Optional Courses

ACOUSTIQUE MUSICALE

MUSICAL ACOUSTICS

Lecturers: Michel ROGER, Marc JACOB, Sébastien OLLIVIER

| Lecturers : 18 | TC : 6 | PW : 0.0 | Autonomy : 4 | Study : 4 | Project : 0.0 | Language : MI

Objectives

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

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

Programme

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

Learning outcomes

- Have a basic knowledge of musical acoustics
- Analyse musical sound signals
- Understand the basics of sound generation mechanisms and the modelling approaches

Independent study

Objectifs : Study of a scientific problem related to music or sound design (measurements, data analysis, sound synthesis, or psychoacoustic tests).
Subjects can be related to the instruments played by the students.

Méhodes : 3 TD, 1 BE (modelling, simulations, experiment, synthesis, listening tests)

Core texts

A. Chaigne et J. Kergomard, *ACOUSTIQUE DES INSTRUMENTS DE MUSIQUE*, Belin, 2008
N.H. Fletcher and T. Rossing *THE PHYSICS OF MUSICAL INSTRUMENTS*, Springer, 2008
M. Castallengo*ECOUTE MUSICALE ET ACOUSTIQUE*, Eyrolles, 2015

Assessment

Note = N1 (50%) knowledge + N2 (50%) know-how
- N1: Written exam
- N2 : Case study (BE) Report

ALGORITHME ET RAISONNEMENT

ALGORITHMS FOR REASONING

Lecturers: Alexandre SAIDI, Emmanuel DELLANDREA

| Lecturers : 6.0 | TC : 0.0 | PW : 0.0 | Autonomy : 10.0 | Study : 16.0 | Project : 0.0 | Language : FR

Objectives

Keywords :

Programme

Learning outcomes

Independent study

Objectifs :

Méhodes :

Core texts

Russell, S. et Norvig, P. Artificial Intelligence: A Modern Approach. Prentice Hall, 3e ed. 2016
Frédéric Benhamou and Alain Colmerauer. Constraint Logic Programming. MIT Press, 2008.
David L., Mackworth Alan K.. Artificial Intelligence: Foundations of Computational. Cambridge U. Pre

Assessment

ALGORITHMES COLLABORATIFS ET APPLICATIONS

COLLABORATIVE ALGORITHMS AND APPLICATIONS

Lecturers: Philippe MICHEL, Alexandre SAIDI

| Lecturers : 8.0 | TC : 16.0 | PW : 8.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

The aim of this course is to model and solve certain complex problems using so-called “collaborative” algorithms. These have the peculiarities of taking an example from nature (genetic algorithms, ant colonies, ..., neural networks) and of using the collective experience of "individuals" (agents) with weak capacities to make one. collective intelligence.
For example, neural networks seek to mimic the brain's ability to solve a problem by using the multitude of neurons (each with poor resolving capacity) that make it up.
The applications dealt with in progress are varied: character recognition, detection of outlines (in an image),

Keywords : multi-agents, robotics, genetic algorithms, ant colonies, neural networks, slam

Programme

Learning outcomes

- computer implementation of the proposed algorithms multi-agent modeling of complex problems

Independent study

Objectifs :

Méhodes :

Core texts

Simon Haykin. , *NEURAL NETWORKS: A COMPREHENSIVE FOUNDATION*, MacMillan Publishing Company,, 1994
Sebastian Thrun *PROBABILISTIC ROBOTICS (INTELLIGENT ROBOTICS AND AUTONOMOUS AGENTS SERIES)*, The MIT Press, 2005
Marco Dorigo*ANT COLONY OPTIMIZATION*, A Bradford Book, 2004

Assessment

> Final mark = 50% Knowledge + 50% Know-how
> Knowledge = final exam
> Know-how = continuous assessment

ANALYSE FONCTIONNELLE : THÉORIE ET APPLICATIONS

FUNCTIONAL ANALYSIS : THEORY AND APPLICATIONS

Lecturers: Martine MARION

| Lecturers : 18.0 | TC : 14.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

For a long time been the study of partial differential equations (PDE) has consisted in the explicit resolution of very few equations. The developments in the theory of Functional Analysis have allowed to investigate much more general problems. This course has two objectives :
- to study functional spaces involved in the study of PDEs
- to investigate linear and nonlinear PDEs

Keywords : Functional analysis, partial differential equations, optimization

Programme

Part I - Linear problems
Chapter 1 : Sobolev spaces
Chapter 2 : Study of linear elliptic problems
Part II - Non linear problems
Chapter 3 : Weak topology
Chapter 4 : Minimization in infinite dimension and application to PDEs

Learning outcomes

- to understand and use the basic functional spaces involved in the study of PDEs
- to understand ans use different méthods to investigate PDEs

Independent study

Objectifs :

Méhodes :

Core texts

H. Brezis, *ANALYSE FONCTIONNELLE*, Dunod, 2005
G. Allaire *ANALYSE NUMÉRIQUE ET OPTIMISATION*, Editions de l'Ecole Polytechnique, 2009

Assessment

Final mark = 80% Knowledge + 20% Know-how
Knowledge N1 = 100% final exam
Know-how N2 =100% f continuous assessment

ANALYSER ET OBSERVER LA MATIÈRE

OBSERVATION AND ANALYSIS OF MATERIALS

Lecturers: Fabrice DASSENOY, Magali PHANER GOUTORBE

| Lecturers : 24 | TC : 4 | PW : 4 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : AN

Objectives

The important progresses made in the field of "materials science" are strongly linked to the development of methods making possible the characterization of solid materials down to the microscale. Most of the analysis techniques are based on the interaction between probes (photon, electron, ion) and the matter.
We will alternate a basic teaching on the physical concepts on which the main characterisation techniques of materials are based and a description of the principle and applications of the most commonly used techniques (XPS photoelectron spectroscopy, X-Ray Diffraction, electron and near field microscopy (STM, AFM)).
The final objective is to give to the future engineer the keys to be able to choose the most appropriated

Keywords : Radiation / matter interaction, characterisation techniques of materials, XPS, RBS, XRD, IR, Electron microscopy

Programme

- Introduction: Classification of the different interaction processes
- Photon-matter interaction
- Energy levels and IR spectroscopy
- X-ray diffraction technique
- XPS and IR techniques
- Ion / matter interaction
- RBS and SIMS techniques
- Electron / matter interaction
- Electron microscopy techniques (TEM / SEM)

Learning outcomes

- To know the principles of materials characterization techniques.
- To know the information provided by these different characterisation techniques
- To Know how to choose a characterisation technique according to the industrial problem

Independent study

Objectifs : The objective of this autonomous work is to identify, from the results (spectra, diffractograms, images) obtained from various characterization techniques, the nature of the material at the origin of these structural, morphological and chemical information.

Méhodes : In groups of 5 or 6, students will have 2 hours (independent work) to interpret the spectra / diffractograms / images obtained from an unknown material. They will then have to present their results during a 15-minute oral presentation and make a proposal for the material at the origin of these

Core texts

M. Ammou, *MICROCARACTÉRISATION DES SOLIDES*, CRAM CNRS, 1989
D. Brune *SURFACE CHARACTERIZATION*, Wiley-VCH, 1997
R.W. Cahn*MATERIALS SCIENCE AND TECHNOLOGY*, VCH Weinheim, 1994

Assessment

2-hour test covering lessons and tutorials (with documents) + mark on the restitution of the autonomous work

AN INTRODUCTION TO METEOROLOGY AND OCEANOGRAPHY

AN INTRODUCTION TO METEOROLOGY AND OCEANOGRAPHY

Lecturers: Richard PERKINS, Pietro SALIZZONI

| Lecturers : 18.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 14.0 | Project : 0.0 | Language : AN

Objectives

The aim of this course is to provide a physical understanding of large-scale oceanic and atmospheric circulations, and the practical consequences of such systems. Large-scale movements are the result of the interaction between thermodynamic imbalances - driven by solar radiation - and the Earth's rotation. Therefore, these two processes are first studied before being combined to explain the functioning of large-scale meteorological and oceanic systems. The problem of climate change will also be discussed.

Keywords : Oceanography, meteorology, currents, waves, tides, solar radiation, Coriolis, Ekman, Froude, Rossby, Sverdrup, Taylor

Programme

1. Introduction
The composition and the physico-chemical properties of the atmosphere and the ocean. The distribution of water over the surface of the earth.

2. Heat transfer in the atmosphere and the ocean
Solar radiation, radiative exchanges between earth and atmosphere; sensible heat transfer, stratification and stability

3. The effects of rotation

Learning outcomes

- Understand the different physical processes which drive motion in the atmosphere and ocean
- Be able to identify the different processes involved in the exchange of mass, momentum and heat between the ocean and the atmosphere
- Be able to estimate the importance of different physical processes through order-of-magnitude calculations
- Be able to explain the phenomena represented on a meteorological chart

Independent study

Objectifs :

Méhodes :

Core texts

Gill, Adrian, *ATMOSPHERE AND OCEAN DYNAMICS*, Academic Press, 1982
Pedlosky, Joseph *GEOPHYSICAL FLUID DYNAMICS.* , Springer Verlag, 1987
Pond, Stephen. & Pickard, George L.*INTRODUCTORY DYNAMICAL OCEANOGRAPHY*, Butterworth-Heinemann, 1983

Assessment

Knowledge 50% + Know-how 50%
Knowledge = 40% Final exam + 60% Continuous assessment
Know-how = 40% Final exam + 60% Continuous assessment

ANTENNES, SIGNAL ET PROCESSEURS

ANTENNA, SIGNAL AND PROCESSORS

Lecturers: Arnaud BREARD, Alberto BOSIO, Julien HUILLERY

| Lecturers : 16.0 | TC : 0.0 | PW : 10.0 | Autonomy : 4.0 | Study : 2.0 | Project : 0.0 | Language : FR

Objectives

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

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

Programme

I - Antennas :
a) Radiation physics
b) Parameters to size an antenna for a given problem: radiation pattern, directivity, gain, polarization, etc
II - Signal:
a) Radar processing: signal model, optimal receiver, detection, estimation
b) Information transmission: coding, digital modulations, channel equalization
III - Processors:
a) Architecture and design through generations of telecommunication networks

Learning outcomes

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

Independent study

Objectifs : 2 slots of 2 hours are left in autonomy for the finalization of the TP reports.

Méhodes :

Core texts

Constantine A. Balanis, *ANTENNA THEORY*, Wiley, 2005
François Le Chevalier *PRINCIPES DE TRAITEMENT DES SIGNAUX RADAR ET SONAR*, Masson, 1989
Manuel Jiménez, Rogelio Palomera, Isidoro Couvertier*INTRODUCTION TO EMBEDDED SYSTEMS*, Springer-Verlag, 2014

Assessment

Final mark = 50% knowledge + 50% know-how
Knowledge = 100% final exam
Know-how = 100% continuous assessment

APPLICATIONS WEB

WEB APPLICATIONS

Lecturers: **Daniel MULLER, René CHALON**

| Lecturers : 12 | TC : 4 | PW : 0.0 | Autonomy : 8 | Study : 8.0 | Project : 0.0 | Language : FR

Objectives

Many publishers develop Web technology applications, whether integrated into the Information System or stand-alone, offered in SAAS mode. The advantage lies in the ease of deployment and maintenance compared to a thick client, and the possibility of remote access compared to a dedicated application.
In another context, the multiplicity of mobile platforms makes it extremely expensive to develop native clients. Thanks to the maturation of standards related to HTML5, the choice of Web technology (WebApp) represents a transversal solution to this problem.
This course reviews the current state of Web standards and their implementation, and presents node.js a

Keywords : Webapp, HTML5, Javascript, nodejs

Programme

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

Learning outcomes

- Be able to develop a simple Web application in nodejs technology
- Have a transversal vision of the available technologies, and their limits, for the development of a Webapp

Independent study

Objectifs : To know how to carry out a project in Node.js using an HTML5 JavaScript API.

