PROGRAMME

Semester 9
General Engineering Modules
2019-2020

ÉCOLE CENTRALE LYON

Sommaire

Semester 9 at Ecole Centrale de Lyon

During S9, students attend the following teaching units:

- ◇ UE Engineering professions (september-november)
- ◇ UE Engineering fields of applications(janvier-mars)
- ◇ UE General engineering modules (october-december)
- ◇ UE languages and Cultures.

UE "General engineering modules" (180h)

In this unit, the student must choose six courses (AF) among nearly fifty. In some conditions, a master course can be replaced by an AF (and vice-versa).

Note:

- ◇ MOD 9.1, 10.2, 10.4 and 11.3 are reserved for students in the métier ISBD.
- ◇ The MOD OUV (outside the slot) is intended for international students enrolled in Master's degrees.

Slot 1	**Monday 8h-10h**
MOD 1.1	Numerical methods for computational fluid dynamics
MOD 2.1	Big Data challenges
MOD 3.1	Elastic Wave Propagation
MOD 4.1	Green Computing
MOD 5.1	Human physiology and biotechnology
MOD 6.1	Nanotechnologies
MOD 7.1	Enterprise Information Systems
MOD 8.1	**Fluid-Structure Interactions (in English)**
MOD 9.1	Intrapreneurial coaching
Slot 2	**Monday 10h15-12h15**
MOD 1.2	**Fundamentals of turbomachines (in English)**
MOD 2.2	**Atmosphere and Ocean Dynamics (in English)**
MOD 3.2	Deep-learning and artificial intelligence: an introduction
MOD 4.2	Energy, Storage, Conversion
MOD 5.2	Uncertainties and heterogeneities in real structures
MOD 6.2	*Matière molle : nanosystèmes et interfaces biologiques*
MOD 7.2	Data Mining and Machine Learning
MOD 8.2	**Stochastic Processes (in English)**
MOD 9.2	**Mechanics of Composite Materials and Structures (in English)**
MOD 10.2	Intrapreneurial coaching
Slot 3	**Tuesday 14h-16h**
MOD 1.3	Nanophotonics
MOD 2.3	*Statistique appliquée aux sciences de l'ingénieur*
MOD 3.3	*Systèmes embarqués sécurisés*
MOD 4.3	Combustion
MOD 5.3	Processing and analysis of visual and audio data
MOD 6.3	**Durability of materials and structures (in English)**

MOD 7.3	**Fundamentals of acoustics (in English)**
MOD 8.3	**Hydraulique fluviale (in English)**
MOD 9.3	Stability of mechanical systems
MOD 10.3	Electric Power System
MOD 11.3	Entrepreneurial coaching
Slot 4	**Friday16h15-18h15**
MOD 1.4	Physics of turbulent flows
MOD 2.4	Power plant turbine technology
MOD 3.4	System identification and sparse decompositions
MOD 4.4	Opertations Research
MOD 5.4	Construction materials
MOD 6.4	Autonomous microsystems
MOD 7.4	Structural dynamics
MOD 8.4	*Représentation et manipulation de données structurées*
MOD 9.4	*Comportement des matériaux*
MOD 10.4	Entrepreneurial coaching
MOD 11.4	Variational methods for PDEs
Slot 5	**Friday 13h30-15h30**
MOD 1.5	Introduction to nonlinear vibrations
MOD 3.5	Diagnosis and Health Monitoring
MOD 4.5	Mechanical assembly: architecture and geometry analyses
MOD 5.5	Tribology
MOD 6.5	**Climate Change and Geo-engineering (in English)**
MOD 7.5	Aerodynamically generated sound
MOD 8.5	Physics for Information technology
MOD 9.5	Computer networks
MOD 10.5	*Ingénierie d'un objet de grande consommation*
Slot 6	**Friday 15h45-17h45**
MOD 1.6	**Environmental Acoustics (in English)**
MOD 2.6	*Reconnaissance et comportement des sols*
MOD 3.6	Advanced Control
MOD 4.6	Database systems
MOD 5.6	**External aerodynamics (in English)**
MOD 6.6	Dynamics of biological human systems
MOD 7.6	Characterization of surfaces and nanostructures
MOD 8.6	Nuclear Energy
MOD 9.6	*Méthodes numériques pour les EDP*

Evaluation of the MOD UE

The MOD UE score is the average of the scores of 6 training actions. The UE is validated if each score is higher than 10.

AF MOD 1.1

Simulation numérique des écoulements

Numerical methods for computational fluid dynamics

Lecturers: Fabien GODEFERD, Christophe CORRE

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

Objectives

The course aims at providing the students with a fundamental knowledge of numerical methods for flow simulation (CFD), insisting on the specifics of such methods, as well as a practical coding experience and application of these methods. The key learning outcomes are: overview of the development process of CFD codes, exploitation of existing codes currently in use for aerospace, energy, transportation engineering applications.

Keywords: Numerical simulation, classification of equations, characteristics, spectral methods, finite differences, finite volumes, finite elements

Programme

Boundary problems are first classified (PDE systems of hyperbolic, parabolic and elliptic types). Various classes of solution methods are next reviewed:
- method of characteristics
- finite differences
- finite volumes
- finite elements
- spectral methods.

Their specific features, key advantages / drawbacks are analyzed along with examples of industrial and research applications.

Learning outcomes

◇ Knowing the underlying principles of the most common numerical methods in use for flow simulation
◇ Deriving the discretized equations and building the associated solution algorithm
◇ Implementing / coding the numerical method and performing a verification and validation analysis
◇ Mastering the key ingredients of an existing CFD code (commercial or academic)

Independent study

Computer Labs : 3 x 4 hours.
Practical application (hands-on approach) of the numerical methods presented during the lectures from a more theoretical viewpoint. Test-cases and problems are kept simple to allow for a systematic analysis at a reduced computational cost.

Affiliated Masters

Acoustics
Space Propulsion
Fluid Mechanics & Energetics

Core texts

Charles Hirsch. *Numerical Computation of Internal and External Flows*. ISBN: 978-0-7506-6594-0, 2007.

Clive A.J. Fletcher. *Computational Techniques for Fluid Dynamics Vols. 1 & 2*. ISBN-13: 978-3540530589, 1997.

John P. Boyd. *Chebyshev and Fourier Spectral Methods*. ISBN-13: 978-0486411835, 2000.

Assessment

Computer Lab Reports (3): 3 x 20% of the final grade
Final exam (2h + 1h for Master's students): 40%

AF MOD 1.2

Aérodynamique et Energétique des Turbomachines

Fundamentals of turbomachines

Lecturers: Alexis GIAUQUE, Isabelle TREBINJAC

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

Objectives

The main objective of this course is to familiarize the students with the physical phenomena, mechanisms and basic computations behind turbomachinery flows.
Starting with aerodynamics and thermodynamics applied to turbomachinery, we will detail the main tools used in the design of turbomachines. More specifically, we will tackle the design of an axial compressor given a specific efficiency objective.
Practical work on a dedicated axial low-speed compressor test bench will be helpful to apprehend theoretical notions seen in class in a concrete case.
Tutorial sessions will be devoted to the design of an axial compressor given specific objectives.

Keywords: turbomachines, compressor, turbine, aerodynamics, energetics, compressibility

Programme

Range of operation of turbomachines
Characteristic curves (nominal point and range of operation)
Usage of integral formulations for the fluid dynamics equations applied to turbomachines.
Aero-thermodynamics analysis in 1D
Real transformations in turbomachines, computation of losses.
2D analysis in the circumferential plane: velocity triangles, load factors for compressors, correlations.
2D analysis in the meridional plane: radial equilibrium.
Introduction to unsteady and 3D phenomena

Learning outcomes

◇ learn the operating rules of turbomachines
◇ know how to design an axial compressor
◇ master compressible aerodynamics
◇ know how to analyze turbomachinery flows

Independent study

Design a subsonic axial compressor (in support of tutorial sessions)
Write a numerical program for the design of the compressor (matlab, python,...)

Affiliated Masters

Master's degree in Aerospace Engineering

Core texts

N. A. Cumpsty. *Compressor aerodynamics*. Longman Scientific & Technical, 1989.
David Japikse, N. C. Baines. *Introduction to turbomachinery*. Concepts ETI, 1997.

Assessment

Final exam, reports on the compressor design, reports after practical sessions

AF MOD 1.3

Nanophotonique

Nanophotonics

Lecturers: Emmanuel DROUARD, Christelle MONAT

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

Objectives

Significant advances have been achieved in Photonics, for light emission, processing, transport and detection, with implications in a wide range of application areas. Progress related to fabrication, which leverage the microelectronics infrastructure and expertise regarding the realization of micrometer scale devices, has enabled the implementation of new concepts of integrated optics for the control of light, which are now commonly used. Current research is very active in the field of sub-micrometer devices, such as photonic crystals, and will benefit to key application areas: information and communications, biology, energy. The aim of this course is to give the physics background underpinning these new technologies, for further investigation in a more specialized literature.

Keywords: Birefringence, Optical Waveguide, Photonic Crystal, Non-Linear Optics

Programme

Light polarization
Planar guided optics
Integrated Optics & Fiber Optics
Photonic crystals and nanophotonics: basics and possible applications
Nonlinear optics: Kerr effect, frequency doubling, wavelength conversion. Illustrations: tunable source, optical switch, frequency comb

Learning outcomes

◇ to be able to describe the light propagation in a birefringent material
◇ to understand and to use the effects of the index profile and the wavelength on optical guided modes
◇ to understand and to be able to use the dispersion properties of micro-nanophotonics structures
◇ to understand the origin of the nonlinear optics phenomena and how they can be applied to optical signal processing

Affiliated Masters

Master NSE

Core texts

B.E. A. Saleh, M.C.Teich. *Fundamental of Photonics*. Wiley, 2007.
Rigneault H., Lourtioz JM.. *La Nanophotonique*. Hermes science publ. Lavoisier, 2005.

AF MOD 1.4

Physique des écoulements turbulents

Physics of turbulent flows

Lecturers: Christophe BAILLY, Christophe BOGEY, Simon PRIGENT

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

Objectives

Turbulence is involved in many technological applications in land transport, aeronautics and space (internal and external aerodynamics, combustion, aeroacoustics, vibroacoustics) and energy. It also plays a decisive role in natural environment (dispersion of pollutants) and geophysical flows (meteorology, climate). This course addresses the major issues of turbulence, and presents the physics of fundamental phenomena and their modeling. The course is based on numerous case studies, as well as the most recent results obtained by numerical simulations and experimental techniques

(Lectures may be delivered in english according to the audience; course material in English)

Keywords: turbulence, fluid dynamics, boundary layer, turbulence modelling, dynamics of vorticity, homogeneous and isotropic turbulence, Kolmogorov theory, numerical simulation of turbulent flows (DNS, LES, RANS), experimental techniques (HWA, LDA, PIV).

Programme

A short introduction to turbulent flow
Statistical of turbulent flow
Wall-bounded turbulent flow
An example of RANS model: the k-epsilon turbulence model
Dynamics of vorticity
Homogeneous and isotropic turbulence, Kolmogorov's theory
Numerical simulation of turbulent flow
Experimental techniques

Learning outcomes

◇ Mastering the basic concepts (turbulent production, boundary layer, vorticity, Kolmogorov))
◇ Overview of experimental and numerical techniques (state of the art)
◇ Skill in turbulence modelling
◇ Skill in analysis of results (signal processing, development of simple models using Matlab)

Independent study

Regular homeworks (4 exercices in a list of most than 10, freely selection) on modelling, analytical problems, bibliography, small scripts using Matlab, ...

2 practical works (numerical simulation of a channel mean flow, and hot wire anemometer measurements in a turbulent round jet), and a small class (4h)

Affiliated Masters

Masters of Fluid Dynamics and Energy
of Acoustics
of Aeronautics

Core texts

Bailly C. & Comte-Bellot G.. *Turbulence*. Springer, 2015.
Davidson P. A.. *Turbulence. An introduction for scientists and engineers*. Oxford University Press, 2004.
Pope S.B.. *Turbulent flows*. Cambridge University Press, 2000.

