ÉCOLE CENTRALE PARIS

leader, entrepreneur, innovator

COURSE CATALOG

FIRST
AND SECOND YEAR




Academic year 2011 - 2012

CENTRALE PARIS

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Table of Contents

Teaching Language

The courses of Ecole Centrale Paris are taught in one of four language options, specified for each course in this catalog:

French, course entirely in French (but may include occasional material in English);

English, course entirely in English:

French or English, there are two classes in parallel, one taught in French, one in English;

English*, the course is taught entirely in English, unless all students registered for the course have a sufficient command of French, in which case the professor may file a petition with the Dean of Studies to teach the course in French.

Period Codes

This catalog describes all courses offered in the first and second years at École Centrale Paris. These two years are divided into four semesters: the Fall semesters (5 and 7) last from 2 September 2010 to 28 January 2011, the Spring semesters (6 and 8) from 31 January to 14 June 2011.

The **Period** entry of each course description contains a 7-character code of the form *EEESTTT* indicating the time schedule of the course and the type of program. Many courses have several period codes, meaning they are offered at different times during the academic year, or open to several programs.

The first three characters of the period code (*EEE*) indicate the type of program:

IN1, first year of engineering studies toward the École Centrale “Ingénieur” degree

IN2, second year of engineering studies toward the École Centrale “Ingénieur” degree

FEP, Fall exchange program (semester 5 or 7)

SEP, Spring exchange program (semester 6 or 8)

The next character (*S*) indicates the semester (5 to 8).

The last three characters (*TTT*) refer to the position in the time schedule:

COM, common core

DE1, elective series 1 (semester 6)

DE2 to **DE7**, elective series 2 to 7 (semester 7)

IE1 to **IE5**, elective series 8 to 12 (semester 8)

DXP, laboratory courses offered in S2 (each series takes place over 4 Wednesdays)

IXP, laboratory courses offered in S4 (each series takes place over 5 Tuesdays)

IS1, SH1, first dedicated week: 2-6 April 2012

IS2, SH2, second dedicated week: 14-21 May 2012

CAA, professional development and leadership

Energy Science

EN1100
Heat Transfer

Professor: Estelle Iacona

Language of instruction: French or English – **Number of hours**: 30 – **ECTS**: 2.5

Prerequisites: Basic notions of thermodynamics and mathematics

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

The general objectives are to master the basic notions of the three modes of heat transfer, to understand how to derive balance equations for heat transfer, and to develop abilities to build elementary models.

Course Contents

Lectures (40% of the scheduled time):

- The three modes of heat transfer: conduction, radiation and convection, and coupling between conduction and convection (phenomenological approach to the heat transfer coefficient).
- Steady-state energy balance in fixed systems.
- Linear models of steady-state heat conduction (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 radiation flux. First expression of the radiation flux.
- Conservation of energy flux and boundary conditions.
- 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 Fourier and Biot numbers. The semi-infinite wall model (or short time response model). Spectral analysis of a thermal signal. Degeneracy of the forced-frequency diffusion phenomenon into propagation. Modeling of finite systems.
- Dimensional approach of forced convection. Notions of mechanical and thermal boundary layers. Reynolds, Prandtl and Nusselt numbers. Classical approaches of internal and external convection (limited to fully developed regimes). Laminar-turbulent transition. Hydraulic diameter.
- Qualitative notions of natural convection.

Tutorials (60% of the scheduled time): The problems studied are generally one-dimensional in order to simplify the mathematical formulation, and to focus on the physics of the phenomena in a engineering design approach. The final problems are generally taken from thermal industrial or everyday cases. The main aim is to build a simple model.

Course Organization

Lectures and tutorials: 25.5 hr. Documents and website in English.

Teaching Material and Textbooks

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

Evaluation

- 1.5-hr optional written exam: simple exercises (no documents allowed).
- 3-hr written final exam. Part 1: simple exercises (no documents allowed). Part 2: build, implement, and validate simple models for a given application (documents allowed).

EN1101
Extra Tutorials in Heat Transfer

Professor: Estelle Iacona

Language of instruction: French – **Number of hours**: 20 – **ECTS**: 0

Prerequisites: EN1100 or equivalent. Attendance to all EN1100 classes is mandatory

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

These tutorials are intended for students who need help with EN1100.

Course Organization

These tutorials are organized as questions answers sessions on the lectures and the exercise sessions. They generally take place on Thursday afternoon.

EN1110
Applied Heat Transfer

Professor: Benoît Goyeau

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: EN1100 or equivalent.

Period: S7 Elective 04 November to December IN27DE4, FEP7DE4

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
- Radiation heat transfer: view factors
- Thermal methodology (how to solve practical problems)

Course Organization

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

Teaching Material and Textbooks

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

Evaluation

- Written exam: 1 hr
- Application of methodology on a practical case: 2 hr

EN1120
Heat Transfer

Professor: Christophe Laux

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic notions of thermodynamics and partial differential equations

Period: S8 Elective 12 March to June SEP8IE5

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.
- General transport theorem, Reynolds theorem. Balance equations for heat transfer. Boundary layer approximations. Heat transfer and fluid flow Reynolds analogy. 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

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: Sébastien Candel (S7), Thierry Schuller (S6, S8)

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Calculus and vector analysis. Some continuum mechanics. Some thermodynamics.

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S7	Elective 03	September to November	IN27DE3, FEP7DE3
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

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 enregy. Balance of energy. 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 moment of 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 an dits 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. Characteristics 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 charcteristic 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 wavec 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

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
- Mandatory 3-hr written final exam with all documents allowed

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

EN1300
Applied Thermodynamics

Professor: Didier Jamet

Language of instruction: French – **Number of hours**: 15 – **ECTS**: 1

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

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

Teaching Material and Textbooks

Course reader (in French)

Evaluation

1.5-hr written final exam, all documents and handheld calculator allowed

EN1400
Combustion Modeling and Simulation

Professor: Nasser Darabiha

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Thermodynamics, Fluid Mechanics, Heat and Mass Transfer

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

The first objective of the course is to introduce the fundamental principles of combustion. These principles are used by engineers to understand and design industrial combustion systems for a wide range of energy related applications, such as, for instance, aerospace, car, power plants, glass and steel industries. In parallel, students will learn methods for combustion modeling. They will apply numerical tools dedicated to the prediction of combustion system performance both in terms of efficiency and pollutant formation. Finally students will perform a simulation of an industrial combustor with the CFD code Fluent in a short term project.

On completion of the course, students should be able to

- estimate burnt gases temperature and chemical composition
- determine the required fuel and oxidizer mass flow rates to ensure a desired power level

Course Contents

- General introduction (6 hr): context (Lecture), combustion chemistry (Lecture), thermochemistry (Lecture), example of burnt gases temperature estimation (Class Work), use of the CHEMKIN code to calculate equilibrium state (Numerical Class Work).
- 0D modeling (3 hr): equations (Lecture), numerical simulations (Numerical Class Work).
- Laminar premixed flames (6 hr): theory (Lecture), estimation of laminar flame speed using the PREMIX code (Numerical Class Work).
- Laminar diffusion flames (3 hr): theory (Lecture), numerical simulations (Numerical Class Work).
- Introduction to turbulent combustion (3 hr): theory (Lecture)
- Introduction to Computational Fluid Dynamics with the Fluent code (6 hr): methodology (Lecture), Fluent tutorial (Numerical Class Work).
- Combustion project. Simulation of an industrial combustor (9 hr): 0D modeling (Numerical simulation), Fluent simulation (Numerical simulation).

Course Organization

Lectures: 12 hr, Tutorials: 15 hr, Final project: 9 hr

Teaching Material and Textbooks

- Course reader: N. Darabiha, E. Esposito, F. Lacas and D. Veynante, Cours de combustion de l'Ecole Centrale Paris, 2004.
- K.K. Kuo, Principle of Combustion, John Wiley and Sons, 2005.
- T. Poinsot and D. Veynante, Theoretical and Numerical Combustion, Edwards, 2005.

Evaluation

Intermediate short projects + Final project

EN1500
Nuclear Engineering

Professor: Pascal Yvon

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

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 such or such reactor in the future energy mix, the pros and cons of the nuclear fuel compared with other fuels, 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, intyrnal 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: 12 hr, Tutorials: 15 hr, Exam: 3 hr

A one-day visit (in addition to the scheduled classes) of a nuclear site (CNPE, Eurodif and/or CEA) will be organized by the students.

Resources

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

Evaluation

3-hr written exam without documents

EN1600
Renewable Energy

Professor: Jean-Claude Vannier

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

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

Two 1.5-hr written exams, all documents and computer allowed.

EN1700
Introduction to Neutronics and Nuclear Reactor Physics

Professor: Richard Lenain

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

The goal of this course is to present the bases of nuclear physics and neutronics, required to understand their applications to nuclear reactor physics. These bases will be needed to raise different questions on nuclear core design and fuel cycle studies. This course is required for a deeper understanding of neutronics, transport energy, and numerical schemes that may be subject to a specialization at the Master's level. It also complements the contents of EN1500.

On completion of the course, students should be able to

- ✧ understand the basics of neutronics and nuclear reactors
- ✧ understand notions of nuclear core design and fuel cycle studies

Course Contents

1. Elements of nuclear physics (10 hr)
   - ✧ Reminders: units, atoms, mass, size, atomic number
   - ✧ The nucleus: properties, nucleus models (Weizsäcker formula, nuclear shell model), stable isotopes, radioactivity, radioactivity law, decay chains; nuclear reactions, conservation laws (A, Z, energy, momentum), binding energies.
   - ✧ The different binary reactions: nuclear balance; Q-value; fission, fusion; fusion products.
   - ✧ Nuclear reactions with neutrons: scattering, capture, fission; nuclear cross-sections, mean free path.
   - ✧ Interaction matter/neutrons: attenuation law, microscopic cross-sections (interactions: diffusion, resonant absorption, fission, yields, ...); macroscopic cross-sections, reaction rate, neutron current and flux, neutron balance equation.
2. Nuclear reactor principles (15 hr)
   - ✧ Introduction to neutronics: characteristics of a few important heavy nuclei (thermal fission), *eta*, chain reaction; neutron life cycle in a reactor (4-factor formula); neutron multiplication factors, reactivity, criticality, feedbacks.
   - ✧ Neutron diffusion equation: neutron balance equation in the diffusion approximation; criticality (keff, eigenvalue, source problem), infinite media; core, reflector.
   - ✧ Kinetics: Nordheim equations, low and high reactivity situations.
   - ✧ Fuel depletion: U and Th chains, wastes.
3. Nuclear reactors (11 hr)
   - ✧ History: from Fermi to PWR.
   - ✧ Principles of PWR design: major orientation for PWR design (moderator, coolant, fuel, ...); reactivity accident and operational transients.
   - ✧ Other reactors: Boiling Water Reactor, Fast breeder-Na cooled, Magnox, Material Test Reactors.
   - ✧ Principles of reactor simulation: principles and application to the two-group diffusion equation.

Course Organization

Lectures: 15 hr, Tutorials: 19 hr, Exam: 2 hr

Teaching Material and Textbooks

- Dictionnaire de la physique, atomes et particules, Encyclopaedia Universalis, Albin Michel
- Y. Chelet, La radioactivité, manuel d'utilisation, NucléoN
- L. Valentin, Le monde subatomique, 2 volumes, Hermann
- S. G. Prussin, Nuclear Physics for Applications, Wiley-VCH
- P. Charles, Energie nucléaire, fusion et fission, Ellipses
- P. Reuss, Précis de neutronique, EDP Sciences
- J. Kenneth et al., Fundamentals of Nuclear Science and Engineering, CRC Press

Resources

Lecturers: Eric Dumonteil, Richard Lenain, Anne Nicolas, Xavier Raepsaet (CEA)

Evaluation

2-hr written final exam

EN1920
Aerodynamics and Energy Science Laboratory

Professor: Laurent Zimmer

Language of instruction: French or English – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: Basic knowledge of fluid mechanics and heat transfer

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

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.

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:

- Day 1: Students choose a topic from the list below. Definition of the physical phenomena to study, bibliography, definition of the experiment, proposition of the experimental setup with the help of a laboratory technician and a laboratory assistant. Proposition of an experimental procedure and definition of objectives.
- Days 2 and 3: Execution of the experimental set-up with the help of the technical team. Experiments. Results analysis.
- Day 4: Oral presentation (15 minutes). Questions and discussion (15 minutes).
- Homework: preparation of a scientific poster.

Experimental setups offered:

- Wind tunnel experiments (4 wind tunnels)
- Flow field velocity measurement with Laser Doppler Velocimetry
- Measurements of index of refraction gradients using an interferometry technique
- Measurements of index of refraction gradients using a Schlieren technique
- Measurements of temperature gradients with a LASER beam deflection technique
- Temperature measurements with thermocouples in thermal fins
- Emission or absorption spectroscopy

Course Organization

Labwork: 24 hr, Exam: 6 hr

Evaluation

Grading is in three parts, equally weighed. The first tier is the evaluation given by the lab assistants during the labwork. The second tier is the grade given by a jury after the oral presentation. The third tier is the grade given by a jury on the scientific poster.

EN2910
Aircraft Design

Professor: Didier Breyne

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period:	S8	Elective 13, One-week module 1	2-6 April	IN28IS1, SEP8IS1
	S8	Elective 13, One-week module 2	14-21 May	IN28IS2, SEP8IS2

Course Objectives

The goal of this training is to let you discover the different stages of an aircraft design process in both a theoretical and a practical perspective. You will be introduced to the typical methods used in an aircraft design office, and apply this knowledge by doing the preliminary design of your own aircraft After completing this training course, you will have acquired knowledge and skills that will enable you to work out the main aircraft characteristics and layout in a very short time frame.

Course Contents

When a team commits to design a new aircraft or to modify an existing aircraft, the project will always follow the same pattern. The process starts by analyzing the market and existing products. Next is the conceptual design which is followed by the preliminary design and detail design before sending the drawings to the workshop which will build a prototype. Obviously, at each stage, several iterations are made as necessary before proceeding to the next stage.

In the process, we will begin by a more 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 sophisticated algorithms.

You will learn how to:

- Define the layout and configuration of the new aircraft
- Work out estimates for empty weight and maximum take-off weight
- Compute wing loading
- Work out estimates for lift and drag
- Work out performance estimates (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 other conceivable product or service.

Course Organization

This course takes place over a dedicated week, either April 4-8 or May 16-20. The students taking the course in April must also take SH3307 "Creativity and innovation".

Computer Science and Electrical Engineering

IS1110
Information Systems

Professor: Guillaume Mainbourg

Language of instruction: English* – **Number of hours**: 30 – **ECTS**: 2.5

Prerequisites: None

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

The IT course is designed to train future engineers to understand and master the tools they will encounter in their career. 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 metholodgy to understand and design the architecture of company information systems;
- to provide an overview of some advanced features of IT and present a panorama of IT career prospects.

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, manipulate data with SQL queries
- Contents: Entity Relationship Modeling, relational databases, SQL language

Information Systems - Bases

- Objectives: Introduce the key components of a computer (including CPU, memory, hard drives), 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

- Objectives: Understand the bases of networks and network architecture 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, convergence

Course Organization

Lectures: 13.5 hr, Tutorials: 15 hr, Exam: 1.5 hr

Teaching Material and Textbooks

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

Evaluation

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

IS1130
Systems Engineering

Professor: Jean-Louis Perraudin

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

Systems engineering is a multidisciplinary general methodological approach that includes all the appropriate activities to design, make evolve and check a system, bringing a solution to the need of a customer. This course introduces the basics of Systems Engineering and a few essential processes. Its aim is to develop a "Systems Approach".

On completion of the course, students should be able to

- understand the "systems approach"
- understand the various processes used in Systems Engineering
- evaluate the requirements and technical information necessary to the definition of a new system
- have a good idea of the tools and methods likely to be used

Course Contents

- Concept of system
- Concepts of Systems Engineering: principles, activities, and processes.
- Process of engineering: needs, requirements, and architecture.
- Need for modeling, optimizing, evaluating, and checking
- Overview of some tools
- Use of a tool on a practical case

Course Organization

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

Teaching Material and Textbooks

Course reader in French

Evaluation

Case analysis

IS1210
Algorithms and Programming

Professor: Marc Aiguier

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 2.5

Prerequisites: None

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

- Understanding the possibilities and limitations of computers
- Learning the basics of programming
- Stating a problem

Course Contents

- Basics of algorithmics (functions and recursion), introduction to time and space complexity
- Linear data structures and hash functions
- Trees and binary trees (implemented with dictionaries) and exercices on binary search trees and balanced trees
- State of the art programming: exceptions, modularity, structural tests
- Formal proof using Hoare logic

The Python programming language will be used in this course.

Course Organization

Lectures: 1.5 hr, Tutorials and Labwork: 25.5 hr, Exam: 3 hr

Teaching Material and Textbooks

Introduction to the Python Programming Language, based on "How to think like a Computer Scientist, Learning with Python" by Allen Downey, Jeffrey Elkner and Chris Meyers

Evaluation

3-hr written final exam with documents and computer

IS1220
Advanced Programming

Professor: Jean-Philippe Rey

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: IS1210 or equivalent.

Period: S7 Elective 02 September to November IN27DE2, FEP7DE2

Course Objectives

- introduce object-oriented design and programming,
- present tools and techniques used in software development,
- acquire methods to produce quality software.

This course is targeted to a multiple audience:

- students who wish to become software developers,
- students taking part in projects involving software development,
- students who write computer programs for their own needs.

On completion of the course, students should be able to

- Design and develop an object-oriented computer program
- Be acquainted with tools used in the software industry
- Know how to define software quality
- Be aware of numerical pitfalls
- Use character strings correctly

Course Contents

Object oriented programming concepts: classes and instances, attributes and methods, inheritance, information hiding, overloading and polymorphism.

Development tools and methods: development cycles, software quality (ISO 9126), version control system, source code documentation.

Internal data representation: integers, floating-point numbers, characters.

Python will be used for the exercices, C++ and Java will be introduced during the course.

Course Organization

Lectures: 9 hr, Tutorials: 9 hr, Labwork: 15 hr, Exam: 3 hr

Teaching Material and Textbooks

- Object-Oriented Software Construction, *Bertrand Meyer*, 2nd ed., Prentice Hall, 1997
- ISO International Standard 9126: Software engineering - Product quality
- IEEE 754: Standard for Binary Floating-Point arithmetic
- The Unicode Standard
- Python Reference Manuals: Python Language Reference, Python Standard Library

Resources

For tutorials, labwork and the final exam, students will use their own laptop computer.

Evaluation

1.5-hr mid-term exam (30%) and 3-hr final exam on computer (70%)

IS1230
Introduction to Databases

Professor: Marie-Aude Aufaure

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

Learning how to design a database. Examine different ways to use a database graphical definition and query tools, SQL, embedded SQL. Understand the limits of each solution.

On completion of the course, students should be able to

- design a database suiting their needs
- manipulate a database using SQL and programming languages
- understand the mechanisms of Database Management Systems

Course Contents

- Database design (Entity-Association Diagrams)
- From EA-Diagrams to Relational Schema
- Introduction to relational algebra
- Views and integrity constraints
- The Structured Query Language (Data Definition Language, Data Manipulation Language)
- Embedding SQL in a programming language (Python, C, Java, etc.)
- Transactions, concurrency and query optimization
- Introduction to multidimensional modeling

Course Organization

Tutorials: 18 hr, Labwork: 16 hr, Exam: 2 hr

Teaching Material and Textbooks

SQL language, The PostgreSQL Reference Manual, Use Cases

Evaluation

Evaluation based on a case study (50%) and the final exam (50%)

IS1240
High Performance Computing for Engineering and Finance

Professor: Frédéric Magoulès

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

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

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

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

Course Organization

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

Evaluation

Project with written report and oral defense

IS1310
Graph Theory for Computer Science: Algorithms and Applications

Professor: Wassila Ouerdane

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: IS1210 or equivalent.

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

Course Objectives

Graphs are fundamental mathematical tools of Operations Research. They allow the modeling of systems that are extremely varied and complex. The aim of this course is, first, to increase the knowledge of graph theory and related algorithm and, second, to treat various problems of graphs for different contexts and domains of application.

