# PROGRAMME

## SEMESTER 9

## Applied Engineering Modules

2019-2020 for options
2018-2019 for engineering fields of application

ÉCOLE CENTRALE LYON

# Options (2019-2020) 9

## Engineering fields of applications (2018-2019) 101

## 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):

| **Slot 1** | **Monday 14:00-16:00** |
|---|---|
| MOM 1.1 | Engineering Systems |
| MOM 2.1 | Management of the Industrial Company |
| MOM 3.1 | Company Law |
| **Slot 2** | **Monday 16:00-18:00** |
| MOM 1.2 | Quality Management |
| MOM 2.2 | Economic Intelligence and Information Protection |
| MOM 3.2 | Human Resources Management and Organizations |
| MOM 4.2 | Natural and Technological Risks |

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 courses 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):

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

| Slot 4 | Friday 8:00-12:00 |
|---|---|
| MOS 1.4 | **Active Control of Noise and Vibrations (English)** |
| MOS 2.4 | Macro Energie |
| MOS 3.4 | Traffic Flow Theory and Management |
| MOS 4.4 | Information Technology |
| MOS 5.4 | Complex Phenomena and Structural Dynamics |
| **Slot 5** | **Friday 13:30-17:30** |
| MOS 1.5 | Functionalised thin Layers and Surfaces |
| MOS 2.5 | Dynamics of Mechanisms |
| MOS 3.5 | Unsteady Flows in Turbomachinery |
| MOS 4.5 | **Coastal and Ocean Engineering (English)** |
| MOS 5.5 | Interactive Data Visualisation |
| MOS 6.5 | Times Series Econometrics |
| MOS 7.5 | Energy and Environmental Impact |

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 (2019-2020)

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# Option AE

## AÉRONAUTIQUE

## 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%

# AF AE 3.1

## Conférences
*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

# AF AE 3.2

## Projet Avion

*Aircraft design project*

**Lecturers: D. Constant, J.-F.-R. Aulagnier (Dassault Aviation), J. Boudet**

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 38 h | Project: 0 h | Language: |

## Objectives

This project concerns the preliminary design of a business jet, with given specifications (number of passengers, range, runaway 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**

D.P. Raymer. *Aircraft Design: A Conceptual Approach*. AIAA, 2012.

L. Jenkinson, J. Marchman. *Aircraft Design Projects*. Elsevier, 2003.

J.D. Anderson. *Aircraft Performance and Design*. McGraw-Hill, 1999.

**Assessment**

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

# AF AE 3.31

## Projet spécifique : Acoustique et Vibrations

*Elective project: Acoustics and Vibrations*

**Lecturers: Christophe Bailly, Sébastien Besset**

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 72 h | Project: 0 h | Language: |

## 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

# AF AE 3.32

## Projet spécifique : Automatique

*Elective project : Control of aircraft*

**Lecturers: Laurent Bako, Anton Korniienko, Gérard Scorletti**

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 72 h | Language: |

## 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**

We can break down the work to be done in three phases:
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 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 contro
◇ 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**

D. Alazard, C. Cumer, P. Apkarian, M. Gauvrit et G. *Robustesse et commande optimale*. Cépaduès éditions, 1999.

A. E. Bryson. *Control of aircraft and spacecraft*. Princeton University Press, 1994.

S. Skogestad and I. Postlethwaite. *Multivariable feedback control: analysis and design*. Wiley-BlackWell, 2005.

**Assessment**

Participation, written report and defense

# AF AE 3.33

## Projet spécifique : Matériaux et Structures

*Elective project: Materials and Structures*

**Lecturers: Michelle Salvia, Bruno Berthel**

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 72 h | Project: 0 h | Language: |

## 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:

**Assessment** Participation, written report and defense

# AF AE 3.34

## Projet spécifique : Propulsion

*Elective project : Propulsion*

**Lecturers: Jérôme Boudet, Laurent Blanc**

| Lectures: 0 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 72 h | Project: 0 h | Language: |

## 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 en engineering problem
◇ use knowledge and know-how for the detailed design of a system

**Core texts**

N.A. Cumpsty. *Compressor Aerodynamics*. Krieger Pub, 2004.

B. Lakshminarayana. *Fluid dynamics and heat transfer of Turbomachinery*. John Wiley and Sons, Inc., 1996.

**Assessment**

Participation, report and oral presentation.

# Option EN

## ENERGIE

## Energy

Directors: Eric Vagnon, Jean-Pierre Cloarec

130h

## 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.

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Filière EE

# ENERGIE EMBARQUÉE

## On-board Energy

Directors: J.P. CLOAREC

## 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 ;
2. Alternative energy sources : biofuels, hydrogen, wood.
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 problematics of energy sources and energy networks.

