnetic compatibility, power electronic, coupling, crosstalk

Programme

Chapter I: The problem of the EMC
Chapter II: Electromagnetic fields and waves
Chapter III: The sources of disturbances
Chapter IV: Study of the conducted and radiated coupling modes
Chapter V: Current means of study and testing
Chapter VI: Methods of prevention and protection
Chapter VII: Electromagnetic fields and biological media

Learning outcomes

◊ Raise awareness of electromagnetic compatibility (EMC) problems
◊ Be able to analyze a complex system and deduce the major parameters influencing the EMC
◊ To know how to propose solutions of improvement and EMC countermeasures

Options/Masters

Transport (aeronautic and land), industry

Core texts

**Objectives**

Know the works needed for nuclear, hydroelectric and wind energy generation
know how to apply safety and design basic rules

**Keywords:** Electrical systems, nuclear power plant, hydropower and dams, safety, design, wind energy

**Programme**

- Nuclear power plants
  1. General lay out of the sites
  2. Regulation (design et generation)
  3. Safety requirements for civil works
  4. Civil work design
  5. Reliability studies for civil works
  6. Containment civil works
  7. Civil works coolers

- Hydro power plants
  1. Civil works and material
  2. The projects
  3. Failure modes
  4. Design functions
  5. Environmental mitigation measures

- Wind Energy project development (on shore and off shore)

**Learning outcomes**

- ◊ Scheme design
- ◊ Safety evaluation

**Options/Masters**

- Energy Option
- Civil engineering Option
- Master in Civil Engineering
Objectives

The aim of this course is to present electric and hybrid vehicles. Modeling, sizing and energy management of hybrid vehicles and their components are studied.

Twelve hours will be spent for practical works to develop and simulate vehicle models. These sessions mainly deal with the development of a model of electric vehicle, the modelling and the energy management of Toyota Prius, and the energy management of serial hybrid vehicles.

Keywords: Hybrid vehicle, electric vehicle, cybernetic model, battery, engine, electrical machine, pollutant, energy management, emission standards, environmental impact

Programme

The teachers in charge of this session are researchers of IFSTTAR working on Electric and Hybrid Vehicles.

1) Hybrid electric vehicle : generalities, definitions, classification and cybernetic modelling.
2) The batteries for electric and hybrid vehicles : introduction, modelling, uses, sizing, security and ageing.
3) Engines and electrical machines : presentation, different types of electrical machines and their controls, different types of engines, anti-pollution norms, application for electric and conventional vehicles.
4) The energy management for hybrid vehicles : definition, optimization, application in the case of Toyota Prius, sizing of the systems, notion of environmental impact.
5) Application : 12h of practical works

Learning outcomes

◊ Understand the operation principles of the main components of hybrid vehicles (engine, battery, electronic converter, ...)
◊ Modelling of a hybrid vehicle
◊ Sizing the components of a hybrid vehicle
◊ Simulate the energy management in a hybrid vehicle

Options/Masters

MOS recommended for Options "Energy" and "Traffic and Transportation" and for students in combined course with the option "electrical engineering" (part of the master on electronics, electrical engineering and automatics).

Core texts


Assessment

Final exam : Multiple choice questionary and open-ended questions.
Report and continuous control during practical works.
Objectives

This course first provides an overview of all the challenges related to traffic and mobility management including the questions of multimodality, intelligent transportation systems, new technologies…. Second, it presents the basics of traffic flow theory and proposes some basic tools to dynamically estimate traffic flow propagation. Continuous approaches permit to quickly assess how congestion spreads over a network while discrete methods permit to derive powerful simulation tools. Finally, the course presents the basics of traffic assignment that permits to describe trip distributions over a transportation network to provide a dynamic description of the travel demand.

