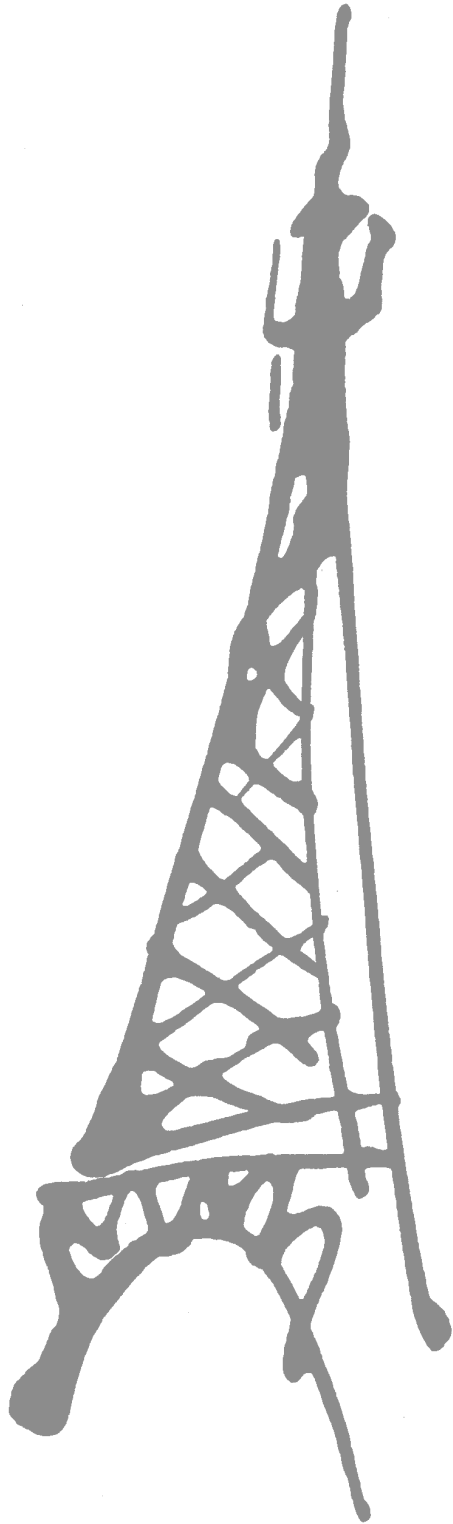# CentraleSupélec

Centrale Paris Engineering curriculum

Embrace Excellence

COURSE CATALOG

CentraleSupélec

Academic year 2017-2018

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Energy Science

EN1100 - Heat Transfer

Professor : Franck ENGUEHARD

Language of instruction : FRANCAIS, ANGLAIS – **Number of hours** : 30 – **ECTS** : 2,5 - **Quota** :

Prerequisites :
Basic notions of thermodynamics and mathematics

Period : S5 between September and January

Course Objectives
The general objectives of this course, ranked by increasing complexity, are:

- To master the basic notions of the three modes of heat transfer,
- To be able to identify the heat transfer modes involved in a given configuration,
- To be able to derive energy balance equations including all heat transfer modes,
- To develop abilities to build elementary models for the resolution of complex thermal problems.

On completion of the course, students should be able to
After completion of this course, the student will:

- Master the basic notions of the three modes of heat transfer,
- Be able to identify the heat transfer modes involved in a given configuration,
- Be able to derive energy balance equations including all heat transfer modes,
- Have acquired a first practise in the building of elementary models for the resolution of complex thermal problems.

Course Contents
Lectures (to be prepared by the student before the application classes, by using the e-learning web site http://e-mentor-en.ecp.fr):

- Notion of energy flux.
- The three modes of heat transfer: conduction, convection and radiation. Coupling between conduction and convection (phenomenological approach and introduction of the heat transfer coefficient).
- Steady-state energy balance in steady-state conditions and for fixed systems.

- Linear models of steady-state heat conduction : thermal resistances and conductances, model and approximation of the fin, special cases of the ideal and infinite fins.
- Notions of opaque bodies and transparent media. Spectral and directional intensity and radiative flux. First expression of the radiative flux.
- Boundary conditions involving radiative fluxes.
- Equilibrium radiation. Spectral and directional absorptivity, reflectivity, and emissivity. Emitted, absorbed, and radiative fluxes. Simple models for radiative transfer.
- Physics of unsteady conduction (thermal diffusion phenomenon); characteristic times and lengths. Dimensional analysis. Physical interpretation and application of the Fourier and Biot numbers. The semi-infinite wall model (or short time response model). Spectral analysis of a thermal signal. Degeneracy of the diffusion phenomenon at fixed frequency into propagation. Modeling of finite systems.
- Dimensional approach of thermal forced convection. Qualitative notions of mechanical and thermal boundary layers. Reynolds, Prandtl and Nusselt numbers. Classical approaches of external and internal convection (limited to fully developed regimes). Laminar-turbulent transition. Notion of hydraulic diameter.

Application classes (100% of the scheduled time):

The 9 application classes (of 3 hours each) are organized as follows:

- The first 20 minutes: discussion on the course studied by the students prior to the class, and statement of its principal results.
- The following hour: resolution of one or several immediate application exercises.
- Rest of the duration of the class: treatment of a problem which synthetises the content of the course.

The exercises and problems studied do not involve complicated mathematical developments in order to focus on the physics of the phenomena in a engineering design approach. The problems treated in the third part of the classes are generally inspired from thermal industrial or everyday cases. The main objective with these problems is to learn how to build simple models from complex configurations.

Course Organization

- Book of the lectures (in English)
- E-learning web site http://e-mentor-en.ecp.fr
- Subjects of the exercises and problems
- Web site of the course

Bibliography / Teaching Material and Textbooks

Jean Taine and Estelle Iacona, A First Course in Heat Transfer, Dunod, 2011.

Resources

The course, of total duration 30 hours, is made of 9 classes of duration 3 hours and of a 3 hour final written exam.

The 9 classes are application classes of <u>8 lectures that the students must have studied previously on the e-learning web site http://e-mentor-en.ecp.fr</u>. In other words, for each of the classes number 1 to 8, the students wishing to benefit the most efficiently of the class <u>must</u> have studied the corresponding lecture on the web site <u>prior to</u> the application class (approximately 90 minutes of homework per lecture).

8 application classes will be open; approximately $560 \div 8 = 70$ students will attend each of them. One of the application classes will be in English (the 7 others will be in French). The content of the class in English will be <u>strictly the same</u> as the one of the 7 classes in French in terms of content and level. <u>The class in English is primarily reserved for students having difficulties with French</u>. The final written exam will be proposed in French and in English, and the students will be able to choose freely the language best suited to them; the statements of the exercises and of the problem to solve will be <u>strictly the same</u> in French and in English.

The application classes are <u>non-mandatory</u>. The students may attend them to take part in the resolution of Immediate Application Exercises (IAE) and of Synthesis ProBlems (SPB) with the support of an educator. They may also work in an autonomous way on these same IAE and SPB via the e-learning web site. The students may choose freely the application classes that they wish to attend; on the other hand, if they decide to attend an application class, they must attend the totality of the 3 hours of the class. Finally, an application class will be attributed to each student, and he/she will be obliged to attend this class and none of the 7 others.

Evaluation

A 3-hr compulsory written exam at the end of the course:

- Part 1: questions on the course and simple exercises of direct application of the course (neither documents nor calculation tools allowed).
- Part 2: build, implement, and validate simple models for a given application (documents and calculator allowed).

EN1110 - Advanced Heat Transfer

Professor : Benoît GOYEAU

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : EN1100

Period : S7 Elective 5 November to January

Course Objectives

This course has two main objectives: the first is to consider various industrial applications to give the students a good understanding of heat transfer phenomena, especially convective heat transfer. This first part will be based on the boundary layer theory considering the scale analysis, the similitude solutions and the integral methodology. A section will also be devoted to radiative heat transfer.

The second objective is practical as it concerns *thermal methodology*. Here, the students, working in small groups, will learn the methodology to treat practical applications.

Course Contents

- Forced convection (external and internal)
- Thermal natural convection
- Stability analysis of thermal natural convection
- Turbulent heat transfer
- Thermal methodology (how to solve practical problems)

Course Organization

Lectures: 15 hr, Tutorials: 18 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

- *Convection Heat Transfer*, A. Bejan, 3rd edition. Wiley (2004)
- *Principles of Heat Transfer*, M. Kaviany (2002)
- Textbook

Evaluation

- Written exam: 2-hr.

EN1120 - Heat Transfer

Professor : Christophe LAUX

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : Basic notions of thermodynamics and partial differential equations

Period : S8 elective 12 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

- Master the basic notions of conductive, convective, and radiative heat transfer
- Understand how to derive balance equations for heat transfer
- Develop abilities to build elementary models for applications of practical interest

On completion of the course, students should be able to

- understand the fundamental principles and mathematical basis underlying the balance equations for heat transfer
- decompose a physical problem for conduction, convection, and radiation into a simple model
- formulate an order of magnitude analysis on the governing differential equations for heat transfer to determine how variables scale with parameters
- compute radiative exchange between surfaces
- design a heat exchanger with given constraints (physical size, heat flux, temperature drop)

Course Contents

- The three modes of heat transfer: conduction, radiation, convection. Phenomenological approach to the heat transfer coefficient: coupling between conduction and convection.
- Steady-state energy balance in fixed systems.
- Steady-state heat conduction. Fin approximation. Ideal and infinite fins.
- Opaque bodies and transparent media. Spectral and directional intensity and flux of radiation. Expression of the radiative flux for radiative transfer between opaque bodies through a transparent medium.
- Conservation of energy fluxes and boundary conditions.

- Equilibrium radiation. Spectral and directional absorptivity, reflectivity, and emissivity. Emitted, absorbed, and radiative flux. Study of radiative transfer: a) Special case of transfer between opaque bodies subjected to equilibrium radiation or surrounded by an isothermal black body. Linearization of the radiative flux. b) General case of transfer between opaque bodies through a transparent medium. View factors. Incident and leaving intensity matricial approach (equivalent to radiative resistance arrays).
- Unsteady conduction. Characteristic times and lengths, dimensional analysis, Fourier and Biot numbers. The semi-infinite wall (or short time response) model. Spectral analysis of a thermal signal. Modeling of finite systems.
- Dimensional approach to forced convection. Notions of mechanical and thermal boundary layers. Reynolds, Prandtl and Nusselt numbers. Laminar-turbulent transition.
- Standard cases (tube, flat plate) of internal and external convection in the fully developed regime.
- Notions of heat exchangers. Temperature fields in co- and counter-flow heat exchangers. Number of Transfer Units. Exchanger efficiency.
- Notions of natural convection. Grashoff and Rayleigh numbers.

The tutorials are devoted to the study of practical problems taken from industrial or everyday cases. Emphasis is placed on the analysis of the problem and the development of an appropriate model. Note: EN1120 covers all the topics taught in EN1100, and also additional subjects such as the general method of radiative transfer between opaque bodies through a transparent medium.

Course Organization

Lectures: 16.5-hr, Tutorials: 16.5-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

A First Course in Heat Transfer, J. Taine and E. Iacona, Dunod (2011)

Evaluation

1-hr midterm exam (M) without documents or computer + 3-hr written final exam (F) consisting of a first part (1 hr) without documents or calculator, and a second part (2 hr) with documents and calculator. Final mark = Sup(F, 0.3M + 0.7F).

EN1200 - Fluid Mechanics

Professor : Ronan VICQUELIN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Calculus and vector analysis, continuum mechanics

Period : S7 elective 3 between september and january

Domain : Sciences pour l'ingénieur

Course Objectives

Fluid mechanics is a central subject in many technological applications. It intervenes in energy conversion, oil exploration, ocean engineering, materials processing, propulsion, aeronautics and space, process engineering, biomechanics and biotechnologies, environment, meteorology, climate change, microfluidics. Its recent developments have been substantial. A number of theoretical problems have been resolved, new experimental methods have provided unique data on many flow processes, novel simulation tools have allowed considerable insights in fundamental and more applied scientific or engineering problems. In this context, a basic understanding of fluid mechanics is essential to engineers and scientists. This course provides the fundamental elements allowing an operational **understanding of central issues in this field**.

The focus is on:

- Physical understanding,
- Training in problem solving,
- Sharing our knowledge and passion for fluid mechanics and its applications.

The course includes detailed presentations of essential aspects in combination with simple experiments, computer demonstrations, fluid mechanics film projections. Problem solving workshops (PSW) are organized after each lecture to train students in tackling real life engineering problems. The midterm and final exams consist in solving practical fluid mechanics problems.

On completion of the course, students should be able to

Understand the physics of fluid flows, manipulate the balance equations of fluid dynamics, estimate forces and moments induced by fluid motion, evaluate head losses and analyze fluid flows in channels and ducts, use dimensional analysis to estimate orders of magnitude of different flow processes, understand the fundamentals of boundary layer theory, determine the characteristic scales of turbulent flows, use the Reynolds average Navier-Stokes equations to study turbulent flow problems, analyze adiabatic and isentropic flows with area change,

understand the physics of shock waves, relate variables across a normal shock, examine flows in nozzles, diffusers and wind-tunnels.

Course Contents

- (1) **Introduction**. The role of fluid mechanics in current technologies. Program, objectives, organisation, staff and methods. Introduction to the study of fluid flow. Continuum concept. Various types of flows. General solution methods of fluid mechanics problems. Description of motion, material derivative, acceleration. Streamlines, trajectories and streaklines. Control volumes and transport theorems. Balance of mass. Description of multispecies mixtures.
- (2) **Balance of species and momentum**. Diffusion velocity and balance of species. General motion of a fluid particle. Rate of rotation, vorticity, rate of strain. Stresses in fluids. Relation between stress and strain rate tensors. Momentum balance equation. Euler and Navier-Stokes equations. Bernoulli's theorem.
- (3) **Balance of energy**. Balance of kinetic energy. Balance of total and internal energies. Applications of Bernoulli's theorem. Balance of mechanical energy. Incompressible flows in ducts, hydraulic machines. Practical methods for head loss estimation. Moody's diagram. Losses at singularities.
- (4) **Macroscopic balance equations**. The momentum and angular momentum theorems. Application to the determination of hydrodynamic forces and moments. Propulsion applications (jet engines an rockets).
- (5) **Dimensional analysis**. A priori estimates, fundamental dimensionless groups. The Pi-theorem and its application to the analysis of drag. Model scale testing, similarity conditions. Examples of application of similarity concepts.
- (6) **Physics of boundary layers**. Various types of shear flows. Boundary layers. A priori estimates of the laminar boundary layer thickness. Characteristic scales and the Karman integral equation. Separation and transition. The boundary layer equations for a laminar flow over a flat plate.
- (7) **Boundary layer analysis**. Boundary layer equations. Synthesis of the boundary layer equations. Solution of the Blasius problem using shooting methods. Numerical solution of the boundary layer equations (computer demonstrations). Effects of pressure gradients. Adverse gradients and flow separation.
- (8) **The physics of turbulence**. Importance of turbulence in practical applications. The nature of turbulence. Estimation of characteristic time and length scales. The Kolmogorov cascade. Statistical analysis of turbulent flows. Reynolds decomposition and Reynolds average balance equations. Introduction to the closure problem and to turbulence modeling.
- (9) **Compressible flows**. Adiabatic flows of compressible fluids. Isentropic flows of real gases. Effects of area changes. Isentropic flows of perfect gases. Isentropic flow tables.
- (10) **Shock waves**. Physics of shock waves. Visualization methods, experimental observations, formation of shock waves. Normal shock wave equations. Determination of the flow properties across a normal shock. Shock tables. Weak shock waves.
- (11) **Nozzles, diffusers, wind tunnels**. Synthesis on one-dimensional compressible flows. Flow regimes in convergent-divergent nozzles. Application to flow acceleration and wind-tunnels.

- (12) **Final exam** (3hr). Application of the balance equations to the solution of an incompressible or compressible flow problem.

Course Organization

Lectures and problem-solving workshops: 33-hr, Final exam: 3-hr

Bibliography / Teaching Material and Textbooks

- S. Candel (2001) Mécanique des fluides, Dunod Paris.
- S. Candel, (under the direction of) (1995) Mécanique des fluides, problèmes résolus. Dunod, Paris
- Lecture notes and problem notes

Evaluation

- Mandatory 2-hr written midterm exam, under the supervision of the course assistant, all documents allowed ; only calculators without communication medium are permitted as electronic device
- Mandatory 3-hr written final exam with all documents allowed ; only calculators without communication medium are permitted as electronic device.

Final mark = MAX(0.4xmidterm+0.6xfinal, final)

EN1201 - Fluid Mechanics

Professor : Franck RICHECOEUR

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 80

Prerequisites : Calculus and vector analysis.

Period : S6 elective 1 between february and june
S8 elective 8 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

This course provides the fundamental elements necessary for an operational **understanding of central issues in this field**.

The focus is on:

- Physical understanding,
- Training in problem solving,
- Sharing our knowledge and passion for fluid mechanics and its applications.

The course includes detailed presentations of essential aspects in combination with simple experiments, computer demonstrations and fluid mechanics film projections. Problem solving workshops (PSW) are organized to train students in tackling real life engineering problems. The midterm and final exams consist in solving practical fluid mechanics problems.

On completion of the course, students should be able to

Understand the physics of fluid flows, manipulate the balance equations of fluid dynamics, estimate forces and moments induced by fluid motion, evaluate head losses and analyze fluid flows in channels and ducts, use dimensional analysis to estimate orders of magnitude of different flow processes, understand the fundamentals of boundary layer theory, determine the characteristic scales of turbulent flows, use the Reynolds average Navier-Stokes equations to study turbulent flow problems, analyze adiabatic and isentropic flows with area change, understand the physics of shock waves, relate variables across a normal shock, examine flows in nozzles, diffusers and wind-tunnels.

Course Contents

- (1) **Introduction**. The role of fluid mechanics in current technologies. Program, objectives, organisation and methods. Introduction to the study of fluid flow. Continuum concept. Various types of flows. General solution methods of fluid mechanics problems. Description of motion, material derivative, acceleration. Streamlines, trajectories and streaklines. Control volumes and transport theorems. Balance of mass. Description of multispecies mixtures.
- (2) **Balance of species and momentum**. Diffusion velocity and balance of species. General motion of a fluid particle. Rate of rotation, vorticity, rate of strain. Stresses in fluids. Relation between stress and strain rate tensors. Momentum balance equation. Euler and Navier-Stokes equations. Bernoulli's theorem.
- (3) **Balance of energy**. Balance of kinetic energy. Balance of total and internal energies. Applications of Bernoulli's theorem. Balance of mechanical energy. Incompressible flows in ducts, hydraulic machines. Practical methods for head loss estimation. Moody's diagram. Losses at singularities.
- (4) **Macroscopic balance equations**. The momentum and angular momentum theorems. Application to the determination of hydrodynamic forces and moments. Propulsion applications (jet engines an rockets).
- (5) **Dimensional analysis**. A priori estimates, fundamental dimensionless groups. The Pi-theorem and its application to the analysis of drag. Model scale testing, similarity conditions. Examples of application of similarity concepts.
- (6) **Physics of boundary layers**. Various types of shear flows. Boundary layers. A priori estimates of the laminar boundary layer thickness. Characteristic scales and the Karman integral equation. Separation and transition. The boundary layer equations for a laminar flow over a flat plate.
- (7) **Boundary layer analysis**. Boundary layer equations. Synthesis of the boundary layer equations. Solution of the Blasius problem using shooting methods. Numerical solution of the boundary layer equations (computer demonstrations). Effects of pressure gradients. Adverse gradients and flow separation.
- (8) **The physics of turbulence**. Importance of turbulence in practical applications. The nature of turbulence. Estimation of characteristic time and length scales. The Kolmogorov cascade. Statistical analysis of turbulent flows. Reynolds decomposition and Reynolds average balance equations. Introduction to the closure problem and to turbulence modeling.
- (9) **Compressible flows**. Adiabatic flows of compressible fluids. Isentropic flows of real gases. Effects of area changes. Isentropic flows of perfect gases. Isentropic flow tables.
- (10) **Shock waves**. Physics of shock waves. Visualization methods, experimental observations, formation of shock waves. Normal shock wave equations. Determination of the flow properties across a normal shock. Shock tables. Weak shock waves.
- (11) **Nozzles, diffusers, wind tunnels**. Synthesis on one-dimensional compressible flows. Flow regimes in convergent-divergent nozzles. Application to flow acceleration and wind-tunnels.
- (12) **Final exam** (3hr). Application of the balance equations to the solution of an incompressible or compressible flow problem.

Course Organization

Lectures and problem-solving workshops: 33-hr, Final exam: 3-hr

Bibliography / Teaching Material and Textbooks

- S. Candel (2001) Mécanique des fluides, Dunod Paris.
- S. Candel, (under the direction of) (1995) Mécanique des fluides, problèmes résolus. Dunod, Paris
- Lecture notes and problem notes

Evaluation

- Mandatory 1.5-hr written midterm exam, under the supervision of the course assistant, all documents allowed ; only calculators without communication medium are permitted as electronic device
- Mandatory 3-hr written final exam with all documents allowed ; only calculators without communication medium are permitted as electronic device

Final mark = MAX(0.4xmidterm+0.6xfinal, final).

EN1300 - Applied Thermodynamics

Professor : Didier JAMET

Language of instruction : FRANCAIS – **Number of hours** : 15 – **ECTS** : 1,0 - **Quota** :

Prerequisites :

Period : S6 between february and june

Course Objectives

- Physical interpretation of the fundamental notions of thermodynamics: energies, entropy, first and second laws
- Mass, energy, and entropy balance equations of open systems
- Understand the concept of exergy
- Understand and study thermodynamic cycles as energy conversion systems

On completion of the course, students should be able to

- understand why and how standard large energy facilities function
- analyze their performance
- identify sources of improvement

Course Contents

- Conditions of thermodynamic equilibrium
- Equations of state and thermodynamic diagrams
- Mass, energy, and entropy macroscopic balance equation for open systems in unsteady conditions
- Main energy conversion systems and their optimization

Course Organization

Lectures: 6 hr, Tutorials: 7.5 hr, Exam: 1.5 hr

Bibliography / Teaching Material and Textbooks

Course reader (in French)

Evaluation

1.5-hr written final exam, with course reader and handheld calculator allowed.

EN1500 - Nuclear Engineering

Professor : Pascal YVON

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 78

Prerequisites :

Period : S8 elective 9 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

- Describe the operating principles, the science, technology, and technological roadblocks of a new generation nuclear plant for electric energy production.
- Describe the nuclear fuel cycle (the characteristics of uranium and other nuclear fuels, and the various front-end and back-end industries and processes), as well as the industrial, theoretical, and experimental solutions for the management of the nuclear waste.

On completion of the course, students should be able to

understand the operation of the various nuclear technologies, the interest of the duifferent types of reactors in the future energy mix, the advantages and drawbacks of nuclear energy compared to other sources of energy, as well as the fields where research will make it possible to overcome technological roadblocks and also to open new options for future fuel cycles and reactor strategies

Course Contents

- Description of the operation of a thermal neutron reactor (PWR). Different types of nuclear reactors.
- Neutronic aspects: neutron-matter interactions, description of the various neutron reactions, neutron balance in a nuclear core, nuclear core in normal operation.
- Thermohydraulic aspects: coolant (water), nominal operation, boiling crisis.
- Heat sink and interactions with the environment
- Materials (pressure vessel, internal structures, fuel). State of the art and current research.
- The fuel cycle: uranium resources and mining, uranium chemistry, enrichment, fuel design and fabrication, in-reactor behavior, reprocessing, recycling (RepU, MOX), transport of radioactive material.

- Nuclear waste: classification, treatment, different policies in various countries, focus on high level waste solutions, long term radiotoxicity, final repositories.
- Future developments: 4th generation reactors (in particular fast breeders), future fuel cycles, long-term resources, thorium, transmutation, fusion.

Course Organization

Lectures: 18 hr, Tutorials: 15 hr, Exam: 3 hr

A one-day visit (in addition to the scheduled classes) of a nuclear site (and/or CEA) could be organized.

Bibliography / Teaching Material and Textbooks

Slides in english available on Claroline

summaries in english available on Claroline

Resources

Lecturers: Pascal Yvon (CEA), Hervé Cordier (EDF), Jean-Luc Salanave (Areva)

Evaluation

3-hr written final exam without documents

This exam will be in 3 parts: reactors (40% of the grade), fuel cycle (40% of the grade) and materials (20% of the grade).

EN1600 - Renewable Energy

Professor : Jean-Claude VANNIER

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 50

Prerequisites : Basic knowledge and skills in electricity, heat transfer, and system controls

Period : S8 elective 11 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

The aim of the course is to present the potentialities of energy systems based on the use of renewable sources. The first part is dedicated to the presentation of the different devices used to produce energy from renewable sources. The second part will focus on the integration, control and management of energy for different cases. Transportation energy systems, power networks and isolated independent systems will be studied as applications. The basis for elements and methods of energy conversion and storage will be presented as well.

On completion of the course, students should be able to

- gain an in-depth understanding of the behavior of the different components interacting in the generation, conversion, control and management of the renewable energy source
- estimate the main issues of renewable energy integration in electrical power networks
- solve simple design and sizing problems for renewable energy installation systems
- estimate their economic impact

Course Contents

- Power systems, electrical machines, converters
- Renewable sources of energy, wind, solar systems, biomass, biofuels
- Integration of renewable energy on electrical power networks
- Economics of renewable energy
- Battery, kinetic storage, supercapacitors, hydraulics systems

Course Organization

Lectures: 24-hr, Tutorials: 9-hr, Exam: 3-hr

Evaluation

One 3.0-hr written exam, all documents and non-communicating computer allowed

EN1800 - Numerical Methods in engineering applications

Professor : Ronan VICQUELIN, Aymeric Vie

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 25

Prerequisites : Calculus and vector analysis; Basics Python programming (a quick reminder is scheduled); Heat transfer; Fluid mechanics (appreciated but not necessary).

Period : S8 elective 11 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

Numerical simulations of physical phenomena have become inevitable. Indeed, on the one hand, benefiting from computational resources in the 21st century is common practice. On the other hand, due to the increasing complexity and transdisciplinary of practical engineering systems, no analytical solutions are available and the cost of experimental investigations becomes prohibitive. Therefore, engineers in charge of the design of such systems have no choice but to rely on numerical simulations.

The course objectives are:

. Understanding of standard numerical methods

. Applications of these methods in problem-solving workshop

. Critical analysis of simulations results

Combining their skills in computer science, heat transfer, fluid mechanics, mathematical analysis and numerical methods, the students will write their own programs from a blank page and answer a couple of practical engineering problems such as:

- Find the optimal residence time in a BioReactor.
- Identify the value and location of the maximum temperature of a heated structure.
- Risk of pollutant dispersion or flame flash-back.
- Prediction of recirculation length backwards a facing step
- ...

For students in the cursus Centrale Paris only, the present course taught in english is completed with a Cours Binôme (see details below)

On completion of the course, students should be able to

Spontaneously solve a simple problem with a small script to implement a numerical resolution; Formalize a physical problem into equations and identify their mathematical nature; Discretize a set of differential equations; Analyze the accuracy and stability of a numerical method; Derive an adapted numerical method in terms of accuracy and efficiency to solve the problem; Ensure the validity of the results though hypotheses checking and numerical errors characterization; Have a critical interpretation of the physical results; Solve problems found in engineering applications.

Course Contents

I. Basics on numerical approximations

1. **Introduction and Finite Differences.** The role of numerical methods in current design chains. Program, objectives, organization and methods. Introduction to numerical methods. Typical partial differential equations (PDE) found in engineering sciences. Classification of PDE. Finite differences. Approximations of derivatives using Taylor series. Order of the approximation. Centered and upwind formula. Taylor table to obtain general arbitrary order approximations.
2. **Numerical solution of ordinary differential equations** . Modified wave number of finite differences formula. Introduction to ordinary differential equations (ODE). Explicit Euler method. Local and global order of accuracy. Stability of ODE numerical schemes. Implicit Euler and trapezoidal method. Linearization of implicit schemes. Stiffness.

II. Solving large linear equations systems: Applications to steady heat equation.

3. **Elliptic PDE 1.** ODE: Runge-Kutta and multi-steps schemes. Examples of Elliptic PDE (steady diffusive problems). Boundary conditions. Direct vs iterative numerical methods. Jacobi and Gauss-Seidel methods.
4. **Elliptic PDE 2**. Succesive Over-Relaxation method. Conjuguate Gradient method. Notions on Krylov methods, preconditioning and multi-grid methods.

III. Methods for unsteady advection/diffusion problems

5. **Hyperbolic and parabolic PDE: Explicit methods.** Examples (convection, unsteady diffusion processes). Application of explicit Euler method with finite differences. Stability analysis with semi-discrete form. Von Neumann stability analysis. CFL and Fourier criteria.
6. **Characterization of numerical errors** . Numerical dispersion and dissipation. Modified PDE after numerical discretization. Consistency. Interpretation of observed numerical instabilities. Fixes of centered advection: Lax-Friedrichs and Lax-Wendroff methods.
7. **Hyperbolic and parabolic PDE: Implicit methods.** Stiffness of unsteady heat equation. Resolution of 1D heat equation with implicit Euler method. Crank-Nicholson. Thomas algorithm. Multi-dimensional cases: Alternating Direction Implicit methods (ADI).

IV. Towards computational fluid dynamics

8. **Methodology in numerical computations** . Problem definition and hypotheses. Non-dimensional equations. Mesh independent results. Post-processing. Hypotheses verifications.
9. **Incompressible Flow equations.** Governing equations of fluid motion (Euler and Navier-Stokes equations). Role of pressure in incompressible flows. Application of explicit Euler method. Poisson equation on pressure. Pressure/Velocity coupling.
10. **Semi-Implicit method for incompressible flows.** Predictor/Corrector steps to update the velocity field. Application of ADI method in the predictor step.
11. **Final project on incompressible flow.** Application of methodology rules. Compute forces.

Course Organization

Each lecture is followed by a problem-solving workshop on computers to (i) apply the concepts and methods seen in class and (ii) treat practical engineering applications in projects.

The whole course spans on 36 hours (33% theory, 67% practice).

For students in the cursus Centrale Paris only, the present course taught in english is completed with a Cours Binôme. The Cours Binôme is a Scientific English complement to Numerical Methods which will be fully delivered and assed in English. The purpose of the language support course is to replace the traditional English language class with specialised input that enhances, scaffolds and supports the main science course. Students following this course Binôme will receive input on the language around scientific philosophy, writing skills development and scientific storytelling.

Bibliography / Teaching Material and Textbooks

Lecture notes and problem notes.

Evaluation

Evaluation is based on the realization of four projects along the duration of the course: 2 small projects to hand out within a week, 2 comprehensive projects (mid-term and final). Deliverables are to be handed out as slides for each group of two people.

EN1920 - Aerodynamics and Energy Science Laboratory

Professor : Laurent ZIMMER

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** : 27

Prerequisites : Basic knowledge of fluid mechanics or heat transfer

Period : S5 between September and January
S6 between february and june

Course Objectives

Train engineers and scientists in experimental working methodology: problem definition, bibliographical work, comparison between experiment and theory, discussion of results, identification of perspectives, oral and written presentation.

Specific experimental investigations may be done following students' interest or first year project "enjeu". Some experiments are held within research facilities.

On completion of the course, students should be able to

identify and formulate a scientific problem and study it experimentally.

Course Contents

Organization of the work performed by the students over the 4-day course:

Students choose an experimental support before the start of the course. This choice is made upon written motivation and quick description of desired experiences. Following this choice, different course complements are sent to ensure that students have the necessary bases (fluid mechanics - heat transfer - data processing) to make full use of the different setup. A working session at the end of the first day is planned to check understanding of these bases. It is expected that students use their knowledge of probability / statistics to best define the concepts of uncertainty of their measures.

• Day 1: Students have first to perform a mini-lab session. The objective is to make students aware of the possibilities and limits of the devices. In parallel, students will have the choice of physical phenomena to study and deepen the literature on the chosen topic. They will then propose a series of experiments and compare their results with theoretical approaches to validate their experimental design and objectives with the help of an assistant.

• Days 2 and 3: Realization of the experimental setup with the assistance of a technical team; Experience and data acquisition; and propose perspectives based on their results. At the beginning of the 3rd session, a short presentation will be made to ensure the appropriateness of the approach. This takes place in the final grade.

• Day 4 morning: Final analysis of the data and preparation of the oral presentation. Afternoon : oral presentation (about 15 minutes). Questions and discussion (20 minutes) with a jury.

• Homework: preparation of a scientific poster.

Experimental setups offered:

• Wind tunnel experiments (4 or 5 wind tunnels)

• Measurements of index of refraction gradients using an interferometry technique

• Measurements of index of refraction gradients using a Schlieren technique

• Temperature measurements with thermocouples in thermal fins

• Emission or absorption spectroscopy for flame or plasma applications

Course Organization

Labwork: 25-hr, Exam: 4-hr

Bibliography / Teaching Material and Textbooks

Several materials will be sent and given, depending on the actual experimental investigation.

Resources

The head of the course is helped by deux technicians et lab-assistant. They will manufacture the different pieces required for each project. Each lab-assistant (either research engineer from CNRS or PhD students at EM2C lab) cares about two groups of students. Their role is to check the scientific coherence of the project, help students obtained and analysing the results.

Evaluation

Grading is obtained with the following

- experimental work : 60%

- oral presentation : 20%

- written document (scientific poster) : 20%

EN2910 - Aircraft Design

Professor : Didier BREYNE

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 22

Prerequisites :

Period : S7 elective 6 in january
S8 elective 13 in may

Domain : Sciences pour l'ingénieur

Course Objectives

The goal of this training is to describe the different stages of the design process of an aircraft, in both a theoretical and a practical perspective. You will be introduced to the typical methods used in the research department of a company, and apply this knowledge by doing the conceptual design of your own aircraft. After completing this training course, you will have acquired the knowledge and skills that will enable you to define the main characteristics of an aircraft in a very short time frame.

Course Contents

The aircraft design process always follows the same pattern. The process starts by making the reverse engineering of existing products. Next is the conceptual design which is followed by the preliminary design and detail design. All the time, a large number of iterations are made before proceeding to the next stage. In the process, we will start with a global or synthetic approach of aircraft design before getting into more and more detail. We will go from a basic concept into full optimization, from using parameters derived from simple statistical data to using high sophisticated algorithms.

The student will learn how to:

- Define the main characteristics of the new aircraft
- Work out estimates for empty weight and maximum take-off weight
- Compute wing loading
- Compute aerodynamic quality of the aircraft
- Compute the performance (take-off, climb, cruise, landing)
- Make an analysis of the aircraft's stability and control
- Compute the applied loads
- Select the structural materials
- Estimate the costs (design, manufacturing, operational)

Of course, the general concepts are not only valid for aircraft design, but can equally be applied to the development of any product.

Course Organization

This course may be taken over a week in January as part of the S7 or over a week in May as part of the S8.