Méhodes : Project in pairs

Core texts

Stoyan Stefanov, *JAVASCRIPT PATTERNS - BUILD BETTER APPLICATIONS WITH CODING AND DESIGN PATTERNS*, O'Reilly Media, 2010
Peter Gasston *THE MODERN WEB : MULTI-DEVICE WEB DEVELOPMENT WITH HTML5, CSS3, AND JAVASCRIPT*, No Starch Press, 2013
Pedro Teixeira*PROFESSIONAL NODE.JS - BUILDING JAVASCRIPT-BASED SCALABLE SOFTWARE.*, Wiley / Wrox, 2012

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge N1 = 100% final exam
Know-how N2 = 100% continuous assessment (project deliverables)

CAPTEURS ET TRAITEMENT D'IMAGES

INTRODUCTION TO IMAGE SENSING AND PROCESSING

Lecturers: Mohsen ARDABILIAN, David NAVARRO

| Lecturers : 16.0 | TC : 0.0 | PW : 0.0 | Autonomy : 8.0 | Study : 8.0 | Project : 0.0 | Language : MI

Objectives

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

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

Programme

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

Learning outcomes

- At the end of this UE the student must be able to understand the process of the formation of digital images
- He will also be able to make use of fundamental techniques for improving and processing digital images

Independent study

Objectifs : The aim is to deepen and put into practice the concepts and techniques covered in the course.

Méhodes : lab work of exercices and resolution of concrete problems using Matlab

Core texts

Rafael C.Gonzalez, Richard E.Woods, *DIGITAL IMAGE PROCESSING*, Pearson Prentice Hall, 2008
Richard Szeliski *COMPUTER VISION: ALGORITHMS AND APPLICATIONS*, Springer, 2010
Dav id A. Forsyth, Jean Ponce*COMPUTER VISION : A MODERN APPROACH*, Prentice Hall, 2007

Assessment

Final mark = 30% knowledge + 70% know how
mark on knowledge = 100% written test
mark on know how = 50% lab work 1 + 50% lab work 2

CIRCUITS ET DISPOSITIFS EN MICRO-ONDES

CIRCUITS ET DISPOSITIFS EN MICRO-ONDES

Lecturers: Arnaud BREARD, Loris PACE

| Lecturers : 14.0 | TC : 4.0 | PW : 4.0 | Autonomy : 6.0 | Study : 4.0 | Project : 0.0 | Language : FR

Objectives

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

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

Programme

1) Microwave circuits
- Transmission lines, equation of the telegraphists, microstrip line, waveguide.
- Impedance matching, S Parameters.
- Passive circuits, filter design, directional couplers.

2) Electromagnetic devices in microwaves
- Resonant cavities, dielectric resonators.
- Antennas, radiation pattern, gain, antenna network, power transfer evaluation in telecommunications and radar

TP: complete study of a microwave: operation of the magnetron, waveguide, resonant

Learning outcomes

- Master the concepts and methods of adaptation of impedances allowing the optimization of the power transfer between two systems.
- Use S parameters : transmission and reflection between two systems.
- Dimension of a waveguide and a microstrip line
- Design a filter

Independent study

Objectifs : Know how to use a circuit simulation tool (ADS) and a 2.5D microwave electromagnetic simulation tool adapted to the printed circuit.
Study and dimension from a specification of the systems seen in progress as well as certain systems mentioned but not studied in detail, in particular the active systems: mixer, frequency doubler, ...

Méhodes : 1 BE of introduction to ADS software, the students are divided into 3 groups, each group working on a different subject.
6 hours are dedicated to this group work which has for deliverable a report and a presentation, the restitution must allow to share the additional courses to all

Core texts

D. Pozar., *MICROWAVE ENGINEERING*, Addison-Wesley, 1990

Assessment

Final mark = 50% knoledge + 50% know-how
Knoledge = 100% final examen
Know-how = 100% continuous assessment

COLLABORER ET MANAGER À L'ÈRE DU NUMÉRIQUE

LAW AND WORK

Lecturers: Jacqueline VACHERAND REVEL, Nicolas HOURCADE

| Lecturers : 32.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

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

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

Programme

The AF consists of 2 independent parts articulated around the same theme.
The courses of labor law propose one initiations into the legal stakes to acquire knowledge on the rules which organize the new individual relationships of the work and the professional relations in the company.
The courses of psychology and sociology of the work and the organizations approach the new stakes in the work and the new modalities of the collaboration within scattered working collectives and within their management with and via digital technologies (telecommuting, work in network, in team multi-localized by project).

Learning outcomes

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

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

Vacherand-Revel, J. et al. (dir), *NOUVELLES PRATIQUES DE TRAVAIL : INNOVATIONS TECHNOLOGIQUES, CHANGEMENTS ORGANISATIONNELS*, L'Harmattan, 2014
Vacherand-Revel, J. (dir) *NUMÉRO THÉMATIQUE DE LA REVUE PTO PORTANT SUR « LE TRAVAIL EN ÉQUIPE À L'ÈRE DE SA MÉDIATISATION NUMÉRIQUE : FIGURES ACTUELLES DE L'INNOVATION ORGANISATIONNELLE.*, Elsevier Edition, revue Psychologie du Travail et des Organisations. Vol 23 (2)., 2017

Assessment

Examination under the shape of questions of course

COMMUNICATION INTERPERSONNELLE ET PRATIQUES PROFESSIONNELLES

SOCIAL RELATIONSHIPS IN COMPANY

Lecturers: Jacqueline VACHERAND REVEL

| Lecturers : 32.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

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

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

Watzlawick, *LA RÉALITÉ DE LA RÉALITÉ : CONFUSION, DÉSINFORMATION, COMMUNICATION*, Seuil Points, 1978
Borxeix et Fraenkel *LANGAGE ET TRAVAIL. COMMUNICATION, COGNITION, ACTION.*, CNRS Éditions, 2001
Goffman*LA MISE EN SCÈNE DE LA VIE QUOTIDIENNE (TOME 1 : PRÉSENTATION DE SOI ET TOME 2 : RELATIONS EN PUBLIC).*, Editions de Minuit, 1973

Assessment

Examination under the shape of questions of course.

DES DÉCHETS ET DES HOMMES

MEN AND THEIR WASTE

Lecturers: **Romain SAUZET**

| Lecturers : 32.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

Identify the importance of a historical, economic, and socio-cultural approach to waste.
Think about human societies from what they reject, from their margins, and their landfills.
Study the impact of production and consumption patterns on the creation and treatment of waste.
Question the anthropological ambivalence of the status of waste (waste or resource?).
Understand the importance of waste recovery while developing a critical reflection on sustainable development.

Keywords : Garbage, Environment, Sustainable Development, Society, Overproduction, Waste, History.

Programme

The course will cover the following topics:
- Anthropological and historical perspectives
- The invention of urban waste in the 19th century
- Geography and economics of waste in the 20th century
- Garbage and pollution in the contemporary city
- The specificity of contemporary waste (plastics, electronic waste)

Learning outcomes

- Critically read press and academic articles in the humanities and social sciences, in French and in English
- Identify the social, environmental, economic, and political issues on the management of waste

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

Serge Latouche, *BON POUR LA CASSE - L'OBSOLESCENCE PROGRAMMÉE*, Les liens qui libèrent, 2015
Yannick Barthe *LE POUVOIR D'INDÉCISION. LA MISE EN POLITIQUE DES DÉCHETS NUCLÉAIRES*, Ed. Economica, 2010
Cyrille Harpet*DU DÉCHET : PHILOSOPHIE DES IMMONDICES*, L'Harmattan, 1999

Assessment

Grade = 100% knowledge
Grade Knowledge = 60% executive summary + 40% ongoing assessment

DESIGN OPTIMAL ET MÉCANIQUE DES FLUIDES NUMÉRIQUE

OPTIMAL DESIGN AND COMPUTATIONAL FLUID DYNAMICS

Lecturers: Christophe CORRE, Stéphane AUBERT

| Lecturers : 16.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 16.0 | Project : 0.0 | Language : AN

Objectives

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

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

Programme

1. Gradient-based optimization in CFD. Finite-difference estimate and adjoint approach. Extension to multi-objective problems. BE#1 & #2 : solution of model and engineering problems.
2. Gradient-free optimization. From direct search to metaheuristics. Ideal multi-objective optimization. BE#3, #4 &#5 : solution of model and engineering problems (heat exchanger, wind farm); start of the project.
3. Derivation of surrogate models for high-cost objectives. BE#6, #7 : solution of a shape optimization or a power maximization problem.
4. Key concepts of robust optimization. Uncertainty quantification and propagation

Learning outcomes

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

Independent study

Objectifs : Develop the ability to apply the optimization techniques described in the course and the ability to perform a critical analysis of the results obtained for an open engineering optimization problem.

Méhodes : Optimization project performed in an autonomous way by group of 2 students. Use of the tools (Matlab, specific codes) made available on the work stations of the computer rooms.

Core texts

K. Deb, *MULTI-OBJECTIVE OPTIMIZATION USING EVOLUTIONARY ALGORITHMS*, John Wiley & Sons, 2008
A. Forrester, A. Sobester *ENGINEERING DESIGN VIA SURROGATE MODELLING : A PRACTICAL GUIDE*, Wiley, 2008
P. Siarry*METAHEURISTIQUES*, Eyrolles, 2014

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge = 100% final exam
Know-how = 100% project

DU MICRO AU MACRO EN MÉCANIQUE

FROM MICRO TO MACRO IN SOLID AND FLUID MECHANICS

Lecturers: Alexandre DANESCU, Mathieu CREYSSELS

| Lecturers : 12.0 | TC : 12.0 | PW : 0.0 | Autonomy : 0.0 | Study : 8.0 | Project : 0.0 | Language : FR

Objectives

The objective of the course is to understand the laws of behaviour and the macroscopic models observed and studied in solid and fluid mechanics from a microscopic description of solids and fluids. The course will provide essential elements to integrate the fact that every body is made up of atoms or molecules interacting more or less strongly into the macroscopic laws of motion. The examples presented in tutorials will illustrate the application of the methods developed in the course. Examples include: carbon nanotubes, elasticity of metamaterials, design of auxetic materials, perfect gases and denser gases.

Keywords : - Discrete and continuum elasticity
- Homogenization theory
- Periodic media
- Voigt and Reuss bounds

Programme

1. Discrete to continuum elasticity : one-dimensional problems
2. Discrete-to-continuum elasticity : multi-dimensional problems
3. Inhomogeneous to effective constitutive relations : the scalar case (thermal diffusion)
4. Inhomogeneous to effective constitutive relations : the vectorial case (elasticity)
5. Case studied : negative Poisson ratio materials
6. Case studied : mechanical behaviour of single wall carbonne nanotubes (SWCNT)
7. Kinetic theory of gases
8. The fundamental Boltzmann equation and its practical applications.