On completion of the course, students should be able to

model and solve problems using graph theory and algorithms

Course Contents

Graph theory is related to the field of discrete mathematics and is widely used to model and solve various problems in computer science (e.g. shortest path, graph coloring, traveling salesman, network routing, task scheduling, etc.). The course focuses on:

- Preliminary basics and notions in graph theory
- Shortest path problem
- Minimum spanning tree problem
- Flow networks
- Scheduling problems

Course Organization

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

Evaluation

1.5-hr optional written exam (documents allowed, but no computer) + 3-hr written final exam (documents and autonomous computers allowed)

IS1320
Mathematical Foundations of Computing

Professor: Marc Aiguier

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic knowledge in algebra, mathematical logic and algorithmic

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

Understanding both basic principles and formal methods which are the basis for all methods used to develop quality computer systems. The course will address the notions which are the basis for:

- ✧ algorithms (recursive functions of Gödel/Herbrand, Turing machine and Lambda calculus). The objective is to formally define what a decision problem is and to give a formal meaning to the notion of algorithm (Church thesis).
- ✧ automatic demonstration which is the basis for all the techniques of computer system verification.
- ✧ symbolic evaluation which is the basis for programming languages and for simulation based on transformation rules.

Course Organization

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

Teaching Material and Textbooks

Course reader (in French)

Evaluation

3-hr written final exam + midterm homework

IS1410
Digital and Collaborative Engineering

Professor: Pascal Morenton

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S7	Elective 02	September to November	IN27DE2, FEP7DE2

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

- Synchronous and asynchronous collaborative engineering
- Concurrent and integrated engineering
- Extended enterprise
- Digital engineering
- Virtual plateau
- CAD, Mechanical CAD (MCAD), Electronic CAD (ECAD)
- Digital mock-up; Digital Factory

Course Organization

Lectures: 9 hr, Tutorials: 9 hr, Labwork: 15 hr, Exam: 3 hr

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

Evaluation

Oral defense of a mini-project

IS1510
Digital Communications and Networks

Professor: Pierre Lecoy

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S7 Elective 04 November to December IN27DE4, FEP7DE4

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).

Understanding and practice of advanced processing used in the new systems (CDMA, OFDM, etc.), of the various networks architectures and protocols and their evolution in telecom recent history and future.

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, system 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

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, the ADSL example
- Signal regeneration, filtering, equalization, error probability

Images and sound compression (MPEG algorithms), triple play

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, Wifi, satellites)

Course Organization

Lectures: 21 hr, Tutorials: 9 hr, Labwork: 3 hr, Exam: 3 hr

Teaching Material and Textbooks

Course reader in French / Slides presented during the courses, available on the Intranet Claroline (with English version)

Resources

Lecturers: Pierre Lecoy (Professor, Ecole Centrale Paris), Dominique Godard (Distinguished Engineer, IBM), Damien Lucas (cofounder of ANEVIA), Walter Peretti (lecturer, ESME), Pierre Carpène (lecturer, Ecole Centrale and ESME)

Evaluation

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

IS2110
Embedded Control Systems

Professor: Philippe Martin, Laurent Cabaret

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 2.5

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, Boolean algebra.

Period: S6 between February and June IN16COM, SEP6COM

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 the control and filtering 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, analyse and implement a simple control or filtering algorithm and its hardware environment.

Course Contents

- Mathematical tools for control systems analysis (stability, simplification by linearization, simplification by perturbation methods)
- Introduction to controller design (static/dynamic performance for tracking/disturbance rejection, feedback, integral effect, antiwindup, PID controller)
- Introduction to multi-sensor fusion and filtering (linear observer and observability, tuning an observer, a glimpse at (extended) Kalman Filtering
- Implementation of a “filter” (controller or observer) on an embedded system (overview of embedded systems hardware/software environment, sampling, antialiasing filter, discretization of a continuous filter, quantization and finite precision arithmetics, 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, Tutorials: 13.5 hr, Labwork: 1.5 hr, Exam: 3 hr

Teaching Material and Textbooks

Course reader in French + exercise booklet

Evaluation

3-hr final written exam with documents but without computer

IS2120
Control Systems

Professor: Philippe Martin

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: IS2110 or equivalent. Basic working knowledge of undergraduate mathematical calculus and linear algebra (differential equations, jacobian matrix, vectors, matrices, eigenvalues). Some basic acquaintance with Matlab/Simulink is helpful (e.g. the "Getting Started" tutorials of Matlab, Simulink and System Control Toolbox).

Period: S7 Elective 05 November to January IN27DE5, FEP7DE5

Course Objectives

This course aims at giving a good working knowledge of analysis and design of linear feedback control of systems. It emphasizes a "global" approach:

- start with a "real" (i.e. nonlinear) plant and control objectives for this plant
- extract an adequately simplified linear model (or a collection of linear models)
- design and tune a control law with a reasonable level of performance and robustness
- implement and test it in simulation against the "real" plant
- conclude with respect to the original objectives: does it work as I expected?

An important part of the course is devoted to (simplified) "real-life" case studies with the help of Matlab/Simulink and System Control Toolbox (learning to use these tools is a side objective of the course).

Course Contents

- Mathematical tools for control systems analysis (stability, simplification by linearization, simplification by perturbations methods)
- Mathematical tools for linear control system analysis (time domain, frequency domain)
- Introduction to controller design (static/dynamic performance for tracking/disturbance rejection, feedback, integral effect, anti-windup)
- The PID controller ("textbook" PID, "industrial" PID with approximate derivative, set-point weighting and anti-windup, introduction to automatic tuning)
- "Classical" control design (root locus, frequency loop shaping)
- "Modern" control design (state feedback, observer, controller-observer with disturbance model)
- Methodology for tuning a robust controller-observer (linear quadratic criteria, choice of weighting matrices, Loop Transfer Recovery, links with "classical" design and PID control)
- Beyond linear control?

Teaching Material and Textbooks

Lecture notes + case studies

Evaluation

3-hr final exam (case study with Matlab/Simulink), documents and computer allowed

IS2130
EE and CS Complex Systems

Professor: Christian Chabrerie

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic notions of Electrical Engineering and Computer Science. A summary of the basic notions will be provided as part of the course.

Period:	S6	Elective 01	February to March	SEP6DE1
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

Course Objectives

Study, on real cases, the notion of complex systems based on Electrical Engineering and Computer Science.

On completion of the course, students should be able to

Understand systems approach

Course Contents

- Complex Systems
- Architectures: partitioning between EE and CS
- Electrical Engineering
- Electronics
- Telecom
- Computer Science

Course Organization

Lectures: 12 hr, Tutorials: 6 hr, Labwork: 6 hr, Exam: 6h

Teaching Material and Textbooks

- Slides + course reader in French for basic notions
- http://perso.ecp.fr/~chabrerc

Evaluation

15-min oral defense + written report

IS2310
Radio Communication Systems

Professor: Julien Mourlon

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

This course provides the students with an introduction to the design of radio communication systems and to the methods and tools necessary to analyse these systems. It is based upon numerous exercises and real case studies (high-definition TV satellite broadcasting, technical and economic planning of a cellular network, ...).

On completion of the course, students should be able to

- ✧ understand the terminology used in radio communications
- ✧ understand the structure and the design of wireless systems
- ✧ apply methods and tools to analyse these systems
- ✧ qualify and quantify with appropriate indicators the performance of a radio communication system
- ✧ understand the current technical, economic and regulatory challenges in radio communications

Course Contents

Radio wave propagation and analysis of radio links:

- ✧ Radio wave propagation. Free space propagation, propagation close to the Earth surface, reflection, diffraction, scattering, refraction. Propagation models.
- ✧ Fast fading. Channel models. Rayleigh channel.
- ✧ Antennas. Characterization, main antenna families.
- ✧ Noise. Source and characterization.
- ✧ Link budget.

Digital communications:

- ✧ Modulation/demodulation. Examples. Performance. Shannon capacity.
- ✧ Channel coding. Introduction to block codes and performance on a Rayleigh channel.

Wireless networks:

- ✧ Multiple access techniques: static (FDMA, TDMA, CDMA…) and random (Aloha, CSMA…) methods.
- ✧ Radio network planning applied to GSM and UMTS.
- ✧ Introduction to ad-hoc networks.

Economic and regulatory issues.

Course Organization

Lectures + Tutorials: 34 hr, Exam: 2 hr

Evaluation

Homework + 2 case studies + Written final exam (2 hr) without documents and without computers

IS2950
Electronics Laboratory

Professor: Pierre Carpène

Language of instruction: French or English – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: Basics of analog and digital electronics

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

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:

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

Resources

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

Evaluation

Oral defense and written report

IS2960
Electronics Laboratory

Professor: Pierre Carpène

Language of instruction: French or English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Good level in analog and digital electronics

Period: S8 Elective 13, 5 Tuesdays between February and June IN28IXP, SEP8IXP

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

Resources

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

Evaluation

Oral defense and written report

Languages

LC0000
Modern Languages, Culture, and Civilisation

Professor: Stephen Brown

Language of instruction: French or English – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

Course Contents

The study of English and another modern language is compulsory. The second language may be chosen from: French as a foreign language (for non-native speakers of French), Chinese, German, Italian, Japanese, Russian, Spanish, or Swedish. Arabic is also taught at Supelec. A third language from the above list may also be studied if the student has acquired a sufficiently high standard in the first two languages.

Language courses are also open to international students in semester- or year-exchange programs. We highly recommend them to take French as a Foreign Language (FLE) at the appropriate level (B1, B2, C1, or C2), 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 may study another language, depending on their course schedule and their level.

LC1000
English

Professor: Stephen Brown

Language of instruction: English – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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

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

- General English
- Preparation for the Cambridge FCE, 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).

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: Laurence Honoré

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: Minimum B1 level in French

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

Course Objectives

- Develop and solidify the four language competences (written and oral understanding, 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

Two options are offered: intensive courses at the beginning of each semester, or weekly courses.

The intensive courses are intended to enable each student to integrate quickly into the academic and social environment of the Ecole Centrale campus.

The weekly courses are offered at several levels, depending on the results of the placement test. Among other goals, they prepare to the TCF (test de connaissance du français) of CIEP (Centre Internation d'Études Pédagogiques).

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 frame)

Teaching Material and Textbooks

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

LC3000
German

Professor: Heidy Ganady

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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: Enrique Pastor-Garcia

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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%)

LC5000
Italian

Professor: Enrique Pastor-Garcia

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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 (structures, lexicon)

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: Enrique Pastor-Garcia

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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%)

LC7000
Chinese

Professor: Enrique Pastor-Garcia

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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%)

LC8000
Japanese

Professor: Enrique Pastor-Garcia

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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%)

LC9000
Russian

Professor: Enrique Pastor-Garcia

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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%)

LCA000
Arabic

Professor: Stephen Brown

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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

This course is taught at Supelec.

Evaluation

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

LCB000
Swedish

Professor: Stephen Brown

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S5	between September and January	IN15COM, FEP5COM
	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM
	S8	between February and June	IN28COM, SEP8COM

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%)

Mathematics

MA1100
Real Analysis

Professor: Lionel Gabet

Language of instruction: French – **Number of hours**: 20 – **ECTS**: 1.5

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

Period: S5 between September and January IN15COM, FEP5COM

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
- Sobolev spaces

Course Organization

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

Teaching Material and Textbooks

Course reader in French

Evaluation

Written exam: 1.5 hr

MA1200
Probability

Professor: Erick Herbin

Language of instruction: French – **Number of hours**: 20 – **ECTS**: 1.5

Prerequisites: MA1100 or equivalent.

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

This course is an introduction to basic concepts of mathematical randomness and description. 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.)

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: 8 hr, Tutorials: 10.5 hr, Exam: 1.5 hr

Teaching Material and Textbooks

Course reader in French

Evaluation

1.5-hr written exam including a first part (30 min) without documents, and a second part (1 hr) where the course reader and hand written notes are allowed. Calculators, computers, and phones are not allowed during the entire exam.

MA1300
Statistics

Professor: Nicolas Vayatis

Language of instruction: French – **Number of hours**: 20 – **ECTS**: 2

Prerequisites: None

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

To give students basic notions of estimation and tests in Statistics

Course Contents

- Sampling
- Estimation
- Tests
- Adjustment
- Regression
- Principal Components Analysis

Course Organization

Lectures: 7.5 hr, Tutorials: 10.5 hr, Exam: 1.5 hr

Teaching Material and Textbooks

Course reader in French

Evaluation

Written exam: 1.5 hr, with a first part of 30 min without documents and a second part of 1 hr with documents. Computers not allowed for either part.

MA1400
Simulation and Optimization

Professor: Pascal Laurent

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 2.5

Prerequisites: Familiarity with basic tools in analysis and linear algebra (Euclidean space, symmetric matrices, spectral analysis). Working knowledge of elementary functionnal analysis: normed space of continous and differentiable functions, geometric point of view, calculus.

Period: S6 between February and June IN16COM, SEP6COM

Course Objectives

The overall goal of the course is to provide an introduction to numerical tools in mathematic with a practical approach in order to analyze, design, simulate and optimize complex engineering systems. There are three parts:

- "Optimization" is a short introduction to numerical optimization with a focus on mathematical tools to analyze usual algorithms: differential calculus, convexity, variational calculus.
- "Differential systems" is an introduction to the numerical approximation of differential systems
- "Analysis of partial differential equations" is a short presentation of basic principles to understand the main properties of simple partial differential equations and of their numerical approximations.

The course is completed by a mini-project on the simulation of simple flows and electrical problems through a finite element software: Comsol.

On completion of the course, students should be able to

- Compute a differential, prove a function is convex, analyze a non-linear system, write basic optimization algorithms.
- Write a basic numerical scheme for a differential system. Analyze error and stability.
- Write a finite difference algorithm. Show elementary properties of approximations.
- Solve simple equations using Fourier analysis.
- Build a finite element approximation with linear elements.
- Analyze the properties of recurrence scheme for approximations of initial value problems.

Course Contents

- Elementary differential calculus: Differential, Basic theorems for extremums.
- Convex functions, Examples and applications to optimization.
- Basic optimization methods: Steepest descent, relaxation, Raphson Newton
- Differential system: initial value problem. Numerical method (Euler, trapeze). Stability. Error.
- Boundary value problem for differential equations. Finite difference and finite element methods.
- Analytical method for Partial Differential Equations: Fourier analysis, Boundary value problems.
- Finite element method applied to a simple Poisson problem.
- Introduction to dynamical problems: Diffusion equation. Stability of implicit and explicit schemes.
- Basic hyperbolic equations: advection, wave equations. Characteristics. Upwind and Lax schemes. CFD.

Programs in Scilab or Python are used to illustrate and experiment all topics studied in the course. A mini project using the finite element software COMSOL is part of the final

examination.

Course Organization

Lectures: 6 hr, Tutorials: 21 hr, Exam: 3 hr

Teaching Material and Textbooks

- P. Laurent-Gengoux: Optimisation et systèmes differentiels. Lecture notes in French.
- P. Laurent-Gengoux: Analyse des équations aux dérivées partielles. Lecture notes in French.

The content of the course is covered by classical textbooks in numerical analysis.

Evaluation

- 3-hr written final exam: 1 hr without documents, 2 hr with documents
- Mini project, graded from -2 to +2

MA2100
Financial Risk Modeling

Professor: Lionel Gabet

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MA1100 and MA1200 or equivalent. Recommended: MA2300

Period: S7 Elective 04 November to December IN27DE4, FEP7DE4

Course Objectives

The course objective is to present the concepts of modern quantitative finance within the framework of discrete-time models:

- Measurements of risk in finance (static and dynamic)
- Usual derivative products and methods for their management
- Discrete-time models for the valorization of derivative products
- Theory of extreme values

Practical applications will be studied through the implementation of standard numerical methods.

On completion of the course, students should be able to

- know the basics of derivative products and understand the various jobs in trading rooms
- master the main concepts of modern quantitative finance (arbitrage, martingales, neutral risk probability, optimal hedging)
- understand the various methods of risk representation and optimization
- implement classical numerical methods (Monte-Carlo, binomial trees)

Note: continuous time models will be taught at the Master's level.

Course Contents

- Introduction to risk measurement in finance. Static risk management. Measures relating a given lost distribution to risk levels. Traditional measures such as variance, Value At Risk (VaR), average loss of a given level. Link between these measures and random variables models used to represent lost distributions. Application to portfolio management. Dynamic risk management for derivative products. Local risk measures for hedging strategies.
- Presentation of complex financial products (in particular derivatives) and of the associated issues and professions.
- Discrete-time mathematical framework for the valuation of derivative financial products. Arbitrage. Methods of pricing and hedging with 1- and n-period binomial trees. Black Scholes model. Simple techniques for option valuation. valuation and hedging of American stock options.
- Introduction to the theory of extreme values and applications to actuarial affairs.
- Numerical methods: binomial trees and Monte-Carlo method.

Course Organization

Lectures and tutorials: 27 hr, Labwork: 6 hr, Exam: 3 hr

Teaching Material and Textbooks

Course reader in French

Resources

Lecturers: Frédéric Abergel, Romuald Elie, Lionel Gabet

Evaluation

Two projects + 3-hr written final exam

MA2200
Advanced Optimization

Professor: Paul-Henry Cournède

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basics of Optimization and Differential Calculus

Period: S7 Elective 05 November to January IN27DE5, FEP7DE5

Course Objectives

Every day, companies from various sectors face optimization and operation research 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:

- Acquire depth in the theory of the mathematical concepts of optimization (based on those studied during the first year) and generalization of the formalization framework of optimization issues
- Present Numerical Optimization and its practical applications (with computers) to industrial problems
- Introduce students 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 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

- Linear/nonlinear, convex/nonconvex optimization
- Numerical optimization
- Parametric identification of models

Course Organization

Lectures: 16.5 hr, Labwork: 16.5 hr, Exam: 3 hr

Teaching Material and Textbooks

Course reader in French

Evaluation

Two written exams (2 hr and 1hr) + Evaluation of all labwork sessions.

MA2300
Random Modeling

Professor: Erick Herbin

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MA1200 and MA1300 or equivalent. 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 03 September to November IN27DE3, FEP7DE3

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 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 most of the results 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

Teaching Material and Textbooks

Notes and solutions of exercises provided online

Evaluation

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

MA2400
Conception - Simulation

Professor: Pascal Laurent

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 06 December to January IN27DE6, FEP7DE6

Course Objectives

The objective of this course is to learn how to use mathematics with an engineering approach, through analysis, modeling, simulation and optimization of complex systems. This subject covers various domains such as design and simulation in the automotive or aeronautics sectors, as well as classical financial models or environmental risk management

The course is based on theoretical and practical approaches of simulations in solid and fluid mechanics, and robust design.

On completion of the course, students should be able to

- Analysis of a problem governed by partial differential equations
- Practical numerical simulation
- Choice of solutions offered to engineers under cost and time constraints

Course Contents

Core program:

- Analysis of elliptic, parabolic and hyperbolic partial differential equations
- Finite element method

Elective program:

- Solid mechanics: mathematical analysis of linear elasticity equations. Analysis and approximation of structured problems. Error estimate. Domain decomposition and parallelism.
- Compressible fluid flow simulation: flow model, discontinuous solutions. Basic solvers (Godounov, flow, splitting, AUSM), extensions. Applications to road traffic equations. Industrial solvers and labwork on Matlab.

Course Organization

Core program: 15 hr (including a 3-hr labwork and a project), elective program: 18 hr, written exam: 3 hr

Teaching Material and Textbooks

- MA1400 course reader.
- Course reader for each elective course
- Comsol and other software

Evaluation

3-hr written exam: 1 hr without documents (core program), 2 hr with documents for elective courses

MA2500
Signal Processing

Professor: Iasonas Kokkinos

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S7	Elective 06	December to January	IN27DE6, FEP7DE6
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

Course Objectives

This course will introduce the fundamental mathematical concepts and techniques of signal processing.

We will address problems such as the reconstruction of continuous signals from discrete measurements, signal compression, the analysis of linear-time-invariant systems using time- and frequency-domain techniques, linear filtering, signal denoising, prediction and tracking.

A solid understanding of these techniques is essential for the analysis of signals and systems emerging in a broad range of areas, such as communications, speech processing, biomedical engineering, time series analysis, multimedia, image analysis and computer vision.