Evaluation

Evaluation will include:

- One-hour written test, without document, which will take place the last day of the course

- A final oral presentation in front of the classroom

EN2930 - Powertrain Design

Professor : Axel COUSSEMENT

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : -

Period : S8 elective 13 in may

Domain : Sciences pour l'ingénieur

Course Objectives

The objective is to give the students the basic working principle, economical and industrial constraints linked to the piston engines, along with the organisation of the automotive industry : Why so few manufacturers ? Why does gasoline engine are less efficient then diesels ? How do you deal why pollutants ? Which materials are used and why ? …

To apply the concepts shown in class it is propose to the student to play the role of a design team: starting with a car brief, they will have to perform the market study, define their product (i.e. car/powertrain) and pre-design it. Moreover, they will have work all together to fit within the mean CO_2 emissions limits.

On completion of the course, students should be able to

On completion of the course, students should be able to understand the principles of piston engines and the dynamics of vehicles, the constraints of powertrain design. They should also be able to formulate and understand vehicle specifications.

Course Contents

During the last decades, car engines have been subject to a deep evolution. Since the 90s electronic is more and more used for engine management and new architectures are appearing (hybrid, down-sizing, ...) increasing further their complexity. Those engine's design is thus very challenging and appeal to many different engineering specialities: mechanics, electronics, combustion, chemistry, electricity, material science, production management, etc.

After a general introduction to piston engines focusing on their working principle but also on the economical and industrial constraints of the automotive industry, it will be proposed to :

- To perform the pre-design of a powertrain: starting with a car brief, they will have to perform the market study, define their product (i.e. car/powertrain) and pre-design it.

Those studies are based on real scenarios encountered in the industry and will emphasize how complex system are designed.

Course Organization

The course is divided into two parts : first a oral course and two mini-projects illustrating it. The time repartion is aproximatively 50%/50%.

Bibliography / Teaching Material and Textbooks

PDF of the slides used in the course.

Evaluation

The evaluation is based a written examan (with course notes) along with the evaluation of the mini-project performed during the course.

EN2940 - Electrical Aircraft

Professor : Christophe DEVAUX

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 24

Prerequisites :

Period : S7 elective 6 in january

Domain : Sciences pour l'ingénieur

Course Objectives

Preliminary design of an electrical Aircraft by applying an industrial methodology. Approach of complex systems. Raising awareness to new energies in air transportation.

On completion of the course, students should be able to

Acquire notions in the aeronautical field : aerodynamics / aeronautical structures / performance of Aircraft. Use of sizing tools and characterization of aerodynamic performance of Aircraft.

Course Contents

5 days composed of lectures and practical sessions.

Bibliography / Teaching Material and Textbooks

Lecture notes / PowerPoint presentations. 2 Softwares: an Aircraft preliminary sizing tool / a simplified Computational Fluid Dynamics engineering software.

Evaluation

Through a final report.

Computer Science and Electrical Engineering

IS1110 - Information Systems

Professor : Guillaume MAINBOURG

Language of instruction : ANGLAIS – **Number of hours** : 20 – **ECTS** : 2,5 - **Quota** :

Prerequisites :
SQL syntax and first practice.

Period : S5 between September and January

Course Objectives

The course has the following objectives:

- to enable students to understand the mecanisms of computers and networks in order to take full advantage of their potential
- to provide the basic skills and methodology to understand and design the architecture of company information systems
- to provide an overview of some advanced features of IT and IT careers

On completion of the course, students should be able to

In the Information Systems course, students will develop the following skills / Structuring a data model representing the proposed use case computer / Using and developing appropriate models, choosing the right modeling scale and simplifying assumptions relevant to the problem/ Exploit any type of data, structured or not, including massive / Compare large scheduling algorithms and how a program works, evaluate the limitations of a computer / Specify, design, realize and validate all or part of a complex system / Understanding the Limitations of Software Solutions / Understand the basic principles of networks and the main network architectures to make the best use of them / Identify and use everyday software necessary for its work / In parallel with the disciplinary competences, the course Information systems will encourage the development of the following competences / Specifying, designing, realizing and validating complex software / Mastering scientific and technical communication. Be accurate, relevant. Gathering relevant and reliable information to support a case / Be able to interact with information systems specialists as a user or as a project manage

Course Contents

Information Systems - Data Modeling

- Objectives: understand the basics of data modeling, learn to use a method to design a consistent and reliable database system, understand how NoSQL complements relational databases, manipulate data with SQL and NoSQL queries

- Contents: Entity Relationship Modeling, relational databases, SQL language

Information Systems - Basics

- Objectives: Introduce the key components of a computer (including CPU, memory, disks), present the main scheduling algorithms and how a program works, understand the potential bottlenecks of a computer system, know the major trends that drive the IT world,
- Contents: Architecture of computers, operating systems, memory management, brief history of Computer Science and the IT industry

Networks and Security

- Objectives: Understand the bases of networks, network architecture and IT security to make the best possible use of today's Information Systems, prepare students to efficiently use the systems they will encounter in their professional career, enable them to communicate with experts as a user or as a project manager
- Contents: network bases, IT networks architecture, Telecom networks architecture, IT security, convergence

Course Organization

Lectures: 9-hr, Tutorials: 10.5-hr

Bibliography / Teaching Material and Textbooks

Textbooks: http://cours.etudes.ecp.fr/claroline/course/index.php?cid=SI1

Resources

This course has been designed by professionals who have their main activity in a company, to strengthen the link of this topic with the actual needs of companies and solutions.

The team includes "Teaching Assistants", students from Year 2 and 3 at Ecole Centrale Paris, who got a high mark to the exam and have teaching skills to be able to lead a Petite Classe.

Evaluation

1.5-hr final written exam (no documents and no computer allowed).

IS1210 - Algorithms

Professor : Fabrice POPINEAU

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,5 - **Quota** :

Prerequisites : First exposure to programming: variables, expressions, tests, conditionals, loops, functions.

Period : S5 between September and January

Course Objectives

- To apply some generic algorithm design techniques
- To compare algorithmic solutions along their time and space complexity
- To show optimization problems and their approximated solutions
- Synthesize efficient algorithms in common engineering design situations.
- Introduce problem complexity classes

On completion of the course, students should be able to

- To build a model of a problem subject to be solved by a computer program and to implement a solution
- To apply algorithm design method
- To analyse algorithms and to estimate their space and time complexity (easy cases)
- To use heuristics to quickly obtain approximated solutions to an optimisation problem

Course Contents

- Space and time complexity (partly reminders)
- Basic data structures : stacks, queues, lists, dictionaries, trees, binary trees, heaps (partly reminders)
- Algorithm design strategies : greedy, divide and conquer, top-down, bottom-up
- Graph algorithms : shortest path, minimum-weight spanning trees
- Optimization : greedy algorithms, heuristics, dynamic programming
- Time complexity for problems. Problem complexity classes

The Python programming language will be used in this course.

Course Organization

Lectures: 9-hr, Tutorials and Labwork: 12-hr,

Bibliography / Teaching Material and Textbooks

A handout in French and copies of slides will be provided online.

Evaluation

3-hr written final exam (FE) with documents, simple calculator and without computer.

IS1220- Object Oriented Software Design

Professor : Paolo BALLARINI

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : IS1210,Algorithms

Period : S6 elective 1 between february and june
S7 elective 2 between september and january
S8 elective 8 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

The course provides students with an introduction to the principles of design and implementation of component-based software systems based on object-oriented programming (OOP). The first part of the course is concerned with an introduction to the basic concepts of OOP (object, class, encapsulation, inheritance, polymorphism, etc..) followed by a second part dedicated to learning of « design patterns », that is learning of techniques for developing flexible programs (i.e. programs that can straightforwardly be expanded / modified). The course is based on the JAVA programming language and refers to the ECLIPSE Integrated Development Environment (IDE). The course also be presents an introduction to high level modeling of systems as a means of supporting the Software Engineering process. To this aim the course contains an introduction to the language "Unified Modeling Language" (UML), which provide programming language independent notaions for design.

More specifically the objectives of the course are summarised by the following points :

1. OOP basic concepts : core concepts of object-oriented programming ; classes, objects, messages ; thinking by classes ; inheritance : classes and subclasses ; motivation : why OOP is important and how it differs from non-OOP.

2. JAVA language basics : overview of the JAVA technology ; data types, variables, arrays, operators, control-flow instructions. Classes and objects : declaring classes ; class constructors ; class variables ; class methods ; creating and using objects.

3. Interfaces : what is an interface (motivation) ; how to declare interfaces ; interface as type. Inheritance : superclass and subclass ; inheritance of methods in a subclass ; overriding and hiding methods ; polymorphism ; abstract methods and abstract classes.

4. Exception handling : what is an exception ? (handling errors in JAVA code). Catching and hanlding (the « try », « catch », « throw » blocks ; Advantages of excpetions.

5. I/O operations in JAVA : I/O from command line ; I/O from files ; byte/character streaming ; scanning and formatting ;

6. Basic principles of concurrent programming. Concurrency in JAVA : multi-threded programs : defining and running threads ; threads interference ; synchronization ;

7. UML modeling : class diagrams and their application to modelling of OO programs.

8. Introduction to code testing. Notion of test unit in JAVA with JUnit. Introduction to Test Driven Development (Agile Extreme programming)

9. Introduction to Graphical User Interface (GUI) programming in Java. Java AWT, Java Swing. Components, containers, buttons, menus, file chooser, etc. Adding control to a GUI: listeners.

On completion of the course, students should be able to

The student will be able to develop, debug and test JAVA code through an IDE (e.g. Eclipse or else). The student will also have acquired a general knowledge about object-oriented programming, hence he/she will be able to apply the OO development philoaophy in general to any software development issue.

The knowledge acquired in this course will also be fundemantel for those students who wish to take the IS 1250 module (« Programmation tablette ») which requires a good knowledge of the basics of the JAVA language

Bibliography / Teaching Material and Textbooks

All material supporting the course will be in english. This will include : the slides of each class of the course, and the text of tutorials (and solutions). The students will also be pointed out to supplementary materials, like : online JAVA tutorials. We will refer to several textbooks, like : « Thinking in JAVA », by Bruce Eckel (also available in PDF online), « Effective JAVA » by Joshua Bloch, « UML for Java programmers » by R.C. Martin.

Evaluation

Written exam time 3-hr + JAVA Project noted (be made during the course and PW).

IS1230 - Introduction to Databases

Professor : Nicolas TRAVERS

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : IS1210,Basics on Information Systems (such as IS1110) would help but is not required

Period : S7 elective 3 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

Following the database introduction lecture on Information Systems during the the first year, this course focuses on Data Bases Management Systems and tools that will allow you to use them. Especially, we will have practice on **databases** on: **modelization** (Entity-Association), querying (**SQL**), programming into the DB (**PL/SQL**), integrity constraints (**Triggers**) and **concurrency** (transactions).

An introduction to **NoSQL** databases will be given in order to compare to the traditionnal databases paradigm. Thanks to all this notions, the student should be able to handle the conception of databases in projects on Information Systems.

On completion of the course, students should be able to

- design a database suiting their needs
- manipulate a database using SQL and programming languages
- Installation and practice on **Oracle**
- understand the mechanisms of Database Management Systems
- understand new databases technics "NoSQL" with **Cassandra**

Course Contents

- Database design (Entity-Association Diagrams)
- From EA-Diagrams to Relational Schema
- Introduction to relational algebra
- Integrity and assertions constraints
- The Structured Query Language (Data Definition Language, Data Manipulation Language)
- Programming language for SQL : PL/SQL

- Triggers : database consistency
- Notions on transactions, concurrency
- Introduction to NoSQL databases
- Cassandra queries (Apache/Facebook)

Course Organization

Course: 10.5-hr,

Labwork in main courses: 22.5 hr (containing 1 marked)

Exam: 2-hr

Bibliography / Teaching Material and Textbooks

SQL language, Use Cases

Online docs : http://sql.bdpedia.fr/

Evaluation

Evaluation based on a evaluated Practice work (algebra and SQL - 30%) and the final exam (70%).

IS1240 - High Performance Computing for Engineering and Finance

Professor : Frédéric MAGOULES

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : Basic knowledge in linear algebra (matrix, vector), numerical analysis (direct methods, iterative methods), and programming

Period : S8 elective 9 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

To provide an overview of the state of the art of high performance computing as applied to engineering and finance. Special references will be given to parallel and distributed computing and how serial or sequential algorithms problems may be parallelized for the efficient solution of large scale problems in computational engineering, financial engineering, analysis, simulation and design.

On completion of the course, students should be able to

- understand modern computer architecture
- have good knowledge of numerical methods well suited for parallel and distributed computing
- be familiar with parallel and distributed programming

Course Contents

- Architecture of scientific computer: type of parallelism, memory architecture.
- Parallelism and programming models: parallelization, performance criteria, data parallelism, vectorization, message passing.
- Parallel algorithm: recursive parallel algorithm, matrix-matrix product, spatial distribution
- Direct methods for large linear systems: LU factorization, Gauss algorithm, Gauss-Jordan algorithm, Crout and Cholesky factorization for symetric matrices
- Parallel factorization of dense and sparse matrices: block factorization, implement of the block factorization in a message passing environment, symbolic factorization, renimbering, elimination tree, bissection methods.

- Iterative methods for large linear systems: Lanczos method, conjugate gradient method, GMRES method, ORTHODIR method, etc.
- Parallelization of Krylov's methods: parallelization of dense matrix-vector product, parallelisation of sparse matrix-vector product
- Brief introduction to C and C++ languages for the exercices

Course Organization

Lectures: 18-hr, Tutorials: 9-hr, Labwork: 9-hr

Bibliography / Teaching Material and Textbooks

PARALLEL SCIENTIFIC COMPUTING Author(s): Frederic Magoules, Francois-Xavier Roux, Guillaume Houzeaux Wiley-ISTE, London, UK. Hardcover: 372 pages 2015: ISBN-13: 978-1848215818

CALCULO CIENTIFICO PARALELO (IN SPANICH) Author(s): Frederic Magoules, Francois-Xavier Roux, Guillaume Houzeaux CIMNE, Barcelona. Paperback: 311 pages 2014: ISBN: 978-84-941686-3-5

HEIRETSU KEISAN-NO SUURI-TO ALGORITHM (IN JAPANESE) Author(s): Frederic Magoules, Francois-Xavier Roux, Takuya Kuwahara Morikita Publishing Co Ltd, Tokyo, Japan. Paperback: 256 pages 2015: ISBN-13: 978-4627807112

CALCUL SCIENTIFIQUE PARALLELE: COURS, EXEMPLES AVEC OPENMP ET MPI, EXERCICES CORRIGES (IN FRENCH) Author(s): Frederic Magoules, Francois-Xavier Roux Dunod, Paris, France. Collection Sciences Sup, Mathematiques Appliquees pour le Master / SMAI. Paperback: 286 pages 2013: ISBN: 978-2-10-058904-3

Evaluation

Project with written report and oral defense + final written exam_

IS1250 - Programming Mobile Devices

Professor : Adel AMRI

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 48

Prerequisites : To have completed the courses IS1220 or courses programming JAVA equivalent.

Period : S8 elective 11 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

The main objective of the course is for students to learn the design, implementation, and deployment of software applications for mobile devices (tablets, smart-phones) under the Android Platform. A brief introduction to the development of applications under the iOS platform (given in the form of a tutorial) will also be presented during the course.

On completion of the course, students should be able to

master Java programming under the Android platform, Graphical User Interfaces, service-oriented code design and implementation.

Course Contents

- Introduction: background and presentation of the different platforms for the development of applications for mobile devices
- The Android platform: architecture, the Android SDK under Eclipse
- Life-cycle and internal structure of an Android application. Basic concepts: *building blocks, Activity & Broadcast, Receivers, Content Providers, Services* .
- Android communication framework: *Intents, Intent Filters, Pending Intents*, inter process communication.
- User interface: MVC model and event handling (Android User Interface)
- Reuse and interoperability
- Use of mobile resources: position sensors, GPS, camera, touch screen, etc.
- Data services: file access, databases (*Content Provider, SQLite*)
- Multimedia-oriented services
- Application security on Android

Course Organization

Lectures: 18-hr, tutorials: 18-hr

Instructors: Adel Amri, Paolo Ballarini, Pascale Le Gall, Philippe Livolsi

Two classes of 20 students each will be taught in parallel, one in French, one in English.

Bibliography / Teaching Material and Textbooks

- Copies of course slides
- Project and labwork topics

Evaluation

Students will create an application under Android. The work will be performed individually or in teams of two students, on the bases of project or practical labwork topics. The final mark will be based on a) the evaluation of the application designed, and b) a quiz.

IS1260 - Software development project

Professor : Frédéric MAGOULES

Language of instruction : FRANCAIS – **Number of hours** : 16 – **ECTS** : 1,0 - **Quota** :

Prerequisites : IS1210

Period : S6 between february and june

Course Objectives

to be announced

On completion of the course, students should be able to

to be announced

Course Contents

to be announced

Course Organization

to be announced

Bibliography / Teaching Material and Textbooks

to be announced

Resources

This activity involves instructors from several departments. It is lead by the TISA department.

Evaluation

The evaluation is based on the project submitted by the students..

IS1270 - Co-build a Python programming course

Professor : Guillaume MAINBOURG

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 20

Prerequisites : Good command of the Python language

Period : S6 elective 1 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives
Participate in the construction of the New Curriculum!

This IS1270 elective aims to contribute to the construction of the EIP course (Computer and Programming Environment) and the 2 "Coding Weeks" that will follow, in the New Curriculum, in the General Sequence 1 (until mid November).

The "target course" EIP is 60 HEE (36 hours of presence and 24 hours free time), and will be complemented, for the future 1st years without prior experience of Python, by an Elective course for "strengthening", 60 HEE also, which will run in parallel. Some of the EIP course sequences will be taken from the current "Information Systems" course.

This IS1270 elective course is to contribute to the design and implementation of the programming part, which will be done using the Python language, already seen by students from the preparatory classes.

Learning objectives for IS1270:
- Better command of the Python language
- Pedagogical approach for a course for 800 students
- Team work

On completion of the course, students should be able to
Better command of the Python language
Pedagogical approach for a course for 800 students

Course Contents
Design and implementation of:
- Python learning modules
- progressive difficulty exercises

Implementation of modules in fun form and / or "challenges" for future 1A

Recommendations for the use of a "framework" for monitoring programs produced by students (Anaconda-like or other)

Recommendations to take into account the wide variety of Python proficiency levels by future 1st years

Course Organization
Co-building with the teaching team in charge of the course.
Work in team project mode with intermediate presentations, during Course predefined slots and in free time

Resources
Students will work closely with the teaching team in charge of these courses in the New Curriculum (notably Guillaume Mainbourg and Céline Hudelot)

Evaluation
Continuous control and evaluation of the deliverables at the end of the project

IS1310 - Problem solving by graphs: from theory to implementation

Professor : Wassila OUERDANE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : IS1210

Period : S6 elective 1 between february and june
S8 elective 8 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

Graphs allow the modeling of systems that are extremely varied and complex. The aim of this course to acquire and/or to strengthen knowledge on graphe theory, while learning through practice and improving its programming skills (Python). The cours will adress theoretical notions and will implement them through a small artificial intelligence (with the aim to explore a labyrinth and collect objects).

On completion of the course, students should be able to

- On completion of the course, students should be able to model, implement and solve problems using graph theory and its differents algorithm,
- Programming in Python.

Course Contents

The course sessions are in interactive mode and under the form of a combibation of lectures, tutorials and practical exercises, in which theoretical notions will be adressed, for instance:

- basic concepts: what is a graph, how to represent a graph, how to explore a graph, the notion of path, chain, etc.
- various classical graph problems (covering tree problem, shortest path problem, etc.)
- the TSP problem and some resolution method (greedy algorithm, backtracking, branch and bound, etc.)

An in parallele, the various studied algoritms and methods will be implemeted in order to: (i) understand their functioning and theoretical foundation, and (ii) implement an artificial intelligence that has the purpose of collecting objects in a labyrinth (medeled as a graph). In

this course, the implementation will adress two modes: PvP (palyer vs Player) and PvE (Player vs Environment). In this context, will discuss some game strategies.

Course Organization

The concepts of this course are addressed by the practice. A class is a combination of lectures, tutorials and practical exercises (using python language). Two levels are available in this course. A basic level for beginners in this field and exploring the graph theory and implementation with python. An advanced level (expert) for the familiar with the theory but wishing to challenge themselves and to resolve complex problems (provide model and solution by using programming with Python language.)

Bibliography / Teaching Material and Textbooks

- J-C Fournier Graphe et applications, 2 volumes, Hermès Paris 2007
- Olivier Cogis et Claudine Robert, Théorie des graphes problèmes, Théorèmes, algorithmes, Ed. vuibert 2004.
- Claude Berge, Graphe et Hypergraphes Ed. Bordas 1973.
- V. Charchra. Applications of Graph Theory Algorithms, North Holland New York, 1979.
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- O. Ore, Graphs and their uses, Mathematical Association of America, Washington (D.C.), 1990.
- R.J. Wilson, Introduction to Graph Theory, 3 ed Wiely, New York, 1986.
- Gondrand Michel et Minoux Michel. Graphes et algorithmes, ed. Eyrolles, Paris, 1979.
- Jaques Labelle, Théorie des graphes. Ed. Modulo, Québec, 1981.
- etc.

Resources

Wassila Ouerdane (Assistant professor at the industrial engineering Lab)

Khaled Belahcene (Enseignant chercheur au laboratiore Génie Industriel)

Evaluation
The evaluation of the course is organized around:

- **Written tests** of 10 mn at the beginning of the sessions.
- **A final written exam** 3.0-hr,

- **A project** (impementing the AI and some algorithms studied in the course);
- **An oral presentation** for the competition between te different AI of the calss.

The final mark is an aggregation of the different evaluations. In addition, the evaluation system is organized according to three levels: Green (everyone must know (10)), Blue (everyone must aquire (14)), Red (the autonomy (18)).

IS1330 - Theoretical computer science and discrete mathematics: formal languages and computability

Professor : Marc AIGUIER

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S8 elective 9 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

Understanding the basic principles and formal tools (ie based on mathematics) at the base of all the methods of design and implementation of information systems. This course will adress the fundamentals of:

- induction and recurrence (lattice theory, well-founded sets and their equivalence with the mathematical induction). The objective is to formalize the basic notions of induction and recursion underlying all discrete mathematics.
- algorithmic (Gödel / Herbrand's recursive functions, Turing machine and lambda calculus and all the theorems of fixed point and the results associated with undecidability). The idea is to define formally (ie mathematically) what a decision problem is and to give a formal denotation of the concept of algorithm (Church thesis).
- the theory of complexity (both complexity classes P and NP, and structuring the class NP - NP-complete and NP-hard problems).
- design systems (rational languages and automata). The objective is to study the formal basis of all methods of modeling of computer systems.

On completion of the course, students should be able to

Knowing how to adress the "discrete" modelling of a given problem for its implementation (decidable problem), understand the basic formal tools for this modelization.

Course Contents

Foundations of induction and recursion

- Order and preorder
- Upper bounds and lower bounds
- Sets and well-founded induction

- Lattices and fixed points (complete lattices and continuous functions, fixed points and monotone functions)

Foundations of algorithms (computable functions and decidable problems and complexity theory)

- Recursive functions (FR): primitive recursive functions, recursive functions (Problem of the Ackermann function) definition of a decidable problem, undecidability of the halting problem, computability on lists and trees (coding functions) universal recursive function (interpreter).
- Step by step Computation (other calculation models): Turing Machines (MT), equivalence theorems (FR MT LC) Church thesis.
- Complexity theory (time complexity, classes P and NP, structuring the class NP - NP-complete and NP-hard problems, first NP-complete problem)

Rational languages and automata

- Free monoid
- Rational languages (pumping lemma)
- Finite Automata (labeled transition systems, completion, determination, minimality, algebraic operations)

Bibliography / Teaching Material and Textbooks

An handout in French, plus tutorials for each pcs concerned

Evaluation

A 3-hr written examination at end of course. Course handout and tutorials for each pcs and their correction allowed. Laptops and other documents not allowed.

IS1350 - Logic for computer sciences

Professor : Pascale LE GALL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S8 elective 12 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

Discrete modeling of a given problem for its implementation and understanding of the formal tools useful for analyzing discrete models.

On completion of the course, students should be able to

understand the foundations underlying tools related to the design of reliable software such as proof assistants (eg prover COQ), tools for the design of computer systems (Method B), constraints solver, prototyping languages, the analysis of code, or test case generation tools ...

Course Contents

Automatic Demonstration

- Propositional logic and predicate (syntax, sematic, demonstration, Church Theorem, Gödel)
- Semi-decision algorithm (Herbrand model)
- Automatic Demonstration (Gentzen sequent calculus, cut elimination)

Evaluation or symbolic computation

- Equational logic
- Algebraic Reasoning
- Algebraic Rewriting
- Rapid Prototyping
- Extensions (rewriting graphs, cellular automata)

Logic Programming

- Clauses

- Resolution
- Prolog: Logic Programming
- Constraint solving
- Constraint Logic Programming

Course Organization

Lectures and pcs.

Bibliography / Teaching Material and Textbooks

Course handout (in French).

Evaluation

Evaluation will be performed by means of a 3-hr final examination. Documents are allowed.

A personal homework under the form of a project will be requested.

IS1410 - Digital and Collaborative Engineering

Professor : Pascal MORENTON, Laurent CABARET

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 48

Prerequisites :

Period : S6 elective 1 between february and june
S7 elective 2 between september and january

Domain : Sciences de l'entreprise

Course Objectives

To present the main concepts, tools and methodologies of the collaborative and digital engineering; to present the best industrial practises in this area and the changes in progress; allow students to manage a multidisciplinary study case with CAD tools

On completion of the course, students should be able to

- Identify the key points of a preliminary engineering study in a multidisciplinary context
- Use the main methodologies, tools and IT systems of collaborative engineering

Course Contents

After a short introduction to the digital and collaborative engineering, students will work, by group of four, on designing and prototyping a system. Two students will work on the mechanical engineering side of the project and two on the electronic engineering side. The computing side will be assume by all the group. More information on
: http://www.designworkshops.fr/index.php?page=cwd

Course Organization

Lectures: 6-hr, Tutorials: 6-hr, Labwork: 18-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- "Formation au logiciel de CAO SPACECLAIM," polycopié Ecole Centrale Paris

- "PLM, la gestion collaborative du cycle de vie des produits," Denis Debaecker, Ed. Hermes
- "Product Lifecycle Management," John Starck, Ed. Springer
- « Altium Designer : Prise en main », textbook École Centrale Paris

Resources

More information on : http://www.designworkshops.fr/index.php?page=cwd

Evaluation

Oral defense of a mini-project.

IS1510 - Digital Communications and Networks

Professor : Pierre LECOY

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 60

Prerequisites : Basics on signal theory, general mathematics and physics (typ. BSc level), notions on information system architecture, interest for telecom services

Period : S7 elective 5 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

Knowledge and understanding of fundamental principles and tools used in the design and operating of digital communication systems and networks, of theoretical basis in signal processing and their applications to coding, processing and transmission of information (voice, data, images) in the new systems (CDMA, OFDM, FTTH etc.). Understanding the various networks architectures and protocols and their evolution. Be informed about telecom market and actors.

Following the course of Information System, this elective course adresses the students request for a knowledge of the principles and methods of digital communications and networks, and interested in designing, implementing and operating these systems, as well as in services development (web, mobile networks, triple play), and in research (information coding and processing, protocols, architectures).

On completion of the course, students should be able to

- understand how communication systems and networks function
- have a prospective vision of their evolution
- make appropriate technical choices
- apply simple network design and dimensioning rules
- be able to work efficiently with specialists

Course Contents

Theory of digital communications:

- Signal theory applied applied to communications,(signals representation, transforms, basics on information theory)

- Signal sampling, analog-to-digital conversion, source coding, differential and predicive coding.
- Multiplexing, multiple access techniques (TDMA, CDMA), application to radio networks.
- Transmission channel, distortion and noise, error correction
- Digital baseband transmission (channel coding, scrambling) and digital modulations, spread-spectrum techniques, OFDM, ADSL and optical communications as examples
- Signal regeneration, filtering, equalization, error probability

Images and sound compression (MPEG algorithms), video broadcasting and streaming

Network architectures and protocols:

- General networks models, layered model (OSI reference) and TCP/IP - UDP
- Link protocols HDLC and PPP, applications
- Local area networks, standards, Ethernet, WIFI, switched LANs
- Routing principles, Internet
- Transport networks: frame Relay, ATM, MPLS, SDH
- Corporate networks architectures, LAN - WAN
- Notions on network management, security, interconnection
- Convergence (IMS), voice and video over IP, mobile video

Mobile communication networks (GSM, UMTS, 4G, Wifi, satellites)

Conference : Telecom players, markets and services

Course Organization

Lectures: 18-hr, Tutorials: 9-hr, Labwork: 3-hr, Conference : 3-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

Course reader in French / Slides presented during the courses, available on the Intranet Claroline (with English version) ; many books in french and english at the library

Resources

Lecturers: Pierre Lecoy (Professor, CentraleSupelec), Philippe Boutin (CentraleSupelec), Damien Lucas (cofounder of ANEVIA company), Pierre Carpene (CentraleSupelec and ESME) Conference Rémi Peyronnet

Evaluation

3-hr written final exam (with documents, no computer) + bonus for participation (case studies and labwork)

IS2110 - Embedded Control Systems

Professor : Philippe BENABES, Maria MAKAROV

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,5 - **Quota** :

Prerequisites : Basic working knowledge of undergraduate mathematical calculus and linear algebra (differential equations, jacobian matrix, vectors, matrices, eigenvalues). Complex numbers, Kirchhoff's circuit laws, Ohm's law, complex impedances, AOP.

Period : S6 between february and june

Course Objectives

This course aims at giving the necessary knowledge to analyse and design simple embedded control systems, both from the hardware and the control algorithm points of view. Namely:

- introduction to the hardware environment (electronics, microprocessor, sensors, actuators)
- introduction to the analysis and design of control algorithms found in embedded systems
- introduction to the implementation of such algorithms on an embedded computer.

On completion of the course, students should be able to

Design, analysis and implementation a simple control algorithm and its hardware environment (sensor, A/D conversion, digital processing, actuators).

Course Contents

- Mathematical tools for control systems analysis (state space form; equilibrium points; stability; simplification by linearization)
- Introduction to controller design (static/dynamic performance requirements for tracking/disturbance rejection; feedback; integral effect)
- The PID controller (effects of P, I, D terms; approximate derivative; antiwindup; setpoint weighting)
- Implementation of a controller on an embedded system (overview of embedded systems hardware/software environment, sampling, antialiasing filter, discretization of a continuous controller, methodology for implementation and testing)
- Tools for sensor conditioning and filter design
- Introduction to microprocessors and digital control

- Basics of DC machines and DC motor drives

Course Organization

Lectures: 12-hr (6-hr automatic control, 6-hr electronics), Tutorials: 15-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

Course reader in French + exercise booklet

Evaluation

3-hr final written exam with documents (without computer).

IS2120 - Control Systems

Professor : Cristina VLAD

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Skills and knowledge acquired during the IS2110 course. Fundamentals of differential calculus and linear algebra (differential equations, jacobian matrix, vectors, matrices, eigenvalues). Basic knowledge of Matlab/Simulink is appreciated (e.g., complete the Mathworks tutorials "Matlab On-ramp", "Simulink On-ramp" and "Using Simulink to Model Continuous Dynamical Systems").

Period : S7 elective 5 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

This course aims to provide fundamental knowledge of analysis tools and control design techniques dedicated to linear systems, represented in time-domain or frequency-domain. After introducing control architectures requiring frequency-domain control design methods, the state-feedback control is discussed, as well as the implementation of this control using a state observer. Then, the optimal design of a state-feedback control is presented. The presented approaches intend to be exhaustive enough in order for students to be able to :

- choose the most appropriate control law for the problem to be solved

- address control problems from various application domains.

Several studies of different industrial systems are proposed, using Matlab/Simulink environment. The simulation tools, necessary to validate different control structures, are presented during the course.

On completion of the course, students should be able to

By the end of the course students will be able to :

- model a system in order to obtain a time-domain or a frequency-domain representation, convenient for control laws design;
- analyze the time/frequency domain behavior of a system in open-loop and closed-loop;
- design control laws satisfying given dynamic performances and establish procedures in order to validate the expected performances;
- use Matlab functions and Simulink tools for control laws design and for validation of their performances using the control model, in a first approach, and then the nonlinear model of physical process.

Course Contents

- Introduction (general aspects): regulation and tracking, control structure of continuous/discrete systems, numerical control structure, useful concepts : tracking dynamics and regulation
- Introduction to Matlab/Simulink
- System modelling: linearization, state-space representation, transfer function in continuous and discrete time, Bode diagram, step response of first order and second order systems, transformation from state-space to transfer function and from continuous to discrete time
- Analysis of feedback systems: Lyapunov stability, open-loop stability, closed-loop stability: Nyquist criterion, stability margins, static and dynamic precision, performances analysis in frequency/time domain: stability - precision - rapidity
- Control design using frequency domain techniques: P.I and P.I.D regulation, anti-windup, feed-forward control
- State-feedback control : controllability, observability, pole placement method, constant set-points and disturbances, integral action
- State observer: observer gain computation, closed-loop system properties, separation principle
- State-feedback observer-based control: handling constant set-points and disturbances, equivalent controller, stability margins
- Linear quadratic control (invariant infinite horizon case) : choice of weight matrices, stability margins, integral action

Course Organization

- Lectures : 18-hr
- Case studies: 15-hr (Matlab/Simulink)
- Final exam: written examination

Bibliography / Teaching Material and Textbooks

Lectures, handout, case studies

Evaluation

Interim evaluation (3-hr): rated PC sessions (Matlab / Simulink)

3-hr final written exam

IS2210 - Optical fibers and optoelectronics

Professor : Pierre LECOY

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 20

Prerequisites : B.Sc. level in general mathematics and physics. Basics of wave propagation, semi-conductors, and signal processing

Period : S8 elective 12 between february and june

Domain : Sciences de la matière et du vivant

Course Objectives

Understanding the physical principles, technology, and practical use of optical fibers, of opto-electronic and integrated photonic components and devices. Review of the applications in the fields of communications and networks, show the diffusion of these technoloies in the fields of imaging, scientific and medical instrumentation, lightening, energy. Be able to make choice and dimensionning fitted to the applications. Discover the research topics and industrial aspects.

On completion of the course, students should be able to

- understand the theoretical and technological basis, and the vocabulary
- choose the components and devices best suited to a given application
- apply simple design and dimensionning rules
- know and use laboratory equipments (OTDR, optical spectral analyser, tools for optical fibers)
- be aware of professional facts

Course Contents

Optical fibers, theory and practical use (3 sessions incl. exercises) :

- propagation theory over multimode and single-mode fibres
- dispersions, attenuation, birefringence, non-linear effects
- technology (manufacturing, connecting), new structures (photonic bandgap fibers)
- measurements on fibers, reflectometry (OTDR)

Components (3 sessions incl. exercises):

- optical components (splitters, wavelength division multiplexers, Bragg gratings, modulators, switches), principles of photonic integrated circuits

- opto-electronic components (principles and materials ; LED, laser diodes, photodiodes, semi-conductor and doped fiber optical amplifiers)
- applications : displays (LCD, plasma panels, OLED), image sensors, photovoltaic cells, LED lighting, fiberoptic sensors

3 sessions of laboratory demonstrations and practical works : use of optical fibers, reflectometry, optical amplifiers, fiber links, optoelectronic components, photovoltaic cells

Fiberoptic transmission and networks (1 session including a case study)

III-V semiconductors technologies, industrial and research aspects : 1 visit at III-V lab, Palaiseau

Course Organization

- 7 lectures including exercises and case study

- 1 visit

- 3 labs (demonstrations and practical work)

- 1 session devoted to student presentations (final evaluation)

Bibliography / Teaching Material and Textbooks

- Lectures slides in french and english

- "Fiber-Optic Communications", P. Lecoy, Wiley, 2008

- Reference books in French and English available from the library

Resources

Lecturers :

- Pierre LECOY, Professor, CentraleSupelec

Practical sessions will take place at "la Fabrique" (formerly LISA lab) and demonstrations will be done by researchers at CentraleSupélec.

