

# OPTIONAL COURSES S8

PROGRAMME  
2020-2021



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## SEMESTER 8 AT ECOLE CENTRALE DE LYON

During S8, students attend the following teaching units:

- ◇ UE Optional courses (UE ELC)
- ◇ UE language and culture
- ◇ UE Engineering training

### 1. Optional Courses

In this unit, a student must choose five courses among 58 that are distributed in 6 slots. Each course represents a total of 32 hours and 3 ECTS. These courses are whether interdisciplinary courses or specific in a field not or little addressed in the core courses.

Slot A	Monday 8:00-12:00
ELC A-1	Finite Element Method, from the Theory to Implementation
ELC A-2	<b>Mechanical Metamaterial: Functionalised by Design (English)</b>
ELC A-5	Optics and Photonics for Engineers
ELC A-6	<b>Rotors Dynamics in Mechanical Engineering (English)</b>
ELC A-7	Mechanics of Thin Structures: Plates and Shells
ELC A-8	<b>Numerical Methods for Mechanics (English)</b>
ELC A-10	Life, Information and Systems
ELC A-11	Gui Programming in C++
ELC A-12	Social, Economical and Political Issues for a Sustainable Development

Slot B	Monday 14:00-18:00
ELC B-1	Functional Analysis, Theory and Applications
ELC B-2	Collaborative Algorithms and Applications
ELC B-3	Non Destructive Testing
ELC B-4	Nuclear Engineering
ELC B-5	Health Engineering
ELC B-6	<b>Hydrology and Water Resources (English)</b>
ELC B-8	Development of Technical Products
ELC B-9	Political Sociology
ELC B-10	Conception of a Sustainable Packaging
ELC B-12	Marketing

Slot C	Tuesday 8:00-12:00
ELC C-1	Mathematical Tools for Biological Problems
ELC C-2	Design of Microwave Circuits and Devices
ELC C-3	Interactive Design and FabLab Practices
ELC C-4	Image Sensing and Processing
ELC C-5	<b>Observation and Analysis of Materials (English)</b>
ELC C-6	Fundamental Soil Mechanics
ELC C-7	Multiphysics Simulation in Mechanical Design
ELC C-8	Philosophy of Sciences and Technologies
ELC C-9	Corporate Finance

<b>Slot D</b>		<b>Wednesday 8:00-12:00</b>
<b>ELC D-1</b>		Probability Theory and Introduction to Random Processes
<b>ELC D-2</b>		<b>Adaptive Filtering: Application to Active Noise Control (English)</b>
<b>ELC D-3</b>		Webapps
<b>ELC D-4</b>		Physics and Chemistry of Surfaces and Interfaces
<b>ELC D-5</b>		<b>Two-Phase Flow in Engineering Systems Related to Energy (English)</b>
<b>ELC D-6</b>		PLM - Digital Mockup
<b>ELC D-7</b>		Social Relationships in Company
<b>ELC D-8</b>		Discrete Event Systems
<b>ELC D-9</b>		Wind Turbines
<b>ELC D-10</b>		Musical Acoustics
<b>ELC D-11</b>		<b>Introduction to Random Vibrations (English)</b>
<b>ELC D-12</b>		<b>Space physics and solar terrestrial coupling (English)</b>

<b>Slot E</b>		<b>Thursday 8:00-12:00</b>
<b>ELC E-1</b>		Algorithms and Reasoning
<b>ELC E-2</b>		Collaborate and Manage in the Era of Digital Technology
<b>ELC E-4</b>		Industrial Process Engineering
<b>ELC E-5</b>		<b>Selection of Materials (English)</b>
<b>ELC E-6</b>		<b>From Microscale to Macroscale in Mechanics (English)</b>
<b>ELC E-7</b>		<b>Aircraft Turbojets (English)</b>
<b>ELC E-9</b>		Globalization and Transculturalities
<b>ELC E-10</b>		Surfaces, Friction, Vibrations

<b>Slot F</b>		<b>Friday 8:00-12:00</b>
<b>ELC F-1</b>		Financial Markets
<b>ELC F-2</b>		<b>Intelligent Mecatronic Systems (English)</b>
<b>ELC F-3</b>		Insulating Materials for Electrical Engineering
<b>ELC F-4</b>		Ecology and Environment
<b>ELC F-5</b>		Order within Chaos
<b>ELC F-6</b>		Antenna, Signals and Processors
<b>ELC F-7</b>		Entrepreneurship and Innovation
<b>ELC F-8</b>		<b>Optimal Design and Computational Fluid Mechanics (English)</b>
<b>ELC F-9</b>		<b>Polymer Materials: Physical Properties and Innovation(English)</b>
<b>ELC F-10</b>		Humans and their Waste
<b>ECL F-11</b>		Probability Theory and Introduction to Random Processes

The students have the possibility to choose one of the [5 courses among the offers of the CHELS](#).

## **2. The engineering training (UE Pro)**

During the S8, the students go on with the activities they started during S7:

- ◇ applied engineering project or research project,
- ◇ sport,
- ◇ tutoring activities.

At the end of S8 (mid April - May of year 2) the student must perform an applied engineering internship of at least 12 weeks.

## **3. UE language and culture**

The students go on with their language courses.

## **4. International students**

Students arriving at Ecole Centrale de Lyon for the S8 have to follow UE ELC. In UE Pro, they follow sport and perform a research project in one of the six laboratories of the Ecole Centrale de Lyon (LMFA, LTDS, INL, LIRIS, Ampère, Camille Jordan). They participate at the discovering inquiry about the engineering profession, and attend conferences. The research project replaces the applied project. Languages activities are also compulsory.



## FINITE ELEMENT METHOD, FROM THE THEORY TO THE IMPLEMENTATION

Lecturers: Abdelmalek ZINE

| Lectures: 24 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 8 h | Project: 0 h | Language:  |

### Objectives

In the engineering field, there are several approximation techniques allowing to solve the differential equations or the partial derivatives governing the studied phenomena.

The most widely used is the Finite Element Method. This method makes it possible to treat any kind of geometry, any kind of boundary value problem arising from electromagnetism, acoustics, fluid mechanics, solid mechanics, biology and even finance!

Moreover, This method has a rigorous mathematical approach, based on variational methods.

This mathematical approach makes it possible to predict the accuracy of the approximation and to improve it via the error estimates.

**Keywords:** Boundary value problems, Variational formulations, Numerical approximation, Finite Element Method, Error estimates

#### Programme

The variational problem, an abstract framework  
Elliptic boundary value problems  
Finite element method, approximation of boundary value problems  
Application to selected engineering problems  
a priori and a posteriori error estimates  
Finite element method for the evolutionary problems (parabolic and hyperbolic)

#### Learning outcomes

- ◇ To be able to write and analyse a variational formulation
- ◇ To be able to write and analyse a finite element approximation
- ◇ To be able to write a Matlab procedure allowing to solve the approximated problem

#### Core texts

- A. ERN ET J. L. GUERMO. *Éléments finis : théorie, applications, mise en oeuvre*. Collection Mathématiques et applications, Springer, 2002.
- J. RAPPAZ ET M. PICASSO. *so Introduction à l'analyse numérique*. Presses polytechniques et universitaire romandes, 1999.
- A. QUARTERONI AND A. VALLI. *Numerical Approximation of Partial Differential Equations*. Springer, 2008.


#### Assessment

A two-hours examination and practical work reports



## MECHANICAL METAMATERIAL : FUNCTIONALIZED BY DESIGN

Lecturers: **O. Bareille, M. Collet**

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

### Objectives

Metamaterials appears as artificial materials incorporating an internal structuring allowing them to adopt unparalleled wave behavior in materials in the natural state. In the case of acoustics, they give rise to very important applications in engineering fields as sound insulation, vibroacoustics, stealth in underwater acoustics, the realization of more efficient transducers.

Today, associated technologies present a very important development potential and already arouse the interest of many industries.

The main objective of this course is to give general training to the students of Ecole Centrale de Lyon on the topic of metamaterials and the capacity they offer to respond to engineering problems.

**Keywords:** Waves, Vibrations, Acoustics, Smart Materials, optimization, Vibroacoustic treatments

#### Programme

1. Waves propagation: return on basis
2. Modelling
  - a) Analytical and SAFE Method
  - b) WFE: Wave Finite Elements
  - c) Shift Cell Operator for Multiphysics coupling
  - d) Plane Waves Expansion PWE
3. Design by using band gap:
  - a) Energy Diffusion : How to control absorption and reflexion
  - b) Finite structure: limitation of band gap phenomena
  - c) Beyond the band gap
    - Focusing
    - Diode and reciprocity breaking
    - Cloaking

#### Learning outcomes

- ◇ Understand Band Gap phenomena
- ◇ Compute Dispersion diagram and diffusion operator
- ◇ Optimize metamaterial interface
- ◇ characterize metamaterial behavior

#### Independent study

The objective of autonomous work is to apply, on a concrete example, an particular aspect of the course dealing either with the modeling, optimization or realization and characterization of mechanical metamaterials. The used method is based on the realization of mini projects o in groups of students. Each group will benefit from 8 hours of supervision. A final restitution of the result of the results will be made in front of all the class.


#### Assessment

Evaluation is divided into :  
1/3 by using a QCM  
1/3 coming from project evaluation  
1/3 made by the class evaluation of the final restitution





Lecturers: Emmanuel DROUARD, Ségolène CALLARD

| Lectures: 14 h | TC: 6 h | PW: 4 h | Autonomy: 4 h | Study: 4 h | Project: 0 h | Language:  |

## Objectives

The recent growth of optical methods in various fields is due to the inherent advantages of these methods (high spatial and temporal resolutions, punctual or global measure, contactless method ...) and recent advances in photonics. The applications cover a wide range of industrial and research fields: automotive, aerospace, health, environment ...

This course aims to provide the knowledge required to the understanding of the most used optical technologies.

**Keywords:** telemetry, interferometry, infrared technology, optical materials processing ...

### Programme

Introduction: major fields of optics  
Spatio temporal coherence, metrology applications  
Notions of photometry  
Noise phenomena in detectors  
Applications to measurement (principles): telemetry, velocimetry, interferometry  
Applications of lasers in material processing

Tutorials: Holography, telemetry, interferometric sensor, Applications of lasers in material processing  
4 lab works (1h each): holography, vibrometry, FTIR spectrometry, laser anemometry

### Learning outcomes

- ◇ How to choose and implement the relevant optical formalism (ray optics, wave optics, electromagnetic, photometry ...)
- ◇ Being able to identify the components of an optical measurement system
- ◇ How to choose a method of measuring or optical processing
- ◇ Identify the kinds of noise in an optical detector

### Independent study

In depth understanding of a particular optical technology  
Problem based learning : brainstorming (2h) / preparation of presentations and restitution

### Core texts

BAHAA E. A. SALEH, MALVIN CARL TEICH. *Fundamental of Photonics*. Wiley, 2007.  
R. FARCY. *Applications des lasers*. Masson, 1993.  
D. SCHUÖCKER. *Engineering Lasers and Their Applications, Handbook of the Eurolaser Academy, Volume 1 & 2*. Springer, 1998.


### Assessment

60% Written test 2h (knowledges)  
40% presentation (50% methodology and 50% know how)



## ROTORS DYNAMICS IN MECHANICAL ENGINEERING

Lecturers: Laurent BLANC, Fabrice THOUVEREZ

| Lectures: 12 h | TC: 10 h | PW: 4 h | Autonomy: 2 h | Study: 4 h | Project: 0 h | Language:  |

### Objectives

The purpose is to get specific knowledge about rotating machinery design. The industrial domains of application go from plane engine dynamics to shaft-lines analysis and micro-pumps or electrical turbines. The lessons go further beyond the concepts seen in MSS and GM generalists curricula core teaching units. They give technological knowledge, as well for modeling issues as for experimental issues, necessary to understand dynamics of structures produced by Safran-Snecma, Safran-Turboméca, General Electric, Siemens, Alstom Power, Rolls-Royce, EDF, Pratt&Whitney...

**Keywords:** structural dynamics, vibrations, modal analysis, finite elements, Campbell diagram, zig-zag diagram, critical speeds, resonance, rolling bearings, squeeze-films, rotors, turbomachines, health monitoring

#### Programme

Lessons :

- design of rotating machinery, specific aspects and tools
- modeling of mono and multi disk shafts
- bladed disks design
- bearings

Lab :

- bladed disk modal analysis by finite elements

#### Learning outcomes

- ◇ - to know the steps of design for rotating machinery
  - ◇ - to read a Campbell diagram and identify risky configurations
  - ◇ - to calculate, by finite elements, the eigenmodes of a rotating machine
- to be aware of the state of art in rotating machinery research paper analysis (2 persons) + oral presentation

#### Core texts

- M. LALANNE AND G. FERRARIS. *Rotordynamics Prediction in Engineering*. John Wiley and Sons, 1998.
- D. W. CHILDS. *Turbomachinery rotordynamics phenomena, modelling and analysis*. John Wiley and Sons, 1993.
- F. F. EHRICH. *Handbook of rotordynamics*. Krieger Publishing company, 1999.