### Departments/Laboratories

STMS

## Programme

EE 3.1 - Oil and gas
EE 3.2 - Alternative energy sources
EE 3.3 - Cogeneration
One project

## 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"

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# AF EE 3.1

## Pétrole et Gaz

*Oil and gas*

**Lecturers: J.P. CLOAREC**

| Lectures: 33 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

## 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

# AF EE 3.2

## Nouveaux carburants
*Alternative fuels*

**Lecturers: J.P. CLOAREC**

| Lectures: 26 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language: |

## 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

Part3 : wood

# AF EE 3.3

## Production thermique

*Cogeneration*

**Lecturers: E. VAGNON**

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

## 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 improvments. 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
• Combustion and Effluents : combustion process, effluents and removal treatment : Emission limitation & regulation.
• 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

# AF EE 3.4

## Projet EN

*Project EN*

**Lecturers:**

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

## Objectives

Keywords:

Filière EI

# ENERGIE D'INFRASTRUCTURE

## Infrastructure energy

Directors: E. VAGNON

## Introduction

**Departments/Laboratories**

E.E.A.

## Programm

## Additional Information

MOD conseillés : « Énergie Nucléaire », "Turbines pour la production d'énergie", "Eoliennes"

# AF EI 3.1

## 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:

# AF EI 3.2

## 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:

Filière BIN

# Bio-Ingénierie et Nanotechnologies

# Bio-engineering and nanotechnology

Directors: Laurenceau Emmanuelle, Vilquin Bertrand

130h

## 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-accrédités :
Energie Electrique, Electronique, Automatique (3EA)
Ingénierie de la Santé (IdS)
Matériaux
NanoScale Engineering (NSE)

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# BIO-INGÉNIERIE

## Bio-engineering

Directors: Emmanuelle Laurenceau

## 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 6.5 - Propagation des ondes élastiques ; MOD 4.3 - Comportement des matériaux ; MOD 7.2 - Matière molle : nanosystèmes et interfaces biologiques ; MOD 6.6 - Dynamique des systèmes biologiques humains

MOS recommandés : MOS 6.3 - Microsystèmes, microcapteurs, microflui

# AF BIO 3.1

## Imageries médicales
*Medical imaging*

**Lecturers: Emmanuelle Laurenceau, Christelle Yéromonahos**

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

## 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

# AF BIO 3.2

## Interactions matériau-vivant

*Living-material interactions*

**Lecturers: Emmanuelle Laurenceau, Vincent Fridrici**

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

## 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:

**Programme**

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

# AF BIO 3.3

## Bioproduction

*Bioproduction*

**Lecturers: Emmanuelle Laurenceau, Florence Raynal**

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

## 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:

**Programme**

Course (4h):
- Principle of genetic engineering
- Production and purification of recombinant protein

BE (4h): Biofermentor

TP (7h): Microbrewery

**Learning outcomes**

◇ 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

# AF BIO 3.5

## Conférences
*Conferences*

**Lecturers: Emmanuelle Laurenceau, Bertrand Vilquin**

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

## 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:

**Programme**

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

# AF BIO 3.6

## Projet
*Project*

**Lecturers: Emmanuelle Laurenceau, Bertrand Vilquin**

| 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:

**Learning outcomes**

◇ 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

# NANOTECHNOLOGIES

## Nanotechnologies

Directors: Bertrand VILQUIN

## 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.

### Departments/Laboratories

STMS , EEA / INL, LTDS

## Programme

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

## 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 ; MOS 6.3

# AF NANO 3.1

## Mémoires pour l'internet des objets

*Memories for Internet of Things*

**Lecturers: Bertrand Vilquin & Ian O'Connor**

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

## Objectives

Through this AF student-engineers 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 es objects. 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:

# AF NANO 3.2

## Surfaces intelligentes

*Smarts surfaces*

**Lecturers: Stéphane Benayoun & Magali Phaner-Goutorbe**

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

## Objectives

Through this AF students-engineers will be required to develop bioinspired surfaces with specific functionality (superhygrophobia, 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:

# AF NANO 3.3

## Guidage photonique

*Photonic guides*

**Lecturers: Pedro Rojo Romeo & Emmanuel Drouard**

| Lectures: 0 h | TC: 0 h | PW: 18 h | Autonomy: 0 h | Study: 2 h | Project: 0 h | Language: |

## Objectives

Keywords:

# AF NANO 3.4

## Nano-optiques

*Nano-optics*

**Lecturers: Christelle Monat & Virginie Monnier**

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

## Objectives

Through this AF, student engineers 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:

# AF NANO 3.5

## Conférences
*Conferences*

**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

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:

# AF NANO 3.6

## Projet
*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:

Filière GCE

# Génie Civil et Environnement

# Civil and Environmental Engineering

Directors: Eric Vincens, Richard Perkins

130h

## 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
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 (EBD) et Bâtiment durable (GBD).

# OUVRAGES

## 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"

# AF OUV 3.1

## Constructions

*Constructions*

**Lecturers: Francesco Froiio**

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

## Objectives

Keywords:

**Core texts**

Jean-Louis Granju. *Introduction au béton armé : Théorie et application*. Eyrolles Afnor éd, 2014.

Henry Thonier. *Conception et calcul des structures de bâtiment : L'Eurocode 2 pratique*. Presses de l'École nationale des ponts et chaussée, 2006.

Muzeau Jean-Pierre. *Manuel de construction métallique*. Eyrolles Afnor éd., 2012.

