PROGRAMME

Semester 8
Optional Courses
2018-2019

ÉCOLE CENTRALE LYON

Sommaire

Introduction

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	**Mechanical Metamaterial: Functionalised by Design (English)**
ELC A-5	Optics and Photonics for Engineers
ELC A-6	**Rotors Dynamics in Mechanical Engineering (English)**
ELC A-7	Mechanics of Thin Structures: Plates and Shells
ELC A-8	**Numerical Methods for Mechanics (English)**
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	**Hydrology and Water Resources (English)**
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-3	Interactive Design and FabLab Practices
ELC C-4	Image Sensing and Processing
ELC C-5	**Observation and Analysis of Materials (English)**
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

Slot D	Wednesday 8:00-12:00
ELC D-1	Probability Theory and Introduction to Random Processes
ELC D-2	**Adaptive Filtering: Application to Active Noise Control (English)**
ELC D-3	Webapps
ELC D-4	Physics and Chemistry of Surfaces and Interfaces
ELC D-5	**Two-Phase Flow in Engineering Systems Related to Energy (English)**
ELC D-6	PLM - Digital Mockup
ELC D-7	Interpersonal communication and professional practices
ELC D-8	Discrete Event Systems
ELC D-9	Wind Turbines
ELC D-10	Ecology and Environment
ELC D-11	Introduction to Random Vibrations
ELC D-12	**Space physics and solar terrestrial coupling (English)**

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

Slot F	Friday 8:00-12:00
ELC F-1	Financial Markets
ELC F-2	**Intelligent Mecatronic Systems (English)**
ELC F-3	Insulating Materials for Electrical Engineering
ELC F-4	Musical Acoustics
ELC F-5	Order within Chaos
ELC F-6	Antenna, Signals and Processors
ELC F-7	Entrepreneurship and Innovation
ELC F-8	**Optimal Design and Computational Fluid Mechanics (English)**
ELC F-9	Polymer Materials: Physical Properties and Innovation
ELC F-10	Humans and their Waste

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.

AF ELC A-1

Méthode des éléments finis, de la théorie à la mise en oeuvre

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. *Eléments 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.

AF ELC A-2

Les métamatériaux mécaniques

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
◇ caracterize 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 of 14 hours in groups of 6 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

AF ELC A-5

Optique et Photonique pour l'Ingénieur

Optics and Photonics for Engineers

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 technologyProblem 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% methodolgy and 50% know how)

AF ELC A-6

Dynamique des rotors en ingénierie mécanique

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 machineryresearch 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

AF ELC A-7

Mécanique des structures minces Plaques et Coques

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 durong 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 anlyses.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. Wionowski-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 pratical work: report + participation.

AF ELC A-8

Méthodes numériques en mécanique

Numerical Methods for Mechanics

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

This course is an introduction to solution methods used in simulation softwares, in solid mechanics, fluid mechanics (CFD) and in 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)

AF ELC B-1

Analyse fonctionnelle théorie et applications

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.

AF ELC B-2

Algorithmes collaboratifs et applications

Collaborative Algorithms and Applications

Lecturers: Philippe MICHEL, Alexandre SAIDI

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

Objectives

Keywords:

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.

AF ELC B-3

Contrôle non destructif

Non Destructive Testing

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 BURAIS
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 méhodes

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.

AF ELC B-4

Ingénierie Nucléaire

Nuclear Engineering

Lecturers: Yves ROBACH, Ségolène CALLARD

| Lectures: 12 h | TC: 10 h | PW: 0 h | Autonomy: 2 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.

AF ELC B-5

Ingénierie pour la santé

Health Engineering

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 : Modelisation of the mechanical behavior of bone
1 BE : 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

written report and oral presentation

AF ELC B-6

Hydrologie et Gestion des Ressources en Eau

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 interactStudents 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

Keywords:

AF ELC B-9

Sociologie des comportements politiques

Political Sociology

Lecturers: Nicolas HOURCADE

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

Objectives

Keywords:

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.

AF ELC C-1

Mathématiques appliquées à la biologie

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 medecine. It contains many applications and exemples.

I - Dynamical Systems
- Space-time modeling

Keywords:

Core texts

J. Murray. *Mathematical biology*. Springer, 2002.
B. Perthame. *Parabolic Equations in Biology*. Springer, 2015.

AF ELC C-3

Design de l'interaction et prototypage rapide par fablab

Interactive Design and FabLab Practices

Lecturers: David NAVARRO, Sébastien POUSSIELGUE

| 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:
- Electronic system design
- Fablab: definition, history, tools
- Methods of innovation, design thinking
- Product innovation, design for laser cutting
- Intro to Fablab tools (3D printing)
- 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

AF ELC C-4

Capteurs et traitement d'images

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 studiedpractice 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

AF ELC C-5

Analyser et observer la matière

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

AF ELC C-6

Mécanique des sols

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 thos who will enter the 3A cursus "Civil Engineering and Environment".