Course Contents

- Continuous- and discrete-time signals
- Convolution and correlation
- Sampling and quantization; Nyquist's theorem
- Fourier series/transform, Discrete Fourier Transform
- Linear, time-invariant systems; time- and frequency-domain analysis; transfer functions
- Z-transform
- Stochastic processes and statistical signal processing

Course Organization

Lectures: 16.5 hr, Exercises: 6 hr, Labwork: 10.5 hr, Exam: 3 hr

The class will consist of eleven lectures, four sessions of analytical exercises, and three programming assignments distributed over seven programming sessions. The lectures are given in English and the programming exercises are performed in Matlab/Octave. The programming exercises, supervised by an assistant, consist in implementing some standard algorithms described during the lectures and aim at consolidating the theoretical techniques described in class.

Teaching Material and Textbooks

A. Oppenheim, I. Young and A. Willsky, “Signals and Systems”

Evaluation

- 3-hr written final exam, without documents and without computer (50%)
- Programming exercises (35%)
- Analytical exercises (15%)

MA2600
Numerical Optimization and Applications

Professor: Laurent Dumas

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic tools in analysis (functions of n variables). Note: this course is not open to students having already taken MA2200.

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

Many problems occuring in industry consist in minimizing (or maximizing) a certain cost function. This course presents various optimization methods to solve such problems. After a general introduction on numerical optimization, two different families of optimization methods will be presented: first, stochastic methods (genetic algorithms, evolution strategies, etc.) and then deterministic descent-type methods (gradient, Newton, etc.). These methods will be numerically implemented in Scilab during lab computer sessions, and then will be applied to the resolution of practical problems.

On completion of the course, students should be able to

- solve multidisciplinary optimization problems
- program with Scilab
- select the appropriate resolution method for concrete problems

Course Contents

- Introduction and examples
- Stochastic optimization methods: genetic algorithms and evolution strategies. Implementation of a GA with Scilab. Validation on classical test functions.
- Stochastic optimization methods: constraints handling
- Stochastic optimization methods: parameter tuning. Implementation of a GA with Scilab: constraints handling.
- Stochastic optimization methods: multi objective optimization
- Deterministic optimization method: basic methods, line searches, steepest descent
- Deterministic optimization methods: Newton methods. Implementation of the BFGS method. Validation on classical test functions.
- Deterministic optimization methods: constraints handling
- Robust optimization. Applications.
- Resolution of 'real world' problems (in telecommunications, car industry, biomechanics, etc.).

Course Organization

Combined lectures and exercises: 33 hr, Exam: 3 hr

Teaching Material and Textbooks

- Lecture slides
- Scilab scripts

See http://www.ann.jussieu.fr/~dumas/UP-optimization.html

Evaluation

Written exam and Scilab project

MA2811
Computational Analysis, Algebra, and Geometry

Professor: Claude Lamoureux

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Two years of college-level Mathematics. No prerequisite is needed on Mathematica nor on the subjects treated in this course, which should be new for any student.

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

- Symbolic and therefore exact resolution of problems in Analysis, Algebra and Geometry in finite and infinite dimension, including resolution of equations and systems of equations of the following types: linear, non-linear but algebraic, differential, retarded, integral or partial differential but easily transformed to integral ones, integro-differential ones, etc.
- Symbolic resolution of optimization problems.

The resolutions not tractable by hand will be treated using symbolic algorithms running on a computer.

On completion of the course, students should be able to

- Recognize if, for a given problem, the methods of this course are relevant or not
- Adapt the problem in order to get the best of this course, with some a priori estimates of the precision of the expected solution(s)
- Treat correctly the adapted problem by hand or/and with the help of a computer
- Compare the eventual result(s) with the initial or adapted real ill- or well-posed problem.

Course Contents

- Symbolic computation
- Main algorithms of symbolic computation in the real, complex, vectorial algebraic domains
- Introduction to existence theorems, e.g. of fixed points

Teaching Material and Textbooks

Course reader

Evaluation

Final exam: written report and programs, followed by oral defense with computer demos

MA2814
Discrete Time Stochastic Processes

Professor: Fabrice Borel-Mathurin

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MA1200 and MA1300 or equivalent. 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 12 March to June IN28IE5, SEP8IE5

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.

Contrary to MA2300 course, the study of concrete examples taken from different areas of engineering is more important here than the definition of rigorous theoretical foundations.

On completion of the course, students should be able to

implement basic probabilistic models to describe random or uncertain phenomena.

Course Contents

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

Course Organization

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

Teaching Material and Textbooks

Course notes

Evaluation

3-hr written exam

MA2815
Mathematical Modeling for Biology

Professor: Véronique Letort

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

In the current context where interdisciplinarity between mathematicas and biology becomes more and more necessary both in private or academic domains, the objectives of this course are:

- to give the students an overview of the problematics raised by life sciences and the interest of an approach based on mathematics modeling
- to present the methods and tools required for modeling work in biology (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, sensitivity analysis, parametric identification from experimental data) and the different kinds of models and their objectives
- to be confronted to applicative cases through practical works including simulations

Course Contents

- What are the objectives of models in biology? The different kinds of models and their specificities
- Methods and generic tools for modeling: parametric identification of models, generalized linear and non linear least squared methods, heuristics, confident intervals, sensitivity analysis, multi-scale analysis, multi-objective optimization.
- Methods and languages to take into account the structure dynamics of biological objects (automata, L-systems, MTG graphs, relational grammars etc.)
- Examples and applications (practicals) from diverse fields of biology: population dynamics, plant growth modeling, ecology, cell growth, epidemiology, etc.
- Conferences

Course Organization

Lectures: 15 hr, Labwork and conferences: 21 hr

Teaching Material and Textbooks

Course reader in French

Evaluation

Labwork reports and oral defense of the projects

MA2817
From Colorimetry to Visual Appearance – Spectral Simulation for Physically Realistic Image Synthesis

Professor: Patrick Callet

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

Discover colorimetry, photometry and how computer graphics, eigenvalue computation and physical modeling allow to see and predict the visual aspect of materials to come or that have disappeared. Link various, often abstract, notions introduced in other courses and put them into practice. Learn “to see the real through the exploration of the virtual world”.

On completion of the course, students should be able to

- perform physical and mathematical modeling, physical measurement, and visual appraisal (metamerism)
- master 3D modeling and solid geometry, study local and global lighting through simulation and illustration (understand the differences), apply notions of colorimetry, radiation and plasma physics
- validate the virtual design of a real product

Course Contents

Physical modeling and 3D modeling, graphical algorithms and spectral rendition with Virtuelium Geometric creations and constructions under Blender.

- White transparencies; complex dielectric function; bases of colorimetry
- Color perception; absorption, reflection, transmission, the ART rule and energy conservation. Spectrophotometry. Practical applications (labwork with spectro-photometer).
- Virtual lights and lighting; lighted cabin and visual aspect. From spectrum to illuminant. Labwork with spectrophotometer (fires, luminaries, etc.).
- Light and matter: generalization. Surface of all reflectances and computation of ambient lighting.
- Spectral ray tracing with polarized light: Virtuelium! Simulation of global lighting (directional, pinpoint or spread sources) of homogeneous and heterogeneous materials.
- Complex dielectric function, ab initio modeling. From spatial plasma to virtual metallurgy. Application to virtual jewelry (precious alloys, gemstones, pearls).
- Nanostructures: photonic and biophotonic; semantic colors, cryptic colors. Application to nacre pigments of cosmetics, inks and paints.

Course Organization

Lectures: 21 hr, Tutorials: 6 hr, Labwork: 5 hr, Exam: 4 hr

Teaching Material and Textbooks

Documents in French + scientific articles in English

Evaluation

Written report and oral defense

MA2818
Introduction to Computer and Artificial Vision

Professor: Iasonas Kokkinos

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Signal Processing, Programming (C or C++ desirable), Optimization (desirable)

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

The aim of this class is to introduce the fundamental mathematical concepts and techniques for problems related to computer vision, as well as to present the current state of the art of this rapidly evolving field.

During the course the students will become acquainted with the broad range of techniques developed around the problems of computer vision, including multi-scale analysis, nonlinear image processing, continuous and discrete optimization, modeling and inference using probabilistic graphical models.

The techniques presented in class have applications in a broad range of cutting-edge problems such as robotics, human-computer interaction, security and surveillance, biometrics and medical image analysis.

Course Contents

The class will consist of eleven lectures and three programming assignments, distributed over eleven programming sessions. The lectures are given in English and the programming exercises are performed in Matlab. The programming assignments consist in developing algorithms around a problem described during the lectures and aim at consolidating the theoretical techniques described in class.

Contents:

- Linear filtering, nonlinear (PDE-based) image processing
- Feature extraction, scale invariance
- Texture analysis, image descriptors
- Image Segmentation Grouping: clustering- and optimization- based techniques
- Motion estimation, registration
- Deformable object models, face analysis
- Object detection: part-based models, classifiers, object tracking
- Stereo 3D vision

Course Organization

Lectures: 16.5 hr, Labwork: 16.5 hr, Exam: 3 hr

Teaching Material and Textbooks

- Forsyth and Ponce: “Computer Vision: A Modern Approach”
- Paragios, Chen and Faugeras: “The Handbook of Mathematical Models in Computer Vision”

Evaluation

Half of the grade will be determined by the performance on the lab assignments. The other half will be determined either by a written final exam (3 hr, no documents, no computer), or by a project chosen after discussion and agreement with the Professor.

MA2819
Advanced Numerical Simulation

Professor: Jacques-Hervé Saiac

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

- To expose students to real-life situations in a numerical laboratory environment and to let them act as young researchers dealing with complex industrial problems like supersonic flows, mesh adaptation, image processing, etc.
- To provide a thorough overview of the current issues and innovative methods in numerical simulations, especially regarding adaptive meshing techniques. This course will also focus on the improvement of the accuracy of numerical solutions using mesh quality control and will introduce the students with recent advances in this field.
- To conduct numerical experiments through tutorials and to carry on as a final term project, the implementation of a computer program to assess the efficiency of adaptive anisotropic meshing techniques in numerical simulations of complex fluid flows and digital image processing.

Course Contents

The lecture will focus on the following topics:

- Weak formulation for PDE based problems. Finite element error analysis for anisotropic meshes. Application to P1 finite elements. Numerical experiment: a one dimensional boundary layer problem. Numerical solution and mesh adaptation.
- Introduction to meshing techniques. Structured and unstructured meshes. Error estimates in 2 and 3 dimensions. State of the art of adaptive anisotropic meshing. Numerical experiment: Construction of an anisotropic mesh adapted to the representation of a complex solution. Capture of sharp discontinuities or shocks. Practice of meshing and scientific visualization softwares.
- Compressible fluids flow and image compression.

Term project: A complete simulation and adaptive meshing loop for a flow problem with shocks or for an application in image compression.

Course Organization

Lectures: 9 hr, Labwork: 24 hr, Exam: 3 hr

Evaluation

Written report on labwork and projects + oral defense

MA2820
Probabilistic Safety Assessment in Nuclear Power Plants

Professor: Richard Quatrain

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MA1200 and MA1300 or equivalent.

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

The main objective of this course is to understand an example of estimation of a very rare probability by an exhaustive approach that gives rise to combinatorial difficulties.

This mathematical problem will be strongly linked to its industrial context. The other objective of this course is to make the students experience the importance of probabilistic uncertainty and call into question the perfection of systems. Probabilistic studies in nuclear safety propose a global approach to evaluate the safety of facilities.

On completion of the course, students should be able to

have good notions on:

- the functioning of a nuclear power plant; nuclear safety
- formalisms of safety dependability studies: reliability diagrams, event tree, failure tree analysis
- algorithms, statistics and probability: quantification of high order failure trees, probabilities of rare events, statistics and experience data, uncertainty calculations
- maintenance optimization
- appraisal of complex systems: human reliability, digital instrumentation and control systems

Course Contents

How to assess the safety of equipments as complex as nuclear power plants? In that domain, conception, construction, and exploitation rules are very strict so as to ensure that the risk of a major accident is minimal. But is it still possible to improve safety ? If yes, by which modifications and at what costs ? Probabilistic Safety Assessment (PSA) studies propose answers by adopting a probabilistic viewpoint. They provide a unique probability value, assessing in a global way the risk of a major accident, and they explain, quantify, and organize every failure concurrence that could lead to accident scenarios.

- D1. Lecture: General presentation of nuclear power plants and of probabilistic studies in nuclear safety
- D2. Lecture/Tutorial: Introduction to RiskSpectrum
- D3. Tutorial: Definition of analysis cases
- D4. Tutorial: Formalization of analysis cases
- D5. Lecture/Tutorial: Obtaining reliability data
- D6. Lecture/Tutorial: Human Reliability Assessment - EDF MERMOS Methodology
- D7. Tutorial: Continuation of analysis cases development
- D8. Lecture/Tutorial: Common Cause failures
- D9. Lecture/Tutorial: Complements on modeling. Quantification algorithms.
- D10. Lecture/Tutorial: Uncertainty calculation
- D11. Lecture/Tutorial: Finalizing analysis cases. Conclusions.
- D12. Written exam

Course Organization

Most classes will be divided into lectures and tutorials. Students will build their own analysis cases in the domain of their choice, with a gradual approach to assimilate the concepts, and will eventually reach a simplified but complete appraisal of a category of feared events.

Teaching Material and Textbooks

Powerpoint slides and EDF or public technical documents

Resources

Lecturers are from the Department of Industrial Risk Management (MRI), EDF Research and Development.

Evaluation

Written report on case analysis (tutorials) + 3-hr written final exam (documents and computers allowed)

MA2821
Multi-agent Modeling of Complex Systems

Professor: Anirban Chakraborti

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Functional analysis and basic probability theory. Programming in either MATLAB, C/C++ or Python

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

Provide an understanding of the fundamental concepts of statistical physics, and its 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 give an exposure of some very elegant 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 the problems associated (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
- practical applications in everyday life

They will be familiar with the challenging practical problems and applications of real life situations. They will have hands-on experience of numerical computations and simulations to address and tackle such problems, enabling them to enter industry and academia with confidence and maturity. Stress will be given to develop the skills of presentation, 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 great variety of such systems which include examples from physics, chemistry, biology, computer science and also social sciences. The concepts and methods of statistical physics turned out to be extremely useful in application to these diverse complex systems, many of which have 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 we do not have to go into the detailed “microscopic” description of the complex system.

The student gain knowledge about:

- Basics of statistical physics and complex systems
- Study of socio-economic networks
- Combinatorial optimization problems
- 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 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 and team activities. The implementation may be done either in MATLAB, C/C++ or Python.

Course Organization

Lectures: 12 hr, Tutorials: 3 hr, Labwork: 15 hr, Exams: 6 hr

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: Anirban Chakraborti (Chair of Quantitative Finance), Nicolas Millot, Gayatri Tilak

Evaluation

Labwork and group project with report and oral defense: 50%, 3-hr written final exam: 50%

Attendance to all classes is mandatory, as evaluation is based on the laboratory work and projects performed in class.

MA2822
Advanced Statistical Methods

Professor: Gilles Faÿ

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MA1300 or equivalent.

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

Course Objectives

In this course, fundamental notions of statistics studied in MA1300 will be implemented. The objectives are to use:

- techniques of parametric and non-parametric estimation
- concepts and methods related to the control of the complexity of statistical models
- usual models such as the mixed strategy widely used in applications
- calibration of predictive models

This course also gives an introduction to applications of statistics. It will illustrate unpredictable modeling and data analysis with examples in signal processing, biology, social sciences, finance or industry.

This course will give the basis to follow Data Mining or Machine Learning courses, to prepare students to the management of random modeling projects using real data.

On completion of the course, students should be able to

- use random modeling and non-parametric statistical techniques
- use the R software
- implement the approaches learned in a project on data analysis and predictive model development.
- validate and understand the limits of statistical models

Course Contents

- Plug-in estimate and bootstrap technique: variance estimate for small samples
- Non-parametric estimation of the density by the kernel method: fault detection
- Non-parametric regression: logistic regression (scoring)
- Complexity study: regularization and model selection - Validation of a predictive model
- Case study: the pitfalls of a statistical model

Course Organization

Lectures: 17 hr, Tutorials: 8 hr, Labwork: 8 hr, Exam: 3 hr

Teaching Material and Textbooks

- Web site

Evaluation

Two 0.5-hr written mid-term exams, a programming project and a 2-hr written final exam

Mechanical and Civil Engineering

MG1100
Mechanics

Professor: Denis Aubry

Language of instruction: French – **Number of hours**: 45 – **ECTS**: 4

Prerequisites: Knowledge and skills in linear algebra (matrices, determinant, dot and cross vector product) and real analysis (differential equation, partial differentiation, multiple integrals, Stokes formula) / Knowledge of velocity, acceleration, forces and moments developped in courses on analytical mechanics

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

The student should be convinced of the ubiquitous presence 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 framework for rigid bodies, deformable solids and fluids. Problems involving mechanics at different scales illustrate the course. Finally some applications to biomechanics and nanotechnology are sketched.

On completion of the course, students should be able to

- identify the adequacy of either a rigid body, or beam or solid model for basic design purpose
- solve simple design issues of mechanical parts and identify relevant mechanical properties
- estimate forces and moments applied by flowing fluids on obstacles

Course Contents

- Strains, stresses, materials behavior and stress concentration effects in deformable solids
- Flow, acceleration, viscosity of fluids, fluid-wall interactions and forces applied on obstacles
- Dynamics of systems of rigid bodies in rotation, and gyroscopic forces in space
- Elongation, bending and torsion of slender three-dimensional structures

Course Organization

Lectures: 15 hr, Tutorials: 27 hr, Exam: 3 hr

Teaching Material and Textbooks

Textbooks:

- Bonet, Wood (1997) Nonlinear continuum mechanics
- Gurtin (1981) An introduction to continuum mechanics
- Baruh (199) Analytical dynamics

Evaluation

2 written exams (1.5 hr each). All documents and computers authorized.

MG1200
Civil Engineering

Professor: Pierre Vezole

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic knowledge in Strength of Materials and Static Mechanics

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S7	Elective 02	September to November	IN27DE2, FEP7DE2
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

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.

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
- Materials sustainability
- Safety requirements; earlier methods and limit states method
- Bridges, big 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, application to cofferdams
- Frame of buildings, main families, bracing, loads roadmap
- Basics of seismic protection

Teaching Material and Textbooks

Course reader in French

Evaluation

Presentation (45-60 min) of a “design office work” done by groups of 3-4 students

MG1300
Structural Dynamics and Acoustics

Professor: Pierre-Étienne Gautier

Language of instruction: French or English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MG1100 or equivalent. Continuum mechanics

Period: S7 Elective 04 November to December IN27DE4, FEP7DE4

Course Objectives

Dynamic vibration and propagation phenomena, in mechanics, play an essential part in many areas: geophysics, sonars, building resistance to wind and swell, stability and comfort of aeronautical and terrestrial vehicles, rotating machinery, non-destructive control, ultrasound scan, actuators.

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, and fluid-structure interaction.

Course Contents

- Structural dynamics, small displacements in a Galilean frame
- Structural dynamics in a moving frame. Geometric stiffness and follower forces.
- 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 and waveguides
- Linearized fluid-structure interaction

Course Organization

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

Teaching Material and Textbooks

Course reader (in English)

Evaluation

3-hr written exam

MG1400
Plasticity and Fracture: Mechanical Behavior of Materials

Professor: Véronique Aubin

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MG1100 or equivalent. Continuum mechanics, linear elasticity, beam theory.

Period: S7 Elective 05 November to January IN27DE5, FEP7DE5

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 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
- ✧ Prediction of the lifetime under cyclic sollicitation: fatigue

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

MG1500
Biomechanics

Professor: Elsa Vennat

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S7 Elective 03 September to November IN27DE3, FEP7DE3

On completion of the course, students should be able to

- characterize and model the mechanical behavior of complex multi-scale materials: porosity, anisotropy, visco-elasticity
- model the dynamics of articulated complex mechanical systems: soft joints, principle of virtual power, Lagrange equations
- understand the specifics of biological materials: experimental protocols, repair, mechano-transduction
- understand the specifics of a multidisciplinary approach: models, methods, actors

Course Contents

- Introduction to cell biology and orthopaedics surgery problems
- Mechanical behavior of the bone and multiscale modeling
- Visco-elastic behavior of living tissues
- Walking Mechanics
- Mechanotransduction (cell response to mechanical loading)

Course Organization

Lectures: 10.5 hr, Exercises: 12 hr, Labwork: 12 hr, Exam: 1.5 hr

Teaching Material and Textbooks

- Y.-C. Fung, Biomechanics: Mechanical Properties of Living Tissues, Springer, 1993
- S.C. Cowin. Bone Mechanics Handbook. CRC Press, Boca Raton, 2001.
- D. Aubry Polycopié de Mécanique 1ère année Ecole Centrale Paris.