#### Assessment

final exam, oral presentation of paper



## MECHANICS OF THIN STRUCTURES: PLATES AND SHELLS

Lecturers: Hélène MAGOARIEC, Cécile NOUGUIER

| Lectures: 14 h | TC: 12 h | PW: 4 h | Autonomy: 2 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

Thin structures, light and allowing optimization of the weight / performance ratio, feature prominently in many industries (aeronautics, civil engineering, chemical engineering, etc.).

The main objective of this course is to provide the future engineers with elements required for modeling and design of buildings based on thin structural elements by analyzing the behavior of 2D thin structures, flat or curved.

In consideration of the material gain conferred by the thinness, the risk of instability is amplified: phenomena such as buckling of plates and shells have to be accounted for. The second objective of this course is to provide the future engineers with the bases to study instabilities of elastic thin structures.

**Keywords:** Solid mechanics, Thin plates and shells, Love-Kirchhoff model, Dimensioning, Elastic instability, Extensometry, Comparison theory / experiments

### Programme

Part 1 - Elastic behavior of plates: 3 Lectures, 3 Tutorials, 1 Practical work; Definition, schematization, hypotheses, and mechanical forces ; internal forces; local balance ; Love-Kirchhoff thin plates model ; boundary conditions.

Practical work: experimental validation of the Love-Kirchhoff model by deflection and strain measurements on different systems.

Part 2 - Elastic behavior of shells of revolution: 2 Lectures, 2 Tutorials; Geometry of surfaces, definition, schematization, mechanical forces ; internal membrane forces ; local balance for shells of revolution ; usual loadings ; Elastic stress, strain, and displacements.

Part 3 - Elastic stability of thin structures: 2 Lectures / Tutorials; Buckling of thin plates and shells; critical load.

### Learning outcomes

- ◇ Being able to dimension plates and shells (stress, displacements, and elastic instabilities)
- ◇ Being able to determine predominant elastic effects in thin structures (stress, strain, displacements)
- ◇ Being able to build a model for 2D thin structures, following the way of modeling used for 1D structures during the previous semesters
- ◇ Being able to compare theory and experiment: engage a critical analysis to validate a model

### Independent study

Theoretical and experimental applications of the course to circular and rectangular plates. Writing of a synthesis document summarizing the experiments and critical analyses. Coordinated / Standard autonomies, group work near the practical works rooms (open access to test devices), ownership of the handout, validation of the theoretical/numerical works, group reflection: processing of measurements and critical analysis.

### Core texts

S. P. TIMOSHENKO, S. WITONOWSKI-KRIEGER. *Theory of plates and shells*. Mc Graw Hill, 1970.

F. FREY. *Traité de Génie Civil de l'Ecole polytechnique fédérale de Lausanne, Vol. 1 à 6*. Presses Polytechniques et Universitaires Romandes,, 2003.

S. P. TIMOSHENKO, J. M. GERE. *Theory of elastic stability*. Dover Publications, 1961.

### Assessment

A written test of 2h (jointly-agreed modalities with educational team and students)  
Grading of tutorials and practical work: report + participation.



**Lecturers: Jérôme BOUDET, Olivier DESSOMBZ, Fabien GODEFERD**

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

## Objectives

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This course is an introduction to solution methods used in simulation softwares, in solid mechanics, fluid mechanics (CFD) and energetics. We present numerical methods allowing the resolution of boundary value problems in these disciplines, the objective being to master the concepts required for a proper use of industrial softwares. A particular effort is devoted to the implementation and the physical interpretation, and interdisciplinarity allows for a better understanding of modellings and physical phenomena.

**Keywords:** numerical methods, finite volumes, weighted residuals, finite elements, solid mechanics, fluid mechanics  
.....

### Programme

- Finite Differences
- Solution methods and properties of numerical schemes
- Finite Volumes
- Variational methods
- Spectral methods
- Finite Elements (1/2)
- Finite Elements (2/2)

### Learning outcomes

- ◇ Being able to properly formulate a model problem in mechanics
- ◇ Being able to implement the basic numerical methods in mechanics
- ◇ Being able to analyze and interpret numerical solutions

### Core texts

- C. HIRSCH. *Numerical computation of internal and external flows (Volumes 1 et 2)*. John Wiley and Sons, 1988.
- H.K. VERSTEEGH AND W. MALALASEKERA. *An introduction to computational fluid dynamics*. Longman, 1995.
- J.C. CRAVEUR. *Modélisation par éléments finis : Cours et exercices corrigés Ed. 3*. Dunod, 2008.

### Assessment

- 2h final exam (60%, knowledge)  
Reports of group work undertaken in exercise sessions and pursued in autonomous time (40%, know how)



## FUNCTIONAL ANALYSIS, THEORY AND APPLICATIONS

**Lecturers: Martine MARION**

| Lectures: 18 h | TC: 14 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

The aim of this course is to present

- Abstract results from functional Analysis
- How these results can be applied to the resolution of linear and nonlinear elliptic partial differential equations

**Keywords:** Functional analysis, Partial differential equations

#### Programme

Part I - Linear PDEs  
Chapter 1 : Hilbert spaces  
Chapter 2 : Weak derivatives and Sobolev spaces  
Chapter 3 : Study of linear elliptic problems  
Part I - Non linear PDEs  
Chapter 4 : Weak topology  
Chapter 5 : Optimization and application to PDES

#### Learning outcomes

- ◇ After this course the student should be able to understand and use
- ◇ functional analysis tools
- ◇ Sobolev spaces
- ◇ Various methods to study PDEs

#### Core texts

H. BREZIS. *Analyse fonctionnelle*. Dunod, 2005.  
G. ALLAIRE. *Analyse Numérique et optimisation*. Editions de l'Ecole Polytechnique, 2009.



## COLLABORATIVE ALGORITHMS AND APPLICATIONS

Lecturers: Philippe MICHEL, Alexandre SAIDI

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

### Objectives

The objective of this course is to model and solve some complex problems using so-called "collaborative" algorithms. These have the peculiarities of taking an example of nature (genetic algorithms, ant colonies, ..., neural networks) and using the collective experience of "individuals" (agents) with weak capacities to make it a collective intelligence. For example, neural networks seek to mimic the ability of the brain to solve a problem by using the multitude of neurons (each having a low resolution capacity) that compose it.

The applications processed in progress are varied: character recognition, contour detection (in an image), resolution of a (simplified) poker game (or other games), decoding of a text, search for a path the shortest (Dijkstra, commercial traveler), fault detection...

**Keywords:** multi-agents, robotics, genetic algorithms, ant colony algorithm, neural networks, slam

#### Programme

Genetic algorithms  
Neural networks  
Simultaneous mapping and localization using robots  
Ant colony algorithm and Collaborative Strategies

#### Learning outcomes

◇ ability to develop code of algorithms proposed  
◇ multi-agent modeling of complex problems  
Solve problemsStudy

#### Core texts

SIMON HAYKIN. *Share Facebook Twitter Pinterest 2 used & new from \$160.00 See All Buying Options Add to List Have one to sell? Sell on Amazon See this i.* MacMillan Publishing Company, 1994.

SEBASTIAN THRUN. *Probabilistic Robotics (Intelligent Robotics and Autonomous Agents series)*. The MIT Press, 2005.

MARCO DORIGO. *Ant Colony Optimization*. A Bradford Book, 2004.

#### Assessment

Test 2h and Practical Works 4 x 4 hours



Lecturers: Arnaud Bréard, Christian vollaire

| Lectures: 18 h | TC: 0 h | PW: 8 h | Autonomy: 6 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

.....  
This course aims to introduce students to the concept of Non Destructive Testing. This technical area is part of the general concept of quality, applied to the manufacturing operations; it plays a key role in all applications requiring a high level of security and reliability (nuclear, aeronautics, automotive, ...). This course is an introduction to three techniques (X-ray, ultrasonic, electromagnetic) that aims to show in a concrete way (based on practical work carried out on real parts) in which frameworks these techniques are implemented and what can be their performances.

**Keywords:** Non Destructive Testing, Electromagnetic methods, NDT by Eddy Currents, X rays, ultra sonic  
.....

### Programme

A) Speaker Noël BURAIIS

General information on electromagnetic methods (magnetic, impedance, eddy currents, waves HF) materials categories.

Structures of sensors, sensor combination, separate dual-function measurements or functions, absolute or differential.

B) Speaker Jean-Michel LETANG

1) Ultrasonic testing (US).

Principle of ultrasound,

normal incidence: transmission coefficient and reflection

oblique incidence: Snell 's law

Production of US and sensors, types of control, visualization

2) X-ray Inspection (XR).

Principle of radiology transmission, interactions photon-matter,

Dosimetry, radiation and biological effects

Production and detection of RX, characteristics of the generators and sensors.

### Learning outcomes

◇ Know the main principles of NDT methods

◇ Know the performance limits and fields of application of méthodes

### Core texts

E.M. HUSSEIN. *Handbook on Radiation Probing, Gauging, Imaging and Analysis: Volume I: Basics and Techniques (Non-Destructive Evaluation)*. Kluwer Academic Publishers, 2003.

CHARLES HELLIER. *Handbook of nondestructive Evaluation*. Mc Graw-Hill, 2003.



**Lecturers: Yves ROBACH, Ségolène CALLARD**

| Lectures: 18 h | TC: 10 h | PW: 0 h | Autonomy: 4 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

Nuclear engineering covers a wide scientific and economical field that is enriched by the multiple relations with other disciplines. Its applications field extends from energy production (nuclear fission and fusion reactors) to the analysis and treatment of materials, the use of radio-elements (radioactive tracers) in medicine, biology and geology beyond to medical applications in radiotherapy and nuclear imaging. The aim of the course is to give the physical basis of nuclear engineering and to illustrate some of the applications previously mentioned. The lessons will be followed by two conferences (Nuclear reactors of next generation and radio-protection) given by specialists of the field.

**Keywords:** Nuclei, nuclear decays, radioactivity, liquid drop model, shell model, fusion, fission.

### Programme

1. Nuclear structure, energy considerations in nuclear physics, notions on cross section of interaction. Nuclear stability and nuclear models.
2. Nuclear instabilities: the different types of radioactivity, basic notions of radio-protection.
3. Nuclear reactions and applications.
4. Nuclear fission, basis of neutronics and principle of operation of a nuclear reactor.
5. Nuclear fusion.
6. Nuclear applications in chemistry, biology, medicine. Radioactive tracers and applications, medical imaging.

### Learning outcomes

- ◇ Be able to identify the application fields of nuclear physics.
- ◇ Evaluate orders of magnitude in nuclear processes.
- ◇ Be able to equilibrate a nuclear reaction and to calculate mass transformation.
- ◇ Be able to distinguish and to describe the different types of radioactive decays.

### Independent study

During the tutorials, students must resolve some exercises, using the concepts developed during the lessons. This work is done by a group of 2 persons and is evaluated by a reporting at the end of each session.

### Core texts

- W.E. MEYERHOF. *Elements de physique nucléaire*. Editions Dunod., 1970.  
DANIEL BLANC. *Noyaux, particules, réacteurs nucléaires*. Masson, 1987.  
P. BONCHE. *Le nucléaire expliqué par les physiciens*. EDP Sciences, 2002.





Lecturers: Emmanuelle LAURENCEAU, Romain RIEGER

| Lectures: 22 h | TC: 0 h | PW: 0 h | Autonomy: 2 h | Study: 8 h | Project: 0 h | Language:  |

## Objectives

The aging of the population and major biological progresses in recent years open new issues for treatment and responses to societal expectations. Thus, engineering problems are becoming more and more important (development of diagnostic devices, production of drugs, miniaturization of devices, biomaterials, tissue engineering). The objective of this lecture is to show the potential of coupling engineering and biology.

**Keywords:** Diagnosis, targeting, medical imaging, biomaterials, biomechanic, drug development

### Programme

- 1- Diagnosis tools
- 2- Nanoparticles for Health
- 3- Drug design and development
- 4- Challenges of orthopedics and biomaterials
- 5- Cellular activity and bone adaptation

- 1 BE-1 : Modelisation of the mechanical behavior of bone
- 1 BE-2 : oral presentation of projects

### Learning outcomes

- ◇ Knowing the different technologies
- ◇ Understanding the different fields of health engineering
- ◇ Analyzing scientific publications
- ◇ Sumarizing information and presenting results

### Independent study

Deepen one of the themes presented in the lectureWork group of 3-4 students on a mini-project related to topics presented in the lecture  
Search and analysis of documents, report writing, preparation of oral presentation

### Core texts

STEPHEN C. COWIN. *Bone Mechanics Handbook*. Stephen C. Cowin, 2001.  
JOHN P. BILEZIKIAN, LAWRENCE G. RAISZ AND T. JOHN. *Principles of Bone Biology*. John P. Bilezikian, Lawrence G. Raisz and T. John, 2008.