Keywords: sand, caly, hydraulic, shearing, 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 buiding located on a soft clay soil
◇ how to calculate hydraulic fluxes and pore pressures under foundations
◇ how to compte a stress field in the soil

Core texts

G. Olivari. *Polycopié de Mécanique des sols I*. SDEC, 0.

AF ELC C-7

Simulation multiphysique en conception mécanique

Multiphysics Simulation in Mechanical Design

Lecturers: Sébastien BESSET, Louis JEZEQUEL

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

Objectives

Keywords:

Core texts

F. Brezzi & M. Fortin. *Mixed and hybrid finite element methods*. Editor1, 0.
C.A. Bredia, S. Kim, T.A. Osswald & H. Power. *Boundary elements XVII*. Editor2, 0.
Klauss J. Bathe. *Finite element procedures in engineering analysis*. Editor3, 0.

AF ELC C-8

Philosophie des sciences et techniques

Philosophy of Sciences and Technologies

Lecturers: Vincent Beaubois

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

Objectives

Keywords:

Core texts

Hottois, Gilbert. *Philosophie des sciences, philosophie des techniques*. Editor1, 2004.
Barberousse A., Kistler M., Ludwig P.. *La philosophie des sciences au XXe siècle*. Editor2, 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

Keywords:

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.

AF ELC D-1

Théorie des probabilités et introduction aux processus aléatoires

Probability Theory and Introduction to Random Processes

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 rigourous way. Then, probability theory is studied extensively and the main calssical theorems are precisely stated, if not proven (Law of large numbers, Central Limit theorem, Borel-Cantelli lemma). Some new notions, such as conditionnal expectation and martingales, are studied.

Keywords: Measure theory, characteristic function, Gaussian vectors, conditionnal 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*. Willey, 1971.

Assessment

Didactest+ final exam (2H)
Note Savoir=Max (exam grade, 1/3*didactest grade+2/3*exam grade)

AF ELC D-2

Filtrage adaptatif application au contrôle actif de bruit

Adaptive Filtering: Application to Active Noise Control

Lecturers: Laurent BAKO, Marie-Annick GALLAND, Sébastien LE BEUX

| 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: apply adaptive filtering methods to a set of problems related to active noise controlCase study per group of 5 students followed by oral presentations of 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 + oral presentation of the study case

AF ELC D-3

Applications Web

Webapps

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

Keywords:

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.

AF ELC D-4

Physico-chimie des surfaces

Physics and Chemistry of Surfaces and Interfaces

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

Keywords:

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.

AF ELC D-5

Ecoulement diphasique et systèmes énergétiques

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 gaz is an essential process ; (iii) fluidized beds and sediment transport, where solid particles are immerged 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 fundemental 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 wth 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.
3.S. Mostafa Ghiaasiaan. *Two-Phase Flow, Boiling, and Condensation*. Cambridge University Press, 2008.

AF ELC D-6

PLM - Maquette numérique

PLM - Digital Mockup

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 ExperienceSmall-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/lentreprise-numerique*. Dassault Aviation, 2015.

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

AF ELC D-7

Communication interpersonnelle et pratiques professionnelles

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

AF ELC D-8

Systèmes autonomes de production (SAP)

Discrete Event Systems

Lecturers: Emmanuel BOUTLEUX, Anton KORNIIENKO

| 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 netwotk 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 fonctional chart, performances checking, Petri networks

Programme

- Control of continuous systems and discrete event systems
- Programmable Logic Controller and GRAFCET langage (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 simulationCase 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.

AF ELC D-9

Eoliennes

Wind Turbines

Lecturers: Florent MOREL, Pierre DUQUESNE

| 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

AF ELC E-1

Algorithme et raisonnement

Algorithms and Reasoning

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

Keywords:

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.

AF ELC E-2

Collaborer et manager à l'ère du numérique

Collaborate and Manage in the Era of Digital Technology

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

AF ELC E-4

Ingéniérie des Procédés Industriels

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

The objective is to present a survey of Process Engineering and Economic Issues of Chemical Industries as 30% to 40% of our students will work in this area.

Chemicals will be processed a lot along its life from design to marketing. This course will focused on each step including Chemistry, Chemical Engineering, Process Engineering and Process Control. The main question is "How produce a chemical: from theory to plant?"