Evaluation

1.5-hr written final exam (50%) + written report (50%)

MG1600
Nanomechanics

Professor: Ann-Lenaig Hamon

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

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

Period: S7 Elective 03 September to November IN27DE3, FEP7DE3

Course Objectives

- Make students aware of the issues associated with the extreme miniaturization of systems
- Explore the coupling between mechanics and physics at nanometer scales

Course Contents

- Chemical bonding: molecule and crystal. Mechanical constants at the electron scale.
- Molecule: Solid dynamics. Introduction to molecular dynamics.
- Crystal: Anisotropic Hooke's law. Application to the perfect crystal. Crystal defects: dislocations. Elements of microplasticity. Band structure; influence of mechanical loading on the conduction properties. MEMS.
- Polymers and elastomers: topology of chains, lattices. Reinforcement.

Teaching Material and Textbooks

Statistical Mechanics of Elasticity, J.H. Weiner, Dover (2002)

Evaluation

Final written exam

MG1960
Civil Engineering Laboratory

Professor: Jean-Marie Fleureau

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: Basic notions on Strength of Materials and Construction Processes

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

Course Objectives

- Provide an introduction to issues of construction: urbanism, architecture, design, economics.
- Teach how to build a rigorous scientific approach: analysis of the problem at stake, justification of the chosen solution.
- Teach how to conduct a relevant Internet data mining.

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 possibly computerized) of the proposed design
- Verify the structural strength of the proposed design and design the main structural elements, including the foundation, by means of simple structural mechanics computer codes

Course Organization

Labwork: 27 hr, Exam: 3 hr

Teaching Material and Textbooks

Course reader in French

Evaluation

Oral defense + powerpoint presentation

MG1970
Design of Mechanical Structures Laboratory

Professor: Véronique Aubin

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 2

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

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

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

- define and set up a scientific experiment using the appropriate methodology
- use software to derive numerical results

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 and design of a dam
- study of the experimental mechanical behavior of a cardboard sheet and design of a bridge
- 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

Analysis of the experimental results is complemented with numerical results from a finite element software.

Course Organization

Labwork: 27 hr, Exam: 3 hr

Teaching Material and Textbooks

Documents from the Mechanics Course (MG1100) + Scientific articles

Evaluation

Students are assessed on quality of practical work (60%), quality of report (20%) and oral defense (20%)

MG2811
Urbanism and Tall Buildings

Professor: Eric Mathieu

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Fundamentals of Strength of Materials

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

Introduce design methods for tall buildings in contemporary urbanism:

- Urban development, urban programming and installation, programming of tall buildings
- Design of tall buildings, technical specifications, urban specifications
- Functional and technical optimization of projects, environmental constraints and fluxes
- Site visits, drawings, projects, calculations, comparisons and results validation

On completion of the course, students should be able to

understand the complexity of urban design and manage a construction project.

Course Contents

- Class 1. Urban development.
- Class 2. Survey sites, urban programming, tall building programming.
- Class 3. Project management, land, costs, technical programming of tall buildings.
- Class 4. Structure dynamics and structural behavior of tall buildings.
- Class 5. Environmental constraints and fluxes.
- Class 6. Site visits.
- Class 7. Workshop 1: drafts, materials, technique, energy.
- Class 8. Technical consulting on the drafts proposed by the students.
- Class 9. Workshop 2: functional optimization, floor plans, sections, elevations, urban integration schemes.
- Class 10. Workshop 3: technical optimization, calculations, implementation.
- Class 11. Workshop 4: preparation of the team final report, 1/1000 models, 3D digital animations.
- Class 12. Final exam, presentation of team projects and of individual studies.

Course Organization

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

Resources

A structural engineer and a building project manager will participate in the teaching.

Evaluation

Individual bibliographical study and team reports

MG2812
Introduction to Acoustics: Industrial and Musical Acoustics

Professor: Pierre-Étienne Gautier

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MG1300 or equivalent. (recommended)

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

- Discover methods and tools used in acoustics through 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. These cases will involve examples in sound synthesis and its 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 (P.-E. Gautier)
- Rolling and squealing nose, aerodynamic noise: applications to railway systems (P.-E. Gautier, SNCF)
- Tire-road contact noise and propagation: weather influence (M. Bérengier, LCPC), automotive acoustics (B. Andro, Renault)
- Physics of instruments with bowing or striking strings (R. Caussé, IRCAM)
- Physical models of musical wind instruments (J. Gilbert, LAUM)
- Psychoacoustics (S. Meunier, LMA)

Course Organization

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

Teaching Material and Textbooks

Course reader (in French)

Evaluation

1-hr written exam and oral defense of a team case study

MG2814
Economy and Design of Dams

Professor: Arézou Modaressi

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic notions in Economics, Engineering Geology / Geotechnics, Hydraulics, Statics, Design of structures

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

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

Teaching Material and Textbooks

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

Evaluation

3-hr written final exam

MG2815
Industrial Processing of Soils and Granular Materials

Professor: Jean-Marie Fleureau

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic knowledge in Mechanics of Materials

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

The objective is to highlight the importance of problems related to the processing of granular materials used in most branches of industry, e.g. civil engineering, and to show the relation between empirical practices and rational scientific knowledge. The course includes a mini-project, lab work, and bibliographical investigations.

Course Contents

1. Characterization of granular materials
   - ✧ Characterization of solid grains
   - ✧ Characterization of the assembly of grains
   - ✧ Parameters of empirical characterization
2. Specificity of the constitutive law of granular materials
   - ✧ Effect of the stress path (quasi-static, cyclic, by vibrations, dynamic, with or without rotation of the principal stress tensor)
   - ✧ Effect of grain size distribution, of the behavior of grains (rigid, brittle, ductile, etc.)
   - ✧ Effect of water content, optimum, relation with negative pore pressure
   - ✧ Effect of the mechanical properties (viscosity, brittleness, etc.) of the binder; influence of temperature
   - ✧ Effect of wetting
3. Examples of application to various materials : Scientific and industrial problems
   - ✧ Soils
   - ✧ Concretes
   - ✧ Pharmaceutical products
   - ✧ Carbon agglomerates
   - ✧ Ceramics
4. Different approaches of constitutive modeling
   - ✧ Non-linear elastic model
   - ✧ Elasto-plastic model
   - ✧ Micro-macro approaches

Course Organization

Lectures: 12 hr, Tutorials: 9 hr, Labwork: 12 hr, Exam: 3 hr

Evaluation

Oral defense of the project and laboratory sessions (3 hr)

MG2816
Micro-Electro-Mechanical Systems (MEMS)

Professor: Denis Aubry

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

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, cellular 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.

Course Contents

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

Course Organization

Lectures: 12 hr, Tutorials: 12 hr, Labwork: 9 hr, Exam: 3 hr

Evaluation

Written report and oral defense

MG2817
Applications of the Finite Element Method

Professor: Serge Prudhomme

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Some knowledge of functional analysis

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

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

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

Teaching Material and Textbooks

Course reader in English

Evaluation

3-hr written final exam (no documents 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.

MG2818
Introduction to Petroleum Exploration and Production

Professor: Alain Quenelle

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Bachelor level in Civil or Mechanical Engineering. Interest for sedimentary geology and for general background on oil industry, offshore production and drilling activities. Good understanding of English required

Period: S8 Elective 13, One-week module 2 14-21 May IN28IS2, SEP8IS2

Course Objectives

- Review the fundamentals of the Petroleum Systems and reflection Seismics with emphasis on industry applications and seismics interpretation
- Acquire technical and practical knowledge on platforms and pipelines designed and installed on deep Offshore (water depth between 500 and 3000 meters)
- Provide students with practical knowledge complementing theoretical fundamentals

On completion of the course, students should be able to

- understand the key problems in petroleum exploration and production activities
- apply their scientific and theoretical knowledge to petroleum activities, challenges and hazards

Course Contents

1. Introduction to Petroleum Geology and Seismics:
   - Energy the Global Picture
   - Petroleum Geology
   - Source Rocks, Reservoirs, Traps
   - Seismics, data Interpretation
   - The exploration process
2. Deep Offshore Structures and Pipelines:
   - definition, classification
   - Rov and AUV
   - Floating Systems
   - Challenges
   - Non-conventional laying
   - Installation: means and methods
3. Offshore drilling
   - From shore to offshore: introduction to drilling technics
   - Safety in offshore activities
   - Drilling campaign preparation, formation fracture gradients
   - Site and meteo-oceano survey
   - Shallow gas hazards
   - SIMOPS operations
   - Well construction
   - Directional drilling
   - Operation: inland barges and submersibles, Tender Rig, Jack-Up, Platforms
   - Deepwater drilling hazards
   - Offshore and subsea drilling equipment

- operation with semi-submersibles, drillships
- Subsea operations and logistics

Course Organization

Lectures: 15 hr, Case studies: 18 hr, Exam: 3 hr

Teaching Material and Textbooks

Course reader (in English)

Resources

Senior engineers from Total: A. Quenelle, A. Lepage, J. Mouillac, Ch. Chomat, G. Magnien, J. Bera, A. Grynko

Evaluation

Final exam: QUIZ with multiple choice questions.

MG2920
Civil Engineering Laboratory

Professor: Jean-Marie Fleureau

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S8 Elective 13, 5 Tuesdays between February and June IN28IXP, SEP8IXP

Course Objectives

- Provide an introduction to issues of construction: urbanism, architecture, design, economics.

On completion of the course, students should be able to

- understand the complexity of urban design and be able to manage a construction project
- understand 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 possibly computerized) of the proposed design
- Verify the structural strength of the proposed design and design the main structural elements, including the foundation by means of simple structural mechanics computer codes

Course Organization

Labwork: 36 hr

Teaching Material and Textbooks

Course reader in French

Resources

Instructors: Jean-Marie Fleureau and François Cointe

Evaluation

Oral defense + powerpoint presentation

Physics

PH1100
Quantum and Statistical Physics

Professor: Jean-Michel Gillet

Language of instruction: French or English – **Number of hours**: 60 – **ECTS**: 5

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

Period: S6 between February and June IN16COM, SEP6COM

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

understand orders of magnitude of basic properties, boundaries of classical physics, approximation methods, structure of the atom, characterization methods, influence of confinement on properties (nanophysics), physical meaning of the second principle, microscopic basics of thermodynamics, origin of conductivity, structure of atomic nucleus.

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
- Conferences
- 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 classes of less than 40 students. Sign-up is required. Attendance is mandatory.

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 (PH1102).

Newsgroup: ecp.etudes.PH1100.Gillet_Amphi

Evaluation

1.5-hr written midterm exam, 3-hr written final exam

PH1102
Physics Tutorials

Professor: Jean-Michel Gillet

Language of instruction: French – **Number of hours**: 21 – **ECTS**: 0

Prerequisites: PH1100 or equivalent. Attendance to all PH1100 classes is mandatory

Period: S6 between February and June IN16COM, SEP6COM

Course Objectives

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

Course Organization

These tutorials are organized as questions answers sessions. They generally take place from 6:45 to 8:15 PM on Thursday evening.

PH1910
Physics Laboratory

Professor: Gloria Foulet

Language of instruction: French or English – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: None

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

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. The subjects are often based on work arising from thesis or contracts supported by industry.

Course Contents

Some subjects:

- Holography
- Echography
- Optical Coherent Tomography
- Fabrication and characterization of thin layers

Course Organization

Labwork: 27 hr, Exam: 3 hr

Evaluation

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

PH2100
Waves

Professor: Hichem Dammak

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S7 Elective 02 September to November IN27DE2, FEP7DE2

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

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
X-ray Beamline Design

Professor: Jean-Michel Gillet

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic knowledge in modern physics and heat transfer. Mechanical engineering skills will be useful. Students must simultaneously register in SH3306.

Period: S8 Elective 13, One-week module 1 2-6 April IN28IS1, SEP8IS1

Course Objectives

This is a multidisciplinary course. Teams of 21 students are challenged with understanding, designing and scaling the physical, mechanical, heating and materials aspects of key technological components of a synchrotron beamline. 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

This course is part of the design workshop combining PH2200 and SH3306, which counts for a total of 5 ECTS. Students must sign up for both courses concurrently and will get the same grade for both courses.

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. The final defense, at synchrotron SOLEIL, is followed by a visit of the SOLEIL facility.

Resources

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

Evaluation

Daily deliverables + participation + oral defense

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

Professor: Pietro Cortona

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100 or equivalent. Basic knowledge of Quantum Mechanics and Statistical Mechanics

Period:	S7	Elective 03	September to November	IN27DE3, FEP7DE3
	S7	Elective 06	December to January	IN27DE6, FEP7DE6

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

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

PH2400
Chemistry: Matter Modeling and Design

Professor: Michel Jouan, Mireille Defrancheschi

Language of instruction: French or English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100 and EN1300 or equivalent. Basics in applied thermodynamics, phase transition. Basics in quantum and statistical physics

Period: S7 Not offered in 2011-2012 IN27NON, FEP7NON

Course Objectives

Starting from the molecules that constitute our surroundings we will show that understanding molecular physical-chemistry is essential to address the main challenges of our world: environment, material design for specific applications, nano- and bio-technologies. The course will focus on ways to modify the behavior of matter through specific actions at the atomic and molecular levels.

On completion of the course, students should be able to

- ✧ understand that mechanisms at molecular level are essential to develop innovative applications with live of inert matter in order to answer human and social needs
- ✧ undertake further specific studies with a wide and interdisciplinary view of scientific challenges

Course Contents

Session 1: refreshers. Chemistry majors will study current progress in molecular chemistry, other students will learn the organic chemistry tools required for this course

Sessions 2-4: solution chemistry, organic chemistry, formulation. Everyday chemistry (cosmetics, gastronomy, odors, colors).

Sessions 5-8: quantum chemistry, introduction to modeling of macroscopic systems. Prediction of macroscopic behavior from microscopic information, molecular dynamics, thermodynamics of mixing.

Sessions 9-11: kinetics, reactivity, catalysis. From the oil industry to pharmaceutical compounds. Picosecond reactivity.

Course Organization

Lectures: 15 hr, Tutorials (exercices, case studies, experimental demos): 19 hr, Final exam: 2 hr

Teaching Material and Textbooks

- ✧ Lecture notes (electronic version only for the coming academic year) in French "La Chimie : du quotidien à l'industriel" (Maud Giot)
- ✧ "General Chemistry" (L. Pauling)
- ✧ "La chimie au quotidien" (M. Defranceschi)

Evaluation

- ✧ project (group of 2 to 5). One aspect of chemistry will be studied during two sessions of 1.5 hr. Subjects will be provided (40% of final mark).
- ✧ 2-hr exam without documents (60% of final mark)

PH2500
A Crash Course in Modern Mathematical Physics

Professor: Igor Kornev

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

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

Period: S7 Elective 05 November to January IN27DE5, FEP7DE5

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.

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%

PH2812
Introduction to Atomic and Molecular Physics

Professor: Nouari Kebaili

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100 or equivalent. Basics knowledge in modern physics

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

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

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-h written final exam

PH2813
Advanced Materials and Novel Devices for Information Technologies

Professor: Brahim Dkhil

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

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

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

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

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: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100, PH2300 and EN1100 or equivalent.

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

The main objective of this course is not to “learn” physics but to “do” physics, using the knowledge of students in 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.

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 knowledge, common sense.

Course Contents

Most of the course is based on science fiction readings. 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.

A typical lecture is organized as follows:

- ✧ After reading short texts, students identify the parts that may be the object of scientific questions
- ✧ Identification of scientific themes
- ✧ Students work in sub-groups on the theme of their choice
- ✧ At the end, each team presents the main models they have built
- ✧ The professor may provide complementary information as needed

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: 30 hr, Exam: 3 hr (+ a 3-hr preparation)

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

- Short quizzes during each lecture
- 1-hr written exam without documents
- Oral defense in teams during the next-to-last session (prepared during the previous session)

PH2815
Quantum Correlations. Is Universe Separable? Schrödinger's Cats

Professor: Dominique Hirondel

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100 or equivalent.

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

Study the theory of measure, which is one of the last great problems not completely solved in Quantum Mechanics (though real progress has been made during the past 20 years).

On completion of the course, students should be able to

Master fundamental tools and concepts of Quantum Mechanics, have a better interpretation of Quantum Theory

Course Contents

ASPECT's experiments will be taken as the basis of illustration, with their famous paradox : polarisations of particles having interacted in the past but now separated, are, because they are described by a linear combination of states, completely UNDETERMINED, that is to say they don't exist, and yet they are strongly CORRELATED !!!

This kind of experiment has been conducted with electrons as well as with photons; from the physical and mathematical point of view, this experiment will be an opportunity to develop, understand and master methods and themes presented during the course:

- ✧ for electrons (spin 1/2), matrix formalism for the spin operator and for 2-component Pauli spinors, and, for photons (spin 1), polarisation states, circular or rectilinear
- ✧ various notions such as parity, angular momentum composition, tensorial product of states, factorisation, and linear combination of quantum states (notion developped here to the point of its paradoxical and counterintuitive consequences, where classical intuition is totally unvalidated, yet the basis of possible applications, such as quantum cryptography, teleportation of states, or quantum computer, not presented here).

Principal implications of the experiments: inaptitude of Hidden Variable Theories to correctly reproduce the predictions of Quantum Mechanics, the causality problem, the problem of information propagation velocity (finite ? supraluminal ?), and mainly the conclusion of QUANTUM NON-SEPARABILITY.

The experimental setup used by ASPECT at Orsay will be studied in detail. The subject will be extended through a recent aspect of the theory of measure : theory of Quantum Decoherence.

Course Organization

Lectures + Tutorials: 33 hr, Exam: 3 hr

Teaching Material and Textbooks

No lecture notes will be provided

classic books such as Quantum mechanics (Landau) will be useful

Evaluation

3-hr written exam with documents

PH2817
Particle Physics

Professor: Raphaël Granier de Cassagnac, Henri Bachacou

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100 or equivalent. Basic notions in quantum mechanics

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

Particle physics has initiated concepts that find applications in various fields: statistical physics, supraconductivity, cancer cure, etc. These lectures will show how particle physics was born from the critical confrontation of quantum mechanics and special relativity. Their goal is to present a comprehensive but simple review of known fundamental particles, as well as learn to manipulate the basic equations of quantum mechanics and special relativity. This will set the floor to discuss in a simplified but realistic way the current ideas of particle physics. Particular care will be put in presenting the way these ideas appeared in time. The question of why society should conduct fundamental research will be discussed.

On completion of the course, students should be able to

Understand special relativity equations and have a basic but comprehensive and modern knowledge of particle physics.

Course Contents

- ✧ Special relativity, key concepts and equations
- ✧ Quantum mechanics reminder, key concepts and equations
- ✧ The discovery of particles: historical perspective
- ✧ Debate on "Fundamental research: social interests and outcomes"

Course Organization

Most of the teaching is done in formal lectures. A significant fraction of the sessions will be devoted to seminars describing the history of the discipline. This part is an opportunity for students to ask numerous questions on fundamental and counterintuitive aspects of the theory. One or two tutorial sections will be organized as well.

Teaching Material and Textbooks

Course reader in French: see http://www.phenix.bnl.gov/~raphael/Cours/

Evaluation

3-hr written final exam, with documents

PH2819
Structure, Chemical Properties and Molecular Symmetry

Professor: Michel Jouan

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100 or equivalent. Basics in physics and chemistry

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

This couse intends to show several chemical applications of group theory. This mathematical tool is indeed very useful for the study of molecules and complex ions, particularly for the study of their geometry, the bonding and the orbitals, and their molecular vibrations. The presentation will be mostly geared toward these applications.

Course Contents

Many properties of molecules, complex ions and solids may be explained more simply when using rules based on symmetry considerations. In this course, we intend to show how symmetry, as a mathematical tool, can be of great help when studying various properties of molecules, complex ions, and also of solids : geometry, bonding, molecular vibrations, and up to reaction mechanisms.