### Assessment

25% know-how: BE-1 (individual written)  
25% methodology: Rapport écrit (collective)  
50% know: BE-2 (individual oral)



HYDROLOGY AND WATER RESOURCES

Lecturers: Richard PERKINS

| Lectures: 18 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 14 h | Project: 0 h | Language: |

Objectives

Water is a natural resource that is essential for life, and although 71% of the earth’s surface is covered in water, only a small fraction of this can be used directly by man. In addition, the useful water is distributed very unevenly over the surface of the earth, and the never-ending growth in the demand for water means that the management of water resources is of critical importance for the future of mankind. The engineer has a central role to play on this.

The objectives of this course are:

- To present and explain the hydrological cycle and its influence on the quality and quantity of useful available water;
- To study the interaction between water and the environment
- To present the different approaches to the management of water resources

Keywords: Atmosphere, Hydrology, Water resources, Water treatment, modelling

Programme

1. Introduction  
Water resources, early systems of water supply and water treatment
2. The hydrological cycle  
The atmosphere: energy balance, humidity, precipitation, evapotranspiration  
Groundwater: rock and soil properties, flow in porous media  
Surface waters: lakes, rivers, humid zones
3. Water supply  
Water quality  
Water treatment  
Water supply systems
4. Political and Economic aspects  
Laws governing the allocation, management and use of water resources. Economic considerations. International conflicts over water usage.

Learning outcomes

- ◇ The student will be familiar with the principal component processes of the hydrological cycle
  - ◇ The student will know how to model a complex process by decomposing it into simpler elements.
  - ◇ The student should be able to use simple models to explain the most important features of measured data.
- Students will use a simple 1-D model of the hydrological cycle in order to understand how the different component processes interact. Students will work with existing models, and they will be able to compare model predictions with data for real sites.

Core texts

BRUTSAERT , W.. *Hydrology: an introduction*. Cambridge University Press, 2005.  
 SHAW, E.M.. *Hydrology in practice*. Taylor & Francis, 1994.  
 PENNINGTON, K.L. & CECH, T.V.. *Introduction to Water Resources and Environmental Issues*. Cambridge University Press, 2010.

Assessment

Report on the modelling work.  
Final exam.




**AF ELC B-8**

*ELABORATION DE PIÈCES TECHNIQUES*

## **DEVELOPMENT OF TECHNICAL PRODUCTS**

**Lecturers: Denis MAZUYER, Bertrand HOUX**

| Lectures: 4 h | TC: 0 h | PW: 4 h | Autonomy: 0 h | Study: 4 h | Project: 20 h | Language:  |

### **Objectives**

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Keywords:

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**Lecturers: Nicolas HOURCADE**

| Lectures: 32 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

.....  
This course allows students to apply and deepen the methods and modes of reasoning of sociology apprehended in the UE SHS in semester 7, by dealing with the theme of political sociology.

The module presents the main objects, methods and theories of the political sociology. Its problematic is organized around the following questions: What are the political behaviors that are expressed in contemporary Western societies? How can they be analyzed? How is political participation linked, on the one hand, to the historical context, and on the other hand (and correlatively) to the social characteristics of individuals?

**Keywords:** Sociology, politics, political behaviour, political participation, collective action, social movements, violence, polls, media...  
.....

### Programme

To follow this course, it is necessary to understand and speak French well.

After defining the notion of political behaviour, the course studies behaviours linked to the electoral process, by presenting the main theories and analysing current issues such as voting orientation, abstention or changes in the political field. It then looks at collective action and social movements, again combining theoretical tools and analysis of topical issues. Finally, a few themes are examined in greater depth, in particular in relation to current events.

### Learning outcomes

- ◇ Discover the subjects of political sociology.
- ◇ Acquire theoretical methods and tools for analysing political behaviour.
- ◇ Acquire solid knowledge of current political phenomena.
- ◇ Understand and analyse social science texts.

### Independent study

Autonomous work is carried out between sessions. It is carried out in groups and consists of a short bibliographical synthesis on a subject given by the teacher (or sometimes chosen by the group). The subject is then dealt with in class, allowing the students to mobilise the knowledge acquired and to discuss it. Four autonomy notes will be requested. Instructions will be given by the teacher for carrying out the work independently. Feedback on the first grades should enable the students to improve the following works.

### Core texts

JEAN-YVES DORMAGEN ET DANIEL MOUCHARD. *Introduction à la sociologie politique*. De Boeck, 2015.  
NONNA MAYER. *Sociologie des comportements politiques*. Armand Colin, 2010.  
O. FILLIEULE, F. HAEGEL, C. HAMIDI ET V. TIBERJ (D. *Sociologie plurielle des comportements politiques*. Les Presses de Sciences Po, 2017.

### Assessment

Final exam (answers to questions on a text): 50  
Working independently: 50%.



## **MATHEMATICAL TOOLS FOR BIOLOGICAL PROBLEMS**

**Lecturers: Philippe MICHEL, Laurent SEPPECHER**

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

### **Objectives**

.....  
This course is an introduction to mathematical tools and methods for biology and medicine. It contains many applications and examples.

Keywords:  
.....

#### **Core texts**

J. MURRAY. *Mathematical biology*. Springer, 2002.

B. PERTHAME. *Parabolic Equations in Biology*. Springer, 2015.



**Lecturers: Arnaud BREARD**

| Lectures: 14 h | TC: 4 h | PW: 4 h | Autonomy: 6 h | Study: 4 h | Project: 0 h | Language:  |

### Objectives

The knowledge of the problems in the field of microwaves becomes unavoidable with the explosion of telecommunications and more generally the development of electronic applications for higher and higher frequencies. The objective of this course is to introduce basic concepts useful in the analysis and design of circuits and microwave devices. The concepts discussed in this course will include understanding a telecommunications system as a whole from the electronic circuit to the transmission of waves.

**Keywords:** Radio frequencies, microwaves, antennas, adaptation, S parameters, waveguide, resonant cavity, filters.

#### Programme

##### 1) Microwave circuits

- Transmission lines. Equation of the telegraphists. Microstrip line. Waveguide.
- Impedance matching. Parameters S.
- Passive circuits. Filter design. Directional couplers.
- Active circuits. Radio frequency amplifier.

##### 2) Electromagnetic devices in microwaves

- Resonant cavities. Dielectric resonators.
- Antennas. Radiation diagram. Gain.
- Antenna Network
- Power balance in telecommunications and radar

TP: complete study of a microwave: operation of the magnetron, waveguide, resonant cavity, measurement of emission using dipole antenna, ...

#### Learning outcomes

- ◇ Master the concepts and methods of adaptation of impedances
- ◇ Dimension of microstrip line
- ◇ Design a filter
- ◇ Knowledge and use of S parameters

#### Independent study

Know how to use a simulation tool (ADS) circuit and electromagnetic simulation 2.5D microwave adapted to the circuit board.

Study and size systems seen in class as well as some systems mentioned but not studied in detail. 1 BE introduction to the ADS software, the students are divided into 6 groups for 3 different subjects (2 variants of the specifications by subject). They have 6 hours to treat it. A report and a group report finalize the activity.

#### Core texts

D. POZAR. *microwave engineering*. Addison-Wesley, 1990.


#### Assessment

Test 50%  
TP 15%  
Group project 35%



## INTERACTIVE DESIGN AND FABLAB PRACTICES

Lecturers: David NAVARRO, Bertrand HOUX

| Lectures: 14 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 18 h | Project: 0 h | Language:  |

### Objectives

The objective of the course is to enable engineering students to become familiar with the concept of "open hardware" in the field of embedded electronics, Design Thinking methodology and to master the tools of digital fabrication of a fablab (3D printer, laser cutting, Arduino electronic systems) and learn to quickly create physical prototypes in a Do It Yourself (DIY) approach.

This module makes it possible to students the use of the fablab. They can thus become familiar with the machines and the spirit of innovation and entrepreneurship linked to this environment.

**Keywords:** Fablab, Design Thinking, Makers, DIY, DIWO, LBD, Arduino, Open Innovation

#### Programme

This module includes a series of lectures and practical sessions. The sessions will be developed around the following themes:

- Fablab: definition, history
- Methods of innovation, design thinking
- Electronic system design
- Intro to Fablab tools (3D printing, laser cutting, CNC)
- Rapid prototyping: projects

#### Learning outcomes

- ◇ Master Open Hardware, become familiar with rapid prototyping methods.
- ◇ Knowing how to manipulate the tools of the Third Industrial Revolution
- ◇ Master the methods of experimental collaborative work
- ◇ Know the advantages of an open approach integrating Design Thinking

#### Independent study

Autonomy aims to develop the appropriation of methods for designing and producing connected objects. Group work, development of a connected product in support of the fablab.

#### Core texts

FABIEN EYCHENNE. *Fab Lab : L'avant-garde de la nouvelle révolution industrielle*. FYP EDITIONS, 28.

JOSHUA NOBLE. *Programming Interactivity: A Designer's Guide to Processing, Arduino, and OpenFramework*. O'Reilly Edition, 2009.

TIM BROWN. *L'Esprit design: Le design thinking change l'entreprise et la stratégie*. Pearson Village, 2010.

#### Assessment

knowledge =10 % et Know to do = 90% by indivisual report and group report



## IMAGE SENSING AND PROCESSING

Lecturers: Liming CHEN, David NAVARRO

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

### Objectives

.....  
This course aims to introduce concepts and basic techniques on the acquisition of images, the structure of conventional sensors and image processing. It covers the foundations and addresses the principles of image formation, image processing, feature extraction and segmentation of images, and motion tracking. The course will cover concepts such as sensor structure (CCD / CMOS), image structure, spatial and frequency analysis of images, image descriptors (shape, contour, etc.), segmentation (point, contours, lines, etc.) and motion tracking. There are many applications, such as medicine, quality control, artificial vision, satellite imagery, etc.

**Keywords:** image formation, spatial and frequency filtering of images, contour detection, segmentation of images (point, line, etc.), image descriptors (shape, contour, etc.), motion tracking  
.....

#### Programme

- Imaging (cameras, radiometry, colors)
- Phototransduction, sensor structure
- Image structure, quantification, noise
- Spatial analysis (manipulation of the histogram, the gradient and the Laplacian)
- Frequency analysis
- Morphology
- The segmentation of images (detection of points, contour)
- Representation and description (form, texture, signature, etc.)
- Motion analysis and tracking (Kalman filter)

#### Learning outcomes

- ◇ At the end of this UE the student must be able to understand the process of the formation of digital images
  - ◇ implement fundamental techniques for improving and processing images
- The pedagogical objective is to deepen and put into practice the concepts and techniques being studied practice of exercises on Matlab and solving concrete problems

#### Core texts

RAFAEL C.GONZALEZ, RICHARD E.WOODS. *Digital Image Processing*. Pearson Prentice Hall, 2008.  
RICHARD SZELISKI. *Computer vision: Algorithms and applications*. Springer, 2010.  
DAVID A. FORSYTH, JEAN PONCE. *Computer vision : a modern approach*. Prentice Hall, 2007.

#### Assessment

The control of knowledge takes into account for 2/3 the reports of the two practical assignments (BEs) and for a third for the final exam





## OBSERVATION AND ANALYSIS OF MATERIALS

Lecturers: Fabrice DASSENOY, Magali PHANER

| Lectures: 22 h | TC: 8 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

The important advances in the science of matter are intimately linked to the development of methods for characterizing a solid at microscopic scale. Most analytical techniques are based on the interaction of particles (photon, electron, ion) with matter.

The course proposes alternatively a fundamental teaching on the physical concepts on which the main techniques are based and a description of the principle and applications of some commonly used techniques (XPS photoelectron spectroscopy, X-ray diffraction, electron and near-field (STM, AFM) microscopies).

The final objective is to allow the future engineer to know how to choose the technique (s) appropriate to his industrial problem.

**Keywords:** Radiation-Matter interaction - material characterization techniques, XPS, RBS, XRD, IR, Electronic Microscopies

#### Programme

- Introduction : Classification of the different interaction processes
- Photon/Matter Interaction
- Energy level and IP spectroscopy
- X ray diffraction
- XPS and IR techniques
- Ion/matter Interaction
- RBS -SIMS techniques
- Electron microscopies (TEM/SEM)
- Electron spectroscopies (EDX,EELS)
- Scanning Probe Microscopies
- Visit of labs facilities INL +LTDS (2h)
- Work in autonomy then restitution / presentation of the results

#### Learning outcomes

- ◇ To know the basic principles of the main techniques of materials characterization
  - ◇ To know the information accessible by these different techniques
  - ◇ To know how to choose an analysis technique according to the industrial problem
- The objective of autonomous work is to solve a complex problem based on the characterization of materials. Students will interpret results from different characterization techniques in order to combine them to determine the nature and the structure of an unknown sample.

#### Core texts

- M. AMMOU. *Microcaractérisation des solides*. CRAM CNRS, 1989.  
D. BRUNE. *Surface Characterization*. Wiley-VCH, 1997.  
R. W. CAHN. *Materials Science and Technology*. VCH Weinheim, 1994.