Evaluation

Partial exam on the case study (1/3 of the grade)

Final exam (2/3 of the grade) : student's presentations on current topics in research and development or use of opto-electronic technologies.

IS2950 - Electronics Laboratory

Professor : Pierre CARPENE

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** : 20

Prerequisites : Basics of analog and digital electronics

Period : S5 between September and January
S6 between february and june

On completion of the course, students should be able to

Master the basics of analog and digital electronics through hands-on experimentation

Course Contents

Each sequence consists in a mini-project by groups of 2 or 3 students, associating system design (CAD, etc.), building, and testing. Proposed themes:

- Radio data transmission
- Acquisition board (ADC)
- Analog filters
- Strain measurements
- Stabilized power feeding
- Magnetic field detection

Course Organization

Four Wednesdays, from 8h30 am to 5h00 pm

Resources

This laboratory module takes place at Laboratoire d'Informatique et des Systèmes Avancés (LISA).

Evaluation

Oral defense and report. The poster be sent by email to the professor in charge of the course within the one week following the oral defense.

IS2960 - Electronics Laboratory

Professor : Pierre CARPENE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 20

Prerequisites : Good level in analog and digital electronics. This course is not open to students who have completed AE IS2950 in the 1st year.

Period : S8 elective 13 in may

On completion of the course, students should be able to

gain an in-depth understanding of the systems studied, by establishing links (similarities and differences) between theory and experimentation

Course Contents

Each sequence consists in a mini-project by groups of 2 or 3 students, associating system design (CAD, etc.), building, and testing. Proposed themes:

- Temperature sensors
- Radio data transmission
- Acquisition board (ADC)
- Analog filters
- Strain measurements
- Stabilized power feeding
- Magnetic field detection

Course Organization

One week (five days) . From 8h30 am to 5h00 pm .

Resources

This laboratory module takes place at Laboratoire d'Informatique et des Systèmes Avancés (LISA).

Evaluation

Oral defense and written report. The report must be sent by email to the professor in charge within one week after the oral defense.

Languages

LC0000 - Modern Languages, Cultures and Civilisation

Professor : Claude MEZIN-WILKINSON

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Contents

The study of English and one other modern language is compulsory. The second language may be chosen from: French as a foreign language (for non-native speakers of French), Arabic, Chinese, German, Hebrew, Italian, Japanese, Russian or Spanish.

Language courses are also open to international students in semester- or year-exchange programs. We highly recommend they take French as a Foreign Language (FLE) at the appropriate level (B1, B2, C1, or C2), with 2 ECTS per semester. Students from non English-speaking countries are advised to take English courses (2 ECTS per semester). Students who are already at the C2 level in FLE or English, and who have a TDC (Test de Dispense de Cours) may study another language.

.

LC1000 - English

Professor : Ninon Vinsonneau

Language of instruction : ANGLAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

On completion of the course, students should be able to

Have effective operational proficiency (the ability to communicate with the emphasis on how well it is done, in terms of appropriacy, sensitivity and the capacity to deal with unfamiliar topics) at the very least. The best students will have mastery, the capacity to deal with material which is academic or cognitively demanding, and to use language to good effect at a level of performance which may in certain respects be more advanced than that of an average native speaker.

Course Contents

A range of general and thematic courses are proposed, including:

- General English
- Preparation for the Cambridge CAE and CPE examinations
- Literature
- Cinema
- Comedy
- Advanced Conversation
- Debating

- Scientific English
- Economic English

Course Organization

Each student is assessed and placed in a group of an appropriate level, corresponding to the Common European Framework of Reference for Languages: A1-A2 (basic user), B1-B2 (independent user) or C1-C2 (proficient user).

Bibliography / Teaching Material and Textbooks

A wide range of handouts, works of Literature, English language textbooks, depending on the course taken.

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LC2000 - French as a Foreign Language

Professor : Geraldine OFTERDINGER

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites : Minimum B1 level in French

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- Develop and solidify the four language competences (written and oral comprehension, written and oral expression) to communicate in the academic, professional and/or personal environments
- Develop and solidify the tools of intercultural understanding to allow students to engage in the discovery of the culture
- Allow students to develop their learning process in an autonomous and responsible way
- Offer various innovative approaches suited to individual needs

On completion of the course, students should be able to

- master French for academic courses, as the common language of international communication on campus, and as a professional communication language
- master French as an effective communication tool to understand contemporary French culture

Course Contents

Those weekly courses are offered at several levels, depending on the results of the placement test.

Classes are organized as practical workshops focusing on oral understanding and communication, written understanding and communication, structural proficiency (grammar, vocabulary). Students will work individually or in groups on themes related to contemporary French culture in relation to its historical past.

Course Organization

A placement test will determine the level of the course: B1, B2, or C1 (European reference framework)

Bibliography / Teaching Material and Textbooks

Specific to each course and group level: printed documents (press, literature), audio/video (films, recordings), textbooks

Evaluation

The evaluation is organized in two ways: continuous assessment and control of the end of half-year.

LC3000 - German

Professor : Sabine GEISERT

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LC4000 - Spanish

Professor : Maria-Dolores SOLER-PARDINILLA

Language of instruction : ESPAGNOL – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Contents

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LC5000 - Italian

Professor : Claude MEZIN-WILKINSON

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Contents

General language course (beginner to advanced levels) focussing on :

- Oral understanding and expression (pronunciation, intonation, rhythm , lexicon, structures)
- Written understanding and expression (lexicon, structures)

Bibliography / Teaching Material and Textbooks

Texbooks, press articles, radio recordings, songs, documentaries, movies, tv broadcasts, literature, poetry, ...

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LC6000 - Portuguese

Professor : Claude MEZIN-WILKINSON

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Organization
Following a test, students are place in a level group.
Lessons are 1.5 hours long per week.

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LC7000 - Chinese

Professor : Claude MEZIN-WILKINSON

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Organization
Following a test, students are place in level groups.
Lessons are 3 hours a week for 1st and 2nd year students, and 1.5 hours a week for 3rd year students.

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LC8000 - Japanese

Professor : Claude MEZIN-WILKINSON

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Contents

General language course based on :

Oral understanding and expression (pronunciation, intonation, rythm, lexicon, structures)
Written understanding and expression (writing systems, structures, lexicon)

Course Organization
Following a test, students are placed in level groups.
Lessons are 1.5 hours long.

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LC9000 - Russian

Professor : Claude MEZIN-WILKINSON

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S7 from September to January
S6 and S8 from February to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Contents

General language course (beginners to advanced students) focused on :

Oral understanding and expression (pronunciation, intonation, rythm, lexicon, structures)
Written understanding and expression (writing system, structures, lexicon)

Course Organization
Following a test, students are place in level groups.
Lessons are 1.5 hours long.

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%)

LCA000 - Arabic

Professor : Claude MEZIN-WILKINSON

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S6 from September to june

Course Objectives

- develop and consolidate the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Organization

Following a test, students are placed in level groups.

Lessons are 1.5 hours long.

Evaluation

Continuous assessment (50%) and written exam / listening-speaking test at the end of each semester (50%).

LCC000 - Hebrew

Professor : Claude MEZIN-WILKINSON

Language of instruction :   – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 and S6 from September to June

Course Objectives

- consolidate and develop the four basic language skills (reading, writing, listening and speaking)
- consolidate and develop intercultural skills and comprehension essential to an international career
- give students an awareness of language that will allow them to develop their self learning skills
- propose a varied and innovative approach to language learning

Course Organization
Following a placement test, students will be placed in level groups.
Lessons are 1.5 hours a week.

Evaluation
50% : Continuous assessment
50% : Written exam / listening-speaking test at the end of each semester

Mathematics

MA1000 - Mathematics

Professor : Erick HERBIN

Language of instruction : FRANCAIS – **Number of hours** : 60 – **ECTS** : 5,0 - **Quota** :

Prerequisites :

Period : S5 between September and January

Course Objectives
The mathematics course consists of 3 parts - Analysis - Probability - Statistics - the experiences of learning of which are specified in index cards MA1000-01, MA1000-02 and MA1000-03

Evaluation
The first session of evaluation is progressive, with an independent evaluation of the 3 parts Analysis - Probability - Statistics.
It is composed of:

- a 30 min MCQ in Analysis,
- A 1h30 written exam in Analysis,
- A 1h30 written exam in Probability,
- A 1h30 written exam in Statistics.

The first session mark on Mathematics is: 1/3 ((1/5 QCM + 4/5 mark exam Analysis) + mark exam Probability + mark exam Statistics).

The second session of evaluation is a unique 3h written exam.

For all the exams, the use of any document and any electronic device is forbidden.

MA1000-01 - Real Analysis

Professor : Erick HERBIN

Language of instruction : FRANCAIS – **Number of hours** : 20 – **ECTS** : - **Quota** :

Prerequisites : Topology (limits, convergence, completeness, compactness, density, etc.). Real analysis (Riemann integral, power series, etc.). Euclidean spaces (basis sets, projections, quadratic forms, etc.).

Period : S5 between September and January

Course Objectives

The objective of this course is to give students the understanding and the ability to work with essential concepts in order to:

- study models of random phenomena (thus, this course is a prerequisite to the Probability course)
- understand the tools and methods needed for many engineering and scientific fields such as physics, signal processing, dynamic control.

Course Contents

- Sigma-algebra, measures and measurable spaces, Lebesgue integral
- Fourier transforms
- Hilbert analysis

Course Organization

Lectures: 9 hr, Tutorials: 9 hr, Exam: 1.5 hr

Bibliography / Teaching Material and Textbooks

Course reader in French

MA1000-02 - Probability

Professor : Erick HERBIN

Language of instruction : FRANCAIS – **Number of hours** : 20 – **ECTS** : - **Quota** :

Prerequisites : MA1100

Period : S5 between September and January

Course Objectives

The goal of this course is to fix the theoretical basis of mathematical randomness. The modern theory of probability is introduced, based on the general measure theory. The basic concepts are: the probability space including the sigma-field of events and the probability measure; the random variables and their law; the integration of random variables ; the independence property; the various types of concergence for a sequence of random variables.

Together with the Statistics course, it provides the knowledge required to take into account variability in the various engineering fields (uncertainties in simulation, modeling of fluctuating physical phenomena, financial mathematics, etc.)

The theoretical framework introduced in this course allows to begin the general study of stochastic processes, in an advanced course, which is particularly useful to represent random or fluctuating phenomena.

On completion of the course, students should be able to

On the completion of the course, students should be able to follow an advanced course (Master 1 level), aiming at studying stochastic processes such as martingales and Markov chains.

Course Contents

- Axioms and discrete probability spaces
- Probability and Random Variables
- Probability on R and Characteristic Functions
- Gaussian Vectors
- Sequences and Series of Random Variables
- Conditional Expectation
- Introduction to Martingales

Course Organization

Lectures: 9 hr, Tutorials: 10.5 hr, Exam: 1.5 hr

Bibliography / Teaching Material and Textbooks

Course reader in French (course and tutorials).

MA1000-03 - Statistics

Professor : Paul-Henry COURNEDE

Language of instruction : FRANCAIS – **Number of hours** : 20 – **ECTS** : - **Quota** :

Prerequisites : MA1200

Period : S5 between September and January

Course Objectives

The objectives are to understand the statistical methodology through the following concepts:

- statistical model, sample
- estimation of a parametric model, error associated to an estimator
- statistical test (or decision) and associated risks.

This course provides the bases for a correct interpretation of numerical data that takes into account of the noise and the uncertainties by using random models.

On completion of the course, students should be able to

- construct point estimators and confidence intervals in simple contexts
- evaluate the performances of an estimator
- construct a statistical test, take a statistical decision understanding the risks
- think critically about statistical statements and modeling
- understand the goals and the basic theory of the linear regression and the principal component analysis

Course Contents

- Statistical model, sampling;
- Refresher on Probability
- Point estimation and confidence intervals
- Moment estimators, maximum likelihood estimators
- Parametric tests, optimal test (Neymann-Pearson)
- Goodness-of-fit tests (chi-square; Kolmogorov-Smirnov)
- Simple Linear regression
- Principal component analysis

Course Organization

Lectures: 9 hr, Tutorials: 9 hr, Exam: 1.5 hr

Bibliography / Teaching Material and Textbooks

Course reader, exercises booklet, slides, and corrected past exams available online

MA1400 - Partial Differential Equations

Professor : Pauline LAFITTE

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,5 - **Quota** :

Prerequisites : MA1100

Period : S6 between february and june

Course Objectives

To use mathematics in the engineer's frame of mind : to model an actual problem, to analyze rigorously, to experiment and to validate the numerical results.

The course presents the mathematical bases of the theoretical and numerical analysis of partial differential equations.

Practical classes provide hands on experience with software for numerical computations.

On completion of the course, students should be able to

model, write, analyze and implement a numerical scheme for a simple problem and to use software for numerical simulation.

Course Contents

- Modeling actual problems with PDEs
- Distribution theory and Sobolev spaces
- Cauchy problems
- Elliptic and parabolic problems
- Elementary Computational Linear Algebra
- Finite difference and finite element approximation : numerical analysis of schemes

Course Organization

Lectures: 12 hr, Tutorials: 10.5 hr, Labwork: 4.5 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

Course notes, tutorial exercises with solutions, slides of the lectures, replay of the lectures

Evaluation

- 3-hr written final exam without documents, grade G out of 20. Computers, calculators, phones are not allowed
- Graded mandatory mini-project, graded by the teacher and by some students, grade P out of 20.
- Final grade = 0,8*G + 0,2*P for the first session of the final exam, Final grade = G for a catch-up session.

MA2100 - Financial Risk Modeling

Professor : Frédéric ABERGEL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 4 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

The course objective is to introduce some fundamental concepts of quantitative finance within the framework of discrete-time models:

- discrete-time models for the pricing and hedging of derivative products;
- standard derivative products and their risk-management;
- risk measures in finance.

Practical applications are studied through the implementation of classical numerical methods.

On completion of the course, students should be able to

- understand basic derivative products and the organization of a trading floor;
- master some fundamental concepts in quantitative finance: arbitrage, martingales, risk-neutral measure, complete markets...;
- use various methods of risk measurement;
- implement classical numerical methods (Monte-Carlo, binomial trees).

Note: general continuous-time models and the related mathematical theories are taught during the 3rd year specialization (M2 level).

Course Contents

This course is an introduction to risk measurement and control in finance.

In a static framework, one considers risk measures based on loss distributions that lead to capital requirements. This approach must be deeply revisited when dealing with "dynamic" hedging strategies adapted to derivative products.

After a general presentation of complex financial products and the related business models and professions, the mathematical framework for the pricing of derivative products in discrete-time will be studied. Such key notions as arbitrage and risk-neutral probability will be presented, and then applied to the pricing and hedging of european- and american-style options in complete markets. The Black and Scholes model and formula will be derived, in a simplified manner, as by-products of the Central Limit Theorem.

The theoretical part of the course will be completed by training sessions (5 or 6 x 1h30 sessions), programming lab work on classical simulation methods (2 x 3h sessions), as well as conferences given by financial market professionals.

Course Organization

Lectures and training sessions: 25h30, programming lab work: 6h, mid-term exam: 1h30, final exam: 3h

Bibliography / Teaching Material and Textbooks

Lecture notes (in french)

Resources

Plenary lectures: Frédéric Abergel

+ teaching assistants

Evaluation

Programming project + 1,5 hr written mid-term exam + 3 hr written final exam

Final grade : 1/3 TP + 2/3 max(CF , 2/3 CF + 1/3 CI)

MA2200 - Optimization

Professor : Jean-Christophe PESQUET

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Basics of Differential Calculus

Period : S7 elective 5 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

Every day, companies from various sectors face optimization issues, in order to improve their competitiveness and profitability: stock or portfolio management, transportation or design issues, control of systems, etc.

In light of this, this course has the following objectives:

- Introduction of the mathematical framework to formalize optimization problems
- Presentation of the concepts for the theoretical study of optimization problems (existence, unicity, optimality conditions
- Presentation of numerical optimization and its practical applications (with computers) to industrial problems
- Confrontation to real industrial issues through conferences from various sectors (energy, biology, etc.)

On completion of the course, students should be able to

- model and mathematically formalize optimization problems, in a wide range of scientific and industrial contexts
- identify the type of a problem and the suitable numerical resolution method
- set up the method (with the use of a toolbox or by the full set-up of the method)
- evaluate the validity of the solution

Course Contents

- Convex/nonconvex optimization, with or without constraints
- Numerical optimization
- Parametric identification of models

Course Organization

Lectures: 21 hr, Labwork: 12 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

Course reader in French

Evaluation

One written exams (3 hr), with written notes and poly, without computer + Evaluation of all labwork sessions.

Final mark=0.75*written exam mark + 0.25*labwork mark

MA2300 - Advanced Probability

Professor : Erick HERBIN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : MA1200, Axioms: probability spaces, events, probability measures. Random variables and expectations. Probability on R and characteristic functions. Gaussian vectors. Sequences of random variables.

Period : S7 elective 3 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

This theoretical course is a continuation of the basic course of probability (MA1200). It introduces the fundamentals of the general theory of stochastic processes, taking into account their evolution in time.

These probabilistic models constitute the basic mathematical objects to represent phenomena with high variability, or uncertain. Among these, Brownian motion is widely used to describe (natural, physical, biological, or financial) phenomena based on stochastic differential equations. It is located at the intersection of important classes such as martingales, Markov processes or Gaussian processes, which provide some of its main properties.

The objective of this course is the theoretical study of the two first families of stochastic processes, in the specific case of discrete parameters, and then, the introduction of Gaussian processes indexed by reals. The course has the classical format of a mathematics course, where the fondamental theorems are proved on the blackboard..

On completion of the course, students should be able to

- understand the theoretical bases of the study of discrete-time stochastic processes and of random gaussian processes
- follow an advanced level course on Stochastic Calculus

Course Contents

- Discrete-time martingales (15 hr): study of discrete-time martingales; martingales and game strategy; convergence results
- Markov chains (12 hr): transition operators, Markov property and canonical Markov chain; classification of state, recurrence/transience; asymptotic results

- Gaussian processes and introduction to Brownian motion (6 hr): law of stochastic processes; Gaussian processes; white noise and introduction to Brownian motion

Course Organization

Lectures: 16.5 hr, Tutorials: 15 hr, Exam: 4.5 hr

Bibliography / Teaching Material and Textbooks

Notes and solutions of exercises provided online

Evaluation

Written midterm exam: 1.5 hr, Written final exam: 3 hr

MA2500 - Signal Processing and Sparsity

Professor : Gilles CHARDON

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S8 elective 12 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

On completion of the course, students should be able to

- analyze and design linear filters
- analyze and process signals using appropriate representations (Fourier, DCT)
- apply simple signal processing techniques (filtering, denoising)

Course Contents

Deterministic signals:

- Fourier transform
- Discrete signals
- Filter analysis and synthesis
- Sampling theorem

Random signals:

- Autocovariance, power spectral density
- Wiener filter, linear prediction and application to speech processing

Audio and image processing

- Image compression
- Time-frequency representation, phase vocoder

Course Organization

Depending on the size of the group, this course will be teached as an inverted classroom.

Bibliography / Teaching Material and Textbooks

Foundations of signal processing, M. Vetterli, J. Kovacevic, V. Goyal

Probability, Random Variables, and Stochastic Processes, A. Papoulis

A Wavelet tour of signal processing, S. Mallat

Evaluation

- 3-hr written final exam (70%)
- Labs (30%)

MA2610 - Scientific computation

Professor : Hachmi BEN DHIA

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : MA1400 MG1100, Basic elements in PDEs, basic in matrix algebra, variational/weak form, basic elements in continuum mechanics, Scilab

Period : S7 elective 4 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

The course is both a rigorous and applied component, contributing to the design of complex systems through modeling, mathematical analysis, approximation and controlled simulation of simple, still relevant engineering problems in the fields of mechanics of solids and fluids.

This covers areas such as energy, transportation and aerospace.

The educational goal is that students following this course acquire a clear undertanding of this chain integrating modeling, mahematical analysis and simulation for studies of complex systems, through simplified solid and fluid mechanics problems.

On completion of the course, students should be able to

- Analysis of problems governed by partial differential equations

- Practical numerical simulation

- Initiation to the choice of appropriate numerical methods

Course Contents

The course is composed of two parts of 5,5x3h each.

Compressible fluid flow simulation:

- Flow models, discontinuous solutions, entropy.

- Basic solvers, extensions.

- Labworks.

Solid mechanics:

- Derivation of the linear elasticity equations.

- Mathematical analysis of the primal variational problem.

- Finite element approach and a priori error estimates.

- Matlab labworks and project.

Course Organization

General introduction and motivations

First Part : Scientific Computation in fluid mechanics (courses, tutorials, practical works)

Second Part : Scientific Computation in solid mechanics (courses, tutorials, practical works)

Conclusions and discussion

Bibliography / Teaching Material and Textbooks

- Course handouts for each part.

- Matlab, Scilab, Python...

Resources

Hachmi Ben Dhia (Professor, CentraleSupélec), Laboratoire MSSMat and Fédération de Math CS

Frédérique Laurent-Nègre (Researcher CNRS), Laboratoire EM2C and Fédération de Math CS

2 external assistants (LW, Project)

Computing rooms of MSSMat and EM2C

Evaluation

Control Mark E: 3-hr written exam: 1,5hr for the solid mechanics part and 1,5h for the fluid mechanics one, with authorized paper documents

Project mark: P

Final mark = (2*E+P)/3

Second session

written or oral evaluation

MA2620 - Ordinary Differential Equations and Dynamic Systems

Professor : Laurent DUMAS

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S8 elective 10 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

The first part of this course is devoted to ordinary differential equations (existence, uniqueness, numerical methods). Then, an introduction to dynamical systems will be presented: linear and non linear cases, Lyapunov functions, gradient flow systems, Hamiltonian systems. This course will be illustrated by various examples taken from physics, economy and biology, and will be completed by computational sessions with Matlab/Scilab.

On completion of the course, students should be able to

follow advanced courses based on dynamical systems.

Course Contents

- Ordinary Differential Equations : Cauchy Lipschitz theorem, numerical methods

- Linear dynamical systems : : equilibrium points, stability, local behavior.

- Non linear dynamical systems : linéarization, Lyapunov function.

- Special cases : gradient flow systems, Hamiltonian systems.

- Cases taken from physics, economy and biology.

Bibliography / Teaching Material and Textbooks

Course reader of similar courses (in French).

http://dumas.perso.math.cnrs.fr/ecp.html

Evaluation

The score is composed of half a score of continuous control and score of the final written exam 3 hr (with support)

MA2630 - Distributions and operators

Professor : Pauline LAFITTE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : MA1400, Real analysis (Lebesgue's Integral, Fourier Analysis, Hilbert Analysis), Partial Differential Equations.

Period : S7 elective 2 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

The goal of this theoretical course is to go back to the sources of the concepts of functional analysis that were introduced in the Analysis and Partial Differential Equations courses in first year.

Historically, the distributions and the operators were introduced to provide a formal mathematical frame for problems arising in Physics. In this way, the concepts of functions were generalized into a theory that allows to treat rigorously fundamental questions of analysis (exchanging limits, exchanging limits and integrals, Fourier transform)...

These concepts provide an answer to the main question : in which functional space do we have to search for the solution of the problem so that it is well-posed, that is, it admits one and only one solution that depends continuously on the data ? In particular, the concept of (general) topology on such spaces plays an essential role in the study of the question of continuity and, more generally, the question of convergence. Depending on the considered cases, they can be defined by a distance, a norm, a family of semi-norms...

In the general frame of the stochastic processes (or random functions), the distributions and the operators are the basic mathematical tools to study Gaussian processes or extensions of the classical Brownian motion. The concepts introduced in this course constitute the basis of the spectral or integral representation of these processes, which allow their fine study (geometric property, Markov property, definition of a stochastic integral, etc.)

On completion of the course, students should be able to

Theoretical bases of functional analysis. This course gives an important basis for students who want to attend a Master 2 connected to fundamental mathematics (for instance in Analysis, Partial Differential Equations or Probability).

Course Contents

This course of fundamental mathematics is organized around the theoretical study of the following notions:

- Hahn-Banach's theorems
- Unbounded operators
- Weak topologies
- Advanced concepts of distributions
- Bochner's theorem

For each of these subjects, the main results are rigorously proved on the blackboard.

Course Organization

Lectures during which the concepts and results are introduced and proved on the blackboard. These are complemented by tutorials.

Bibliography / Teaching Material and Textbooks

Course notes and partial solutions of the exercises.

Evaluation

Homeworks, Personal project, Written midterm exam: 1.5 hr, Written final exam: 3 hr ; no documents allowed

MA2814 - Introduction to Random Modeling

Professor : Fabrice BOREL-MATHURIN

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : MA1200 MA1300, Axioms: probability spaces, events, probability measures. Random variables and expectations. Probability on R and characteristic functions. Gaussian vectors. Sequences of random variables. Statistic tests. Regression. Note: this course is not open to students having already taken MA2300.

Period : S8 elective 10 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

This course is a continuation of the basic course of probability theory M1200. In a pedagogical format "from examples to theory", it introduces the representation of high variability or uncertain phenomena, which are present in various fields of industry.

An important part of the course is devoted to the review of basic probability. The focus on the study of concrete examples is particularly important.

This course is an introduction to the theory of stochastic processes that appears in physical and financial modeling, and signal/image processing. Students will study the most important family of discrete-time stochastic process: random walks, martingales, and Markov chains. They are basic concepts to define strategies and simulation algorithm. All the mandatory concepts (basic probability, conditional expectation, stopping times,...) will be recalled at the beginning of the course.

Contrary to MA2300 course, the study of concrete examples taken from different areas of engineering (networks, internet, gambling, meteorology, ...) is more important here than the definition of rigorous theoretical foundations. A large quantity of exercises will be adressed within the course in order the students to master practically all the usual techniques. Regarding the time remaining, some very concrete case (exemple: Google PageRank) might be studied and implemented in class.

On completion of the course, students should be able to

implement basic and classical discrete-time probabilistic models to describe random or uncertain phenomena.

Course Contents

Course:

- Refresher on probabilistic formalism (9 hrs)
- Discrete-time martingales (12 hrs)
- Markov chains (12 hrs)

Homework:

- Implementation/practical situations (10 to 15hrs)

Course Organization

Lectures: 21 hrs, Tutorials: 12 hrs, Homework : 10 to 15 hrs, Final exam: 3 hrs

Bibliography / Teaching Material and Textbooks

Course notes and a self contained bibliography

Evaluation

Midterms:

- a mandatory one (1 hr work in class or a homework)
- an optional one (project consisting in a model implementation and a small report)

Final exam: 3-hr written exam.

MA2815 - Mathematical Modeling for Biology

Professor : Véronique LETORT

Language of instruction : FRANCAIS – **Number of hours** : 32 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites :

Period : S7 elective 6 january

Domain : Mathématiques et sciences de l'information

Course Objectives

In the current context where interdisciplinarity between mathematicas and biology becomes more and more necessary both in private or academic domains, modeling plays a central role in the competences expected from an engineer. The objectives of this course are:

- to give the students an overview of the problematics raised by life sciences, the interest of an approach based on mathematics modeling and the different kinds of models and their objectives
- to present the methods and tools required for a good modeling work in biology, namely identification of biological processes to include in the models, choice and/or developemnt of an adequate formalism, development of an associated simulation tool, analysis of model behaviour, local and global sensitivity analysis (mostly variance-based), structural and pratical identifiability, parametric estimation from experimental data
- to be confronted to applicative cases through practical works (projects) including simulations

On completion of the course, students should be able to

Have a good knowledge of different modelling approaches and associated mathematical tools, with particular focus on the specificities of living systems (large variability, redundancy, multi-scale interactions, etc)

Programming with R.

Course Contents

This course will present some theoretical noions concerning:

- The different kinds of models and their specificities

- Methods and generic tools for model analysis: local (derivative-based) and global or semi-global (SRC, PCC, Sobol, FAST, Morris) sensitivity analysis, overview on some methods for parameter estimation, structural (transfer function method) and pratical identifiability analysis, discernability and model comparison, presentation of some heuristic methods for discrete optimisation, inspired from biological systems.
- Examples and applications (practicals) from diverse fields of biology: population dynamics, plant growth modeling, ecology, cell growth, epidemiology, etc.

As an integrative course, a large place will be given to the realisation of a project that will be the opportunity to apply all the presented methods. The project will be a priori taken in the field of epidemiology and will include economical, societal, or human aspects in addition to scientific aspects.

Course Organization

Lectures: no more than 2hr a day, most of the time being devoted to the project.

Bibliography / Teaching Material and Textbooks

Slides and synthetic course reader in French

Resources

I am associate professor in mathematical modeling for biology at the laboratory of Applied Mathematics and Systems, ECP. I am available to answer the students' questions. Other participants can be colleagues from research or industry domains.

Evaluation

Reports and oral defense of the projects (questions about the mathematical methods can be included in the oral defense).

MA2822 - Advanced Statistics

Professor : Christine KERIBIN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : MA1300

Period : S6 between february and june
S8 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

This course puts in practice the notions introduced in MA1300 (Statistics). The goal is to face models and methods with their respective limitations. Theoretical and practical elements on parametric and nonparametric statistics, multivariate analysis and statistics under dependence are proposed. Applications from various domains illustrate the ubiquity of those methods. This course provides complementary technical grounds for subsequent studies on Machine Learning or Data Mining.

On completion of the course, students should be able to

- use random modeling parametric and nonparametric statistical techniques
- use the R software
- propose, implement and tune a prediction model
- validate and understand the limits of a statistical model

Course Contents

- Multivariate linear regression, model selection
- Nonparametric regression, nonparametric density estimation, bandwidth selection
- Monte-Carlo methods, resampling method
- Cross-validation of a model

Course Organization

Lectures: 6x3 hr, TP : 3x3hr, TD : 2x3hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

- Slides available on-line.

Resources

Lab and tutorial classes by researchers and PhD students.

Evaluation

3-hr written final exam, closed notes, closed books, computer and calculator not allowed

MA2823 - Introduction to Machine Learning

Professor : Chloé-Agathe AZENCOTT

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Notions of linear algebra, probabilities, and scientific programming in Python (numpy).

Period : S7 elective 4 between september and january

Domain : Mathématiques et sciences de l'information

Course Objectives

This course gives an overview of the most important trends in machine learning, with a particular focus on statistical risk and its minimization with respect to a prediction function. A substantial lab section involves group projects on data science competitions and gives students the ability to apply the course theory to real-world problems.

The course should familiarize the students with:

• basic machine learning concepts such as risk, regularization, overfitting, model complexity, or cross-validation;

• a range of machine learning algorithms for classification and regression, including Bayesian methods, linear and logistic regressions, nearest-neighbors, tree-based approaches, kernel methods, and neural networks;

• dimensionality reduction and clustering;

• the optimization techniques that are implemented by these machine learning algorithms.

On completion of the course, students should be able to

• formulate a real-world data analysis problem in machine learning terms;

• choose, among a range of classical techniques, the algorithms that are best suited to solve it;

• apply, analyze, and evaluate these algorithms in a meaningful way.

Course Contents

• statistical risk

- overfitting

- regularization

- model evaluation

- machine learning algorithms for classification and regression

- dimensionality reduction

- clustering

Course Organization

Lectures: 20 hr, Labs: 13 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

- Hastie, Tibshirani, and Friedman, The Elements of Statistical Learning, 2nd Edition, Springer Verlag, 2009
- Shawe-Taylor and Cristianini, Kernel Methods for Pattern Analysis, Cambridge University Press, 2004
- Bishop, Pattern Recognition and Machine Learning, Springer Verlag, 2009

Evaluation

Programming project (40%) + written exam without documents (60%). Electronic devices (calculators, computers, phones,...) are not allowed in the final exam.

MA2824 - Differential Geometry

Professor : Julien DUVAL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : Advanced course in differential calculus

Period : S8 elective 9 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

This course is part of the Differential Geometry course of the MSc of Fundamental Mathematics of University Paris XI. To learn how to deal with manifolds

On completion of the course, students should be able to

Manifolds, vector fields, degree

Course Contents

- immersions,
- submersions,
- diffeomorphisms,
- submanifolds,
- manifolds,
- Sard theorem,
- degree and applications

Course Organization

Lectures: 21 hr, Tutorials: 12 hr, Exam: 3 hr

All courses will take place at Orsay.

Bibliography / Teaching Material and Textbooks

J. Milnor, topology from the differential viewpoint.

Evaluation

3-hr written final exam, without documents

MA2825 - Algebra and cryptology

Professor : Remi GERAUD

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Basic algebra and computer science (L3)

Period : S8 elective 12 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

This theoretical course covers fundamental concepts and tools of commutative algebra, from the perspective of modern cryptology. Particularly, some elements of number theory are introduced (finite fields, law of quadratic reciprocity, elliptic curves).

Cryptography is a set of skills which provides security of information systems. This field, at the frontiers of Mathematics, Computer Science and Electronics, provides ways to guarantee the confidentiality and integrity of digital information.

In addition to fundamental mathematical concepts, this course will introduce algorithmic tools required for applications. Basic notions of algebra will be presented and certain algebraic structures will be studed in detail, notably those useful for public-key cryptology (finite and polynomial rings, finite fields, ...). Notions of algorithmic number theory will also be presented, for applications in the field of cryptology.

On completion of the course, students should be able to

In addition to the basic elements of modern cryptology, this course will provide a solid culture in algebra and number theory. It is an important foundation course for students hoping to follow an MSc in the field. It should also provide a broader view of modern mathematics to students wishing to pursue their studies in other directions.

Course Contents

- Groups, rings, fields, finite fields. Ideals and spectra.
- Quadratic residues, reciprocity, symbols, characters.
- Algorithms for finite fields, primality testing, and factorisation.
- Elliptic curves on finite fields.
- Applications : error-correcting codes, digital signatures, zero-knowledge identification, public-key encryption, and key exchange.

Course Organization

Course 22 hr, Tutorials 9.5 hr.

Bibliography / Teaching Material and Textbooks

Textbook written for the course, exercises, correction of exercices, annals, and bibliography provided therein.

Evaluation

Mid-term written exam 1.5 hr (without any support) + Final written exam 3 hr (without any support).

MA2827 - Foundations of discrete optimisation

Professor :

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Basic knowledge of graph theory will be helpful, but not required since the course will be self-contained. Programming skills (in any programming language of your choice) will be necessary for completing the lab exercises.

Period : S8 elective 11 between february and june

Domain : Mathématiques et sciences de l'information

Course Objectives

Discrete optimization is concerned with the subset of optimization problems where some or all of the variables are confined to take a value from a discrete set. Examples include several important problems in various fields of applied mathematics and computer science, such as

- Finding the best (shortest, cheapest, most scenic) route from one place to another.
- Connecting cities using a road network that minimizes the cost.
- Selecting a subset of projects, each requiring a subset of available resources, to maximize profit.
- Finding the best assignment of students to universities.