Assessment

Continuous assessment (4 homeworks, freely selection in a list), practical works and a small class.

AF MOD 1.5

Introduction aux vibrations non-linéaires

Introduction to nonlinear vibrations

Lecturers: Joël PERRET-LIAUDET, Fabrice THOUVEREZ

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

Objectives

This course is an introduction to the main phenomena related to the problems of nonlinear vibrations. The minimum knowledge and rules useful to the engineer will be introduced to diagnose and treat these problems. Many examples from engineering problems will illustrate the course. We can mention the dynamics of frictional contacts (squeal noise), clearance systems (rattling), rotors dynamics and gear transmissions, bridges subjected to wind ...

Keywords: nonlinear vibrations, dynamics of systems, stability, bifurcations, nonlinear modes, principal resonances, super-harmonics, sub-harmonics, self-sustained vibrations, galloping, flutter phenomena

Programme

- ◇ Generalities on nonlinear vibratory problems in engineering, classification of sources
- ◇ Description and Analysis Tools, Nonlinear Modal Analysis
- ◇ Loss of equilibrium stability and self-sustained vibrations (galloping phenomena, squealing)
- ◇ Phenomena of nonlinear resonances (principal and harmonics)
- ◇ Concept of strange responses (chaos)
- ◇ Introduction to methods specific to the treatment of nonlinear phenomena

Learning outcomes

- ◇ detect and / or diagnose nonlinear vibration phenomena
- ◇ characterize the main kinds of vibration responses
- ◇ identify the main phenomena that lead to these dynamic responses
- ◇ model some nonlinear problems and use specific methods

Independent study

Study of vibro impacting systems.
Study of hertzian contacts under normal excitations

Core texts

A. H. Nayfeh, B. Balachandran. *Applied Nonlinear Dynamics: Analytical, Computational and Experimental Methods*. Wiley, 1995.

Vidal, Bergé, Pommeau. *L'ordre dans le Chaos*. Hermann, 1984.

P. Manneville. *Instabilités, chaos et turbulence*. Ed. Ecole Polytechnique, 2004.

Assessment

Written Exam (50%)
Practical work (50%)

AF MOD 1.6

Acoustique Environnementale

Environmental Acoustics

Lecturers: Marie-Annick Galland, Didier Dragna

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

Objectives

Noise is considered by the population as one of the main and most important nuisances. Taking into account acoustic constraints is therefore of primary importance in many fields, for example in building engineering or evaluation of transportation systems. This course presents basic notions in acoustics particularly suited to engineers working in related sectors. More specifically will be developed acoustics of rooms and industrial or public environments, outdoor sound propagation in an urban environment, as well as the various techniques used to control (usually reduce) sound levels: passive techniques (noise barriers, use of absorbing materials) or active ones (anti-noise). Subjective aspects will also be introduced with notions on sound perception, sound quality and annoyance.

Keywords: Acoustics, room acoustics, noise control, outdoor propagation, sound perception

Programme

I- Basic equations and models in acoustics
II- Sound perception: from deciBel scales to nuisances
III- Room acoustics: modal theory and energetic approach (Sabine theory, ray tracing, reverberation time and quality indices)
IV- Noise reduction and control: airborne sound insulation (single and double- leaf partitions), barriers, absorbing materials, active control
V- Outdoor propagation: effects of ground, buildings, meteorological conditions, … ; sound maps

Learning outcomes

◇ Develop a coherent approach for diagnosing a problem in environmental acoustics
◇ Build a simplified model
◇ Propose a technical solution and evaluate the margin of error.

Independent study

Practical work:
- Room acoustics: measurement of reverberation time and sound quality indices in the cinema room of ECL; numerical simulation with CATT-Acoustic software.
- Outdoor propagation: Sound map design and analysis; numerical simulation with SoundPlan software
- Case study in noise control

Affiliated Masters

This set of lectures is one of the teaching units of the Master of Sciences in Acoustics (M2; see http://master-acoustics.ec-lyon.fr/).
It can also be taken as a teaching unit of the Masters in Aerospace Engineering, Mechanics or Civil Engineering,

Core texts

A. Pierce. *Acoustics, Introduction to its physical principles and applications*. Mc Graw -Hill, 1981.
H. Kuttruff. *Room acoustics*. Spon Press, 2000.
D.Bies, C.Hansen. *Engineering noise control*. Spon Press, 2009.

Assessment

Written Exam (50%); Practical work (50%)

AF MOD 2.1

Défis informatiques du Big Data

Big Data challenges

Lecturers: Stéphane DERRODE, Emmanuel DELLANDREA

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

Objectives

The quantitative explosion of data is at the origin of new orders of magnitude that impact the capture, storage, analysis and visualization of data. The outlook for the processing of big data is still partially unknown: prospective analysis (climate, marketing...), risk management (insurance, industrial, natural) or even medical (genomic, epidemiology) and security (fight against organised crime).
The proposed teaching will enable us to discover the main problems raised by the emergence of these data flows (storage, interrogation, analysis and visualization) and their commercial exploitation. The ethical and legal issues raised by the collection and use of these data will also be examined.

Keywords: Big Data, NoSQL, Hadoop, Open-data.

Programme

Introduction: the technical / economic / ethical issues of big-data
Databases: NoSQL and MongoDB
Open data and public data
Big Data analytics
TP #1 : Map-Reduce with Apache/Hadoop
TP #2 : data visualization : OpenStreetMap
TP #3 : Semantic Web (Resource Description Framework).

Learning outcomes

◇ Understand the economic, ethical and technical issues raised by big-data
◇ Use a map-reduce algorithm running under Hadoop
◇ Have a critical mind on new tools based on massive data
◇ At the end of this module, the student must be able to deepen his / her skills on big-data

Independent study

Deepen a topic by writing a summary note in groups of 4/5 (eg Big Data and startup, Data-Centers).
- Bibliographical review of readings
- Interview of a big data scientist

Affiliated Masters

Master of Science in Computer Science, University of Lyon

Core texts

Pirmin Lemberger et Marc Batty. *Big Data et Machine Learning - Manuel du data scientist*. Dunod, 2015.

Rudi Bruchez. *Les bases de données NoSQL et le Big Data : Comprendre et mettre en oeuvre*. Eyrolles, 2015.

Jean-Charles Cointot et Yves Eychenne. *La Révolution Big data - Les données au coeur de la transformation de l'entreprise*. Dunod, 2014.

Assessment

The teaching will be evaluated by a classical exam and by the bibliographic review (autonomous work).

AF MOD 2.2

Dynamique de l'Atmosphère et l'Océan

Atmosphere and Ocean Dynamics

Lecturers: Richard PERKINS, Lionel SOULHAC

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

Objectives

The aim of this course is to provide students with an understanding of the basic processes governing the large-scale circulation of air in the atmosphere. Atmospheric flows are the result of the interaction between two major physical processes – heat transfer from the equator to the poles, and rotation of the earth. Because of the difference between the specific heat capacity of air and water, the ocean acts as a heat reservoir which can stabilize or destabilize the atmosphere. Heat transfer from the equator to the poles is accomplished through the combined action of atmospheric and oceanic flows, and this course therefore studies the thermodynamic and physical process involved.

Keywords: Atmosphere, ocean, heat transfer, humidity, moisture radiation, rotation, Rossby, Ekman, Richardson, Geostrophic, Clouds, currents, internal waves

Programme

Introduction: physico-chemical properties of the atmosphere and the ocean
Atmospheric thermodynamics: radiative exchanges, stratification and stability
The moist atmosphere: cloud physics
Stratified fluids: internal waves on density interfaces and in continuously stratified fluids
The effects of rotation: the equation of motion in a rotating system, geostrophic and quasi-geostrophic winds, the thermal wind
Forced motion: the Ekman layer, Ekman pumping
Waves in rotating systems: the β plane approximation, Rossby waves, the Rossby adjustment problem
Large scale circulation patterns

Learning outcomes

◇ At the end of this course students will be capable of calculating the evolution of the properties of a mass of air as it moves through the atmosphere.
◇ At the end of this course students will be familiar with the different types of internal waves in the atmosphere and ocean.
◇ Students will be capable of calculating the direction and strength of the geostrophic or quasi-geostrophic wind as a function of the pressure gradient
◇ Students will be able to explain the principal features of a meteorological chart.

Independent study

Examples sheets for each subject to apply the material covered in the lectures
3 design classes, covering aspects of the course in greater depth

Affiliated Masters

Sciences de l'Océan, Atmosphère et Climat (SOAC); Mécanique

Core texts

GILL, A.E. *Atmosphere-ocean dynamics*. Academic Press, 1982.
FLEAGLE, R.G. & BUSINGER, J.A. *An introduction to atmospheric physics.*. Academic Press, 1980.
HOLTON, J.R. & HAKIM, G.J.. *An introduction to dynamic meteorology*. Academic Press, 2012.

Assessment

Knowledge: Exam on the material covered in the course (40%); Skills: reports on the three design classes (60%)

AF MOD 2.3

Statistique appliquée aux sciences de l'ingénieur

Statistical engineering

Lecturers: Céline HELBERT

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

Objectives

The course is divided into two parts. In the first part we introduce two classical statistic models : linear and logistic regression. The estimation and the prediction of theses models are presented. The second part focuses on the design and analysis of computer experiments from uncertainty quantification to bayesian optimization.
The aim of this course is also to provide training in data manipulation and practical implementation of the studied models. To do this, a substantial part of the course is oriented towards the implementation using R through the study of a large number of data sets.

Keywords: Linear regression, model selection, experimental design, logistic regression, computer experiments, sensitivity analysis, bayesian optimization

Programme

Chap 1: Linear regression: model, estimation, prediction, evaluation, model selection.
Chap 2: Experimental designs
Chap 3: Logistic regression
Chap 4: Gaussian process regression
Chap 5: Computer experiments
Chap 6: Sensitivity analysis and global optimization

Learning outcomes

◇ Knowing what probabilistic model is the most accurate for a given situation
◇ Knowing how to estimate and to predict the proposed probabilistic model.
◇ Being able to choose the relevance design of experiments.
◇ Knowing how to implement a linear regression, and a gaussian process regression on R

Affiliated Masters

Option MD/Filière MIR (highly recommended)
Master mention "Mathématiques appliquées, statistique" (mandatory)
Master mention "Statistique et économétrie" (mandatory)

Core texts

A. Antoniadis, J. Berruyer, R. Carmona. *Regression non linéaire et applications*. Economica, 1992.
J.J. Droesbeke, J. Fine, G. Saporta. *Plans d'expériences, application à l'entreprise*. Technip, 1997.
Rasmussen, Williams. *Gaussian Processes for Machine learning*. MIT Press, 2006.

Assessment

Written exam 1:30 (100%)

AF MOD 2.4

Les turbines pour la production d'énergie

Power plant turbine technology

Lecturers: Pierre DUQUESNE , Alexis GIAUQUE

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

Objectives

In this course, we pay attention to the different turbomachinery, alone or in association, used for energy production right now or in the near future. The available resources are analysed and are discussed dependent on the type, on the geometry and on the main dimensions of the different turbomachinery and their operating modes.
A part of the electricity produced with turbomachinery came from direct extraction of the energies of the wind (wind turbines), from the rivers (run-of-river turbines) or from the water head (hydraulic turbines). The last part of the production came from an association of different turbomachinery (compressor, turbine and heat source), often called gas turbines or steam turbines. These systems producing both heat and mechanical power (converted to electricity power)

Keywords: Energy production, hydraulic turbines, wind turbines, gas turbines, steam turbines

Programme

- Hydraulic turbines: geometries (impulse and reaction turbine, Francis, Kaplan, Pelton), energy transfer (Euler equation), efficiency, similitude law, cavitation phenomena.
- Wind turbines: geometries, size, blade numbers, power recoverable (Betz law), regulation.
- Gas turbine: introduction to energy production from a heat source, energy exchange in the different component (concepts of shaft work and stagnation variables), transformations graphical representation, components description.
- Steam turbines: Rankine's cycle, Hirn's cycle and improvement (reheat, extraction)

Learning outcomes

◇ Understand the energy production with turbomachinery
◇ Know how to design a hydraulic turbine
◇ Know how to design a wind turbine
◇ Know how to calculate the cycle of steam or gas turbine

Independent study

Explain the operation of a Pelton turbine and illustrating dimensional analysis from the laboratory.