#### Assessment

2 hour- exam about the course( with documents) + a mark concerning the work in group and its oral presentation



## FUNDAMENTAL SOIL MECHANICS

Lecturers: Eric VINCENS

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

### Objectives

.....  
This course set the bases of Fundamental Soil Mechanics necessary for anyone who will work in Civil Engineering and in especially in Geotechnics. It brings about all the requisite for the understanding of the mechanical behaviour of the soil which is a complex polyphasic material (air, water, grains). They make the link between knowledge of Continuum Mechanics (UE MSS) and concrete applications that will be addressed in 3A. This course is highly recommended for those who will enter the 3A cursus "Civil Engineering and Environment".

**Keywords:** sand, clay, hydraulic, shearing resistance, consolidation, limit analysis, retaining walls  
.....

#### Programme

- 1 - Physical characteristics and classification of soils
- 2 – Hydraulics of soils
- 3 – Consolidation of fine soils
  - 3.1 – Oedometer test
  - 3.2 – Consolidation settlements
- 4 - Shear resistance of soils
  - 4.1 – Shear tests
  - 4.2 – Stress path
- 5 - Active and passive pressure of soils on walls

#### Learning outcomes

- ◇ how to compute basic physical and mechanical properties of soils
- ◇ how to compute the settlements of a building located on a soft clay soil
- ◇ how to calculate hydraulic fluxes and pore pressures under foundations
- ◇ how to compute a stress field in the soil

#### Core texts

G. OLIVARI. *Polycopié de Mécanique des sols I*. SDEC.



## MULTIPHYSICS SIMULATION IN MECHANICAL DESIGN

**Lecturers: Sébastien BESSET, Manuel COLLET**

| Lectures: 14 h | TC: 0 h | PW: 0 h | Autonomy: 6 h | Study: 12 h | Project: 0 h | Language:  |

### Objectives

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Keywords:

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#### Core texts

F. BREZZI & M. FORTIN. *Mixed and hybrid finite element methods.*


C.A. BREDIA, S. KIM, T.A. OSSWALD & H. POWER. *Boundary elements XVII.*

KLAUSS J. BATHE. *Finite element procedures in engineering analysis.*



## PHILOSOPHY OF SCIENCES AND TECHNOLOGIES

**Lecturers: Romain Sauzet**

| Lectures: 28 h | TC: 0 h | PW: 0 h | Autonomy: 4 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

.....  
The objective of this course is to clarify what scientific and technological activities are, in order to have a better understanding of their impacts on societies and different environments. The sessions will aim to address fundamental issues in philosophy of science (scientific change; confidence; the collective dimension of science; the role of values in science), in order to better study both general problems of the world of technics and technology (technoscience; technological evolution) and specific problematic objects (Big Data; Nano-technologies; etc.).

**Keywords:** Sciences, Technics, Technology, Epistemology  
.....

#### Core texts

ALAN CHALMERS. *Qu'est-ce que la science?*. Livres de Poche, 1987.

BARBEROUSSE A., KISTLER M., LUDWIG P.. *La philosophie des sciences au XXe siècle*. Flammarion, 2000.

SÉRIS, JEAN-PIERRE. *La technique*. PUF, 2013.




AF ELC C-9

FINANCE D'ENTREPRISE

## CORPORATE FINANCE

**Lecturers: Sylvie MIRA-BONNARDEL**

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

### Objectives

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Keywords:

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#### Core texts

MARION A.. *Analyse financière Concepts et méthodes*. Dunod, 2015.


LEGROS G.. *L'évaluation des entreprises Méthodes et études de cas*. Dunod, 2015.

PIERRE VERNIMMEN P., QUIRY P., LE FUR Y.. *Finance d'entreprise*. Dalloz, 2016.



## MACHINE LEARNING AND APPLICATIONS

Lecturers: Yohann DE CASTRO & Céline HELBERT

| Lectures: 14 h | TC: 6 h | PW: 0 h | Autonomy: 2 h | Study: 10 h | Project: 0 h | Language:  |

### Objectives

In this course, we will present the field of machine learning, its foundations, the problems it addresses (supervised / unsupervised learning, batch / online, etc.) and the most recent methods that are currently studied. . Beyond the description of the theoretical concepts (empirical minimization of the risk, combinatorial complexity, etc.), this module proposes many practical works allowing to implement numerically the methods approached (conventional algorithm, cross validation, etc.) and of to experiment with certain phenomena such as over / under learning. This work will be done in Python, and will require programming and the use of dedicated packages.

**Keywords:** Machine Learning; Supervised Learning; Statistics; Probability; Optimisation; Deep Learning; Artificial Intelligence; SciKitLearn;

#### Programme

Decision theory, Classification and Regression;  
Logistic regression and LDA;  
Cross Validation, Multiclass classification;  
Decision trees, forest, boosting and bagging;  
Deep Learning;

#### Learning outcomes

◇ Python (SciKitLearn)  
◇ Statistics  
◇ Algebra  
Solve real data problems thanks to Scikitlearn;  
Learn standard methods in Supervised Learning;  
Learn deep neural networks;PBL, TD, TP

#### Core texts

CHRISTOPHE GIRAUD. *Introduction to High-Dimensional Statistics*. CRC Press, 2014.  
MASSIH-REZA, A.. *Apprentissage machine: De la théorie à la pratique-Concepts fondamentaux en Machine Learning*. Eyrolles, 2015.  
PEDREGOSA, F. AND VAROQUAUX, G. AND GRAMFORT, A. A. *Scikit-learn: Machine Learning in Python*. Journal of Machine Learning Research, 2011.

#### Assessment

Exam (70 %), ML project (30 %)



## ADAPTIVE FILTERING: APPLICATION TO ACTIVE NOISE CONTROL

Lecturers: Laurent BAKO, Marie-Annick GALLAND, Alberto BOSIO

| Lectures: 12 h | TC: 6 h | PW: 8 h | Autonomy: 6 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

In recent years, adaptive filtering has found an increasing number of applications (echo cancellation in telephony, channel equalization in communication systems, denoising of bio-medical signals, ...). This course aims to discuss the basic principles, the scope of applicability, and the implementation aspects of adaptive filtering. The originality of the course resides in a multi-disciplinary treatment of the adaptive filtering problem going from the design methods (Signal Processing) to hardware implementation with embedded digital processors (Digital Electronics). A specific focus will be put on the problem of active noise control in Acoustics, a typical application of adaptive filtering.

**Keywords:** Wiener filter, adaptive filtering algorithms (LMS, RLS, ...), digital signal processors, Acoustics, active noise control

#### Programme

Introduction to adaptive filtering  
Wiener filter and quadratic optimization  
LMS algorithm  
Architecture of DSPs  
Hardware implementation  
Introduction to Acoustics  
Passive noise control  
Active noise control and applications

#### Learning outcomes

- ◇ Understand the theory of adaptive filtering
- ◇ Apply adaptive filtering algorithms
- ◇ Explain the architecture of digital signal processors
- ◇ Implement adaptive filtering methods for active noise control

#### Independent study

Goals: to design an active control system in all its dimensions : acoustic diagnosis, algorithm choice, DSP implementation  
Project by group of 5 students followed by an oral presentation. The work is based on experimental, on Matlab and Simulink programs. Each group has to propose a solution and to comment the results.

#### Core texts

SIMON HAYKIN. *Adaptive Filter Theory*. 5th Ed, Prentice Hall, 2013.  
PHIL LAPSLEY, JEFF BIER, AMIT SHOHAM, E.A. LEE. *DSP Processor Fundamentals: Architectures and Features*. Wiley-Press, 1997.

#### Assessment

Evaluation : 1h written exam + Practical Work + oral presentation of the project



Lecturers: Daniel MULLER, René CHALON

| Lectures: 10 h | TC: 0 h | PW: 0 h | Autonomy: 14 h | Study: 8 h | Project: 0 h | Language:  |

### Objectives

Many publishers develop Web technology applications, whether integrated into the Information System or stand-alone, offered in SAAS mode. The advantage lies in the ease of deployment and maintenance compared to a thick client, and the possibility of remote access compared to a dedicated application.

In another context, the multiplicity of mobile platforms makes it extremely expensive to develop native clients. Thanks to the maturation of standards related to HTML5, the choice of Web technology (WebApp) represents a transversal solution to this problem.

This course reviews the current state of Web standards and their implementation, and presents node.js a technology on the server side, emerging and innovative for the creation of Web applications.

**Keywords:** Webapp, HTML5, Javascript, nodejs

#### Programme

- What is Web 2.0?
- HTML5, CSS3 and JavaScript APIs
- JavaScript, the language - Client-side Frameworks
- Introduction to NoSQL
- Node.js or JavaScript on the server side

#### Learning outcomes

- ◇ Be able to develop a simple Web application in nodejs technology
- ◇ Have a transversal vision of the available technologies, and their limits, for the development of a Webapp
- To know how to successfully complete a project under Node.js with the use of a JavaScript HTML5 API. Project in pairs

#### Core texts

- STOYAN STEFANOV, . *JavaScript Patterns - Build Better Applications with Coding and Design Patterns*. O'Reilly Media, 2010.
- PETER GASSTON. *The Modern Web : Multi-Device Web Development With HTML5, CSS3, and JavaScript*. No Starch Press, 2013.
- PEDRO TEIXEIRA, . *Professional Node.js - Building JavaScript-Based Scalable Software*. Wiley / Wrox, 2012.


#### Assessment

Examination in the form of a MCQ accounting for 50% of the score, completed with the BE/ project score





Lecturers: Denis MAZUYER, Juliette CAYER-BARRIOZ

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

## Objectives

.....  
This course covers the fundamentals of the properties of surfaces and liquid or solid interfaces. From an introduction to intermolecular forces, a physical description of the liquid state and of complex systems, where matter is in a highly divided state such as molecular aggregates, molecules in solutions, or particles in suspension, is presented. They are characterized by the creation of extremely high surface / volume ratios. The control of the physico-chemical properties of these interfaces is necessary to optimize their production processes and their properties of use. These concepts are applied to the behavior of objects such as living tissue, cosmetics, paints and processes such as coating or detergency.

**Keywords:** surface energy, intermolecular forces, surfaces, wetting, colloids  
.....

### Programme

- I. Intermolecular and Surface forces
  - Van der Waals forces
  - Solvation forces
  - Double layer (DLVO theory)
  
- II. Liquid/solid Interfaces
  - Surface energy and interfacial tension : adhesion
  - Wetting and capillarity
  - Thin liquid films
  
- III. Adsorption phenomena and surface modifications
  - Self-assembled molecular systems and Langmuir films
  - Polymers at the interface
  
- IV. Micelles, emulsions and foams
  - Surfactants and micellar systems
  - Colloidal stability
  - Rheological properties, molecular structure and interactions

### Learning outcomes

- ◇ To understand adhesion and surface energy concepts
  - ◇ To know the main intermolecular forces, wetting, capillary and adsorption laws
  - ◇ To be able to implement a design strategy for colloidal media and analysis of their properties
- To deepen and relate the concepts learnt in class and to be able to be confronted to new knowledge  
Problem-based learning, case study and oral presentations

### Core texts

- J.N. ISRAELACHVILI. *Intermolecular forces*. Elsevier, 2011.  
H.-J. BUTT, K. GRAF, M. KAPPL. *Physics and Chemistry of Interfaces*. Wiley, 2006.  
J.-M. DI MEGLIO. *Les états de la matière, de la molécule au matériau*. Dunod, 2001.

### Assessment

BE marks (50%) + final exam (50%)



## TWO-PHASE FLOW RELATED TO ENERGY PRODUCTION

Lecturers: Mathieu CREYSSELS, Mikhael GOROKHOVSKI

| Lectures: 24 h | TC: 8 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

Two-phase flows (referred to as gas-liquid, gas-solid, or solid-liquid flows) cover a wide range of industrial applications. Examples include (i) water-cooled reactors and boiling systems, where bubbles move in the liquid ; (ii) internal combustion engines and spray drying systems (production of powders), where the liquid spray dynamics in the gas is an essential process ; (iii) fluidized beds and sediment transport, where solid particles are immersed into gaseous or liquid flows. These flows may be also observed in numerous phenomena in the nature: rains and clouds, volcanic eruptions, geysers. The objective of this course is to understand the fundamental physics of a two-phase flow, to introduce its modeling, and to highlight its eventual application in the energy production processes.

**Keywords:** Two-phase flows, interface and instabilities, change-of-phase heat and mass transfert, atomization, spray dynamics and combustion, coal and biomass combustion

### Programme

This course is an attempt to provide the essential physics of two-phase flows in the context of energy production processes.