# AF OUV 3.2

## Ouvrages de transport

*Tranportation facilities*

**Lecturers: Eric VINCENS**

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

## Objectives

Keywords:

**Core texts**


Bernard-Gély Anne, Calgaro Jean-Armand, Michotey J. *Conception des ponts*. Presses de l'École nationale des ponts et chaussée, 1994.

Carillo Philippe, Jaumard Dominique. *Conception d'un projet routier : guide*. Eyrolles, 2015.

Leboeuf Michel. *Grande vitesse ferroviaire*. Cherche Midi, 2014.

# AF OUV 3.3

## 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:

Filière ENV

# ENVIRONNEMENT

## Environmental Engineering

Directors: Richard Perkins

## 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 caracterising 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%,

# AF ENV 3.1

## Qualité et traitement des eaux

*Water quality and water treatment*

**Lecturers: Richard Perkins & Sébastien Cecillon**

| Lectures: 16 h | TC: 0 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 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. Adaption 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**


Gray, N.F.. *Water Technology - An Introduction for Environmental Scientists and Engineers*. Elsevier, 2010.

Spellman, F. R.. *Handbook of Water and Wastewater Treatment Plant Operations*. CRC Press, 2013.

Henze, M., Harremoes, P. Cour Jansen, J. la, Arvin. *Wastewater Treatment : Biological and Chemical Processes*. Springer, 2002.


**Assessment**

Reports on activities carried out during the design classes.

# AF ENV 3.2

## Systèmes d'information géographique (SIG)

*Geographical Information Systems*

**Lecturers: Jean-Sébastien Beaulne, Perrine Charvolin**

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

## 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**

Allali,Gérard. *Apprendre QGIS par l'exemple: Quand le Système d'Information Géographique devient libre*. CreateSpace Independent Publishing Platform, 2015.

Brimicombe, Allan. *GIS Environmental Modeling and Engineering*. CRC Press Reference, 2009.

Dixon Barnali, Venkatesh Uddameri. *GIS and Geocomputation for Water Resource Science and Engineering*. American Geophysical Union, 2016.

**Assessment**

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

# AF ENV 3.3

## 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**

Bear, J.. *Dynamics of Fluids in Porous Media*. Dover Civil and Mechanical Engineering, 1988.
Domenico, P.A. & Schwartz, F.W.. *Physical and Chemical Hydrogeology*. John Wiley & Sons, 1998.
Freeze, R.A. & Cherry, J.A.,. *Groundwater*. Prentice Hall, 1979.

**Assessment**

Reports on the modelling activities performed as part of the course.

Filière EBD

# ÉNERGIE - BÂTIMENT DURABLE

## Energy and Sustainable Building

Directors: Eric VINCENS

## Introduction

**Departments/Laboratories**

MSGMGC

## Programme

## Additional Information

MOD recommandés : "Aléas et hétérogénéités dans les structures" / "Matériaux de construction"
MOS recommandé : "Ouvrage de production d'énergie" / "Procédés généraux de construction

ÉCOLE CENTRALE LYON

# AF BD 3.1

## Introduction à l'énergétique du bâtiment

*Introduction to Building Energy Performance*

**Lecturers:**

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

## Objectives

Keywords:

# AF BD 3.2

## Constructions
*Constructions*

**Lecturers:**

| Lectures: 18 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 12 h | Project: 0 h | Language: |

## Objectives

Keywords:

# AF BD 3.3

## 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:

# AF BD 3.4

## Les systèmes ENR

*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:

# AF BD 3.5

## Projet d'option
*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:

Filière GBD

# GÉNIE CIVIL - BÂTIMENT DURABLE

## Civil Engineering - Sustainable Building

Directors: Eric VINCENS

## Introduction

**Departments/Laboratories**

MSGMGC

## Programme

## Additional Information

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

MOS recommandé : "Ouvrages de production d'énergie" / "Géotechnique"

# AF BD 3.1

## Introduction

*Introduction to Building Energy Performance*

**Lecturers:**

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

## Objectives

Keywords:

# AF BD 3.2

## Constructions à section homogène

*Constructions with homogeneous sections*

**Lecturers:**

| Lectures: 18 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 12 h | Project: 0 h | Language: |

## Objectives

Keywords:

# AF BD 3.3

## 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:

# AF BD 3.4

## Systèmes d'énergies renouvelables

*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:

# AF BD 3.5

## Projet d'option
*Project*

**Lecturers:**

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

## Objectives

Keywords:

# Option INFO

## INFORMATIQUE

## Computer Science

Directors: Mohsen ADABILIAN, Daniel MULLER

130h

## Introduction

**Departments/Laboratories**

MI, EEA, LIRIS

## Programme

## 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 : Alexandre.Saidi@ec-lyon.fr.

# AF INFO 3.1

## Technologies informatiques du Big Data

*Big-data Technologies*

**Lecturers: Stéphane Derrode, Emmanuel Dellandréa**

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

## Objectives

Keywords:

**Core texts**


Philippe Lacomme. *Bases de données NoSQL et big data : Concevoir des bases de données pour le Big Data : cours et travaux pratiques*. Ellipses, 2014.