This course belongs to physical chemistry and is composed principally of four parts.

- Molecular symmetry: symmetry operators and symmetry groups. Examples of geometry for various molecules. Predicting the geometry and the symmetry of simple molecules using Gillespie's VSEPR theory.
- Molecular vibrations and symmetry; application to the numbering of vibrations in isolated molecules or ions and in solids.
- Selection rules for infrared and Raman activity. Local symmetry and group vibration. Exemples of attribution de spectra. Notions on degenerate levels and their splitting.
- Transition metal complexes; electronic structure and magnetism (cristal field effect); Jahn-Teller effect. Molecular orbitals. σ and π bonding in complexes; back-donation.

A practical session on the infrared and Raman spectrometers of the Laboratory will be included, as well as various practical exercises.

Course Organization

Lectures: 13.5 hr, Tutorials: 15 hr, Labwork: 6 hr, Exam: 1.5 hr

Teaching Material and Textbooks

- Lecture notes
- F.A. Cotton "Chemical applications of group theory"

Evaluation

1.5-hr written exam

PH2820
Optoelectronic Technologies

Professor: Pierre Lecoy

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

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

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

To understand the physical principles, technology, and practical use of optical fibers, of opto-electronic and integrated optics components and devices; review the applications and show their diversity in fields of telecommunications, networks, imaging, scientific and medical instrumentation, energy systems; 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)

Course Contents

Optical fibers, theory and practical use (2 sessions incl. exercises and lab):

- 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 and lab):

- optical components (splitters, wavelength division multiplexers, Bragg gratings, modulators, switches);
- opto-electronic components (LED, laser diodes, photodiodes, semi-conductor and doped fiber optical amplifiers).
- Applications: displays (LCD, plasma panels, OLED), photovoltaic cells, LED lighting.

Image sensors CCD and CMOS (1 session).

III-V compounds semi-conductor technologies, industrial aspects and R (one session is devoted to a visit to the Alcatel-Thalès III-V lab, Palaiseau).

Optical networks and transmission systems (1 session: case study).

Short lab project (3 sessions at LISA laboratory) on subjects to be chosen by students:

- digital transmission over optical fibers or free-space infrared, LED lighting and display, solar cells, etc.

Course Organization

- 5 lectures including exercises and demonstrations / manipulations in laboratory and on the field (e.g. OTDR on campus network)
- 1 conference and one visit
- 1 case study and 3 labs (short project)
- 1 session devoted to student presentations (final evaluation)

Teaching Material and Textbooks

- Lectures slides
- "Fiber-Optic Communications", P. Lecoy, Wiley, 2008
- Reference boos in French and English available from the library

Resources

Lecturers

- Pierre LECOY, Professor, Ecole Centrale Paris
- Bruno DARRACQ, Professor, University Paris-Sud

Several sessions will take place at LISA (Laboratory of computer and advanced systems, Ecole Centrale) where students will have access to equipment in electronics, opto-electronic and optical fibers. These sessions will be conducted with the assistance of Walter Peretti and Bruno Delacressonnière.

Evaluation

Short written test (20%) + student's presentations on current topics in research and development or use of opto-electronic technologies.

PH2930
Nuclear Physics Laboratory

Professor: Dominique Hirondel

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PH1100 or equivalent. Due to site visit restrictions, the students registered in this lab series must have a French passport

Period: S8 Elective 13, 5 Tuesdays between February and June IN28IXP, SEP8IXP

Course Objectives

- Provide an introduction to the field of nuclear physics and energy

On completion of the course, students should be able to

- Sound knowledge of potential hazards due to nuclear industry
- Master of analysis and diagnostic technics
- Potential of nuclear physics and technology

Course Contents

- One day introductory course. Morning Nuclear physics. Afternoon : reactors and neutrons
- 3 afternoons practicals at INSTN Driving ISIS reactor. Measurments of radiactive lifetime . Study of alpha emission. Gamma spectrometry.
- 3 visits including OSIRIS reactor, Van der Graaf accelarator ...

Course Organization

Labwork and visits: 36hr

Evaluation

Eight lab or visit reports

Chemical Engineering

PR1100
Structure and Properties of Materials

Professor: Hervé Duval

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

Course Objectives

The course presents the properties of a wide range of industrial materials including metals, ceramics, glass, and polymer composites. It shows how a thorough understanding of microstructures makes it possible to confer the desired physical or mechanical properties on materials for engineering.

Course Contents

- Introduction: Materials for Mechanical Engineering. Cycle of Materials.
- Manufacture of Materials
- Lattices and Defects
- Equilibrium State
- Transformations and Treatments
- Elasticity and Thermo elasticity
- Yield Strength and Plasticity
- Rheology and Creep
- Fatigue and Fracture
- Life Cycle of Materials

Course Organization

Lectures: 19 hr, Tutorials: 14 hr, Exam: 3 hr

Teaching Material and Textbooks

- Course reader : Génie des matériaux, de J.B. Guillot
- M. Ashby and D. Jones, Materials Engineering

Evaluation

3-hr written exam with documents

PR1300
Introduction to Materials

Professor: Jean-Hubert Schmitt

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 04 November to December IN27DE4, FEP7DE4

Course Objectives

Give students with no prior experience with Material Science an overview of materials-related problems and on their key role in the process of production of goods and services and in "making real" innovative approaches.

Based on the study of the main classes of materials, each 3-hr module will present the key issues of one class, illustrate specific aspects related to their production, design or recycling, present in detail one or two characteristic properties with possible links with microstructural aspects. The problems will be presented in relation with the design of an end object such as aircraft parts, MEMS, or biomaterials.

Course Contents

- Introduction: General presentation of problems and issues of materials in various domains, introduction to the choice of materials.
- Metals, elaboration/production: Main uses, recycling, crystalline structure and properties, elasticity, strength. Application: mechanical design.
- Metals, forming: Macro and micro plasticity, deformation and rupture. Application: automotive structures.
- Ceramics, elaboration: Main uses, structure an properties, fragile rupture, thermal shock. Application: high temperature behavior, engines.
- Ceramics, functional properties: Magnetic and electrical properties of oxides, diffusion. Application : piezo in probes, electronic components.
- Polymers, elaboration: Main uses, recycling, viscous behavior and cristallization.
- Composites: design allowing combination of antagonistic properties, recycling, production et recycling. Examples of application: illustration of specific mechanical properties.
- Materials for civil engineering and rocks: mechanical behavior at very long times (e.g. rock creep), chemical-mechanical approach (e.g. concrete).
- Living materials, from wood to cells: Heterogeneity and anistropy of properties, introduction to biomaterials (compatibility) and biomimetic design.
- Surfaces: problems related to surfaces (reactivity, oxidation, coating, surface treatments, etc.). Application: local hardening of parts for friction improvement.
- Two general conferences (1h30) will illustrate materials problems in a specific economic area
- Exam: final presentation of the team project, oral defense and short report. Topic: starting from a usual object, find its current mode of production and the associated materials-related issues, understand and explain the choice of the current materials used for this object, and imagine possible and realistic choice of other materials for similar purposes.

Course Organization

Lectures and Tutorials: 33 hr, Exam: 3 hr

Evaluation

Oral defense and report on a team project

PR1920
New Technologies Laboratory

Professor: Guillaume Puel

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: None

Period: S6 between February and June IN16DXP, SEP6DXP

Course Contents

The students will work on the use of powerful lasers with industrial and research applications. The lab classes will take place at Groupement d'Intérêt Scientifique GEPLI (Groupe d'Etude des Procédés Laser Industriels) at Arts et Métiers - Paristech.

Examples of subjects:

- Laser welding of zinc-coated metal plates
- Production by laser sintering
- Production by laser spraying of metallic powder
- Laser repairing and surfacing

Course Organization

Labwork: 27 hr, Exam: 3 hr

Resources

Lecturers: Jean-Paul Longuemard, Thierry Malot, Guillaume Puel

Evaluation

Oral defense and written report

PR1930
Materials and Corrosion Laboratory

Professor: François Wenger

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: None

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

Course Objectives

The aim of this activity is to offer to each working group of 2 or 3 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 (structural, mechanical, chemical), or materials behavior (corrosion) in particular environments.

On completion of the course, students should be able to

- ✧ deal with the methodological aspects of experimental studies
- ✧ know the analysis methods of structural, mechanical and chemical properties of materials
- ✧ know the behavior of metallic materials in an aqueous environment
- ✧ understand corrosion and the influence of electrochemical and biological phenomena

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.

Examples of topics offered (may change from year to year):

- ✧ Impact of thermal processing on the structure and the properties of steel
- ✧ Relationship between the microstructure of an aluminium alloy and its mechanical properties
- ✧ Steel corrosion in aqueous environments. Micro-organisms (bacteria) interference in the corrosion mechanism.

Course Organization

Labwork: 27 hr, Exam: 3 hr

Teaching Material and Textbooks

- ✧ Articles from the bibliographic research
- ✧ 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.

PR1950
Multiscale Surface Analysis

Professor: Pierre Ponthiaux

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basics of materials science (chemistry, structure, mechanical behavior), metallurgy, and corrosion (optional)

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

The surface is the site of interactions of a material with its environment. Surfaces properties have a major influence on the functionalities, fiability and durability of mechanical systems. The aim of this course is to provide students with basic knowledge for understanding surface properties and for analyzing the various degradation processes affecting surfaces. This moduleis in two parts:

- Overview of the state-of-the-art in various techniques of observation and characterization such as used in R or in industry
- Presentation of the basic knowledge required to analyze and solve the main problems of degradation of surfaces by corrosion, mechanical wear and tribocorrosion (combined effects of friction and corrosion)

On completion of the course, students should be able to

- use the main methods to characterize surface properties
- select the methods best suited to analyze the behavior of surfaces and their degradation processes

Course Contents

- Definition of a surface
- Introduction to surface observation: optical microscopy, scanning electron microscopy (SEM and FIB), near-field microscopy (including AFM)
- Chemical and structural analysis: XRD, EDX, Raman, XPS, UPS, AES, EBSD, GDOES, XRF
- Introduction to surface characterization: topography (roughness, microtopography); mechanical properties (micro and nano-hardness, adhesion, etc.)
- Corrosion, mechanical wear, tribocorrosion

Course Organization

Lectures: 12 hr, Tutorials: 10.5 hr, Labwork: 12 hr, Exam: 1.5 hr

Teaching Material and Textbooks

- G. Béranger, H. Mazilles, Corrosion et anticorrosion, Lavoisier, Hermes Science (2002)
- J.P. Babelon, J. M. Dorlot, Des matériaux, 3rd ed., Presses Intern. Polytechnique (2000)
- Techniques de l'Ingénieur (Electrochemical corrosion and electrochemistry)

Evaluation

Oral defense (45min/group) + report

Contents of the report: 1. The problem and its industrial context, 2. A literature review on the state of the art, 3. A program of scientific study to analyze and solve the issue, 4. An estimate of the duration and cost for the implementation of the proposed study.

Evaluation is based on: quality of labwork, oral defense, report, and participation.

PR2100
Water Treatment and Underground Water Protection

Professor: Estelle Couallier, Arezou Modaressi

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

This course aims to study the interactions between mankind and the water drawn from nature. Processes used to produce or to treat water after its use (urban wastewater, industrial effluents) of a given quality (drinking water, water used in processes) are reviewed. The question of natural water will be also addressed through an introduction to the contamination of groundwater and the study of the influence of polluted sites over the contamination/protection of underground water.

On completion of the course, students should be able to

- know the methods for analysis, treatment and production of water of a given quality
- design such installations
- understand the transport and transfer of different types of pollutants in ground water
- know the main treatments techniques for such pollutants

Course Contents

- Introduction: availability of water, laws, standards, biological and physicochemical processes for treating water and effluents (6 hr).
- Soil pollution/protection and underground water contamination (participation of external experts), mechanisms of transport and transfer of pollutants in groundwater (6 hr).
- Labwork on simulation of underground water pollution (9 hr)
- Labwork on water analysis and treatment processes or exercises on design of installations, depending on availability of equipment (9 hr)
- Water in industry. Water management at the basin level.

Course Organization

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

Teaching Material and Textbooks

PowerPoint presentations, exercises, several books available at the ECP library

Evaluation

- Written exam (3 hr)
- Brief lab reports

PR2940
Chemical and Environmental Engineering Laboratory

Professor: Mohammed Rakib

Language of instruction: French or English – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: No prerequisite but training in Chemical Engineering and knowledge of the basic notions of Analytical Chemistry and Electrochemistry would be useful.

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

Course Objectives

Work on the chemical processes used in environmental applications to treat wastewater in order to concentrate the pollutants and enable product recycling

On completion of the course, students should be able to

- be familiar with the basic theory of membrane and electromembrane processes
- use pilot units (electrodialysis, ultrafiltration, nanofiltration and electrochemical operations)
- use modern analytical tools (titrator, atomic absorption, XRD)

Course Contents

- Wastewater treatment (concentration, separation)
- Clean processes
- Salted effluent treatment (regeneration of acid and base from a salt by water splitting)
- Membrane processes
- Electromembrane processes

Course Organization

Presentation of topics: 3 hr, Labwork: 20 hr, Oral presentation with preparation: 7 hr

Teaching Material and Textbooks

Course notes and scientific articles from the bibliographical research carried out during this activity (2 or 3 articles)

Evaluation

Students are graded on the quality of the labwork, written report and oral defense

PR3100
Chemical Engineering and Sustainable Development

Professor: Dominique Pareau (S7), Moncef Stambouli (S6, S8)

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Heat transfer, basis of fluid mechanics, thermochemistry, chemical kinetics

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S7	Elective 02	September to November	IN27DE2, FEP7DE2
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

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

- Lecture: introduction, flow models, mass and energy balance
- Case study: membrane electrolyzer for the production of chlorine, hydrogen, and soda
- Lecture: perfectly stirred reactors
- Case study: design of industrial wastewater treatment reactors
- Lecture: plug flow reactor
- Case study: production of styrene
- Lecture: liquid-vapor equilibria, single and multi-stage distillation
- Case study: ammonia recycling in solar cell production
- Lecture: multi-stage distillation
- Case study: production of bioethanol
- Lecture: solvent extraction
- Case study: design of an extraction step in the nuclear fuel reprocessing
- 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: electrochemistry, electrochemical processes
- Case study: design of a fuel cell for a car
- Lecture: membrane processes
- Case study: design of a membrane bioreactor for industrial waste treatment

- Lecture: electromembrane processes
- Case study: electrodialysis in the process of chlorine production

Course Organization

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

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

- Homework: presentation related to the case study at the beginning of each class by a group of 3 or 4 students (40% of the final grade);
- Final exam: case study during a 3-hr session in teams of 3 or 4 students and written report (60% of the final grade).

PR3300
Chemical Engineering and Sustainable Development 2

Professor: Dominique Pareau

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PR3100 or equivalent. Heat transfer, basics of chemical kinetics, fluid mechanics and thermodynamics

Period: S8 Not offered in 2011-2012 IN28NON, SEP8NON

Course Objectives

The objective of modern Chemical Engineering is to design, implement and optimize environmentally friendly processes for use in the manufacture of an extensive range of products in many sectors including the pharmaceutical, petro-chemical, fine chemical, food, cosmetics, water and waste treatment, high-tech, biotechnology and traditional industries.

Many techniques of process engineering are increasingly used in the recycling and recovery of materials and for pollutant abatement in liquid and gas effluents, thus making them key techniques for sustainable development strategies on a global scale.

This course is the continuation of PR3100. It provides further insight and exposure to the generalist techniques of Chemical Engineering. The skills acquired by the students can be readily applied to many other fields of engineering.

On completion of the course, students should be able to

- master the basic notions of process engineering for the design of industrial systems in biotechnologies, energy production, water and waste treatment
- apply these methods to novel application areas
- understand the design of environmentally friendy processes and techniques

Course Contents

- Lecture: Basic concepts in chemical engineering, flow models; mass and energy balance.
- Lecture: Non ideal reactors. Case study: Design of an industrial reactor for the production of antibiotics.
- Lecture: Non ideal reactors. Case study: Design of a pipeline for the production of agri-food.
- Lecture: Non ideal reactors. Case study: Application of reactor models to a biological system (blood flow, penetration of chemotherapy inside a tumor.
- Lecture: Mass, heat and momentum transfer: dimensional invariants. Case study: dissolution of irradiated fuel in the PUREX process.
- Lecture: Coupled heat and mass transfer: humidification-drying. Case study: evaporation of a nuclear fuel storage pool.
- Lecture: Coupled heat and mass transfer: humidification-drying. Case study: design of an air cooling tower in a thermal power plant.
- Lecture: Coupled heat and mass transfer: humidification-drying. Case study: drying of active principles in the pharmaceutical industry
- Lecture: Multi-component distillation. Case study: modeling and simulation of a distilling column with ASPEN (commercial software)
- Process simulation under ASPEN
- Process simulation under ASPEN

Key concepts: ideal and non-ideal flow models, real reactors, mass and heat transfer (drying, humidification, multi-compnent distillation, simulation of processes under ASPEN

Course Organization

Lectures: 12 hr, Tutorials: 15 hr, Combined lectures and tutorials: 6 hr, Exam: 3 hr

Teaching Material and Textbooks

- Course reader in French
- Perry Chemical Engineer's Handbook 7th edition 1997 Mac Graw Hill
- W. Mac Cabe, J. Smith P. Harriott: Unit Operations of Chemical Engineering (7th edition)(McGraw Hill Chemical Engineering Series)
- M. Smith, "Chemical Engineering Kinetics", 3rd Ed., McGraw-Hill

Evaluation

- Three 15-min written tests, with documents
- 3-hr written final exam, with documents

PR3400
Smart Experimentation

Professor: Michel Jouan

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Not offered in 2011-2012 IN28NON, SEP8NON

Course Contents

Experimental design (15 hr)

- Two-level complete and fractional factorial designs
- Error: importance and evaluation. The concept of optimal design
- Classical hypothesis for interpretation; complementary trials
- Mathematical model: isoresponse curves and surfaces. Optimisation
- Taguchi method.

Data analysis: modeling and calibration (15 hr)

- Univariate linear modeling
- Multivariate linear modeling
- Factor analysis (principal components analysis)
- Factor-based regression (Partial Least Squares Regression)
- Non linear modeling (genetic algorithm and neural networks)

Course Organization

Lectures: 12 hr, Tutorials: 12 hr, Labwork : 6 hr, Exam: 6 hr

Evaluation

Two 1.5-hr midterm exams and a 3-hr written final exam

PR3910
Biotechnologies Laboratory

Professor: Filipa Lopes

Language of instruction: French or English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basics in biology, if possible basics in microbiology

Period: S8 Elective 13, One-week module 2 14-21 May IN28IS2, SEP8IS2

Course Objectives

Industrial biotechnologies are increasingly used for the manufacturing of drugs, vitamins or food products. White biotechnologies are concerned with the production by biotransformation of molecules of interest from vegetal resources. The objective of this course is to discover the different aspects of such processes. Students will consider first the upstream part of the process, the strain used, the operation of a fermentation, the measurement and analysis techniques allowing the characterization of the product, and finally the downstream processing. This module begins with a one-day introduction to microbiology at Ecole Centrale. Then, experiments will be conducted over a period of three days in an industrial research and development center (ARD company, near Reims). Students will be supervised by Ecole Centrale Paris professors and by engineers of ARD.

On completion of the course, students should be able to

- ✧ better understand fermentation processes
- ✧ have learned various measurement and analysis methods

Course Contents

- ✧ Microbiology and industrial fermentations
- ✧ Upstream operations: characterization of the raw materials, preparation of the fermentation broth, observation and preparation of the inoculum, sterilization of the plant and the fermentation broth.
- ✧ Seeding of the bioreactor; control and operation of the fermentation; analysis and measurements.
- ✧ Treatment of the products; operation of separation methods applied to the fermentation broth, purification of the product.
- ✧ Cleaning of all equipment used; data processing; final report preparation.

Course Organization

This module will take place at Ecole Centrale Paris on May 11 and at Pomacle, Reims, on May 14-16.