Learning outcomes

- Understanding the interplay between microstructure geometry/physics and macroscopic mechanical behaviour.
- Simplification of complex physical problems
- Formulation/computation of effective constitutive behavior in elasticity
- Relating the microscopic properties of fluids to their macroscopic behaviour

Independent study

Objectifs : The classes are not concerned with framed autonomy activities

Méhodes :

Core texts

Assessment

Case studied results : 1/3 of the final mark
Written examination (2h) : 2/3 of the final mark

DYNAMIQUE DES ROTORS EN INGÉNIERIE MÉCANIQUE

ROTORS DYNAMIC IN MECHANICAL ENGINEERING

Lecturers: Laurent BLANC, Fabrice THOUVEREZ

| Lecturers : 12.0 | TC : 10.0 | PW : 0.0 | Autonomy : 6.0 | Study : 4.0 | Project : 0.0 | Language : AN

Objectives

The purpose is to acquire knowledge about rotating machines design. Application domains are turbojet engine dynamics, shaft dynamics, micropumps, electrical turbines... Notions seen in UE MSS and GM are extended: technological, modelling and experimental knowledge are given to nderstand dynamic aspects of products by Safran - Snecma, Safran - Turbomeca, GE, Siemens, Alstom Power, Rolls-Royce, EDF, Pratt&Whitney...

Keywords :

Programme

Lesson = exercices
- rotating machine design cycle, properties and tools
- modelling monshaft and multishaft rotors
- bladed disks modelling
- bearings phenomenology

Lab
- FE modelling of a bladed disk

Learning outcomes

- To know the key steps in rotating machines design
- To read a Campbell diagram
- To calculate by finite elements a rotating machine eigenmodes

Independent study

Objectifs : To get informed about rotating machines state of the art

Méhodes : Research paper analysis, by binom + presentation to the group

Core texts

M. Lalanne, G. Ferraris, *ROTORDYNAMICS PREDICTION IN ENGINEERING.*, John Wiley and Sons, 1998
D. W. Childs *TURBOMACHINERY ROTORDYNAMICS PHENOMENA, MODELLING AND ANALYSIS*, John Wiley and Sons, 1993
F. F. Ehrich*HANDBOOK OF ROTORDYNAMICS*, Krieger Publishing company, 1999

Assessment

Final exam, presentation on a research paper

ECOLOGIE ET ENVIRONNEMENT

ECOLOGY AND ENVIRONMENT

Lecturers: **Jean-Pierre CLOAREC**

| Lecturers : 16.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 16.0 | Project : 0.0 | Language : FR

Objectives

Keywords :

Programme

Learning outcomes

Independent study

Objectifs :

Méhodes :

Core texts

François Ramade, *ELÉMENTS D'ECOLOGIE : ECOLOGIE FONDAMENTALE.*, Dunod, 2005
François Ramade *ELEMENTS D'ECOLOGIE : ECOLOGIE APPLIQUÉE.*, Dunod, 2005
Meunier*AIDE-MÉMOIRE DE THERMODYNAMIQUE DE L'INGÉNIEUR : ENERGÉTIQUE - ENVIRONNEMENT*, Dunod, 2004

Assessment

ELABORATION DE PIÈCES TECHNIQUES

DEVELOPMENT OF TECHNICAL PRODUCTS

Lecturers: Denis MAZUYER, Bertrand HOUX

| Lecturers : 4.0 | TC : 0.0 | PW : 4.0 | Autonomy : 0.0 | Study : 4.0 | Project : 20.0 | Language : FR

Objectives

This course aims to study the interactions of materials, shapes and processes in the design and industrialization of technical objects. Based on real case studies, this module will address the manufacturing processes of plastic and metallic materials, the strategies to a material (functional criteria and implementation) and a process (economic and technical criteria) as well as the definition of a shape (functional criteria, process and material). We will focus in processes involving transformations of matter: injection, extrusion, thermoforming for polymers, etc., plastic deformations for metals, the addition of 3D matter in additive manufacturing on metallic materials and plastics.

Keywords : Shaping processes, Plastics, Injection, extrusion, thermoforming. Metallic materials, Plastic deformation, Stamping, Additive Manufacturing

Programme

I. Injection of plastics
- Design and sizing,
- Definition and choice of tools,
- Simulation, implementation and configuration of the injection process.

II. Additive manufacturing and 3D printing
- Main design principles in additive manufacturing
- Topological and mechanical optimizations
- Numerical and experimental simulation of additive manufacturing processes

Learning outcomes

- Be able to choose a shaping process
- Understand the key points of plastic injection process and be able to design a part mechanical object with injected matter
- Be able to design a stamped metal mechanical object
- To be able to design a metallic mechanical object by additive manufacturing

Independent study

Objectifs : 5 sessions of 4 hours will be carried out by working on a project (including 1 session devoted to oral presentation of the project).

Méhodes : The teaching will be based on an adaptation of the problem-based learning method allowing a concrete enlightening of these processes from real case studies and scenarios.

Core texts

J.-F. Agassant, P. Avenas, J.-P. Sergent, B. Vergnes, M. Vincent, *LA MISE EN FORME DES MATIÈRES PLASTIQUES - 3ÈME ÉDITION*, Lavoisier, 1996

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge = 100 % final exam
Know-how = 100% continuous assessment

ENTREPRENDRE ET INNOVER

ENTREPRENEURSHIP AND INNOVATION

Lecturers: **Thierry FARGERE, Patrick SERRAFERO**

| Lecturers : 32.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

Entrepreneurship and innovation are now part of the critical business skills - creating value - of the modern engineer, whether they are :

- in an internal context of the established company, in the form of intrapreneurship and creation of new activity,
- in a context external to the established company, in the form of entrepreneurship and the creation of a start-up.

Keywords : Entrepreneurship, Intrapreneurship, Innovation, Value Creation - SUSI: Start-Up / Innovative System

Programme

- Lectures on entrepreneurship and innovation management
- Tutorials on the formalization of the profession of a new activity,
- Tutorials on the formalization of critical and innovative business processes,
- Interventions of external experts in entrepreneurship and innovation,
- Final delivery review of a start-up project.

Learning outcomes

- Design a new Business Model
- Formalize the profession of a new activity / company
- Set up an innovative value offer
- Formalize the critical and innovative business processes necessary to create value

Independent study

Objectifs : Carry out the exercise "Bring your own SUSI - Start-up / Innovative System" as a team

Méhodes : - Writing of the business model and business knowledge of your SUSI.
- Practice of the appropriate methods and concepts presented in class.

Core texts

Osterwal der A., Pigneur Y.., *BUSINESS MODEL NOUVELLE GÉNÉRATION : UN GUIDE POUR VISIONNAIRES, RÉVOLUTIONNAIRES ET CHALLENGERS*, Pearson, 2011
Bla nco S., Le Loarne-Lemaire S. *MANAGEMENT DE L'INNOVATION*, Pearson, 2012
Kalousis G., Léger- Jarniou C.*CONSTRUIRE SON BUSINESS PLAN*, Dunod, 2014

Assessment

- Presentation of the "Business Model SUSI"
- Entrepreneurial file on the SUSIpedia Knowledge Box.

EOLIENNES

WIND TURBINES

Lecturers: Eric VAGNON, Pierre DUQUESNE

| Lecturers : 10.0 | TC : 10.0 | PW : 4.0 | Autonomy : 6.0 | Study : 2.0 | Project : 0.0 | Language : FR

Objectives

While the electrical energy production is more and more diversified, the energy from wind is a rising solution. Projects of new plants are numerous. These projects include wide offshore farms as well as low power plants in rural environment or in places where the grid is not present. Wind energy is then a important industrial issue and presents many employment perspectives.
The objective of this course is to present the technologies that are used to convert wind energy into electrical energy. The addressed issues deal with fluid mechanics, electrical engineering and power electronics. The presented technologies are related to power plants from a few kW to several MW. Also the special features of

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

Programme

- Possible energy recover from wind energy
- Blade aerodynamics
- Aerodynamics interactions: installation and site effects
- Wind turbine electrical engineering
- Power conversion configurations for plants non connected to the grid, connected to the grid offshore
- Synchronous generator and dedicated power electronics
- Maximum Power Point Tracking

Practical works : (4h), Synchronous generator in variable speed operation and power

Learning outcomes

- Describe wind turbine parts and their role.
- Explain physical principles used in the conversion from wind energy to mechanical energy and from mechanical energy ort electrical energy.

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

Bin Wu et al., *POWER CONVERSION AND CONTROL OF WIND ENERGY SYSTEMS.*, Wiley, 2011
Olimpo Anaya-Lara. *WIND ENERGY GENERATION - MODELING AND CONTROL*, Wiley, 2009

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge = 100% final exam
Know-how = 100% continuous assessment

FILTRAGE ADAPTATIF : APPLICATION AU CONTRÔLE ACTIF DE BRUIT

ADAPTIVE FILTERING : APPLICATION TO ACTIVE NOISE CONTROL

Lecturers: Laurent BAKO, Alberto BOSIO, Marc JACOB, Marie Annick GALLAND

| Lecturers : 12.0 | TC : 6.0 | PW : 8.0 | Autonomy : 6.0 | Study : 0.0 | Project : 0.0 | Language : MI

Objectives

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

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : To design an active control system in all its dimensions : acoustic diagnosis, algorithm choice, performance, DSP implementation

Méhodes : Project by group of 5 students followed by an oral presentation. The work is based on experimental data and on Matlab and Simulink programs to be adapted. Each group has to propose a reasoned solution and to analyze the results.

Core texts

Simon Haykin, *ADAPTIVE FILTER THEORY*, Prentice Hall, 2013
Phil Lapsle y, Jeff Bier, Amit Shoham, E.A. Lee *SP PROCESSOR FUNDAMENTALS: ARCHITECTURES AND FEATURES* , Wiley-Press, 1997

Assessment

Final mark = 33% Knowledge + 67 % Know-How, with
Knowledge = 100% Exam
Know-How = 100% Continuous assessment

FINANCE DE MARCHÉ

MARKET FINANCE

Lecturers: Christian DE PERETTI

| Lecturers : 16.0 | TC : 12.0 | PW : 0.0 | Autonomy : 4.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

The objective of this course is to provide a summary of the knowledge needed to practice capital markets and derivatives finance.
This module will also facilitate the follow up of some IM financial options in the 3rd year and of the Master SAFIR (Actuarial and Financial Sciences and Risk Engineering).
The course will develop the basics of asset and derivative valuation and management.

Keywords : asset valuation, portfolio management, financial derivatives.

Programme

- Part I: Introduction to Capital Market Finance
  - o Chap. 1 : The Value of Time
  - o Chap. 2 : The Money Market
  - o Chap. 3 : Bonds
  - o Chap. 4 : Equities
  - o Chap. 5 : Derivatives
  - o Chap. 6 : Ethics in Finance, Virtuous Funds, "Vice" Funds

- Part II : Managing Equity-Bond Portfolios

Learning outcomes

- Methodological skills for finance professionals.