In this course, we will study the fundamental concepts of discrete optimization such as greedy algorithms, dynamic programming and min-max relationships. Each concept will be illustrated using well-known problems such as shortest paths, minimum spanning tree, min-cut, max-flow and bipartite matching. We will also identify which problems are *easy* and which problems are *hard*, and briefly discuss how to obtain an approximate solution to hard problems.

On completion of the course, students should be able to

- Identify which optimisation problems are easy and which are hard.
- Design efficient algorithms for easy problems.
- Have a basic understanding of how hard problems are approximately solved in practice.

Course Contents

Briefly, the following topics will be covered in the course.

- Shortest Paths
- Minimum Spanning Trees, Disjoint Paths
- Minimum Cut and Maximum Flow
- Bipartite Matching
- P, NP, and NP-Complete Problems
- Convex Relaxations

A more detailed description of the topics follows.

1. Shortest Path

Summary. Given a directed graph (vertices, arcs and arc lengths), the goal is to find the minimum length or shortest path from one vertex to another. This problem can be solved efficiently when the graph does not contain a negative length directed circuit.

Preliminaries:

- Graph preliminaries
- Complexity preliminaries

Shortest Path:

- Breadth-first search
- Djikstra's algorithm
- Bellman-Ford algorithm
- Floyd-Warshall algorithm

2. Minimum Spanning Tree, Disjoint Paths

Summary. Given an undirected graph (vertices, edges and edge lengths), a spanning tree is a subgraph that consists of all vertices and whose edges form a tree. The minimum spanning tree problem requires us to find the spanning tree with the minimum length. The problem can be solved efficiently for arbitrary (real-valued) edge lengths. Given a directed graph, the disjoint paths problem requires us to find the maximum number of arc disjoint paths between two vertices, where two paths are arc disjoint if they do not contain a common arc. The problem is equivalent to finding the maximum number of vertex disjoint paths between two subset of vertices, and the maximum number of internal vertex disjoint paths between two vertices. All the disjoint path problems can be solved efficiently.

Minimum Spanning Tree:

- Prim's algorithm
- Kruskal's algorithm

Disjoint Path:

- Menger's theorem(s)
- Algorithm for finding maximum number of arc-disjoint paths

3. Minimum Cut, Maximum Flow

Summary. Flow is a function on the arcs of a directed graph such that its value is non-negative, less than the length (or capacity) of the arc, and for all vertices other than a source vertex and a sink vertex, the excess flow is 0. The maximum flow problem requires us to find the flow with the maximum value. A cut is a set of arcs from one subset of vertices that contain the source to another subset of vertices that contain the sink. The minimum cut problem requires us to identify the subsets of vertices which minimize the capacity of the cut. The maximum flow problem and the minimum cut problem are equivalent to each other, and both can be solved efficiently for directed graphs with non-negative arc capacities.

- Max-Flow Min-Cut theorem
- Ford-Fulkerson algorithm
- Dinit's algorithm

4. Minimum Cost Flows and Circulations

Summary. Given a directed graph, along with a function for each arc that measures the cost of passing a unit flow through the arc, the minimum cost flow problem requires us to find the flow with the lowest cost. Circulations are a variant of flow with no source or sink. Given a cost function and a demand function, the minimum cost circulation problem requires us to find the circulation with the lowest cost such that the flow in each arc is greater than or equal to the demand. Both the problems can solved efficiently.

- Reducing shortest path and max-flow to minimum cost flow
- Reducing minimum cost flow to minimum cost circulation
- Algorithm for computing minimum cost circulation

5. Bipartite Matching

Summary. Given an undirected graph, a matching is a set of disjoint edges. The weight of a matching is the sum of the lengths or weights of the edges contained in the edge. The matching problem requires us to find the maximum weight matching of a given graph. The problem can be solved efficiently when the given graph is bipartite.

- Konig's theorem
- Algorithm for cardinality bipartite matching
- Hungarian algorithm for weighted bipartite matching

6. P, NP, and NP-Complete Problems

Summary. We define two types of decision problems (problems with a "yes" or "no" answer): those with a polynomial-time algorithm (P), and those with a polynomial-time checkable certificate (NP). Any NP problem can be reduced to the satisfiability (SAT) problem, which makes SAT NP-complete. The NP-completeness of several other problems is proved by reducing SAT to those problems. We also define NP-hard problems, which may not have polynomial-time checkable certificates, and may not even be decision problems.

- Random access machine
- Cook's theorem
- Reductions

7. Convex Relaxations

Summary. Convex relaxations offer an elegant way to obtain approximate solutions for difficult (NP-hard) problems. The idea is to formulate a problem as an integer program and then relax the integer constraints to obtain a convex program, which can be solved efficiently. We show some well-known examples of accurate convex relaxations for the multiway cut and the max-cut problem.

- Convex programming preliminaries
- Multiway cut
- Maximum cut

Course Organization

The course consists of seven lectures (3 hours each), which will cover the aforementioned topics.

In addition, there will be five lab sessions (3 hours each) where the students will write the code for the following problems:

- 1. Computing Shortest Paths on the Paris Metro
- 2-3. Interactive Binary Image Segmentation via Minimum Cut
- 4-5. Automatic Photo-Stitching via Bipartite Matching

Bibliography / Teaching Material and Textbooks

Slides will be provided on the instructor's webpage (http://cvn.ecp.fr/personnel/pawan/teaching.html). Students are encouraged to look at the slides from previous offerings of the course to get an idea of the level of detail.

In addition, the following course notes by Alex Schrijver will also be helpful (http://homepages.cwi.nl/~lex/files/dict.pdf).

Previous exam papers and other example problems will be provided on the instructor's webpage.

Evaluation

Students will be evaluated based on their lab work (50%) and a final exam that will last 3 hours (50%). The use of printed materials such as slides, notes and textbooks will be permitted during the exam. No electronic devices will be allowed. Bonus points will be available for class participation and would likely play a very important role in your final grade

MA2828 - Design of an anti-noise wall by fractal protections

Professor : Anna ROZANOVA-PIERRAT

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : Course of the first year of the course of Centrale: EDPs and Numerical Analysis, Algorithm and Software Development.

The elective course of the second year "Waves" would be a plus.

Period : S8 elective 13 may

Domain : Mathématiques et sciences de l'information

Course Objectives
Understand the contribution of geometry, including irregular and even fractal geometries, in the design and development of new products.
Understanding theoretical and numerical techniques.
Design an anti-noise wall to minimize surrounding noise.

On completion of the course, students should be able to
Using the theory (mathematical and physical) and knowledge of industrial market demand, be able to model and calculate numerically an anti-noise wall.

Course Contents
To understand the contribution of the geometry, we will analyze why an irregular boundary can be dangerous when it comes to the construction of an aircraft garlic, but it can be crucial and indispensable in microprocessor cooling systems in anechoic chambers, anti-noise walls near airports or roads.
In order to give the reasons for which in some cases geometrical irregularity is needed, and what kind of irregularity one needs to achieve the fixed objective, we will introduce the notions of the fractal geometry with some results known in physics and mathematics.
We will see in particular that the phenomena of the localization and the absorption of the waves are connected by the spectral analysis of the model.
To familiarize with the concepts of the anechoic chambers, there will be a visit of the electromagnetic anechoic chamber of CetraleSupélec (the Gif campus) with a demonstration of the measurements taken.
These questions of modeling and the theoretical understanding will be used to arrive at the project of designing either an "ideal" noise barrier (the most absorbent for a chosen material) in the context of aircraft noise or Trains or cars either from an "ideal" electromagnetic anechoic chamber or to optimize electromagnetic stealth.

The project includes: choice of the target object to be conceived, the modeling of the problem with multisteps, numerical simulation, analysis of the obtained results and conclusion.
This main project will be accompanied by a mini-project: a simulation of a fractal and its localized modes.

Course Organization

Resources
Work in a group.

A visit of the electromagnetic anechoic chamber of CentraleSupélec (the Gif campus) with a demonstration of the measurements .

Programs (FreeFem++ in 2D, COMSOL in 3D or MATLAB).

Evaluation
A defense and a final report.

Mechanical and Civil Engineering

MG1100 - Mechanics

Professor : Guillaume PUEL

Language of instruction : FRANCAIS – **Number of hours** : 45 – **ECTS** : 4,0 - **Quota** :

Prerequisites : Knowledge and skills in linear algebra (matrices, determinant, dot and cross vector product) and real analysis (differential equations, partial differentiation, multiple integrals, Stokes formula) -- Knowledge of velocities, accelerations, forces and moments developed in courses on analytical mechanics

Period : S5 between September and January

Course Objectives

The student should be convinced of the *ubiquity* of the concepts and tools of mechanics in any industrial project implying either basic or advanced technology. The basic concepts are introduced in a *common unified framework* for deformable solids, fluid flows and rigid bodies. Problems involving mechanics at different scales illustrate the course, with some applications to *robotics*, *biomechanics* and *nanotechnology* typically.

On completion of the course, students should be able to

- *Identify the adequacy* of a mechanical model (rigid or deformable body, 2D or 3D model, slender structures ...) for basic design purpose
- *Solve simple design issues* of mechanical parts and identify relevant mechanical properties such as *strength* and *stiffness*
- Estimate forces applied by fluid flows on obstacles

Course Contents

- Strains and stresses in a material medium, strength and failure, material behaviors (deformable solids and viscous fluids), solutions of elementary problems
- Dynamics of three-dimensional systems of rigid bodies, gyroscopic effects, links between rigid bodies
- Elongation, bending and torsion of slender three-dimensional structures

Course Organization

Lectures: 15 hr, Tutorials: 27 hr, 2 Exams (1 hr 30 each)

Bibliography / Teaching Material and Textbooks

Textbooks:

- Bonet, Wood (1997) Nonlinear continuum mechanics
- Gurtin (1981) An introduction to continuum mechanics
- Baruh (1999) Analytical dynamics

Evaluation

2 written exams (1.5 hr each). All documents authorized ; calculator allowed.

MG1200 - Civil Engineering

Professor : Brice BOSSAN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Basic knowledge in Strength of Materials and Static Mechanics

Period : S6 elective 1 between february and june
S7 elective 2 between september and january
 S8 elective 8 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

- Introduction to Civil Engineering (geotechnics, materials, building methods), general technical culture.
- Practical use of scientific tools already known (mathematics, physics, basics in mechanics and strength of materials) to solve various problems by simplifying them enough, through practical applications.
- Acquisition of simple logical reasoning and awareness of the importance of correct appreciation of orders of magnitude.
- Consideration of uncertainties on all assumptions used for building design, and specific study of seismic protection
- Building/environment interactions. Design and sustainable development. Method selection and consequences.

On completion of the course, students should be able to

Basic knowledge of Civil Engineering activities (design, construction methods, ...).

Appreciation of orders of magnitude (calculation sheets).

Basic knowledge of Sustainability applied on Civil Engineering.

Course Contents

- General framework: Civil engineering jobs; process from the need to the building execution works through design and markets devolution phases.
- Reminders of basics of Strength of Materials.
- Elementary soil mechanics, geotechnical reconnaissance; superficial and deep foundations; improvement or reinforcement of soil.

- Metallic framework; wood framework.
- Concrete material; reinforced concrete; prestressed concrete; elementary concepts and calculations.
- Bridges, viaducts; transversal and longitudinal structures; construction processes.
- Dams: technologies; construction methods; drainage and watertightness; flood management; monitoring.
- Marine constructions (sea walls, piers, dry docks). Design. Building methods.
- Embankments, technologies, design methods, building methods.
- Frame of buildings, bracing, loads roadmap.
- High-rise buildings (towers)
- Basics of seismic protection.

Course Organization

Lectures or Tutorials according to the subject dealt with.

Bibliography / Teaching Material and Textbooks

PowerPoint used during Tutorials.

Resources

Teachers : Engineers and experts belonging to major French companies of Civil Engineering (design, construction, ...).

Evaluation

Two steps evaluation :

1 - (40%) : Written control of Strength of Materials (paper documents and simple calculator allowed)

2 - (60%) : Oral presentation (45-60 min) of a construction study performed by groups of 4-6 students.

MG1300 - Vibrations and Acoustics

Professor : Pierre-Etienne GAUTIER

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : MG1100,Continuum mechanics

Period : S7 elective 3 between september and january

Domain : Sciences pour l'ingénieur

Course Objectives

Dynamic vibration and propagation phenomena, in mechanics, play an essential part in many areas: geophysics, building resistance to wind and swell, stability and comfort of aeronautical and terrestrial vehicles,

The aim of this course is to provide students with essential knowledge and methods for the analysis and quantification of these phenomena in structural dynamics and acoustics.

On completion of the course, students should be able to

know the basics of structural dynamics, acoustics, .

Course Contents

- Structural dynamics, small displacements in a Galilean frame
- Virtual Power Principle. Mass and stiffness operators. Eigenmodes. Rayleigh quotient.
- Galerkin and Finite Element methods.
- Vibration of beams
- Harmonic and transient response of a discretized system
- Random vibrations
- Acoustic models and sources
- Acoustic resonances

Course Organization

Lectures: 13.5 hr, Tutorials: 19.5 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

Course reader (in English)

Evaluation

3-hr written exam (coff 0,7)+ analysis of a scientific paper (coeff 0,3)

MG1400 - Plasticity and Fracture: Mechanical Behavior of Materials

Professor : Véronique AUBIN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : MG1100,Continuum mechanics, linear elasticity, beam theory

Period : S7 elective 4 between september and january

Domain : Sciences de la matière et du vivant

Course Objectives

Due to service life, high performance and low cost requirements, today engineers cannot design mechanical structures only through elasticity assumptions. The objective of this course is to highlight the mechanical behavior of the main classes of materials under different loading conditions, to understand the physical basis of the micromechanisms involved, and to choose and to use relevant modeling for design, in the framework of numerical methods.

On completion of the course, students should be able to

- understand the non-linear mechanical behavior of materials : plasticity, anisotropy, fracture, design for extreme loadings
- analyse experimental results
- analyse numerical results from Finite Element Method modeling
- understand relationship between mechanical properties and physical micromechanisms
- choose and use the relevant model for structural design

Course Contents

- Thermal loading and thermo-elasticity
- Light structures: anisotropic elasticity of composite materials
- Polymers and elastomers elasticity
- Plasticity of metallic crystals and alloys
- Computation of irreversible strains
- Design of a structure by finite elements
- Crack tolerance: fracture mechanics

Bibliography / Teaching Material and Textbooks

- Chaboche and Lemaître, Mechanics of Materials, Dunod
- Besson, Cailletaud, Chaboche, Forest, Non linear Mechanics of Materials, Hermès, 2001

Evaluation

3-hr written exam (70%), project (30%).

MG1500 - Biomechanics

Professor : Elsa VENNAT

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 32

Prerequisites : basics in biology, continuum mechanics, strength of materials, kinematics.

Period : S8 elective 9 between february and june

Domain : Sciences de la matière et du vivant

Course Organization

Lectures: 10.5 hr, Exercises: 12 hr, Labwork: 12 hr, written exam: 3hr

Evaluation

3-hr written exam (50%), written report on the practical work (50%).

MG1600 - Nanomechanics

Professor : Ann-Lenaig HAMON

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : MG1100: Introduction to continuum mechanics (isotropic linear elasticity)
PH1100: Introduction to quantum mechanics (Schrödinger equation), thermodynamics and statistical physics
Optional: introduction to crystallography and solid state physics.

Period : S7 elective 5 between september and january

Domain : Sciences de la matière et du vivant

Course Objectives

Due to the increasing miniaturization of systems, frontiers between mechanics and physics become more fuzzy and uncertain. Our goal is to highlight:

- The influence of physical phenomena on the atomic scale on mechanical properties on a macroscopic scale (thermoelasticity, anisotropy, elements of microplasticity...);
- New physical interactions to be taken into account in order to describe the mechanical behaviour of systems on micro- or nanometric scales (molecular dynamics for "discrete" atomic systems, quantum mechanics...).

Nano-objects are major technological high stakes for the future decades, for public health as well as for information or environment and energy. This class is an introduction to the nanometric scale where quantum and statistical physics, mechanics and thermodynamics are closely intertwined.

On completion of the course, students should be able to

- Use an energy approach for macroscopic mechanics (thermoelasticity and virtual power principle) in parallel with the variational approach in quantum mechanics. This notion is thus the guiding principle of the class. Implemented in a graded numerical "practical work" using finite elements;
- Change models according to their relevancy on a given scale (notions of microplasticity, "classical" atomistic models, quantum physics, thermodynamics vs. statistical physics).

Course Contents

- Crystal mechanical behaviour: Anisotropic Hooke's law, application to the perfect crystal. Thermoelasticity. Crystal defects: dislocations, elements of microplasticity;
- Polymers and elastomers: statistical mechanics (chain topology, lattices, reinforcement);
- Mechanical quantities of interest on the electron scale: Chemical bonding, molecule and crystal;
- Introduction to molecular dynamics, to ab-initio computations.

Course Organization

Students are confronted with the comprehension of the mechanical behaviour on a macroscopic scale such as metals or polymers considering their atomic structure. In pratice, a session is devoted to a computational "experimentation".

On the atomic scale, students are confronted to materials which are more or less disordered and described with probabilistic tools (wavefunctions, averages). They will discover how, on the macroscopic scale they can get a deterministic behaviour.

They will also become aware of the fact that, for nanometric systems, such a partition is challenged.

Bibliography / Teaching Material and Textbooks

- On Claroline: slides, solutions, forums;
- Teacher's lecture notes including a bibliography section.

Resources Mostly supervised by the lecturer in charge (Ann-Lenaig Hamon) for theory as well as exercises

Evaluation

- Computational "practical work" with written report (per group) (30% of the grade);
- Final written exam (70% of the grade);
- Presenteeism: .The malus of $2^{(n-3)}$ is still actual on the final grading from the 2nd unjustified absence.

MG1700 - Design of maintenance system of railroad way

Professor : Andrea BARBARULO

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 30

Prerequisites : MG1100,Basic knowledge of continuum mechanics, dynamics, physics and industrial engineering.

Period : S7 elective 6 january

Domain : Sciences pour l'ingénieur

Course Objectives

During this multidisciplinary course, students will to have to design and to size a system of supervision and maintenance of a railroad way. The objective of the course is to use the diverse skills acquired by the students to interact with a complex system and size certain parts of this system.

On completion of the course, students should be able to

- Know how to size a structure from notions of mechanics, material, physics, vibrations

- Know how to choose and run a model for a pre-sizing

- Analyze mechanisms of degradation in service and prediction of the lifetime in fatigue (way, rail, roadbed, catenary, etc.)

- Cost analysis, choice of strategy

Course Contents

- Dynamics of rigid solids, wave propagation, vibrations, electromagnetism, sensors, mechanics of the continuum media

- Computer-aided design, pre-sizing, digital model

- Wear, fatigue, crack propagation, material, in-service loadings

Course Organization

The pupils will work in mode project throughout the week reserved (approximately 50 hours) with daily deliverables.

Bibliography / Teaching Material and Textbooks

Reference books

Evaluation

Daily deliverables + participation + oral defense..

MG1960 - Civil Engineering Laboratory

Professor : François COINTE

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** : 20

Prerequisites : Basic notions on Strength of Materials and Construction Processes

Period : S5 between September and January
S6 between february and june

Course Objectives

- Provide an introduction to issues of construction: urbanism, architecture, design, economics.
- Learn how to build a rigorous scientific approach: analysis of the problem at stake, justification of the chosen solution.
- Learn how to conduct a relevant Internet data mining.
- Learn communication skills: interaction between the participants of a group, oral presentation..
- Respect the deadlines for the completion of a work: presentation, written documents..

On completion of the course, students should be able to

- understand the complexity of urban design and to manage a construction project
- gain notions of construction and civil engineering

Course Contents

- Design a complex structure starting from a plane view, according to town-planning, architectural, functional criteria (with the help of a bibliographic search and a visit of illustrative examples in Paris).
- Build a model (real and computerized) and plans of the proposed design
- Verify the structural strength of the proposed design and design the main structural elements by means of simple structural mechanics computer codes

Course Organization

Labwork: 27 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

Course reader in French

Evaluation

Practical work (40%), behavior (10%), oral defense (25%) and scientific poster (25%)

MG1970 - Design of Mechanical Structures Laboratory

Professor : Elsa VENNAT

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** : 20

Prerequisites : Basic knowledge of continuum mechanics: stress, strain, elasticity

Period : S5 between September and January
S6 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

Teach scientific experimental methodology:

- how to define the problem precisely and the model that should be used
- how to set up the experiments
- how to discuss the experimental results and compare them with other sources
- how to take into account safety issues

On completion of the course, students should be able to

- perform and analyse mechanical tests and observe the microstructure
- be able to discuss the validity of experimental results
- discuss the links between the microstructure of materials with the macroscopical mechanical properties
- compare results of numerical simulation to experimental observations

Course Contents

This laboratory course deals with the experimental study of the mechanical behavior of several materials and their effects on the design of complex structures simulated with a numerical tool.

The students can choose one of the following subjects:

- fabrication of a composite material, study of the associated experimental mechanical behavior and design of a mechanical part
- fabrication of concrete, study of the associated experimental mechanical behavior, analysis of the stress heterogeneities by photoelasticimetry and finite element ananlysis

- study of the experimental mechanical behavior of a cardboard sheet and design of a bridge, experimental validation
- experimental study of a steel, influence of thermal treatments on the microstructure and link to the mechanical behavior
- experimental study of an aluminum, mechanical characterization using digital image correlation, comparison with numerical simulation
- experimental study of a biological material, the bone, analysis of its microstructure and porosity, characterization of the mechanical behaviour by compression tests and nano-indentation

The analysis of the experimental results is complemented with numerical results from a finite element software using Comsol or Abaqus.

Course Organization

Labwork: 27 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

Documents from the Mechanics Course (MG1100) + Scientific articles

Evaluation

Practical work (40%), behavior (20%), oral defense (20%) and scientific poster (20%)

MG2812 - Introduction to Acoustics: Industrial and Musical Acoustics

Professor : Pierre-Etienne GAUTIER

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 42

Prerequisites : It is recommended to have completed the course MG1300 or equivalent

Period : S8 elective 11 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

- Discover methods and tools used in acoustics with examples in industrial cases and musical acoustics
- Become familiar with the main models used in acoustics from an industrial point of view

Case studies will be presented by researchers and engineers from industry showing, whenever possible, parallel approaches for both musical and industrial applications.

On completion of the course, students should be able to

- understand basic problems in acoustics from an industrial perspective
- develop methods to solve these problems

Course Contents

- Introduction to acoustics , basic acosutic sources, waveguide propagation, room acoustics (P.-E. Gautier)
- Psychoacoustics (S. Meunier, LMA Marseille)
- Rolling and aerodynamic noise: applications to railway systems (P.-E. Gautier)
- Propagation: weather influence, ground effects , noise barriers
- Physics of musical instruments (R. Caussé, IRCAM-Paris)

Course Organization

Tutorials and exercises (integrated sessions): 33h, Exam: 3h

Bibliography / Teaching Material and Textbooks

Course reader (in French). slides from course

Evaluation

CFO: 3-hr written exam

MG2814 - Economics and Design of Dams

Professor : Arézou MODARESSI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 30

Prerequisites : Basic notions in Economics, Hydraulics, Statics, Design of structures

Period : S8 elective 9 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

Give a global vision on the role of dams on water and energy management in the sustainable development framework. Different technologies of dam construction and the basic knowledge of their design will be developed, especially in relation to their safety.

On completion of the course, students should be able to

- plan the integration process of a dam in its natural and human context, and the decision process for its construction according to environmental, technical, and social criteria
- design dams in a given site
- anticipate the requirements for operation and maintenance, and monitoring / control of the safety of a dam in operation

Course Contents

- Dams: their role and their environment, their integration within the socio-economic background of land reclamation
- Dams and reservoirs, water resources management and energy production. Global sizing by economic analysis
- Dams and reservoirs, environmental and social aspects, impact analysis
- Gravity dams: stability, design, construction technologies
- Arch dams: principles of behavior, verification and design
- Exercise of application. Stability of a Roller Compacted Concrete (RCC) Dam
- Foundations and their treatment. Stability of the supporting base
- Earth and rockfill-dams: conception, stability, behavior computation
- Water control organs : flood evacuation, emptying and filling
- Hydropower plants
- Monitoring: principles, instruments, interpretation

Course Organization

Tutorials: 21 hr, Labwork: 12 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

- Case study documents and technical papers
- French and English textbooks

Resources

Arezou Modaressi CentraleSupélec supervisor

Etienne Frsossard Company's contact (Tractebel- Engie)

Both are available to answer the students' questions and demands.

No specific materiam needed, only a blackboard and a projector.

Evaluation

3-hr written final exam

MG2816 - Micro-Electro-Mechanical Systems (MEMS)

Professor : Denis AUBRY

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 36

Prerequisites : MG1100,Basic knowledge in Continuum Mechanics, Solids and Fluids

Period : S8 elective 10 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

In many technological areas, the miniaturization of systems is a major industrial issue. Micro-Electromechanical-Systems (MEMS) are often preferred to purely electronic systems for applications of measurement and control because they offer signicant advantages in terms of energy consumption (low insertion losses and insulation), reliability, fast response time. They are used in a variety of industrial applications such as automobiles, aeronautics, medicine, biology, telecommunications (ABS, smart phones, micro-switches, sensors, actuators).

Our objective is to present the operating principles, industrial applications, and fabrication processes for selected MEMS. In these examples, the main *multiphysics coupling mechanisms* will be described: vibrations, flow-structure interactions, thermal and electrical interactions. Numerical simulations of these coupling mechanisms will be presented through *intensive use of a multiphysics software*.

On completion of the course, students should be able to

- MEMS technology: applications, micromachining, design process and principles
- Design of sensors, actuators, gyroscopes, switch, micromotor
- Mutiphysics problems solving including: mechanics, temperature, fluids, electric and magnetic fields
- Applied skills with a multiphysics finite element software

Course Contents

- Interest and use of MEMS
- Main fabrication processes
- Multiphysics coupling: vibrations of microsystems, distortion by ohmic or capacitve effects, piezo-electric effects, microflow-structure coupling and fluid dampening in thin films
- Numerical simulations of real MEMS

Course Organization

Lectures: 12 hr, Tutorials: 12 hr, Project : 9 hr, Exam: oral presentation

Bibliography / Teaching Material and Textbooks

- Minhang Bao, Analysis and Design Principles of MEMS devices, Elsevier, 2005
- J. A. Pelesko, D. H. Bernstein, Modeling MEMS and NEMS, Chapman & Hall/CRC, 2003

Evaluation

Written report and oral defense of the project.

MG2817 - Applications of the Finite Element Method

Professor : Andrea BARBARULO

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 35

Prerequisites : Some knowledge of functional analysis

Period : S8 elective 12 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

The finite element method has become a method of choice for computational engineering and science simulations. The main objective of the course is to develop skills to effectively use the finite element method for the analysis of problems in solid and fluid mechanics. Students will learn the basic principles of the method, how to develop suitable finite element models, and how to interpret the numerical results. A second objective is to familiarize students with the COMSOL Multiphysics software. The skills acquired in this course will be useful for the supervision of conception and design projects.

On completion of the course, students should be able to

- derive the weak formulation of any initial- and boundary- value problem
- write the corresponding finite element formulation
- implement the model in COMSOL Multiphysics and solve the problem
- assess the accuracy of the finite element solution

Course Contents

The course will present the main theoretical aspects of the finite element method and its application to engineering problems using COMSOL Multiphysics. Topics will include:

- Variational formulation of classical 1D BVPs
- Finite element space and solution procedures
- Variational formulation of classical 2D BVPs
- Finite elements in 2D and in 3D
- Matrix assembly
- Mesh generation, convergence analysis, and discretization errors
- Adjoint problems
- Initial and boundary-value problems
- Multimodel/multiphysics applications

The theory will be illustrated by the development of COMSOL models drawn from applications in solid and fluid mechanics such as: linear elastic stress analysis, large deformations, thin plate and shell modeling, heat transfer, incompresible flows, etc.

Course Organization

Lectures: 15 hr, Labwork: 18 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

Lecture notes in English

Evaluation

3-hr written final exam (no document allowed, but computer allowed for the practical part). The project reports may count as up to 4 bonus points added to the mark of the final exam (if the student has more than 3 non justified absences, the bonus point will be lost).

MG2818 - Introduction to Oil & Gas Exploration & Production

Professor : Pierre JEHEL

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 20

Prerequisites : Good level in English (course in English); Background: Bachelor level in civil or mechanical engineering. Students interested in drilling, project management,… and in general, in the Oil & Gas industry.

Period : S8 elective 13 may

Domain : Sciences pour l'ingénieur

Course Objectives

- Complement theoretical studies with practical experience from Oil & Gas Industry
- Review of the fundamental of the Gas and LNG activities
- Provide background on drilling techniques
- Give technical and practical knowledge on surface facilities including platforms and pipelines designed and installed in deep offshore
- Presentation of hazard and safety issues related to Oil and Gas Exploration and Production

On completion of the course, students should be able to

- Understanding the key problems in petroleum exploration and production activities
- Applying their scientific and theoretical skills to subjects proposed in workshops

Course Contents

1. Natural Gas - LNG

- Introduction and specificities of natural gas
- Environment challenges
- Oil chain, gas chain
- Gas demand and supply
- Natural gas: production, treatment and transportation
- Liquefied natural gas: properties, processes

2. Drilling operations

- Introduction to drilling techniques

- Safety in offshore activities
- Well engineering
- Well construction
- Directional drilling
- Onshore and offshore Operations
- Drilling hazards

3. Subsea systems

- Definition, classification
- SURF hardware (Subsea Umbilicals, Risers,Flowlines)
- Subsea field layouts
- Subsea infrastructures
- Subsea installations

4. Oil and Gas Project Management

- General overview
- Project management basis
- O&G projects including planning, contracts, safety issues, cost control,…
- International projects

5. Geology

- Oil systems geology
- Technical approaches for oil exploration
- Oil wells characterisation

Course Organization

Courses are given by several Professors from Total Professeurs Associés

Bibliography / Teaching Material and Textbooks

Prints of the slides (in English), films,...

Resources

Senior engineers from Total and TPA (Total Professeurs Associeted).

Evaluation

Different subjects are given at the beginning of the week to groups of 3 to 4 students to develop during the week and present at the end.

MG2819 - New sensing systems for automotive seating

Professor : Laurent DANIEL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 20

Prerequisites : Basic background in Mechanics and Physics. Students will have to sign a confidentiality agreement with the industrial partner so as to protect the sensitive informations possibly released during the project.

Period : S8 elective 13 may

Domain : Mathématiques et sciences de l'information

Course Objectives

Automotive seats have been through a strong evolution in the past years. Treated before as purely mechanical systems, they now integrate mechatronic systems for motion actuation, heating or cooling systems, or passenger security. The next generation seats will incorporate sensing functionalities, so as to collect data such as passenger complexion, position, breath or heart rythm, or steadiness. These informations can then be used to ajust comfort or security functions. The objective of this course is to design a mechatronic system able to collect such information from the passenger of an automotive seat.

On completion of the course, students should be able to

- Design a mechatronic system using their knowledge in Mechanical design, Material science and Physics.

- select and use design tools

- integrate a system into a complex environment

- handle the complexity of industrial systems

- engage in team working

Course Contents

- Solid mechanics, continuum mechanics, vibrations, electromagnetism.

- Computer Assisted Design, analytical design, numerical design.

Course Organization

The students will work in project mode during a full week (approx. 50 h.) with daily deliverables.

Evaluation

Daily deliverables + implication + final defence

MG2920 - Sustainable Buildings and Architecture Laboratory

Professor : François COINTE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 24

Prerequisites : Ideally, students should have some basic notions on Energy, Strength of Materials and Construction Processes

Period : S8 elective 13 may

Domain : Sciences pour l'ingénieur

Course Objectives

- Provide an introduction to issues of urbanism and sustainable development

On completion of the course, students should be able to

- understand the complexity of the design and building in civil engineering
- understand the notions of construction, civil engineering, architectural design and energy issues of buildings

Course Contents

Construction, which consumes and discards resources and energy in great quantities, is one field where architects, contractors and engineers act urgently to develop and promote techniques and policies able to assist the drive towards sustainability.

During this five-day workshop, students will work in teams of 3-4 students to design a campus building in response to a recent international design competition, and will provide an analysis of their design in terms of the energy and environmental performance of the building.

Course Organization

Labwork: 36 hr (plus a half-day site visit)

Students enrolled in this course during the booked weeks will also attend two sessions positioned on Tuesday outside the booked weeks.

Bibliography / Teaching Material and Textbooks

- Reference documents provided in class
- Documents on the buildings seen during the half-day site visit in Paris
- Compilation of documents on contemporary campuses, to be used as a documentary basis

Resources

Instructors: François Cointe, Ulisse Vizzardi, Alain Boccato

Evaluation

Oral defense + reports.

Physics

PH1100 - Quantum and Statistical Physics

Professor : Jean-Michel GILLET

Language of instruction : FRANCAIS, ANGLAIS – **Number of hours** : 60 – **ECTS** : 5,0 - **Quota** :

Prerequisites : MA1100 MA1200, Sound knowledge of Newtonian and Maxwellian physics. Linear algebra, basics of probabilities, Fourier transform

Period : S6 between february and june

Course Objectives

This course aims at providing knowledge essential for the students in their future careers as engineers. It is built from the two corner stones of modern physics: quantum physics and statistical physics.

- quantum physics essentially describes the behavior of objects at the atomic scale;
- statistical physics provides the link from the microscopic to the macroscopic scale. It describes the behavior of large populations of identical particles. It links the microscopic properties that have a quantum nature with classical or macroscopic properties such as magnetization, temperature, heat capacity and other thermodynamic quantities.

The first half of the course is devoted to an introduction to quantum physics and the study of basic examples (e.g. the hydrogen atom and the harmonic oscillator). Most of the second half of the course is dedicated to the basics of statistical physics. The course ends with applications to solids, gases and a brief introduction to nuclear physics.

On completion of the course, students should be able to

Master orders of magnitude for basic properties, know how to determine classical physics range of applicability, how to implement the approximation methods, take advantage of the structure of the atom to master the properties, be familiar with some methods for characterizing properties of matter and be able to model and predict the change in the properties by confinement (nanophysics). Be aware of the physical meaning of the second principle, then understand the microscopic basis of thermodynamics, the origin of the conductivity, the reasons leading to the structure of the atomic nucleus and control the field of applications.

Course Contents

- Birth of a new physical theory

- Quantum wave physics
- Quantum formalism
- Time evolution
- Harmonic oscillators
- Angular momentum and spin
- From hydrogenoid atoms to the atom
- Conference
- Methods of approximation
- Ensembles of particles, microcanonical and canonical statistical treatment
- Quantum statistics and classical limit
- Ideal gases of fermions, the Sommerfeld metal
- Basics of nuclear physics

Course Organization

Lectures: 20 hr, Tutorials: 35.5 hr, Exams: 4.5 hr

Choice between 2 pedagogical systems:

- Lectures in the lecture hall (amphitheatre) followed by tutorials in smaller groups (typically, less than 40 students)
- Lectures and tutorials given by the same professor, in a class of less than 50 students. Sign-up is required. Attendance is mandatory.