Lemberger Pirmin. *Big data et machine learning, Manuel du data scientist*. Dunod, 2015.

Srinath Perera. *Hadoop MapReduce cookbook : recipes for analyzing large and complex datasets with Hadoop MapReduce*. PACKT Books, 2013.

# AF INFO 3.2

## Les systèmes d'information par la pratique

*Information systems in practice*

**Lecturers: Charles-Edmond Bichot, Daniel Muller**

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

## Objectives

Keywords:

**Core texts**

J-L Tomas, Y. Gal. *ERP et conduite des changements*. Dunod, 2011.
J-L Deixonne. *Piloter un projet ERP*. Dunod, 2011.
F. Pinckaers, G. Gardinier. *OpenERP pour une gestion d'entreprise efficace et intégrée*. Eyrolles, 2008.

# AF INFO 3.3

## Internet des objets
*Internet of Things (IoT)*

**Lecturers: Daniel Muller, René Chalon**

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

## Objectives

Keywords:

**Core texts**


R. Briand et al.. *Livre Blanc - Objets Communicants et Internet des objets*. Association Instituts Carnot, 2011.

P. Mulder. *Node.js for Embedded Systems – Building Web Interfaces for Connected Device*. O'Reilly Media, 2015.

M. Boudellal. *Smart Home - Habitat connecté, installations domotiques et multimédia*. Dunod, 2014.

# AF INFO 3.4

## Apprentissage automatique
*Machine Learning*

**Lecturers: Liming Chen, Emmanuel Dellandrea**

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

## Objectives

Keywords:

**Core texts**

C. M. Bishop. *Pattern Recognition and Machine Learning*. Springer, 2006.
K. P. Murphy. *Machine Learning : A Probabilistic Perspective*. MIT Pres, 2012.
Goodfellow, Y. Bengio, and A. Courville,. *Deep Learning*. MIT Pres, 2016.

# AF INFO 3.5

## Vision par ordinateur

*Computer Vision*

**Lecturers: Mohsen Ardabilian, Liming Chen**

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

## Objectives

Keywords:

**Core texts**

D. Forsyth, J. Ponce. *Computer Vision -- A Modern Approach*. Prentice Hall, 2002.
R. Szeliski. *Computer Vision -- Algorithms and Applications*. Springer, 2010.
R. Hartley, A. Zisserman. *Multiple View Geometry in Computer Vision*. Cambridge University Press, 2004.

# AF INFO 3.6

## Calcul et modélisation géométrique pour l'informatique graphique

*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

Keywords:

**Core texts**

Pascal Frey, Paul-Louis George. *Mesh Generation, 2nd Edition*. Wiley-ISTE, 2008.

Mario Botsch, Leif Kobbelt, Mark Pauly, Pierre All. *Polygon Mesh Processing*. K Peters/CRC Press, 2020.

M. de Berg, M. van Kreveld, M. Overmars, O. Schwar. *Computational Geometry Algorithms and Applications*. Springer-Verlag, 1997.

# AF INFO 3.7

## Système temps réel, embarqué et mobile

*Real Time, Embedded and Mobile System*

**Lecturers: Alexandre Saidi, Fabien Delpiano**

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

## Objectives

Keywords:

**Core texts**

M. Yaynal. *Concurrent Programming: Algorithms, Principles, and Foundations*. Springer-Verlag, 2013.
A. Burns & A. Wellings. *Concurrent and Real-Time Programming in ADA*. Cambridge U. Press, 2007.
X. Fan. *Real-Time Embedded Systems*. Newnes, 2015.

# AF INFO 3.8

## Projet 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

Keywords:

# Option MD

## 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/

Filière IM

# Mathématiques et Ingénierie du Risque

## Applied mathematics, and risk engineering

Directors: Elisabeth Mironescu

## 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.

### Departments/Laboratories

Département Mathématiques-Informatique, Institut Camille Jordan

## Programme

MD fo IM3.1 - Mathematics in action
MD fo IM3.5 - Project
2 modules to choose among :
MD fo IM3.2 - An introduction to financial mathematics
MD fo IM3.4 - Data Mining et Big Data
MD fo IM3.3 - An introduction to Inverse Problems

## Learning Outcomes

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

## 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.

## Requirements

1 MOD (1st semester) among "Applied statitics 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"

## Assessment

Mean of the 4 courses

## Option Website

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

## 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 Econométrie, Statistique
Biostatistique Biomathématique Bioinformatique et Santé (B3S) du master Santé publique

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# AF IM 3.1

## Mathématiques en situation

*Mathematics in action*

**Lecturers: Christophette Blanchet, Céline Helbert, Laurent Seppecher**

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

## Objectives

In this course, we give some extra knowledge on applied mathematics.
Some courses are given by different researchers/teachers on topics such as PDEs, Statistics, Probability, Optimization.
Conferecences by industrials working in "applied mathematics" are proposed as well.

Keywords: Applied Mathematics, Numerical and random simulation.