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

Edwin J. Elton, Martin J. Gruber, Stephen J. Brown, William N. Goetzmann, *MODERN PORTFOLIO THEORY AND INVESTMENT ANALYSIS*, Wiley, 2014
J.C. Hull *OPTIONS, FUTURES, AND OTHER DERIVATIVES*, Times Books, 2011
M.W. Baxter and A.J.O. Rennie*FINANCIAL CALCULUS*, Cambridge University Press, 1996

Assessment

- A one-hour written intermediate exam (during class time) halfway through the course.
- Final written examination of two hours in the form of exercises.
- Participation bonus

FINANCE D'ENTREPRISE

COST MANANGEMENT AND ENTREPRENEURIAL FINANCE

Lecturers: **Sylvie MIRA**

| Lecturers : 32.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

Learn to establish a financial diagnosis from a company's accounting documents
Learn to design a financing plan
Learn to evaluate a company

Keywords : Financial analysis
Cash flow statment
Company's value

Programme

From accounting records to financial records
Evaluation of profitability and return on equity
Cash flow statment
Financial diagnosis
Business valuation

Learning outcomes

- Know how to establish a financial diagnosis
- Know how to evaluate a company's working capital
- Know how to design the cash flow statment
- Know how to calculate a company's value

Independent study

Objectifs : Apply knowledge to real cases

Méhodes : Financial case studies
Financial decision making with a business game

Core texts

MARION A, *ANALYSE FINANCIÈRE CONCEPTS ET MÉTHODES*, Dunod, 2015
VERNIMMEN P., QUIRY P., LE FUR Y. *FINANCE D'ENTREPRISE*, Dalloz, 2020
LEGROS G.*L'ÉVALUATION DES ENTREPRISES - MÉTHODES ET ÉTUDES DE CAS*, Dunod, 2015

Assessment

Case studies

GEOGRAPHICAL INFORMATION SYSTEMS

GEOGRAPHICAL INFORMATION SYSTEMS

Lecturers: Ariane EMMANUELLI, René CHALON

| Lecturers : 7 | TC : 0.0 | PW : 0.0 | Autonomy : 4 | Study : 21 | Project : 0.0 | Language : AN

Objectives

With this course, the objective is to get familiar with Geographical information systems (GIS) and to understand and use their fundamental tools, as well as the possibilities GIS offer and their limits. For this, the open-source software QGIS will be used, and real data from various sources representative of the transverse nature of these tools will be analysed, with particular emphasis on the environment.
This course is shared with: Master SOAC (M1); Master RisE / Water & Wind engineering (M1).

Keywords : GIS, data, visualisation, QGIS

Programme

1. What is a GIS ? / Getting started with QGIS /. Graphic semiology and styles / Map types
2. OpenStreetMap / Where to find data ?
3. Attribute tables / Symbols
4. Creating a layer / Georeferencing
5. Data selection / Joining attributes / Geoprocessing
6.. Data collection using a smartphone

Each lecture will be applied straight away in the form of a tutorial.

Learning outcomes

- Finding relevant data
- Presentation of data on a map with good use of semiology
- Proficiency in QGIS
- Being able to use GIS for various topics

Independent study

Objectifs : Group project : presenting and synthetising a study

Méhodes : The last slot is reserved for project presentations, while the penultimate one is an autonomy slot. The latter aims at giving the students time to finalise their projects as well as to have discussions and self-evalutations between groups.

Core texts

QGIS project, *QGIS USER GUIDE*, url : https://docs.qgis.org/3.22/en/docs/user_manual/, 2022

Assessment

The students are marked based on their group project, with 60 % of the mark for a report and 40 % for the presentation.

INGÉNIÉRIE DES PROCÉDÉS INDUSTRIELS

PROCESS ENGINEERING

Lecturers: **Jean-Pierre CLOAREC, Eric BLANCO**

| Lecturers : 20.0 | TC : 0.0 | PW : 0.0 | Autonomy : 8.0 | Study : 4.0 | Project : 0.0 | Language : FR

Objectives

Keywords :

Programme

Learning outcomes

Independent study

Objectifs :

Méhodes :

Core texts

R. PERRIN, JP SCAIARFF, *CHIMIE INDUSTRIELLE 1 ET 2 (2ÈME ÉDITION).*, Dunod, 2002
JP. CORRIOU *COMMANDE DES PROCÉDÉS (3ÈME ÉDITION)*, Tec &Doc Lavoisier, 2012

Assessment

INGÉNIERIE ET SYSTÈMES HAUTE TENSION

HIGH VOLTAGE ENGINEERING AND SYSTEMS

Lecturers: Ayyoub ZOUAGHI, N'Gnui Thomas AKA

| Lecturers : 10 | TC : 6 | PW : 4 | Autonomy : 4 | Study : 8 | Project : 0.0 | Language : FR

Objectives

The development of the futur energy network is conditioned by the mastery of the major technical problems related to the transmission of increasingly large quantities of electrical energy to consumption centers which may be located thousands of kilometers away. The main way to increase the power to be transported and reduce losses is to increase the transmission voltage. This increase in voltage depends on the insulation systems of the components used and their resistance to various constraints, particularly electrical. The objective of this course is to provide the necessary bases for understanding the dielectric breakdown of materials under high voltage stresses, and the rules for the dimensioning of more reliable systems.

Keywords : High voltage ; dielectric materials ; plasma and discharge ; space charge ; partial discharge ; breakdown ; HVDC network

Programme

1. HVAC and HVDC energy networks and components ; new constraints and challenges of futur electrical networks ; environmental impact of materials.
2. Dielectric materials: Polarization, conduction, relaxation, losses.
3. Plasma and gas discharges: From micro-discharge to lightning.
4. Dielectric strength of solid and liquid materials: Breakdown ; partial discharge ; aging ; new materials.
5. Design of high voltage components (transformers, gas insulaed switchgear, cables...).

Learning outcomes

- Understand the technological and environmental challenges related to high voltage grids.
- Understand the consequences of strong electric fields on materials and systems.
- Get the necessary tools for the conception of reliable energy grid components.

Independent study

Objectifs : Make the right choice of materials for a given system.
Practical work : Corona effect in HVDC lines; surface discharges ; breakdown voltage measurement, protection against lightning.
Study and design : Numerical simulation of the electric field using Comsol Multiphysics; simulation of partial discharges under Matlab/Simulink.

Méhodes : Bibliographic study and / or realization of projects by groups of students.
Preparation of the oral presentation.
Construction of visual supports and associated explanations.

Core texts

P. Robert, *MATÉRIAUX DE L'ELECTROTECHNIQUE, VOLUME II, TRAITÉ D'ELECTRICITÉ, D'ELECTRONIQUE ET D'ELECTROTECHNIQUE, EPFL* , 2007
A. Küchler, *HIGH VOLTAGE ENGINEERING, FONDAMENTALS, TECHNOLOGY, APPLICATIONS* , 1996
R. Fournié, R. Coelho,*DIÉLECTRIQUES – BASES THÉORIQUES*, Techniques de l'Ingénieur, 2003

Assessment

Final mark = 50 % Knowledge + 50 % Know-how
Knowledge = 100 % Final exam. Know-how = 100 Continuous assessment

INGÉNIERIE NUCLÉAIRE

NUCLEAR ENGINEERING

Lecturers: Anne-Segolene CALLARD, Anne LAMIRAND, Bertrand VILQUIN

| Lecturers : 20 | TC : 12 | PW : 0.0 | Autonomy : 2.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

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

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : During the tutorials, students must resolve some exercises, using the concepts developed during the lessons.

Méhodes : This work is done by a group of 2 persons and is evaluated by a reporting at the end of each session.

Core texts

W.E. Meyerhof, *ELEMENTS DE PHYSIQUE NUCLÉAIRE*, Editions Dunod., 1970
Daniel Blanc *NOYAUX, PARTICULES, RÉACTEURS NUCLÉAIRES*, Masson, 1987
P. Bonche*LE NUCLÉAIRE EXPLIQUÉ PAR LES PHYSICIENS*, EDP Sciences, 2002

Assessment

Final mark =60% Knowledge + 40% Know-how
Knowledge =100% final exam
Know-How= 100% continuous assessment

INGÉNIERIE POUR LA SANTÉ

HEALTH ENGINEERING

Lecturers: Emmanuelle LAURENCEAU, Romain RIEGER

| Lecturers : 20 | TC : 0.0 | PW : 0.0 | Autonomy : 4 | Study : 8.0 | Project : 0.0 | Language : FR

Objectives

The aging of the population and the great advances in biology in recent years are opening up new avenues in terms of care and responses to societal expectations. In these advances, engineering problems take an increasingly important place (Development of diagnostic devices, production of drugs, miniaturization of devices, Biomaterials, Tissue engineering). The objective of the course is to show the potentiality of approaches coupling engineering and biology.

Keywords : Nanobiotechnology, biomaterials, biomechanics, sensors

Programme

- Biotechnologies for health and molecular diagnostics
- Imaging and drug delivery
- The challenges of orthopedics and biomaterials
- Cellular activity and bone adaptation

Learning outcomes

- - Know the different technologies - Understand the different fields of engineering for health - Analyze scientific documents - Summarize information and present results

Independent study

Objectifs :
- Group work of 3-4 students on a mini-project relating to one of the topics covered in class

Méhodes :
- Document research and analysis, report writing, preparation of the oral presentation

Core texts

Assessment

Knowledge = 100% oral presentation
Know-how = 100% written report
Final mark= 50% knowledge + 50% know-how

INTRODUCTION AUX VIBRATIONS ALÉATOIRES

INTRODUCTION TO RANDOM VIBRATIONS

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

| Lecturers : 12.0 | TC : 8.0 | PW : 8.0 | Autonomy : 0.0 | Study : 4.0 | Project : 0.0 | Language : AN

Objectives

Many mechanical engineering problems concern the vibratory response of mechanical structures subjected to random forces. Examples include slender structures excited by wind, offshore platforms excited by wave action, road-excited vehicles, buildings subjected to earthquakes, frictional noise induced by roughness, aircraft fuselages excited by a turbulent boundary layer, etc. The objective of this course is to provide the student with elements of random vibrations. We will introduce the concepts of random signals and their spectral properties and provide methods for estimating the probabilistic

Keywords : Vibration, linear systems, stochastic process, spectral properties

Programme

Chapter 1 Stochastic processes
Generalities of probability, random variable, random vector, stochastic process, spectral analysis, continuity, derivation, integration
Chapter 2 Vibrations in small deformations
1 degree of freedom oscillator, n degree of freedom systems, deformable solids
Chapter 3 Spectral Response of Linear Systems
Presentation of the problem, average, correlation and spectrum of the response, correlation and spectrum between excitation and response
Chapter 4 Threshold and Maximum Probability

Learning outcomes

- Know how to calculate and interpret the power spectral densities of random signals
- Know how to calculate the frequency response functions of simple mechanical systems
- Know how to estimate the spectral quantities of the responses of linear systems excited by random signals

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

A. LE BOT, *INTRODUCTION AUX VIBRATIONS ALÉATOIRES.* , DUNOD, 2019
A. LE BOT *FOUNDATION OF STATISTICAL ENERGY ANALYSIS IN VIBROACOUSTICS.* , Oxford University Press, 2015
G. FLEURY*ANALYSE SPECTRALE - MÉTHODES NON-PARAMÉTRIQUES ET PARAMÉTRIQUES.* , Ellipses,, 2001

Assessment

How to do (practical activities) : 50%
Initial knowledge (final test) : 50 %

LES ENJEUX DE LA TRANSITION ÉCOLOGIQUE

SOCIAL, ECONOMICAL AND POLITICAL ISSUES FOR A SUSTAINABLE DEVELOPMENT

Lecturers: Laure FLANDRIN, Romain SAUZET

| Lecturers : 24.0 | TC : 0.0 | PW : 0.0 | Autonomy : 8.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

From the study of a specific theme (in this case, the ecological transition), this course offers students the opportunity to apply and deepen the methods and modes of reasoning of the human and social sciences apprehended. in the basic modules of semester 7. Teachings, bibliographic and documentary research in social and human sciences allow students to learn to prepare a summary and, more broadly, to develop their general culture and critical thinking.

Keywords : Philosophy, Politic, Economy, Justice, Green growth, Indicators of wealth, inequalities.

Programme

This module aims to understand the challenges of ecological transition. In the 1970s, the observation of a crisis in growth models and a depletion of resources due to human activities call into question the objectives set up in the post-war period. This crisis of values brings out the question of development as a choice, at the level of international organizations, countries, companies, and individuals - consumers or development actors. It is about understanding the foundations of ecological transition; its political, social, and economic translation; the tools that are put in place to implement it at the level of individuals, companies, countries, international organizations.