Bibliography / Teaching Material and Textbooks

Course reader in French "Eléments de physique quantique et physique statistique" (J-M Gillet). Reference textbooks in English. "Quantum Mechanics" (Schiff), "Statistical Physics" (Reiff), "State of Matter" (Goodstein)

Resources

On the pedagogical plateform Claroline, one can find:

- self evaluation exercises
- exercises (questions and answers)
- simulations

Office hours: (about) once a week for invidual Q&A (PH1102).

Evaluation

1.5-hr written midterm exam,1.5-hr written final exam

PH1102 - Physics Tutorials

Professor : Jean-Michel GILLET

Language of instruction : FRANCAIS – **Number of hours** : 21 – **ECTS** : 0,0 - **Quota** :

Prerequisites : PH1100,Attendance to all PH1100 classes is mandatory

Period : S6 between february and june

Course Objectives

These tutorials are intended for students who need help with PH1100.

Course Organization

These tutorials are organized as questions & answers sessions. They take place once a week from 6:45 to 8:15 PM

PH1910 - Physics Laboratory

Professor : Gloria FOULET

Language of instruction : FRANCAIS, ANGLAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** : 26

Prerequisites :

Period : S5 between September and January
S6 between february and june

Course Objectives

To encourage students to develop their sense of observation and innovation and their critical capacities. The work guides the students more towards the acquisition of structured scientific procedures rather than towards any particular technique. Consequently emphasis lies on the acquisition of sound working practices rather than on the results obtained. The work is carried out by small groups of students under supervision in research laboratories. The topics researched are taken from a wide range of engineering fields.

Course Contents

Some subjects:

- Optical Holography. Applications
- Echography
- The superconductivity

Course Organization

Labwork: 26 hr, oral defense: 3 hr

Evaluation

Grading is based on the quality of labwork (coefficient 2), written report (coefficient 1), oral defense (coefficient 1), and participation (coefficient 1).

PH2100 - Waves

Professor : Hichem DAMMAK

Language of instruction : FRANCAIS, ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Maxwell's equations and electromagnetic waves in vacuum.

Period : S7 elective 2 between september and january

Domain : Sciences de la matière et du vivant

Course Objectives

Lectures provide basic elements necessary for all the disciplines that use waves: acoustics, seismology, telecommunications, guided waves, imaging techniques, etc.

On completion of the course, students should be able to

master Fourier analysis, understand concepts of waves and their applications in different domains.

Course Contents

- Wave propagation in vacuum. Plane wave development and Fourier analysis. Image processing.
- Radiation. Antenna directivity. Radar.
- Wave propagation in solids.
- Reflection and refraction. Absorption.
- Guided waves. Fibre optics.
- Analogy with acoustic waves.

Course Organization

Lectures: 12 hr, Tutorials: 21 hr, Exam: 3 hr

Lectures are offered in both languages : French and English

Bibliography / Teaching Material and Textbooks

Textbooks: lessons, problems and solutions.

Resources

Website on the pedagogical plateform including simulations.

Evaluation

3-hr written exam with documents.

PH2200 - Synchrotron X-ray Beamline Design

Professor : Pierre-Eymeric JANOLIN

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 42

Prerequisites : Basic knowledge in modern physics and heat transfer. Mechanical engineering skills will be useful. Students must simultaneously register in SH3300.

Period : S7 elective 6 january

Domain : Sciences de la matière et du vivant

Course Objectives

This is a multidisciplinary course. Teams of about 20 students are challenged with understanding, designing and scaling the physical, mechanical, heating and materials aspects of key technological components of a synchrotron beamline. The use of CAD tools is encouraged. For more information, see http://www.designworkshops.fr/

On completion of the course, students should be able to

- apply design concepts using basic notions of modern physics
- identify the key heat transfer modes to model and design systems. Use Comsol.
- know the key points for a pre-project study in a multidisciplinary context
- master the use of Ashby diagrams for materials selection
- understand orders of magnitude for mechanical and physical properties of usual materials
- develop teamwork abilities, know and identify different roles in a team (on the basis of Belbin tools); manage a workgroup, collect and share information, shape and defend the results of the work in front of an audience / a jury.

Course Contents

This module is a project-based learning activity, with emphasis on the following topics:

- Crystallography, radiation by an accelerated particule, fluorescence, absorption, scattering, diffraction of short wavelength radiation
- Heat transfer: convection, radiation, conduction, fluid mechanics
- Computer-Aided Design (CAD), numerical modeling, design pre-project, pre-scaling of mechanical systems.

- Selection of materials, standard mechanical properties, strength of materials in an extreme environment, surface states, elaboration and shaping processes
- Experiencing teamwork under time pressure, chairing a meeting, oral expression

Course Organization

Students who leave early in S8 will not be able to enroll in Synchrotron.

Students enrolled in PH2200 and who do the S8 Centrale engineering program, have the opportunity to enroll in a humanities SH3300 2 day course.If the student succeed the course, he will get 2 ECTS and will be exempted of Humanities education in S8. The student who succeed PH2200 and SH3300 thus get 5 ECTS.

Students will work in project mode during the one-week module (about 50 hr) and will attend four half-day preparation and debrief sessions on prior and subsequent weeks. **Students in PH2200 should not be enrolled in sports during the week of Synchrotron course**

The students enrolled in this course must attend the final defense, at synchrotron SOLEIL scheduled at the beginning of February; it is followed by a visit of the SOLEIL facility. Students leaving CentraleSupélec for their S8 will have their contribution to the final defense filmed during one the debrief sessions following the synchrotron week.

Bibliography / Teaching Material and Textbooks

Reference textbooks and databases. ShareDoc (asynchroneous collaborative platform), Adobe Connect (video-conferencing and synchroneous collaborative work platform), Spaceclaim (CAD) and Comsol (heat transfer).

Resources

The use of CAD tools (e.g. SPACECLAIM or SOLIDWORKS) is encouraged. Students who wish to learn these tools will be given access to a license of SPACECLAIM and will be provided with online tutorial sessions. Alternate design tools (drawings, models,...) are also very useful, in particular for the design of specific components of the beamline.

Evaluation

1/3 on the involvment during the week (evaluated by the profs as well as the other team members)

1/3 on the final presentation (one presenter per group, everybody in the group gets the same grade)

1/3 on the final report (common grade for the entire team)

PH2250 - Embarked nuclear reactor

Professor : Eric DIASCORN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 42

Prerequisites : Basic knowledge in nuclear physics and heat transfers. Due to site visit restrictions, the students registered in this courses must have a French passport.

Period : S7 elective 6 january

Domain : Sciences de la matière et du vivant

Course Objectives

his multidisciplinary course has been prepared for 2 teams of 21 students each. Students will have to understand, design and size several parts of an embedded nuclear boiler: core, steam generator, tank and radiation protection shield. Specific calculation codes could be used

On completion of the course, students should be able to

- Will know how to identify relevant heat transfers; systems simulation and sizing.
- Will have acquired knowledge of pre-project study key points within a multidisciplinary context.
- Will be able to identify the various roles to play in a team. They will know group leading and coordination, they will be able to retrieve and share information.
- Will know how to prepare and present their work (be able to express themselves in front of an audience / orals).

Course Contents

- Modeling operation of the neutron core of a nuclear pressurized water reactor. Factors of instability research.
- Thermo-hydraulic study of the core;
- Heat transfers: conduction, single and two-phased convection. Fluids mechanics.
- Radiation protection: sizing and shields optimization.
- Teamwork and project work, oral expression

Course Organization

This course takes place at Ecole des Applications Militaires de l'Energie Atomique, situated at Querqueville's Sergeants school. For reasons related to the courses location, only French students will be authorized to apply to this class. Accommodation on site.

Students will be working according to a project process during the week planned for this purpose.

Orals will take place at Centrale Supelec, Châtenay-Malabry campus.

Bibliography / Teaching Material and Textbooks

Reference books and databases.

Flica: numerical method dedicated to the study of core thermal-hydraulic analysis.

Serpent: three-dimensional continuous-energy Monte Carlo reactor physics burnup calculation code.

Evaluation

Daily deliverables + participation + defense.

PH2260 - Quantum cascade lasers

Professor : Thomas ANTONI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 42

Prerequisites : Quantum and Statistical Physics (PH1100), Partial Differentieal Equations (MA1400), Heat Transfer (EN1100)

Period : S7 elective 6 january

Domain : Sciences de la matière et du vivant

Course Objectives

The aim of this course is to learn new concepts in modern maths and physics and to realize how they enable technological breakthroughs that can be industrialized. This course is also a first opportunity to tackle the basic principles of nanotechnologies. In addition to scientific knowledge, it will also develop the soft skills of the engineer job through teamwork, written and oral communications.

On completion of the course, students should be able to

- turn a theoretical concept into an actual object
- pose the problem
- estimate orders of magnitude and iterate
- criticize a result
- know how to tackle multi-physics systems

Course Contents

- quantum physics (electronic transport, band structures, semiconductors)
- optics (mode guiding, cavities, emission)
- lasers
- basics of nanotechnologies
- partial differential equations
- numerical simulations through Matlab

Course Organization

This course is open to fourty students and will take place over a full week.

The students will be divided into two teams of twenty people, each team having to deliver a numerical quantum laser. The teams will be composed of four groups of five students, each group being more specifically responsible for developing a basic unit of the device.

Bibliography / Teaching Material and Textbooks

None

Evaluation

Oral presentation and reports by every group.

PH2300 - The Structure of Matter: from Solid-State Physics to Nano-Materials

Professor : Pietro CORTONA

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : PH1100,Basic knowledge of Quantum Mechanics and Statistical Mechanics

Period : S7 elective 5 between september and january

Domain : Sciences de la matière et du vivant

Course Objectives

- Provide basic knowledge of solid-state physics
- Introduce advanced topics, such as nano-sciences and opto-electronics, based on specific examples
- Give a broad oerview of material properties and their applications

On completion of the course, students should be able to

- deepen their knowledge in specific subjects of material science, solid-state physics or nano-materials
- develop autonomous research in the aforegoing fields

Course Contents

- Order in solids: the crystal lattice.
- Scattering of electromagnetic waves. Diffraction.
- Vibrations of crystals. Phonons. Thermal properties.
- Metals and conductivity: the Drude and Sommerfeld models.
- Band structure. Electrons in bulk solids and in nano-materials.
- Semiconductors. Quantum wells: applications in the opto-electronics field.
- Superconductivity: the strange properties of matter at low temperatures.
- Defects of crystals and their influence on the physical properties of materials.

Course Organization

Combined lectures and tutorials: 33-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- Course reader in French "Physique de la matière" (Cortona, Jérôme, Dhkil)
- N. W. Ashcroft and N. D. Mermin, "Solid State Physics," HRW International Editions
- Y. Quéré, "Physique des Matériaux," Ellipses

Resources

Exercices and slides are available on the course webpage.

Evaluation

3-hr written exam

PH2500 - A Crash Course in Modern Mathematical Physics

Professor : Igor KORNEV

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 30

Prerequisites : PH1100,Basics in quantum mechanics, topology and linear algebra.

Period : S8 elective 11 between february and june

Domain : Sciences de la matière et du vivant

Course Objectives

The fundamental laws of nature are geometrical rather than algebraic. This course introduces students to some of the key concepts of modern theoretical physics. The aim of this course is to achieve an understanding and appreciation of geometrical methods in physics.

On completion of the course, students should be able to

- Understand the concepts of geometrical methods and their role in modern physics.
- Analyse physics problems using appropriate techniques from group theory and differential geometry.
- Apply their knowledge to diverse situations in physics and engineering

Course Contents

Topics include a selection from advanced topics in group theory and differential geometry.

- Introduction: Discrete and continuous symmetries; Mathematical background for groups. (6hrs)
- Quantum mechanics and rotation invariance (3hrs).
- The group of rotations. Angular momentum and ladder operators. (6hrs)
- Spin. How quantum mechanics leads to the use of SU(2). (6hrs)
- Riemannian metrics, connections, geodesics, curvature. (6hrs)
- General Relativity; Einstein's Theory of Gravitation. (6hrs)

Course Organization

Lectures and weekly homework assignments.

Bibliography / Teaching Material and Textbooks

- Geometrical Methods of Mathematical Physics by Bernard Schutz
- General Relativity by R.M. Wald
- Auxiliary references: Riemannian Geometry by Manfredo do Carmo

Evaluation

- Homework: there will be, on average, one homework assignment every week - 40%
- Final exam - 60%

PH2600 - Relativities

Professor : Nathalie BESSON

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 4 between september and january

Domain : Sciences de la matière et du vivant

Course Objectives

In the early twentieth century, investigative tools increased knowledge in the areas of the infinitely large and the infinitely small. It then appeared that the classical view of physics was failing to describe the Universe. Special and general relativity represent a significant and necessary paradigm shift. Understanding them, while they oppose intuition, requires placing them in their historical context, developing mathematical tools, in particular geometrical ones, for their handling and delving into their main areas of validity. The latter include particle physics for the infinitely small and special relativity, and cosmology and astrophysics, for the infinitely large and general relativity. In conclusion, the main technological application, the GPS, which is now commonly used, will be presented.

On completion of the course, students should be able to

The course should allow the acquisition of concepts inherent to relativity, manipulation of mathematical tools, especially geometric and tensor, applications in the fields of particle physics, cosmology, astrophysics and technology.

Course Contents

1.   Special relativity

a.   Historical introduction

i.   From geocentrism to Galileo

ii.   Newton's law in classical mechanics

iii.   Measure of the speed of light

iv.   Late XIX century enigmas: Maxwell equations, Michelson/Morley experiment

b.   Fundamental principles

i.   Einstein solution, special relativity, postulates

ii.   Implications, revisit physics

iii.   Geometrical deformations

c.   Minkowsky geometry

i.   Space-time, metric

ii.   Four-vectors manipulation

iii.   Mechanics in the relativistic framework

d.   Application to particle physics

i.   Point objects: energy-momentum conservation, boost

ii.   Composite objects: length contraction

2.   General relativity

a.   A curved surface in an Euclidian space: metric

b.   Equivalence principle: effect on photons and clocks, gravitational redshift, curved space-time

c.   Description of curved space-time: tensors, bases, surfaces and volumes

d.   Equation of motion: covariant derivative, equation of motion

e.   Variationnal principle: geodesics, constant of motion

f.   Einstein equation: tidal forces and curvature, energy-momentum tensor

g.   Around stars: Schwarzschild geometry, gravitational redshift, orbits and effective potential (massive particles and photons), Perihelia, light deflection

h.   Black holes: Geometrical issues at the black hole horizon, beyond the horizon, alternative coordinates (Kruskal-Szekeres), astrophysical black holes, Hawking radiation

i.   Cosmology: Geometry of the Universe, cosmological models, measuring cosmological parameters, dark matter and dark energy.

Course Organization

27h courses + 6h TD + 3h written exam. At the end of each 1h30 course, a few minutes are devoted to an exercize, the maximum mark which can be obtained is 2 points for the nine exercizes on special relativity and 2 points for the nine exercizes on general relativity.

Bibliography / Teaching Material and Textbooks

A handbook is available and specific material given for each course on claroline

Evaluation

Mandatory final exam: 3-hr written exam.

PH2812 - Introduction to Atomic and Molecular Physics

Professor : Igor KORNEV

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : PH1100,Basics knowledge in modern physics

Period : S8 elective 10 between february and june

Domain : Sciences de la matière et du vivant

Course Objectives

This course aims at providing the student with a knowledge that is complementary to the PH1100 physics course. It introduces to atomic and molecular physics using both traditional lectures and exercise sessions for a better involvement of the students. It gives a wide perspective onto a major domain of physics with applications to chemistry and spectroscopy methods.

On completion of the course, students should be able to

Apply basic concepts in quantum physical-chemistry

Course Contents

- Structure of the atom : hydrogen atom ; orders of magnitude ; several electrons atoms ; central field model ; electronic configuration ; spin-orbit coupling ; emission and absorption ; radiative dipolar transitions ; X-rays
- External fields effects : strong field and weak field Zeeman ; polarisation of transitions ; magnetic resonance ; optical detection ; Stark effect
- Study of diatomic molecules ; electronic structure of $H2+$; several electrons molecules ; vibration and rotation of molecules

Course Organization

Lectures: 16-hr, Tutorials: 17-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- Course reader (in French)
- Atoms and Molecules (M. Weissbluth, Academic Press) or Physics of Atoms and Molecules (Bransden and Joachain, Benjamin Cummings Ed.)

Evaluation

3-hr written final exam

PH2813 - Advanced Materials and Novel Devices for Information Technologies

Professor : Brahim DKHIL

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : Basic knowledge in solid state physics, electromagnetism, electronics, materials science

Period : S8 elective 8 between february and june

Domain : Sciences de la matière et du vivant

Course Objectives

The main goal of this interactive course is to present the state-of-the-art in research in the field of advanced electronic materials used in information and communication technologies. The novel devices considered are spintronics, mobile phones, sensor arrays and imaging systems, mass storage devices, random access memories, microwave communication systems or quantum computing.

On completion of the course, students should be able to

- Design a database suiting their needs
- Understand pros and cons of query tools; SQL and programming languages in dealing with databases

Course Contents

Research on new physical properties, ever more innovative, still unknown or not yet associated tpgether, permits the emergence of original materials because of a better control of matter at a nanoscale level, thus allowing novel nanostructures. Therefore, the knowledge and understanding of the physical mechanisms and phenomena involved in these physical properties, at different scale levels, should not be missed as they are a key step between the fabrication of the materials and their technological applications.

This course will highlight outstanding properties such as superconductivity, colossal magnetoresistance or giant piezoelectricity. The microscopic mechanism involved in these properties will be presented, by especially stressing the relationship between the structure (atomic, electronic, magnetic, nanometric, etc.) and the specific properties. The topics will address: dielectrics and ferroelectrics, magnetism and superconductivity, magnetoelectrics and multiferroics, optical phenomena and metamaterials, nano-objects: synthesis and

characterization, collective phenomena and phase transition, electronic conduction and size effects.

Course Organization

Lectures: 18-hr, Tutorials: 9-hr, Labwork: 6-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- Lecture notes: Advanced materials and novel devices for IT, B. Dkhil et al.
- Physics of solid state (C. Kittel)
- Solid State Physics (N.W. Aschcroft and N.D.Mermin)
- Nanomaterials (J. Chen)

Evaluation

Quiz (0.5-hr), report on team project, oral defense on the project (2.5-hr)

PH2814 - Science-Fiction and Physics

Professor : Pascal BERNAUD

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 30

Prerequisites : This teaching activity is related to physics but also energy, mechanical engineering, and so on, depending on the chosen text and on the speciality devoted inside the team in charge of the study of the text.

Period : S8 elective 13 may

Domain : Sciences de la matière et du vivant

Course Objectives

The main objective of this course is not to "learn" physics but to "do" physics, using the knowledge students have of physics to understand and model specific problems. The work is done in teams. However, the instructors will provide training on subjects not usually taught at Ecole Centrale: relativity, introduction to astrophysics, allometry etc.

This teaching activity takes place in one single but full week and, beside the scientific challenge to solve all the questions "given" by the Sci-Fi story, the team organisation plays some important rule for the result.

On completion of the course, students should be able to

- acquire a critical sense vis a vis readings or other type of information
- learn how to use order-of-magnitude analysis, out-of-the-box thinking, common sense
- show team working ability

Course Contents

Sci-Fi stories are used as raw material for this teaching activity. The goal is to determine if what is described in the texts is compatible with the laws of physics. To this end, the problem must be modeled and then solved as realistically as possible. Additional material (for instance elements on star evolution, neutron stars, black holes, similitude, allometry, etc) may be introduced by the professor as needed.

The week is organized as written below:

- On Monday introduction to the methodology through examples by the teaching staff

- election of the stories and team building

- analytical reading of the texts

- first analysis of different topics to study and problems to solve

- sharing time between teams, possibility of creation of super-teams devoted to solve some problems out of the school basic curriculum

- analysis and problem solving

- writing of a detailed report

- preparation of a defense

- defense of every team, facing all the other students

Professors are advisers during the first day and methodology demonstration, but also all week long when listing the problems to be solved and methods to be used for these problem solving.

This course is typically a good opportunity to delve into the following topics:

- statistical physics
- quantum physics
- heat transfer: steady and unsteady conduction, convection, radiation
- fluid mechanics
- strength of materials
- celestial mechanics
- astrophysics, stellar evolution…

Course Organization

Combined lectures and tutorials: one full week

Exam: oral defense of a teamwork during the final day + written report

Bibliography / Teaching Material and Textbooks

All necessary documents are provided by the instructors for topics including relativity, stellar evolution, neutron stars, black holes, ...

Resources

Lecturers: Pascal Bernaud (Centrale Paris), Ann-Lenaig Hamon (Centrale Paris), Peter Schattschneider (TU Wien)

Evaluation

- final written report
- oral presentation in teams, during the final day of the week

PH2821 - Applications of statistical physics to complex socio-economical systems

Professor : Gregory SCHEHR

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 30

Prerequisites : Basic probability theory. Programming in either MATLAB, C/C++, Python or R

Period : S8 elective 12 between february and june

Domain : Sciences de la matière et du vivant

Course Objectives

Provide an understanding of the fundamental concepts of statistical physics, and their application to the study of diverse complex systems in natural and socio-economical environments, which share the characteristics of competition for resources among interacting agents and their adaptation to dynamically changing environments.

The course will explore some very elegant, thought-provoking and intriguing models, tools and analyses in the studies of complex systems, inspired by ideas and concepts in statistical physics. The students will learn how to conduct numerical laboratory experiments and simulations of complex systems, and ways to tackle related problems (both individually and in teams).

On completion of the course, students should be able to

Understand the theoretical concepts of:

- basics of statistical physics and its inter-disciplinary applications
- complex systems and difficulties in handling them
- multi-agent based modeling and its advantages
- random networks and their applications

Emphasis will be laid on developing presentation skills, working individually (with original ideas) and working in a collaborative team as well.

Course Contents

Statistical physics has been defined as that "branch of physics that combines the principles and procedures of statistics with the laws of both classical and quantum mechanics, particularly with respect to the field of thermodynamics. It aims to predict and explain the

measurable properties of macroscopic (bulk) systems on the basis of the properties and behaviour of their microscopic constituents. The term "complex systems" was coined to cover the wide-ranging variety of such systems which include examples from physics, chemistry, biology, computer science and also social sciences. The concepts and methods of statistical physics proved to be extremely useful in application to these diverse complex systems, many of which involve many competing agents. The understanding of the global behaviour of complex systems seems to require such concepts as stochastic dynamics, correlation effects, self-organization, self-similarity and scaling, theory of networks and combinatorial optimization, and for their application it is not necessary to go into the detailed "microscopic" description of the complex system.

The students gain knowledge about:

- Basics of statistical physics and complex systems
- Study of socio-economic networks
- Random networks
- Multi-agent modeling: kinetic-exchange and game-theoretical

The classes are divided into two forms: (a) theoretical (lectures) and (b) practical (programming exercises and projects). During lectures, the basic theory and the recent trends will be presented by the instructor. In the practical classes, students will be assigned to groups and will work on lab exercises and projects. The practical classes, supervised by an assistant, will mainly consist of implementing some standard algorithms described during the lectures and aim at consolidating the theoretical techniques described in class. Also, simple projects will be allotted to small teams, where some notions of the theoretical part will need to be applied and implemented. The project will enable the candidate to conduct some independent work as well as team activities. The implementation may be done either in MATLAB, C/C++, Python or R.

Course Organization

Lectures: 14-hr, Tutorials: 3-hr, Labwork: 15-hr, Exams: 4-hr

Bibliography / Teaching Material and Textbooks

Presentations and supplementary materials will be uploaded on the website at the end of every lecture. No course reader provided.

Resources

Lecturers: Grégory Schehr (CNRS, Univ. Paris-Sud, LPTMS), Kevin Primicerio (Chaire de finance quantitative, Labo. M. A. S.), Marcus Cordi (Chaire de finance quantitative, Labo M.A.S).

Evaluation

Labwork and group project with oral defense: 75%, 1-hr mid-term written exam (mandatory): 25%.

PH2930 - Nuclear Physics Laboratory

Professor : Jean-Christophe BODINEAU

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 30

Prerequisites : PH1100, Due to site visit restrictions, the students registered in this lab series must have a French passport.

Period : S8 elective 13 may

Domain : Sciences de la matière et du vivant

Course Objectives

This module provides an experimental introduction to the physics of nuclei and nuclear technologies. It aims at educating engineers/researchers with clear and sound ideas about this field.

On completion of the course, students should be able to

- understand the basics of nuclear physics (structures of nuclei, radiations, natural and artificial radioactivity, fusion-fission-transmutation, nuclear astrophysics, etc)
- deal with radiation hygiene
- master nuclear detection and diagnostic techniques
- exploit the potentials of nuclear technologies

Course Contents

- One-day introductory courses (1-nuclei, 2-radiations, 3-energy, 4-cosmos)
- One-day introductory demonstrations at the science museum "Palais de la découverte" (cloud and spark chambers, radioactive sources, alpha-beta-gamma-cosmic rays detectors, deuteron accelerator and neutron beam, etc)
- Three half-days labworks (driving ISIS reactor, measurements of radioactive lifetimes, study of alpha emission, gamma-ray spectroscopy)
- One-day visit at CEA labs in Bruyères (TERA supercomputer, linear accelerator, etc)

Lunches with the speakers and former centralians.

Course Organization

Lectures, labwork and visits: 36-hr

Week booked 2 + two Tuesdays

Bibliography / Teaching Material and Textbooks

- Lecture notes about radiations
- Slides of the presentations

Evaluation

Written reports.

Chemical Engineering

PR1100 - Introduction to Materials

Professor : Jean-Hubert SCHMITT

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : You can not be enrolled in this course PR1100 if you followed the course MG1400 current semester 7

Period : S6 elective 1 between february and june
S8 elective 8 between february and june

Domain : Sciences de la matière et du vivant

Course Objectives

- Give an overview of material-related problems and their key role in all sectors of the economy
- Show the multidisciplinary approach required to solve these problems
- Study the main classes of materials and explain their functional and structural properties
- Establish the relationships between the processing, structure, and properties of materials

On completion of the course, students should be able to

- select the suitable material for a given application
- understand the relationships between the processing, the structure and the properties of materials
- implement simple physical models to describe the behavior of materials

Course Contents

Introduction: presentation of problems and issues of materials in various domains

The main classes of materials: definition from the nature of chemical bonding, resulting properties and use, material selection

- Structures and phase transformations of materials
- Order and disorder: from crystal to amorphous
- Defects (0D to 3D)
- Thermodynamic equilibria: from Gibbs energy to phase diagrams

- Kinetics of phase transformation: phase nucleation and growth

Material properties

- The mechanisms of plastic deformation, modeling at the microscale
- Damage and fracture of materials
- Functional properties (thermal and electrical conductivity, ferroelectricity, magnetism, optics)

Invited conferences to illustrate materials problems in specific economic area

Course Organization

Lectures: 21 hr, Tutorials: 12 hr, Exam: 3 hr

Bibliography / Teaching Material and Textbooks

- Course reader : Génie des matériaux, de J.B. Guillot
- M. Ashby and D. Jones, Materials Engineering

Resources

Instructors: V. Aubin, B. Dkhil, H. Duval, J.-H. Schmitt

Evaluation

3-hr written exam with documents and calculator

PR1930 - Materials and biomaterials - Laboratory

Professor : Mehdi AYOUZ

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** : 12

Prerequisites :

Period : S5 between September and January
S6 between february and june

Course Objectives

The aim of this activity is to offer to each working group three students, supervised by a teaching assistant or a researcher, an introduction to the scientific experimental approach in a four-day mini-project dealing with materials, the analysis of their properties (thermal, hygroscopic, structural, mechanical, chemical), or materials behavior under different constraints; physicals, chemicals or biological. The experimental results are confronted to analytical or numerical models in order to improve these models and make them more relevant.

On completion of the course, students should be able to

- Deal with the methodological aspects of experimental studies
- Analytical/numerical modeing of physical phenomena and confrontation with experiments
- Know the analysis methods of thermal, hygroscopic, structural, mechanical and chemical properties of materials
- Know the behavior of materials and biomaterials under different constraints such as pressure, humidity, temperature, etc.
- Introduction to methods of observation and modeling of biological activity as bacteria, algae, yeasts,

Course Contents

In addition to the experimental work, students perform a short bibliographic study to analyze the problematic of their case and to establish the state of the art. They are asked to demonstrate the relevance of the technical choices and experimental procedures implemented. After the experimental work, they prepare a summary report to describe how their work addresses the initial problem. They can also propose additional experiments to complement the work performed. The experimental results are usually confronted to analytical and/or numerical models in order to improve these models and make them more relevant.

Examples of topics offered (may change from year to year):

- Control and reduction of atmospheric pollution of vehicles : modeling and observing the growth of oxide particles in the car bodies
- Hygroscopic characterization of wood-based materials used as isolating material in buildings.
- Correlation between microstructure and mechanical properties of ceramic for biomedical applications.
- Structural hardening of an alloy Al-4%Cu.
- Determination of the porous morphology by transport in scarce gas phase.
- Observation and modeling of the biological activity in wood-based materials.
- Micro localization of the micro-organism in a photo-bioreactor: observation and modeling.

Course Organization

Labwork: 27-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- Articles from the bibliographic research.
- Numerical programs: MATLAB, COMSOL, programs of quantum physics, C/F90 codes,..
- Books on the basic notions and on the technical study of materials.

Evaluation

Oral defense and report.

Evaluation criteria: quality of experimental work, oral defense, written report, participation, and involvement.

The following factor shall be applied to determine the final grade: - Experimental work: coef 2 - Oral presentation: 1 coef - Written document coef 1 - Behavior: 1 coef.

PR2100 - Water Treatment and Underground Water Protection

Professor : Arézou MODARESSI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 20

Prerequisites :

Period : S8 elective 12 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

This course aims to study and understand the interactions between mankind and the water drawn from nature, in particular:

- the processes used to produce or treat water after its use (urban wastewater, industrial effluents) of a given quality (drinking water, water used in processes).

- the study of underground water and its treatment and protection management with respect to the dynamics of contaminents, monitoring and decontamination techniques.

On completion of the course, students should be able to

- know the methods for analysis, treatment and production of water with a given quality

- design a part of such installations

- understand the hydraulics of underground water and related aspects and parameters

- understand the transport and transfer mechanisms of different types of pollutants in ground water and be able to model them

- know the main management and treatments techniques according to the type of pollution

Course Contents

- Introduction: availability of water, laws, standards, biological and physicochemical processes for treating water and effluents (6 hr),

- Introduction to hydrogeology, contaminantsand their dynamics in underground water, ground water management, monitoring and treatment of polluted sites (3hr),

- Modelling hydraulics and mechanisms of transport and transfer of pollutants in groundwater (6 hr),

- Labwork on numerical simulation of underground water protection and pollution case studies (9 hr),

- Labwork on water analysis and treatment processes or exercises on design of installations, depending on availability of equipment (9 hr).

Course Organization

Tutorials: 15-hr, Labwork: 18-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

PowerPoint presentations

Scientific papers

Internat websites

Resources

Arezou Modaressi supervisor responsable

Barbara Malinowska responsable for process Labwork

external teachers

comsol-Multiphysics software

Labwork at LPGM

Evaluation

- (50%)Written exam (3 hr)

- (25%)Brief lab reports

- (25%)Synthetic reports on numerical simulation labwork and the case study

PR2940 - Experimental activity - Processes and Environment

Professor : Barbara MALINOWSKA, MATTHIEU RIVOLLIER

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 32 – **ECTS** : 2,0 - **Quota** : 15

Prerequisites : There are no prerequisites. Nevertheless basic knowledge in process engineering can be useful. Similarly, some notions in chemistry and electrochemistry can also be useful.

Period : S5 between September and January
S6 between february and june

Course Objectives

Propose to the students, working in groups of two or three, supervised by teacher or researcher, an initiation to the scientific research through a project.

Acquire the knowledge base enabling:

- perform a bibliographic research on a scientific subject;
- be able to plan the experimentation in laboratory;
- present clearly the results;
- have a critical view on obtained results;
- working with the respect to the safety regulations for laboratories.

On completion of the course, students should be able to

- Apply in practice the methodological aspects of experimental studies
- Know the the basic concepts of membrane and/or electromembrane processes
- Use the pilot units (electrodialysis, ultrafiltration, nanofiltration, electrolysis)
- Use modern analytical tools (titration, atomic absorption spectrometry, infrared spectrometry FTIR-ATR)

Course Contents

This activity begins by a bibliographical research. The aim is to establish the state of the art versus the proposed subject and to place the project in the general context. Then, to reach the purpose, the students must perform the experiments by implementing the operations under the conditions chosen by themselves. In the end of experimental work, they have to analyse and discuss the obtained results.

The proposed subjects concern:

- treatment of solid, liquid or gaseous effluents
- methods/operations : lixiviation, separation/concentration of pollution (membrane and/or electromembrane processes, liquid-liquid extraction, …)

Course Organization

Practical work in the laboratory (LGPM)

- Presentation of the projects: 3 hr
- Partial visit of laboratory: 1h
- Bibliographic search, labwork and results analysis: 22 hr
- Preparation of the presentation and oral defense of projects: 6 hr

Written report to prepare within a week.

Bibliography / Teaching Material and Textbooks

Scientific articles from the bibliographical research carried out during this activity.

Resources

Lecturers and researchers (TBC): Arnaud BUCH, Julien LEMAIRE, Barbara MALINOWSKA, John PACHON,

Evaluation

- Experimental work quality (coeff. 2)
- Oral defense (coeff.1)
- Behavior and respect for safety regulations in the laboratory (coeff. 1)
- Written report (coeff. 1)
- Assiduity (coeff between 0 to 1according to absences)

PR3100 - Chemical Engineering and Sustainable Development

Professor : Moncef STAMBOULI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Heat transfer, basis of fluid mechanics, thermochemistry, chemical kinetics

Period : S6 elective 1 between february and june
S8 elective 8 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

This course is a general introduction to the techniques and methods employed in Chemical Engineering. It will allow students to acquire skills that are easily transposable to a number of other fields of engineering. One of the main objectives of Chemical Engineering is to design, implement and optimize environmentally friendly processes for use in the manufacture of an extensive range of products in many areas including the pharmaceutical, petrochemical, fine chemical, food, cosmetics, water and waste treatment, high-tech, biotechnology and traditional industries.

Many techniques and processes are widely used in the recycling and recovery of materials and the treatment of liquid and gas effluents, thus making them powerful allies of sustainable development policies on a global scale.

On completion of the course, students should be able to

- master the basic concepts of chemical engineering allowing them to design simple units in various fields (biotechnologies, energy production, water and waste treatment, …)
- extend these skills in new applications
- design environment-friendly processes

Course Contents

Expected courses (an update can be in progress)

- Lecture: introduction, flow models, mass and energy balance
- Case study: production of bioethanol

- Lecture: perfectly stirred reactors (1)
- Case study: production of an active pharmaceutical principle
- Lecture: perfectly stirred reactors (2)
- Case study: design of industrial wastewater treatment reactors
- Lecture: plug flow reactor
- Case study: production of styrene
- Lecture: liquid-vapor equilibria, single-stage distillation
- Case study: seawater desalination
- Lecture: multi-stage distillation with constant molar fluxes
- Case study: production of bioethanol
- Lecture: basis of mass transfer
- Case study: modeling of in vitro and in vivo treatments of oral intoxications
- Lecture: mass transfer
- Case study: design of a purification unit for polluted air
- Lecture: fuel cell
- Case study: design of a fuel cell for a car

Course Organization

Lectures: 15-hr, Tutorials: 15-hr, Oral presentations by students : 3-hr, Final Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- Course book + slides
- Techniques de l'ingénieur Procédés J 4010 ; J 1070 ; J 1072 ; J 1073 ; J 1074
- Perry Chemical Engineer's Handbook 7th edition, 1997, Mac Graw Hill

Evaluation

- Oral presentation on a bibliographic topic (40% of the final grade);
- Final exam: a 3-hr session in teams of 3 or 4 students and written report (60% of the final grade).