Keywords: Transportation systems, congestion, multimodal network, traffic dynamics, capacity and bottlenecks

Programme

1a/ Introduction to traffic management
1b/ Traffic data: definitions and analysis
2/ Practical application: Data analysis of a congestion period
3a/ Introduction to traffic flow theory
3b/ The cumulative count curves: a simple model for freeway congestion
4/ Macroscopic models and kinematic wave theory
5/ Static traffic assignment and network equilibriums
6/ Practical application 2: operation studies
7/ Dynamic traffic assignment

Learning outcomes

◇ Listing the basic principles of traffic management
◇ Mastering the cumulative count curves to predict traffic states evolution on freeways
◇ Identifying from traffic data basic traffic states in particular stop-and-go waves in congestion
◇ Characterizing the impacts of traffic stochasticity on network capacity and demand

Core texts


Assessment

Student evaluation is done based on two practical applications and a final exam.
ECOULEMENTS INSTATIONNAIRES EN TURBOMACHINE
Unsteady flows in turbomachinery

Lecturers: Stéphane AUBERT, Alexis GIAUQUE

| Lectures: 24 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 4 h | Project: 0 h | Language: | |

Objectives

Exchanges between the fluid and the structure are involved in turbomachinery either to extract energy from the fluid (turbines), or to transfer energy to the fluid (compressors). While these energy levels may be very large, one part may be diverted to feed unsteady mechanisms, leading some time to the machine blowout. The course objective is to study some of these unsteady mechanisms and to answer basic questions: why and how are they generated, how do they grow, is it possible to control them or to delay their onset, is it possible to simulate them numerically or to measure them experimentally?

Keywords: turbomachinery, unsteady flows, aeroelasticity, instabilities, coupled phenomena

Programme

1. Out-of-design performances degradation: operability reduction due to cumulative effects in multi-rows machines; quasi-steady or fully unsteady phenomena
2. Rotor-stator interactions: potential effects in subsonic and supersonic regimes; wakes behaviour through turbines and compressors channels; forced vibration of the structure
3. Aerodynamic instabilities: description, analysis and model of surge; rotating stall; example of recent research in multi-stages axial compressors
4. Fluid-structure coupling and aeroelasticity instabilities: history of failures related to flutter; specificities of flutter in turbomachinery

Learning outcomes

◊ To name the main unsteady phenomena in turbomachinery
◊ To formulate interaction scenarios between these phenomena
◊ To evaluate the characteristic frequencies of these phenomena
◊ To split in basic physical phenomena the complex behaviour of a turbomachine from data based on simulations or measurements

Options/Masters

Aeronautic Option; Aerospace Engineering Master

Assessment

2h written exam
**Objectives**

The aim of this course is to provide students with a general physical understanding of the engineering aspects of ocean waves and their impact. The first part of the course is devoted to wave dynamics, and the second part to wave interaction with structures or with the sea bed.

**Keywords:** Surface water waves, ocean engineering, coastal engineering, shore protection, fluid-structure interaction, vibrations, sediment transport

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**Programme**

1. **Introduction**
   - Physico-chemical characteristics of the ocean; tides

2. **Small amplitude surface waves**
   - General formulation, the dispersion equation, water particle kinematics, energy, wave reflection, shoaling, wave refraction and diffraction, wave-current interaction, mass transport, momentum flux.

3. **Wind-wave interaction**
   - Generation of waves by the wind, the short-crested sea, wave spectra

4. **Wave impact**
   - Wave forces on structures (e.g. cylinder) – application to oil platforms - Interaction between the wave and the sea bed (wave damping, sediment transport) – Coastal protection (sea walls, breakwaters, groynes...)