Learning outcomes

- Apply the methods of the human sciences to understand a social issue.
- Knowing how to prepare a summary
- Develop your general culture
- Train your critical mind

Independent study

Objectifs :

Méhodes :

Core texts

Afeissa, Hicham-Stéphane. Ethique de l'environnement. Nature, Valeur, Respect . Vrin, 2007.
Larrère, Catherine. Les philosophies de l'environnement . PUF, 1997.
Callon, Michel, Lacousmes P., Barthe Y. Agir dans un monde incertain. Seuil, 2001.

Assessment

Grade = 100% knowledge
Grade Knowledge = 60% final exam + 40% ongoing assessment

LES MÉTAMATÉRIAUX MÉCANIQUES

MECHANICAL METAMATERIALS

Lecturers: Manuel COLLET, Olivier BAREILLE

| Lecturers : 6 | TC : 6 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 20 | Language : MI

Objectives

Metamaterials appears as artificial materials incorporating an internal structuring allowing them to adopt unparalleled wave behavior at the large scale. In the case of acoustics, they give rise to very important applications in engineering fields as sound insulation, vibroacoustics, stealth in underwater acoustics, the realization of more efficient transducers.
Today, associated technologies present a very important development potential and already arouse the interest of many industries.
The main objective of this course is to give general training to the students of Ecole Centrale de Lyon on the

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

Programme

1. Waves flow: basis

2. Modelization
a) Analytical and semi-analytique SAFE
b) WFE : Wave Finite Elements
c) Shift Cell Operator for coupled and damped problem
d) ExpansionPWE

3. Structural design based on Bragg and resonnant band gap :

Learning outcomes

- Understanding of physical behavior of metamaterials
- Use of associated design numerical methodolgy
- know-how to use them on specfic classical problem through a mini-project

Independent study

Objectifs : Apply to a concrete case the methods introduced in the course covering the entire field of knowledge while promoting creativity in design choices

Méhodes : The used pedagogical method is based on the realization of mini projects of 14 hours in groups of 6 students. Each group will benefit from 8 hours of supervision for precising the problem and proposing methodologies. A final restitution of the results will be made in front of all the class.

Core texts

Assessment

1/3 by using a QCM
1/3 coming from project evaluation
1/3 made by the class evaluation of the final restitution

MACHINE LEARNING ET APPLICATIONS

MACHINE LEARNING ET APPLICATIONS

Lecturers: Yohann DE CASTRO, Céline HARTWEG-HELBERT

| Lecturers : 24 | TC : 0.0 | PW : 0.0 | Autonomy : 2.0 | Study : 6 | Project : 0.0 | Language : MI

Objectives

Keywords :

Programme

Learning outcomes

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

Christophe Giraud, *INTRODUCTION TO HIGH-DIMENSIONAL STATISTICS*, CRC Press
Massih-Reza, A. *APPRENTISSAGE MACHINE: DE LA THÉORIE À LA PRATIQUE-CONCEPTS FONDAMENTAUX EN MACHINE LEARNING.*, Editions Eyrolles (2015)
Shai Shalev-Shwartz and Shai Ben-David*UNDERSTANDING MACHINE LEARNING - FROM THEORY TO ALGORITHMS*, Cambridge University Press

Assessment

MARKETING

MARKETING

Lecturers: Sylvie MIRA, ELISABETH COUZINEAU-ZEGWAARD

| Lecturers : 32.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

Understand marketing.
Understand how to implement a marketing approach

Keywords : Market study.
Customers behavior.
BtoB marketing.
Marketing and social networks

Programme

Marketing methods and tools
Market research
BtoB marketing
E-marketing
Marketing strategy

Learning outcomes

- Be able to carry out a market study.
- Be abble to design customers personas
- Be able to design a marketing strategy

Independent study

Objectifs : Conduct marketing studies

Méhodes : Case studies

Core texts

FERRANDI Jean-Marc, LICHTLE Marie-Christine, AMBROISE Louise, COTTET Fabrice, *MARKETING*, Dunod, 2021
TRUPHEME Stéphane, GASTAUD Philippe *LA BOÎTE À OUTILS DU MARKETING DIGITAL*, Dunod, 2020

Assessment

Case studies

MATÉRIAUX POLYMÈRES : PROPRIÉTÉS PHYSIQUES ET INNOVATIONS

POLYMER MATERIALS : PHYSICAL PROPERTIES AND INNOVATIONS

Lecturers: Frédéric DUBREUIL

| Lecturers : 12.0 | TC : 12.0 | PW : 4.0 | Autonomy : 4.0 | Study : 0.0 | Project : 0.0 | Language : AN

Objectives

Functional materials, for construction or design, polymer materials also have the possibility of being recycled. Understanding their physical properties as well as better control of their implementation (by 3D printing for example) and their recyclability is the subject of much research.
The physico-chemical and mechanical properties are approached in this course, which also presents concrete cases of innovation in this field. Emphasis will be placed on the life cycle of materials, from implementation to sorting and then recycling. Societal impact of polymers on the environment will be achieved through group work and the production of a

Keywords : thermoplastics, thermosets, elastomers, polysaccharides, proteins, surfaces, synthesis

Programme

General presentation of polymers,
Synthesis of polymers, Characterization and properties of the polymer chain,
Review of major classes of polymers (thermoplastics, thermosets, elastomers)
Physical properties of polymers,
The glass transition temperature and other characteristic temperatures,
Flow and rheology of polymers,
Shaping and recycling,
Natural polymer materials and major fields of application,
Wood and natural fibers, starch, Proteins

Learning outcomes

- Establish correlations between the physical-chemistry of polymers and their macroscopic properties Knowledge of the mechanical properties of polymers Know how to select a polymer analysis method Choice for given application the polymer, its treatment and its implementation

Independent study

Objectifs : Analysis of the impact of polymers on the environment
Comparison between the media image of polymers and scientific reality: confrontation of figures and phenomena

Méhodes : Development of a problem related to the theme
Creation of a poster for a group of 4 students
Restitution during a poster session in front of a large audience: scientific, non-scientific

Core texts

Jean-Louis Halary, Francoise Lauprêtre, Lucien Monnerie, *DE LA MACROMOLÉCULE AU MATÉRIAU POLYMÈRE : SYNTHÈSE ET PROPRIÉTÉS DES CHAÎNES*, Belin, 2006
Jean-Louis Halary, Francoise Lauprêtre, Lucien Monnerie *MÉCANIQUE DES MATÉRIAUX POLYMÈRES*, Belin, 2008
Jo Perez*MATÉRIAUX NON CRISTALLINS ET SCIENCE DU DÉSORDRE*, PPUR, 2001

Assessment

Written exam 2h
Pratical Report
Restitution of autonomy

MATHÉMATIQUES APPLIQUÉES À LA BIOLOGIE

MATHEMATICAL BIOLOGY

Lecturers: Philippe MICHEL, Laurent SEPPECHER

| Lecturers : 16.0 | TC : 8.0 | PW : 0.0 | Autonomy : 0.0 | Study : 8.0 | Project : 0.0 | Language : FR

Objectives

The course is an introduction to mathematical methods in biology and medicine. It will be illustrated by numerous examples and applications.
The course has two parts:
I - Dynamic systems
II - Spatio-temporal models

Keywords : Mathematics for biology, ordinary differential equations, partial differential equations, population dynamics, Markov chains, propagation phenomena

Programme

Partie I - Systemes dynamiques
Partie II - Modeles biologiques spatio-temporels

Learning outcomes

- understand basic mathematical models in biology and medicine acquire mathematical skills (EDO, EDP, CM) apply mathematical concepts to the study of different models

Independent study

Objectifs :

Méhodes :

Core texts

J. Murray, *MATHEMATICAL BIOLOGY*, Springer, 2002

Assessment

> Final mark = 50% Knowledge + 50% Know-how
> Knowledge = final exam
> Know-how = continuous assessment

MÉCANIQUE DES SOLS

SOIL MECHANICS

Lecturers: Eric VINCENS, Francesco FROIIO

| Lecturers : 14.0 | TC : 14.0 | PW : 0.0 | Autonomy : 4.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

This module aims to lay the essential background of Fundamental Soil Mechanics essential to geotechnician to understand and predict the behavior of a complex multiphase (air, water, solid) material : soil. It makes the link with Solid Mechanics (UE MSS), of which he shows a concrete application. It is notably intended for future students of the Ecological Transition & Territories option.

Keywords : sand, clay, hydraulic, shear, consolidation, limit analysis, support

Programme

1 - Physical characteristics and classification of soils.
2 - Soil hydraulics
3 - Consolidation of fine soils
3.1 - Oedometric test
3.2 - Consolidation settlements
4 - Resistance of soils to shearing
4.1 - Shear tests
4.2 - Stress paths
5 - Limit analysis - thrust and earth stop

Learning outcomes

- know how to calculate - the physical and mechanical properties of soils - soil settlements due to the presence of a structure on the site - hydraulic flows and under-pressures under structures - a stress field in a soil

Independent study

Objectifs :

Méhodes :

Core texts

Assessment

know-how score: 10min MCQs at the start of the session in continuous assessment
knowledge score: final test with part "with documents" and other "without document"

MÉCANIQUE DES STRUCTURES MINCES : PLAQUES ET COQUES

MECHANICS OF THIN STRUCTURES : PLATES AND SHELLS

Lecturers: Cécile NOUGUIER, Hélène MAGOARIEC

| Lecturers : 14.0 | TC : 10 | PW : 4.0 | Autonomy : 4 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

Thin structures, light and allowing optimization of the weight / performance ratio, feature prominently in many industries (aeronautics, civil engineering, chemical engineering, etc.). The main objective of this course is to provide the future engineers with elements required for modeling and design of buildings based on thin structural elements by analyzing the behavior of 2D thin structures, flat or curved.
In consideration of the material gain conferred by the thinness, the risk of instability is amplified: phenomena such as buckling of plates and shells have to be accounted for. The second objective of this course is to provide the future engineers with the bases to study instabilities of elastic thin structures.

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

Programme

Part 1 - Elastic behavior of plates: 4 Lectures, 2 Tutorials, 1 Practical work; Definition, schematization, hypotheses, and mechanical forces ; internal forces; local balance ; LoveKirchhoff thin plates model ; boundary conditions.
Practical work: experimental validation of the Love-Kirchhoff model and study of an approximate solution.
Part 2 - Elastic behavior of shells of revolution: 2 Lectures, 2 Tutorials; Geometry of surfaces, definition, schematization, mechanical forces ; internal membrane forces ; local balance for shells of revolution ; usual loadings ; Elastic stress, strain, and displacements.
Part 3 - Elastic stability of thin structures: 2 Lectures/Tutorials; Buckling of thin plates and

Learning outcomes

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

Independent study

Objectifs : Theoretical and experimental applications of the course to circular and rectangular plates. Writing of a synthesis document summarizing the experiments and critical anlyses.

Méhodes : Coordinated / Standard autonomies, group work near the practical works rooms (open access to test devices), ownership of the handout, validation of the theoretical/numerical works, group reflection: processing of measurements and critical analysis.