**Programme**

Computer experiments, uncertainty quantification
Inverse problem for image processing
Complements on mathematical techniques
Conferences aroung mathematical engineering

**Learning outcomes**

◇ Design and discuss a mathematical model describing a complex system
◇ Analyze a mathematical model (deterministic or stochastic)
◇ Implement a simulation with a suitable software
◇ Be aware of the different job oppurtinities for a mathematical engineer

# AF IM 3.2

## Introduction aux mathématiques financières

*Introduction to financial mathematics*

**Lecturers: Elisabeth Mironescu**

| Lectures: 14 h | TC: 0 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.
The course (MOD) Stochastic processes must be followed before this course.

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

**Programme**

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

**Learning outcomes**

Prepare numerical implementation with some computations on examples.Subjects of the numerical implementation sessions are given in advance.

**Core texts**


Lamberton, D. et Lapeyre B.. *Introduction au calcul stochastique appliqué à la finance*. Ellipses, 1997.

N. El Karoui et E. Gobet. *Les outils stochastiques des marchés financiers*. Les editions de l'Ecole Polytechnique, 2011.

Lamberton, D. et Lapeyre B.. *Introductionto stochastic Calculus applied to finance*. Chapman and Hall 2nd Edition, 2008.


**Assessment**

2 BE on computer
1 final exam

# AF IM 3.3

## Introduction aux problèmes inverses

*An introduction to Inverse Problems*

**Lecturers: Abdelmalek ZINE**

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

## 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

**Core texts**

A. Kirsh. *An introduction to the mathematical theory of inverse problems*. Springer-Verlag, 1996.
H. Brézis. *Analyse fonctionnelle - Theorie et applications*. Masson, 1983.
C.R. Vogel. *Computational methods for inverse problems*. SIAM, 2002.

**Assessment**

Written Exam 2hours,
Practical work

# AF IM 3.4

## Data Mining et Big Data

*Data Mining and Big Data*

**Lecturers: Céline HELBERT, Alexandre SAIDI**

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

## Objectives

Data analysis in high dimensions from text or numerical data.

Keywords: Data Mining, Text Mining, machine learning, regression, data science.

**Programme**

Part 1 : Algebra in high dimension (SVD, Google matrix)
Part 2 : Statistical learning (penalized linear models, PCR, PLS, additive models, CART, random forests, unsupervised learning)
Part 3 : Text Mining

**Learning outcomes**

◇ Statistical learning from voluminous data sets
◇ Extracting knowledge form textual data

**Core texts**

Charu C. Aggarwal & al.. *Mining Text Data*. Springer, 2012.

Trevor Hastie, Robert Tibshirani, Jerome Friedman. *The Elements of Statistical Learning : Data Mining, Inference and Prediction*. Springer, 2011.

# AF IM 3.5

## Projet MIR

*Project MIR*

**Lecturers: Elisabeth MIRONESCU, Christophette 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
◇ Analyzis of a determnistic or random model
◇ Use of an appropriated software to perform simulations
Write a report, build a presentation.Group Work, pair work.

**Independent study**

Objectives: Write a report, build a presentation.
Methods: Group Work, pair work.

**Assessment**

Report and defense.

Filière ADE

# Aide à la décision pour l'entreprise

## Firm's decision making

Directors: Sylvie Mira Bonnardel

## Introduction

**Departments/Laboratories**

CLES

## Programme

# 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: |

## Objectives

Keywords:

# AF ADE 3.2

## 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.

Iribarne P. *Les Tableaux de bord de la performance - Les concevoir et les aligner sur les facteurs clés de succès, les déployer en actions prioritaires*. DUNOD, 2009.

Johnson, Whittington, Scholes, Angwin, Regnér, Fré. *Strategique*. PEARSON, 2014.

# AF ADE 3.3

## 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**

Foucard JL.. *La Boîte à outils du Pilote des Systèmes d'Information*. Dunod, 2010.
Laudon K. *Management des systèmes d'information*. Pearson, 2010.
Selmer C.. *Concevoir le tableau de bord*. Dunod, 2011.

# AF ADE 3.4

## Projet ADE

*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:

# Option TT

## Transport et Trafic

## Traffic and Transportation

Directors: Olivier BAREILLE

130h

## 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.

**Departments/Laboratories**

## 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.

Filière TE

# TRAFIC ET ENVIRONNEMENT

## Traffic and environment

Directors: Olivier BAREILLE

## 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

# AF TE 3.1

## 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:

# AF TE 3.2

## 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:

# AF TE 3.3

## 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:

# AF TE 3.4

## Logistique desTransports

*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: |

## 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: |

## 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: |

## Objectives

Keywords:

Filière TV

# TECHNOLOGIES DES VÉHICULES

## Vehicle technology

Directors: Olivier BAREILLE

## Introduction

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

**Departments/Laboratories**

## Programme

## Employment Sectors

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

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# AF TV 3.1

## 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:

# AF TV 3.2

## 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:

# AF TV 3.3

## Dynamique des véhicules

*Vehicule Dynamics*

**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:

# AF TV 3.4

## Organes et architecture véhicule

*Vehicle's Body and Architecture*

**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:

# AF TV 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: |

## Objectives

Keywords:

# AF TV 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: |

## Objectives

Keywords:

# ENGINEERING FIELDS OF APPLICATIONS (2018-2019)

ÉCOLE CENTRALE LYON

# AF MOS 1.1

## Aérodynamique transsonique
*Transonic aerodynamics*

**Lecturers: Isabelle Trébinjac**

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

## Objectives

Keywords:

**Core texts**

N.A. Cumpsty. *Compressor Aerodynamics*. Krieger Publishing Company, 2004.
J.D. Anderson. *Modern Compressible Flow*. Mc Graw Hill, 2003.