PR3101 - Chemical Engineering and Sustainable Development

Professor : François PUEL

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Heat transfer, basis of fluid mechanics, thermochemistry, chemical kinetics

Period : S7 elective 2 between september and january

Domain : Sciences pour l'ingénieur

Course Objectives

This course is a general introduction to the techniques and methods employed in Chemical Engineering. It will allow students to acquire skills that are easily transposable to a number of other fields of engineering. One of the main objectives of Chemical Engineering is to design, implement and optimize environmentally friendly processes for use in the manufacture of an extensive range of products in many areas including the pharmaceutical, petrochemical, fine chemical, food, cosmetics, water and waste treatment, high-tech, biotechnology and traditional industries.

Many techniques and processes are widely used in the recycling and recovery of materials and the treatment of liquid and gas effluents, thus making them powerful allies of sustainable development policies on a global scale.

On completion of the course, students should be able to

- master the basic concepts of chemical engineering allowing them to design simple units in various fields (biotechnologies, energy production, water and waste treatment, …)
- extend these skills in new applications
- design environment-friendly processes

Course Contents

Expected courses (an update can be in progress)

- Lecture: introduction, flow models, mass and energy balance
- Case study: production of bioethanol
- Lecture : Liquid-vapor equilibria, single stage distillation

- Case Study : seawater desalination
- Lecture : Multistage distillation
- Case Study : Recycling ammonia by distillation (photovolataic cell manufacturing process)
- Lecture : distillation : Constant Molar flow rates - Mac Cabe Thiele Method
- Case Study : recovery of PEG by rectification
- Lecture: perfectly stirred reactor and plug flow reactor (1) - isothermal mode
- Case study: production of an active pharmaceutical principle
- Lecture: perfectly stirred reactor and plud flow reactor (2) - polythermal mode
- Case study: design of industrial wastewater treatment reactors
- Case study: production of styrene
- Lecture: basis of mass transfer : local mass balance - Stationary duffusion
- Case study: mass transfer in gas phase
- Lecture: mass transfer - Forced convection
- Case study: water contanination in lead pipe
- Lecture: Mass Transfert - Double film model - Design of a mass transfer technology - Modeling
- Case study: Sulphur oxide elimination in a gas flow

Course Organization

Lectures: 15-hr, Tutorials: 15-hr, Oral presentations by students : 0.25-hr, Final Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- Course book + slides
- Techniques de l'ingénieur Procédés J 4010 ; J 1070 ; J 1072 ; J 1073 ; J 1074
- Perry Chemical Engineer's Handbook 7th edition, 1997, Mac Graw Hill

Evaluation

- Oral presentation on a bibliographic topic (30% of the final grade);
- Final exam: a 3-hr session (70% of the final grade)..

PR4200 - Electrical Power Systems

Professor : Amir ARZANDE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : basic notions in physics

Period : S7 elective 4 between september and january

Domain : Sciences pour l'ingénieur

Course Objectives

The objective of the course is to address two types of electric power systems: the power transmission network and electrical drive systems for applications like traction or propulsion. A power grid is an infrastructure to transport electricity from production centers to the consumers. It is composed of various components of which the most visible ones are power lines. The field of energy transport is still evolving to integrate the scientific and technical progress. The developments in power electronics now allow the realization of conversion from high voltage AC to high voltage DC and thus, the transport via DC, which was expensive in the eyes of Thomas Edison, is now feasible. A recent issue concerns the charging of electric vehicle batteries.

Electrical drive systems are another type of electric power system in which the electric motors and power converters work together, including more often a DC link, in order to drive a mechanical load.

On completion of the course, students should be able to

Students should be able to understand the working principles of the main elements of a power system, of an electrical drive system with application in traction and analyze its components and their operation.

Course Contents

- General information on electrical networks.

- Single- and three-phase electrical circuits.

- Power electronics: rectifier and inverter.

- Network components: cables and lines.

- Sources in the networks: electrical machines (synchronous machine).

- Electric traction: Electric motors (asynchronous motor and DC motor).

- Application examples.

Course Organization

Lectures: 18-hr, Tutorials: 15-hr, Exam: 3-hr

Each course is 3 hours and each tutorial is 3 hours.

Each turotiral is organized as follows: We start by studying a problem and continue through a simulation in Matlab-Simulink. Students are required to install and activate the campus license Total Academic Headcount Student (TAH) on the campus of CentraleSupélec). This license allows the students to access throughout the campus to MathWorks software on their personal PC.

Bibliography / Teaching Material and Textbooks

The course material in French consists of the following: 1) handouts 2) Power Point presentation of certain courses

Resources

The course is provided by 4 teachers at CentraleSupélec.

The tutorials are provided by 8 teachers from CentraleSupélec.

Evaluation

A 3-hr written exam is divided in two parts: one part on general knowledge, and another with exercises. Handouts and computers without internet will be allowed during the exercises.

PR4300 - Cogeneration and Energy Production

Professor : Tanguy POLINE

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 35

Prerequisites : General basic knowledge in physic (mechanics, thermodynamics,...)

Period : S8 elective 10 between february and june

Domain : Sciences pour l'ingénieur

Course Objectives

1/ Acquire general knowledge on energy production and consumption.

2/ Cogeneration/electricity plant:

- develop a project analysis (equipment, design, economic profitability)
- gain experience in operations (troubleshooting, control philosophy, environment)

3/ Be able, on a wide variety of energy related subjects (resources, technologies, processes, equipments, consumers), to perform a quick qualitative and numerical analysis.

On completion of the course, students should be able to

- Gain interdisciplinary knowledge in energy, and especially in cogeneration
- Quantify and perform a rough check of energy data in interdisciplinary areas

Course Contents

Cogeneration:

- Cogeneration principles, energy resources, specific costs.
- Basic cogeneration components: steam turbine, gas turbine, boiler, engine. Comparison.
- Heat recovery steam generator design. Technical details on the gas turbine.
- Plant operation: control philosophy, troubleshooting, costs, water management, environmental constraints.
- Potential visit in Rotterdam of industrial plants over one full day

Energy production and consumption:

- Presentation of main energy process lines with CO_2 (coal, liquid fuel, natural gas, bituminous).
- Partial presentation of main energy process lines without CO_2 (nuclear, hydraulic, wind, solar, bio, geothermal).
- Electricity and gas market.
- Sustainable development: classification of energy savings (electricity, industry, housing, transport).

Course Organization

Tutorials: 30-hr + one day visit + exam

Bibliography / Teaching Material and Textbooks

Handout & electronic associated pdf

Evaluation

1/3: oral presentation

2/3: final exam (MCQ + exercices) over 2.5-ht.

PR5100 - Biology

Professor : Christophe BERNARD

Language of instruction : FRANCAIS – **Number of hours** : 15 – **ECTS** : 0,5 - **Quota** :

Prerequisites :

Period : S6 between february and june

Domain : Sciences de la matière et du vivant

Course Objectives

We will cover general principles that define the living, seen as a complex system, using a multi-scale approach from the cell to the living organism. Two main concepts will be discussed:

- Understanding living organisms to repair them (health reasons),
- Understanding living organisms to use them for industrial purposes.

We shall show that these challenges can only be addressed though a multidisciplinary approach. Biology is, in fact, at a crossroad of many fields taught at Centrale Paris.

On completion of the course, students should be able to

Use and integrate engineering methods in biology.

Course Contents

General principles

- How does the cell work? Going from the gene to the proteine
- Metabilism and energy production in a cell
- Studying an organ: - offering a common crossroad between different fields
- Biology as a multidimensional dynamic system, characterized by invarients in different scales, from gene to the behavior of the living organisim.

Applications

- Genetic engineering to repair cells or to make them build important molecules (such as for medications)
- Biology for industrial purposes (bioengineering, depollution, biofuels)

- Interfaces living/non-living (nanotechnologies, artifical organs, etc.)
- Modeling the living

Course Organization

The course will be organized around various modeling levels.

Bibliography / Teaching Material and Textbooks

Materials provided during the class.

Resources

Team:

Christophe Bernard (INSERM), Véronique Letort (MA), Elsa Vennat (MG), Filipa Lopes (PR)

Evaluation

Final written exam (80% of score) + quiz during the sessions (20% of score)

PR5210 - The Genome

Professor : Diana LE ROUX

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : Basic knowledge of molecular biology.

Period : S7 elective 3 between september and january

Domain : Sciences pour l'ingénieur

Course Objectives

The main objective of the course is to inform future engineers about the functioning of the genome as a whole, and its analysis by *in vivo* or *in silico* methods such as transgenic mice and high-throughput sequencing technology, which uses statistical and mathematical tools to infer gene regulatory networks and data integration. Recently, the control of the genome reprogramming has led to the production of stem cells at will, which opens new and promising approaches to cell and gene therapy, which should ultimately help treat many inherited, infectious, or acquired diseases. The course will address these novel and revolutionary genome reprogramming strategies. Furthermore, we will evidence the limits to what can be deduced as well as expected from genomics.

On completion of the course, students should be able to

- be aware of technical tools and developments that enable to better understand how genomes operate ;
- understand the contributions of genomes to one's identity and the general principles that drive physiologic and pathologic immune evolution;
- appreciate how genomic information can be used for developing improved therapeutics;
- learn about the current status of stem cells and the new therapeutic developments;
- have a strategic vision of the way to get ahead in the field of genomics: from data mining to the extraction of innovative knowledge.

Course Contents

- Structure and regulation of genomes. Introduction to statistical methods for gene prediction and the analysis of high dimensional genomic data. Survey of high throughput tools that connect genotypes and phenotypes. Impact of genome on drug design.

- Using the genome for gene and cellular therapies and to develop personalized medicine strategies.
- Dynamic reprogramming of the genome: cellular plasticity.
- Basic functioning principles of the immune system which integrates genomic and other elements to constitute one's identity.

Course Organization

Lectures and tutorials: 33-hr, Exam: 3-hr, an individual ten-minute presentation on a biological topic will be requested.

Bibliography / Teaching Material and Textbooks

Course notes and slides available online

Evaluation

Oral presentation (20%), 3-hr final written exam (no documents and no computer allowed), (80%).

PR5300 - Biotechnology: Applications and Modeling

Professor : Filipa LOPES

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 4 between september and january

Domain : Sciences pour l'ingénieur

Course Objectives

Biotechnology is defined as "the application of science and technology for the processing of materials by biological agenst and enzymes to produce goods and services". These application areas are very broad and cover many industry sectors: health, food, sewage treatment, cosmetic, ... It is multidisciplinary, integrating the engineering sciences, biology and math for its development.This course is a general introduction to biotechnology and fermentation engineering in particular, considering the overall environment of a fermentation process, from the choice of the biological agent to the recovery of products and the modeling these bioprocesses.

On completion of the course, students should be able to

Control of fermentation engineering basic concepts applicable to different areas (food, health, environment, ...)

Course Contents

- Microbiology, eukaryotic cells vs prokaryotes, bacteria, yeast, microbial metabolism, regulation of metabolism, microbial growth, control microbial growth.
- molecular biology tools applied to industrial microbiology
- The bioreactor: Implementation of a fermentation process, different types and modes of bioreactors, microbial kinetics, mass transfer, agitation and aeration bioreactors, measurements and control of bioreactors. Separation and purification of fermentation products: filtration, chromatography, centrifugation.
- Bioprocess modeling (development and validation of the model, identification of parameters)
- Industrials interventions with biotechnology applications in various industrial sectors is expected
- Teaching will be realized through courses and tutorials.

Course Organization

Course and exercises: 33-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

Copy of Powerpoint slides, recommended books by stakeholders.

Resources

Several speakers, specialists in the various areas covered, involved in teaching.

Evaluation

3-hr written final exam (F) consisting of a first part (1-hr) without documents or calculator, and a second part (2-hr) with documents.

Industrial Engineering, Management, and Economic systems

SE1100 - Corporate Accounting and Finance

Professor : Danièle ATTIAS

Language of instruction : FRANCAIS – **Number of hours** : 27 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S5 between September and January

Domain : Sciences de l'entreprise

Course Objectives

The course will allow students to:

- understand the general operations of a company in an international environment and discover criteria of economic performance
- learn the typology of the various financial resources that are essential for corporate operations and development
- learn the fundamentals of financial analysis to be able to use financial data for corporate operations

On completion of the course, students should be able to

- understand a company from economic and financial standpoints, taking into account its environment
- know the typology of financial resources
- master the main corporate accounting and financial concepts, and use them

Course Contents

- Focus on value-adding companies in a profoundly changing international environment; triangle investment-production-technology
- Typology of financial resources available to companies, their cost and the implied trade-offs in terms of investment decisions
- Understanding the main accounting documents (balance sheet and income statement), and their purpose
- Interpreting economic and financial results (income statement intermediate balance, working capital need, cash management)

Course Organization
Amphis : 12-hr, E-learning and a activity report 15-hr

Bibliography / Teaching Material and Textbooks

All documents presented during the lectures are available on line, in addition to the content of the e-learning modules

Evaluation

Continuous control based on exercises and decisions taken at each stage of the game.

8 decisions are scored, collective decisions per group of 4 students. These 8 decisions (whose scoring criteria are given at each stage) represent 70% of the final mark.

This game ends at the end of the year with the writing of an activity report that summarizes and discusses the management and financial choices taken by the group. This activity report submitted at the end of december represents 30% of the final score.

SE1200 - Business Administration

Professor : Eléonore MOUNOUD

Language of instruction : FRANCAIS – **Number of hours** : 27 – **ECTS** : 2,0 - **Quota** :

Prerequisites : This course requires openness, curiosity and readiness to discuss economical, sociological and behaviorial issues regarding management, meaning managerial issues in and around organizations. This course addresses management from a rather "soft" perspective. Hence, students with a heavy rational, positivist, mathematical background should expect to be a bit surprised, if not puzzled, at some point of the class.

Period : S5 between September and January

Course Objectives

The course provides students with a structured understanding of how companies operate and can be managed. After the class, students should be familiar with concepts such as governance, strategy, partnering, organizing, etc.

On completion of the course, students should be able to

- Setting key issues regarding marketing of products and services
- Analyze corporate and business strategies within their competitive environment, taking into account its core competencies
- Analyze the main features of a corporate organizational structure and its key organizational processes
- Understand the main operational challenges and the logic of performance improvement
- Contextualize technological choices made on innovation projects; understand the importance of inter-functional teams for innovation

Course Contents

- Introduction: objectives, stakeholders, operation management and strategic management
- Marketing of products and services
- Corporate and business strategy
- Growth and strategic maneuvers
- Organizational models : structures and processes
- Operations management and management control
- Management of technology and innovation

Course Organization

Lectures: 12-hr, Tutorials: 12-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

Course reader in French + copy of the slides presented in class

Evaluation

- 3-hr written final exam (3.5-hr for international students) WITHOUT DOCUMENTATION and without calculator
- optional written midcourse exams
- oral participation in tutorials

SE1300 - Corporate and Market advanced Finance

Professor : Danièle ATTIAS

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : SE1100,Basic knowledge in general accounting and finance

Period : S7 elective 2 between september and january

Domain : Sciences de l'entreprise

Course Objectives

Building on the first year course SE1100, the course's objectives are to:

- Understand how a company operates in its economic and financial environments (markets, economic situation)
- Use financial and economic tools necessary to run a company: accounting and financial analysis, diagnostic and economic models
- Understand the issues of corporate finance via equity or debt

On completion of the course, students should be able to

- Master main corporate accounting and financial concepts and know how to use them in corporate operations
- Distinguish between cash-flow and income statement results
- Master the characteristics of the two main groups of financial resources and financial ratios.

Course Contents

- Accounting practices in companies, especially monetary representation
- Using corporate financial analysis tools: income statement intermediate balance, working capital, change in working capital, etc.
- Business plan, business model
- Finance a company via equity or debt
- The company in its environment: challenges of globalization, analysis of financial crises and their economic impact on companies

Course Organization

Lectures: 21-hr, Tutorials: 12-hr , Final exam: 3-hr

Bibliography / Teaching Material and Textbooks

Course readings are available on course website, together with class discussions and exercises and case studies

Evaluation

3-hr written exam (70%) + TD notes (30%).

SE1400 - Economics

Professor : Pascal DA COSTA

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 2,0 - **Quota** :

Prerequisites : No

Period : S7 between september and january

Course Objectives

The goal of the class of economics is to provide the basic concepts required to understand and analyze the economic environment. Each topic will be covered with real facts and statistics, and then explained with the theories of economics.

On completion of the course, students should be able to

- know recent economic theories, their purpose and their limits
- know processes to generate knowledge in economic analysis, in the fields of competition, growth financing, currency, economic policies, and international trade
- develop and implement simple mathematical models in micro and macroeconomics

Course Contents

- Market and regulation: perfect and imperfect competition, market failures. Power of actors and market structures. Price discrimination. Positive and negative externalities: innovation and pollution. Natural monopoly. Asymmetric information. Competition and innovation.
- Monetary economics: from the economy of debt to the economy of financial markets. The European fight against inflation. Financial globalization and its risks. The role of money as an intermediate in trade, as a unit of account and as a value protector. The role of the Central Bank.
- Fluctuations and economic policies: Monetary policy, Fiscal policy. Unemployment.
- International economics and globalization. International trade: regulation of world trade, theories of international trade. International finance: exchange rate, balance of payments, international monetary and financial system.
- New theories of growth and economics of the environment: Education and innovation, the two engines of growth. Technical progress and the environment.

Course Organization

Lectures: 10.5-hr, Tutorials: 9-hr, Exam: 4.5-hr

Bibliography / Teaching Material and Textbooks

- Course reader.
- Begg, Fischer, Dornbusch (2002) Macroéconomie, Dunod.
- Begg, Fischer, Dornbusch (2002) Microéconomie, Dunod.
- Blanchard, Cohen (2002) Macroéconomie, Pearson Education.
- Burda, Wyplosz (1998) Macroéconomie : une perspective européenne, Boeck Université.
- da Costa (2013) Etats-Unis, Europe, Chine : des Etats au cœur des crises économiques et financières mondiales, l'Harmattan.
- Mucchielli, Mayer (2005) Economie internationale, Dalloz.
- Picard (1992) Eléments de microéconomie, Montchrestien.
- Stiglitz (2000) Principes d'économie moderne, De Boeck Université.
- Varian (1995) Analyse microéconomique, De Boeck Université.

Evaluation

Optional 1.5-hr written midterm exam (no documents, no calculator), 3-hr written final exam (documents and calculator allowed).

Mark = sup(0.4 midterm + 0.6 final, final).

SE1600 - Advanced Economics

Professor : Mehdi SENOUCI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : SE1400,Economics

Period : S7 elective 5 between september and january

Domain : Sciences de l'entreprise

Course Objectives

This course aims to deepen the knowledge of theoretical and empirical tools of economic analysis introduced in the Economics course (SE1400) to develop the understanding of several key themes of the contemporary world. The first part of the course develops standard microeconomic theory and addresses the issues of competition, governance, and the environment. The second part discusses various macroeconomic themes (growth, inequality, crises) and introduce to the data analysis by linear regression.

On completion of the course, students should be able to

- Knowledge of the methods of modern economics
- Ability to develop and solve formal economic models under different sets of hypotheses, in micro and macroeconomics
- Ability to debate on contemporary economic issues
- Ability to interpret a linear regression

Course Contents

- Neoclassical microeconomics: perfect markets, market failures
- Information, incentives, governance
- Technological change and economic growth
- Inequality
- Money, debt, and crises
- Introduction to econometrics: linear regression

Course Organization

Lectures: 22.5-hr, Tutorials: 9-hr, Exams: 4,5-hr

Bibliography / Teaching Material and Textbooks

- Handouts, presentations, course website
- Samuelson (1973 [1948, 1st edition]) *Economics*, McGraw-Hill
- Mas Colell, Whinston & Green (1995) *Microeconomic Theory*, Oxford University Press
- Varian (1995) *Analyse microéconomique*, De Boeck Université
- Varian (1992) *Microeconomic Analysis*, W. W. Norton
- Acemoglu & Robinson (2012) *Why Nations Fail? The origins of power, prosperity and poverty*, Crown Publishing

Evaluation

Optional 3-hr midterm exam (M) (no documents and no calculator allowed) and mandatory 3-hr final exam (F) (documents and calculator allowed only for final exam F). Mark = Sup(0.4xM+0.6xF, F).

SE1950 - Reverse Engineering and Rapid Prototyping Laboratory

Professor : Pascal MORENTON

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** : 9

Prerequisites :

Period : S5 between September and January
S6 between february and june

Course Objectives

The course presents the reverse engineering and rapid prototyping tools and techniques, from the initial 3D digitization of the product till the rapid prototyping, through digital conception and simulation.

Using case studies, participants will think through the challenges of how to maintain the "digital chain", study specific techniques and evaluate methods based on the needs of a company.

Besides, participants will actually use tools and machines (including structured light and laser).

Course Contents

- Usage of conception tools in Computer Aided Design (CATIA V5, SPACECLAIM)
- Geometrical modeling
- 3D scanners and non-contact digitizing instruments
- Rapid prototyping
- Study of "digital chain"

Course Organization

Labwork: 27-hr, Exam: 3-hr

Bibliography / Teaching Material and Textbooks

Ecole Centrale Paris course book: "CATIA V5 training"

Evaluation

Oral presentation and realization of a scientific poster.

Evaluation criteria: quality of experimental work, oral defense, scientific poster, participation, and involvement.

The following factor shall be applied to determine the final grade: - Experimental work: coef 2 - Oral presentation: 1 coef - Written document coef 1 - Behavior: 1 coef

SE2150 - Complex System Engineering

Professor : Antoine RAUZY

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,5 - **Quota** :

Prerequisites : This course requires having basic knowledge about programming with Python, so to be able to implement the virtual experiments that will be performed during the « petite classe » (tutorials).

Period : S6 between february and june

Course Objectives

The objective of this course is to introduce students to a panel of complex system modeling techniques, principles and formalisms. It aims at showing not only what can be obtained from models but also limits of models.

On completion of the course, students should be able to

The course will provide students with a theoretical knowledge and practical skills about the science of models and model engineering.

Course Contents

This course discusses the following topics :

- Business Process Modeling
- Design Structure Matrices
- System Architecture
- Modeling with Graphs
- Modeling with Finite State Automata
- Constraint Satisfaction Problems
- Handling uncertainties
- Languages
- Limits of calculability

Course Organization

This course is organized into 9 sessions. Each session starts with a lecture, followed by a tutorial.

Bibliography / Teaching Material and Textbooks

The lectures will be delivered in French. The slides (in French too) will be given to students. A number of other documents, including some Python programs, will be given for the tutorials.

Evaluation

A final examination 3.0-hr , documents and computer not allowed ;

SE2200 - radical innovation

Professor : Bernard YANNOU

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 4 between september and january

Domain : Sciences de l'entreprise

Course Objectives

This course offers students the opportunity to implement a radical innovation methodology based on the use of Radical Innovation Design® for several months on projects brought and accompanied by multi-sector industrial partners of all sizes (from SMEs to multinationals). The students will thus have the opportunity to understand the process of radical innovation on a real case, and to acquire an extremely valuable experience with innovative companies. They will approach the corporate world through group work in constant liaison with industrial and educational managers, deliverables and concrete deadlines, and professional rendering. The teaching of the methodology Radical Innovation Design® will bring them rigor and method in a framework for innovating in companies. But the IR course is also a place of creativity and experimentation.

ATTENTION: **Any student choosing this course will also have to choose one of the innovation projects of type RI "Radical Innovation" that work in partnership with the course and, conversely, any student who chooses an RI innovation project will have to register to this course. This is a specificity validated by the research department and the person in charge of the innovation projects.**

The initial ideas for innovation will be provided by a panel of innovative companies with which we are currently discussing, in fields as varied as the automobile, sports or health. For more information, visit the Radical Innovation course: www.cips.ecp.fr

The objectives of the IR course are:

- Understand the need to structure and professionalize the supply chain of innovation in companies;
- Understand and master an innovative approach, ie user-driven radical innovation methodology, Radical Innovation Design®;
- Implement this methodology on a real business case and achieve the development of an innovative and value-creating concept for the company;
- To acquire an experience that is easily valorisable from project work in connection with an innovative company and, why not, to open up possibilities for future collaboration (internships, caesura, employment ...).

On completion of the course, students should be able to

- become efficient and participative players and/or managers of design projects aimed at product or service innovation
- know how to define and achieve the stages of innovative projects: framing the initial issue, building up expertise, being creative to produce concepts of high potential of value creation, integrating a stage of digital or physical modeling, evaluating feasibility of solutions according to the expected requirements

Course Contents

1. Introduction to the course a. Introduction of innovation engineering b. Innovating in need seeker mode c. Exploring the front end of innovation - Which methodology?

2. Overview of RID methodology a. Presentation of RID methodology (motivations, principles, process, tools, expected results) b. Application to handitennis wheelchair

3. Synopsis of investigation and Need reframing a. RID Dashboard b. Synopsis of investigation c. TD: Identification of key knowledge and skills, organization of investigation d. Need reframing

4. Causality, usage scenarios and value buckets a. Observation and representation of usage b. Identification of existing solutions c. Causality of problems and pains d. Usage scenarios e. Ambition perimeter i. Kano analysis ii. Definition of value buckets iii. Motivated choice of an ambition perimeter

5. Problem solving a. Scenario creativity b. UIPC monitoring c. Concept creativity d. Validation and prototyping

6. Business Model Canvas serious game or "How to design a business model compatible with RID methodology?"

7. Preparation of RID project presentation

Course Organization

We offer a training to RID illustrated by numerous industrial examples. During this course, students apply the methodology from an initial idea of innovation proposed by one of the partner companies. Each year, some concepts proposed by the students are taken over by the partner companies and lead to the market launch of innovative products or services. Companies actively engage in participatory pedagogy during the period concerned (September to January). They:

- Provide an initial idea of innovation, in the form of a short text of a few lines: market to be investigated, ideas for new products or services (brief marketing), existing range of products to be improved and, at best, new ideas Uses to develop or "user pain" to treat ...

- They are present during the launching ceremony of the projects (groups of projects composed of 4 to 6 students) during the 2nd session.
- Are present in the final defenses of the projects as members of the jury.
- Exchange with the project group (s) and accompany them in their advancement from September to December.

The project groups are supervised by an educational tutor of the teaching team, but are encouraged to discuss with their partner company to validate the progress of the project (sending of documents, phone exchanges, organization of several meetings ...). As a general rule, the second part of the 3-hour sessions is devoted to a supervised TD where students work on their innovation project.

Bibliography / Teaching Material and Textbooks

2 scientific papers are provided for illustrating the course:

- Yannou B., Cluzel F., Farel R. (2016) 'Capturing the relevant problems leading to pain and usage driven innovations: the DSM Value Bucket algorithm', to appear in Concurrent Engineering - Research And Applications (CERA).
- Yannou B., Farel R., Cluzel F., Bekhradi A., Zimmer B. (2016) 'The UNPC innovativeness set of indicators for idea or project selection and maturation in healthcare', International Journal of Design Creativity and Innovation, doi: 10.1080/21650349.2016.1161562

Resources

5 assistants, 5 companies

Evaluation

- A final project grade during the ProveIt seminar presentations
- Respect of requirements
- Modulation of the final grade according to your contributions inside the group

SE2300 - Strategy and Marketing

Professor : Eléonore MOUNOUD

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : SE1100 SE1200 MA1300

Period : S7 elective 4 between september and january

Domain : Sciences de l'entreprise

Course Objectives

The general objective is to give a global view of the main concepts and reasoning modes in strategy and marketing, so as to give students a better global understanding of companies, and to enable them to put these concepts and reasoning modes in practice.

On completion of the course, students should be able to

- place the strategy of a business unit in the context of its competitive environment and taking into account its core competencies
- perform a strategic diagnostic
- identify the possible strategic options and make strategic recommendations for a domain of activity or an organization
- perform a marketing diagnostic
- define and implement a marketing action plan according to the 4P
- be aware of mega trends and their impacts on business models
- understand how governance issues are related to strategic choices

Course Contents

Strategy:

- Introduction: the facets of strategy, strategic management, business models
- Strategic diagnostic: PESTEL analysis, the 5 strengths of Porter, analysis of the competitive environment, value chain, strategic capacity, SWOT
- Strategic choices: strategic segmentation, generic strategies, Ansoff matrix, strategic portfolio management (BCG), modes of strategic development
- Trends : how to go sustainable, digital, collaborative,

Marketing:

- Introduction: the role of marketing in companies and the process of marketing planning
- Marketing analysis: consumer behavior, marketing surveys, marketing diagnostic
- Marketing and concepts of segmentation, targeting, and positioning
- The marketing mix and its components: product, packaging, brand, price, communication, promotion, distribution

Course Organization

Lectures: 15-hr, Tutorials: 18-hr, Exam: 3-hr

For each of the two parts of the course, a textbook is used as reference for readings.

Before each class, students are requested to read a specific book chapter and to read and prepare the case study :

- each group write a synthetic note (preliminary question)

- one group makes an oral presentation on the case

Bibliography / Teaching Material and Textbooks

No written teaching material will be available except the list of the course key concepts as well as the course and case key learnings. Students are suggested to buy the following reference books :

* Garrette B., Dussauge P.,Durand R. « STRATEGOR », 6TH édition, Dunod, 2013

**Armstrong G., Kotler P., Le Nagard E., Lardinoit T. « PRINCIPES DE MARKETING», 11TH Édition, Pearson Education,   2013

Evaluation

- Written final exam (50% of the final mark): 2 hr, no documents and no calculators nor computers allowed. Only students who cannot be in Paris for the final exam because they are in an foreign university are exceptionnaly allowed to have a specific final (written or oral) exam before they leave.

- Continuous assessment (50% of the final mark):

- 25%: group presentation on a case study
- 25%: synthetic note and oral participation in case study discussions.

SE2350 - Industrial ecology: towards industries in symbiosis

Professor : François CLUZEL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites : Basic knowledge in process engineering, thermal science, and more generally in engineering

Period : S7 elective 6 january

Domain : Sciences de l'entreprise

Course Objectives

Understand the basic concepts of complex industrial systems design (multi-physics, multi-scale, multiagent), with a multidisciplinary approach in collaborative design mode.

On completion of the course, students should be able to

- Design a complex industrial system (multidisciplinary, multi-scale, multi-actor)
- Implement a systemic approach
- Manage a project in an agile way and work in collaborative design mode
- Integrate sustainability challenges (environmental in particular) into industrial projects

Course Contents

The course deals with different aspects of complex industrial system design:

- Systemics and quantitative modelling based on technico-economic analysis of materials and energy exchange networks
- Collaborative design of an exchange system at the scale of the system himself, or at the scale of the industrial area, the city, the territory...

The course mobilizes knowledge in energy, thermal sciences, process engineering, on the service of collaborative design of a complex system. Inputs in industrial engineering, systemics, project management and technico-economic analysisallow the students standing back and designing the whole system, bringing value to several shareholders and with a low environmental impact.

The students apply those concepts in group and in collaborative project mode (groups of 20 students with a project leader and several subgroups with well defined responsibilities), on a

real industrial system proposed by an industrial partner, who actively follows the students during the week. The students have also the opportunity to visit an industrial site.

Here are examples form past years:

- 2015 (first year of the course): subject proposed by Air Liquide in order to loop and optimize materials and energy flows (mainly industrial gases network like Hydrogen or CO_2) on Jouy En-Josas site with the perspective of the construction of the new Air Liquide "campus" building and its integration to Paris-Saclay. Visit of Jouy-en-Josas site and meeting with directors.
- 2016 and 2017: subject proposed by Sedibex, incinerator of hazardous wastes managed by Veolia, on the seashore industrial area of Le Havre, in order to extend the existing steam network (vapor produced by wastes combustion) toward new industrial clients. Visit of the steam production unit CPCU at Vitry sur Seine, connected to the urban heat network of Paris (2016), and visit of the Enoris waste incinerator, connected to the urban heat network Massy-Antony (2017).

Course Organization

The course is organized as follow (provisional schedule):

- Day 1 morning: course introduction, introduction to systemics and case study
- Day 1 afternoon: introduction to industrial ecology, introduction to agile project management, presentation and launching of the project
- Day 2 morning: visit of an industrial site related to the project
- Day 2 afternoon, 3, 4: work in project mode (groups of 13 to 14 students), with regular milestones with supervisors (teachers and industrial partners)
- Day 5 morning: projects completion and oral defense preparation
- Day 5 afternoon: oral defense in the presence of industrial partners, debriefing.

Bibliography / Teaching Material and Textbooks

Electronic documents:

- Introduction to systemics and case study
- Agile project management tool
- Introduction to industrial ecology and eco-industrial parks
- The project is fed by numerous "sheets" (tool sheets, techno sheets, actor sheets...) given to the student all along the project progress

Resources

Teachers from different disciplines take part of this course (industrial engineering, energy science, process, engineering...), as well as industrial partners (regular and direct exchanges (meeting, phone, visioconf, e-mail) with the client).
A visit of an industrial site is planned.

Evaluation

The course is evaluated by an oral defense of each project group during the last afternoon of the week, in the presence of teachers and industrial partners. Students receive a group score modulated by their personal contribution to the group deliverables and the quality of these deliverables.

SE2400 - Introduction to Supply Chain

Professor : Walid BEHIRI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : It is recommended to have taken introductory courses in areas such as business administration or accounting and finance.

Period : S7 elective 3 between september and january

Domain : Sciences de l'entreprise

Course Objectives

The goal of this course is to face the major issues and challenges of the production and distribution of goods and services, and to learn about approaches and methods, looking especially at organizational issues and business processes. This course also aims at pointing out the needs of qualitative and quantitative decision-making tools to optimize the production and distribution of goods and services.

On completion of the course, students should be able to

- Understand the challenges of the production and distribution of goods and services for corporate performance
- Understand the various issues in the field
- Have started using approaches, methods and tools to deal with these issues

Course Contents

- Introduction to issues in the production and distribution of goods and services
- Supply chain management and relationship with other departments of a company (product design, accounting and finance, marketing and sales, purchasing, information systems, etc.)
- Basic concepts (resources, inventories, flows, lead times, capacity, productivity)
- Supply chain planning
- Production/inventory management
- Transport and distribution
- Basic of production management (production layout and organization, quality, reliability, maintenance, etc.)
- Design of production systems
- Japanese techniques (continuous improvement, lean manufacturing, etc.)
- After sales service, spare part management, recycling and remanufacturing
- Service operations management

Bibliography / Teaching Material and Textbooks

- Case studies
- Textbooks mostly in English on Operations Management, Supply Chain Management, Production Management

Evaluation

3-hr written final exam with documents and computer (but students are only allowed to use pdf readers and Excel)..