**Learning outcomes**

◊ Identify the different wave regimes
◊ Know how to calculate the properties of shallow water waves
◊ Understand how wave properties evolve as a wave moves from deep water to shallow water
◊ Model the forces on an object subject to a wave-induced flow

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**Options/Masters**

Civil and Environmental Engineering, Energy
Masters: Mécanique (compatible), SOAC (compatible)

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**Core texts**


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**Assessment**

Final exam + lab report + design study
AF MOS 4.2

POLLUTION ATMOSPHERIQUE

ATMOSPHERIC POLLUTION

Lecturers: Lionel Soulhac, Pietro Salizzoni, Didier Dragna

| Lectures: 16 h | TC: 4 h | PW: 0 h | Autonomy: 0 h | Study: 8 h | Project: 0 h | Language: ⓧ |

Objectives

The aim of this course is to provide students with the scientific and methodological tools to enable them to:
- Understand the issues and problems arising from atmospheric pollution, particularly in relation to industrial emissions (both low level and accidental releases) and urban air quality.
- Understand the physical processes that determine local-scale meteorological processes and the transport, dispersion and transformation of atmospheric pollutants, and the models used to represent these processes.
- Understand the underlying principles, and the limitations, of the different techniques that are used to model atmospheric pollution.

Keywords: Atmosphere, Pollution, Environment, Risk, Modelling

Programme

1. General introduction
2. Dynamics of the atmospheric boundary layer
3. The influence of the surface of the earth
4. Flow over complex terrain
5. Atmospheric dispersion-1
6. Atmospheric dispersion-2
7. Concentration fluctuations
8. Explosions

The lectures will be supplemented by two Examples Classes (2h each) and two design classes (4h each) which will be devoted to the use of an atmospheric dispersion model to study the release of a pollutant into the atmosphere.

Learning outcomes

◊ Awareness of the issues and problems related to atmospheric pollution
◊ Understanding of the main physical processes which determine the transport and dispersion of pollutants in the atmosphere
◊ Familiarity with the different approaches and techniques for modelling atmospheric pollution
◊ Implement an atmospheric dispersion model

Options/Masters

Options: Civil and Environmental Engineering, Energy, Transportation
Masters: Mécanique (compatible), SOAC (compulsory)

Core texts


Assessment

Final Exam (50%) + design report (50%)
INFORMATIQUE D’ENTREPRISE

MANAGING BUSINESS INFORMATION SYSTEMS

Lecturers: Daniel Muller, Mohsen Ardabilian

| Lectures: 0 h | TC: 28 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: 🇫🇷 |

Objectives

Through a series of conferences led by professionals, this course aims to bring a better knowledge of the systems, applications, methods, and trades of IT in enterprise, whose realities are often very different and much richer than the vision that can have students.

Keywords: Enterprise Computing, Information Systems, Computing Trades

Programme

Some conferences held in previous years:

"e-payment services", Cédric Lamarzelle, Atos Worldline
"Architecture orientée services", Matthieu Girardin, CGI
"Informatique et libertés", Correspondant informatiques et libertés, Centrale Lyon
"Virtualisation HPC et Big Data", Jean-Daniel Bonnetot, OVH,
"Les métiers de l'Open-Source", Valentin Clavreul, Smile
"Outsourcing Applicatif", Philippe Ihuel, Sopra Group
"Le SI des opérations", Xavier Leblanc, L’Oréal

Depending on the availability of companies and stakeholders, other topics may be discussed, such as: Economic Intelligence and Security of IS, Cloud Computing, Mobile Applications, ERP, CRM, CMS, etc.

Learning outcomes

◊ Understand the complexity and diversity of enterprise computing
◊ Having an idea of the various enterprise computing trades

Options/Masters

Computer Science

Assessment

MCQ covering all conferences, based on questions submitted by each of the speakers
Objectives

This training action aims to introduce students to the technological watch, both theoretically and practically. In coordination with the teaching team, the students will put into practice the technological watch by conducting their own study on a freely chosen topic. Each student will have to present his results to all his peers during the workshops organized for this purpose.