Evaluation

Final labwork report

PR4200
Electric Energy Networks

Professor: Jean-Pierre Fanton

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S7	Elective 04	November to December	IN27DE4, FEP7DE4
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

Course Objectives

Electrical Networks are the technical tools required to distribute electric energy, from the point of production to the point of use. They ensure the transport of energy, i.e. the matching of production with consumption. Understanding their technology is key to master global energy problems. Although electric power has major advantages, it also brings strong constraints, such as issues with large-scale storage. Its transport and implementation involve compliance with technical rules that are complex, diverse, and imperative: use of alternating current and multiphase systems, successive changes of voltage, etc. Our goal is to highlight the origin of these rules and to describe them with sufficient accuracy for the engineering design, specification, or analysis of global energy systems.

On completion of the course, students should be able to

understand and analyze the design and operation of a large electrical network, estimate key design parameters, and propose adequate design improvements.

Course Contents

- General concepts on electric energy networks
- Single-phase circuits
- Multi-phase circuits
- Power Electronics applied to DC electrical networks
- Networks constitution: cables and lines
- Energy sources in networks: synchronous machines
- Monitoring and control of networks: voltage and frequency
- Power load flow
- Unbalanced systems
- Transients

The course includes the visit of a large network dispatching unit.

Course Organization

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

Teaching Material and Textbooks

- Course reader (French and English versions)
- Barret JP., Bornard P, Meyer B: “Simulation des réseaux,” Eyrolles, 1997
- Prévé C: “Réseaux électriques industriels 1”, Lavoisier, 2005
- Escané JM: “Réseaux d'énergie électrique. Modélisation : lignes, câbles,” Eyrolles, 1997

Evaluation

Homework handed in at end of course or 3-hr written final exam (student's choice)

PR4300
Cogeneration and Energy Production

Professor: Tanguy Poline

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Thermodynamics, heat transfer. General basic knowledge in physics/chemistry, mechanics mathematics.

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

Course Objectives

Acquire general knowledge on energy production and consumption.

Cogeneration/electricity plant:

- develop a project analysis (equipment, design, economic profitability)
- gain experience in operations (troubleshooting, control philosophy, environment)

Be able, on a wide variety of energy-related issues (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.

Energy production and consumption:

- Main energy process lines with CO_2 (coal, liquid fuel, natural gas, bituminous).
- 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: 33 hr, Exam: 3 hr

Teaching Material and Textbooks

Course notes

Evaluation

Short exam: 30 min. Oral presentation: 12 min. Final exam (quizz + written exam): 2.5h.

PR5100
Biology

Professor: Jean-Luc Zimmermann

Language of instruction: French or English – **Number of hours**: 15 – **ECTS**: 1

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

Course Objectives

- Provide students with a solid basic background in the fields of life sciences.
- Introduce the major questions which are dealt with by economic sectors where life sciences are useful: food, pharmacy, fine chemistry.
- Enlarge the scientific training of the students with the mode of reasoning of a scientific field that is poorly formalized.
- Contribute to the training of the students in the ethical and human fields by the study of subjects that bear strong society implications: genetic fingerprints, cell cloning, genetically modified organisms.

On completion of the course, students should be able to

The students discover how the knowledge of the mechanisms underlying the functioning of living cells can be used to solve a modern biotechnological problem: creation of a bacterial or eukaryote cell line that over-expresses a protein of pharmaceutical interest. Starting from the description of the important question of the production of insulin in the pharmaceutical industry, the students realize how the macromolecules and mechanisms that have been selected by evolution in the processes that occur in living cells can be utilized in modern biotechnology. With this knowledge, scientists and engineers are able to create, optimize and cultivate a new living organism with new properties that can be useful in the industry.

Course Contents

- Composition of the cell factory. Cellular types and viruses. Prokaryotes, eukaryotes and archea. Intracellular organelles and their roles.
- Genetic and molecular biology. Structure and function of DNA. Replication and transcription. Gene expression. Maturation of primary transcripts, translation of mRNAs and maturation of proteins. Genomics databanks.
- Genetic engineering. Gene sequencing. PCR. Plasmids, cloning and expression vectors. Bacterial transformation. Host cells.
- Cellular functions of proteins. Structural levels of proteins. Electrophoresis and liquid chromatography of proteins. Protein databanks.
- Industrial aspects of biotechnology: selection of clones, dimensioning of production processes, quality control, security.

Course Organization

Classes with exercises in groups of 30-40 students, one class in English.

Lectures: 12 hr, Industrial conference: 1.5 hr, Exam: 1.5hr

Teaching Material and Textbooks

Textbook “Sciences du Vivant Biotechnologies”. Presentation slides and exercises available online.

PR5210
The Genome

Professor: Diana Le Roux

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic knowledge of molecular biology

Period: S7 Elective 05 November to January IN27DE5, SEP7DE5

Course Objectives

The objective is to inform future engineers about the functioning of the genome as a whole, and its analysis by in vivo methods such as transgenic mice and high throughput in silico methods such as microarray technology, which includes 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 and the bioethical issues associated with these developments.

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, and in particular appreciate how genomic information can be used for developing improved therapeutics.
- ✧ be informed about the ethical, legal, and social issues regarding genome patenting.
- ✧ learn about the current status of stem cells and the bioethical issues raised by the new developments and technical improvements.
- ✧ possess a strategic vision of the field of genomics in health care and the important role of multi-displinary collaboration.

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.
- ✧ Genome patenting: ethical, legal, and social issues.
- ✧ Using the genome for gene and cellular therapies. Large scale bioproduction of genome-based therapeutics.
- ✧ Dynamic reprogramming of the genome: cellular plasticity and production at will of cells for therapeutic applications. Bioethical issues.

Specific examples, exercises, and visits to leading research laboratories will illustrate the program.

Course Organization

Lectures: 30 hr, Lab visit: 1/2 day, Exam: 3 hr

Teaching Material and Textbooks

Course notes and slides available online

Evaluation

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

PR5300
Biotechnology: Applications and Modeling

Professor: Filipa Lopes

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 06 December to January IN27DE6, FEP7DE6

Course Objectives

Biotechnology is defined as the application of science and technology to transform materials using biological agents and enzymes in order to produce goods or provide services. Biotechnology is currently applied in many industries, including health, agriculture, food production cosmetics, by-product and waste treatment and many others.

The general objective of this course is to introduce students to biotechnological and chemical engineering by taking into consideration the general background of a given process, form the choice of the biological agent to the purification of the desired final product. Modeling of biological processes will constitute a significant part of this course.

On completion of the course, students should be able to

have a good command of basic fermentation engineering and its application in various areas (agriculture, food, health, environment, etc.).

Course Contents

- Microbiology: eucaryots vs procaryots, bacteria, yeasts, microbial metabolism, microbial growth, methods for growth control
- Bioreactors and fermenters: various methods of operation, microbial growth kinetics, transfer, agitation and mixing, measure and control of bioreactors
- Downstream processing: separative techniques and purification of fermentation products (filtration, chromatography, centrifugation)
- Process modeling
- Presentation of biotechnological applications by industry representatives

Course Organization

Lectures and exercises: 34 hr, Exam: 2 hr

Teaching Material and Textbooks

Course notes, recommended readings

Evaluation

2-hr written final exam, without documents and computers

PR5950
Cellular and Molecular Biology Laboratory

Professor: Jean-Luc Zimmermann

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: PR5110 or PR5200 or equivalent.

Period: S8 Elective 13, One-week module 2 14-21 May IN28IS2, SEP8IS2

Course Objectives

- Transfer one's theoretical knowledge in cellular and molecular biology in a real laboratory project: cloning of a gene into a plasmid, bacterial cell transfection
- Experience several dimensions of modern experimental work in biology and biotechnology: importance of the time factor, confrontation of experimental results and theory
- Gain hands on experience of methods and technologies that are routinely used in cellular and molecular biology: DNA electrophoresis, bacterial transformation, PCR, cell transfection, cell counting

On completion of the course, students should be able to

- understand research work in a biology laboratory
- apply common techniques in molecular and cellular biology

Course Contents

- Molecular biology - Manipulation of DNA, digestion, visualization and extraction of DNA. Use of restriction enzymes, agarose electrophoresis, plasmidic DNA extraction. Cloning in a bacterial vector: DNA digestion and ligation, transformation of bacteria. Applications of PCR, influence of several experimental parameters: Mg2+ concentration, hybridation temperature, PCR on colonies.
- Cellular biology - Transitory transfection: lipofectamin, calcium phosphate. Cell counting, Freeze / thaw of cells.

Course Organization

Labwork: 33 hr, Exam: 3 hr

Teaching Material and Textbooks

Course reader

Evaluation

Laboratory report

Industrial Engineering, Management, and Economic Systems

SE1100
Corporate Accounting and Finance

Professor: Danièle Attias

Language of instruction: French – **Number of hours**: 27 – **ECTS**: 2

Prerequisites: None

Period: S5 between September and January IN15COM, FEP5COM

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 basics of financial flows, markets and stakeholders
- 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
- Introduction to financial markets, interest rates and cost of financial resources for companies
- 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

Lectures: 16 hr, Tutorials (E-learning): 10 hr, Exam: 1 hr

Teaching Material and Textbooks

- Course readings are available on course website, together with class discussions and exercises
- Official reports of a major company.

Evaluation

1-hr written exam on the material covered in lectures and e-learning modules

SE1200
Management

Professor: Eléonore Mounoud

Language of instruction: French – **Number of hours**: 27 – **ECTS**: 2

Prerequisites: This course requires openness, curiosity and readiness to discuss economics, psychology, individual and collective human behavior, 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 IN15COM, FEP5COM

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

- Analyze the main strategy of a company in its 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 a process of performance improvement
- Contextualize technological choices made on innovation projects; understand the importance of inter-functional teams for innovation

Course Contents

- Introduction: objectives, stakeholders, operations and product life cycles
- Marketing of products and services
- Corporate strategy
- Growth process and strategic maneuvers
- Structure and processes, informal organization
- Performance driving and operations management
- Management of innovation and technology
- Company managers: between projects and responsibilities

Course Organization

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

Teaching Material and Textbooks

Course reader in French + copy of the slides presented in class

Evaluation

- 3-hr written final exam (3.5-h for international students)
- optional written midcourse exams
- oral participation in tutorials

SE1300
Corporate and Market Finance

Professor: Danièle Attias

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: SE1100 or equivalent. Basic knowledge in general accounting and finance

Period: S7 Elective 02 September to November IN27DE2, FEP7DE2

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 cost accounting, financial analysis, economic models
- Understand the issues of corporate finance

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

Course Contents

- Accounting practices in companies, especially monetary representation
- Forecasting and company management: principles and practice of basic cost accounting
- 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 (including 4 hr of e-learning), Final exam: 3 hr

Teaching Material and Textbooks

Course readings are available on course website, together with class discussions and exercises

Evaluation

3-hr written exam

SE1400
Economics

Professor: Pascal da Costa

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period: S7 between September and January IN27COM, FEP7COM

Course Objectives

The goal of the class 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 economic analysis.

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

One of the tutorial series is given in English.

Teaching Material and Textbooks

- Course reader in French
- Blanchard, Cohen (2002), Macroéconomie, Pearson Education
- Mucchielli, Mayer (2005), Economie internationale, Dalloz
- Varian (1995), Analyse microéconomique, De Boeck Université

Evaluation

Optional 1.5-hr written midterm exam, 3-hr written final exam. Note = sup(0.4 midterm + 0.6 final, final)

SE1500
Enterprise Modeling

Professor: Jihed Touzi

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: IS1110 or equivalent.

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

The course Enterprise Modeling makes it possible to model corporate knowledge considering all its dimensions: process, decision, information, product, organization, etc. This course gives an overview of modeling methods, techniques and tools to help companies improve their performance and decision-making.

On completion of the course, students should be able to

- build models of an enterprise (or a part of it), using well adapted modeling tools
- explain corporate structure and operations
- analyze corporate behaviors and evaluate performance
- help decision-making
- manage integration and interoperability problems

Course Contents

- Review of definitions and use of models, modeling, metamodels.
- Introduction to Enterprise Modeling: definitions, various enterprise models.
- Review of engineering methods for information systems using UML: class diagrams, use case diagrams, activity diagrams, practice.
- Process modeling: methods (BPMN, UML, IDEF), practice.
- Enterprise modeling: methods, frameworks, tools, characterization, comparison, application domains.
- Exercises and case studies.

Course Organization

Lectures: 12 hr, Tutorials: 12 hr, Labwork: 9 hr, Exam: 3 hr

Teaching Material and Textbooks

Lecture slides

During the practical sessions, the students will use free modeling software tools on their laptops

“Enterprise Modeling and Integration: Principles and Applications”, Francois Vernadat, Kluwer Academic Publishers, ISBN-13: 978-0412605505

Evaluation

- practical work and homework (50%)
- 3-hr written exam (50%)

SE1600
Economics 2

Professor: Pascal da Costa

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: SE1400 or equivalent.

Period: S7 Elective 06 December to January IN27DE6, FEP7DE6

Course Objectives

Advanced theories in economics building on SE1400

On completion of the course, students should be able to

- understand and use recent economic theories
- develop and implement mathematical models in micro and macroeconomics
- understand the basics of quantitative research

Course Contents

- Industrial economics
- Macroeconomics modeling (emphasis on macroeconometric models and general equilibrium models)
- Environment and natural resources economics
- Theories of endogeneous growth

Course Organization

Lectures: 22.5 hr, Tutorials: 7.5 hr, Exam: 6 hr

One of the tutorial series is given in English.

Teaching Material and Textbooks

- Course reader in French
- Jones (2000) Théorie de la croissance endogène, De Boeck Université
- Schubert (2000) Macroéconomie, comportements et croissance, Vuibert
- Varian (1995) Analyse microéconomique, De Boeck Université

Evaluation

Two intermediate 1.5-h written exams and a 3-h written final exam.

SE1650
Modern Macroeconomics Modeling

Professor: Christophe Cahn

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

The objective is to study a set of issues in applied economics that emphasize the dynamic aspect of economic decisions. Although the goal of this course is the practical use of economic models, the course also provides basic techniques before analyzing specific problems of dynamic optimization. We will present and integrate important tools such as dynamic programming, numerical techniques, and simulations based on econometrics. These tools will be used in many applications, both in microeconomics and macroeconomics. In general, this approach allows to estimate the structural parameters and to analyze the effects of economic policies.

On completion of the course, students should be able to

understand econometric estimations, macroeconometrics modeling, general equilibrium modeling, and modeling in real business cycle.

All these models and economic forecasts are used by the economic services of banks, central banks (FED, ECB, ...), ministries of economy and finance, quantitative research, etc.

Course Contents

The researcher in economics often has to infer the underlying parameters that represent the preferences, technology or any other quantity that structures an economy, based on observations about individual households or firms that the macroeconomics aggregates. When such inferences are successfully established, we can test various competing hypotheses about economic behavior and evaluate their effects experimentally.

Course Organization

Lectures and exercises : 31.5 hr, Exams: 4.5 hr

Teaching Material and Textbooks

- Schubert, Macroéconomie, comportements et croissance, Vuibert (2000)
- Epaulard A., Les modèles appliqués de la macro-économie, Les Topos, Dunod (1997)

Resources

Lecturers: Christophe Cahn, Pascal da Costa

Evaluation

1.5-hr mandatory intermediate exam and 3-hr final exam

SE1950
Reverse Engineering and Rapid Prototyping Laboratory

Professor: Pascal Morenton

Language of instruction: French or English – **Number of hours**: 30 – **ECTS**: 2

Prerequisites: None

Period:	S5	December to January	IN15DXP, FEP5DXP
	S6	between February and June	IN16DXP, SEP6DXP

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: 33 hr, Exam: 3 hr

Teaching Material and Textbooks

Ecole Centrale Paris course book: “CATIA V5 training”

Evaluation

Oral presentation and final report

SE2100
Industrial Engineering

Professor: Jean-Claude Bocquet

Language of instruction: French – **Number of hours**: 18 – **ECTS**: 1

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

Course Objectives

- Understand the basic concepts (systems, processes, organizations, etc.) and a few analytical and sizing tools for companies producing goods or services
- To apply a few methods of analysis and sizing

On completion of the course, students should be able to

Analyze and design systems and processes in a company

Course Contents

- General introduction, systems and processes: systems; processes; economic, environmental and societal values
- Demands engineering, conception processes: system engineering, V cycle, functional analysis, AMDEC, life product cycle, conception processes
- Industrialization, production: specialized workshops, line of production, MRP, just-in-time, lean, 6sigma, production costs, prices
- Supply chain: supply networks, logistical chain, supply decision, operations management, vehicle round problem, shortest way problem
- Running, SLI, after sales service: integrated logistical support, owning global cost, maintenance, work safety, availability, reliability, default rate, bayesian networks

Course Organization

Lectures: 7.5 hr, Tutorials: 7.5 hr, Exam: 3hr

Resources

At each lecture, the students will see an industrial example and the fundamental academic concepts. The tutorials will mainly lean on real cases, implementing methods but also role games and performance simulation competition using the same data.

Evaluation

- Written exam (mcq)
- Project by groups of 5 with report and oral presentation

SE2200
Design and Innovation of Products and Services

Professor: Bernard Yannou

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 03 September to November IN27DE3, FEP7DE3

Course Objectives

The objective is to allow students to discover **concepts, methods and tools** related to the **innovative design of products and services** through a **structured industrial process** and through targeted and organized creativity **workshops of the multi-disciplinary design team**.

The course is built upon the "Radical Innovation Design" method. Its principles are to lead a multidisciplinary innovative project through a radical exploration of the problem (problem-setting stage) and of its conceptual solution (problem-solving stage) which will probably create higher value. Operational, tactial and strategic aspects of knwoledge management, competency management, and creativity management (to co-innovate rather that to innovate in silos) contribute to a radical exploration of problems and solutions and to the construction of solid value creation proofs.

The theme of this year is "Design for Elderly People". Five highly innovative companies have accepted to collaborate with us by proposing "initial innovation statements". They are:

- DORO, Swedish company, world leader in mobile phones for the elderly
- ASSYSTEL, French leader in teleassistances boxes (fall detections by domotic sensors and automatic phone calls)
- SANOFI-AVENTIS, world leading pharmaceutical company aiming to develop serious games to stimulate post VCAs (vasculo-cerebral accidents)
- LEGRAND, world leader in electric domotic appliances. They goal is to make their devices compatible with with safety control scenarii of elderly people (such as daily medicine consumption)
- VIVAGO : Finnish company that has developed a watch that measures new physiological features enabling to detect loss of consciousness within a few seconds

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 modeing, evaluating feasibility of solutions according to the expected requirements

Course Contents

- Introduction to design sciences - Presentation of application cases - Bernard Yannou
- Radical Innovation Design I - Problem setting - Bernard Yannou
- Design for elderly people - Benjamin Zimmer, Mickaël Carré (84) (Médialis company)
- Usage observation, product and service benchmarking - Stéphane Gauthier (Plans créatifs company)
- Requirements chart - Defining expected functions and target performances - Bernard Yannou
- Mid-point review (présentation intermédiaire) - Is your innovative problem well set? Are you well organized? (2 jurys comprised of lecturers and company representatives)
- Industrial design I - A few techniques to quickly sketch and prototype - Philippe Costard (Synergie Design company)

- Radical Innovation Design II - Problem solving - How to explore design concepts and choose the one creating the most value? - Bernard Yannou
- Industrial design II - Lessons learned on good and bad designs - Philippe Costard
- Service design - Laurent Polet
- Eco-design - Yann Leroy
- The “Prove it!” seminar - Prove that you got the most value-creating innovative concept! (2 jurys comprised of lecturers and company representatives)

Course Organization

Lectures: 18 hr, Tutorials: 18 hr

Teaching Material and Textbooks

The course is based upon two recent handbooks written in French, but equivalent book chapters or papers in English will be provided on demand:

- Yannou B., Bigand M., Gidel T., Merlo C., Vaudelin J.-P., (2008), La conception industrielle de produits, Volume I: Management des Hommes, des projets et des informations, Hermès Sciences, Lavoisier: Paris.
- Yannou B., Deshayes P., (2006), Intelligence et innovation en conception de produits et services. collection « L'esprit économique », série « Economie et innovation », Paris, L'Harmattan-Innoval, ISBN 2-296-00644-2.

Evaluation

- Average of the mid-term review and the ProveIt seminar presentations
- Respect of requirements
- Modulation of the final grade according to your contributions inside the group

SE2300
Strategy and Marketing

Professor: Cécile Préaubert

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: SE1100, SE1200 and MA1300 or equivalent.