AF MOD 2.6

Reconnaissance et comportement des sols

Soils survey and soils behaviour

Lecturers: Eric VINCENS

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

Objectives

Any civil work or building change the natural balance of soils and this risk has to be taken into account with a deep knowledge of site conditions and suitable scientific tools.
The targets of this training course are :
- to bring to the students all necessary knowledge to draft a complete soil survey and lab tests programme for a specific site,
- to explain methodology and tools used for slope enad banks stability calculations,
- to introduce more sophisticated modeling methods used by geotechnical companies to analyse the soils behaviour.

Keywords:

Programme

Soil surveys (in situ and lab tests)
Slope stability
Experimental behaviour of soils (clays and sands)
Elastoplasticity for soils

Learning outcomes

◇ Overview on geological, geomechanical and hydraulic models
◇ Ability to analyse slope and banks stability
◇ Understand the soil behaviour according to its nature

Independent study

Lab courses "Visual identification of soils" and "clay identification"
"Shear test on sand". Lab report is expected for each session.
BE : Analysis of a hydraulic work (models, on site and lab tests, surveys)

Affiliated Masters

Master of Mechanics
Master de Génie Civil

Core texts

G. Olivari. *Mécanique des sols*. Polycopié ECL-SDEC, 0.
P. Mestat. *De la rhéologie des sols à la modélisation des ouvrages géotechniques*. Editor2, 2000.

Assessment

- Microtests: closed-book examination
- Lab Activities
- Final exam: closed-book examination

Score : 2/3 exam + 1/3 activities (microtest+lab)

AF MOD 3.1

Propagation des ondes élastiques

Elastic Wave Propagation

Lecturers: Louis JEZEQUEL, Sébastien BESSET

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

Objectives

In the field of Vibro-acoustics, the control of the behavior of structures is hampered by the difficulty of using the finite element method. In this way, wave propagation view is essential and condtitutes the basis of many analytical methods used in industry. Its implementation in the field of transport has made it possible to optimize the vibro-acoustic comfort of vehicles. In the field of Civil Engineering, the calculation of the vibro-acoustic behavior of buildings has been made necessary by the evolution of standards of safety and comfort. On the other hand, wave analysis of aeroelastic or hydro-elastic problems reveals major dynamic phenomena such as shock waves, radiation and acoustic transparency of structures.

Keywords: Propagation, vibroacoustics, radiation, seismic, stratified media, fluid-structure coupling.

Programme

I - Introduction: Propagation of a mono-dimensional medium - Harmonic waves - Power flow
II - Wave analysis in solids: Propagation in a finite space - Propagation in a half-space - Waves in stratified media - Waveguide - Case of periodic media
III - Vibro-acoustic analysis: Non-modal behavior of structures - Integral formulation - Energy methods - Static analysis of dynamic problems
IV - Ground-structure coupling: Superficial foundations dynamics - Modeling of foundations by piles - Numerical simulation models
V - Fluid-structure coupling: Propagation in pipes - Study of water hammers - Acoustic transparency and radiation of the walls

Learning outcomes

◇ Understanding the main vibro-acoustic phenomena
◇ Understanding vibratory energy exchanges between elastic media
◇ Learn about the vibro-acoustic calculation tools used in mechanical design
◇ Understanding the seismic design rules

Independent study

Learning and deepening a part of the course through a bibliographic analysis and reflection on an application problem.

Affiliated Masters

MSc mechanics
MSc of civil engineering
MSc acoustics

Core texts

A. Bedford & D.S. Drumheller. *Introduction to elastic wave propagation*. Wiley, 1994.

F.E. Richard, JR Hall & R.D. Woods. *Vibrations of Soils and Foundation*. Prentice Hall, 1970.

James F. Doyle. *Wave Propagation in Structures. Spectral Analysis using fast discrete Fourier transforms - Second Edition*. Springer, 1997.

Assessment

Technical study
exams

AF MOD 3.2

Apprentissage profond & Intelligence Artificielle : une introduction

Deep Learning & Artificial Intelligence : an introduction

Lecturers: Liming Chen, Emmanuel Dellandréa, Alberto Bosio

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

Objectives

By allowing breakthroughs supposed to be impossible until recently in a growing number of domains such as computer vision, speech recognition, autonomous driving or games, deep learning has revolutionized the artificial intelligence domain that has become one of the major pillars of our society. In this course, our goal is to introduce deep learning concepts and technics.

Keywords: Deep learning, artificial intelligence, reinforcement learning, PyTorch.

Programme

- Introduction to machine learning and deep learning
- Classification/regression and gradient descent
- Computational graphs & backpropagation
- Training deep neural networks
- Convolutional Neural Networks (CNN)
- Recurrent Neural Network & LSTM
- Sequence to sequence and attention
- Unsupervised learning: deep auto-encoder
- Deep reinforcement learning
- Embedded Deep Learning

Learning outcomes

◇ Understanding deep learning principles.
◇ Mastering technics to control learning processes.
◇ Being able to deploy a deep learning approach with the PyTorch framework.

Independent study

The deep learning principles introduced into the lectures will be implemented during the tree practical sessions using the PyTorch framework and a GPU card for embedded applications.

Affiliated Masters

Master of Computer Science of Lyon

Core texts

Ian Goodfellow, Yoshua Bengio, Aaron Courville. *Deep Learning*. MIT Press, 2016.

Bert Moons, Daniel Bankman, Marian Verhelst. *Embedded Deep Learning Algorithms, Architectures and Circuits for Always-on Neural Network Processing*. Springer, 2019.

Richard S. Sutton, Andrew G. Barto. *Reinforcement Learning: An Introduction (2nd Edition)*. MIT Press, 2018.

Assessment

50% savoir (written exam), 50% savoir-faire (evaluation of the assignments)

AF MOD 3.3

Systèmes embarqués sécurisés

Secure embedded systems

Lecturers: Cedric Marchand, David Navarro

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

Objectives

Today, embedded systems are everywhere whether in our pockets, homes or cars but also in industry, aeronautics or space industry. More and more of these systems are being used in applications where manipulated data are sensitive and need to be protected. In addition, the rise of connected objects, which are more and more numerous, have awaken ended users to security issues.
In this course, we will discuss the basic principles of security and their integration in embedded systems. The classic attacks as well as some countermeasures will be presented. Finally, specific areas such as counterfeiting or security in RFID systems will be addressed.

Keywords: Embedded systems, sécurity, cryptography

Programme

Definition of the concepts of embedded systems, security.
Introduction to embedded systems, microcontroller and FPGA.
Introduction to cryptography
Attacks and Countermeasures on Information Systems and Embedded Systems
Security primitives for electronics.
Specific area: the fight against counterfeit electronic products
Application area: Security in RFID systems

Learning outcomes

◇ Seize the security issues in the field of embedded systems
◇ Identify weaknesses and possible attacks on a system
◇ Know the basic mechanisms of security
◇ Propose solutions combining multiples basic securie blocks to improve the security of a system

Independent study

BE : Software programming of an embedded system
TP1 : Programming standard encryption algorithm (AES) on STM32 embedded target
TP2 : Attack of the encryption algorithm thanks to the side channels (Challenge)

Affiliated Masters

Master EEEA, "embedded systems"

Core texts

Hans Delfs, Helmut Knebl. *Introduction to Cryptography*. Springer, 2002.
Mohammad Tehranipoor, Cliff Wang. *Introduction to Hardware Security and Trust*. Springer, 2011.
Lilian Bossuet, Lionel Torres. *Foundations of Hardware IP Protection*. Springer, 2017.

Assessment

70% Knowledge, 30% savoir-faire

AF MOD 3.4

Identification des systèmes et décomposition parcimonieuse des signaux

System identification and sparse decompositions

Lecturers: Julien HUILLERY, Laurent BAKO

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

Objectives

The understanding of physical phenomena coupled with the advancement of observation technologies, the needs of analysis, diagnosis and control of engineering systems make more and more use of experimental modeling. This modeling work is a prerequisite for the synthesis of control laws of dynamic systems or the analysis and processing of signals. The goal of this course is to provide advanced principles and methods of signal and system modeling. "System identification" aims to associate a mathematical model with a dynamic system on the basis of noisy data measured with sensors. The "sparse decomposition of signals" aims at a compact modeling of a signal via its decomposition in a dictionary.

Keywords: experimental modeling, system identification, parametric estimation, sparsity, dictionary of signals, time-frequency representations, compressed sensing, optimization

Programme

Part I: Systems Identification
Introduction to Signal and System Modeling: System Point of View
Concept of model structure: definition and examples
Estimation methods based on the minimization of the prediction error
Elements for the analysis: identifiability, persistence of excitation, frequency richness of a signal
Asymptotic properties of the estimators: consistency, convergence in distribution

Part II: Sparse Decomposition of Signals
Introduction to Signal and System Modeling: Signal Point of View
Sparse decomposition of signals: principle and algorithms
Dictionaries of representation: time-frequency and wavelets
Compressed sensing: a new paradigm for measurement

Learning outcomes

◇ Understanding the application issues of signals and systems modeling
◇ Construct and identify a model of system from experimental measurements
◇ To know the usual bases of representation of signals
◇ Determine a sparse representation of a signal

Independent study

The lectures are completed with 3 practical works under Matlab / Simulink:
BE 1: Implementation of identification methods on an example
BE 2: Sparse decomposition of signals
BE 3: Compressed Sensing

Affiliated Masters

Parcours "Génie des Systèmes Automatisés" (GSA) du Master EEEA
Parcours "Medical Imaging, Signals and Systems" (MISS) du Master IDS

Core texts

L. Ljung. *System Identification: Theory for the User (2nd Edition)*. PTR Prentice Hall, 1999.
S. Mallat. *A wavelet tour of signal processing, the sparse way*. Academic Press, 2009.
S. Boyd and L. Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004.

Assessment

Knowledge (50%): 2h written exam
Practice (50%): 3 reports

AF MOD 3.5

Diagnostic et Sûreté de Fonctionnement

Diagnosis and Health Monitoring

Lecturers: Emmanuel BOUTLEUX

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

Objectives

To detect failure before they appear is a big challenge for any kind of complex systems. From modern car full of automation (sensors, actuators, control/command strategies) to more-electric airplanes, from industrial power plant to robotics applications, methods are needed to inform that a failure or default as appeared, appears or will appear.
That course will focus on automatic detection methods based on model-based approaches or artificial intelligence approaches.

Keywords: Diagnosis, health monitoring, identification, pattern recognition,FMECA

Programme

Context
Fonctional approches like FMECA (Failure Modes, Effects and Criticality Analysis)
Reliability
Diagnosis approaches:
- model-based
  - identification
  - error detection
- artificial intelligence
  - pattern recognition
  - clustering
  - decision rules

Perspectives

Learning outcomes

◇ To realise challenges and difficulties associated with health monitoring
◇ To be able to applied pattern recognition techniques
◇ To be able to properly identify mathematical model for diagnosis purposes

Independent study

3 times 4h BE using Matlab (good knowledge of Matlab is a must)

Affiliated Masters

GI, GSA

Core texts

Bernard Dubuisson. *Diagnostic, intelligence artificielle et reconnaissance des formes*. Hermès Science Publications, Collection : ic2 prod, 2001.

Bernard Dubuisson. *Diagnostic et reconnaissance des formes*. Traité des nouvelles technologies. Série diagnosti, 1990.

Alain Villemeur. *Sûreté de fonctionnement des systèmes industriels*. Edition Eyrolles, 1988.