Scope :

- i) Spray production and dispersion of particles. The gas-liquid interface.
- ii) Combustion in two-phase flows (coal particles and sprays) ; industrial burners.
- iii) Heat-and-mass transfert in the presence of phase transition ; water-cooled reactors and boilers

### Learning outcomes


- ◇ To introduce the role of two-phase flows, its specifics in the vast domain of fluid mechanics, and its applicability in the industry
- ◇ To come up with understanding of fundamentals of two-phase flows, and consequently, with understanding of different regimes of such flows
- ◇ To characterize sprays, including atomization, particles dispersion and the combustion processes. To characterize the heat exchanger with the phase transition.
- ◇ To develop the ability of using the numerical models of two-phase flows which are implemented into industrial codes.

### Core texts

- CROWE C., SOMMERFELD, TSUJI Y.. *Multiphase flows with droplets and particles..* CRC Press, 1998.
- WHALLEY P.B.. *Two-phase flow and heat transfer.* Oxford University Press, 1996.
- DE GENNES, BROCHARD-WYART, QUÉRÉ. *Gouttes, bulles, perles et ondes..* Belin, 2005.



Lecturers: Paul CLOZEL, Didier LACOUR

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

## Objectives

Knowledge of the industrial process of product development in a PLM (Product Lifecycle Management) context, from the digital mockup, the application softwares, the collaboration and the management of data, using the Information system of the Company.

- give elements necessary for the analysis of the industrial practices in the field of PLM, integrated in the Information system of the Company
- prepare the students to introduce tools and methods used in engineering / production.
- present the state of the art in the field of the integrated engineering, digital mockup and SGDT.

**Keywords:** PLM (Product Lifecycle Management), CAD, SGDT, Information System, Catia, Digital Mockup,

### Programme

Global information system of the Company: needs and technical Architecture.  
Development of product in a PLM context.

PLM environment: project, project team, containers, process, workflow, life cycle  
Advanced mockup, knowledge, automation (macros)

3 case studies :

- Vertical application (integration of conception / production – example : folded cut sheet steel-, unicity of information, coherence of information)
- Automations of Catia tasks with macro and programming
- bases of the tool Catia V5, V6 3D Experience : small-project: application on cases using the concepts, the tools and the methods of application softwares and PLM.

### Learning outcomes

Bases of the tool Catia V5, V6 3D Experience  
Small-project: application on cases using the concepts, the tools and the methods of application softwares and PLM

### Core texts

DENIS DEBAECKER. *Le projet PLM par l'expérience*. Hermes 2013, ISBN-13: 978-2746245389, 2013.

DASSAULT AVIATION. *l'entreprise numérique*: <http://www.dassaultaviation.com/fr/dassault-aviation/innovation/entreprise-numerique>. Dassault Aviation, 2015.

DASSAULT SYSTEMS. *www.3ds.com*. Dassault Systems, 2016.



INTERPERSONAL COMMUNICATION AND PROFESSIONAL PRACTICES

Lecturers: Jacqueline VACHERAND-REVEL

| Lectures: 32 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

Objectives

Interpersonal communication, in face-to-face or remote, occupies a pre-eminent place in social life and in the professional lives of the engineers. To evolve with agility and talent in contexts internationalized of work, in teams multi-business, in manager or behave with efficiency in the diverse events which mark out professional life, to know well how to communicate establishes a high value-added activity and a factor of distinction. He allows to analyze his stakes and to become aware of risks of misunderstandings which underlie them in the exercise of the jobs by the engineer.

Keywords: Interpersonal communication, languages of the interaction, the psychosocial and cultural stakes, the crisis communication.

Programme

Left 1: the communication: instrumental and interactionnistes approaches.  
Left 2: the languages and the psychosocial stakes in the interpersonal communication.  
Left 3: the communication in the professional practices (e.g. crisis management, presentation of one in job interview, teamwork, negotiation.

Learning outcomes

- ◇ Acquire abstract and methodological tools to analyze the communication.
- ◇ Capacity to understand the psychosocial stakes in communication and its difficulties.
- ◇ Capacity to understand the intraculturelles and intercultural variations of the communication.
- ◇ Develop know-how and social skills in diverse professional situations

Core texts

WATZLAWICK. *La réalité de la réalité : confusion, désinformation, communication*. Seuil Points, 1978.  
BORXEIX ET FRAENKEL. *Langage et travail. Communication, Cognition, Action..* CNRS Éditions, 2001.  
GOFFMAN. *La mise en scène de la vie quotidienne (Tome 1 : présentation de soi et tome 2 : relations en public)..* Editions de Minuit, 1973.


Assessment

Examination under the shape of questions of course



## DISCRETE EVENT SYSTEMS

Lecturers: Emmanuel BOUTLEUX, Anton KORNIENKO

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

### Objectives

Many industrial processes are working through a discrete time operation sequence. Flexible production units or manufacturing lanes composed what is called discrete event systems and are controlled by logical loops.

First the aim is to handle a set of specifications for such a close-loop process and to build up the control part of the loop. Industrial applications are nowadays mainly embedded in a Programmable Logic Controller (PLC).

The other aim is to discover and learn how to use Petri network tool so as to model part or totality of a close-loop discrete process. The model can be used to check the close-loop behaviour by properties analysis or simulation.

**Keywords:** Programmable Logic Controller, Behavior modelisation, Sequential functional chart, performances checking, Petri networks

#### Programme

- Control of continuous systems and discrete event systems
- Programmable Logic Controller and GRAFCET language (also called Sequential Functional Chart – SFC)
- Petri networks (principles, most used structures, property analysis)

#### Learning outcomes

- ◇ To modelise discrete event systems behavior
- ◇ To use a model so as to check and compare performances
- ◇ To know a conventional programming language for PLC
- ◇ To be aware of PLC singularities

#### Independent study

To find and to handle a Freeware dedicated to Petri networks simulation Case study

#### Core texts


GENDREAU D.. *7 facettes du GRAFCET, approches pratiques de la conception à l'exploitation, pratiques de la conception à l'exploitation*. CEPADUES-Editions, 2000.  
MORENO, S/PEULOT. *LE GRAFCET. Conception-Implantation*. CASTEILLA – TECHNIPLUS, 17.  
DAVID, R/ALLA, A. *Du GRAFCET aux réseaux de Petri*. Hermès, 1992.

#### Assessment

Final mark is composed with 50% individual writing test + 50% based upon practical activities.



Lecturers: Pierre DUQUESNE, Eric VAGNON

| Lectures: 10 h | TC: 10 h | PW: 4 h | Autonomy: 6 h | Study: 2 h | Project: 0 h | Language:  |

## Objectives

While the electrical energy production is more and more diversified, the energy from wind is a rising solution. Projects of new plants are numerous. These projects include wide offshore farms as well as low power plants in rural environment or in places where the grid is not present. Wind energy is then a important industrial issue and presents many employment perspectives.

The objective of this course is to present the technologies that are used to convert wind energy into electrical energy. The addressed issues deal with fluid mechanics, electrical engineering and power electronics. The presented technologies are related to power plants from a few kW to several MW. Also the special features of plants not connected to the grid, connected to the grid or offshore are presented.

**Keywords:** Wind, Wind turbine, Fluid mechanics, Electrical Engineering, Power Electronics

### Programme

Talk (4h) by a engineer in the field of wind turbines : resource, market state and trends.

Possible energy recover from wind energy

Blade aerodynamics

Aerodynamics interactions: installation and site effects

Wind turbine electrical engineering

Power conversion configurations for plants non connected to the grid, connected to the grid, offshore

Synchronous generator and dedicated power electronics

Maximum Power Point Tracking

Practical works : (4h)

Synchronous generator in variable speed operation and power electronics for grid connection or (students can choose)

Fluid mechanics

### Learning outcomes

◇ Describe wind turbine parts and their role

◇ Explain physical principles used in the conversion from wind energy to mechanical energy and from mechanical energy ort electrical energy

### Core texts

BIN WU ET AL.. *Power conversion and control of wind energy systems*. Wiley, 2011.

OLIMPO ANAYA-LARA. *Wind energy generation -- Modeling and control*. Wiley, 2009.

### Assessment

Final mark =

0.5\* Final Exam (individual written test) mark

+

0.5 \* Mark of the presentation on practical works



Lecturers: Alexandre SAIDI, Emmanuel DELLANDREA

| Lectures: 6 h | TC: 0 h | PW: 0 h | Autonomy: 10 h | Study: 16 h | Project: 0 h | Language:  |

## Objectives

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Keywords:

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### Core texts

RUSSELL, S. ET NORVIG, P. *Artificial Intelligence: A Modern Approach*. Prentice Hall, 2003.

FRÉDÉRIC BENHAMOU AND ALAIN COLMERAUER. *Constraint Logic Programming*. MIT Press, 2008.

DAVID L., MACKWORTH ALAN K.. *Artificial Intelligence: Foundations of Computational*. Cambridge U. Press, 2010.



Lecturers: Jacqueline VACHERAND-REVEL, Nicolas HOURCADE

| Lectures: 32 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

Through the study of a particular theme (the collaboration and the management in the era of the digital technology), this module allows the pupils to learn about a new discipline (the right) and to deepen the methods and the ways of reasoning of the human and social sciences arrested in basic modules in psychology and in sociology. Teachings allow the pupils to form and to develop their culture and their critical mind to think and to build the innovations of tomorrow and to act, in a lit way, within companies today, which form from now on unstable ecosystems.

**Keywords:** Law, social psychology and sociology of the work and the organizations, the collaboration, the managerial innovations, the remote work, the digital technologies.

### Programme

THE AF consists of 2 independent parts articulated around the same theme.

The courses of labor law propose one initiations into the legal stakes to acquire knowledge on the rules which organize the new individual relationships of the work and the professional relations in the company.

The courses of psychology and sociology of the work and the organizations approach the new stakes in the work and the new modalities of the collaboration within scattered working collectives and within their management with and via digital technologies (telecommuting, work in network, in team multi-localized by project).

### Learning outcomes

- ◇ Acquire legal knowledge in labor law.
- ◇ Deepen the knowledge in psychology and sociology of the work.
- ◇ Understand the stakes in the current transformations of the work and the companies.
- ◇ Study the forms of professional collaboration with the digital technologies

### Core texts

VACHERAND-REVEL ET AL.(DIR). *Nouvelles pratiques de travail : innovations technologiques, changements organisationnels*. L'Harmattan, 2014.

JUTAND (DIR). *La métamorphose numérique : vers une société de la connaissance et de la coopération*. Manifestô Alternatives, 2013.

CLOT. *Le Travail à coeur*. La Découverte, 2010.

### Assessment

Examination under the shape of questions of course





## INDUSTRIAL PROCESS ENGINEERING

Lecturers: Jean Pierre CLOAREC, Eric BLANCO

| Lectures: 20 h | TC: 0 h | PW: 0 h | Autonomy: 8 h | Study: 4 h | Project: 0 h | Language:  |

### Objectives

How to produce a chemical product, from theoretical process to industrial production ? This course shows how notions seen in UE ECS, FLE and PCM are combined together in industrial process engineering.

The course is continuously illustrated by concrete industrial examples and cases based on the production of substances for pharmacy, agrofood, metallurgy and chemistry.

Students work on a realistic case study based on real factory plans and data, in order to calculate different unit operations (e.g. chemical reactors, industrial distillation).

This course is given by specialists in automatics (Eric Blanco, ECL, Laboratoire Ampère) and process engineering (P. Denis, P. Guichardon: Centrale Marseille, Laboratoire de Mécanique, Modélisation & Procédés Propres).

**Keywords:** Control of industrial processes, chemical engineering, chemical reactor engineering, industrial distillation

#### Programme

- 1 – Unit operations in process engineering (Pascal Denis)
- 2 – Process command and control (Eric Blanco)
  - > P&ID Schemes,
  - > Discret event systems : modelling and control using GRAFCET
  - > Continuous systems : a review of industrial controller
- 2 – Story of manufacturing : Unit operations
- 3 – Case study: study of plans and data of a real chemical production factory
- 4 – Chemical reaction engineering (Pascal Denis)
- 5 – Industrial distillation : mechanisms and dimensionning (Pierrette Guichardon)

#### Learning outcomes

- ◇ Work as a team on a industrial process case study
- ◇ Read and build an instrumentation diagram
- ◇ Model and manage functional sequences

#### Independent study

understand and design a transformation process. Work in groups of 4-5 students. Each team studies and designs one of the unit operations of the complete industrial process. Report and cross-correction

#### Core texts


R. PERRIN ET J P. SCAIARFF. *Chimie industrielle 1 et 2 (2ème édition)*. Dunod, 2002.  
J.P. CORRIOU. *Commande des procédés (3ème édition)*. Tec &Doc Lavoisier, 2012.

#### Assessment

Final exam, case study.



**Lecturers: Vincent FRIDRICI**

| Lectures: 14 h | TC: 2 h | PW: 0 h | Autonomy: 4 h | Study: 4 h | Project: 8 h | Language:  |

### Objectives

The objectives of this AF are to provide students with methodological inputs on the selection of materials. This requires a good knowledge of the properties of the materials (some common core reminders are given) and needs setting up selection criteria, applied on a materials database. The Granta EduPack material selection software will be presented and used.

The course will be complemented by presentations by industry speakers on the selection of materials related to design, life cycle assessment and the environmental impact of products and materials.