Period: S7 Elective 05 November to January IN27DE5, FEP7DE5

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
- ✧ use statistical and qualitative methods to understand the consumer and perform an internal/external marketing diagnostic
- ✧ develop a marketing strategy
- ✧ define and implement a marketing action plan according to the 4P
- ✧ evaluate and use promotional tools

Course Contents

Strategy:

- ✧ Introduction: the facets of strategy, strategic management
- ✧ 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

Marketing:

- ✧ Introduction: the role of marketing in companies and the process of marketing planning
- ✧ Marketing analysis: consumer behavior, marketing surveys, marketing diagnostic
- ✧ Marketing strategy and concepts of segmentation, targeting, and positioning
- ✧ The marketing mix and its components: product, packaging, brand, price, communication, promotion, distribution

Course Organization

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

Teaching Material and Textbooks

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, to read and prepare the case study, and to write a synthetic note.

Evaluation

- Written final exam (50% of the final mark): 3 hr, no documents and no calculators allowed

- Continuous assessment (50% of the final mark):
  - ✧ 20% : 2 or 3 written exams during tutorial sessions
  - ✧ 15%: group presentation on a case study
  - ✧ 15%: synthetic note and oral participation in case study discussions

SE2400
Production and Distribution Management

Professor: Chengbin Chu

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: It is recommended to have taken introductory courses in areas such as business administration or accounting and finance.

Period: S7 Elective 04 November to December IN27DE4, FEP7DE4

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

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
Demand Forecasting and Inventory Management

Professor: Evren Sahin

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MA1200 and MA1300 or equivalent.

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

- Analyze the challenges of managing flows in logistics chains
- Present related methods and approaches
- Develop quantitative models (deterministic and stochastic), to measure the impacts of various flow parameters on the performance of logistic chains, and to optimize these parameters
- Understand the link with other types of decisions in supply chain management

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 various challenges in managing flows
- use approaches, methods and tools to manage stocks

Course Contents

- Introduction to flow management: manage by order / by anticipation, input revewal/manage by future needs, real cases in several industrial sectors, links between flow management and lean approach
- Mono-periodic stock management: Newsboy model and others
- Multi-periodic stock management
- Kanban method and extensions
- Managing by future needs
- Case study on lean approach in a company

Course Organization

Tutorials: 34 hr, Exam: 2 hr

Teaching Material and Textbooks

Slides

Evaluation

2-hour written exam.

SE2550
Introduction to Purchasing

Professor: Philippe Rougevin-Baville

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 09 February to March IN28IE2, SEP8IE2

Course Objectives

Provide students with the basic knowledge and skills to master the main purchasing processes in which they will be involved, whatever their function 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
- know the main alternative regarding the purchasing division organization
- 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

Course Organization

Lectures: 14 hr, Case studies: 14 hr, Tutorials: 6hr, Exam: 2 hr

Teaching Material and Textbooks

PowerPoint slides and case studies

Evaluation

2-hr written final exam + class participation in case study discussions

SE2600
Enterprise Architecture and Modeling

Professor: Pierre-Frédéric Rouberties

Language of instruction: French or English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: There is no prerequisite for this course. The following knowledge may help: general knowledge about how a company is structured and operates; general knowledge about system engineering.

Period: S7 Elective 03 September to November IN27DE3, FEP7DE3

Course Objectives

Business leaders have to take two types of **strategic decisions**:

- on the **external positioning** of their company: formulating a corporate strategy by defining the position on the market (which products and services? which markets? which customer segments? in front of which competitors? with which performance targets?);
- on the **internal structure** of their company: making organization choices to execute the strategy (which resources will we need to implement the strategy? how to best mobilize these resources? how to optimize our business processes? which activities can we automate through Information Systems? which activities should we outsourced? which activities should we do internally?)

As a complement to the strategy course, this course on **Enterprise Architecture and Modeling** aims at delivering the basic concepts required for the design of the optimal structure of a company. Its objectives are to:

- refresh participants on what a company is and what are its main functions;
- provide the basis to represent Actors, Activities (Process Modeling) and Information required by any company to operate, in a **Company Model**;
- give tips to design a consistent though flexible and scalable company structure;
- explain how the company is transformed through a portfolio of Transformation Projects (Organization and Information Systems projects) and how to achieve quick **transformations** while preserving the quality and consistency of the structure.

On completion of the course, students should be able to

- understand the fundamentals of a a company
- create a model for a company and its IS
- translate business objectives into a company transformation project, linking several disciplines (organizational design, process, IS)

Course Contents

What is a Company?

- Systemic approach of a company
- Reminder on the main functions of the enterprise and their relationships

Definition of Enterprise Architecture

Introduction to Model and Meta-Model / Modeling languages and notations (UML, BPMN, …)

How to transform Company Objectives into Processes and Information Systems

How to design a Company Model facing the challenge of complexity

- How to define Business Objects in the Enterprise
- How to define and optimize Business Processes

The Transformation Process of a company (Agility challenge)

How to build a consistent and scalable enterprise architecture? the role of the Foundation (Synergy challenge)

Course Organization

The course will be delivered mostly in tutorials, except for the general concepts that will be delivered in lectures. Teaching is based on real case studies that will allow students to:

- put themselves in an active resolution mode on concrete issues
- formalize the concepts emerging from case studies into theoretical frameworks

Teaching Material and Textbooks

Course material includes:

- Presentations
- Case studies
- CEISAR white papers (http://www.ceisar.org/)
- Testimonies

Evaluation

- Mandatory intermediate exam: case studies in teams with report and oral defense
- 3-hr written final exam. Part 1: questions on the class material, part 2: modeling exercise. Computer and documents allowed. The final mark is the average of the two exams.

SE2650
Risk Assessment and Management

Professor: Enrico Zio

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: MA1200 and MA1300 or equivalent.

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

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 management and management have become everyone's business.

The course addresses the safety 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 adequate tools for tackling the problem with the required scientific rigor and practical efficacy. The expertise offered is that expected from a safety and reliability analyst and manager.

This course also provides a good background preparation for the Master's level course on Modeling and Simulation Methods for the Reliability, Safety, and Risk Analysis of Complex Engineering Systems.

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 systems's environment

Course Contents

- Dimensions of risk: frequency and consequences. History of risk management.
- Hazard identification, functional analysis, Hazard Operability (HAZOP), analysis and Failure Modes, Effects and Criticality Analysis (FMECA)
- Probabilistic Risk Assessment (PRA)
- Fault tree and event tree analysis
- Framework of risk management
- Decision analysis for risk management
- Optimization and game theory for risk decision making
- Crisis management

Course Organization

Lectures: 28.5 hr, Tutorials: 3 hr, Labwork: 3 hr, Exams: 1.5 hr

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: Enrico Zio, Marc Bouissou, Yanfu Li, Romain Couillet, Terje Aven, Vincent Mousseau, Denis de Montgolfier

Evaluation

- Mini-project on risk management in groups of 3 students
- 1.5-hr final exam with questions on course material, and exercises with numerical calculations (no documents and no computer allowed, but non-programmable handheld calculator allowed)

SE2700
Modeling for Decision Making

Professor: Vincent Mousseau

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

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

Course Organization

Lectures: 12 hr, Tutorials: 12 hr, Labwork: 9 hr, Exam: 3 hr

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.

Evaluation

Written exam and presentation of a mini-project on a case

SE2750
Stochastic Modeling and Theory of Queues and their Applications

Professor: Oualid Jouini

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Basic knowledge of probability

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

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 three case studies in which we use queueing models. The case studies are applications in 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 system
- Queueing networks
- Simulation of queueing system
- Advanced queueing system
- 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: 3 hr

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

3-hr written final exam (documents and computers allowed)

SE2800
Production Planning and Scheduling

Professor: Chengbin Chu

Language of instruction: English* – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

This courses introduces different modeling tools (Petri nets, graphs, mathematical programming) and solving tools (branch and bound, dynamic programming, heuristics and metaheuristics) for production planning and scheduling problems.

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
- Concept of computational complexity
- Basic scheduling models and project management models
- Cyclical scheduling
- Non cyclical 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

Oral presentation of a mini-project on a case study

SE2850
Llenroc Plastics: Market-Driven Integration of Manufacturing and Distribution Systems

Professor: Peter Jackson

Language of instruction: English – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S8 Elective 13, One-week module 2 14-21 May IN28IS2, SEP8IS2

Course Objectives

Llenroc Plastics is a comprehensive case study in redesigning the manufacturing and distribution systems for a medium-sized manufacturer of high pressure decorative laminates. This case study demonstrates that by taking a view that integrates marketing, distribution, manufacturing, and engineering, a company can transform itself into a world-class competitor.

Course Contents

- Llenroc Plastics Company Overview
- The Cumulative Flow Plot
- Distribution and Transportation Systems
- Llenroc Plastics Plant Tour
- Project at a glance
- Beyond Just-in-time: the No B-C strategy
- Cyclic scheduling
- Simulations during the Labworks

Course Organization

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

Resources

Peter Jackson is a professor in the School of Operations Research and Information Engineering at Cornell University.

Evaluation

Written report and oral defense

SE2900
Project Management

Professor: Franck Marle

Language of instruction: French – **Number of hours**: 15 – **ECTS**: 0.5

Prerequisites: None

Period: S7 between September and January IN27COM, FEP7COM

Course Objectives

Introduce the main issues and techniques in project management

Practice with several tools and methods, with focus on validity and implementation challenges

Show that project management is a crossroad for many disciplines, such as fundamental sciences, engineering sciences and human sciences

On completion of the course, students should be able to

- ✧ Define a clear measurable and non-ambiguous target for a project
- ✧ Plan the project in terms of scheduling, costs and human resources to maximize the chance to reach the expected objectives
- ✧ Keep the project on track, be it on the agreed target, or on a new target

Course Contents

- ✧ Project launch: decision to launch, definition of the project targets and differentiation with the targets of the product that will be a result of the project
- ✧ Project planning and organization: work breakdown, scheduling, cost and resources planning
- ✧ Project Control: risk management, project quality, project status monitoring and control
- ✧ Project Closure

Teaching Material and Textbooks

Slides related to lectures, additional documents, especially papers from technical journals

Evaluation

Final 1.5-hr written exam

Intermediate paper

SE3100
Law

Professor: Michel Abello

Language of instruction: French – **Number of hours**: 24 – **ECTS**: 2

Prerequisites: None

Period:	S6	between February and June	IN16COM, SEP6COM
	S7	between September and January	IN27COM, FEP7COM

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: 18 hr, Tutorials: 4.5 hr, Exam: 1.5 hr

Teaching Material and Textbooks

Course reader and slides

Evaluation

1.5-hr written quizz

SE3200
Law 2

Professor: Michel Abello

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: SE3100 or equivalent.

Period: S8 Elective 10 February to April IN28IE3, SEP8IE3

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 and case studies in 3-hr sessions

Teaching Material and Textbooks

Course reader

Evaluation

1.5-hr written exam

SE3300
Entrepreneurship: A First Approach

Professor: Jean-François Galloüin

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 06 December to January IN27DE6, FEP7DE6

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

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

A case study is discussed with oral and written discussions. Three classes are dedicated to this work. Students are in a "real" entrepreneuring situation.

Teaching Material and Textbooks

Slides for each class.

Evaluation

Final report and oral presentation of a group work (9 hr on schedule + homework).

Humanities and Social Sciences

SH1100
Cultural Awareness Activities — Session 1

Professor: Lisa Carrière

Language of instruction: French or English – **Number of hours**: 18 – **ECTS**: 0.5

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

Course Contents

- SH1101 - How to use polls without being manipulated (Mathieu Geoffrey)
- SH1102 - Did you say "Contemporary art?" (Rozen Prat)
- SH1103 - Improvisational theater (Olivier Courbier)
- SH1104 - Walt Disney and innovation (Philippe Sisbane)
- SH1105 - Baroque music (Catherine Cessac)
- SH1108 - Europe (Jean-Christophe Dallemagne)
- SH1109 - Contemporary geopolitics (François Lafargue)
- SH1110 - An approach to sculpture. Reproductions and mouldings (Patrick Callet)
- SH1111 - Anglo-American Journalism: A beginner's guide (English) (Peter Humi)
- SH1112 - An approach to the town (Éric Mathieu)
- SH1113 - Myth and operas (Stéphane Longeot)
- SH1114 - Activities for social apportunity (Lisa Carrière et al.)
- SH1115 - Beautiful for all (Sophie Chapdelaine de Montvalon)
- SH1116 - Acoustics and Creation of Contemporary Music (René Caussé)
- SH1117 - Questioning our society, grasping a changing world: from journalism to documentary filmmaking (given in English)

Course Organization

6 half days or 3 full days in February

Evaluation

Take-home essay or oral work depending on chosen module

SH1200
Cultural Awareness Activities — Session 2

Professor: Lisa Carrière

Language of instruction: French – **Number of hours**: 18 – **ECTS**: 0.5

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

Course Contents

- SH1202 - The artist, the scientist and the industrialist (Jérôme Poggi)
- SH1203 - A new look at theater (Véronique Sacri)
- SH1204 - Writing and producing a short film (Philippe Sisbane)
- SH1206 - American cultures (Christopher Cripps)
- SH1207 - Enterprise in China: the new player in the world economy (Alain Wang)
- SH1208 - What is at stake in the construction of Europe (Laurent Michon)
- SH1209 - Contemporary geopolitics (François Lafargue)
- SH1210 - Introduction to industrial design (Joseph Mazoyer)
- SH1212 - An approach to built spaces (Eric Mathieu)
- SH1213 - An invitation to Paris Opera (Nathalie Guilbaud)
- SH1214 - Sociology of music (Sylvie Berbaum)
- SH1215 - Improvisational theater (Olivier Courbier)

Course Organization

6 half days or 3 full days in May

Evaluation

Take-home essay or oral work depending on chosen module

SH1300
Philosophy of Sciences

Professor: Étienne Klein

Language of instruction: French – **Number of hours**: 15 – **ECTS**: 0.5

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

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.

Teaching Material and Textbooks

Course reader in french and a copious and 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.

SH1400
Personal Development Seminar

Professor: Christian Michelot

Language of instruction: French – **Number of hours**: 12 – **ECTS**: 0.5

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

Course Objectives

- approach personal development through questioning their own desires, motivations and attitudes
- explore emotional, affective, imagined and creative perceptions and what significance is given to them
- develop a capacity for self reflection and an open attitude towards others
- recognise the underpinnings of human relationships

Course Contents

This seminar provides an opportunity for self discovery; learning more about personal attitudes and actions by using diverse techniques of art, drama, games, physical and mental activities

Students will be asked to choose three activities out of those proposed. There will be groups of 15 students (on average) for each activity.

A few examples:

- How to manage one's time amid constraints and wishes?
- Introduction to a philosophy of the body and of space through Tai-Chi and Nei-Kung
- Tools for innovation
- Listening, listening to oneself, being listened to
- Express and develop one's potential through theater
- Turn one's voice into one's spokesperson
- Couch stories and the powers of speech
- Personal impact and communication
- Itinerary and professional perspectives
- Psychoanalysis, work, family and you
- The messenger body or conceiving the body differently
- Mind, the key to success
- Self-assertion in one's relationships
- The art of storytelling
- Acting techniques and speaking out
- The game of interpersonal communication

Course Organization

Self analysis is the core of this 2-day seminar.

The emphasis is on learning by participation: case studies, scenarios, role play, dialogues, practical exercises, individual and group analysis of given situations, along with studying the theoretical bases. It is expected that the students will gain a basic understanding of the disciplinary principles that are behind these approaches.

Evaluation

Based on participation

SH2100
Business Games

Professor: Christian Michelot

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 1.5

Prerequisites: Basic knowledge in management/accounting and experience of group work would be helpful

Period: S7 between September and January IN27COM, FEP7COM

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.

Company role playing games offer a practical, enjoyable, playful and synthetic approach to economics and management and constitute a valuable experience and insight into collective decision-making, interdependence and organization of a team, of management of conflicts, of personal action and positioning in a group.

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 consecutive days, alternating simulations 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

SH2200
Coaching for Student Organizations

Professor: Cynthia Colmellere

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 3

Prerequisites: Being involved in a non-profit campus organization (BDE, ADR, WEI, RAID, FORUM, VIA, etc.)

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Develop ability to work in a team
- Develop critical thinking, analysis and innovation attitudes
- Foster transfer of learning in non-profit organizations to the professional domain
- Better understand the methods and techniques of negotiation

Course Contents

This coaching is offered to students involved in on-campus student organizations (BDE, ADR, WEI, RAID, FORUM, VIA, etc.).

The coaching is specific to each organization. It will focus on the organization's mode of operation and internal structure, and on the actions to be lead and their meaning.

Course Organization

The module is composed of two parts: 12-hr of coaching during the year, and a 18-hr seminar among the following modules:

- SH2201: Teamwork
- SH2203: Introduction to negotiation, management and teamwork

SH2201
Coaching for Student Organizations — Teamwork

Professor: Christophe Ruston

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 3

Prerequisites: be a member of a student organization

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Examine carefully and humanely "How do I find or take my place in a group?"
- Become aware of the interest of working in a group
- Group training to resolve specific problems and take decisions
- Develop one's ability to speak up, to listen and to integrate other's opinions, notably in a multicultural context
- Identify personal attitudes that encourage communication within the group
- Identify the conditions that facilitate running and efficient meeting

On completion of the course, students should be able to

contribute productively to a working group, and even run it

Course Contents

- How to define a "group", a "team" and their specificities?
- How groups function, based on psycho-sociological concepts: how is a group organized and developed?
- The various roles that can be held in a working community and their impact on production
- The role of listening in group communication: verbal attitudes
- Different types of meetings and their purpose: solving problems, taking decisions, brainstorming...
- Tools and methods to run a meeting

Course Organization

12-hr coaching during the year and a 18-hr seminar

SH2203
Coaching for Student Organizations — Introduction to Negotiation, Management and Teamwork

Professor: Anne-Claire Lesage, Antonia Ceppi

Language of instruction: French – **Number of hours**: 30 – **ECTS**: 3

Prerequisites: be a member of a student organization

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Experience the interest in cooperation
- Initiate you in negotiation
- Animate a meeting efficiently
- Know the conditions for efficiency and cohesion in a team
- Discuss the question of leadership and management
- Question your relation to power and authority

Course Organization

12-hr coaching and a 18-hr seminar using exercises such as being placed in a situation and role playing, supported by methodological and conceptual contributions

Teaching Material and Textbooks

- *Comment réussir une négociation* - R. Fisher et W. Ury - Seuil
- *Le travail en équipe* - R. Mucchielli - ESF
- *La cohésion des équipes* - P. Cauvin - ESF
- *La motivation dans l'entreprise* - C. Levy Leboyer - Editions d'organisation
- *La crise des motivations* - C. Levy Leboyer - PUF
- *La conduite des réunions* - R. Mucchielli - ESF
- *Management situationnel* - D. Tissier - Insep Consulting
- *Qu'est-ce que l'autorité*in*La crise de la culture* - H. Arendt - Galimard

Evaluation

Oral evaluation exercise during the module

SH2300
Seminar Series: Management

Professor: Cynthia Colmellere

Language of instruction: French or English – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Develop skills in oral or/and written expression
- Improve ability to convince and persuade
- Understand your management abilities
- Enhance your leadership skills
- Acquire managerial dynamics in different contexts
- Develop abilities to lead and motivate a team

Course Contents

Students may choose among the following seminars:

- SH2324. Human Phenomena in Project Management
- SH2327. Negotiating
- SH2329. From Autority to Responsibility in Working Organizations
- SH2330. Develop Leadership Skills (Daring and Creativity)
- SH2331. Taking one 's Place in a Professional Context
- SH2332. Risks and Crisis Management
- SH2333. Teamwork and Running a Meeting
- SH2334. Negotiation and Management

SH2324
Management — Human Phenomena in Project Management

Professor: Olivier Gourbesville

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

Identify and understand human phenomena in project management

On completion of the course, students should be able to

- use an analytical chart/grid of the system of actors involved in a project [sociogram]
- detect and interpret the most frequently occurring human phenomena in the lifespan of a project
- take the floor, manage and run interviews, and chair meetings within the context of managing a project

Course Contents

- Reminder and recapitulation of the main features of projects
- Spotting, identifying and analyzing human phenomena connected with these features
- The different players or protagonists and their respective strategies (issues, at stake, power, conflict)
- Taking into consideration and allowing for the human dimension in devising project management procedures
- The dynamics of the team running the project
- The relationship between the head person leading the project and the project director
- The managerial role of the project leader
- The key factors underlying success of CDR projects

(Other topics may be dealt with in accordance with the requests of the participants.)