Assessment

50% based on BE average results
50% on final exam

AF MOD 3.6

Automatique Avancée

Advanced Control

Lecturers: Anton KORNIIENKO, Xavier BOMBOIS

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

Objectives

For increasingly complex systems and increasingly tighter and contradictory performance specifications, the design of a controller achieving the best trade-off between these specifications must be tackled via an optimization problem. In LQ/LQG control, these specifications are recast into a criterion reflecting the trade-off between control performance and its cost. The drawback of this approach is that control performance can only be guaranteed if the model used for the design is an accurate representation of the system. The necessary robustness of the controller can be ensured via Hinfinity control, a generalization of classical frequency domain control. These two control approaches will be presented and compared. Examples will allow the students to use them in practice.

Keywords: LQ/LQG control, H2 control, Hinfinity control, multivariable control

Programme

The course will start by a recap on classical control methods and classical control performance specifications. We will then present the LQ/LQG control design approach and its generalization i.e. H2 control. Attention will be paid to the additional performance specifications that can be tackled with this specific control design method and to the different ways to achieve this control action (input-output approach or state-feedback with observer structure). Finally, the second advanced control design method (Hinfinity control) will be presented. This method allows to deal with similar performance specifications as LQ/LQG control, but can also tackle the robustness issues related to model uncertainty.

Learning outcomes

◇ To be able to specify an optimization criterion for LQ/LQG control and for Hinfinity control based on a list of performance specifications
◇ To be able to design a controller using an advanced control method
◇ To be able to analyze the achieved closed-loop system and its control performance

Independent study

3 exercise sessions:
BE1 : LQ/LQG Control
BE2 : H_infinity Control
BE3 : LQ/LQG vs H_infinity synthesis

Affiliated Masters

Master EEEA, Control Systems Engineering Track (GSA)

Core texts

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

Kwakernaak H.. *H2-Optimization – Theory and Applications to Robust Control Design*. Annual Reviews in Control, 26 (1), pp. 45-56, 2002.

Skogestad S. and Postlethwaite I.. *Multivariable Feedback Control, Analysis and Design.*. John Wiley and Sons Chischester, 2005.

Assessment

Open book exam (2h) : 50%
Evaluation of exercise sessions: 50%

AF MOD 4.1

Green Computing

Green Computing

Lecturers: Sébastien LE BEUX, Ian O'CONNOR

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

Objectives

This course focuses on the functionality, performance and energy efficiency of execution of applications on computating architectures. In this context we will addressed parallel hardware architectures (multi-core processors, SIMD machines), hardware resources of communications (bus and network) as well as the efficient deployment of applications on these hardware resources: task placement and mapping, hardware / software partitioning and compatibility between architectures and algorithms. Techniques for estimating energy consumption will be presented and will enable the estimation of the cost of memory access, computing and communication.

Keywords: Energy consumption in digital electronic systems, Low energy and power consumption techniques, Parallel computing architectures, Deployment of applications, algorithm architecture compatibility

Programme

Principles of hardware / software partitioning and processor sizing
Multi-core architectures and programming
Strategies for deploying tasks and reducing energy consumption
Energy cost of inter-core communication or distributed computing
Multi-level abstraction energy estimation of software execution

Learning outcomes

◇ Understand the origins and consequences of energy consumption in computing architectures
◇ Be capable of evaluating energy consumption in processors
◇ Be capable of optimizing the programming of algorithms on processors to minimize energy consumption

Independent study

Study class: analysis of energy-efficient supercomputers (green500.org)

Affiliated Masters

Master Electronics, Electrical Energy, Control (3EA)

Core texts

M.T. Schmitz et al. *System-Level Design Techniques for Energy-Efficient Embedded Systems*. Springer, 2004.

T.D. Burd et al. *Energy-efficient microprocessor design*. Kluwer, 2002.

Assessment

50% final test, 50% practical activities

AF MOD 4.2

Energie Stockage-Conversion

Energy, Storage, Conversion

Lecturers: Guy STREMSDOERFER, Jean-Pierre CLOAREC

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

Objectives

Keywords:

Core texts

CEA. *Memento sur l'énergie « Energy handbook »*. CEA, 2015.

AF MOD 4.3

Combustion pour la propulsion

Combustion

Lecturers: Mikhael GOROKHOVSKI, Alexis GIAUQUE

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

Objectives

Keywords:

Core texts

R. BORGHI ET M. DESTRIAU. *La combustion et les flammes*. Editions Technip, 1995.
K.K. KUO. *Principles of Combustion*. Wiley-Interscience Publication, 2005.
I. GLASSMAN & RA. YETTER. *Combustion*. Elsevier, 2008.

AF MOD 4.4

Recherche opérationnelle

Opertations Research

Lecturers: Abdelmalek ZINE, Alexandre SAIDI

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

Objectives

Keywords:

Core texts

Ch-E. Bichot et P. Siarry. *Partitionnement de graphe*. Hermes, 2010.

P. Venkataraman. *Applied Optimization with Matlab*. Wiley, 2009.

A. Billionnet. *Optimisation discrète : De la modélisation à la résolution par des logiciels de programmation mathématique*. Dunod, 2006.

AF MOD 4.5

Analyse des assemblages : géométrie et architecture

Mechanical assembly: architecture and geometry analyses

Lecturers: Bertrand HOUX, Didier LACOUR

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

Objectives

Present methods and tools for analyzing the geometric quality of assemblies.
Mastering the architecture and geometry of assemblies is a major industrial objective. The geometrical quality of the parts and the architecture of the assemblies can have direct repercussions on the assembly capacity of the product, but also on the services it must provide.
This course presents the modern methods of assembly simulation by integrating the geometrical defects of their components. It thus identifies the theoretical concepts on which these methods are based, in order to understand their fields of application and their limits.

Keywords: Assembly, architecture, geometric specifications, ISO GPS standards, tolerancing, metrology, influencing analysis, assembly simulation, statistics

Programme

Quantification of the specifications and analysis of their influences on the assembly (sensitivities) by torsors of small displacements.
Statistical Approaches, Monte Carlo.
Geometric Specification Methods, Geometrical Product Specification (GPS).
Algorithms used in three-dimensional metrology (numerical methods of association).

Learning outcomes

◇ Knowledge of methods and tools for analyzing the geometric quality of assemblies.
◇ Write and interpret standardized geometric specifications.
◇ Analyze influences and contributions on a concrete model.
◇ Establish and implement a three-dimensional control strategy.

Core texts

Anselmetti B.. *Tolérancement – Volumes 1 a 4*. Hermès - Lavoisier, 2010.
Charpentier F.. *Mémento de spécification géométrique des produits – Les normes ISO-GPS*. AFNOR, 2015.
Bourdet P. & Mathieu L.. *Tolérancement et métrologie dimensionnelle*. Cetim, 1999.

Assessment

1 examen final (2h)
1 BE avec compte-rendu noté

AF MOD 4.6

Systèmes de bases de données

Database systems

Lecturers: Liming CHEN

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

Objectives

Databases are at the heart of any information system that is nowadays omnipresent in our everyday life (work, organization, web, etc.). The aim of this course is to study the principles of programming relational and semi-structured databases that are the foundation of any application in the various information systems. It also discusses the implementation aspects of database systems such as concurrency control or query optimization.

Keywords: databases, structured data and non structured data modelling, data storage and access, relational languages, concurrency control, query optimization, integrity constraints

Core texts

H.Garcia-Molina, J.D.Ullman, J.Widom. *Database systems: the complete book*. Pearson Prentice Hall, 2002.

Georges Gardarin. *Bases de données (http://georges.gardarin.free.fr/Livre_BD_Contenu/XX-TotalBD.pdf)*. Eyrolles, 2003.

AF MOD 5.1

Physiologie humaine et biotechnologies

Human physiology and biotechnology

Lecturers: Emmanuelle LAURENCEAU

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

Objectives

The objective is to upgrade the basic knowledge in physiology and to enable understanding of the mechanisms of communication and regulation of the organism. Integration between the different functions will be tackled from concrete examples for biomedical applications based on the study of systems such as cardiovascular and immune systems. A second part will allow understanding the function of a living cell in its natural environment and to apprehend the potentialities of the cells and the biomolecules which compose them in the sectors of health. Emphasis will be placed on the link between structure, environment and ability to fulfill a biological function. The course will be illustrated by developments in molecular biology.

Keywords: cells, molecular biology, cardio-vascular and immune systems, biomedical applications

Programme

Organization of the living cell
Organization of the human body: Cardiovascular, immune systems
Basic biological mechanisms
Cells in their environment
Lab: Analysis of cells by optical microscopy and grouwth cell
BE: Pharmacology
BE: Analysis of cardiac function by imaging

Learning outcomes

◇ Know the basics in cellular and molecular biology
◇ Understanding the functioning of the human body and the structure-biological function relationships
◇ Understanding health sector issues
◇ Apply knowledge to problem solving

Independent study

To extend the course on the cardiovascular system and pharmaco-kinetics

Affiliated Masters

Master of Health Engineering (IDS)
Mandatory MOD for BIO speciallization of BIN Option

Core texts

Alberts Bruce M. (Collab.) Johnson Alexander (Coll. *Biologie moléculaire de la cellule*. Flammarion Médecine-Sciences, 2004.

Étienne Jacqueline. *Biochimie génétique, biologie moléculaire*. Masson, 2006.

Silverthorn Dee Unglaub. *Physiologie humaine*. Pearson education, 2007.

Assessment

Practical evaluations (Lab, BE), final exam

AF MOD 5.2

Aléas et hétérogénéités dans les structures

Uncertainties and heterogeneities in real structures

Lecturers: Francesco FROIIO, Eric VINCENS

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

Objectives

Solid and structural mechanics is usually taught in undergraduate courses based on the assumption of homogeneous materials and according to the deterministic approach as concerns the mechanical properties of materials and loading conditions.

However, real structures are subjected to loading conditions with inherent randomness. Further sources of uncertainty concern the mechanical properties of materials and result from the relevant fabrication procedures. How to deal with these elements of complexities while keeping the design procedure as simple as possible is the main topic of this course.

Keywords: Structural design, semi-probabilistic approach, eurocodes, non-homogenous cross-section elements, reinforced concrete

Programme

Main sub-topics :
- characterisation of static loading conditions and of the mechanical properties of material, introduction to reliability of structures, partial safety factors
- A few models from structural mechanics
- Design of structural elements with non-homogenous cross section, limit state design

Learning outcomes

◇ Understanding of i) the random variability of external actions and ii) of the sources of uncertainty in material charcterisation and structural modelling
◇ Practice of the European standards for structural design (eurocodes, semi-probabilistic approach)
◇ Practice of structural models as applied to real structures
◇ Limit state design of structural elements with non-homogenous cross-sections

Independent study

Tutorial #1 : Snow loads and wind actions on real structures
Tutorial #2 : Bending moment diagrams for a reinforced concrete slab
Tutorial #3 : Limit state design of a reinforced concrete slab

Affiliated Masters

Master of Civil Engineering

Core texts

J.-A. Calgaro. *Introduction aux Eurocodes : sécurité des constructions et bases de la théorie de la fiabilité*. Presses de l'École Nationale des Ponts et Chaussée, 1999.

R. Park, T. Paulay. *Reinforced concrete structures*. John Wiley & Sons, 1975.

Y. Sieffert. *Le béton armé selon les Eurocodes 2*. Dunod, 2010.

Assessment

Evaluation:
- Student report on Tutorial #1 (1/3 of the final score)
- Closed-book final exam (2/3 of the final score)

AF MOD 5.3

Traitement et analyse des données visuelles et sonores

Processing and analysing of visual and audio data

Lecturers: Mohsen ARDABILIAN, Emmanuel DELLANDREA

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

Objectives

Keywords:

Core texts

A. Divakaran. *Multimedia Content Analysis: Theory and Applications.*. Springer, 2008.
R. Szeliski. *Computer Vision -- Algorithms and Applications*. Springer, 2010.
R. O. Duda, P. E. Hart & D. G. Stork,. *Pattern Classification*. Wiley Interscience, 2004.