# AF MOS 1.2

## 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 becoming 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 the vehicles. This course deals with sound sources related to ground and air transport and their consequences for the perceived noise levels inside and outside the vehicle.

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

**Programme**

I - Noise sources in air and land transportation. Legislation and certification.
II - Analysis of structure-borne noise. Vibroacoustics. Statistical energy analysis (SEA). Elements of numerical vibroacoustics.
III - Analysis of aircraft noise.
IV - Atmospheric sound propagation.
V - Localization and identification of sources. Noise reduction methods for transportation noise.

**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**

M. P. Norton. *Fundamentals of noise and vibration analysis for engineers*. Cambridge University Press, 1989.

F. Fahy. *Engineering Acoustics*. Academic Press, 2001.

T.D. Rossing. *Springer Handbook of Acoustics*. Springer Verlag, 2007.

**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:

**Learning outcomes**

- ◇ Dynamic confort
- ◇ Dynamic behavior
- ◇ Driven suspension

**Core texts**


Giancarlo Genta. *Motor Vehicle Dynamics, Modeling and Simulation,*. Series on Advances in Mathematics for applied Scie, 1997.

T. D. Gillespie. *Fundamentals of vehicule dynamics*. society of automotive engineers, Warrendale, 1992.

# AF MOS 1.4

## 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 synthetized 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 unefficient. 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**

Stephen ELLIOTT. *Signal Processing for Active Control,*. Academic Press, 2001.
Leonard MEIROVICH. *Dynamic and control of structures*. John Wiley and Sons, 1990.
P.A. Nelson, S.J. Elliott. *Active Control of Sound*. Academic Press, 1992.

**Assessment**

- reports on practical works
- MCQ
- oral presentation of a recent scientific paper (by groups of 2 or 3 students)

# AF MOS 1.5

## Couches ultraminces et surfaces fonctionnalisées

*Functionalized thin layers and surfaces*

**Lecturers: Stéphane Benayoun, Bertrand Vilquin**

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

## Objectives

Keywords:

# AF MOS 2.1

## Algorithmes pour la décision en entreprise

*Decision support algorithms*

**Lecturers: Joël Perret-Liaudet, Philippe Michel**

| Lectures: 14 h | TC: 4 h | PW: 0 h | Autonomy: 0 h | Study: 10 h | Project: 0 h | Language: |

## 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**

Colin F. Camerer. *Behavioral Game Theory: Experiments in Strategic Interaction*. The Roundtable Series in Behavioral Economics, 2003.

J. Dréo, A. Pétrowski, P. Siarry, E. Taillard. *Métaheuristiques pour l'optimisation difficile*. Eyrolles, 2003.

**Assessment**

Exam 2h / BEs

# AF MOS 2.2

## Informatique Graphique

*Computer Graphics*

**Lecturers: Raphaëlle Chaine**

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

## Objectives

Keywords:

**Core texts**

Peter Shirley. *Fundamentals of Computer Graphics*. AK Peters (Second Edition), 2009.

Tomas Akenine-Moller, Eric Haines, Naty Hoffman. *Real-Time Rendering*. AK Peters (Third Edition), 2008.

Henrik Wann Jensen. *Realistic Image Synthesis Using Photon Mapping*. AK Peters, 2005.

# AF MOS 2.3

## Choix des matériaux et des assemblages

*Choice of materials and assemblies*

**Lecturers: Stéphane Benayoun, Michelle Salvia**

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

## Objectives

Keywords:

**Core texts**

M.F. Ashby, Y Bréchet, L. Salvio. *Sélection des Matériaux et des procédés de mise en oeuvre*. Presse Polytechniques et Universitaires Romandes, 2001.

J.M. Berthelot. *Matériaux composites : Comportement mécanique et analyse des structures*. Lavoisier, 2005.

# AF MOS 2.4

## Macro Energie
*Macro Energy*

**Lecturers: Jean-Pierre CLOAREC**

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

## 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**

JEAN FAVENNEC. *Géopolitique de l'énergie*. Technip, 2007.
CÉDRIC LESTRANGE ET AL. *Géopolitique du pétrole*. Technip, 2005.
SAMUELE FURFARI. *Enjeux géopolitiques - vol. 1et 2*. Technip, 2007.

**Assessment**

knowledge: 2 h final test (70%)
know-how: literature studies (30%)

# AF MOS 2.5

## 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

Keywords:

# AF MOS 3.1

## 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: |

## Objectives

Keywords:

**Core texts**

P. Degauque, J. Hamelin. *Compatibilité Electromagnétique*. Dunod, 1990.

Yvon Mori. *Compatibilité électromagnétique*. Lavoisier, 2007.