Core texts

S. P. Timoshenko, S. Wionowski-Krieger, *THEORY OF PLATES AND SHELLS*, Mc Graw Hill, 1970
F. Frey *TRAITÉ DE GÉNIE CIVIL DE L'ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE, VOL. 1 À 6*, Presses Polytechniques et Universitaires Romandes, 2003
S. P. Timoshenko, J. M. Gere*THEORY OF ELASTIC STABILITY*, Dover Publications, 2009

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge mark = 100% final exam
Know-how mark = 100% continuous assessment

MÉTHODE DES ÉLÉMENTS FINIS, DE LA THÉORIE À LA MISE EN OEUVRE

FINITE ELEMENT METHOD, FROM THE THEORY TO IMPLEMENTATION

Lecturers: Abdel-Malek ZINE

| Lecturers : 24.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 8.0 | Project : 0.0 | Language : FR

Objectives

In the engineering field, there are several approximation techniques allowing to solve the differential equations or the partial derivatives governing the studied phenomena.
The most widely used is the Finite Element Method. This method makes it possible to treat any kind of geometry, any kind of boundary value problem arising from electromagnetism, acoustics, fluid mechanics, solid mechanics, biology and even finance! Moreover, This method has a rigorous mathematical approach, based on variational methods.
This mathematical approach makes it possible to predict the accuracy of the approximation and to improve it

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

Programme

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

Learning outcomes

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

Independent study

Objectifs :

Méhodes :

Core texts

A. Ern et J. L. Guermond, *ELÉMENTS FINIS : THÉORIE, APPLICATIONS, MISE EN OEUVRE*, Mathématiques et applications, Springer, 2002
J. Rappaz et M. Picasso. *INTRODUCTION À L'ANALYSE NUMÉRIQUE*, Presses polytechniques et universitaire romandes, 1999
A. Quarteroni and A. Valli*NUMERICAL APPROXIMATION OF PARTIAL DIFFERENTIAL EQUATIONS*, Springer, 2008

Assessment

- 2-hour supervised Exam.
- Reports of two practical works

MÉTHODES NUMÉRIQUES EN MÉCANIQUE

NUMERICAL METHODS IN MECHANICS

Lecturers: Jérôme BOUDET, Fabien GODEFERD, Olivier DESSOMBZ

| Lecturers : 14.0 | TC : 14.0 | PW : 0.0 | Autonomy : 0.0 | Study : 4.0 | Project : 0.0 | Language : AN

Objectives

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

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

Programme

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

Learning outcomes

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

Independent study

Objectifs :

Méhodes :

Core texts

C. Hirsch, *NUMERICAL COMPUTATION OF INTERNAL AND EXTERNAL FLOWS (VOLUMES 1 ET 2)*, John Wiley and Sons, 1988
H.K. Versteegh and W. Malalasekera *AN INTRODUCTION TO COMPUTATIONAL FLUID DYNAMICS*, Longman, 1995
J.C. Craveur*MODÉLISATION PAR ÉLÉMENTS FINIS : COURS ET EXERCICES CORRIGÉS*, Dunod, 2008

Assessment

Final mark = 60% Knowledge + 40% Know-how
Knowledge mark = 100% final exam
Know-how mark = 100% continuous assessment

MONDIALISATION ET TRANSCULTURALITÉS

GLOBALIZATION AND TRANSCULTURAL ISSUES

Lecturers: Cécile LACOIN

| Lecturers : 28.0 | TC : 0.0 | PW : 0.0 | Autonomy : 4.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

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

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

Programme

The course presents concepts and methods for the analysis of globalization issues today, by putting them into perspective. Specifical themes are being analyzed in order to understand the cross-cultural stakes such as: the various stages of globalization across the centuries, the diversity of the forms of capitalism, the relationship to work, the transformation in the perception of bodies and exchanges between people, the various meanings of nature, the cultural

Learning outcomes

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

Independent study

Objectifs : In groups of 3 or 4 students. Each group identifies an issue or an artwork at the museum and
compares it with objects of another culture.

Méhodes : Students are attending a guide tour of the Musée des
Beaux Arts and have to choose one of the artworks to present.

Core texts

Appadurai, Arjun. , *CONDITION DE L'HOMME GLOBAL*, PAYOT, 2013
Legendre, Pierre. *TOUR DU MONDE DES CONCEPTS*, FAYARD, 2013
Sauquet Bernard, Vielajus Martin *L'INTELLIGENCE INTERCULTURELLE*, Charles Leopold Mayer, 2014

Assessment

50% Knowledge - 50% Know-how
Knowledge : 50% final exam - 50% continuous assessment
Know-how : 50% final exam - 50% continuous assessment

OPTIQUE ET PHOTONIQUE POUR L'INGÉNIEUR

OPTICAL METHODS

Lecturers: Emmanuel DROUARD, Christelle MONAT

| Lecturers : 14.0 | TC : 6.0 | PW : 4.0 | Autonomy : 4.0 | Study : 4.0 | Project : 0.0 | Language : MI

Objectives

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

Keywords : Telemetry, Interferometry, Infrared technology, Optical materials processing

Programme

Introduction: major fields of optics
Spatio temporal coherence, metrology applications
Notions of photometry
Noise phenomena in detectors
Applications to measurement (principles): telemetry, velocimetry, interferometry
Applications of lasers in material processing
Tutorials: Holography, telemetry, interferometric sensor, Applications of lasers in material processing
4 lab works (1h each): holography, vibrometry, FTIR spectrometry, laser anemometry

Learning outcomes

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

Independent study

Objectifs : In depth understanding of a particular optical technology

Méhodes : Problem based learning : brainstorming (2h) / preparation of presentations and restitution

Core texts

B.E. A . Saleh, M. C. Teich, *FUNDAMENTAL OF PHOTONICS*, Wiley, 2007
R. Farcy *APPLICATIONS DES LASERS*, Masson, 1993
D. Schuöcker*ENGINEERING LASERS AND THEIR APPLICATIONS, HANDBOOK OF THE EUROLASER ACADEMY, VOLUME 1 & 2*, Springer, 1998

Assessment

Final Mark = 60% Knowledge + 40% Know-how
Knowledge 60% = 100 % Final exam (written test)
Know-how 40% = 100% Final oral presentation

ORDRE, CHAOS, FRACTALES

CHAOS AND FRACTALS

Lecturers: Christophe BAILLY, Didier DRAGNA

| Lecturers : 22.0 | TC : 0.0 | PW : 0.0 | Autonomy : 10.0 | Study : 0.0 | Project : 0.0 | Language : MI

Objectives

The concept of deterministic chaos has profoundly changed the way we approach the modeling of many problems. Poincaré's three body problem in celestial mechanics and Lorenz' work in meteorology are two now famous emblematic examples. The course introduces the main ideas and theoretical notions used to describe the behavior of these chaotic, nonlinear dynamical systems. A small number of effective degrees of freedom is very often sufficient to observe chaos, which makes the mathematical analysis affordable. The field of application was historically rather that of mechanics, but all fields of physics and even beyond (biology, medicine, economics, social sciences) are concerned, as will be illustrated in the course as well as in the case

Keywords : Dynamical systems, stability, bifurcations, limit cycle, strange attractor, chaos, fractal dimensions, Lyapunov exponents, control, identification and reconstruction.

Programme

1-Introduction to dynamical systems. 2-Stability of equilibria. Lyapunov stability, fixed points, limit cycles, Poincaré-Bendixon theorem, canonical bifurcations, attractor. 3-Fractals: introduction, generation, percolation, dimensions. 4-Sensitivity to initial conditions: introduction, Lyapunov exponents for maps, Lyapunov exponents for dynamical systems, long-time prediction. 5-Chaos in Hamiltonian systems: illustration in celestial mechanics, two- and restricted three-body problems; some properties of Hamiltonian systems, resonances, KAM theorem, stability of the solar system. 6-Control of chaos: motivation, algorithms and illustrations. 7-Identification and reconstruction from time series.

Learning outcomes

- To know the fundamental concepts for studying dynamic systems
- To appropriate these concepts through simple numerical case studies
- Be able to explain the behavior of nonlinear dynamic systems

Independent study

Objectifs : Master course concepts by solving case studies (to be done in Matlab or Python). Study cases: van der Pol oscillator, 2-D prey-predator model, fractals of Newton, chaos game, Julia and Mandelbrot fractals, logistic map and Sharkovsky theorem, ...

Méhodes : ... Henon strange attractor, Lorenz attractor (weather, synchronization and encryption), Rössler attractor, chaotic mixing, restricted three-body problem, Henon map, reconstruction of Lorenz and Rössler systems, application in medicine.

Core texts

Strogatz, S.H., *NONLINEAR DYNAMICS AND CHAOS (2ND EDITION)*, Westview Press, 2015
Alligood, K., Sauer, T., Yorke, J. *CHAOS: AN INTRODUCTION TO DYNAMICAL SYSTEMS*, Springer, 1996
Ott, E.*CHAOS IN DYNAMICAL SYSTEMS*, Cambridge University Press, 1993

Assessment

Knowledge 50%, Know-how 50%;
Knowledge = 40% Final written exam + 60% Assigned homework;
Know-how = 40% Final written exam + 60% Assigned homework;

PHILOSOPHIE DES SCIENCES ET TECHNIQUES

PHILOSOPHY OF THE SCIENCES AND THE TECHNIQUES

Lecturers: Romain SAUZET

| Lecturers : 28.0 | TC : 0.0 | PW : 0.0 | Autonomy : 4.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

This course aims to clarify the nature of scientific and technological activities, that is to say, the standards that govern them as well as the tensions that drive them, to better understand their impacts on societies and different environments. The sessions will deal with fundamental questions in the philosophy of science (e.g. change in science; trust; the collective dimension of science; the role of values in science), in order to better study general issues in the technical and technological world (e.g. technoscience, technological evolution) as well as specific problematic objects (e.g. Big Data; Nano-technologies; etc.).

Keywords : Science, Technics, Technology, Epistemology, Technical objects.

Programme

- Science and technology?
- What is knowledge? The change in knowledge.
- General problems in philosophy of science
- The collective dimension of science
- Science in action
- Anthropology of techniques
- Technical evolution: technique and living things
- Big Data / AI / War and technology.

Learning outcomes

- Understanding the challenges of scientific activity
- Understand scientific evolution
- Understand the intertwining between scientific research and technological research
- Mobilize philosophical concepts to analyze specific cases

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

Alan Chalmers, *QU'EST-CE QUE LA SCIENCE?*, Livres de Poche, 1987
Barberousse A., Kistler M., Ludwig P. *LA PHILOSOPHIE DES SCIENCES AU XXE SIÈCLE*, Flammarion, 2000
Séries, Jean-Pierre*LA TECHNIQUE*, PUF, 2013

Assessment

Grade = 100% knowledge
Grade Knowledge = 60% final exam + 40% ongoing assessment

PHYSICO-CHIMIE DES SURFACES ET DES INTERFACES

PHYSICAL CHEMISTRY OF SURFACES AND INTERFACES

Lecturers: Denis MAZUYER, Juliette CAYER-BARRIOZ

| Lecturers : 8.0 | TC : 8.0 | PW : 0.0 | Autonomy : 4.0 | Study : 8.0 | Project : 4.0 | Language : MI

Objectives

This course covers the fundamentals properties of liquid or solid surfaces and interfaces. From a unified overview of intermolecular forces, a physical description of the liquid state and of complex systems where matter is in a highly divided state such as surfactants aggregates, solutions or dispersions is presented. They are characterized by the creation of extremely high surface / volume ratios. The control of the physico-chemical properties of these interfaces is necessary, at molecular scales to optimize their manufacturing and to monitor their functions, from biotechnology to civil engineering. These concepts are applied to the behavior of objects such as living tissue, cosmetics, paints and processes such as coating, detergency or therapeutic targeting.