Keywords: Technology Watch, Information and Communication Technologies, Innovation

Programme

Introduction to technological and strategic intelligence
The stakes - The tools
The main areas of technology watch - choosing a problem
Individual presentations by students of selected topics

Learning outcomes

◊ Being able to lead a technological watch
◊ Identify innovations in his sector of activity
◊ Being able to account in front of peers

Options/Masters

Computer Science

Core texts


Assessment

MCQ, oral presentation, process and watch report
Natural resources and their management

Lecturers: Pietro Salizzoni, Mathieu Creyssels, Richard Perkins

| Lectures: 14 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 14 h | Project: 0 h | Language:  

Objectives

The aim of this course is to provide students with the background knowledge required to understand the distribution, availability and exploitation on the earth's natural resources. The course also addresses the impact of the use of natural resources on the environment and on society.

Keywords: Natural resources, environment, energy, economic growth

Programme

1. Introduction - the earth, its composition, natural resources and their distribution
2. Mineral resources
3. Water resources
4. Energy sources
5. Impact of climate change
6. Man and the environment – historical overview
7. Future scenario – growth or collapse?

Learning outcomes

◊ Students should be familiar with the broad classes of natural resources and their distribution on earth.
◊ Students should be aware of the different demands made on the earth's natural resources, and the underlying reasons for those demands
◊ Students should be aware of the impact of resource exploitation on the environment and society
◊ Students should acquire a basic understanding of the links between exploitation of resources and the growth or collapse of society.

Options/Masters

Options: Civil and Environmental Engineering, Energy
Masters: RisE (compulsory)

Core texts

MACKAY D. Sustainable Energy – without the hot air. UIT Cambridge, 2008.

Assessment

Final exam and mini-project
Objectives

This set of courses present the methodology for the design of the foundations of buildings but also the design of all types of soil reinforcements. These courses draw on the necessary acquired knowledge of soil mechanics from MOD2.6 or ELC-C6.

Keywords: shallow foundations, retaining walls, soil reinforcement, deep foundations,

Programme

Shallow foundations
Deep foundations
Retaining walls and soil reinforcement

Learning outcomes

◊ know how to analyse the data and constraints contained in a geotechnical report
◊ design a geotechnical device (foundation, reinforcement)
◊ know how to choose a technological solution

Options/Masters

civil engineering and environment
Master in civil engineering

Core texts

Objectives

This course aims at giving the mathematical foundations for the study of partial differential equations posed in an unbounded domain. We will focus on model equations (Laplace, Helmholtz, wave equation) to present the mathematical framework and the main ideas for the design of numerical methods.

Keywords: Propagation phenomena. Partial differential equations. Unbounded domains.

Programme

Part I: Basic facts for stationary and harmonic problems

Part II: Time dependent problems

Part III: Focus on the Helmholtz problem in the free space

Learning outcomes

◊ To be able to identify conditions for closing a problem in an unbounded domain.
◊ To be able to design a numerical method for PDEs in unbounded domains.
◊ To be able to quantify the accuracy of such a numerical method.

Options/Masters

Applied mathematics. Aerospace engineering. Acoustics

Core texts


Assessment

Final exam + Simulation projets
**Objectives**

The behavior of real structures often exceeds the basic mechanics framework for various reasons. The non-deterministic nature of the structures, the presence of nonlinearities are taken into account to better understand the behavior of these structures in real cases operating in engineering.

We propose here to give tools and address the conventional methods of engineering for introducing randomness and non-linearities in the systems, and to describe and more realistically the behavior of real structures and their optimization. These tools will be introduced through simple but significant examples. They will be borrowed from the industrial environment.

**Keywords:** Solid Mechanics, Structural Dynamics, Engineering of complex systems, Uncertainty, Optimization, Stability, Nonlinear Systems

**Programme**

1) Introduction  
2) Instability  
3) Nonlinear behavior and methodology  
4) Dispersions  
5) Structural optimization

**Learning outcomes**

◊ Formulate a complex problem in structural dynamics  
◊ Traduction Désactiver la traduction instantanée Explain physical phenomena in structural dynamics Google Traduction pour les entreprises :Google Kit du traducte  
◊ Evaluate according to the dynamic operating criteria of an object  
◊ Knowing the sources of uncertainties and nonlinearities and how to model them

**Options/Masters**

AEROSPACE and AVIATION - LAND TRANSPORT - CIVIL ENGINEERING - ENERGY

**Core texts**


**Assessment**

Written test  
Personal work
Objectives

The goal of this class is to present the tools and methods at the end of the Big Data processing chain: visual analysis and data communication. This step is crucial not only for data analysts, but also for decision-makers who need to understand complex results without being experts, using intuitive graphical interfaces and dashboards.