SE2500 - Modeling and analysis of Supply Chain

Professor : Jakob PUCHINGER

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 35

Prerequisites : MA1200 MA1300

Period : S8 elective 8 between february and june

Domain : Sciences de l'entreprise

Course Objectives

This course follows two major objectives. First, broad knowledge of various aspects of supply chain management are presented, allowing students to understand the strategic importance of this topic for the performance of companies. Second, various optimisation problems occurring along the supply chain will be analysed in detail. Linear and mixed integer programming will be introduced in order to study supply chain management related optimization problems. This will allow students to acquire the basic skills to solve such problems in practice. Every lecture unit will introduce major concepts and will be followed by case studies and/or practical exercises.

On completion of the course, students should be able to

- understand the challenges of managing production and distribution processes
- use operations research based approaches to model supply chain management aspects
- use excel solver to practically solve numerical supply chain management problems

Course Contents

- Introduction to supply chain management
- Linear and mixed integer programming modelling
- Basics of linear and mixed integer programming solvers
- Networks design
- Demand forecasting and aggregate planning
- Sales and operations planning
- Inventory management
- Transport planning

Bibliography / Teaching Material and Textbooks

- S. Chopra and P. Meindl, Supply Chain Management: Strategy, Planning, and Operation, Global Edition, 6/E, Pearson, 2016.

- H.P. Williams, Model Building in Mathematical Programming, Wiley, 2013.

- This course requires one laptop per 2 students as well as current installation of MS Excel

Evaluation
60% Homework

40% Final Exam

SE2550 - Introduction to Purchasing

Professor : Philippe ROUGEVIN-BAVILLE

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 50

Prerequisites :

Period : S8 elective 10 between february and june

Domain : Sciences de l'entreprise

Course Objectives

Provide students with the basic knowledge and skills to master the main purchasing processes in which they will be involved, whatever position they will hold in the company.

Provide background to future Purchasing VP or Chairman to evaluate the full benefits they can expect from the Purchasing function, and to identify the main drivers to enhance the purchasing power.

On completion of the course, students should be able to

- identify and monitor the key purchasing processes
- elaborate a purchasing policy consistent with the company strategy
- understand how to prepare and how to conduct a purchasing negotiation
- know the key management principles of a purchasing division
- identify the created value that can be leveraged through the purchasing power

Course Contents

- Introduction to the Purchasing function - Connection with the main company processes
- Purchasing policy - Marketing approach
- Organization - Position within a company
- Risk management
- Negotiation
- Make or buy - Outsourcing
- Legal perspective
- Supplier assessment
- Ethics - Management
- Performance measurements

- Purchasing Leverage Power - Value creation

Course Organization

Lectures: 14-hr, Case studies: 14-hr, Tutorials: 6-hr, Exam: 2-hr

Bibliography / Teaching Material and Textbooks

PowerPoint slides and case studies

Evaluation

2-hr written final exam + quality of preparation of case studies + participation in case study discussions.

SE2650 - Risk Assessment and Management

Professor : Enrico ZIO

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 45

Prerequisites : MA1200 MA1300

Period : S8 elective 11 between february and june

Domain : Sciences de l'entreprise

Course Objectives

Nowadays, many areas of engineering require a systematic approach to system design and management, within given safety and reliability limits.

Furthermore, the safety issues are relevant not only from the viewpoint of the technical-scientific profile of the future professional: their evaluation and control are included in specific regulations and laws with respect to standards of emissions, environmental impact, and the filing of safety reports by industries at risk, as regulated by the Seveso rules. Companies and organization then need to be able to understand and explain their risks, and the ways they handle them, to their investors, employees, and customers. Risk assessment and management have become everyone's business.

The course addresses the safety and reliability issues related to modern industrial activities and illustrates the methodologies available for the evaluation, the management, and the control of the associated risks. The objective is to provide the most common tools adequate for tackling the problem with the required scientific rigor and practical efficacy.

The expertise acquired by the students is that expected from a safety and reliability analyst and manager. This course also provides a good background preparation for the Master's level courses of the tof the Industrial Engineering (GI) option.

On completion of the course, students should be able to

- Have a general knowledge of all aspects of risk management
- Use effectively some of the methods of risk assessment (e.g. hazard identification, fault tree and event tree analyses)
- Identify the risk-critical points of a system and optimally decide on their elimination or protection of the system's environment

Course Contents

- Dimensions of risk: frequency and consequences. History of risk management
- Hazard identification: functional analysis, Hazard and Operability analysis (HAZOP), Failure Modes Effects and Criticality Analysis (FMECA)
- Definitions and fundamental formulas: reliability, availability, failure rate, MTTF, MTTR...
- Probabilistic Risk Assessment (PRA)
- Fault tree and event tree analysis; other methods

Course Organization

Lectures: 21-hr, Tutorials: 6-hr, Labwork: 3-hr, Exams: 6-hr

Bibliography / Teaching Material and Textbooks

- Copy of slides and selection of downloadable papers
- Enrico Zio, An Introduction to the Basics of Reliability and Risk Analysis. World Scientific Publishing Company, 2007
- Terje Aven, Foundations of Risk Analysis: a Knowledge and Decision-Oriented Perspective. Wiley, 2003

Resources

Lecturers: Nicola Pedroni, Enrico Zio and others

Evaluation

- Midterm exam: 3-hr
- Final exam: 3-hr

SE2700 - Modeling for Decision Making

Professor : Vincent MOUSSEAU

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 60

Prerequisites :

Period : S8 elective 9 between february and june

Domain : Sciences de l'entreprise

Course Objectives

Decision making is one of the major activities of engineers and managers. More than ever, in a globalised context, in complex and uncertain situations, managers are to make decisions at strategic, tactical and operational levels, which involve high stakes (financial, human, etc.) for the firm competitiveness.

In order to cope with such complex decision problems, future engineers and managers need to master concepts and methodologies which allow to formalize decision problems. This course aims at introducing several classical models that make it possible to represent and solve decision problems in various contexts (decision under uncertainty, multiple criteria decision)

On completion of the course, students should be able to

- master several methods/models for decision making/aiding
- operationalize these methods within the context of decision problems in actual organizations/firms
- step back and have a critical view on decision making methods, hence analyzing their merits and limitations

Course Contents

- Introduction to decision making/decision aiding, basic concepts
- Decision in presence of risk, decision under uncertainty, utility theory, decision trees
- Decision with multiple criteria and preference modeling, introduction to several basic aggregation procedures
- Presentation of models involving various modeling tools (graphs, linear programming, etc.); presentation of modeling and resolution tools
- Data Envelopment Analysis
- Project to put the theory in practice

A video presentation of this course is available at
http://www.lgi.ecp.fr/pmwiki.php/PagesPerso/SE2700

Course Organization

The course are roganized in a "flipped classrom". Lectures takes the form of a serie of vidéos which the sudent have to watch before the day of the class. the points taht are unclear of that the students did'nt understand and discussed, and then the rest of the time is devoted to exercises. Such way of proceeding should enable each student to adapt his/her progress in the course and benefit as much as possible from the course.

Lectures: vidéos which the students should watch before the class

Exercises: 24-hr,

Labwork: 9-hr,

Exam: 3-hr

Bibliography / Teaching Material and Textbooks

- Ph. Vincke. Multicriteria decision-aid, Wiley, 1992.
- C. Guéret, C. Prins, M. Sevaux. Programmation linéaire, 65 problèmes d'optimisation modélisés et résolus avec Visual Xpress, Eyroles, 2003.
- H.P. Williams. Model building in mathematical programming. Wiley, 1999 4th ed.
- D. Vanderpooten. Aide à la décision : une approche par les cas. Ellipses, 2002, 2nd ed.
- W. Cooper, L. Seiford, and K. Tone. Introduction to Data Envelopment Analysis and its use, Springer, 2006.

Resources

videos before the lecture

list of exercices during the class

Evaluation

2-hr written exam (with documents allowed) and presentation of a project on a case

SE2750 - Stochastic Modeling and Theory of Queues and their Applications

Professor : Oualid JOUINI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 51

Prerequisites : Basic knowledge of probability

Period : S6 elective 1 between february and june
S8 elective 8 between february and june

Domain : Sciences de l'entreprise

Course Objectives

Queueing theory is one of the area of operational research. It provides various tools needed to model, analyze and optimize many real-world situations. The objective of this course is to present and develop the basic analysis methods of queueing and queueing network systems. We provide various applications for system modelign and analysis using queueing models. The case studies are applications for manufacturing (inventory management) and service systems (call centers and health care systems).

On completion of the course, students should be able to

- use queueing theory in order to model various situations where the resources are limited and the system parameters are random
- use the basic approaches, methods and tools required for the analysis and optimization of these types of systems

Course Contents

- Introduction to stochastic processes
- Markov chains
- Simple queueing systems
- Advanced queueing systems
- Case study: estimating customer waiting time in call centers
- Case study: appointment scheduling in health care service
- Case study: analysis of inventory systems (make-to-order and make-to-stock systems)

Course Organization

Tutorials: 33-hr, Written exam: 2-hr

Bibliography / Teaching Material and Textbooks

- Copy of slides and case studies
- Kleinrock L. (1975), Queueing Systems, A Wiley-Interscience Publication, Vol. 1
- Asmussen S. (2003), Applied Probability and Queues, 2nd edition Springer-Verlag, New-York

Evaluation

2-hr written final exam (documents and computers allowed)

SE2800 - Production Planning and Scheduling

Professor : Walid BEHIRI

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 65

Prerequisites :

Period : S8 elective 12 between february and june

Domain : Sciences de l'entreprise

Course Objectives

This courses introduces different modeling tools (Petri nets, graphs, mathematical programming) and solving approaches (branch and bound, dynamic programming, heuristics and metaheuristics) for production planning and scheduling problems. The students will learn the methodology of constructing appropriate methods to solve a given problem.

On completion of the course, students should be able to

Analyze and solve a given planning and scheduling problem by proposing an appropriate method

Course Contents

- Introduction to production management and hierarchical management
- Introduction to computational complexity
- Basic scheduling models and project management models
- Cyclic scheduling
- Non cyclic scheduling (critical machine, parallel machines, flow shop, job shop)
- MRP and lot sizing
- Capacity planning

Course Organization

Lectures: 16.5-hr, Tutorials: 16.5-hr, Exam: 3-hr

Evaluation

- Realization of a mini-project on a case study (45%)
- 3-hr exam (55%)

SE2920 - Agile Management of Complex Projects

Professor : Franck MARLE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 5 between september and january

Domain : Sciences de l'entreprise

Course Objectives

1. Discover main concepts, methods and tools related to complex project management, notably those related to new management and organizational styles (agile management, network organization).

2. Comprehend through records and practice the limits of classical methods in the context of complex projects, both in terms of results reliability and implementation difficulties.

3. Gain knowledge and skills on some advanced methods that permit to cope with these organizational and technological (r)evolutions.

On completion of the course, students should be able to

...specify, plan and control a complex project, including the conceptual and practical specificities of complexity.

Expected improvements are on the following skills:

- specifying project expectations and requirements, in terms of general objectives (related to economic, societal, and environemental dimensions) and specific requirements for its result (product, service, installations...)
- choosing solutions to respond to these expectations: creativity, systems architecture, multicriteria assessment and decision-making
- implementing a process and an organization that allow for realizing what has been decided previously: planning, resource assignment, budgeting, monitoring and controlling,
- managing risks and uncertainties associated to these three dimensions Product / Process / Organization,
- managing interdependencies between these dimensions, these actors, at the different stages of lifecycle (during and after the project),
- organizing a project team with agile principles, with network organization, not based on vertical hierarchy, and a more coordinated and cooperative operating mode.

Course Contents

They are organized among the chronology of the project : project objectives, scope statement, creativity, decision-making, matrix-based interdependency modeling, Work Breakdown Structure, PERT network, Gantt chart, risk management, earned value management, project indicators / result indicators. Some notions will be developed all along the course, like complexity, and risk and uncertainty management.

The course includes diverse mathematical approaches, such as graph theroy, decision theory, multicritera decision-making and optimization techniques (partitioning / clustering algorithms for instance). It aims at comprehending through practice the difficulties to make decisions under a complex and uncertain context, while anticipating indirect consequences of a decision, of a change, of an innovation.

Course Organization

The course features three types of activities:

- lectures and exercices,
- conferences by experts in the field,
- a project

Bibliography / Teaching Material and Textbooks

Supports of oral presentations, templates for some tools, bibliography for basic concepts and for advanced and complexity-related concepts.

Resources

Franck Marle and Ludovic-Alexandre Vidal are professors at Centrale Supélec. They will be present all along the course for lectures, practical sessions and coaching on the project. Teaching asssitants may be also present, depending on the number of students.

The external experts are regular lecturers at Centrale Supélec (to be confirmed).

Evaluation

The evaluation consists of :

1) knowledge assessment through an exam.

2) skills assessment through the evaluation of a project, of its result, but also its organization (during the project) and its presentation (at the end of the project). It includes for each project a group and an individual evaluation.

SE3100 - Law

Professor : Jérôme TASSI

Language of instruction : FRANCAIS – **Number of hours** : 15 – **ECTS** : 0,5 - **Quota** :

Prerequisites :

Period : S6 between february and june

Course Objectives

To introduce students to the fundamental notions of law in business that will be necessary in their future professional career, and more particularly to Industrial Property and Computing Law

Course Contents

- General introduction to law
- Labour law
- Corporate law
- Contract law
- Trademark law and copyright
- Computing law
- Patent law

Course Organization

Lectures: 12 hr, Tutorials: 3.00 hr, Exam: 1.5 hr

Bibliography / Teaching Material and Textbooks

Course reader and slides

Evaluation

1.5-hr written quizz

SE3200 - Law 2

Professor : Jérôme TASSI

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : SE3100

Period : S8 elective 10 between february and june

Domain : Sciences de l'entreprise

Course Objectives

Advanced law course, useful for the development of an entrepreneur

Course Contents

5 courses of 6h (3h conference and 3h workshop) + 1 course of 4h30 (3h conference and 1h30 workshop)

- Community Law (1 session)
- Common Law (1 session, in English)
- Chinese Law (2 sessions)
- Contract Law 2 (2 sessions)
- Company Law 2 (2 sessions)
- Criminal Law (1 session)
- Competition Law (2 sessions)

Course Organization

Lecture in 3-hr sessions

Bibliography / Teaching Material and Textbooks

Course reader

Evaluation

1.5-hr written exam

SE3300 - Entrepreneurship: A First Approach

Professor : Jean-François GALLOUIN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : None

Period : S7 elective 3 between september and january

Domain : Sciences de l'entreprise

Course Objectives

- Give a first overview of entrepreneurship
- Help students consider launching a company as a credible alternative to a career in a big company
- Have a first look at the entrepreneur toolbox: business model, business plan, sales, marketing, finance.

On completion of the course, students should be able to

- have a better idea on what to look at when they want to launch a company
- have integrated fundamentals in marketing, finance and law for entrepreneurship
- Basic notions: lean startup, Business Model Canvas

Course Contents

- Motivation and obstacles to create a company
- Testimonies by entrepreneurs: what to do, what to avoid
- To create or to go into a company?
- Innovation marketing
- Financing a start-up
- Business plans: why, for whom?
- Fundamentals of law: social law, business law, corporate law
- Go to Market: from the product to the client

Bibliography / Teaching Material and Textbooks

Slides for each class.

Evaluation

1.5-hr quiz (no documents, no calculators).

SE3301 - Entrepreneurship: A First Approach

Professor : Jean-François GALLOUIN

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : None

Period : S8 elective 9 between february and june

Domain : Sciences de l'entreprise

Course Objectives

- Give a first overview of entrepreneurship
- Help students consider launching a company as a credible alternative to a career in a big company
- Have a first look at the entrepreneur toolbox: business model, business plan, sales, marketing, finance.

On completion of the course, students should be able to

- have a better idea on what to look at when they want to launch a company
- have integrated fundamentals in marketing, finance and law for entrepreneurship
- Basic notions: lean startup, Business Model Canvas

Course Contents

- Motivation and obstacles to create a company
- Testimonies by entrepreneurs: what to do, what to avoid
- To create or to go into a company?
- Innovation marketing
- Financing a start-up
- Business plans: why, for whom?
- Fundamentals of law: social law, business law, corporate law
- Go to Market: from the product to the client

Bibliography / Teaching Material and Textbooks
Slides for each class.

Evaluation
1.5-hr quiz (no documents, no calculators).

Humanities and Social Sciences

SH1300 - Philosophy of Sciences

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 12 – **ECTS** : 0,5 - **Quota** :

Prerequisites : None

Period : S6 between february and june

Course Objectives

This course aims to undertake and indulge in a philosophical questioning and reflection of the most contemporary knowledge, notably stemming from physics. An important place and prominence is devoted to the problem of time.

On completion of the course, students should be able to

The level of the course is adapted to students trained in the preparatory classes geared to admission to the top scientific " grandes écoles ". The fundamental purpose is to open and broaden their mind by presenting to them and acquainting them with the scientific knowledge obtained throughout the twentieth century and by urging them to reflect on its implications.

Course Contents

During the first session of the lecture series in the lecture theater the students will be required to vote (by a simple show of hands) in order to select five themes and topics from a list of a dozen offered.

- first day: The question of time
- 2nd day: The question of time (following-on sequence)
- 3rd day: From where does the effectiveness of mathematics stem in physics ?
- 4th day: Science and ethics
- 5th day: Einstein

Course Organization

The courses are given in lecture theaters. The active paticipation and involvement of the students is warmly and specifically encouraged.

Bibliography / Teaching Material and Textbooks

Textbook in french and a rich bibliography.

Evaluation

A written examination, taking the form of a dissertation whose theme is to be chosen among four or five subjects proposed. The dissertation/essay compiled and drafted by groups of three students, is to be submitted within a fortnight following the end of the course.

SH2100 - Business Games

Professor : Christian MICHELOT

Language of instruction : FRANCAIS – **Number of hours** : 30 – **ECTS** : 2,0 - **Quota** :

Prerequisites : Basic knowledge in management/accounting and experience of group work would be helpful

Period : S7 between september and january

Course Objectives

- Discover the company and its main functions
- Get introduced to management and accounting
- Experiment with and become aware of the processes that develop and unfold in a working group (decision, organization)
- Analyze one's individual contribution to the work group

Course Contents

Business games are simulations of the life of several firms competing on the same market. One game unit comprises from 5 to 6 teams made up of 5 or 6 players each.

Each player takes charge of a specific area of responsibility : production, finances, human resources, marketing, general management. Initially when play begins, the situation of the companies is identical. The task of each team is to analyze this initial situation and to take decisions: sales, production, price targets.

The decisions implemented by each team when compounded and confronted subsequently produce a new state or reconfiguration of the market where the different companies' situations become differentiated and diverge. The analysis of this fresh situation gives rise to new decisions and hence several successive cycles follow one after the other.

Key concepts covered:

- Economic decision making
- Strategy (internal, external growth, value sharing)
- Main functions of a company (production, finance, sales, human resources)
- Marketing concepts
- Offer and demand analysis in various markets, business plan
- Cost price, income statement, balance sheet, finance plan
- Group dynamics and decision making
- Cooperation and competitive dynamics, negotiation

Course Organization

The games take place over 4,5 consecutive days, alternating simulations and debriefings.

Bibliography / Teaching Material and Textbooks

Given at the beginning of the game

Resources

There are two types of teachers: instructors in charge of playing sessions and coachs in charge of discussion sessions and debriefings.

Evaluation

Evaluation is based on:

- knowledge acquired in accounting/management and group dynamics
- leadership and involvement
- quality of analyses during the debriefings, both in strategy/management and in team work

SH2300 - Seminar Series: individuals, labour, organisations

Professor : Cynthia COLMELLERE

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7elective 6 january

Domain : Sciences humaines et sociales

Course Objectives

Starting with the basics of sociology, psychology, philosophy, politics, ethics, students will :

- Better know companies and the various working environments of engineers, specifically in relation to company organization and management,
- Understand the social and political and economic contexts of these various working environments,
- Understand the technical, scientific, social, human, economic and managerial dimensions of work and their relations,
- Understand individual and collective behavior at work,
- Understand the relations and the mechanisms of power in situations of cooperation, negotiation, conflicts,
- Understand the phenomena of abnormality and fraud,
- Understand failures and success of organizational change.

On completion of the course, students should be able to
critical thinking
analysis, argumentation and synthesis abilities
reflective approach

Course Contents

Examples of courses provided :

- Fraud, control, governance
- Negotiation and management
- Suffering at work: a growing problem?
- Politics, medias and working life

Evaluation

Written work at the end of the course (at least 50% of the final mark)

Oral participation

individual work and team work

SH2400 - Seminar Series: International and Intercultural

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS, ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 6 january

Domain : Sciences humaines et sociales

Course Objectives

These courses aim to help students better understand the cultures in their material, symbolic, linguistic, religious and social dimensions. They offer students the knowledge, methodological and practical skills to work in a context of great mobility and exchange of persons, knowledge, uses, practices, values and ideas.

These courses are based on anthropology, ethnology, history, politics, sociology, geopolitics.

Course Contents

Examples of courses:

- international mobility and intercultural skills
- Stakes and Challenges of future leaders in China
- Societal challenges for future enginees (course in english)

Evaluation

Written examination

Oral participation and presentation

Individual and team works

SH2500 - Seminar series: Perspective on Key Social Issues

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 6 january

Domain : Sciences humaines et sociales

Course Objectives

These courses aim to help the students to:

- Understand and analyze the major issues related to contemporary environmental, human and social problems: for example: global warming, challenges arising in the energy field, social justice, participation in civil society…
- Fully grasp the impact and effects of human practices on the natural, economic, social environment.
- Comprehend these issues from ethical, social, politic and economic perspective

In order to direct their actions in front of " big contemporary challenges " by means of an approach based on the human sciences (psychology, sociology, economy, geography, demography, anthropology, etc.).

Course Contents

Examples of courses:

- Understanding social influence mechanisms
- Socialization, culture and social inequities
- Economy and social justice

Evaluation

Written assignments following completion of the course

Oral participation

Individual work and team work on case studies

SH2550 - Perspective on Key Social Issues

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites :

Period : S7 elective 2 between september and january

Domain : Sciences humaines et sociales

Course Objectives

These courses aim to help the students to:

- Understand and analyze the major issues related to contemporary environmental, human and social problems: for example: global warming, challenges arising in the energy field, social justice, participation in civil society…
- Fully grasp the impact and effects of human practices on the natural, economic, social environment.
- Comprehend these issues from ethical, social, politic and economic perspective

In order to direct their actions in front of " big contemporary challenges " by means of an approach based on the human sciences (psychology, sociology, economy, geography, demography, anthropology, etc.).

On completion of the course, students should be able to

Analysis, synthesis, argumentation, critical-thinking skills. Basics of fieldwork (interviews, questionnaires, observations).

Course Contents

course proposed : socialisation, inequities, cultures

understand and analyze stakes linked to inequities and discriminations issues

understand the effects of these inequities on socialisation

understand social justice, public and economic policies as dimensions of engineer's actions facing these issues

Course Organization

Each course session lasts three hours. Each session is divided into lecture and case studies, debates or presentations.

Bibliography / Teaching Material and Textbooks

presentations, videos, articles, case studies...

Evaluation

Evaluation is individual

Written evaluation at the end of the course, 50% of the final course mark

Written and oral progress works + participation, 50% of the final course mark

SH2600 - Seminar series: Science, Technology, Society

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 6 january

Domain : Sciences humaines et sociales

Course Objectives

Theses courses aim at helping future engineers understand the representations of science and technical progress to better their action and its effects. These courses are based on scientific studies, sociology of innovation, history of science and techniques, philosophy, ethics and politics.

Students will be able to understand and analyze in various contexts and situations:

- The elaboration of the scientific and technical knowledges ·
- Distribution,
- Appropriation,
- Practices
- Effects on individuals and society, specifically in termes of controversies

Course Contents

Examples of courses:

- History of science and techniques,
- Sociology of innovation,
- Sociology of interest groups in Europe
- Synchrotron

Evaluation

Written examination at the end of course

Oral participation and presentations

Individual studies and team works

SH2650 - Science, Technology, Society

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites :

Period : S7 elective 5 between september and january

Domain : Sciences humaines et sociales

Course Objectives

The courses offered in the elective SHS E5 "science technology and society" deal with science and innovations through their development, their use and their effects on individuals and society. These courses aim to help engineering students to understand representations of science and technological progress. The main objectivs are: adress key issues in several scientific fields, understand evolutions of social and institutional contexts of scientific and technological research through history, main stakes of scientific work and their evolutions.

Students will be able to understand and analyze in a variety of contexts and situations:

- The construction of the scientific and technical knowledges ·
- their dissemination,
- their appropriation,
- their use
- their effects on individuals and society, specifically in terms of controversies.

On completion of the course, students should be able to

Analysis, synthesis, argumentation ; critical thinking skills. Methodology of fieldwork (basics: tools, methods, practices).

Course Contents

Following issues will be addressed through theoretical and methodological contributions, case studies and debates: Paradigms and scientific revolutions, Scientific and technical progress, Social construction of risks and risk perceptions, Scientific Controversies, place and role of scientific expertise, ethics in science, ethics in engineering.

Course Organization

Each session lasts 3 hours. Lectures (theoretical and methodological contributions), case studies, student presentations...are proposed.

Courses are given to small classes (twenty students) .

Bibliography / Teaching Material and Textbooks

Presentations, written documents (articles, case studies ...), videos

Evaluation

The evaluation is individual.

50% of the final mark: Written work at the end of the course or to complete within the two weeks following the end of the course.

50% of the final mark: Intermediate works (oral or written) + participation (individual and collective) throughout the course;

SH2700 - Seminar series: Innovation, Arts and Creativity

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S7 elective 6 january

Domain : Sciences humaines et sociales

Course Objectives

The main objective of theses courses is to adress the issue of innovation through artistic creation. Students will be able to:

- Understand the production of artistic works in various domains: architecture, painting, literature, design …
- Understand the relations between the various domains of the artistic creation ant science and techniques
- Understand the individual and collective dimensions of this work
- Understand the influence of the cultural, social, economic and political contexts in which they take place.

These courses are based on history, sociology, architecture, politics.

Course Contents

Examples of courses:

- Art history, history of ideas
- Art and science : an innovative and creative dialogue

Evaluation

Written examination

Oral participation and presentations

Individual and team works

SH2750 - Innovation, Arts and Creativity

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 40

Prerequisites :

Period : S7 elective 4 between september and january

Domain : Sciences humaines et sociales

Course Objectives

The main objective of this course is to introduce students to history of art. Creation and dissemination of artworks (painting, architecture, etc) are studied. They are replaced in the cultural, social, economic and political contexts in which they take place.

Course Contents

Examples of courses:

- Art history, history of ideas

Evaluation

Written examination

Oral participation and presentations

Individual and team works

SH3200 - Seminar Series: individuals, labour, organisations

Professor : Cynthia COLMELLERE

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 36 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S8 in march

Domain : Sciences humaines et sociales

Course Objectives

Starting with the basics of sociology, psychology, philosophy, politics, ethics, students will :

- Better know companies and the various working environments of engineers, specifically in relation to company organization and management,
- Understand the social and political and economic contexts of these various working environments,
- Understand the technical, scientific, social, human, economic and managerial dimensions of work and their relations,
- Understand individual and collective behavior at work,
- Understand the relations and the mechanisms of power in situations of cooperation, negotiation, conflicts,
- Understand the phenomena of abnormality and fraud,
- Understand failures and success of organizational change.

Course Contents

Examples of courses provided :

- Negotiation and management
- Suffering at work: a growing problem?
- Conflicts and mediation

Evaluation

Written work at the end of the course

Oral participation

individual work and team work.

SH3300 - Seminar series: Science, Technology, Society

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S8 in march

Domain : Sciences humaines et sociales

Course Objectives

Theses courses aim at helping future engineers understand the representations of science and technical progress to better their action and its effects. These courses are based on scientific studies, sociology of innovation, history of science and techniques, philosophy, ethics and politics.

Students will be able to understand and analyze in various contexts and situations:

- The elaboration of the scientific and technical knowledges ·
- Distribution,
- Appropriation,
- Practices
- Effects on individuals and society, specifically in termes of controversies

Course Contents

Examples of courses:

- Social entrepreneurship,
- Medias and social control,
- Gender and Science

Evaluation

Written examination at the end of course

Oral participation and presentations

Individual studies and team works.

SH3400 - Seminar Series: International and Intercultural

Professor : Cynthia COLMELLERE

Language of instruction : ANGLAIS, FRANCAIS – **Number of hours** : 36 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S8 in march IN28SH1 SEP8SH1

Domain : Sciences humaines et sociales

Course Objectives

These courses aim to help students better understand the cultures in their material, symbolic, linguistic, religious and social dimensions. They offer students the knowledge, methodological and practical skills to work in a context of great mobility and exchange of persons, knowledges, uses, practices, values and ideas.

These courses are based on anthropology, ethnology, history, politics, sociology, geopolitics.

Course Contents

Examples of courses:

- Firm, cultures, diversity
- Educaiton and social change
- Challenges for the new leaders of China

Evaluation

Written examination

Oral participation and presentation

Individual and team works.

SH3500 - Seminar series: Perspective on Key Social Issues

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S8 in march

Domain : Sciences humaines et sociales

Course Objectives

These courses aim to help the students to:

- Understand and analyze the major issues related to contemporary environmental, human and social problems: for example: global warming, challenges arising in the energy field, social justice, participation in civil society…
- Fully grasp the impact and effects of human practices on the natural, economic, social environment.
- Comprehend these issues from ethical, social, politic and economic perspective

In order to direct their actions in front of " big contemporary challenges " by means of an approach based on the human sciences (psychology, sociology, economy, geography, demography, anthropology, etc.).

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Course Contents

Examples of courses:

- Assuming responsabiity in duty
- Sustainable development : questionning growth
- Understanding social influence mechanisms

Evaluation

Written assignments following completion of the course

Oral participation

Individual work and team work on case studies.

SH3600 - Seminar series: Innovation, Arts and Creativity

Professor : Cynthia COLMELLERE

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 2,0 - **Quota** :

Prerequisites :

Period : S8 in march

Domain : Sciences humaines et sociales

Course Objectives

The main objective of theses courses is to adress the issue of innovation through artistic creation. Students will be able to:

- Understand the production of artistic works in various domains: architecture, painting, literature, design …
- Understand the relations between the various domains of the artistic creation ant science and techniques
- Understand the individual and collective dimensions of this work
- Understand the influence of the cultural, social, economic and political contexts in which they take place.

These courses are based on history, sociology, architecture, politics.

Course Contents

Examples of courses:

- Art history
- Art and Science : a creative and innovative dialogue

Evaluation

Written examination

Oral participation and presentations

Individual and team works.

Sports

SP1100 - Sports and Physical Education

Professor : Stéphane BLONDEL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 0,0 - **Quota** :

Prerequisites :

Period : S5 between September and January

Course Objectives

Better know yourself to adjust to effort

- Determine where you stand
- Learn your capabilities and limits
- Understand your body to better take charge of your physical life

On completion of the course, students should be able to

- understand how to adjust to effort
- set achievable goals
- analyze their failures and successes
- control their emotions
- fulfill their responsibilities

Course Contents

Badminton, Basketball, Bodybuilding, Boxing, Climbing, Dance, Fencing, Field Hockey, Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis, Track & Field, Volleyball.

Course Organization

Physical activities: 36-hr

Evaluation

Continuous assessment, competitions.

SP1200 - Sports and Physical Education

Professor : Stéphane BLONDEL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 0,0 - **Quota** :

Prerequisites :

Period : S6 between february and june

Course Objectives

Communicate to move forward together

- Access the cultural heritage of Physical Activity and Sports
- Confront others to develop teamwork abilities
- Learn how to better listen, communicate, and adjust to various roles

On completion of the course, students should be able to

- develop specific individual skills to serve the group
- become better integrated in a team
- participate in a joint project
- change roles: practitioner, referee, manager, coach

Course Contents

Badminton, Basketball, Bodybuilding, Boxing, Climbing, Dance, Fencing, Field Hockey, Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis, Track & Field, Volleyball.

Course Organization

Physical activities: 36-hr

Evaluation

Continuous assessment, competitions

SP2100 - Sports and Physical Education

Professor : Stéphane BLONDEL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 0,0 - **Quota** :

Prerequisites :

Period : S7 between september and january

Course Objectives

Taking responsibilities, Creating

Develop resources in order to succeed through:

- Efficiency in individual and collective action
- Self-confidence
- Personal fulfillment

On completion of the course, students should be able to

understand how to:

- optimize their skills
- invest in a project
- commit to action
- make decisions

Course Contents

Badminton, Basketball, Bodybuilding, Boxing, Climbing, Dance, Fencing, Field Hockey, Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis, Track & Field, Volleyball.

Course Organization

Physical activities: 36-hr

Evaluation

Continuous assessment.

SP2200 - Sports and Physical Education

Professor : Stéphane BLONDEL

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 0,0 - **Quota** :

Prerequisites :

Period : S8 between february and june

Course Objectives

Taking responsibilities, Creating

Develop resources in order to succeed through:

- Efficiency in individual and collective action
- Self-confidence
- Personal fulfillment

On completion of the course, students should be able to

understand how to:

- optimize their skills
- invest in a project
- commit to action
- make decisions

Course Contents

Badminton, Basketball, Bodybuilding, Boxing, Climbing, Dance, Fencing, Field Hockey, Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis, Track & Field, Volleyball.

Course Organization

Physical activities: 36-hr

Evaluation

Continuous assessment, competitions

Leadership and Engineering

WL1100 - Workshops on Professional Development and Leadership

Professor : Philippe Moustard

Language of instruction : FRANCAIS – **Number of hours** : 51 – **ECTS** : 2,5 - **Quota** :

Prerequisites : Good level in French.

Period : S5 between September and January

Course Objectives

- Develop a set of key skills to become an innovative engineer: teamwork, communication, complex problem solving, leadership
- Move from a school paradigm into a professional one

On completion of the course, students should be able to

- work effectively in a team
- master the basics of oral / written communication
- master basics of complex problem solving
- basics of leadership understanding

Course Contents

Develop a set of key skills to become an innovative engineer:

- Teamwork: organize, decide, manage within a team; team member roles; influence of character on team performance
- Written and oral communication: structure and synthesis, increase written and oral impact, interpersonal communication, public speaking
- Approach to solve complex problems: frame the issue; inductive, experimental and recursive approaches; doubt and complexity
- leadership : legitimacy, common mission

Move from a school paradigm into a professional one

- From receiving a well-framed problem set, to framing yourself the problem
- From understanding, to making real

- From individual performance, to team performance
- From certainty, to uncertainty

Course Organization

3 seminars of 1 to 2 days in groups of 40 students supervised by 1 or 2 professors, with the potential support of invited speakers. Activities are based on experiment, case studies, participation team work and group work.