Keywords: Chemistry, Chemical Engineering, Process Engineering and Process Control

Programme

1 – An overview of Chemical Industry :
- > Main area of activities
- > Geopolitics and Strategies (raw materials and energy)

2 – Story of manufacturing : Unit operations
3 – The 3T rules : Transport, Transfer, Transformation
4 – Science of reactors
5 – Separation process
6 – Environnement and Safety
7 – Process Control
- > P&ID Schemes,
- > Discret event systems : modelling and control using GRAFCET
- > Continuous systems : a review of industrial controller

Learning outcomes

understand and design a transformation process.Study of a typical issue (group: 4/5 students) 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 éditon)*. Tec &Doc Lavoisier, 2012.

Assessment

Test (2 hours), exercices and case studiy.

AF ELC E-5

Savoir choisir un matériau

Selection of materials

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 CES 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 on one hand, and examples of selection of materials in different industrial sectors on the other hand.
A work in autonomy in group will be realized on a subject chosen by the students.

Keywords: materials, selection, selection methodology, CES software

Programme

- material selection methodology
- selection criteria and material selection software CES
- 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. In this part of the course, the training is provided by industry speakers who also come to present their profession of engineer
- 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 materialsWork in groups of 3 students: bibliographic survey, analysis of a specification, use of CES 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 group project (80%)
1-hour individual written test without documents (20%)

AF ELC E-6

Du micro au macro en mécanique

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

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

AF ELC E-7

Propulseurs aéronautiques

Aircraft Turbojets

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 turbo-jet 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.

AF ELC E-9

Mondialisation et transculturalités

Globalization and Transculturalities

Lecturers: Cécile Lacoin, Vincent Beaubois, Laure Flandrin, Marie Goyon, Nicolas Hourcade

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

Objectives

Keywords:

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.

AF ELC F-1

Finance de marché

Financial Markets

Lecturers: Christian DE PERETTI

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

Objectives

Keywords:

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.

AF ELC F-2

Systèmes mécatroniques intelligents

Intelligent Mechatronic Systems

Lecturers: Mohamed ICHCHOU, Christian VOLLAIRE, Manuel COLLET, Anton KORNIIENKO, Sébastien LE BEUX

| Lectures: 16 h | TC: 2 h | PW: 4 h | Autonomy: 6 h | Study: 4 h | Project: 0 h | Language: |

Objectives

Nowadays, the mechanical systems are more and more often replaced by mechatronic systems. These "intelligent" systems combine mechanical, electrical, 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 an 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. Electro-Mechanical Conversion (4h)
6. Practical implementation (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 systemA 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)

AF ELC F-3

Matériaux pour les composants des réseaux d'énergie

Insulating Materials for Electrical Engineering

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 applicationLaboratory: 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

AF ELC F-4

Acoustique musicale

Musical Acoustics

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. Kergomard. *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

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

Objectives

Keywords:

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.

AF ELC F-6

Antennes, signal et processeurs

Antenna, Signals and Processors

Lecturers: Arnaud BREARD, Julien HUILLERY, Sébastien LE BEUX

| 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

Independent study

A scientific publication related to one of the three aspects of the course will be analyzed.Each group composed of 3 to 4 students study a different article. A written summary that must report the scientific approach of the paper is asked.

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.

Assessment

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

AF ELC F-7

Entreprendre et innover

Entrepreneurship and Innovation

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

Keywords:

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.

AF ELC F-8

Design optimal et mécanique des fluides numérique

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 proble-mOptimization 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

AF ELC F-9

Matériaux polymères propriétés physiques et innovations

Polymer Materials: Physical Properties and Innovation

Lecturers: Elise CONTRAIRES, Michelle SALVIA

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

Objectives

Keywords:

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.

AF ELC A-10

Vivant, Information et Système

Life, Information and Systems

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 :
- writte 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%

AF ELC A-11

Programmation des interfaces graphiques en C++

Gui Programming in C++

Lecturers: Stéphane DERRODE, Emmanuel DELLANDREA

| Lectures: 4 h | TC: 4 h | PW: 16 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. This context will
- To address new concepts, such as event-driven programming or design patterns;
- To deepen the concepts of inheritance, polymorphism, abstract class or exception handling;
- To introduce methods and tools of "good practices" of development as test programming, code version management or documentation of sources.

Teaching is shoed mainly in the form of tutorials, allowing the student to accumulate gradually the knowledge and skills of GUIS programming.

Keywords: Object-oriented programming, GUIs, Design Pattern, Test-programming, C++, QT.

Programme

Lesson #1 (2h) : Advanced C++ and event-driven programming
Lesson #2 (2h) : Graphical user interface with QT.