Keywords : Surface energy, intermolecular forces, interfaces, wetting, colloids

Programme

I. Intermolecular and surface forces: Polarization and Van der Waals forces, Solvatation forces, Electric double-layer (DLVO)
II. Solid/liquid interfaces: Surface energy and adhesion, Wetting and capillarity, Spreading of thin liquid films
III. Adsorption and surface modifications, Self-assembled systems and Langmuir films, Polymer interfaces
IV. Micelles, emulsions et foams: Surfactants and micellar systems, Stability of colloids, Flows, molecular structure and their interactions

Learning outcomes

- Understand the key concepts of adhesion and surface energy
- Know and apply the main intermolecular forces, the laws of wetting, capillarity and adsorption
- Be able to implement a design approach for colloidal systems and analysis of their properties

Independent study

Objectifs : Make links between the concepts covered in class and tackle new knowledge not treated in class

Méhodes : Problem-based learning methods, real cases studies and oral presentations

Core texts

J.N. Israelachvili, *INTERMOLECULAR FORCES*, Elsevier, 2011
H.-J. Butt, K. Graf, M. KappL *PHYSICS AND CHEMISTRY OF INTERFACES*, Wiley, 2006
P.-G. De Gennes, F. Borchard-Wyart, D. Quéré*GOUTTES, BULLES, ONDES ET PERLES*, Belin, 2005

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge = 100 % final exam
Know-how = 100% continuous assessment

PRODUCTION ET DISTRIBUTION DE L'ÉNERGIE ÉLECTRIQUE

ELECTRICAL ENERGY

Lecturers: **Loris PACE, N'Gnui Thomas AKA**

| Lecturers : 0.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

Keywords :

Programme

Learning outcomes

Independent study

Objectifs :

Méhodes :

Core texts

Assessment

PROGRAMMATION DES INTERFACES GRAPHIQUES EN C++

PROGRAMMING OF GRAPHIC INTERFACE

Lecturers: Emmanuel DELLANDREA, Stéphane DERRODE

| Lecturers : 8 | TC : 8 | PW : 8 | Autonomy : 8.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

The aim is to provide students with advanced skills in object-oriented programming (OOP), through GUI programming. This module will allow
- to address new concepts, such as event-driven programming or design patterns;
- to deepen the concepts of inheritance, polymorphism, abstract class or exception handling;
- to introduce methods and tools of "good practices" of development as test programming, code version management or documentation of sources.

Teaching is shoed mainly in the form of tutorials, allowing the student to accumulate gradually the knowledge

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

Programme

- Lesson #1 (2h) : Specificity of C/C++ programming
- Lesson #2 (2h) : Advanced C++ (1)
- Lesson #3 (2h) : Advanced C++ (2)
- Lesson #4 (2h) : Advanced C++ and event-driven programming (3)

- TD #1 (2h) : C/C++ programming initiation
- TD #2 (2h) : C++ basics
- TD #3 (2h) : Operators and genericity
- TD #4 (2h) : Inheritance and exceptions

Learning outcomes

- Create a program based on a graphical user interface (QT)
- Design robust and documented programs
- Learn to work in groups on the same project, thanks to a collaborative platform like Github

Independent study

Objectifs : The autonomous work is to achieve, by pairs of students, a GUI for a mini-game (Tic, 2048, ...)

Méhodes : Each pair works on a collaborative development platform (e.g. Github), allowing the sharing of source codes.

Core texts

Frédéric Drouillon, *DU C AU C++, DE LA PROGRAMMATION PROCÉDURALE À L'OBJET (2IÈME ÉDITION)*, ENI editions, 2014
Claude Delannoy *PROGRAMMER EN C++ MODERNE: DE C++11 À C++20*, Eyrolles editions, 2019
Brice-Arnaud Guérin et Tristan IsraëlC++ *ET QT5, DÉVELOPPEZ DES APPLICATIONS PROFESSIONNELLES*, ENI editions, 2019

Assessment

Final mark = 50% Knowledge + 50% Know-how

Knowledge = Final exam

PROPULSEURS AÉRONAUTIQUES

AIRCRAFT TURBOJETS

Lecturers: Xavier OTTAVY, Pierre DUQUESNE

| Lecturers : 10.0 | TC : 4.0 | PW : 4.0 | Autonomy : 10.0 | Study : 4.0 | Project : 0.0 | Language : AN

Objectives

This lecture has several objectives:
- to get deeper into the details concerning the notions of aero-energetics in the frame of open systems with compressible flows, which are essential for the understanding and the study of the performance of turbojet engines.
- to list and sort the different propulsion systems for aeronautics (turbojet, turbofan, turboprop...) with the associated aircraft.

Keywords : aéroénergétique, écoulements compressibles, turboréacteur, turbofan, turbopropulseur, poussée,performances

Programme

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

Learning outcomes

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

Independent study

Objectifs : Calculation of the performance of a turbofan engine for 2 operating points (take off and cruise).

Méhodes : Calculation of the performance of a turbofan engine and practical works with a mini turbo-jet engines.

Core texts

Assessment

PROTOTYPAGE RAPIDE PAR FABLAB

FABLAB PRACTICES

Lecturers: David NAVARRO, Bertrand HOUX

| Lecturers : 14.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 18.0 | Project : 0.0 | Language : FR

Objectives

Keywords :

Programme

Learning outcomes

Independent study

Objectifs :

Méhodes :

Core texts

Eychenne Fabien, *FAB LAB : L'AVANT-GARDE DE LA NOUVELLE RÉVOLUTION INDUSTRIELLE*, FYP EDITIONS, 2012
Joshua Noble *PROGRAMMING INTERACTIVITY: A DESIGNER'S GUIDE TO PROCESSING, ARDUINO, AND OPENFRAMEWORK*, O'Reilly, 2012

Assessment

SAVOIR CHOISIR UN MATÉRIAU

SELECTION OF MATERIALS

Lecturers: Vincent FRIDRICI

| Lecturers : 14.0 | TC : 2.0 | PW : 0.0 | Autonomy : 4.0 | Study : 4.0 | Project : 8.0 | Language : AN

Objectives

The objectives of this AF are to provide students with methodological inputs on the selection of materials. This requires a good knowledge of the properties of the materials (some common core reminders are given) and needs setting up selection criteria, applied on a materials database. The Granta EduPack material selection software will be presented and used.
The course will be complemented by presentations by industry speakers on the selection of materials related to design, life cycle assessment and the environmental impact of products and materials.
A work in autonomy in group will be realized on a subject chosen by the students.

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : - implement a material selection approach for a given application
- deepen the study of the properties of materials

Méhodes : Work in groups of 3 students: bibliographic survey, analysis of a specification, use of Granta EduPack software, ...
Submission of a written report and oral presentation

Core texts

M. Ashby, *CHOIX DES MATÉRIAUX EN CONCEPTION MÉCANIQUE*, Dunod, 2012
M. Colombié *MATÉRIAUX MÉTALLIQUES*, Dunod, 2000
M. Ashby*MATÉRIAUX ET ENVIRONNEMENT : CHOIX ÉCO-RESPONSABLE EN CONCEPTION*, Dunod, 2011

Assessment

Note = 30% know + 70% know-how
Know = 100% final exam
Know how = 100% continuous assessment

SIMULATION MULTIPHYSIQUE EN CONCEPTION MÉCANIQUE

MULTIPHYSICS SIMULATION IN MECHANICAL DESIGN

Lecturers: Sebastien BESSET, Manuel COLLET

| Lecturers : 14.0 | TC : 0.0 | PW : 0.0 | Autonomy : 6.0 | Study : 12.0 | Project : 0.0 | Language : FR

Objectives

The objective of the course is to present the formulations and the discretization methods capable of simulating coupled problems. For this purpose, the integral and variational formulations, adapted to fluid and solid media, will be analyzed and put in complementarity. Digital implementations on concrete examples will be carried out within the framework of 3 BE. The fluid-structure coupling, with and without flow, will be particularly studied as well as the electromagnetic and electro-static coupling in the case of solid and fluid media (piezoelectics, ferro-fluids, magneto-strictives).

Keywords : multiphysics, discretization, coupling, integral formulation

Programme

1 / Discretization of problems
Case of media without flow: Integral formulations; Variational formulations.
Case of flowing fluids: Finite volumes, Variational formulations.
2 / Fluid-structure coupling
Vibro-acoustics of structures coupled to a compressible and non-compressible fluid.
Calculation of the behavior of structures subjected to a fluid flow.
3 / Thermo-mechanical coupling
Formulation of thermo-mechanical problems
Calculation of stationary and transient behaviors. Application to the braking system.

Learning outcomes

- Understanding the complexity of a multiphysics problem
- Knowing how to formulate a coupling between two physics
- Know the tools adapted to the resolution of a multiphysics problem
- Knowing how to analyze and criticize the results of the resolution

Independent study

Objectifs : This activity is not concerned with framed autonomy activities outside personal work.

Méhodes : This activity is not concerned with framed autonomy activities outside personal work.

Core texts

F. Brezzi & M. Fortin, *MIXED AND HYBRID FINITE ELEMENT METHODS.*
C.A. Bredia, S. Kim, T.A. Osswald & H. Power *BOUNDARY ELEMENTS XVII.*
Klauss J. Bathe*FINITE ELEMENT PROCEDURES IN ENGINEERING ANALYSIS.*

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge N1 = 100% final exam
Know-how N2 = 100% continuous assessment

SOCIOLOGIE DES COMPORTEMENTS POLITIQUES

POLITICAL SOCIOLOGY

Lecturers: Nicolas HOURCADE

| Lecturers : 32.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

This course allows students to apply and deepen the methods and modes of reasoning of sociology apprehended in the UE SHS in semester 7, by dealing with the theme of political sociology.
The module presents the main objects, methods and theories of the political sociology. Its problematic is organized around the following questions: What are the political behaviors that are expressed in contemporary Western societies? How can they be analyzed? How is political participation linked, on the one hand, to the historical context, and on the other hand (and correlatively) to the social characteristics of individuals?

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : Autonomous work is carried out between sessions. It is carried out in groups and consists of a short bibliographical synthesis on a subject given by the teacher or chosen by the group. Several autonomy notes will be requested.

Méhodes : Instructions will be given by the teacher for carrying out the work independently. Feedback on the first mark should enable the students to improve the following works.

Core texts

Jean-Yves DORMAGEN et Daniel MOUCHARD, *INTRODUCTION À LA SOCIOLOGIE POLITIQUE*, De Boeck, 2019
Nonna MAYER *SOCIOLOGIE DES COMPORTEMENTS POLITIQUES*, Armand Colin, 2010
O. FILLIEULE, F. HAEGEL, C. HAMIDI et V. TIBERJ (dir.)*SOCIOLOGIE PLURIELLE DES COMPORTEMENTS POLITIQUES*, Presses de Sciences Po, 2017

Assessment

Final mark = 50% knowledge + 50% know-how
Knowledge = 100% final exam
Know-how = 100% continuous assessment

SPACE PHYSICS AND SOLAR-TERRESTRIAL COUPLING

SPACE PHYSICS AND SOLAR-TERRESTRIAL COUPLING

Lecturers: Raffaele MARINO, Christophe CORRE

| Lecturers : 26.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 6.0 | Project : 0.0 | Language : AN

Objectives

Aerospace engineering concerns the development of technologies for atmosphere and space. The design of vehicles, launch systems and payloads cannot thus disregard a deep understanding of such operational environments. The main purpose of this class is to provide a detailed description of the physics of the interplanetary space and of the outermost layers of the Earth's atmosphere, as well as to describe the coupling between solar activity and Earth's dynamics.
The interplanetary medium and the upper atmosphere are in the plasma state and they both develop a strong turbulent character. Theory and modeling of space plasmas and anisotropic turbulence will be proposed here,

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : Study of scientific articles focusing one of the subjects of the class, or development of short scientific projects.

Méhodes : Articles/projects will be assigned to singles or groups of students and a final report will be produced.