M. Mardiguian. *Manuel pratique de CEM ; prédiction et solutions aux perturbations*. Editions Prana R & D, 1992.

# AF MOS 3.2

## Ouvrages de Production d'Energie

*Structures for Power Generation*

**Lecturers: Pierre BRUN**

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

## 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

# AF MOS 3.3

## Véhicules hybrides : modélisation et gestion de l'énergie

*Hybrid electric vehicles : modelling and energy management*

**Lecturers: Florent Morel**

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

## 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 developement 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, environnemental 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**

Lino Guzzella, Antonio Sciarretta. *Vehicle Propulsion Systems -- Introduction to Modeling and Optimization*. Springer, 2013.

Chris Mi, M. Abul Masrur, David Wenzhong Gao. *Hybrid Electric Vehicles: Principles and Applications with Practical Perspectives*. Wiley, 2011.

**Assessment**

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

# AF MOS 3.4

## Modélisation et gestion du trafic

*Traffic Flow Theory and Management*

**Lecturers: Ludovic Leclercq**

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

## 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/ Pratical 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/ Pratical 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**

Treiber, Keisting. *Traffic Flow Dynamics: Data, Models and Simulation*. Springer, 2013.
Daganzo. *Fundamentals of Transportation and Traffic Operations*. Pergamon Press, 1997.
Elefteriadou. *An Introduction to Traffic Flow Theory*. Springer, 2014.

**Assessment**

Student evaluation is done based on two practical applications and a final exam.

# AF MOS 3.5

## 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 turbomachinary

**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

# AF MOS 4.1

## Gestion des ressources naturelles

*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**

Diamond, J.W. *Collapse: How Societies Choose to Fail or Succeed*. Penguin Book, New York., 2011.
MacKay D. *Sustainable Energy – without the hot air*. UIT Cambridge, 2008.
Agnew, C. and Woodhouse, P.. *Water resources and development.*. Routledge., 2011.

**Assessment**

Final exam and mini-project

# AF MOS 4.2

## Pollution Atmosphérique
*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, particular 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**

BLACKADAR, A.K. *Turbulence and diffusion in the atmosphere*. Springer Verlag, 1997.

**Assessment**

Final Exam (50%) + design report (50%)

# AF MOS 4.3

## 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

Keywords:

# AF MOS 4.4

## Nouvelles Technologies de l'Information et de la Communication

*Information Technology*

**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

Keywords:

**Core texts** F. Jakobiak. *L'intelligence économique, techniques et outils*. Dunod, 0.

# AF MOS 4.5

## Génie de l'Océan et du Littoral

*Coastal and Ocean Engineering*

**Lecturers: Richard Perkins, Julian Scott**

| Lectures: 18 h | TC: 0 h | PW: 4 h | Autonomy: 0 h | Study: 6 h | Project: 0 h | Language: |

## 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

**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

**Options/Masters**

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

**Core texts**

DEAN, R.G. & DALRYMPLE, R.A. *Water wave mechanics for engineers and scientists.*. Prentice Hall, 1991.

POND, S. & PICKARD, G.L. *Introductory dynamical oceanography*. Pergamon Press, 1983.

NIELSEN, P. *Coastal bottom boundary layers and sediment transport*. World Scientific Publishing, 1992.

**Assessment**

Final exam + lab report + design study

# AF MOS 5.1

## Géotechnique

*Advanced Foundation Engineering*

**Lecturers: Eric Vincens**

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

## 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 necessar 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**

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

**Options/Masters**

civil engineering and environment
Master in civil engineering

**Core texts**

G. Filliat. *La pratique des sols et fondations*. EDITIONS DU MONITEUR, 1981.
P. Mestat. *De la rhéologie des sols à la modélisation des ouvrages géotechniques*. LCPC, 2000.

# AF MOS 5.3

## Problèmes en domaines non bornés : analyse mathématique et simulation numérique

*Physical problems in unbounded media : mathematical analysis and numerics*

**Lecturers: Laurent Seppecher, Gregory Vial, Malek Zine**

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

## 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**

J.-C. Nédelec. *Acoustic and Electromagnetic Equations*. Springer, 2001.
D. Givoli. *Numerical Methods for Problems in Infinite Domains*. Elsevier, 1992.
L. Lehmann. *Wave Propagation in Infinite Domains*. Springer, 2007.

**Assessment**

Final exam + Simulation projets

# AF MOS 5.4

## Phénomènes complexes en dynamique des structures

*Complex phenomena in structural dynamics*

**Lecturers: Olivier Dessombz et Jean-Jacques Sinou**

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

## 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**

A.H. Nayfeh and D.T. Mook. *Nonlinear Oscillations.*. John Wiley & Sons, 1979.
A. Preumont. *Vibrations aléatoires et analyse spectrale*. Presses Polytechniques Romandes, 1990.
D.-J. Ewins. *Modal Testing: theory and analysis, Research*. Study Press, 1984.