AF MOD 5.4

Matériaux de construction

Construction materials

Lecturers: Eric VINCENS

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

Objectives

This course presents the main materials used for construction, their manufacturing, production and characterisation. Their mechanical behavior will be adressed justifying the area of use and for each of them the selection criteria will be given according to encountered problems of durability.

Keywords: aggregates, bitumen, cement, concrete, steel, earth, stone

Programme

The main chapters are constituted of :
- Aggregrates
- Black products: bitumen, bitumen emulsions….
- Binders: cement, plaster, lime
- Concrete: regular, high performance, fiber-reinforced, self-placing
- Wood
- Steel for construction
- Materials with low embodied energy : earth, dry stone

The use of these materials will be envisioned in relation to the industrial and normative context, the key role of the environment that tends to affect both the physical and mechanical properties of the material will be pointed out.

Learning outcomes

◇ know how to identify and characterize materials for construction
◇ know the problems of durability of the materials in their environment

Independent study

Lab activities : 2*2h
- particle size analysis and size analysis by sedimentation
- activity of clayey soils in backfill : Methylen Blue test

Affiliated Masters

Master of Civil Engineering

Core texts

G. Dreux. *Nouveau guide du béton et de ses constituants*. Eyrolles, 1998.

H. di Benedetto. *Matériaux routiers bitumeux 1 : Description et propriétés des constituants*. Lavoisier, 2004.

JP. Ollivier, JM. Torrenti, M. Carcassès. *Propriétés physiques du béton et de ses constituants*. Lavoisier, 2012.

Assessment

- Microtests: closed-book examination
- Final exam: closed-book examination

Score : 2/3 final exam + 1/3 activities (microtests+lab)

AF MOD 5.5

Tribologie : principes et applications

Tribology

Lecturers: Denis MAZUYER

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

Objectives

Keywords:

Core texts

G.W. Stachowiak and A. Batchelor. *Engineering Tribology*. Butterworth-Heinemann, 2013.
F.P. Bowden and D. Tabor. *Friction and Lubrication of Solids*. Oxford University Press, 1954.
J.M. Georges. *Frottement, Usure et Lubrification*. CNRS Editions, Eyrolles, 2000.

AF MOD 5.6

Aerodynamique externe

External aerodynamics

Lecturers: Julian SCOTT, Jérôme BOUDET

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

Objectives

Understand and describe the forces (lift and drag) induced on a body by flow.
Identify the associated design parameters.
Formulate and apply flow models appropriate to aerodynamics.
Estimate the accuracy of predictions resulting from such models from a design perspective.

Keywords: Aerodynamics, Lift, Drag, Aeronautics, Aircraft, Lifting Surfaces.

Programme

1. Flight dynamics. Piloting and control surfaces. Longitudinal flight equilibrium. Flight stability.
2. Two-dimensional wing design. Essential elements of aerofoil theory. Thin aerofoil theory. Models: potential flow, panel methods.
3. Lift and 3D effects. Lift/circulation relationship and its consequences for 3D flow. Elliptic loading and its generalisation. Models: lifting-surface and lifting-line theories.
4. Drag control. Laminar and turbulent boundary layers. Parameters influencing transition. Components of drag on an aircraft.
5. Compressibility effects. Mach number, shock waves. Transonic and supersonic aerofoils. Models: Prandtl-Glauert and Ackeret theories.

Learning outcomes

◇ Understand the basic principles of aircraft flight.
◇ Master the basic models of aerodynamics.
◇ Pre-design of lifting surfaces in aerodynamics.

Independent study

Practical class: study of an aerofoil in a wind tunnel and comparison with numerical simulations.
Examples class: basic aircraft modelling: illustrations.
Examples class: geometrical design of an aerofoil satisfying a given specification.

Affiliated Masters

Aeronautics and Space Master
Mechanics Master (specialisation Fluid Mechanics and Energy)

Core texts

E.L. Houghton, P.W. Carpenter. *Aerodynamics for Engineering Student*. Butterworth-Heinemann, 2003.
D.P. Raymer. *Aircraft Design: A Conceptual Approach*. AIAA, 2012.
B.W. McCormick. *Aerodynamics, Aeronautics and Flight Mechanics*. Wiley, 1994.

Assessment

Written exam (55%, "savoir").
Participation in and reports on examples and practical classes (45%, "savoir faire").

AF MOD 6.1

Nanotechnologies

Nanotechnologies

Lecturers: Magali PHANER-GOUTORBE, Virginie MONNIER

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

Objectives

Nanoscience and nanotechnology deal with understanding of the specific properties of structures at nanometric scale, as well as elaboration and characterization of these nanostructures. Nanotechnology allow to push the miniaturization limits and to develop new applications and new functionalities in micro- and optoelectronics, materials science, biology and medicine, energy and environment. This course will present the specific properties of nanostructures and nanomaterials, as well as imaging and elaboration tools at the nanometric scale. It will focus on the technological achievements that already exist or are likely to emerge in the near future.

Keywords: Physics of low dimensional systems, scanning probe microscopies, nanolithography, nanomaterials, nano-electronics, nano-biotechnologies, nanotechnologie for energy and environment

Programme

Introduction to nanoscience and nanotechnology.
Application of nanotechnologies in usual and future objects
(smartphone, nanorobot, medical nanocapsule ...)
Imaging and characterization tools of nanostructures.
Nano-lithography techniques.
Nanomaterials, nanowires and nanoparticles.
Nano-electronics, molecular electronics, single electron transistor.
Nanobiotechnologies: DNA and proteins microarrays, self-assembling and biology, biomimetic structures.
Nanotechnology for energy and environment
BE magnetic nanoparticles - data storage and biomedical applications
TP Atomic Force Microscopy

Learning outcomes

◇ To control the issues of nanotechnologies in the fields of information technology, materials, medicine, biology, energy and environment.
◇ To understand the physical principles in low dimensional structures.
◇ To think at the future development of nanotechnologies

Independent study

Deepening of part of the course
Specific studies of objects using nanos, work in group
oral presentation

Affiliated Masters

Possible equivalence for the master NSE and strong link with masters MISTE and EEEA
Recommended for the BIN option

Core texts

M. LAHMANI, C. BRECHIGNAC, P. HOUDY. *Les nanosciences. Tome 1: Nanotechnologies et nanophysique*. Editions Belin, 2004.

M. LAHMANI, C. BRECHIGNAC, P. HOUDY. *Les nanosciences. Tome 2: Nanomatériaux et nanochimie*. Editions Belin, 2006.

M. LAHMANI, C. BRECHIGNAC, P. HOUDY. *Les nanosciences. Tome 3: Nanobiotechnologies et nanobiologie*. Editions Belin, 2007.

Assessment

Evaluation of the practical activity.
Tutorial evaluation
Oral presentation evaluation .

AF MOD 6.2

Matière molle : nanosystèmes et interfaces biologiques

Soft material: nanosystems and biological interfaces

Lecturers: Denis MAZUYER

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

Objectives

Keywords:

Core texts

P.-G. de Gennes, F. Brochard, D. Quéré,. *Gouttes, perles et ondes*. Belin, 2001.

P. Coussot, Ph. Ancey,. *Rhéophysique des pâtes et des suspensions*. EDP Sciences, 2000.

D. Tabor. *Gases, Liquids and Solids and Other States of Matter*. Third edition, Cambridge University Press, 1991.

AF MOD 6.3

Durabilité des matériaux et des structures

Durability of materials and structures

Lecturers: Bruno BERTHEL, Michelle SALVIA

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

Objectives

In order to develop efficient, reliable and safe products, it is necessary to take into account the damage mechanisms of materials and parts. The topic of this course is how to predict the failure of materials under mechanical loading, taking into account the surrounding, in the field of carriage. Each class of materials having different failure process, damage mechanisms of each one are studied and formalized. This course contain theoretical lectures (fracture mechanics, fatigue,...) and practical works (fractography, acoustic emission,..).

Keywords: Fatigue, Fracture mechanics, Finite element method, Fractography, Acoustic emission.

Programme

Fracture mechanics: material features, stress singularities and energetic criteria.
Fatigue of materials: fatigue and endurance domains, factors affecting fatigue life, design against fatigue and crack growth rate laws.
Multiaxial fatigue: definition and criteria.
Specificity of polymer and composite materials
Practical work on fractography: study of the fracture surfaces of parts and determination of the cause of failure.
Practical work on the interest of the acoustic emission in the field of structural health monitoring
Practical work on the applications of the finite element analysis in failure analysis

Learning outcomes

◇ Identify the different damage and failure processes of materials used in the field of carriage and know how to study the fracture surfaces of materials.
◇ master the basics of fracture mechanics and fatigue of materials. Know how to use a multiaxial fatigue criterion.
◇ Know the specificities of composite materials and have notions on the field of structural health monitoring (especially in acoustic emission).
◇ apply what students have learned to explain a research problem and make a critical analysis.

Independent study

Assignments consisting of preparing practical works, writing reports and analyzing a scientific article. All these activities are team-work.

Affiliated Masters

Semester 9, Aeronautical engineering option: possible choice
Master Aerospace Engineering: obligatory for M2 « Dynamic and Sustainability of Composite Materials (DDC) » option
Master MISTE: equivalent to TC3- Mechanics and materials

Core texts

D. HULL. *Fractography: Observing, Measuring and Interpreting Fracture Surface Topography*. Cambridge University Press, 1999.

P. C. POWELL. *Engineering with polymers*. Chapman & Hall, 1992.

C. BATHIAS, A. PINEAU. *Fatigue des matériaux et des structures (Volumes 1 à 4)*. Lavoisier, 2009.

Assessment

Pratical works (50%) + oral presentation (50%)

AF MOD 6.4

Microsystèmes Autonomes

Autonomous microsystems

Lecturers: Ian O'CONNOR, Pedro ROJO-ROMEO

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

Objectives

Keywords:

Core texts

S. Senturia. *Microsystem Design*. Springer, 2000.

N. Maluf. *An Introduction to Microelectromechanical Systems Engineering*. Artech, 2004.

AF MOD 6.5

Changements climatiques et Géo-ingénierie

Climate Change and Geo-engineering

Lecturers: Pietro SALIZZONI, Julian SCOTT, Richard PERKINS

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

Objectives

Although there is now general agreement that our climate is evolving at an increasing rate, there is little agreement about what should be done to slow down these changes, and it is now unlikely that a simple reduction in greenhouse gas emissions will have any significant impact. Climate change will affect all aspects of the engineering profession, and will need to be taken into account in every project. It may also become necessary to envisage direct intervention to modify the earth's climate, and various techniques have already been proposed. This course will provide students with a general overview of the mechanisms which determine the earth's climate, so that they can offer informed participation in the engineering projects that are likely to emerge in response to climate change.

Keywords: Climate change, greenhouse gases, carbon, paleoclimatology, global warming, oceans, atmosphere, meteorology, modeling, dynamical systems

Programme

Introduction: Definition of climate, the principal processes, evidence for climate change
Radiative transfer: solar radiation, atmospheric absorption, aerosols
Climate modelling: modelling assumptions, input data, results, sensitivity to assumptions and input data.
Carbon cycle: transfer processes, carbon capture and storage (sequestration)
Climate reconstruction: historical evidence for climate change, measurement techniques
Possible scenarii: influence of different processes, climate evolution
Impact of climate change: Meteorological, agricultural, economic, and political
Geo-engineering: the different techniques envisaged, reversibility, risks, consequences, practical difficulties
The MOD 2.2 (DAO) provides complemntary notions to this MOD.

Learning outcomes

◇ At the end of this course, the student will understand the notion of climate and the processes which create it.
◇ Students will be able to evaluate critically the available evidence concerning climate change
◇ Students will understand the basis and the principles of climate modelling, the hypotheses used, and the data that are required
◇ Students will be aware of the likely physical, political and economic consequences of climate change

Affiliated Masters

Science of the Ocean, Atmosphere and Climate (SOAC)

Core texts

SALTZMAN, B. *Dynamical Paleoclimatology*. Academic Press, 2002.
BURROUGHS, W.J. *Climate Change A Multidisciplinary Approach*. Cambridge University Press, 2007.
COWIE, J. *Climate Change Biological and Human Aspects*. Cambridge University Press, 2009.