Keywords: Data visualization, multidimensional projection methods, graph layout algorithms, benchmark and visualization software development, test methodology, JavaScript.

Programme

Introduction to data visualization; Principles of visual encoding, perception, cognitive principles and design; Typology of graphics, interaction and animation techniques; Case studies, paper prototyping; Algorithmic aspects and software architectures of visualization; Case studies and use of industry reference tools (Table, Raw, Google Fusion Table); Initiation and advanced JavaScript; Web visualization project.

Learning outcomes

◊ At the end of the course, the student will be able to make an informed choice about the methods and parameterization of visual data analysis methods to be used.

Options/Masters

Computer Science

Core texts


Assessment

Graded homeworks (40%) final visualization projet (60%)
Tissue engineering and biomaterials

Lecturers: Emmanuelle Laurenceau, Vincent Fridrici

| Lectures: 24 h | TC: 0 h | PW: 0 h | Autonomy: 4 h | Study: 0 h | Project: 0 h | Language: |

Objectives

The objective of this lecture is to address the problems of repair and replacement of biological tissues, as well as give the basics and principles of tissue engineering through various examples (orthopedics, vascular, dental, skin)

Keywords: materials-living interactions, biomaterials, tissue reconstruction, prostheses

Programme

- Cells and extracellular matrix
- Biocompatibility and biomaterials
- Biomaterials in dentistry
- Tissue engineering of bone and mechanical behavior
- Vascular prostheses, orthopedic ...
- Tissue engineering of skin and Tribology
- Medical devices

Learning outcomes

- Knowing the basics of cell function
- Explain the principles of tissue engineering
- Select a material for a given application
- Evaluate a scientific publication

Options/Masters

- Bioengineering and Nanotechnology Option
- Recommended module for the IDS Master

Core texts


Assessment

Written final exam
**STRATEGIE D’ENTREPRISE**

**STRATEGIC MANAGEMENT**

**Lecturers:** Sylvie Mira Bonnardel

| Lectures: 28 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |  

**Objectives**

Understand strategic management combining design with implementation
Identify relevant and sustainable business models
Be able to analyze competition

**Keywords:** Strategic management, innovation, firm's administration

**Programme**

- Designing the firm's strategy between exploration and exploitation
- Strategic business model
- Competitive strategies
- Business ecosystems
- Innovation management: organisation, process and decision making

**Learning outcomes**

- Industry analysis
- Strategic diagnose
- Innovative business model design

**Options/Masters**

Mandatory course for Maths & Decision

**Core texts**


**Assessment**

Case studies
Projects
**Objectives**

Taking as starting point the example of a lab-on-chip for biological analysis, this course will cover and explain the problems related to the integration of various components and functions in a miniaturized system. An introduction to microfluidics (physics at the microfluidic scale, influence of scaling laws on the miniaturization of systems, hydrodynamics of microfluidic systems, distribution, mixing and separation in microsystems) and concepts necessary for the understanding of the difficulties involved in the acquisition and interpretation of signals of very low amplitude will be presented. The course will focus in particular on chemical and biological sensors case studies.