A work in autonomy in group will be realized on a subject chosen by the students.

**Keywords:** materials, selection, selection methodology, Granta EduPack software

#### Programme

- material selection methodology
- selection criteria and material selection software
- synthetic analyzes of the major families of materials and their properties
- life cycle assessment and environmental impact
- development of specific industrial case studies chosen in fields of activity using a wide range of materials: metals and alloys, polymers and composites, ceramics
- sessions are also devoted to the restitution of the work carried out by students in autonomy, on subjects related to materials and their place in the world today

#### Learning outcomes

- ◇ know how to select a material: drawing up and analyzing the specifications, developing criteria, researching materials and analyzing the results
- ◇ use and deepen the knowledge acquired in common core
- ◇ collect and analyze data with logic and method
- ◇ ability to give oral presentation and prepare written report about work in autonomy and in group

#### Independent study

- implement a material selection approach for a given application
  - deepen the study of the properties of materials
- Work in groups of 3 students: bibliographic survey, analysis of a specification, use of Granta EduPack software, ...  
Submission of a written report and oral presentation

#### Core texts

- M. ASHBY. *Choix des matériaux en conception mécanique*. Dunod, 2012.  
M. COLOMBIÉ. *Matériaux métalliques*. Dunod, 2000.  
M. ASHBY. *Matériaux et environnement : choix éco-responsable en conception*. Dunod, 2011.

#### Assessment

- oral presentation + written report on students project (55%)
- 1-hour individual written test without documents (30%)
- active participation in BE (15%)



## FROM MICROSCALE TO MACROSCALE IN MECHANICS

Lecturers: Alexandre DANESCU, Julian SCOTT

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

### Objectives

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The macroscopic constitutive relations are an useful approximaton of the microscopic interactions at the discrete level. The main goal of this course is two-folded : (a) we explain the methods that provide the scale change between the microscopic and the macroscopic description of the materials properties and (b) we extend the method so as to take into account the equivalent continuum "homogeneous" description for "structures media" (stratified, porous, etc.).

**Keywords:** Heterogeneous continua, elasticity with microstructure, homogenization, Boltzmann equation, H-theorem, thermodynamical equilibrium, Chapman-Enskog theory  
.....

#### Programme

1. Physical bases of elasticity (the one-dimensional case)
2. Physical Bases of elasticity (the multi-dimensional case)
3. Diffusion in heterogeneous media
4. Homogenization in elasticity
5. Statistical description of gases
6. Consequences of the Boltzmann equation

#### Learning outcomes

- ◇ understanding the physical bases of continuum theories
- ◇ constructing equivalent continuum models for structures materials

#### Core texts

- N.W. ASHCROFT, W.D. MERMIN. *Physique des solides*. Brooks Cole, 1976.  
L.B. LOEB. *Kinetic Theory of Gases*. Dover, 2004.  
S. CHAPMAN, T.G. COWLING. *The mathematical theory of non-uniform gases*. Cambridge University Press, 1995.

#### Assessment

2/3 - written exam (2h, documents admitted) + 1/3 project



Lecturers: Xavier OTTAVY, Isabelle TREBINJAC

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

## Objectives

This lecture has several objectives:

- to get deeper into the details concerning the notions of aero-energetics in the frame of open systems with compressible flows, which are essential for the understanding and the study of the performance of turbojet engines.
- to list and sort the different propulsion systems for aeronautics (turbojet, turbofan, turboprop, ...) with the associated aircraft.
- to learn how to calculate the performance of turbojet engines, for a prescribed operating point, and to know how to simply design a propulsion system.

**Keywords:** Aero-energetics, compressible flows, Turbojet engines, turbofan, turboprop, thrust, performance

### Programme

- Aero-thermodynamics of the steady quasi-monodimensional flows (quantification and effects of the exchanges of work, heat and viscous shear layers)
- Complements of aero-thermodynamics for open systems with compressible flows
- Characterisation of compressors and turbines (exchanged energy, efficiency, performance map, mechanical behaviour, vibrations and material)
- Aero-mechanical characterisation of the other components (combustor, nozzle, ...)
- Performance analysis of the turbojet engines
- First approach and tools for the design of turbojet engines

### Learning outcomes

- ◇ To understand the operating of the parts of turbojet engines (fan, compressor, combustor, turbine, nozzle,...)
- ◇ To understand and analyse the thermodynamic cycle of turbojet engines
- ◇ To be able to calculate the performance of turbojet engines (thrust, efficiency, consumption, ...)
- ◇ To be aware of the new concepts that will drive the design of the new turbojet engines.

### Independent study

Calculation of the performance of a turbofan engine for 2 operating points (take off and cruise) Calculation of the performance of a turbofan engine and practical works with a mini turbojet engines


### Assessment

Examen écrit (QCM portant sur la compréhension du cours et résolution d'un problème), rapport de BE et rapport de synthèse du TP.



## GLOBALIZATION AND TRANSCULTURALITIES

Lecturers: Cécile Lacoïn, Laure Flandrin, Marie Goyon, Nicolas Hourcade, Romain Sauzet

| Lectures: 28 h | TC: 0 h | PW: 0 h | Autonomy: 4 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

Globalization subverts our time. We are cooperating with partners from other countries. Companies multiply their exchanges, they delocate and relocate permanently. Movies, series and sport events have a global audience. Under the visible standardization carried by globalization, local peculiarities stand out and maintain economical and social processes within the cultural field. Therefore, globalization can be characterized by a process of « glocalization ». The course analyses all forms of globalization (which is neither a recent phenomenon, nor a simple one) and enables to develop skills in cross-cultural understanding by analysing various issues, such as economy, nature, culture, languages, body....

**Keywords:** Globalization, glocalization, cross-cultural issues, economy, labour, nature, body, culture, modernity, languages

### Programme

The course presents concepts and methods for the analysis of globalization issues today, by putting them into perspective. Specific themes are being analyzed in order to understand the cross-cultural stakes such as: the various stages of globalization across the centuries, the diversity of the forms of capitalism, the relationship to work, the transformation in the perception of bodies and exchanges between people, the various meanings of nature, the cultural events (series, sport events), the languages, the modernity (with a visit to the "Musée des Beaux Arts de Lyon").

The course is presented by five lecturers in human sciences and languages.

### Learning outcomes

- ◇ Understanding globalization and its issues
- ◇ Developing critical thinking and raising awareness of the own culture
- ◇ Identifying the differences between several cultures and their interactions
- ◇ Developing abilities to communicate and interact with people from other cultures

### Independent study

In groups of 3 or 4 students. Each group identifies an issue or an artwork at the museum and compares it with objects of another culture. Students are attending a guide tour of the Musée des Beaux Arts and have to choose one of the artworks to present.

### Core texts

APPADURAI, ARJUN. *Condition de l'homme global*. Payot, 2013.

LEGENDRE, PIERRE. *Tour du monde des concepts*. Fayard, 2013.

SAUQUET BERNARD, VIELAJUS MARTIN. *L'intelligence interculturelle*. Charles Leopold Mayer, 2014.



Lecturers: Christian de PERETTI

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

## Objectives

The objective of this course is to provide an overview of the financial markets structure and on the various existing products. It will give some essential principles in financial economics as well as some principles for the valuation and management of these products. Excel applications will be carried out. This module will also facilitate the follow-up of some IM options in 3rd year and the Master co-habilitated with ISFA.

Exceptionally this year, most of the course will be given by Alberto Talero, Trader at BNP-Paribas London, assisted by the usual TD instructors. The end of the course will be provided by Christian de Peretti.

**Keywords:** Financial markets, bonds, equities, financial derivatives, pricing, portfolio management, risk.

### Programme

Part I: Introduction to Market Finance

Chap. 1 : Value Of Time

Chap. 2 : Money Market

Chap. 3 : Bonds

Chap. 4 : Shares

Chap. 5 : Financial Derivatives

Chap. 6: A little ethics

Part II: Equity Portfolio Management

Chapter 1: Securities returns

Chapter 2: Decision Theory

Chap 3 : Markowitz's mean-variance model

Chap 4: Fama and French's index model

Part III: Financial Derivatives management

- Principle of evaluation

- Replication portfolio

- Arbitration strategies

### Learning outcomes

◇ Financial asset pricing

◇ Portfolio management

◇ Use of financial derivatives

Appication with Excel on the processing of stock market financial data:

- modeling of return series,

- portfolio management. Descriptive statistics on stock market return series to reveal their statistical properties.

Use their statistical properties to do mean-variance portfolio optimization.

### Core texts

EDWIN J. ELTON, MARTIN J. GRUBER, STEPHEN J. BROWN. *Modern Portfolio Theory and Investment Analysis*. Wiley, 0.

J.C. HULL. *Options, Futures, and Other Derivatives*. Prentice-Hall, 0.


M.W. BAXTER AND A.J.O. RENNIE. *Financial Calculus*. Cambridge University Press, 1996.

### Assessment

2-hour exam, 100%.



**Lecturers: Manuel COLLET, Anton KORNIENKO, Cédric MARCHAND**

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

## Objectives

Nowadays, the mechanical systems are more and more often replaced by mechatronic systems. These "intelligent" systems combine mechanical, electronic, control theory and embedded information technologies. Initially coming from a rather high technology fields (as aerospace for example), today they take an important place in the product proposed to regular consumer market. The design of mechatronic systems requires a multidisciplinary approach between Mechanics and electrical Engineer professions. The main goal of this course is to understand this approach, the important elements of different implied fields and illustrate it on an active vibration control example.

**Keywords:** Mechatronics, Active control, Vibrations, Frequency based approach

### Programme

1. Introduction to Mechatronics (2h)
2. Mechanical systems (4h)
3. Control of flexible mechanical systems (4h)
4. Embedded electronics for mechatronic systems (4h)
5. Active damping of structures (2h)
6. Practical implementation (2 BE 4h + TP 4h)

### Learning outcomes

- ◇ Know how to identify different parts of a mechatronic system
- ◇ Learn the principles and methods of design of a mechatronic system and its parts
- ◇ Be able to analyze the technical constraints coupled between different parts
- ◇ Be able to derive the most important elements of mechatronic system specification

### Independent study

Promote critical thinking and develop analysis skills of a scientific article on one of the subjects of intelligent mechatronic system  
A Rapport for 2 persons 1-3 pages with critical analysis of the article is to be sent before exam

### Core texts

ROBERT H. BISHOP. *Mechatronics: an introduction*. Taylor and Francis, 2005.  
A. PREUMONT. *Active control of structures*. J. Wiley & Sons, 2008.  
ROLF ISERMAN. *Mechatronic Systems: Fundamentals*. Springer, 2005.

### Assessment

The overall mark combines the marks form homework, final exam, practical exercise sessions (BE and TP)



Lecturers: Abderrahmane BEROUAL, Naoufel HADDOUR

| Lectures: 14 h | TC: 10 h | PW: 8 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

The electro-energy development is conditioned by the control of major technical problems arising from the need to produce and transmit electrical energy quantities increasingly important to the consumption centers that can be thousands of kilometers. The main way to increase the power to transport and to reduce losses is to increase the transmission voltage. This increase in voltage depends on the insulation systems of the components used and their resistance to different stresses and especially the electrical ones. The objective of this course is to provide the basic knowledge necessary to understand the dielectric breakdown of insulating structures and their integration into components of electric power systems.

**Keywords:** Electrical engineering materials; electrical insulation; composite materials ; nano-materials; dielectric breakdown; components of energy networks; transformers; capacitors; cables; insulators; bushings; connectors.

### Programme

#### Introduction

1. Dielectric constant and dielectric losses: polarization; complex dielectric permittivity; equivalent circuits and dielectric losses.
2. Dielectric strength of gas: Corona; discharge in small and large gaps; electronegative gases; vacuum.
3. Dielectric strength of liquids: conduction and EHD; pre-breakdown and breakdown.
4. Dielectric strength of solids: physicochemical characteristics - classes; treeing phenomena, breakdown, statistical approach.
5. Composites – Nano-materials: effective dielectric constant; percolation; nanomaterials; dielectric strength.
6. Aging mechanisms of insulations – diagnosis.
7. Insulating structures in the components of electrical networks.

### Learning outcomes

- ◇ Acquire the basic knowledge necessary to understand the physical phenomena leading to dielectric breakdown of materials
  - ◇ Have tools for the design and dimensioning of insulating structures for high voltage components and systems
  - ◇ Acquire skills to diagnose the systems and high voltage switchgear
- Make the right choice of insulation materials and systems for a given application
- Laboratory: dielectric characterization - dielectric losses; Corona; Dielectric strength; Flashover of insulators; insulating barriers.
- BE: Nano- materials

### Core texts

- P. ROBERT. *Matériaux de l'Electrotechnique, Volume II, Traité d'Electricité, d'Electronique et d'Electrotechnique de l'EPFL, Lausanne*. Dunod, 2007.
- R. COELHO ET B. ALADENIZE. *Les diélectriques, Traité des nouvelles Technologies, série Matériaux*. Hermes, 1993.
- M. AGUET ET M. IANOZ. *Haute Tension, Volume XXII, Traité d'Electricité, d'Electronique et d'Electrotechnique*. Dunod, 1987.