**Assessment**

Written test
Personal work

# AF MOS 5.5

## Visualisation interactive de données

*Interactive Data Visualization*

**Lecturers: Romain Vuillemot**

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

## 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** | Tamara Munzner. *Visualization Analysis and Design*. CRC Press, 2014.<br>Scott Murray. *Interactive Data Visualization for the Web*. O'Reilly, 2017. |
| **Assessment** | Graded homeworks (40%) final projet (60%) |

# AF MOS 6.1

## Ingénierie tissulaire et biomatériaux

*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**

B.D. Ratner et al. *Biomaterials science : an introduction to materials in medicine*. Elsevier Academic Press, 3rd edition, 2013.

R. Lanza et al. *Principles of tissue engineering*. Elsevier Press, 4th edition, 2013.

**Assessment**

Written final exam

# AF MOS 6.2

## Stratégie 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**

Frery F. *Stratégique*. Pearson,  Paris, 2014.

Jaouen A., Le Roy F. *L'innovation managériale*. Dunod, Paris, 2013.

Meier O. *Stratégies et changement - Innovations et transformations des organisations*. Dunod, Paris, 2013.

**Assessment**

Case studies
Projects

# AF MOS 6.3

## Microsystèmes, microcapteurs, microfluidique

*Microsystems, biosensors, microfluidics*

**Lecturers: Emmanuelle Laurenceau, Ian O'Connor**

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

## 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**

Cooper Jonathan M. *Biosensors*. Oxford University Press, 2004.
Folch Albert. *Introduction to BioMEMS*. CRC Press, 2013.
Tabeling Patrick. *Introduction à la microfluidique*. Belin, 2003.

**Assessment**

BE evaluations

# AF MOS 6.5

## Économétrie des Séries Temporelles

*Time series econometrics*

**Lecturers: Christian de Peretti**

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

## 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

Chap 5. Vector Autoregressive Models (VAR)
Models for jointly processing a set of stationary time series.

Chap 6. Notion of cointegration, model VECM
Models for jointly processing a set of non-stationary time series.

**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 SAFIR.

**Core texts**

Walter Enders. *Applied Econometric Time Series, 4th Edition*. Wiley, 2015.

**Assessment**

1) Project 50%
2) Exam 1 hour 50%

# AF MOS 7.1

## Stabilité des machines tournantes

*Stability of rotating machines*

**Lecturers: F. Thouverez et L. Blanc**

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

## Objectives

Rotating machines as propulsion systems (turbojet engines, …), or power production (wind turbine, alternator, …) or any system requiring rotating structure (pump, gyroscope, …) take à large place in everyday life. These machines follow the dynamical equations and often in a multi-physical context: fluid-structure interaction, mecatronic 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 rottating 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**

Roland Bigret. *Stabilité des machines tournantes et des systèmes*. Publication CETIM, 1997.

Fredric F. Ehrich. *Handbook of Rotordynamics*. Krieger Publishing Company, 2004.

MI Fiswell, JET Penny, SD Garvey, AW Lees. *Dynamics of rotating machines*. Cambridges Aerospace series, 2010.

**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 phenoma
◇ data analysis and compared studies

**Options/Masters**

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

**Core texts**

J. Lemaître. *A course on damage mechanics*. Springer Verlag, New York, 1996.

Karbhari Vistasp M., Ansari Farhad. *Structural health monitoring of civil infrastructure systems*. Woodhead Publishing CRC Press, 2009.

Adams Douglas E. *Health monitoring of structural materials and components*. Wiley, 2007.

**Assessment**

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

# AF MOS 7.3

## Procédés généraux de construction

*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

# AF MOS 7.5

## Energie et impact sur l'environnement

*Energy and environmental impact*

**Lecturers: Jean-Pierre Cloarec**

| Lectures: 12 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 20 h | Project: 0 h | Language: |

## 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 organasition 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 cyclle 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 & environement considerations
◇ Relate economical logic, social & ecological responsabilities
◇ Fastly deepen a field relating environment and energy

**Options/Masters**

Advised for the option "Energy"

**Core texts**

Joseph Martin, Pierre Wauters. *Eléments de Thermodynamique Technique*. Presses Universitaires de Louvain, 2014.

François Ramade. *Eléments d'Ecologie : Ecologie Appliquée*. Dunod, 2003.

François Ramade. *Eléments d'Ecologie : Ecologie Fondamentale*. Dunod, 2005.

**Assessment**

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

# AF MOS 8.1

## 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**


AKRICH M., CALLON M. ET LATOUR B. *A quoi tient le succès des innovations?, Gérer et comprendre,*. Annales des Mines, 11988.

BROWN TIM. *L'Esprit design: Comment le design thinking change l'entreprise et la stratégie*. Pearson Education, 2014.

GAGLIO G. *Sociologie de l'innovation*. , PUF, 2012.

# AF MOS 8.3

## 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
◇ Negiciate with stakeholders: customers, suppliers, business angels

**Core texts**

Alexander Osterwalder, Yves Pigneur, Alan Smith. *Business Model Generation. A Handbook for Visionaries, Game Changers, and Challengers*. WILEY, 2010.

Eric Ries. *The Lean Startup. How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*. CURRENCY, 2017.

**Assessment**

Pitch and business plan

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