**Keywords:** Miniaturized systems, sensors and biosensors, integration, microfluidics

**Programme**

Chemical, biological and physical microsensors  
Electrokinetics, distribution and mixing in microsystems  
Electronic detection, the importance of noise, electronic displacement of the sample  
BE: Study of biosensors  
BE: Microfluidics  
BE: Electronic signal processing

**Learning outcomes**

◊ Know the basics of micro sensor operation  
◊ Develop a microsystem for a given application  
◊ Extract data  
◊ Analyze a scientific article

**Options/Masters**

Bioengineering and Nanotechnology Option  
Recommended module for the IDS Master  
Recommended module for the NSE Master  
Recommended module for the EEEA Master (ESE track)

**Core texts**


**Assessment**

BE evaluations
 objectives

A time series is a series of observations indexed by time. The main applications of the time series are the modeling of the macroeconomic and financial series by discrete time stochastic processes. They can also be used in other sciences such as physics, biology, geology (Nile floods), health (hormone levels in the blood) ...

This course naturally follows the statistics and econometrics courses of 2A, but it is not essential to have taken these courses beforehand. The goal of this time series course is to quickly scan a large number of econometric models without going into mathematical details, and apply them to real data with the Eviews software.

Keywords: Stochastic discrete time process, econometrics, estimates, tests, economic interpretation, Eviews software.

Programme

Chap 1. Introduction to the concept of time series.

Chap 2. Autoregressive moving average models (ARMA) Basic model.

Chap 3. Models of autoregressive conditional heteroscedasticity (ARCH) Models specific to the returns of financial securities. They take into account periods of volatility observed on the financial markets.

Chap 4. Notion of unitary root and ARIMA models Models for non-stationary series, such as the macroeconomic series and the price series in finance


Learning outcomes

◊ Mathematical modeling
◊ Forecasts
◊ Hypothesis tests
◊ Applicable in economics, finance, physics, biology etc ...

Options/Masters

Economic statistics, bank / market finance (financial forecasts, pricing of derivatives), other Master with ISFA.

Core texts


Assessment

1) Project 50%
2) 1-hour exam 50%
Objectives

Rotating machines as propulsion systems (turbojet engines, ...), or power production (wind turbine, alternator, ...) or any system requiring rotating structure (pump, gyroscope, ...) take a large place in everyday life. These machines follow the dynamical equations and often in a multi-physical context: fluid-structure interaction, mechatronic interaction... This course has for objective to supply the key elements of modelling of this kind of system by concentrating on stability aspects. This point is indeed essential because lot of energy is concentrated in these machines and thus their stability is a major issue in their proper functioning and more globally in the safety.

Keywords: Rotating machines, stability, vibration

Programme

First part:
Reminder of dynamical equation for elastic structure in rotation
Descriptions of the modal characteristics in fixed and rotating frame, interpretation

Second part:
Analysis of stability of the linear systems:
- equations with constant coefficients
- equations with periodic coefficients

Introduction to the stability of non-linear systems

The third part:
Stability problems for rotors:
Phenomenological analysis and understanding of mechanisms
Analysis of the structural components leading to instabilities:
· Symmetry, damping, buckling in the rotating parts
· Characteristics of support components: ball bearings, squeeze-film, hydrodynamic bearings, ...
· Coupling rotor/stator
Fluid/structure coupling leading to instabilities
Non-linear phenomena responsible for instabilities

Learning outcomes

◊ Understand the specificity of the rotting machines
◊ To be able to put in equation a rotating machine problem
◊ to be able to analyse dynamics and stability of a rotating machine
◊ know the various organs of a rotating machine and their specificities

Core texts


Assessment

Note of BE
Note of paper analysis
Note of written test
AF MOS 7.2

SURETÉ DE FONCTIONNEMENT DES SYSTÈMES ET DES STRUCTURES

STRUCTURAL AND SYSTEM HEALTH MONITORING

Lecturers: Michelle Salvia, Olivier Bareille

| Lectures: 0 h | TC: 28 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

Objectives

In the transportation and the energy-supply industry, a rigorous and reliable maintenance strategy shall be applied. In this course, the methods of control and health-monitoring will be described. Their advantages and limitations will be addressed and discussed. Some specific materials and technique dedicated to the structural health monitoring will be reviewed. The topic will be treated from the durability point of view, keeping in mind that the industrial goal is to increase the service-life and the overall operational condition efficiency of systems and structures.