### Assessment

Knowledge testing includes a written examination, micro-tests and TP / BE





Lecturers: Sébastien OLLIVIER, Michel ROGER

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

### Objectives

Introduction to musical acoustics and its applications (instrument making, music, digital audio). Physical and perceptive aspects of musical signals will be studied. Musical instruments are designed to generate sounds the frequencies of which can be accurately controlled. Studying and modelling their physics allow to highlight how sound can be generated. We will model acoustical and mechanical resonators, free oscillations, and self-sustained oscillations of wind and bowed string instruments. Electro-acoustic analogies will be introduced and applied to the modelling of microphones, and loudspeakers and resonators.

Maximum 24 students

**Keywords:** Musical acoustics, self-sustained oscillations, nonlinear acoustics, physical modelling synthesis, electroacoustics, signal processing

#### Programme

- Introduction to musical acoustics
- Properties of musical sounds (signal, physics, perception)
- Classification of musical instruments from the physical viewpoint
- Free oscillations musical instruments (percussions, piano, plucked string, ...)
- Wind instruments (resonators, brass, reed, flute, ...), bowed string, self-sustained oscillations (stability, bifurcations, ...)
- Electroacoustic analogy, application to acoustic resonators and electroacoustic devices
- Digital audio, sound synthesis, signal processing of musical sounds

#### Learning outcomes

- ◇ Have a basic knowledge of musical acoustics
- ◇ Analyse musical sound signals
- ◇ Use electroacoustic analogies and model elementary systems
- ◇ Understand the basics of sound generation mechanisms

#### Independent study

Study of a scientific problem related to music or sound design (measurements, data analysis, sound synthesis, or psychoacoustic tests). Subjects could be defined in collaboration with music master students. Bibliography, modelling, simulations, experiment, or psychoacoustic tests. Report and oral presentation

#### Core texts

- A. CHAIGNE ET J. KERGMARD. *Acoustique des instruments de musique*. Belin, 2008.
- N.H. FLETCHER AND T. ROSSING. *The physics of musical instruments*. Springer, 2008.
- M. CASTALLENGO. *Ecoute musicale et acoustique*. Eyrolles, 2015.

#### Assessment

Written Report. Report + oral presentation



AF ELC F-5

ORDRE, CHAOS, FRACTALES

## ORDER WITHIN CHAOS

Lecturers: Christophe BAILLY, Didier DRAGNA, Christophe BOGEY

| Lectures: 22 h | TC: 0 h | PW: 0 h | Autonomy: 10 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

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Keywords:

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#### Core texts

BERGÉ P., POMEAU Y., VIDAL CH.. *L'ordre dans le chaos*. Hermann, 1984.


ALLIGOOD K., SAUER T., YORKE J.. *Chaos: An introduction to dynamical systems*. Springer, 1996.

MANNEVILLE P.. *Instabilités, chaos et turbulence*. Editions de l'Ecole Polytechnique, 2004.



## ANTENNA, SIGNALS AND PROCESSORS

Lecturers: Arnaud BREARD, Julien HUILLERY, Alberto BOSIO

| Lectures: 16 h | TC: 0 h | PW: 10 h | Autonomy: 4 h | Study: 2 h | Project: 0 h | Language:  |

### Objectives

We live in a world bathed in electromagnetic waves in which wireless systems are growing rapidly. The first objective of this course is to give a circular view of the various components and disciplines involved in the design of electromagnetic wireless systems and to expose three of those in particular: the antennas, the signals and the processors. For this purpose, the radar and telecoms systems will be considered as applicative context. If in principle both of these systems use antennas and processors so as to propagate and process signals, we will see that they offer a diversity of issues that will be discussed in this course.

**Keywords:** Antenna, Radiation diagram, Directivity, Polarization, Adaptation, Frequency bandwidth, Signal processing, Digital modulation, information coding, channel equalization, Radar processing, Detection/Estimation, Processor, Onboard electronic systems.

### Programme

I - Antenna:

- a) Basics: radiation diagram, directivity, gain, polarization, adaptation, S parameters, link budget, efficiency
- b) Antenna design: antennas for mobile communications, base antenna, Wi-Fi, array of antennas

II - Signal:

- a) Radar processing: signal model, optimal receiver, detection, estimation
- b) Information transmission: coding, digital modulations, channel equalization

III - Processors:

- a) Architecture and design through generations of telecommunication networks
- b) Issues: size and energy tradeoff for onboard electronic systems, all-digital perspectives.

The course is organized in lectures accompanied by practice classes.

### Learning outcomes

- ◇ To design an antenna according to a given specification
- ◇ To design a digital modulation scheme for information transmission
- ◇ To implement a radar processing scheme on an Arduino card
- ◇ To use a HF measurement system, a vector network analyzer and an oscilloscope

### Core texts

CONSTANTINE A. BALANIS. *Antenna theory: analysis and design*. Wiley, 2005.

FRANÇOIS LE CHEVALIER. *Principes de Traitement des Signaux Radar et Sonar*. Masson, 1989.

TRAVIS F. COLLINS, ROBIN GETZ, DI PU, AND ALEXANDE. *Software-Defined Radio for Engineers*. Artech House, 2018.

### Assessment

Practice classes reports (by pair)  
Final test (individual)  
Savoir : 50%, Savoir-faire : 50%



Lecturers: Sylvie MIRA-BONNARDEL, Patrick SERRAFERO

| Lectures: 32 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

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Keywords:

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### Core texts

OSTERWALDER A., PIGNEUR Y.. *Business Model nouvelle génération : un guide pour visionnaires, révolutionnaires et challengers*. Pearson, 2011.

BLANCO S., LE LOARNE-LEMAIRE S.. *Management de l'Innovation*. Pearson, 2012.

KALOUSIS G., LÉGER- JARNIOU C.. *Construire son Business Plan*. Dunod, 2014.



OPTIMAL DESIGN AND COMPUTATIONAL FLUID DYNAMICS

Lecturers: Christophe CORRE, Stéphane AUBERT

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

Objectives

The course is devoted to the presentation and the practical application of a panel of numerical techniques currently used by the engineer to perform the optimal design of fluidic devices (shape optimization, optimal choice of design parameters of geometrical or other nature). The course displays two key original features:
- the described techniques are systematically linked with the CFD tools available for the engineer, with a distinction between open-source (modifiable) tools and close (commercial) codes.
- the presentation progresses from problems where a large quantity of information is available for the design (numerous values of objective functions and gradients) to problems where only a very limited amount of information is available (few values of the objective functions).

Keywords: gradient-based optimization, adjoint approach, direct search, ideal multi-objective optimization, genetic algorithms, metaheuristics, surrogate models, robust optimization

Programme

Gradient-based optimization in CFD. Finite-difference estimate and adjoint approach. Extension to multi-objective problems. BE#1 & #2 : solution of model and engineering problems.

Gradient-free optimization. From direct search to metaheuristics. Ideal multi-objective optimization. BE#3, #4 & #5 : solution of model and engineering problems (heat exchanger, wind farm); start of the project.

Derivation of surrogate models for high-cost objectives. BE#6, #7 : solution of a shape optimization or a power maximization problem.

Key concepts of robust optimization. Uncertainty quantification and propagation (Polynomial Chaos). BE #8 : robust optimization of a previously solved problem.

Learning outcomes

- ◇ Develop a good overview of current key optimal design problems in aerospace and energy engineering
◇ Be able to select and apply an optimization technique relevant for the design problem at hand
◇ Know how to apply a surrogate model in order to limit the cost of an optimization process
◇ Be able to take into account uncertainties on some design parameters

Independent study

Develop the ability to apply the optimization techniques described in the course and the ability to perform a critical analysis of the results obtained for an open engineering optimization problem. Optimization project performed in an autonomous way by group of 2 students. Use of the tools (Matlab, specific codes) made available on the work stations of the computer rooms.

Core texts

K. DEB. Multi-objective optimization using evolutionary algorithms. John Wiley & Sons, 2008.
A. FORRESTER, A. SOBESTER. Engineering Design via Surrogate Modelling : A Practical Guide. Wiley, 2008.
P. SIARRY. Métaheuristiques. Eyrolles, 2014.

Assessment

Final grade = 50% knowledge grade, 50% know-how grade
Knowledge grade = exam grade (2h, without lecture notes)
Know-how grade = project grade



## POLYMER MATERIALS: PHYSICAL PROPERTIES AND INNOVATION

Lecturers: Elise CONTRAIRES, Michelle SALVIA, Frédéric DUBREUIL

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

### Objectives

WARNING : This course is given in English

Polymers can be functional materials, used for building, transports of design. Some of them have the ability to be recycled and all these materials are widely used nowadays.

The understanding of their physical properties is a huge field of materials research and it is now possible to form responsive and smart materials.

An important and actual question is the recyclability of these polymers.

All these topics are part of the course, with a focus on physical properties, mechanical properties such as gel breaking and adhesion, friction in rubber...

Their life-cycle is studied with a course on processing, sorting and processing polymers.

Problem-based learning activities and presentations by two engineers from companies complete the course.

**Keywords:** thermosettings, thermoplastics, elastomers, physical chemistry of polymer networks

### Programme

General presentation of polymers,  
Synthesis and polymerization, characterization and properties of polymer chains, Review of the families of polymer materials  
Physical properties of polymers  
Glass transition temperatures and other important temperatures of polymers  
Flow and rheology in polymers  
Process and recycling  
Natural polymers and applications  
Wood and natural fibers, starch, proteins  
Recent innovations in polymers

### Learning outcomes

- ◇ Knowledge of the mechanical properties of polymers
- ◇ Choice of an analysis method to characterize a polymer property
- ◇ Choice of a polymer for a given application, its treatment and process

Analysis of the impact of polymers on the environment  
Comparison between mediatic issues and scientific numbers  
Choose and develop a specific issue linked to the global theme  
Prepare a scientific poster by group of 4 students  
Explain the poster during a poster session with scientific and non scientific people

### Core texts


JEAN-LOUIS HALARY, FRANCOISE LAUPRÊTRE, LUCIEN MON. *De la macromolécule au matériau polymère : Synthèse et propriétés des chaînes* Broché. Belin, 2006.  
JEAN-LOUIS HALARY, FRANCOISE LAUPRÊTRE, LUCIEN MON. *Mécanique des matériaux polymères*. Belin, 2008.  
Jo PEREZ. *Matériaux non cristallins et science du désordre*. PPUR, 2001.

### Assessment

One written exam 2h  
One lab work report  
One poster restitution



Lecturers: Julien HUILLERY, Bénédicte LAFAY, Gérard SCORLETTI

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

## Objectives

Insights on life, its forms, structure and organization, functioning and changing, are indispensable to the comprehending of the world that we are part of and on which we rely. It is nowadays understood that the behavior of a living organism as a whole cannot be explained by its constituents alone and that many properties of life arise at the system level only. As well, the notion of information is at the heart of the mechanisms of adaptation, reproduction and evolution of living forms. The aim of this course is to introduce the engineer students to the relevance and contribution of system and information theories to the deciphering of life organization and processes.

**Keywords:** Life, DNA, RNA, Replication, Transcription, Evolution, Adaptation, Emergence, Genetic information, Information theory, Information coding, Information transmission, Systems, Feedback, Regulation, Networks, Interconnections.

### Programme

- I – Life
  - a) The process of life
  - b) Biological information
- II – Information
  - a) Information theory and biology
  - b) Interactions and information networks
- III - Systems
  - a) Dynamic models for living systems
  - b) Feedback

The course is organized in lectures accompanied by tutorial classes.

### Learning outcomes

- ◇ To know some key aspects about the Living
- ◇ To identify the current issues related to the study of living organisms
- ◇ To adopt a systemic point of view when analyzing the behavior of living organisms (inverse engineering)
- ◇ To understand the issues regarding the coding and the transmission of genetic information

### Independent study

Scientific literature related to the three aspects of the course will be analyzed. Each group composed of 7 to 8 students study a different article. Each group is asked to :

- write a summary that must report the scientific approach of the paper.
- do an oral presentation to the whole class.
- prepare questions for an other group
- evaluate an other group

### Core texts

- L. VON BERTALANFFY. *General System Theory, Foundations, Development, Applications*. George Braziller, 1968.
- C.E. SHANNON. *A Mathematical Theory of Communication*. Bell System Technical Journal, 1948.
- N. WIENER. *Cybernetics or Control and Communication in the Animal and the Machine*. MIT Press, 1948.

### Assessment

- Class tutorials reports (by pair)
- Bibliographic study (by group)
- Final test (individual)
- Savoir : 30%; Savoir-faire : 70%



## GUI PROGRAMMING IN C++

Lecturers: Stéphane DERRODE, Emmanuel DELLANDREA

| Lectures: 6 h | TC: 4 h | PW: 14 h | Autonomy: 8 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

The aim is to provide students with advanced skills in object-oriented programming (OOP), through GUI programming in C++ language. This context will make it possible to

- deepen the concepts of inheritance, polymorphism, or exception handling;
- address new POO concepts (event-driven programming, generic class, operator overloading);
- introduce methods and tools of "good practices" of development as test programming, code version management or documentation of sources.