Assessment

Exam (50%) Reports on the 3 design class exercises (50%)

AF MOD 6.6

Dynamique des systèmes biologiques humains

Dynamics of biological human systems

Lecturers: Didier DRAGNA

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

Objectives

The human body is an extraordinary complex dynamic system, whose physical modeling is essentialy multidisciplinary. A large number of regulatory process aim at constantly monitoring the internal environement of the body, what is referred to as the homeostasis. In this course, physical modeling of human biologogical systems are presented. Some current applications in bioengineering (artificial heart, medical robotics and imaging) are introduced.

Keywords:

Programme

1. Modeling of biological human systems
1.1 Mechanical models:
- the neuro-musculoskeletal system
strength of materials, rigid and flexible multibody systems, biomaterials.
- auditory system
fluid mechanics, acoustics.
1.2 Multiphysics models:
- cardiovascular system
heart mechanics, circulation, network analysis, articial heart.
2. Medical robotics
3. Medical imaging
inverse problems, non-destructive testing, ultrasounds, X-rays, MRI.

Independent study

1. Simulation of the motion with a multibody model
2. Signal processing for an electrocardiogram
3. Oral presentation and report on a research article.

Core texts

D. A. Neumann. *Kinesiology of the musculoskeletal system. Foundations for physical rehabilitation*. McGraw-Hill, 2002.

L. Waite. *Biofluid mechanics in cardiovascular systems*. McGraw-Hill, 2006.

C. Guy et D. Ffytche. *Introduction to the principles of medical imaging*. Imperial College Press, 2005.

AF MOD 7.1

Systèmes d'information en entreprise

Enterprise Information Systems

Lecturers: Romain VUILLEMOT

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

Objectives

Information systems are essential in modern organizations as they implement the organizational processes of the organization and allow the circulation of information. The good health of organizations, from global groups to small businesses, is increasingly dependent on the performance of their information systems. It is therefore crucial for engineers and future managers to understand the functioning and organization of information systems even if they do not work directly there.

Keywords: Information systems, processes, urbanization, service-oriented architecture, big data, analytics, KPI, cloud computing, enterprise data management, CRM, ERP.

Programme

Chapter 1: Introduction
Chapter 2: Technical architectures and major constituents of the IS in business
Chapter 3: Projects, Costs and Standards of an IS
Chapter 4: Service Oriented Architecture, Cloud Computing and Big Data
Chapter 5: KPIs and Piloting an IS
Chapter 6: Trends and Impact of Big Data and AI in IT

Learning outcomes

◇ Définir et mettre en oeuvre des outils de mesures (KPI) de performances de SI
◇ Utilisation d'un ERP et cas d'utilisation concrêts

Independent study

Study offices around a problem of urbanization of the information system.
Drafting of a briefing note on a topic of choice, linked to information systems (e.g. sustainable development, etc.)

Core texts

Christophe Longépé. *Le projet d'urbanisation du SI*. Lavoisier, 2009.

Yves Caseaut, Gérard Roucairol. *Urbanisation, SOA et BPM : Le point de vue d'un DSI*. Broché, 2008.

Jacques Printz, Yves Caseau. *Architecture logicielle : Concevoir des applications simples, sûres et adaptables*. Dunod, 2009.

Assessment

Knowledge assessment through examination (60%) and know-how through evaluation of the briefing note (40%)

AF MOD 7.2

Extraction de Connaissances

Machine Learning and Data Mining

Lecturers: Alexandre SAIDI

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

Objectives

Keywords:

Core texts

U.M. Fayyad & al. *From Data Mining to Knowledge Discovery in Databases*. Editor1, 1996.
Stan Matwin & al. *Challenges in Computational Statistics and Data Mining*. Jan Mielniczuk, 2016.
I.H. Witten, E. Frank. *Data Mining - practical ML Tools & Techniques*. Editor3, 2005.

AF MOD 7.3

Acoustic sources and propagation

Acoustic sources and sound propagation

Lecturers: Vincent Clair, Didier Dragna, Gilles Robert

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

Objectives

This advanced course of acoustics is focused on sources of sound and their propagation. The basics of acoustics, such as the linear acoustic equations and the quantitative evaluation of sound, are briefly presented before going further into the description of sources and their radiation in bounded or unbounded spaces. The sound radiated by vibrating structures and the acoustic propagation in inhomogeneous media are also discussed. The objective of the course is to provide the theoretical background required to approach a complex problem of sound generation and/or radiation. This course also provides a basis for students who might be interested in more specialised sub-domains of acoustics.

Keywords: Acoustics, sound waves, acoustic sources, acoustic radiation, duct acoustics, sound induced by vibrating structures, propagation in inhomogeneous media.

Programme

I – Equations of linear acoustics (wave equation, acoustic energy, harmonic waves)
II – Plane and spherical waves, Boundary conditions, Surface impedance
III – Acoustic levels and spectral analysis (Decibels, power spectral density, weightings)
IV – Acoustic propagation in ducts (duct modes, cut-off frequency, low frequency models)
V – Sources (elementary sources, Green's function, source distribution)
VI – Radiation from vibrating structures (boundary integral equation, Rayleigh integral)
VII – Acoustic propagation in inhomogeneous media (geometrical and paraxial approximations)
VIII – Further elaborations (thermo-viscous absorption, diffraction by rigid bodies)

Learning outcomes

◇ Understanding of sound generation and radiation in classical configurations.
◇ Modelling and resolution of an acoustics problem.
◇ Communicating with experts in acoustics.
◇ Acquiring a theoretical basis to approach a specialized domain of acoustics.

Independent study

Two practical work sessions: 1) Measurement of the acoustic power of a source in anechoic and reverberant rooms. 2) Duct propagation near a sudden change of section.
A small class on source localisation with an industrial partner (MicrodB).

Affiliated Masters

Master of Science in Acoustics

Core texts

A. D. Pierce. *Acoustics: an introduction to its physical principles and applications*. The Acoustical Society of America, 1989.

L. E. Kinsler et al.. *Fundamentals of acoustics*. John Wiley & Sons, 1982.

D.T. Blackstock. *Fundamentals of physical acoustics*. John Wiley & Sons, 2000.

Assessment

Knowledge: written exam of individual knowledge (50%)
Know-how: evaluation of the practical activities (50%)

AF MOD 7.4

Dynamique des structures

Structural dynamics

Lecturers: Olivier DESSOMBZ, Louis JEZEQUEL

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

Objectives

Dynamic analysis of structures using modal synthesis and finite elements methods has found a large number of industrial applications (aeronautics, automotive, shipbuilding, railway, civil engineering). The main aim of this course is to present these methods in a general framework by conducting in parallel and in interaction a numerical approach and an experimental approach based on vibratory tests. The correction of models and the influence of damping are also discussed.

Keywords: Finite elements - modeling - numerical methods - numerical modal analysis - substructuring - modal synthesis - damping

Programme

PART 1: MODELS FINISHED ELEMENTS
- Introduction
- Finite element discretization
- Modification of the global matrix formulation
- Standard Conservative Problems
- Spectral problem
- Temporal integration of the transient problem
- Case of rotating machines

PART 2: OPTIMIZATION OF DYNAMIC BEHAVIOR
- Origin of dissipation
- Modeling of damping
- Introduction of damping materials
- Identification of damping matrices
- Modal synthesis
- Perturbation of dynamic models
- Link to design processes

Learning outcomes

◇ Modeling a Finite Element Structure
◇ Use a general purpose finite element industrial calculation code
◇ Understanding the Fundamentals of Finite Element Methods

Independent study

Practical activities: 2 lab of 4h (experimental) + 4h design classes on software

Affiliated Masters

Mechanical Engineering

Core texts

J.-F. IMBERT. *Analyse des structures par éléments finis (3ème ed)*. Cepadues, 1995.
M. GERARDIN, D. RIXEN. *Théorie des vibrations*. Masson, 1996.
L. MEIROVITCH. *Computational methods in structural dynamics*. Sijthoff Nordhoff, 1980.

Assessment

50% Knowedge (Exam)
50% know-how (TP1 1/4, TP2 1/4, BE 1/2)

AF MOD 7.5

Bruits d'origine aérodynamique

Aerodynamically generated sound

Lecturers: Michel ROGER

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

Objectives

Keywords:

Core texts

GOLDSTEIN. *Aeroacoustics*. McGraw-Hill, 1976.

AF MOD 7.6

Caractérisation des surfaces et des nanostructures

Characterization of surfaces and nanostructures

Lecturers: Fabrice DASSENOY, Maria-Isabel DE BARROS

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

Objectives

Nanotechnologies are concerned with a very divided state of matter and an exacerbated role of the surfaces compared to the volume. The physicochemistry and the chemistry of the exposed surfaces are very important for applications. The first atomic layers present on the solids are particularly reactive in many processes.
This course proposes the study of the main techniques of characterization of surfaces and of low dimensionality structures. It will be illustrated by specific applications in the field of nanotechnology and biology.

Keywords: Surfaces, Interfaces, Nanostructures, Surface analyses, microscopy, Electron spectroscopies

Programme

I - Chemical analysis of the surface of solids.
Electron spectroscopies (photoelectron, Auger), ion spectroscopy (ToF-SIMS)
Information on surface chemical bonds.
II- Morphological analysis of the surface at a subnanometric scale
Near-field microscopies (Tunneling microscopy, Atomic Force Microscopy, near-field optical microscopy) tunneling spectroscopy, measurement of interaction forces. Illustrations: (reconstruction of surfaces, single molecule, photonic crystals ...)
III - Characterization of interfaces
Analytical Transmission Electron Microscopy, electron diffraction, X-ray analysis and electron energy loss spectroscopy. Examples of applications (thin layers, colloids ...)

Learning outcomes

◇ To know how to refer to good characterization techniques for the study and analysis of surfaces and nanostructures
◇ To know the basic principle of the main techniques of characterization of surfaces and nanostructures

Core texts

R. W. Cahn. *Materials science and technology : a comprehensive treatment*. VCH, 1994.

Assessment

2h test

AF MOD 8.1

Interactions fluide-structure

Fluid-Structure Interactions

Lecturers: Mohammed ICHCHOU, Gilles ROBERT

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

Objectives

This lecture provides an insight into fluid-structures interactions problems encountered in many engineering cases. Precisely, two main objectives are drawn. The first objective of the lecture is to provides a relevant method to formulate a coupling problem between a fluid and a solid. The second considered objective is a presentation of several mechanisms in a step by step process to allow better understanding of phenomenons and their modeling. The nature of the fluid and the solid lead to different situation of academic and industrial interest as well.

Keywords: Fluid-structure coupling, compressible fluid, incompressible fluid, added mass, coupled modes, radiation effects, coincidence, wall pressure

Programme

I- fluide-structure coupling classification
II- Modeling and main mechanisms
III- Inertai couplaging and elastic coupling
IV- Dissipative couplaging dissipatif, radiation
V- radiation of simple structures (unbounded and bounded)
VI- Numerical modeling in the non converctive case,.
VII- Fluide-structure coupling with convection.

Learning outcomes

◇ classify fluid-structure problems
◇ modeling of a variety of fluid-structure situations
◇ numericaly solve few fluid-structures problems
◇ characterisation of wall pressure

Independent study

Practical tests (experiments) and numerical excercices through a FEM code

Affiliated Masters

Acoustics
Aeronautics and Space
Mechanical Engineering

Core texts

H. J.-P. Morand & R. Ohayon. *Fluid-Structure Interaction*. Wiley, 1995.
E. de Langre. *Fluides et solides*. Editions de l'Ecole Polytechnique, 2002.