Individual interviews

Bibliography / Teaching Material and Textbooks

Lecture notes are provided for all topics. Sample recommended reading:

- M. Belbin. Les rôles en équipe. Editions de l'Organisation, 2006
- J.C. Corbel. Management de projet : fondamentaux, méthodes, outils. Editions de l'Organisation, 2007
- B. Minto. The Minto Pyramid Principle: Logic in Writing, Thinking & Problem Solving. Minto International, 1996
- M. Rosenberg. La communication non-violente au quotidien. Jouvence, 2003
- E. de Bono. Les six chapeaux de la réflexion. Editions de l'Organisation, 2005

Evaluation

Continuous assessment based on the evaluation of oral and written team reports

Mandatory attendance to the workshops and lectures

WL1200 - Workshops on Professional Development and Leadership

Professor : Philippe Moustard

Language of instruction : FRANCAIS – **Number of hours** : 24 – **ECTS** : 1,5 - **Quota** :

Prerequisites : WL1100

Period : S6 between february and june

Course Objectives

- Help students develop their leadership, and their innovative and entrepreneuring skills
- Help students build their academic and professional paths
- written and oral communication

On completion of the course, students should be able to

implement basic leadership, innovation and entrepreneurship skills

Basics of communication within a group

Course Contents

Help students develop their leadership, and their innovative and entrepreneuring skills

- innovation processes and business plan fundamentals
- fundamentals of leadership
- ability to address positive and constructive feedback, non-violent communication

Help students build their academic and professional paths

- Present oneself professionally (resume, introduction letter, interview)
- Present personal professional experience

Course Organization

3 seminars of 1 to 2.5 days in groups of 40 students supervised by 2 professors, with the support of invited speakers. Pedagogical activities are based on experiment, case studies, participation and team work.

Bibliography / Teaching Material and Textbooks

Lecture notes are provided for all topics. Example of suggested readings:

- Alexander Osterwalder & Yves Pigneur, Business Model Nouvelle Génération, Pearson 2010
- D. Genelot, Manager dans la complexité, INSEP Consulting ed., 1992
- R. Heifetz, Leadership on the Line. Boston: Harvard Business School Press, 2002
- P.M. Senge, The 5th discipline, Currency, 1994

Evaluation

Continuous assessment based on the evaluation of oral and written team reports

Mandatory attendance to the workshops and lectures

WL1300 - Workshops on Professional Development and Leadership

Professor : Philippe Moustard

Language of instruction : FRANCAIS – **Number of hours** : 12 – **ECTS** : 0,0 - **Quota** :

Prerequisites :

Period : S7 between september and january

Course Objectives

- Help to develop innovative thinking
- Implement a set of key skills to become an innovative engineer: teamwork, communication, complex problem solving, leadership
- Move into a professional paradigm to manage a project

On completion of the course, students should be able to

- introduction to innovation in engineering
- work effectively in a team
- Implementation of oral / written communication skills
- know how to identify the real problem
- basics of project management

Course Contents

Develop a set of key skills to become an innovative engineer:

- Teamwork: organize, decide, manage within a team; team member roles; influence of character on team performance
- Oral communication: develop convincing ability
- Complex problem solving : real issue identification, uncertainty management, hypothesis assessment, quick estimations
- project management
- Creativity: group creativity methods
- leadership and self knowledge

Move from a school paradigm into a professional one

- From receiving a well-framed problem set, to framing yourself the problem
- From understanding, to making real
- From individual performance, to team performance
- From certainty, to uncertainty

Course Organization
2 seminars of 0,5 and 1 day in groups of 40 students supervised by 1 or 2 professors, with the potential support of invited speakers. Activities are based on experiment, case studies, participation, team work and group work.

Evaluation
Pass / Fail based on quality of participation.
Mandatory attendance.

WL2100 - Innovating Leadership

Professor : Luc ROULLET

Language of instruction : ANGLAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 54

Prerequisites : WL1100 WL1200. Be involved with passion in a start-up company or in a project (innovation, student organization or other).

Period : S8 elective 13 may

Domain : Professionnalisation : leader, entrepreneur, innovateur

Course Objectives

Context

The context in which we all operate is an ever-accelerating and challenging world, where innovation and transformation are part of daily work.

Main Objective

Develop your own personal power and your ability to generate collective power, with confidence, efficiency and lightness. This requires to:

- know yourself better and explore new resources within you
- better read and use group dynamics to mobilize new resources in your group and ecosystem

On completion of the course, students should be able to

With a group

- Achieve projects with more efficiency, lightness and confidence, especially in intercultural environments
- Increase awareness of an organization as a living system, and ability to vivify it
- Identify the most efficient leverage points to intervene in a group
- Face complex problems, especially those involving people, and explore with a group the most difficult questions till resolution
- Navigate through power dynamics with ease and impact
- Create a robust innovation dynamic, with scientific rigor and fun in the collective work

With yourself

- Increase your self-awareness and self-confidence
- Increase your autonomy in goal-setting, learning by doing and self-assessment
- Be at ease and focused in the midst of high discomfort
- Impact an audience, small or large, with your speech
- Approach culture differently: explore how culture shapes us and how we shape it too

Course Contents

The main topics are :

- Operational power: ability to get things done and to learn in the process
- Relational power: ability to transform relationships for the group's success
- Purpose: create a mobilizing vision, for yourself, your team and enroll new allies
- Ways of being: explore yourself, your patterns, with yourself and within a group
- Cosmopolitan leadership: use cultural differences as an opportunity
- Leadership embodiment: be present, calm, focused and impactful in all situations
- Survive in the exercise of leadership: build and use your holding environment

Course Organization

The course is built to present leadership models and provide a space to reflect on our own practices and capabilities, experienced in projects and in the classroom. Personal, small group and plenary work will nurture and help us realize how to evolve and improve our impact in the exercise of leadership.

- 10 half-day courses with a balanced mix of pedagogic forms
- An intermediate reflection paper
- A 360° questionnaire on your leadership skills
- Final reflection paper on your personal and collective learning around leadership

Bibliography / Teaching Material and Textbooks

Reading material is provided in preparation of or after class to put the classroom experience in perspective.

Resources

This class mobilizes our own leadership resources from beginning to end.

Evaluation

- 1/2 for class participation
- 1/6 for the intermediate reflection paper
- 1/3 for final reflection paper.

WL2200 - Ethics and Responsibility in Engineering

Professor : Jean-Marc CAMELIN

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** : 72

Prerequisites : Be aware of these issues individually, through associations, hobbies, or a related innovation project

Period : S8 elective 13 may

Domain : Professionnalisation : leader, entrepreneur, innovateur

Course Objectives

High level engineers have a key role in the evolution of our society. This course is designed for students intending to pursue a career either in management, potentially as very high-level decision makers (decision making in conscience), or in research, including fundamental research (representation of future uses of their research). The objectives are to:

- expose each student to the ethical, social, societal, economical and political consequences of their actions as an engineer, in an increasingly multicultural environment
- help students develop an awareness of ethical and societal issues in their future professional career
- educate students on what influences their decision making, beginning with their choices of curriculum and job

On completion of the course, students should be able to

- know how to take the necessary distance from the professional context to consider the ethics of action
- understand the constraints arising from the socio-economic system in order to question them
- demonstrate critical thinking and discernment about the system
- transform challenges and constraints into opportunities to conduct his career in accordance with his personal ethics

Course Contents

- Introduction to ethics: responsibility, concept, history, reference texts, tangible actions involved, meaning.

- Illustration of the problem: labor and work (concept, role, suffering at work, empowerment), environment (sustainable development, decisions, impact), world global issues.
- Understanding the System: the current system (capitalism, economic regulation, impact on the actions of decision makers, measures, GDP), alternatives (how to think the world differently, microcredit, virtual economy), science and the engineer of the 21st century (role of the engineer within the system, his/her influence on ethical issues, research and its impact).
- Ethics as an action: individual issues (I decide and act in conscience), political decision (provide guidance to the whole society), broadening the issue (global-international-national-local levels, time representations in the short-medium-long term, the CEO decision-making process: strategy, innovation), you as a student (how I understand my environment and how I project myself into the future as an engineer, my gap year, my professional dreams).

Course Organization

The introductory seminar brushes up on the concepts covered by the terms ethics and reponsibility and is used to define, as a group, the directions of the week of seminar, based on students's expectations and context. In particular, some S8 student projects may interact with the course.

Conferences during the week will illustrate practical examples on the importance of the problem, devote time to work on understanding the overall system within which the issue arises, and finally lead the students to concrete action and potential projections for their professional career.

Each conference includes a theoretical part, an illustrative part (case study, documentary analysis, talk by an expert), and a discernment part.

Bibliography / Teaching Material and Textbooks

Bibliography:

- L'économie est une science morale, Amartya Sen
- Mort de la globalisation, John Saul
- Souffrance en France, Christophe Dejours
- Extension du domaine de la manipulation, Michela Marzano
- Responsable porteur de sens, Lenhardt
- The Necessary Revolution: How Individuals and Organizations are Working Together to Create a Sustainable World, Peter Senge
- Le capitalisme est-il moral, Comte-Sponville
- Responsabilité et jugement, Hannah Arendt
- L'Ethique, Spinoza
- Alcibiade, Platon
- L'esprit des lois, Montesquieu
- Ethique et Responsabilité, Paul Ricoeur

- Ethique comme philosophie première, Emmanuel Lévinas
- La génération future a-t-elle un avenir ? Développement durable et mondialisation, Christian de Perthuis
- Bioéthique et liberté, Axel Kahn & Dominique Lecourt
- La Méthode - tome 6 : Ethique, Edgar Morin
- Ethique et ordre économique, Anne Salmon, CNRS

Resources

- Fabienne Bergé - enseignante ADPL - coach indépendante
- Anne Tricault - enseignante en Master - coach PRH
- Patricia Midy - enseignante ADPL - coach indépendante
- Bruno Lefèbvre - Associé Fondateur Alteralliance - spécialiste psycho-dynamique du travail
- + témoignages d'Anciens et autres conférenciers

Evaluation

- Oral presentation of group project conducted throughout the seminar
- Production of a group paper
- Acrive participation during conferences.

Global Challenges, Projects, and Internships

WP1100 - Challenges of the 21st Century: Introduction

Professor : Franck RICHECOEUR

Language of instruction : FRANCAIS – **Number of hours** : 50 – **ECTS** : 3,0 - **Quota** :

Prerequisites :

Period : S5 between September and January

Course Objectives

The objectives of the course are to help students to:

- Better understand their future role as engineers facing 21st century challenges,
- Discover in depth one of the many challenges they could have to work on during their career,
- Tackle fuzzy problems and uncertainty as encountered by engineers,
- Work in team on a real project that represents a first experience.

The seven thematics studied are the following:

- Economic and social mutations
- Energy
- Environment
- Health and biotechnologies
- Information and knowledge
- Design of the future City
- Transportation and mobility

On completion of the course, students should be able to

- understand broadly the issues related to the challenge they study,
- learn methods of documentary analysis and project management,
- deal with complex systems
- report well written conclusion
- present orally technical material
- team work

Course Organization

- General introduction seminars to each of the challenges (six 3-hr seminars)
- Workshop on one of the challenges (eight to ten 1.5-hr working sessions)
- A team project, continued over semester 6

Each challenge is directed by professionals from academia (*Référent Enjeu Interne* or REI).

Evaluation

- Report and oral defense on the problem statement of the project at mid-semester,
- Report and oral defense of the ongoing project at the end of the semester.

WP1200 - Challenges of the 21st Century: Team Project

Professor : Franck RICHECOEUR

Language of instruction : FRANCAIS – **Number of hours** : 50 – **ECTS** : 3,5 - **Quota** :

Prerequisites :

Period : S6 between february and june

Course Objectives

- Develop the ability to work within a team
- Develop a multi-disciplinary approach to problem solving: technical, economic, marketing, social, etc.
- Expose students to complexity (fuzzy problems, multi-solutions problems)
- Expose students to "real life" problems
- Apply techniques of problem solving, communication, etc.
- Acquire knowledge in the field of the project

On completion of the course, students should be able to

- better work within a team
- increase their ability to deal with complexity
- better communicate (written and oral communication)
- have acquired knowledge on one of the global challenges
- solve problems with a 360° approach (technical, marketing, economical, social, etc.)
- increase their ability to deal with fuzzy problems

Course Organization

Students work in teams of four to six, supervised by a project client (CPR) and a pedagogic referent (RP). Each challenge is directed by professionals from academia (*Référent Enjeu Interne* or REI) and industry (*Référent Enjeu Externe* or REE).

Evaluation

The progress of the project team is evaluated using a project review at mid-semester (oral defense and report). The project is assessed in a final defense in which conslusions of the study are presented. The rating reflects the overall work done by the team during the semester.

After the final defense, all teams compete for the Project Grand Prize, awarded by a jury of specialists from academia and industry.

WP2100 - Sustainable Development

Professor : Pascal DA COSTA

Language of instruction : FRANCAIS – **Number of hours** : 36 – **ECTS** : 3,0 - **Quota** :

Prerequisites : No

Period : S6 elective 1 between february and june
S8 elective 8 between february and june

Domain : Sciences de l'entreprise

Course Objectives

- Become aware of the coupling between resources, energy, the environment, the climate, the economy, geopolitics, demographics, at the different scales of the problem (local to global)
- Know the key figures of sustainable development (current situation and scientific predictions) and understand how these figures are constructed (assumptions and models).

On completion of the course, students should be able to

Knowledge of the major global issues of the XXI century and their solutions.

The evaluation covers a conssistant individual project in writing a newspaper article or science paper on a contemporary issue of sustainable development, in French (English accepted) of 8 500 characters maximum (spaces included).

You will also find on the platform the articles written by your elders in previous years, which were published in reviews or journals!

Once your work made, you'll have to evaluate other works: the evaluation phase by peers is mandatory. it also results in a rating.

Course Contents

- Origins of economic growth and its effect on the increasing "unavailability" of natural resources (end of oil)
- Economic models of optimal management of natural, renewable and non-renewable resources
- Demography: evolution of the world population

- Climate: green house effect and climate change
- Resource management (reserves, geographical distribution, price) : resources for energy (oil, gas, coal, uranium), raw materials (minerals), Waste management and recycling
- Technical state-of-the-art and new technologies for energy and water management
- Vegetal resources and use of soil in Agriculture

Course Organization

Video: 8 hours, Quizz: 4 hours, Articles: 8 hours, Tutorials: 3 hours, Exam (project): 12 hr, Peer Assessment: 3h.

Bibliography / Teaching Material and Textbooks

- Course reader + Videos + lecture slides + course website: quizzes and forum
- E. Iacona, J. Taine, B. Tamain, "Les enjeux de l'énergie," Dunod 2008
- V. Masson-Delmotte and A. Pailler, "Climat : le vrai et le faux," Le Pommier, 2011
- M. Dufumier, "Malbouffe au nord," NIL, 2012
- P. da Costa, Rio : une gouvernance mondiale de l'environnement face à la crise écologique ?, reporterre, 1 juin 2012.

Resources

This multidisciplinary course is taught by specialists of the various dimensions of sustainable development:

- Pasca Da Costa (CentraleSupélec): Economics and development
- Estelle Iacona CentraleSupélecs): Energy and fossil resources
- Claire Bordes (CentraleSupélec) : Water geopolitics
- Marc Dufumier (INRA, Agro): Vegetal resources
- Gilles Pison (INED, EHESS): Demographics
- Valérie Masson-Delmotte (CEA): Climate
- Jean-Pierre Chevalier (CNAM) - Mineral resources

Evaluation

Quizz + Team work: 12-hr (essay) and Peer Assessment: 3-hr.

WP5000 - Philosophical approach of strategy and innovation

Professor : Eléonore MOUNOUD

Language of instruction : FRANCAIS – **Number of hours** : 12 – **ECTS** : 0,0 - **Quota** :

Prerequisites : lectures 1&2 of the MOOC "On Strategy: what managers can learn from great philosophers?"

Period : S7 between september and january

Course Objectives

- encourage new perspectives
- offer some concrete management tools
- present some basics in philosophy
- invite to critical thinking

Course Organization

3 hr conference

2 half days of coaching (45 min for each project team)

Bibliography / Teaching Material and Textbooks
https://www.youtube.com/watch?v=8H9Z2TYEARg
https://fr.coursera.org/learn/management-philosophy

Evaluation

Validation based on participation

WP5100 - Innovation Project S7

Professor : Eléonore MOUNOUD

Language of instruction : FRANCAIS – **Number of hours** : 110 – **ECTS** : 7,0 - **Quota** :

Prerequisites :

Period : S7 between september and january

Course Objectives

Our ambition is to help students develop their creative abilities (imagination and use of knowledge) to contribute to the process of innovation, through projects that can be of various types: scientific, technological, or design of products, services or processes. The two objectives are to:

1. Adopt an ambitious and open posture, consider the various dimensions of the project (scientific, technical, economic, social), and use state-of-the-art knowledge to explore new opportunities. For these objectives, students will learn to:

- Restate the client's request to better define the needs and issues associated with the project
- Test their ideas against the state of the art
- Develop their creativity and their ambition to change the system

2. Work in project mode, i.e. produce as a team a real result meeting the needs of a client, using the methods of problem-solving and project management. More specifically, students learn to:

- Formalize the problem by preparing a contract with a client
- Design and implement a well-structured problem-solving approach
- Follow the good practices of project management and teamwork

On completion of the course, students should be able to

better understand the innovation process in one of two ways, depending on the type of project:

- through the discovery and practice of engineering methods to produce new knowledge (research), technologies (development), techniques (industrialization), markets (business development), or companies (creation)
- through the understanding of how their project contributes to an innovative process

Course Contents

Types of projects offered:

- Company startup
- Definition and commercialization of innovative offers
- Design of products and services
- Scientific research
- Technological contests

Course Organization

110 hr reserved on the time schedule.

Milestones

- Milestone 1 : Mission statement (relevance)
- Milestone 2 : Documentary report (robustness)
- Milestone 3 : Deliverables & final written report
- Oral defense

Evaluation

The following elements are taken in consideration in the final grade:

1. Relation with the initial request and quality of the final deliverable:

- Qualification and reformulation of the request
- Quality of the relation with the client and degree of satisfaction of the client with the final result
- Validity and robustness of the results obtained

2. Process of innovation:

- Analysis of the client's request and identification of the client's needs and issues
- Undertanding of the state of the art (bibliographic study required)
- Method of exploration of the novelty (research, creativity, design).

WP5200 - Innovation Project S8

Professor : Eléonore MOUNOUD

Language of instruction : FRANCAIS – **Number of hours** : 150 – **ECTS** : 9,0 - **Quota** :

Prerequisites :

Period : S8 between february and june

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Course Objectives

Our ambition is to help students develop their creative abilities (imagination and use of knowledge) to contribute to the process of innovation, through projects that can be of various types: scientific, technological, or design of products, services or processes. The two objectives are to:

1. Adopt an ambitious and open posture, consider the various dimensions of the project (scientific, technical, economic, social), and use state-of-the-art knowledge to explore new opportunities. For these objectives, students will learn to:

- Restate the client's request to better define the needs and issues associated with the project
- Test their ideas against the state of the art
- Develop their creativity and their ambition to change the system

2. Work in project mode, i.e. produce as a team a real result meeting the needs of a client, using the methods of problem-solving and project management. More specifically, students learn to:

- Formalize the problem by preparing a contract with a client
- Design and implement a well-structured problem-solving approach
- Follow the good practices of project management and teamwork

On completion of the course, students should be able to

better understand the innovation process in one of two ways, depending on the type of project:

- through the discovery and practice of engineering methods to produce new knowledge (research), technologies (development), techniques (industrialization), markets (business development), or companies (creation)
- through the understanding of how their project contributes to an innovative process

Course Contents

The S8 Innovation Project (WP5200) is usually the continuation of the S7 Innovation Project (WP5100). The students who took WP6100 during S7 may either join an existing Innovation Project or propose a new Innovation Project.

Course Organization

240-hr of personal and teamwork, including 150-hr reserved on the time schedule

Evaluation

The following elements are taken in consideration in the final grade:

1. Relation with the initial request and quality of the final deliverable:

- Quantification and reformulation of the request
- Quality of the relation with the client and degree of satisfaction of the client with the final result
- Validity and robustness of the results obtained

2. Process of innovation:

- Analysis of the client's request and identification of the client's needs and issues
- Undertanding of the state of the art (bibliographic study required)
- Method of exploration of the novelty (research, creativity, design)

3. Perspective on the deliverables in terms of novelty and contribution:

- Evaluation of the innovation by comparison with the state of the art
- Proof of the value added for the client.
- Idenfication of the conditions of success of the innovation, in particular of the factors and actors that may help or impede its development.

WP6100 - Student Organization Project S7

Professor : Géraldine Carbonel, Eléonore MOUNOUD

Language of instruction : FRANCAIS – **Number of hours** : 110 – **ECTS** : 7,0 - **Quota** :

Prerequisites : The project must be validate by the Committee on Student Organization Projects before the start of the project

Period : S7 between september and january

Course Objectives

The objective is to help students learn how to:

- define objectives on the basis of a stated need or an idea
- design and implement a well-structured process to reach these objectives
- develop their creativity and ability to innovate
- experience individual and group dynamics
- open to socio-economic problems through practical problems
- become familiar with Information and Communication Technologies

Course Contents

This project gives students the opportunity to get involved in a student organization activity, either on campus or outside Centrale Paris. In all cases, they will be asked to take significant responsabilities in the project. Projects are selected on two criteria: service to the community, and quality of the learning process.

Each project must be supervised by a professor.

Example of projects from previous years: Forum, CEC, JCE...

Course Organization

110 hr reserved on the time schedule.

The project organization is defined by the project supervisor and the project team.

One month after the start of the project, students must produce:

- the list of all students involved in the project

- the list of objectives and deliverables
- an organigram detailing the distribution of responsabilities and interfaces
- a provisional budget
- for recurring projects, a balance sheet validated by the treasurer of UDE-Manifestation

Meetings must be held on a regular basis, if possible with the supervisor.

Main contact for any student organization project modalities : Géraldine Carbonel

Bibliography / Teaching Material and Textbooks

The student organization projects require a thorough understanding of the courses available in the first two years of the engineering curriculum, notably:

- The workshops on professional development and leadership

- The project management course

- The challenges of the 21st century project (1st year)

- The social science courses

- The business games

- The required courses and certain electives related to the chosen

Evaluation

The projetcs are evaluated on the following criteria :

- the rigour of process(es) put in place
- the quality of achievements and deliverables as a whole
- the maturity and judgement of the students

Written report and oral defense, evaluated by a Jury

WP6200 - Student Organization Project S8

Professor : Géraldine Carbonel, Eléonore MOUNOUD

Language of instruction : FRANCAIS – **Number of hours** : 150 – **ECTS** : 9,0 - **Quota** :

Prerequisites : Not open to students having already taken WP6100. The project must be validate by the Committee on Student Organization Projects before the start of the project

Period : S8 between february and june

Course Objectives

The objective is to help students learn how to:

- define objectives on the basis of a stated need or an idea
- design and implement a well-structured process to reach these objectives
- develop their creativity and ability to innovate
- experience individual and group dynamics
- open to socio-economic problems through practical problems
- become familiar with Information and Communication Technologies

Course Contents

This project gives students the opportunity to get involved in a student organization activity, either on campus or outside Centrale Paris. In all cases, they will be asked to take significant responsabilities in the project. Projects are selected on two criteria: service to the community, and quality of the learning process.

Each project must be supervised by a professor or staff member of Centrale Paris.

Example of student organization projects from previous years in S8: Raid (sports tournament), Centrale 7 (international rugby tournament),...

Course Organization

150-hr reserved on the time schedule

The project organization is defined by the project supervisor and the project team.

One month after the start of the project, students must produce:

- the list of all students involved in the project

- the list of objectives and deliverables
- an organigram detailing the distribution of responsabilities and interfaces
- a provisional budget
- for recurring projects, a balance sheet validated by the treasurer of UDE-Manifestation

Meetings must be held on a regular basis, if possible in the presence of the supervisor.

Main contact for any student organization project modalities : Géraldine Carbonel

Bibliography / Teaching Material and Textbooks

Les projets associatifs s'appuient sur les enseignements et méthodes développés en première et deuxième année du cycle ingénieur :

- en atelier ADPL

- dans le cours de management de projet

- au cours de l'activité Enjeu en 1ère année

- dans les enseignements de Sciences Humaines

- dans les jeux d'entreprise

- dans le parcours commun pour les compétences de base et selon la nature des projets dans les cours d'électifs

Evaluation

The projects are evaluated on following criteria :

- the rigour of process(es) put in place
- the quality of achievements and deliverables as a whole
- the maturity and judgement of the students.

Intermediate report + final report and oral defense, evaluated by a Jury.

WP8100 - First Line Operator Internship

Professor : Angela MINZONI

Language of instruction : FRANCAIS – **Number of hours** : 210 – **ECTS** : 0,0 - **Quota** :

Prerequisites :

Period : S7 september

Course Objectives

The objective of this internship is to learn by doing, and to discover:

- the company, from the perspective of a production operator
- the production function: manufacturing, logistics, maintenance
- human relations in a professional environment
- the job of a production operator

and to gain perspective on this experience by keeping an internship diary.

Course Organization

- the internship must take place on at least 6 consecutive weeks and on the same production platform
- two short introduction workshops to understand the stakes of this internship and to help in its search
- media article on current topics in industry
- post internship review

Bibliography / Teaching Material and Textbooks

M. B. Crawford, "Shop class as Soul Craft. An inquiry into the value of work," Penguin Press, 2009.

Evaluation

Written report (50%) and participation to the internship re-view (50%)

WP8110 - International Solidarity Mission

Professor : Jean-Marc CAMELIN

Language of instruction : FRANCAIS – **Number of hours** : 210 – **ECTS** : 0,0 - **Quota** : 50

Prerequisites :

Period : S7 september

Course Objectives

The objective of International Solidarity Mission is to provide material assistance to populations living in vulnerable conditions

On completion of the course, students should be able to

- Work in an organization (NGO, students associations), to lead and to improve the organization
- Manage a project
- Take into account the social and economic issues of the local population
- Ensure respect for social values (ethic)
- Change his or her point of view

Course Contents

The international solidarity mission can be done in lieu of the blue-collar internship (WP8100), under the conditions exposed in the studies procedure handbook. Eligibility criteria can be found in the document "critères d'éligibilité", on claroline (stage humanitaire).

Course Organization

The humanitarian mission must be at least 6-week long, continuous and in the same position, and take place between semesters S6 and S7.

It requires a year-long preparation in order to acquire the necessary skills before leaving:

- good knowledge of the local population's needs and expectations;
- precise knowledge of the local culture and social codes;
- specific and technical knowledge of the content of the mission and the equipment used for the mission;

- ability to face unexpected events thanks to:a specific preparation to humanitarian work, delivered by the association in charge of the mission **and** to first aid training

Moreover, students must prepare for the safety problems they may have to face in their working and living environment.

Contact : Jean-Marc Camelin et Géraldine Carbonel

Bibliography / Teaching Material and Textbooks

- First aid training
- Specific preparation for the humanitarian work, delivered by the association in charge of the mission
- oral defense

Evaluation

- Individual written report (50%)
- Team oral defense (50%)

Course list by period

Semester 5

EN1100 Heat Transfer

EN1920 Aerodynamics and Energy Science Laboratory

IS1110 Information Systems

IS1210 Algorithms

IS2950 Electronics Laboratory

LC0000 Modern Languages, Cultures and Civilisation

LC1000 English

LC2000 French as a Foreign Language

LC3000 German

LC4000 Spanish

LC5000 Italian

LC6000 Portuguese

LC7000 Chinese

LC8000 Japanese

LC9000 Russian

LCA000 Arabic

LCC000 Hebrew

MA1000-01 Real Analysis

MA1000-02 Probability

MA1000-03 Statistics

MG1100 Mechanics

MG1960 Civil Engineering Laboratory

MG1970 Design of Mechanical Structures Laboratory

PH1910 Physics Laboratory

PR1930 Materials and biomaterials - Laboratory

PR2940 Experimental activity - Processes and Environment

SE1100 Corporate Accounting and Finance

SE1200 Business Administration

SE1950 Reverse Engineering and Rapid Prototyping Laboratory

SP1100 Sports and Physical Education

WL1100 Workshops on Professional Development and Leadership

WP1100 Challenges of the 21st Century: Introduction

Semester 6

EN1300 Applied Thermodynamics

EN1920 Aerodynamics and Energy Science Laboratory

IS1260 Software development project

IS2110 Embedded Control Systems

IS2950 Electronics Laboratory

LC0000 Modern Languages, Cultures and Civilisation

LC1000 English

LC2000 French as a Foreign Language

LC3000 German

LC4000 Spanish

LC5000 Italian

LC6000 Portuguese

LC7000 Chinese

LC8000 Japanese

LC9000 Russian

LCA000 Arabic

LCC000 Hebrew

MA1400 Partial Differential Equations

MG1960 Civil Engineering Laboratory

MG1970 Design of Mechanical Structures Laboratory

PH1100 Quantum and Statistical Physics

PH1102 Physics Tutorials

PH1910 Physics Laboratory

PR1930 Materials and biomaterials - Laboratory

PR2940 Experimental activity - Processes and Environment

PR5100 Biology

SE1950 Reverse Engineering and Rapid Prototyping Laboratory

SE2150 Complex System Engineering

SE3100 Law

SH1300 Philosophy of Sciences

SH1500 Science, technology, Society

SP1200 Sports and Physical Education

WL1200 Workshops on Professional Development and Leadership

WP1200 Challenges of the 21st Century: Team Project

Elective 01

EN1201 Fluid Mechanics

IS1220 Object Oriented Software Design

IS1270 Co-build a Python programming course

IS1310 Graph Theory for Computer Science: Algorithms and Applications

IS1410 Digital and Collaborative Engineering

MA2822 Advanced Statistics

MG1200 Civil Engineering

PR1100 Introduction to Materials

PR3100 Chemical Engineering and Sustainable Development

SE2750 Stochastic Modeling and Theory of Queues and their Applications

WP2100 Sustainable Development

Semester 7

LC0000 Modern Languages, Cultures and Civilisation

LC1000 English

LC2000 French as a Foreign Language

LC3000 German

LC4000 Spanish

LC5000 Italian

LC6000 Portuguese

LC7000 Chinese

LC8000 Japanese

LC9000 Russian

SE1400 Economics

SH2100 Business Games

SP2100 Sports and Physical Education

WL1300 Workshops on Professional Development and Leadership

WP5000 Philosophical approach of strategy and innovation

WP5100 Innovation Project S7

WP6100 Student Organization Project S7

WP8100 First Line Operator Internship

WP8110 International Solidarity Mission

Elective 02

IS1220 Object Oriented Software Design

IS1410 Digital and Collaborative Engineering

MA2630 Distributions and operators

MG1200 Civil Engineering

PH2100 Waves

PR3101 Chemical Engineering and Sustainable Development

SE1300 Corporate and Market advanced Finance

SH2550 Perspective on Key Social Issues

Elective 03

EN1200 Fluid Mechanics

IS1230 Introduction to Databases

MA2300 Advanced Probability

MG1300 Structural Dynamics and Acoustics

PR5210 The Genome

SE2400 Introduction to Supply Chain

SE3300 Entrepreneurship: A First Approach

Elective 04

MA2100 Financial Risk Modeling

MA2610 Scientific computation

MA2823 Introduction to Machine Learning

MG1400 Plasticity and Fracture: Mechanical Behavior of Materials

PH2600 Relativities

PR4200 Electrical Power Systems

PR5300 Biotechnology: Applications and Modeling

SE2200 radical innovation

SE2300 Strategy and Marketing

SH2750 Innovation, Arts and Creativity

Elective 05

EN1110 Advanced Heat Transfer

IS1510 Digital Communications and Networks

IS2120 Control Systems

MA2200 Optimization

MG1600 Nanomechanics

PH2300 The Structure of Matter: from Solid-State Physics to Nano-Materials

SE1600 Advanced Economics

SE2920 Agile Management of Complex Projects

SH2650 Science, Technology, Society

Elective 06

EN2910 Aircraft Design

EN2940 Electrical Aircraft

MA2815 Mathematical Modeling for Biology

MG1700 Design of maintenance system of railroad way

PH2200 Synchrotron X-ray Beamline Design

PH2250 Embarked nuclear reactor

PH2260 Quantum cascade lasers

SE2350 Industrial ecology: towards industries in symbiosis

SH2300 Seminar Series: individuals, labour, organisations

SH2400 Seminar Series: International and Intercultural

SH2500 Seminar series: Perspective on Key Social Issues

SH2600 Science, Technology, Society

SH2700 Innovation, Arts and Creativity

Semester 8

LC0000 Modern Languages, Cultures and Civilisation

LC1000 English

LC2000 French as a Foreign Language

LC3000 German

LC4000 Spanish

LC5000 Italian

LC6000 Portuguese

LC7000 Chinese

LC8000 Japanese

LC9000 Russian

SP2200 Sports and Physical Education

WP5200 Innovation Project S8

WP6200 Student Organization Project S8

Elective 08

EN1201 Fluid Mechanics

IS1220 Object Oriented Software Design

IS1310 Graph Theory for Computer Science: Algorithms and Applications

MA2822 Advanced Statistics

MG1200 Civil Engineering

PH2813 Advanced Materials and Novel Devices for Information Technologies

PR1100 Introduction to Materials

PR3100 Chemical Engineering and Sustainable Development

SE2500 Modeling and analysis of Supply Chain

SE2750 Stochastic Modeling and Theory of Queues and their Applications

WP2100 Sustainable Development

Elective 09

EN1500 Nuclear Engineering

IS1240 High Performance Computing for Engineering and Finance

IS1330 Theoretical computer science and discrete mathematics: formal languages and

computability

MA2824 Differential Geometry

MG1500 Biomechanics

MG2814 Economics and Design of Dams

SE2700 Modeling for Decision Making

SE3301 Entrepreneurship: A First Approach

Elective 10

MA2620 Ordinary Differential Equations and Dynamic Systems

MA2814 Introduction to Random Modeling

MG2816 Micro-Electro-Mechanical Systems (MEMS)

PH2812 Introduction to Atomic and Molecular Physics

PR4300 Cogeneration and Energy Production

SE2550 Introduction to Purchasing

SE3200 Law 2

Elective 11

EN1600 Renewable Energy

EN1800 Numerical Methods in engineering applications

IS1250 Programming Mobile Devices

MA2827 Foundations of discrete optimisation

MG2812 Introduction to Acoustics: Industrial and Musical Acoustics

PH2500 A Crash Course in Modern Mathematical Physics

SE2650 Risk Assessment and Management

Elective 12

EN1120 Heat Transfer

IS1350 Logic for computer sciences

IS2210 Optical fibers and optoelectronics

MA2500 Signal Processing and Sparsity

MA2825 Algebra and cryptology

MG2817 Applications of the Finite Element Method

PH2821 Applications of statistical physics to complex socio-economical systems

PR2100 Water Treatment and Underground Water Protection

SE2800 Production Planning and Scheduling

Elective 13, One-week module

EN2910 Aircraft Design

EN2930 Powertrain Design

IS2960 Electronics Laboratory

MA2828 Design of an anti-noise wall by fractal protections

MG2818 Introduction to Oil Gas Exploration Production

MG2819 New sensing systems for automotive seating

MG2920 Sustainable Buildings and Architecture Laboratory

PH2814 Science-Fiction and Physics

PH2930 Nuclear Physics Laboratory

WL2100 Innovating Leadership

WL2200 Ethics and Responsibility in Engineering

Humanities Module

SH3200 Seminar Series: individuals, labour, organisations

SH3300 Science, Technology, Society

SH3400 Seminar Series: International and Intercultural

SH3500 Seminar series: Perspective on Key Social Issues

SH3600 Innovation, Arts and Creativity

Courses with bold codes may be taken in English. See the corresponding