Core texts

M.G. Kivelson, C.T. Russell , *INTRODUCTION TO SPACE PHYSICS* , Cambridge University Press, 1995
M. Moldwin *AN INTRODUCTION TO SPACE WEATHER* , Cambridge University Press, 2008

Assessment

Final grade = 70% knowledge grade, 30% know-how grade
Knowledge grade = 100% exam grade
Know-how grade = 100% project grade

SURFACES, FRICTION, VIBRATIONS

MECHANICAL SYSTEMS AND CONTACTS

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

| Lecturers : 12.0 | TC : 12.0 | PW : 0.0 | Autonomy : 0.0 | Study : 8.0 | Project : 0.0 | Language : MI

Objectives

In many mechanical systems and mechanisms, contact dynamics are often of prior importance in ensuring integrity, energy efficiency and environmental respect. Designing these systems remains complex due to the couplings between the dynamic response of the system and local tribological behavior at the surface scale.
The objective of this course is to give a multidisciplinary approach on these issues. In particular, the main phenomena involved will be provided (description of the lubricated, dry contacts, in normal and tangential stresses, friction laws). The resulting vibroacoustic problems will be put into perspective: vibroimpact, squealing, global dynamic behavior induced by local interactions.

Keywords : Contacts, mechanical systems, tribology, dynamics of systems, advanced design

Programme

The following topics will be addressed with courses, TD and BE:
- Kinematic aspect of contact drive systems
- Contact theory, dry and lubricated
- Normal contact dynamics
- Friction instabilities

Learning outcomes

- Understand the main concepts of contact dynamics
- Understand the basics of lubrication
- To be able to predict the performance of mechanisms
- To be able to build an advanced design methodology of dynamic systems

Independent study

Objectifs : The courses are completed by a group activity based on solving a problem that will deepen the concepts seen in class. This activity will concern in particular the study of screeching in the context of a windshield wiper.

Méhodes : Problem-based learning method

Core texts

K.L. Johnson, *CONTACT MECHANICS*, Cambridge University Press, 2001
V. L. Popov *CONTACT MECHANICS AND FRICTION*, Springer, 2010
A. Cameron*THE PRINCIPLES OF LUBRICATION*, John Wiley & Sons Inc, 1981

Assessment

Final mark = 25% Knowledge + 75% Know-how
Knowledge N1 = 100% final exam
Know-how N2 = 100% continuous assessment

SYSTÈMES AUTONOMES DE PRODUCTION (SAP)

DISCRETE EVENT SYSTEMS

Lecturers: Emmanuel BOUTLEUX, Anton KORNIIENKO

| Lecturers : 8.0 | TC : 4.0 | PW : 16.0 | Autonomy : 4.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

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

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

The other aim is to discover and learn how to use Petri netwotk tool so as to model part or totality of a close-

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : To find and to handle a Freeware dedicated to Petri networks simulation

Méhodes : Case study

Core texts

GENDREAU D., *7 FACETTES DU GRAFCET, APPROCHES PRATIQUES DE LA CONCEPTION À L'EXPLOITATION, PRATIQUES DE LA CONCEPTION À L'EXPLOITATION*, CEPADUES-Editions, 2000
MORENO, S/PEULOT *LE GRAFCET. CONCEPTION-IMPLANTATION*, CASTEILLA – TECHNIPLUS
DAVID, R/ALLA, A*DU GRAFCET AUX RÉSEAUX DE PETRI*, Hermès, 1992

Assessment

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

SYSTÈMES MÉCATRONIQUES INTELLIGENTS

SMART MECATRONICS SYSTEMS

Lecturers: Manuel COLLET, Anton KORNIIENKO, Cédric MARCHAND

| Lecturers : 14 | TC : 2 | PW : 4 | Autonomy : 4 | Study : 8.0 | Project : 0.0 | Language : MI

Objectives

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

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : Promote critical thinking and develop analysis skills of a scientific article on one of the subjects of intelligent mechatronic system

Méhodes : A Rapport for 2 persons 1-3 pages with critical analysis of the article is to be sent before the exam

Core texts

Robert H. Bishop, *MECHATRONICS: AN INTRODUCTION*, CRC Press, 2005
A. Preumont *ACTIVE CONTROL OF STRUCTURES*, J. Wiley & Sons, 2008

Assessment

Final mark = 50% Knowledge + 50% Know-how
Knowledge = 50% final exam + 50% continuous assessment
Know-how = 0% final exam + 100% continuous assessment

THE PHYSICS AND MODELLING OF FREE SURFACE FLOWS

THE PHYSICS AND MODELLING OF FREE SURFACE FLOWS

Lecturers: Didier DRAGNA, Richard PERKINS

| Lecturers : 0.0 | TC : 0.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : AN

Objectives

The objective of this course is to present the different types of free surface flows (bubbles, drops, steady and unsteady flows in a channel), the physical processes that determine the flow and the ways in which the flow can be modelled, both analytically and numerically. Many of the topics introduced in this course are explored further, and in more detail, in courses in the 3rd year.

Keywords : Free surface, surface tension, capillary effects, Bernoulli equation, Weber, Froude, waves, solitons, Saint Venant, SPH

Programme

Introduction to free surface flows: the situations in which they occur, general features of free surface flows, the physical processes that are involved, and the associated characteristic length and time scales
Bubbles and drops: surface tension effects and associated boundary conditions, relevant dimensionless numbers and associated flow regimes, bubble and drop dynamics, interfacial effects
Open channel flows: relevant dimensionless numbers and associated flow regimes, rapidly-varying and slowly varying steady flows, unsteady flows – surge waves, flood waves, solitons and periodic gravity waves

Learning outcomes

- For a given situation, students will be able to identify the relevant dimensionless numbers and the flow regimes associated with them
- For a given situation, students will be able to write the relevant equations that govern the flow, and the associated boundary conditions.
- Students should be able to compute the major characteristics (depth and velocity) of the free surface flow in an open channel.
- Students should be able to identify the most suitable numerical model, and define the necessary data for the boundary conditions.

Independent study

Objectifs :

Méhodes :

Core texts

Clift, R., Grace, J.R. & Weber, M.E., *BUBBLES, DROPS AND PARTICLES*, Academic Press, 1978
Dean, R.G. & Dalrymple, R.A. *WATER WAVE MECHANICS FOR ENGINEERS AND SCIENTISTS*, World Scientific Publishing, 1991

Assessment

Final exam (2h): 40%
Lab reports : 60%

THÉORIE DES PROBABILITÉS ET INTRODUCTION AUX PROCESSUS STOCHASTIQUES

PROBABILITY THEORY AND INTRODUCTION TO STOCHASTIC PROCESSES

Lecturers: Marie-Christophette BLANCHET, Elisabeth MIRONESCU

| Lecturers : 16.0 | TC : 16.0 | PW : 0.0 | Autonomy : 0.0 | Study : 0.0 | Project : 0.0 | Language : FR

Objectives

The course will be given in English if necessary.
It is a mathematical advanced course which is strongly recommended to students who want to proceed in Mathematics in France or abroad. In the following of teh cours of S7 we introduced in a rigourous way neaw notions such as characteristic function, Gaussian processes, Law of 0-1, Borel-Cantelli lemma. NEw modelisation tools such as conditionnal expectation and martingales, are studied.

Keywords : characteristic function, Gaussian processes, conditionnal expectation, stopping times, discrete time martingales

Programme

Characteristic functions
Gaussian processes
Random sequences, limit theorems
Conditional expectation, martingales and stopping time

Learning outcomes

- Modelisation with discrete stochastic processes

Independent study

Objectifs :

Méhodes : Preparatory works on simulation problems

Core texts

VALériE GirArdin Et nikoLAos Limnios , . *PROBABILITÉS EN VUE DES APPLICATIONS, TOMES I ET II,*, Vuibert,, 2008
Williams FELLER *AN INTRODUCTION TO PROBABILITY THEORY AND ITS APPLICATIONS, 3RD EDITION.* , Willey, 1971

Assessment

Final Mark= 100%kowledge
Knowledge=max(final exam; 75%final exam+25% continous assesment)

TRIBOLOGY AND BIO-INSPIRED SURFACE ENGINEERING

Lecturers: **Stéphane VALETTE**

| Lecturers : 16 | TC : 8 | PW : 0.0 | Autonomy : 8 | Study : 0.0 | Project : 0.0 | Language : AN

Objectives

The objective of the course is to establish the relationships between surface functionality and surface morphology, in a biomimicry approach. In terms of surface functionality, the focus will be on the wettability and optical properties of natural textured surfaces. The course should develop knowledge in biomimicry and bio-inspiration of surfaces by offering a description of biological surfaces in terms of morphology and surface chemistry. The morphology and chemistry of plant and animal surfaces will be studied in detail. The morphology/chemistry/wettability relationships of these surfaces will be the focus of this training action. The physics of wetting and adhesion will be studied in detail. The different wettability models will be presented both

Keywords : biomimicry, bio-inspired surface, vegetal surface, animal surface, morphology, wetting, adhesion, structural color, adhesion, biodiversity, ecological transition

Programme

Physics of wetting and adhesion I
Physics of wetting and adhesion II
Physics of wetting and adhesion III
Physics of wetting and adhesion - Applications
Structures and functions of plant surfaces for biomimetic innovations
Structures and functions of animal surfaces for biomimetic innovations
Wetting of bio-inspired surfaces
Bibliographic review: bio-inspired super-hydrophobic surfaces
Biomimicry and optical properties: structural coloring

Learning outcomes

- - Know the morphology of natural surfaces (plant and animal) - shapes, dimensions, multi-scale aspects
- - Know the main chemical compounds forming the surface of plant leaves or insect cuticles
- - Know the physical laws of wettability
- - Know how to establish the relationship between wettability and surface morphology - Know how to establish the relationship between structural coloration and surface morphology

Independent study

Objectifs : Preparation of exercices for training classes.
Bibliographic study of recent biomimicry and surface engineering publications: training in the scientific approach in the context of the ecological transition

Méhodes : Bibliographic study of recent publications, synthesis and oral presentation

Core texts

Eddie Y. K. Ng, Yuehao Luo, Eddie Yin-Kwee Ng, *BIO-INSPIRED SURFACES AND APPLICATIONS*, World Scientific, 2016
Edward Yu. Bormashenko *PHYSICS OF WETTING - PHENOMENA AND APPLICATIONS OF FLUIDS ON SURFACES*, De Gruyter, 2017
Robin H. A. Ras and Abraham Marmur*NON-WETTABLE SURFACES: THEORY, PREPARATION AND APPLICATIONS*, Royal Society of Chemistry, 2017

Assessment

Final mark = Knowledge mark = 70% final exam mark + 30% bibliographic assessment mark

VIVANT, INFORMATION ET SYSTÈME

LIFE, INFORMATION AND SYSTEM

Lecturers: Julien HUILLERY, Bénédicte LAFAY, Gérard SCORLETTI

| Lecturers : 12.0 | TC : 16.0 | PW : 0.0 | Autonomy : 4.0 | Study : 0.0 | Project : 0.0 | Language : MI

Objectives

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

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

Programme

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

Learning outcomes

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

Independent study

Objectifs : Scientific literature related to the three aspects of the course will be analyzed

Méhodes : Each group composed of 7 to 8 students study a different article. A written summary that must report the scientific approach of the paper is asked. An oral presentation to the whole class is finally given.

Core texts

Bertalanffy, L. v. , *GENERAL SYSTEM THEORY, FOUNDATIONS, DEVELOPMENT, APPLICATIONS*, George Braziller, New York., 1968
Shannon, C.E. *A MATHEMATICAL THEORY OF COMMUNICATION*, Bell System Technical Journal, 1948
Wiener, N. *CYBERNETICS OR CONTROL AND COMMUNICATION IN THE ANIMAL AND THE MACHINE*, MIT Press, 1948

Assessment

Final mark = 30% knowledge + 70% know-how
Knowledge = 100% final exam
Know-how = 100% continuous assessment