AF MOD 8.2

Processus Stochastiques : modèles et méthodes numériques

Stochastic Processes

Lecturers: Christophette BLANCHET, Elisabeth MIRONESCU

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

Objectives

This course deals with modelisation using time continous processes. The goal is to present both theoritical and pratical aspects on Markov processes. It is more specifically for students of Mathematic, Actuarial and quantitative finance options and Masters. It is requiered to have followed a course on theory of probability (for example the course in S8 in Ecole Centrale de Lyon)

Keywords: Brownian Motion, Martingales, Ito calculus, Numerical simulations, Monte Carlo Markov chain methods

Programme

0. Probability theory (Reminders)
1. Stochastic processes, Brownian Motion
2. Martingales
3. Stochastic integral
4. Stochastic differential equations
5. Diffusion approximation
6. (BE) Methods of Monte Carlo Markov Chains and sampling.

Learning outcomes

◇ Modelisation with time-continous Markov processes
◇ Ito calculus
◇ Approximation of a diffusion. Practical aspects
◇ Gibbs algorithme or annealing method; Practical aspects

Independent study

Preparatory works on BE's problems

Affiliated Masters

Option MD-MIR (advisable for an advanced program in applied mathematics)
Master Econométrie et Statistiques Parcours GRAF (Mandatory)
Master Mathématiques Appliquées, Statistique, Parcours Math en Actions (Mandatory).

Core texts

Francis Comets et Thierry Meyre. *Calcul stochastique et modèles de diffusions.*. Série Mathématiques pour le Master/SMAI, Dunod, 2006.

Nicole El Karoui et Emmanuel Gobet. *:Les outils stochastiques des marchés financiers*. Editions de l'Ecole Polytechnique 2011., 2011.

Bernard Bercu et Djalil Chafaï. *Modélisation stochastique et simulation.*. Série Mathématiques pour le Master/SMAI, Dunod, 2007.

Assessment

All : a two-hour examination.
Master Math en action et GRAF : one more one-hour examination

AF MOD 8.3

Hydraulique Fluviale

River Hydraulics

Lecturers: Richard PERKINS, Pierre BRUN

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

Objectives

Since the dawn of civilization, mankind has exploited rivers as a resource to meet certain needs – for drinking water, for irrigation, transport and energy, for example – but also as a way of disposing of industrial and domestic waste. Consequently, mankind is obliged to coexist with rivers, in close proximity, and has had to learn to adapt to the natural variations that occur in the life of a river. The aim of this course is to provide students with an introduction to the different aspects of hydraulic engineering, through the development of simple models for the basic physical processes that occur in a free-surface flow. The two design classes and the lab class will enable students to put into practice some aspects of the material covered in the lectures.

Keywords: River, free surface, waves, floods, dams, sediment transport, erosion, specific energy, subcritical flow, supercritical flow, hydraulic jump, specific force, Chézy, Manning, Strickler, Froude, Shields

Programme

Introduction: hydrological cycle, river systems
Uniform flow in open channels: critical depth, specific energy, specific force, the hydraulic jump.
Gradually varied flow: flow resistance, uniform flow and the normal depth, flow regimes, surface profiles
Unsteady flows in open channels: rapidly-varied flow, slowly varying flow, the method of characteristics, dam break flows, flood routing
Hydraulic structures
Sediment transport: movement of solid particles, bed forms – ripples, dunes and antidunes, erosion threshold, bed load and suspended load transport, cohesive sediments (muds).

Learning outcomes

◇ At the end of this course, students will be able to identify the flow regime, based on the depth and the flow rate.
◇ Students will be able to calculate the response of a free surface flow to a change in channel cross-section
◇ Students will be able to calculate the propagation of a wave caused by a change in flow rate or water level.
◇ Students will be able to assess the stability of the banks of a channel.

Independent study

Examples sheets for each subject to apply the material covered in the lectures
1 lab class and 2 design classes, covering aspects of the course in greater depth

Affiliated Masters

Mécanique

Core texts

CHANSON, H. *The Hydraulics of Open Channel Flow: an Introduction*. Elsevier, 2004.

VIOLLET, P.-L., CHABARD, J.-P, ESPOSITO, P & LAURE. *Mécanique des Fluides Appliquée*. Presses de l'ENPC, 1999.

RAUDKIVI, A.J. *Loose Boundary Hydraulics*. Balkema, 1998.

Assessment

Knowledge: Exam on the material covered in the lectures (60%) Skills: Lab report (40%)

AF MOD 8.4

Représentation et manipulation de données structurées

Representation and manipulation of structured data

Lecturers: Daniel MULLER

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

Objectives

Keywords:

Core texts

E. R. Harold, W. Scott Means. *XML in a Nutshell*. 3rd Edition - O'Reilly, 2004.

E. van der Vlist. *XML Schema, the W3C's Object-Oriented Descriptions for XML*. O'Reilly, 2002.

J. E. Simpson. *XPath and XPointer, Locating Content in XML Documents*. O'Reilly, 2002.

AF MOD 8.5

Physique pour les technologies de l'information

Physics for Information technology

Lecturers: Ségolène CALLARD

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

Objectives

In information technology, functionnalities of data trasnsmission, data processing, storage and display are ensured by devices which operations rely on fundamental physics (quantum mechanics, electronics, material science, optics, magnetism). The goal of this course is to review the underlying physical principles at stake in current technology. Indeed, though technoloies and devices may evolve rapidly, the basics physics remains the same. A focus will be also made on the physical limitations of each technology.

Keywords: Q-bit, photon quantum cryptography, logical device, semiconductor, transisto, optical fiber, optical modulation, magnetic memories.

Programme

Chapter 1: General introduction/ information properties, quantum mechanics
Chapter 2: Quantum cryptography and teleportation
Chapter 3: Basic devices for logical circuit
Chapter 4: New electronic devices
Chapter 5: optical fiber
Chapter 6: Photorefractive materials
Chapter 7: Fundamental of magnetism
Chapitre 8: Magnetic memories

Learning outcomes

◇ Acquire a global vision in the field of information technology
◇ Identify the physical principles used in a technology
◇ Gather up ones knowledge and know-how to understand a device operation.
◇ Know the physical limits of a given technology

Independent study

Deepen ones knowledge on a perculiar technology.
Oral restitution.

Core texts

Rainer Waser (Ed.). *Nanoelectronics and information technology*. Wiley (Germany), 2012.
Saleh, Teich. *Fundamentals of photonics*. Wiley-Interscience, 2007.
Charles Kittel. *Introduction to Solid State Physics*. Wiley, 2005.

Assessment

2h exam without documentation (50%), oral presentation (30%), Reports on practical activities (20%)

AF MOD 8.6

Energie Nucléaire

Nuclear Energy

Lecturers: Yves ROBACH, Ségolène CALLARD

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

Objectives

Nuclear energy represents a great technological and economic area, covering multidisciplinary skills and various jobs (project management, engineering,safety, ...). This module, that favours an industrial approach aims to give students both scientific and technical training in the various fields of nuclear energy. A wide part will be devoted to the study of current nuclear power reactors. This course will also provide an overview of the solutions to answer nuclear safety and people protection.

Keywords: Nuclear reactors, nuclear power plants, nuclear safety.

Programme

Basis of nuclear physics.
Basis of neutronics.
Reactor kinetics.
Current nuclear reactor plants: Operation and control.
Nuclear safety.
Fuel cycle.
Materials for nuclear engineering.

Learning outcomes

◇ To understand the scientific, economic and environmental issues of nuclear power.
◇ To understand the specificities of nuclear industry.
◇ To set nuclear energy regard to other energies

Core texts

Jacques LIGOU. *Introduction au génie nucléaire*. Presses polytechniques et universitaires romandes, 1997.

John R. LAMARSH. *Introduction to nuclear engineering*. Addison Wesley Publishing company, 2013.

Paul BONCHE. *Le nucléaire expliqué par des physiciens*. EDP Sciences, 2002.

Assessment

Final written exam (2 hours).
Tutorials evaluation.

AF MOD 9.1

Parcours Intrapreneur 1

Intrapreneurial coaching 1

Lecturers: Marie Goyon, Sébastien Poussielgue

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

Objectives

Keywords:

Learning outcomes

◇ communication, pitch
◇ prototyper

Core texts

Brown Tim. *L'Esprit design: Comment le design thinking change l'entreprise et la stratégie*. Pearson, 2014.

AKRICH M., CALLON M. et LATOUR B. *A quoi tient le succès des innovations?, Gérer et comprendre*. Annales des Mines, 1988.

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

AF MOD 9.2

Mécanique des matériaux et structures composites

Mechanics of Composite Materials and Structures

Lecturers: Michelle SALVIA, Olivier BAREILLE, Mohammed ICHCHOU

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

Objectives

The aim of this course is the modelling of composite materials and structures which are classically considered in several sectors (aeronautic, naval and automotive industries among others). The focus is mainly on metallic/composite mechanical behaviour positioning. The lecture will provide key aspects connected to physical as well as modelling abilities of anisotropic and composite materials and structures. Both linear and non-linear mechanical responses of these materials is studied. For instance phenomena which are involved in composite carbon-epoxy parts are also investigated. This course aims to provide the basic knowledge and understanding of the mechanics of composite materials in order to permit their efficient use in design applications.

Keywords: anisotropic materials, laminate theory, sandwich, homogenization, dynamic behaviour, damage and Failure

Programme

Material and microstructure (2 hours)
Material symmetry (2 hours)
Engineering elastic constants (2 hours)
Laminate theory (2 hours)
Sandwich theories (2 hours)
Multi-scale methods : homogenization (2 hours)
Dynamical behavior (2 hours)
Failure criteria (2 hours)

Learning outcomes

◇ composites types - composites behaviour - dynamics of composites
◇ homogenisation - failure modes

Independent study

Analysis of a scientific recent paper

Affiliated Masters

Aeronautics and Space

Core texts

Carl T. Herakovich. *Mechanics of Fibrous Composites*. John Wiley & Sons, 2004.
J.N. Reddy. *Mechanics of laminated composite plates*. CRC Press, 1997.
D Gay, S V Hoa, S W Tsai. *Composite Materials: Design And Applications*. CRC Press, 2003.

AF MOD 9.3

Stabilité des Systèmes Mécaniques

Stability of mechanical systems

Lecturers: Louis JEZEQUEL, Jean-Jacques SINOU

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

Objectives

When designing structures and mechanical systems, it is imperative to control the risks of instability arising from many phenomena. Mention may in particular be made of the various couplings of a non-conservative nature related to the existence of friction or of contact between a moving elastic structure and a fluid or a solid. Moreover, the phenomena of buckling and blistering are increasingly dimensioning given the lightening of the structures associated with the use of new materials. In the fields of transport, civil engineering and energy, we can cite: brake noise, resistance to crashes, instabilities of rotating machines, risk of building collapse, stability of drilling systems. ...

Keywords: Stability, brake squeezing, fluid-structure, rotating machines, aeroelastic coupling, hydro-elastic coupling

Programme

I. General stability analysis
II. Buckling of elastic structures
III. Non-conservative elastic structures
IV. Stability of gyroscopic systems
V. Application to friction structures
VI. Applications to structures coupled with flow

Learning outcomes

◇ Develop a synthetic vision of the risks of instabilities of mechanical systems in the design phase.
◇ Learn about computational tools to predict risks of instability.
◇ Understand the coupling phenomena at the origin of the instabilities.

Independent study

Learning and deepening part of the course.
Bibliographic analysis and reflection on a problem of application.

Affiliated Masters

Mechanical Engeeniring

Core texts

Wanda Szemplinska-Stupnicka. *The behavior of Nonlinear Vibrating systems Vol. 1. Fundamental concepts and methods : applications to single-Degree of freedom Systems*.

Robert D. Blevins. *Flow-Induced vibration*.

Roland Bigret. *Stabilité des machines tournantes et des systèmes*.