TD #1 (2h) : Presentation of some design patterns by pairs of students (#1)
TD #2 (2h) : Presentation of some design patterns by pairs of students (#2)

TP #1 (4h) : QtDesigner.
TP #2 (4h) : Design patterns.
TP #3 (4h) : Git and Doxygen.
TP #4 (4h) : Exceptions handling and test-programming.

Learning outcomes

◇ Create a program based on a graphical user interface (QT)
◇ Identify and implement adequate design patterns when they appear
◇ Design robust and documented programs
◇ Learn to work in groups on the same project, thanks to a collaborative platform like Github

Independent study

The autonomous work (12h) is to achieve, by pairs of students, a GUI for a mini-game (Tic, 2048, ...)Each pair works on a collaborative development platform (e.g. Github), allowing the sharing of source codes.

Core texts

Courtois, Jonathan. *Créer des applications avec QT 5 - Les essentiels*. D-Booker Editions, 2013.

Erich Gamma, Richard Helm, Ralph Johnson, John M.. *Design Patterns: Elements of Reusable Object-Oriented Software*. http://www.uml.org.cn/c%2B%2B/pdf/DesignPatterns.p, 1997.

Assessment

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

AF ELC A-12

Les enjeux du développement durable

Social, Economical and Political Issues for a Sustainable Development

Lecturers: Laure Flandrin

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

Objectives

Keywords:

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, Lacousmes P., Barthe Y. *Agir dans un monde incertain*. Seuil, 2001.

AF ELC B-10

Conception d'un emballage responsable

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

Keywords:

Core texts

Hélène Teulon. *Le guide de l'éco-innovation*. Eyrolles, 2014.
Monique Gouiran. *Les indicateurs clés de la RSE*. Afnor, 2012.
Philippe Osset. *L'analyse de cycle de vie d'un produit/service*. Afnor, 2008.

AF ELC B-12

Marketing

Marketing

Lecturers: Sylvie MIRA-BONNARDEL

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

Objectives

Keywords:

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.

AF ELC D-10

Ecologie et Environnement

Ecology and Environment

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 registred students

Quota: 24 students maximum

Keywords: Environment, ecology, 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
-impact of human industrial activities : the case of acid rains, eutrophication
-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 ").
- every 2 years: a journey to Freiburg (Germany) in the eco-district Vauban is envisaged, in alternation with a visit of a water-treatment plant in Lyon (bacterial processing of effluents).

Learning outcomes

◇ Comprehend and formulate an environmental problem (hypothesis, orders of magnitude...)
◇ Associate economic / societal responsability / ecoresponsability
◇ Comprehend the scientific, technical, societal dimensions of a concrete environmental situation
◇ Identify the interactions bewtween 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, debateS-tudy of an environmental controversy. Group work. Thorough document search and documents criticlaanalysis; the goal of each group is to prepare a contradictory debate between students of a same group, in front of the rest of the class.

Core texts

Ramade. *Eléments d'Ecologie : Ecologie fondamentale*. Dunod, 2005.

Ramade. *Elements d'Ecologie : Ecologie appliquée.*. Dunod, 2005.

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

Assessment

Weekly individual micro-tests
Final exam : individual written exam without documents, 2h.

AF ELC D-11

Introduction aux vibrations aléatoires

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, power spectral density

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. *Foundation of statistical energy analysis in vibroacoustics*. Oxford University Press, 2015.
Le Bot A. *Introduction aux vibrations aléatoires*. Polycopié, 2015.
G. Fleury. *Analyse spectrale - Méthodes non-paramétriques et paramétriques*. Ellipses, 2001.

Assessment

The final mark will take into account practical activities (2 TP, 1 BE) and the final test.

AF ELC D-12

Space physics and solar-terrestrial coupling

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, solar system dynamics.
- First space explorations, mission design, in-situ and remote sensing observations.
- Space plasmas: main plasma descriptions, magnetohydrodynamic turbulence.
- Statistical data analysis, numerical simulations.
- Solar wind: physical properties, turbulence and heating, space environment.
- Plasma instruments, spacecraft measurements and orbital parameters, research articles on space physics.
- Solar-terrestrial coupling: Earth's environment, space weather, dynamics of stratosphere, mesosphere and ionosphere, interplay of waves and turbulence in geophysical flows.
- Heliospheric and climate models, radar/lidar, 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

AF ELC E-10

Surfaces, friction, vibrations

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

Keywords:

AF ELC F-10

Des déchets et des hommes

Humans and their Waste

Lecturers: Thomas LEROSIER

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

Objectives

Keywords:

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.

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