Keywords: structures surveillance, ageing, material damages for structures, signal processing, wear and damage index

Programme

- The SHM steps
- Measurement and sensor systems
- Composite material in aeronautics : application of the SHM
- Smart materials
- Damage models and predictive models

Learning outcomes

- establishing a monitoring strategy
- identification of damage phenomena
- data analysis and compared studies

Options/Masters

- transportation, aeronautics, space, energy
- industrial maintenance
- smart system design

Core texts


Assessment

- Final exam (knowledge - coeff. 0,3)
- Document analysis and practical exercises (know-how - coeff. 0,6)
- Practice (methodology - coeff. 0,1)
CIVIL ENGINEERING WORKS

Lecturers: Pierre BRUN

| Lectures: 0 h | TC: 28 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |}

Objectives

Learning of construction methods
Learning of work in civil work companies
Special works

Keywords: Civil works, methods, construction

Programme

Civil works - Introduction
Security in civil works
Sustainable construction and energetic reghabilitation
Cost estimation
Diaphragm walls, grouting and piles
Soils and rocks excavations
Rivers works
Hydraulic works
Foundation consolidation and embankments compaction

Learning outcomes

◊ Efficiency on works
◊ Knowledge of methods
◊ Technical general knowledge
Energy and environmental impact

Objectives

The industrial sector of energy strongly influences environment, during the energy production processes, for its storage, its transport and its use. The course "Energy and environmental impact" has for vocation to supply to the future engineers a culture and examples of tools and methods about environment, in connection with the industry of the energy sector and other major branches of industry (eg: transport).

At the end of the course, the students should be in capacity to:
- analyze a production process of energy from a thermodynamic perspective
- diagnose the possible improvements in an industrial installation of power production;
- Analyze in environmental terms scientific documents

Keywords: dynamics of ecosystems; organization of ecosystems; carbone cycle; climate change & energy production pathways; thermodynamics; exergetic analysis; persistant pollutants;

Programme

1- Dynamics of ecological systems
   Systemic approach
   Physical organisation of ecosystems
   Transfers of matter & energy at the local, regional and global scales
   Climate change

2- Environmental impact of energy sectors
   Mitigation strategies
   Horizontal study of the environmental impacts of industrial pathways
   Persistant organic polluants : from combustion to environmental impact

3- Evolution of energy sectors
   Methods of improvement : life cycle analysis, ecoconception
   Technological evolutions : CO2 capture & storage. Evolution of powerhouse architectures.

Learning outcomes

◊ Understand and formulate an environmental problem (hypothesis, orders of magnitude)
◊ Take into account the uncertainty generated by complexity of energy & environment considerations
◊ Relate economical logic, social & ecological responsibilities
◊ Fastly deepen a field relating environment and energy

Options/Masters

Advised for the option "Energy"

Core texts


Assessment

BE : 50% (know-how)
Final exam 2h: 50% (knowledge)
INTRAPRENEUR

Lecturers: GOYON Marie, POUSSIELGUE Sébastien

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: ❓ |

Objectives

Keywords:

Core texts


ENTREPRENEUR

STARTUP CREATION

Lecturers: MIRA BONNARDEL Sylvie

| Lectures: 28 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

Objectives

During the course students work on their startup with experts’ coaching.
2 Objectives: develop entrepreneurial skills and achieve the startup creation

Keywords: startup creation, business model, fund raising

Programme

Half of the course is dedicated to the startup project.
During the other half, experts in finance, law, business models, share their knowledge with the students.

Learning outcomes

◊ Lead a startup project
◊ Identify key persons
◊ Negotiate with stakeholders: customers, suppliers, business angels

Core texts


Assessment

Pitch and business plan
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