Assessment

Final Exam, Design Classes

AF MOD 9.4

Comportement des matériaux

Material behaviour

Lecturers: Thierry HOC, Vincent FRIDRICI, Laurent BLANC, Bruno BERTHEL

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

Objectives

Keywords:

Core texts

J. Lemaître, J.-L. Chaboche, A. Benallal, R. Desmo. *Mécanique des matériaux solides*. Ed. Dunod.

D. François, A. Pineau, A. Zaoui.. *Comportement mécanique des matériaux : volumes 1 et 2*. Ed. Lavoisier.

AF MOD 9.5

Réseaux informatiques

Computer networks

Lecturers: René CHALON

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

Objectives

This course is presenting main concepts and protocols of computer networks. Design features and architectures of local area networks, medium and high speed networks as well as Internet protocols are systematically and methodically detailled. This conceptual and practical approach enables each one to better understand the current supply, the evolution and the prospect of present and future computers networks.

Keywords: networks, ISO model, Ethernet, Internet, IP, Wi-Fi, TCP, UDP, DNS, HTTP

Programme

Lecture :
1- Introduction: main concepts, ISO model ans TCP/IP architecture
2- Physical layer: physical medium and data transmission
3- Local Area Network: topology, Ethernet, Wi-Fi
4- Network layer: internet principles, IP protocol, addressing, routing, IPv6
5- Transport layer: TCP, UDP, SCTP
6- Application layer: client/server model, DNS, e-mail, FTP, World Wide Web

Labs:
1- Detailed study of Ethernet with a netwok simulator
2- Detailed study of IP with a netwok simulator
3- Study of HTTP protocol

Learning outcomes

◇ To know computer networks concepts
◇ To analyse and design Ethernet local aera networks
◇ To analyse and design TCP/IP based networks

Independent study

Every student gets a personal licence of the network simulator for making the labs and designing his/her own network architectures

Affiliated Masters

Computer Science

Core texts

G. Pujolle et al.. *Les réseaux*. Eyrolles, 2018.
D. Comer. *Internetworking with TCP/IP - Volume 1, Principles, Protocols and Architecture*. Pearson, 2015.
C. Servin. *Réseaux et Télécoms*. Dunod, 2013.

Assessment

50% knowledge: 2 hours written exam without documents
50% know-how: mean of lab marks (1/3 each)

AF MOD 9.6

Méthodes numériques pour les EDP

Numerical methods for PDEs

Lecturers: Grégory VIAL, Laurent SEPPECHER

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

Objectives

We will present the most common methods to approximate solutions to partial differential equations. Rather than giving an exhaustive list of the most efficient methods used in industrial codes, we will describe the mathematical foundations for the setting and the analysis of the principal methods. Some of them will be implemented with Matlab.

Keywords: Numerical methods. Scientific computing. Partial differential equations.

Programme

Chapter 1. Basics on the theory of linear PDEs, and finite difference methods.
Chapter 2. Finite element methods for elliptic problems
Chapter 3. Numerical approximation for scalar conservation laws

Learning outcomes

◇ To identify the nature of a PDE and the main difficulties for its numerical approximation
◇ To learn the main categories of numerical methods
◇ To identify the behavior of the methods and their limitations
◇ To be able to implement the main methods for simple problems

Independent study

Implementation of numerical methods on simple but typical examples

Affiliated Masters

"Maths in action"
"Finance and insurance"

Core texts

A. Ern, J.-L. Guermond. *Éléments finis : théorie, applications, mise en œuvre. Mathématiques et applications*. Springer, 2002.

B. Després, F. Dubois. *Systèmes hyperboliques de lois de conservation : Application à la dynamique des gaz.*. École Polytechnique, 2005.

Assessment

Knowledge (60%) : 2H exam
Practicals (40%) : matlab implementation

AF MOD 10.2

Parcours Intrapreneur 2

Intrapreneurial coaching 2

Lecturers: Marie Goyon, Sébastien Poussielgue

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

Objectives

Keywords:

Learning outcomes

◇ planification de projet
◇ communication de projet / pitch
◇ prototypage

Core texts

AKRICH M., CALLON M. ET LATOUR B. *À quoi tient le succès des innovations ?*

BROWN T., *L'Esprit design: Comment le design thinking change l'entreprise et la stratégie.* Pearson Education, 2014.

CROZIER M. ET FRIEDBERG E., *L'Acteur et le Système*.

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

AF MOD 10.3

Le système électrique

Electric Power System

Lecturers: Eric VIGNON

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

Objectives

The electric power system is a major infrastructure of the modern countries. The deregulation of this sector during these last years has deeply modified its management in a large number of country in particular in Europe.
Thus the objective of the course is on one hand to give the technical bases allowing to understand the operation of the electric system and on the other hand to present the organization of this one through the roles and the relations between the different actors: producers, transmission system operators, energy balance responsible and consumers.

Keywords: power generation, power transmission, transmission system operator, consumption-generation balance, short and long term planning

Programme

Introduction: the electric system in the global energy context
Generation/consumption balance
Voltage planning
The different actors of the electric system; their roles et their relations in the context of market dergulation
Network planning
Analyse of some system failures: blackout...
How does an energy stock exchange works ?

Learning outcomes

◇ To know the constraints and the technical or economic advantages of a large electric system
◇ To differentiate the role of the various actors of the electric system
◇ To define the actions allowing the management of the electric system
◇ To interpret and explain some evolutions observed on a network

Independent study

Analyse of transmissions cases - load-flow
Visit of the dispatching in Lyon (if possible. This installation is a restricted area one- this visit cann't be done during the last academic year)
Simulation of an energy stock exchange

Affiliated Masters

EEEA: Electronique, Energie Electrique, Automatique
Electronic, Electric Energy, Control

Core texts

P. Bastard et al. *Voyage au coeur du sytème*. Eyrolles, 1999.
Persoz et al. *Planification des réseaux électriques*. Eyrolles, 1984.

Assessment

knowledge 70%
know-how 30%

AF MOD 10.4

MOD Parcours Entrepreneur 1

Entrepreneurial coaching

Lecturers: Sylvie MIRA BONNARDEL

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

Objectives

Coaching for students working on their startup in order to help them understand customer's needs, define the value proposition, identify revenue streams and design the detailed business model.
Conferences of experts (law, business angels, ...)

Keywords: Business model, value proposition, start up

Programme

Coaching on the start up project based on adapted topics such as law, intellectual property, finance, pitch...

Learning outcomes

◇ Be able to identify market opportunities
◇ Be able to build the differenciate value proposition
◇ Be able to design a detailled business model canvas
◇ Be able to pitch the project

Independent study

Work on the start up project

Core texts

Osterwalder A., Pigneur Y. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. Willey, 2010.

Ries E. *The Lean Startup: How Constant Innovation Creates Radically Successful Businesses*. Penguin, 2011.

Masterson AK. *Business Model Generation: The Blueprints Every Entrepreneur in Every Industry Needs Today to Achieve Maximum Profits*. CreateSpace Independent Publishing Platform, 2014.

Assessment

Pitch in the middle and at the end of the course

AF MOD 10.5

Ingénierie d'un objet de grande consommation

Engineering of a mass consumption object

Lecturers: Jose PENUELAS, Charles-Edmond BICHOT

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

Objectives

The objective is to show to students who have not previously studied scientific studies the importance of engineering science and techniques for a known object: the CD. This course is an opportunity to introduce the multidisciplinary approach specific to the engineer by using the concepts and tools of physics, materials science, computer science, signal processing and automation Which coexist in the design and realization of a CD.

Keywords: Engineering, Material science, Physics, Signal processing, Computer science, Automation, Design science

Programme

1 - Overview
2 - Physics: the laser
3 - Material science applied to the CD
4 - The Fundamentals of Informatics
5 - Representation of Information
6 - Design
7 - Signal processing: from analog to digital
8 - Automatic control: the basic principles of control

Learning outcomes

◇ Understand the multidisciplinary nature of everyday objects design
◇ To learn fundamentals in the disciplines involved

Core texts

T. Goussard. *Java 8, les fondamentaux du langage Java avec exercices et corrigés*. ENI.

Assessment

Depending of the experimental work (that includes design, physics & computer science = 1/3), and the final exam (without document = 2/3)

AF MOD 11.3

MOD Parcours Entrepreneur 2

Entrepreneurial coaching

Lecturers: Sylvie MIRA BONNARDEL

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

Objectives

Coaching for students working on their startup in order to help them to understand customer's needs, define the value proposition, identify revenue streams and design the detailed business model.
Conferences of experts (law, business angels, ...)

Keywords: Business model, value proposition, start up

Programme

Coaching on the start up project based on adapted topics such as law, intellectual property, finance, pitch...

Learning outcomes

◇ Be able to identify market opportunities
◇ Be able to build the differenciate value proposition
◇ Be able to design a detailled business model canvas
◇ Be able to pitch the project

Independent study

Work on the start up project

Core texts

Osterwalder A., Pigneur Y. *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*. Willey, 2010.

Ries E. *The Lean Startup: How Constant Innovation Creates Radically Successful Businesses*. Penguin, 2011.

Masterson AK. *Business Model Generation: The Blueprints Every Entrepreneur in Every Industry Needs Today to Achieve Maximum Profits*. CreateSpace Independent Publishing Platform, 2014.

Assessment

Pitch in the middle and at the end of the course

AF MOD 11.4

Méthodes variationnelles pour les EDP

Variational methods for PDEs

Lecturers: Martine MARION

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

Objectives

Variational methods, also called energy methods, are a major tool in the study of partial differential equations (PDEs) for linear and nonlinear problems. They rely on estimates of the solutions in well chosen functional spaces and the use of powerful methods borrowed from the theory of functional analysis.
The aim of this course is twofold :
- to study the tools in analysis underlying these methods
- to apply them to the study of stationary PDEs (elliptic problems) as well as unsteady problems.

Various problems borrowed from mathematical physics will be investigated.
Perequisites : it is recommended to have some background on Functional Analysis (at the level of the S8 course on this topic)

Keywords: Partial differential equations, weak solutions, linear and non linear problems, variational methods

Programme

Chapter 1: Sobolev spaces
- elements of distribution theory
- trace and density theorems

Chapter 2: Linear elliptic problems
- Variational methods
- Eigenvalues problems

Chapter 3: Nonlinear elliptic problems
- Weak topology
- Galerkin method

Chapter 4: Parabolic problems
- Vector valued functions
- Variational formulation of a model problem

Learning outcomes

◇ To learn the analysis tools at the basis of the study of PDEs
◇ To be able to apply them to actual problems

Affiliated Masters

Master program "Maths in Action"

Core texts

H. Brézis. *Analyse fonctionnelle*. Dunod, 2005.

L. Evans. *Partial Differential Equations*. AMS, 1998.

J.-L. Lions. *Quelques méthodes de résolution des problèmes aux limites non linéaires*. Dunod et Gauthier-Villars, 1969.

Assessment

Knowledge (70%) : 2H exam
BE (30%)

AF MOD OUV

Ouverture socio-économique et culturelle

Socio-economic and cultural outreach

Lecturers: Florence MILON

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

Objectives

Learning about the specific features of "the French engineer" and of the French corporate culture. Understanding and developing cross-cultural communication. Helping with the integration of foreign 3rd-year students.

Keywords: cultural awareness, cultural difference, cross-cultural communication, integration, communication, relations, French corporate culture

Programme	Foreign students (18 hours + forum) EML students (12hours + forum + 3 conferences) Theoretical approach to cross-cultural communication. Viewing cross-cultural films, multinational workshops on cultural topics. Analysing foreign-student integration (first contacts, problems faced...) through questionaires, finding possible solutions. Surveys with French engineers. Meetings with a French engineer posted overseas and a French-based foreign engineer. Assisting with end-of-studies internship search (CV, cover letter, interview simulation) Organising an international evening (discovering various cuisines)
Learning outcomes	◇ Oral and written communication skills ◇ cultural and cross-cultural competences
Independent study	Cross-national pairwork (preparing the survey, writing a discovery report on a topic related to the professional field of choice)
Core texts	M. SAUQUET, M. VIELAJUS. *L'intelligence interculturelle, 15 thèmes à exploiter pour travailler au contact d'autres cultures*. Charles Léopold Mayer, 2014.
Assessment	CV, cover letter, interview (foreign students only), oral presentation of survey, discovery report.

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