Teaching will also be in the form of tutorials allowing the student to accumulate gradually the knowledge and skills of GUIs programming.

**Keywords:** Object-oriented programming, GUIs development, C++ language, QT Designer.

#### Programme

- Lesson #1 (2h) : Specificity of C programming.
- Lesson #2 (2h) : Advanced C++ and event-driven programming.
- Lesson #3 (2h) : Graphical user interface with QT.
  
- TD #1 (2h) : C++ programming.
- TD #2 (2h) : event-driven programming.
  
- TP #1 (4h) : C/C++.
- TP #2 (2h) : Git.
- TP #3 (4h) : C++.
- TP #4 (4h) : QtDesigner.

#### Learning outcomes

- ◇ Create a program based on a graphical user interface (QT)
  - ◇ Design robust and documented programs
  - ◇ Learn to work in groups on the same project, thanks to a collaborative platform like Github
- The autonomous work is to achieve, by pairs of students, a GUI for a mini-game (Tic, 2048, Awalé game...) Each pair works on a collaborative development platform (e.g. Github), allowing the sharing of source codes.


#### Assessment

- Evaluation of mini-project by pair of students = 50%
- Final examination = 50%





Lecturers: Laure Flandrin

| Lectures: 24 h | TC: 0 h | PW: 0 h | Autonomy: 8 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

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Keywords:

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### Core texts

AFEISSA, HICHAM-STÉPHANE. *Ethique de l'environnement. Nature, Valeur, Respect*. Vrin, 2007.


LARRÈRE, CATHERINE. *Les philosophies de l'environnement*. PUF, 1997.

CALLON, MICHEL, LACOUMES P., BARTHE Y. *Agir dans un monde incertain*. Seuil, 2001.



## CONCEPTION OF A SUSTAINABLE PACKAGING

Lecturers: Michelle SALVIA, Catherine GIRAUD-MAINAND

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

### Objectives

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Keywords:

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#### Core texts

HÉLÈNE TEULON. *Le guide de l'éco-innovation*. Eyrolles, 2014.

MONIQUE GOIRAN. *Les indicateurs clés de la RSE*. Afnor, 2012.

PHILIPPE OSSET. *L'analyse de cycle de vie d'un produit/service*. Afnor, 2008.



**Lecturers: Sylvie MIRA-BONNARDEL**

| Lectures: 32 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

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Keywords:

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### Core texts


LE NAGARD-ASSAYAG E.. *Le marketing de l'innovation Concevoir et lancer de nouveaux produits et services*. Dunod, 2015.

GOUDEY A.,. *Marketing pour ingénieurs*. Dunod, 2010.

CHAFFEY D. (COLLECTIF). *Marketing digital*. Pearson, 2014.



Lecturers: Jean-Pierre CLOAREC

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

## Objectives

- present the fundamental phenomena governing natural ecosystems, with a systematic vision based on engineering sciences (ex: physical chemistry, thermodynamics, dynamics of the systems).
- give tools and methods to comprehend the links between environment and human activities, in particular industrial activities
- mobilize fundamental knowledge on complex environmental case studies, and show critical mind to analyze realistic situations.
- Perform in autonomy critical bibliographic search about a concrete environmental case, and analyze information with a critical mind
- the course and its activities can be given in French or English, depending on composition of registered students

Quota: 48 students maximum

**Keywords:** Environment, ecology, climate, sustainable development, pollution, ecosystems, industry, effluents processing, engineering sciences, carbon footprint, bibliographical search

### Programme

Lectures :

- Notions of biosphere & ecosystems, sources & circulation of pollutants in the biosphere
- Climate
- Transfrontier pollutions.
- Calculation of environmental footprint
- Chemical and microbiological processing of waste liquid effluents
- Influence of national cultures on the perception of environmental questions : the case of Germany

Practical activities:

- students project: study of an environmental controversy (cf below " work in autonomy ").
- journey to Freiburg ( Germany) : study and visit of eco-district Vauban, visit of Industrial Research center 'Fraunhofer Institute' of solar energies.

### Learning outcomes

- ◇ Comprehend and formulate an environmental problem (hypothesis, orders of magnitude...)
- ◇ Associate economic / societal responsibility / ecoresponsability
- ◇ Comprehend the scientific, technical, societal dimensions of a concrete environmental situation
- ◇ Identify the interactions between elements of an environmental case and develop a systemic approach to comprehend it

### Independent study

Comprehend a complex environmental case, critical search for information, critical mind, debate, study of an environmental controversy. Group work. Thorough document search and documents critical analysis; the goal of each group is to prepare a contradictory debate between students of same group, in front of the rest of the class.

### Core texts

RAMADE. *Éléments d'Ecologie : Ecologie fondamentale*. Dunod, 2005.

RAMADE. *Éléments d'Ecologie : Ecologie appliquée*. Dunod, 2005.

MEUNIER. *Aide-mémoire de thermodynamique de l'Ingénieur : Energétique - Environnement*. Dunod, 2004.

### Assessment

Work for environmental controversy.  
Final exam : individual exam 2h.



## INTRODUCTION TO RANDOM VIBRATION

Lecturers: Alain LE BOT, Julien HUILLERY, Joël PERRET-LIAUDET

| Lectures: 12 h | TC: 8 h | PW: 8 h | Autonomy: 0 h | Study: 4 h | Project: 0 h | Language:  |

### Objectives

A large number of problems in mechanical engineering are concerned with structures submitted to random forces.

The objective of the course is to give elements of random vibrations to students. We introduce the notion of random signal and their spectral properties and provide methods to estimate the response of systems to random forces.

Numerous examples are provided.

**Keywords:** Vibration, linear system, stochastic process, spectral analysis

### Programme

Course Introduction to random vibrations

Chapter 1 Stochastic process

- Generalities on probabilities
- Random variable
- Random vector
- Stochastic process
- Spectral analysis
- Continuity, derivation, integration

Chapter 2 Linear vibration

1. Single resonator
2. Multiple resonator
3. Deformable structures

Chapitre 3 Spectral response to linear systems

- Presentation of the problem
- Mean, correlation and spectrum of response
- Cross correlation and spectrum excitation - response

Chapitre 4 Probability of threshold and maximum

- Probability density of response
- Probability of threshold
- Probability of maxima

### Learning outcomes

- ◇ Compute and interpret power spectral densities of random signals
- ◇ Compute frequency response function of linear systems
- ◇ Compute spectral response of linear systems loaded by random forces

### Core texts

LE BOT A. *Introduction aux vibrations aléatoires*. Dunod, 2019.

LE BOT A. *Foundation of statistical energy analysis in vibroacoustics*. Oxford University Press, 2015.

G. FLEURY. *Analyse spectrale - Méthodes non-paramétriques et paramétriques*. Ellipses, 2001.

### Assessment

The final mark will be based on :

- practical works (30%)
- bureau d'étude (20%)
- final test (50%)



SPACE PHYSICS AND SOLAR-TERRESTRIAL COUPLING

Lecturers: R. Marino, C. Corre

| Lectures: 26 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 6 h | Project: 0 h | Language: |

Objectives

Modern aerospace engineering concerns the development of technologies for atmosphere and space. The design of vehicles, launch systems and payloads cannot thus disregard a deep understanding of such operational environments. The main purpose of this class is to provide a detailed description of the physics of the interplanetary space and of the outermost layers of the Earth's atmosphere, as well as to describe the coupling between solar activity and Earth's dynamics.

The interplanetary medium and the upper atmosphere are in the plasma state and they both develop a strong turbulent character. Theory and modeling of space plasmas and anisotropic turbulence will be proposed here, technologies and tools to investigate these environments will also be introduced.

Keywords: space plasmas; solar wind turbulence; stratosphere, mesosphere and ionosphere; solar-terrestrial coupling; space weather; space and atmospheric missions; numerical modeling.

Programme

- The Sun and the heliosphere: introductory space physics.
- First space explorations, mission design, in-situ and remote sensing observations.
- Space plasmas: main models for the description of plasmas, magnetohydrodynamic turbulence.
- Notions on statistical data analysis and numerical simulations.
- Solar wind: physical properties and turbulence.
- Plasma instruments, spacecraft measurements and orbital parameters, research articles on space physics.
- Solar-terrestrial coupling: Earth's environment, dynamics of stratosphere, mesosphere and ionosphere, interplay of waves and turbulence in geophysical flows.
- Basic notions on heliospheric and climate models, space weather and balloon observations.

Learning outcomes

- ◇ Gain extensive knowledge on space plasma physics and turbulence in the interplanetary medium.
- ◇ Understanding dynamics of mid/upper atmosphere and the coupling with the solar activity and the solar wind.
- ◇ Acquiring competencies on tools and technologies in space and atmospheric research (space missions, balloon-borne experiments, numerical models, etc.)
- ◇ Being able to identify key aspects and major results in a research article, as well as learning how to do a bibliographic search.

Independent study

Study of scientific articles focusing one of the subjects of the class, or development of short scientific projects. Articles/projects will be assigned to singles or groups of students and a final report will be produced.

Core texts

M.G. KIVELSON, C.T. RUSSELL. *Introduction to Space Physics*. Cambridge University Press, 1995.  
M. MOLDWIN. *An Introduction to Space Weather*. Cambridge University Press, 2008.

Assessment

Final grade = 70% knowledge grade, 30% know-how grade  
Knowledge grade = exam grade (2h)  
Know-how grade = project grade



**SURFACES, FRICTION, VIBRATIONS**

**Lecturers: Joël PERRET-LIAUDET, Denis MAZUYER**

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

**Objectives**

.....  
In a lot of mechanical systems and mechanisms, contact dynamics is often a major concern to ensure the integrity, energy performance and environmental friendliness of the structure. The design is no easy task because of couplings between the dynamic response and the tribological response at the interfaces. The objective of this course is to shed some light on this specific multidisciplinary issue. We provide the students with elements to understand the main phenomena (description of dry and lubricated contacts, normal and tangential excitation loads, friction behaviour). The resulting vibroacoustic behaviour will be precise: squeal noise, vibroimpacts, global dynamic responses induced by local interactions...

**Keywords:** Contact, mechanisms, tribology, system dynamics, advanced design  
.....

**Programme**

- This course deals with several topics:
- kinematics aspects of drive systems by contact
  - Tolerances, variability and topology of surfaces
  - Dry and lubricated contact theory
  - Dynamics of normal contacts
  - Friction instabilities

**Learning outcomes**

- ◇ advanced design
- ◇ mechanisms performance
- ◇ contact dynamics
- ◇ lubrication

**Independent study**

A practical work in this course will illustrate the concepts studied in class. This activity concerns the study of squeal noise of a wiper glass system. PBL Method.

**Core texts**

JOHNSON K.L.. *Contact mechanics*. Cambridge University Press. 2001.

**Assessment**

Final test (50%) - knowledge mark  
Practical activities (50%) - competence mark



AF ELC F-10

*DES DÉCHETS ET DES HOMMES*

## HUMANS AND THEIR WASTE

**Lecturers: Romain Sauzet**

| Lectures: 32 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

### Objectives

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Keywords:

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#### Core texts

SERGE LATOUCHE. *Bon pour la casse, L'obsolescence Programmée*. Les liens qui libèrent, 2015.

YANNICK BARTHE. *Le pouvoir d'indécision. La mise en politique des déchets nucléaires*. Ed. Economica, 2005.

CYRILLE HARPET. *Du déchet : Philosophie des immondices*. L'Harmattan, 1999.





Lecturers: Elisabeth MIRONESCU, Christophette Blanchet

| Lectures: 32 h | TC: 0 h | PW: 0 h | Autonomy: 0 h | Study: 0 h | Project: 0 h | Language:  |

## Objectives

The course will be given in English if necessary.

It is a mathematical advanced course which is strongly recommended to students who want to proceed in Mathematics in France or abroad. Measure theory and analysis are introduced in a rigorous way. Then, probability theory is studied extensively and the main classical theorems are precisely stated, if not proven (Law of large numbers, Central Limit theorem, Borel-Cantelli lemma). Some new notions, such as conditional expectation and martingales, are studied.

**Keywords:** Measure theory, characteristic function, Gaussian vectors, conditional expectation, stopping times, discrete time martingales

### Programme

Probability spaces, random variables  
Moments of random variables, characteristic functions  
Random sequences, limit theorems  
Conditional expectation, martingales and stopping time

### Core texts

VALÉRIE GIRARDIN ET NIKOLAOS LIMNIOS. *Probabilités en vue des applications, tomes I et II*. Vuibert, 2008.  
WILLIAM FELLER. *An Introduction to Probability Theory and Its Applications, 3rd edition*. Wiley, 1971.

### Assessment

Didactest+ final exam (2H)



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