Teaching Material and Textbooks

Course reader in French comprising notably thematic lists and a bibliography

Evaluation

Active participation and involvement in the exercises required (group work, case studies, simulations)

SH2327
Management — Negotiating

Professor: Thierry Linne

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Learning to decode and elucidate professional negotiating situations
- Understanding and integrating different typologies of negotiations
- Putting into practice and implementing negotiation techniques and tools

On completion of the course, students should be able to

improve negotiation skills

Course Contents

- Basic foundations of negotiation
- Corporate negotiating situations
- Principles and running of negotiation processes and procedures
- Practical case studies with simulation/role play of negotiating situations (workshops)
- Prerequisites and conditions for the success of a negotiation

Teaching Material and Textbooks

Course reader in French

Evaluation

Individual work, personal involvement and participation

SH2329
Management — From Authority to Responsibility in Working Oganizations

Professor: Jean-Christophe Berlot

Language of instruction: English – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- ✧ Feeling the effect of taking and assuming responsibility
- ✧ Understanding its meaning and what issues are involved

On completion of the course, students should be able to

gain a dynamic understanding of ethics.

Course Contents

Can I "feel" myself responsible and accountable?

For three days by using increasingly complex role play and simulation activities (drawn from corporate life, topical events and current, everyday life) and connected theoretical points, the engineering student will be led to discover in practice the feeling of vertigo, of dizziness connected with every decision making act, the necessity and the pleasure of being able to use the first person pronoun "I", the possibility of feeling oneself responsible and accountable for a collective choice, including within the running of the module itself.

Evaluation

Participation

SH2330
Management — Develop Leadership Skills (Daring and Creativity)

Professor: Hamid Haguini

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Self-knowledge and knowing others
- Develop his/her boldness and creativity
- Get out of the comfort zone and dare
- Prepare his/her future professional practice

On completion of the course, students should be able to

- adapt leadership style to the situation
- using creativity and ability to influence
- develop relational capabilities

Course Contents

- A vision of leadership through innovation
- Leadership styles and roles in organizations
- Assertiveness and communication rules in Transactional Analysis
- The questioning in the interactional systemic approach (paradox and complexity)

Evaluation

Written exam (multiple choice questionnaire on Leadership lasting 30 minutes), Individual oral/viva (10-minute per person defense, criteria: boldness and audacity), teamwork (oral defense: 15-20 minutes per team, criterion: creativity)

SH2331
Management — Taking One's Place in a Professional Context

Professor: Myriam Berz

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

Acquiring concepts to have a better understanding of:

- the structure in terms of organizational and human complexity
- the mechanisms underlying the professional relationships
- developing personal assets, working on personal areas of improvement in order to find one's place in a professional environment

Course Contents

Day 1:

- Representations of the working world
- Human needs at work, personal relationship to the world of work
- Missions, functions, position, role
- Professional legitimacy
- Different types of skills expected from a professional
- Self-diagnostic

Day 2:

- Authority and legitimacy
- Communication and relationships within a professional context
- Dealing with emotions in work situations
- Finding one's place in the work unit: interacting with hierarchy, colleagues, collaborators

Day 3:

- Assertiveness in professional relationships
- Knowing how to make a request
- Knowing how to express a problem, a critical point of view

Teaching Material and Textbooks

Workshop, self-diagnostic, case studies, and training situation (use of a video camera)

SH2332
Management — Risks and Crisis Management

Professor: Patrick Obertelli, Joël Génard

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Understand and react when faced with crisis situations
- Ascertain psychological and sociological foundations of human behavior and actions in crisis situations

Course Contents

- Training in a simulation exercise of crisis management with an action team comprising professionals from the sector
- Visit of a crisis management center, meeting with key players in crisis management
- Training in communication during a crisis
- Benchmarks and anchorage points of human behavior faced with situations of risk(s)
- Standards of acceptance of risk
- Individual and collective defense mechanisms when confronted with risk
- Factors enabling adapted and suitable behavior

Evaluation

Written report

SH2333
Management — Teamwork and Running a Meeting

Professor: Gérard Vaël

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Improve your capacities and your skills in the field of managing and running a group
- Acquire the basis of the conditions for successfully working in a group

Course Contents

- The aim of working in a team and the conditions for success
- The role of the players
- Autonomy and practising delegation
- The factors for cohesion and cooperation
- Recognition and the conditions for motivation

Evaluation

Participation

SH2334
Management — Negotiation and Management

Professor: Corinne Goetz

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Discover key negotiation mechanisms that managers or project managers will encounter
- Develop methodology to approach negotiation through three steps: consult, confront, and conciliate
- Train to argue in various environments
- Learn how to manage conflicts efficiently
- Develop a strategic approach
- Learn how to conclude

On completion of the course, students should be able to

Adoption of tools for approaching the different missions of future managers or project managers:

- negotiation with an employee or manager on targets, means, bonuses
- business negotiation
- social negotiation
- multicultural negotiation
- crisis management

Course Contents

- Definition of negotiation, integrative and distributive models
- Consultation Phase- inform and being informed: analysis of context, stakes, how others think, principles of active listening - synchronization, reformulation, questionning - and the negotiation dimensions - facts, speech, opinions, feeling - negotiator style
- Confrontation Phase
- Conciliation Phase : game of alliances, finding solutions, taking the decision, the manager-mediator

Evaluation

Continuous assessment based on skills of acquisition, capacity to progress and teamwork

SH2400
Seminar Series: International and Intercultural

Professor: Patrick Obertelli

Language of instruction: French or English – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Learn how to work with people from other cultures
- Be aware of the cultural influence on one's professional behavior
- Work in a European context

Course Contents

Students may choose among the following modules:

- SH2403. Being an Engineer In Europe
- SH2404. Managing across Cultures
- SH2406. The Cultural Environments to Engineering Careers

SH2403
International and Intercultural — Being an Engineer in Europe

Professor: Jean-Christophe Dallemagne

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

Offer a complete panorama of the current and future impacts of European integration and extended membership both from within and outside in the context of its relations with the World Trade Organization (WTO). This approach is not limited to the economic and legal aspects, but encompasses all the technical aspects that future international project leaders ought to take into account.

Note: this seminar is open to all interested students, whether or not they already took the SH1108 Cultural Awareness Activities on the European Union.

Course Contents

- The consequences entailed by the free circulation of goods and its effects on the logistics and distribution functions of companies
- Standardization and European lobbying and pressure groups
- The Europe of banks and insurance companies
- The opening of public markets to free competition and European indirect fiscality and tax systems
- The concept of Europe involving strengthened cooperation and the Lisbon Treaty
- The Cotonou convention and North-South technology transfers
- Al Invest and Asia-Invest: the role of the RP France in Brussels
- Means of reply to the call for proposals of the European Commission

Course Organization

- Formal lectures and presentations
- Answers to questions raised by students (intuitu-personae pedagogy)
- Practical case studies derived from the centralized database of case studies of the European Union (Centrale des cas de la Communauté Européenne) (General Direction for the domestic market and trade)
- Implementation in the company of the “key concepts”.

(No overlap with the material covered in SH1108)

Teaching Material and Textbooks

Documentation list (Folio)

Internet sites of the Commission and other European Union institutions

Evaluation

Compilation of a strategic note analyzing the impact on a specific sector

SH2404
International and Intercultural — Managing across Cultures

Professor: Philippe Wuppermann

Language of instruction: English – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: Have already spent significant time abroad in order to contribute to the learning experience with tailor-made case studies

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Understand what is at stake in cross-cultural management
- Self-knowledge and knowing the others: identify cultural norms and values
- Gain awareness of the impact that cultural styles have on behaviors in a variety of contexts, and more specifically on management
- Experience the added-value provided by cultural diversity
- Practice problem-solving in a cross-cultural environment

Course Contents

Day 1. Individual Culture

- What is culture?
- The different layers of culture: circle posters
- Self-knowledge and knowing others through the GOLDEN approach
- Energizing: communication, strategies of contact, etc.
- Information-gathering: managing changes, learning styles, etc.
- Decision-making: management style, task-oriented vs. relation-oriented, etc.
- Lifestyle: managing time, organizational style, etc.

Day 2. National Culture

- Stereotypes and culture
- The postcard activity
- Fons-Trompenaars's 7-dimension model

Day 3 (half day). Managing Across Cultures / Case Studies

- Stereotypes and culture
- The Derdians
- Problem-solving across cultures: case studies brought by the students

Teaching Material and Textbooks

Each student will be given a paper copy of the slides and exercises

SH2406
International and intercultural — The Cultural Environments to Engineering Careers

Professor: Michel Sauquet

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- To develop among the students an awareness of the multiplicity of human, societal, professional cultures and thinking patterns they will encounter in the course of their professional life and which may affect it
- To help the students find their way among these cultural environments: scientific and technological culture, public space and governance, business culture, charity and aid culture, international cultures
- To make them aware that none of these environments is irrelevant to their job
- To instill an attitude of "mindfulness of the Other" whereby the students, stepping away from their own cultural societal framework, accept that the other may have for his/her methods and behavior reasons, logics that they themselves ignore
- Invite them to question their own responses, a mind-set they may not be aware they have
- Develop students' ability to handle with ease situations when they will have to respond to unexpected challenges and to account for their thinking both orally and on paper

Course Contents

Five cultural environments will be taken into consideration:

- Scientific and technological cultures
- Potitical cultures: governance
- Business cultures
- Humanitarian cultures
- World cultures

Course Organization

Ecole Centrale Paris - Châtenay-Malabry or Fondation Charles Léopold Mayer - Paris

This module will contain exchanges with practitioners of the relevant domain and visits:

- **Claudia Neubauer**, director of the Fondation Sciences citoyennes
- **Matthieu Calame**, director of the Fondation Charles Léopold Mayer
- **Ousmane Sy**, former member of the Malian Government
- **Pierre-Yves Guihéneuf**, coordinator of the Institut de la concertation
- **Philippe Pierre**, former Human Resources Director and head of training units in L'Oréal, consultant
- Visits to the Health Care Center of**Médecins du Monde** and the MDM headquarters

Evaluation

Continuous assessment

SH2500
Seminar series: SHS Perspective on Key Social Issues

Professor: Cynthia Colmellere

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Introduction to a specific socio-institutional or socio-economic field.
- Initiation to the understanding of important long-term social problems from the perspective of social sciences: psychology, sociology, economics, geography, demography, and anthropology.
- Introduction to methods used in humanities and social sciences: interviews, observation, surveys, and content analysis.
- Presentation of professional opportunities to Centrale engineers.

Course Contents

Choose between:

- SH2504 European Geopolitics International Crisis Management
- SH2505 Health at Work: are Well-being and Efficiency Compatible ?

SH2504
SHS Perspective on Key Social Issues — European Geopolitics International Crisis Management

Professor: Claire Bordes

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

- Understanding of European defense security issues
- Understanding of International organizations interactions (UN, NATO, and EU) using case studies of international crisis management: Afghanistan, Balkan, and Somalia

On completion of the course, students should be able to

- get analysis and data processing methods
- develop abilities to reformulate issues and synthesize data

Course Contents

- International Crisis Management theory, evolution actors
- Case study: Africa, Balcan, Afghanistan, and Somalia

Evaluation

International Crisis Management Simulation

SH2505
SHS Perspective on Key Social Issues — Health at work: are Well-being and Efficiency Compatible?

Professor: Samuel Michalon

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period: S7 Elective 07 4-10 January IN27DE7, FEP7DE7

Course Objectives

Nowadays, the phenomenon of psycho-sociological risks with its consequences can't be ignored. We will think collectively about the emergence of psycho-sociological risks at work. We will discover the main economic, societal and human issues related to these risks. As a future worker, and putting yourself in the position of a manager, you will be asked to think about the role you would like to play in the business world and to analyze what are the individual and collective solutions to keep a good balance between well-being and efficiency at work.

On completion of the course, students should be able to

- identify the tensions and the risks for human health in the work organization
- integrate, in your managerial practices, the dimensions of well-being and of health
- identify the key persons inside the institutions to deal with problematic situations

Course Contents

- Human expectations about work
- Question the so-called "innovative organizational practices" and the place of individuals in these new systems
- The causes of suffering at work: autonomy, recognition, quality of work, and workload
- Symptoms: stress, nervous breakdown, and burn out
- How to change and increase well-being at work
- Legal framework to protect health
- The balance between personal and professional life

Evaluation

Proactive behavior (50 %) and final exam (50 %)

SH3200
Seminar Series: Management

Professor: Patrick Obertelli

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Develop skills in oral or/and written expression
- Improve ability to convince and persuade
- Understand your management abilities
- Enhance your leadership skills
- Acquire managerial dynamics in different contexts
- Develop abilities to lead and motivate a team

Course Contents

Students may choose among the following modules:

- SH3201. Globstrat
- SH3203. Preparing for Playing a Role of Leader in the Industrial World
- SH3204. Assuming Responsibility in one's Duties
- SH3205. Sociology, Organizations and Risks
- SH3206. Management in Action
- SH3207. Negotiation
- SH3208. Effective Public Speaking in a Corporate/ Multi-Cultural Environment
- SH3209. Integrating Human Factor and Social Stakes in Corporate World

SH3201
Management — GlobStrat

Professor: Agnès Morsain

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

GlobStrat is a business game. It consists of a strategic management training tool that covers the following aspects: defining development strategy, putting this strategy into place (incorporating factors such as innovation, differentiation, diversification, and globalization), and evaluating long-term added value potential (6 yrs+). GlobStrat integrates cooperative strategies with competitors (strategic alliances, operational partnerships) in various domains (outsourcing, commercial licensing, buy-ins). It is particularly adapted to help understand value creation strategies in an international environment that is both competitive and cooperative. It develops the ability to work as part of a senior management team in a company or on a project.

Course Contents

- Getting to grips with a case, elaboration of long-term development strategy
- Preliminary decision-making with built-in feedback/analysis loop
- Midway strategic auditing
- Second stage decision-making with built-in feedback/analysis loop
- Report writing and presentation stage
- Debriefing

Course Organization

- Globstrat enables students to take charge of a virtual real-life company
- A competitive dynamic develops as teams come face-to-face with each other. The environment is in constant evolution.
- Understanding how a business works, how value is created and how competitive dynamics need to be taken into account, is essential for an engineer in the 21st century.
- Various sector of company activity (production, HR, finance, marketing, etc) are represented, thus introducing a wide range of skills that need to be mastered.
- Most-successful companies are those with the most original strategies, as they avoid head-on competition.
- Within the senior manager group there is role sharing; leadership skills are developed in the search for compromise solutions that enable progress.

Evaluation

Oral viva using Powerpoint.

SH3203
Management — Preparation for Playing a Role of Leader in the Industrial World

Professor: Pierre Nougaret

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Perfecting and completing the skills of young engineers who already have a good scientific level by instilling in them a better knowledge of the corporate world and professional situations
- Convincing the participants that a manager can succeed only by placing the men and women he/she leads at the center of tackling problems facing the company
- Heightening the awareness of future managers of the way they are perceived and the impact of their attitudes on their global credibility and charisma
- Improving the trainees' knowledge of modern management methods: setting up multi-disciplinary teams is one of the keys to solving complex issues (relationships with customers, social dialogue and industrial relations, achieving progress to improve productivity)
- Making students aware that a company official/leader should also be involved in the outside world (social and environmental dimensions of his/her duties)
- Developing participants' ability to feel at ease in oral or written communication

Course Contents

- Discovery of the diversity of situations and interlocutors (internal and external) with which managers will be faced.
- Discussion on the theme: Why, given identical levels of training, do young engineers enjoy more rapid success in attaining leadership positions?
- Main scenario on the theme: Restoring the profitability of a company. Participants will determine ways to contribute to putting a company back in the black and achieving good labour relations. The groups will partly reflect the corporate organisation chart and partly be patterned around multi-disciplinary structures. A general strike will break out and team members will have to react swiftly and find ways to avoid production line stoppages at their customers' plants and cope with the problems that arise, allaying the fears of shareholders, suppliers, bankers, etc.
- Insights into relationships and human behavior : becoming aware of our own individual reactions and discerning those of our interlocutors and counterparts (avoiding contact, for example).

Course Organization

- The trainee will be placed in a role play situation: the main scenario is based on a real case study experienced by the instructor as CEO.
- Confrontation with ill-defined situations and uncertainty: in a crisis situation the decision-making process will be studied in a context where the assessment of actors in the company is particularly difficult.
- Confrontation with the key challenges of the 21st century: participants will discover that in order to guarantee its sustainability and future development a company is compelled to seek out and retain the best world-wide practices according to international benchmarks (in terms of staff motivation, product design, information systems total quality, value creation approach, etc.)

- Multi-disciplinary approach: trainees will become aware that all levels of management are required to get involved in solving every strategic problem facing a company. They will test out this observation when participating in multi-disciplinary work groups.
- Development of innovation, creativity and leadership: confronted with a real, concrete situation the engineering students will be allocated a role as an actor in the company and will experience a wide variety of situations, leading them to imagine and come up with solutions and involve others in their dynamic, etc.

Evaluation

Continuous assessment

SH3204
Management — Assuming Responsibility in one's Duties

Professor: Jean-Christophe Berlot, Robert Philipoussi

Language of instruction: English – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

To what extent can I "feel" responsible? What does it mean to "have" responsibility? How must I / should I assume and come to terms with it?

Over five days, with the help of increasingly complex concrete role playing exercises and placement in professional situations (drawn from corporate life, associations and companies, current events and everyday life), real case studies derived from the personal experience of the course instructors and the associated theoretical points, by meeting individuals and officials exercising duties of responsibility, the engineering students will discover in practice the depth of emotion involved in any decision-making process, the necessity and the pleasure of being able to say "I", the possibility of feeling responsible for a decision taken collectively or in a group, including within the module itself.

The whole course paves the way for a dynamic understanding of ethics.

Course Contents

2 to 2,5 days in the classroom, possibly also with the participation of outside speakers and lecturers in order to:

- identify what are the issues at stake: in what situations is ones responsibility at stake? What questions and what difficulties does this raise?
- grasp the concepts through practical role playing situations and concrete case studies; how can I "assume" responsibility and to what extent can I, to what extent must I? What does my behavior reveal?
- take advantage of the concrete situations experienced to set the associated theoretical foundations and framework.

1 to 1.5 day of carrying out an external survey :

- In a company: Areva, SG, etc.
- Among local actors/players: officials in charge of associations (cf. Associations promoting local integration - of the disabled, the long-term unemployed, etc.), local authorities, individuals responsible for sustainable development, etc. (precise details to be determined with the personal network of contacts of the lecturers and instructors and everyones personal availability).

1 to 1.5 day of follow-up work, with:

- debriefing after the survey,
- updating of the models devised,
- placement in a group situation linked to the feedback from the survey,
- drawing up a balance sheet or assessment on a personal and group level of the positive benefits of the seminar.

A "road map" will be completed after the end of each half-day session by each of the engineering students so as to enable them to record and log their discoveries, surprising insights and what they have learned from their experiences.

Course Organization

- The ideas of collective contribution and responsibility traditionally constitute ideal jumping-off points for ethical thinking. Each role play or placement in a concrete situation culminates in a theoretical and applied decoding assessment in the company and society.
- Concrete role playing simulations: preparation of a company recovery plan (linked for example to economic change - company relocation, etc), the issues at stake and responsibility/accountability concerning redundancies, lay-offs and severance.
- Meetings with local decision makers.
- One day will be devoted to the development of an innovative product, in accordance with three key stages: selection and appointment of a Chief Executive Officer from among the students; definition of an innovative product in sub-groups, and preparation of a decision-making session of the management committee to validate its launch; decision of the management committee (simulation of a decision-making process, leadership, the responsibility and accountability for innovating); assuming the consequences of the launch, social accountability (assertive and decisive leadership to react to and cope with a crisis).

Role play simulations, meetings and stock-taking appraisal sessions or round-ups will provide students with the methods, a critical and investigative spirit, and the guidelines for progress so vital for their individual development and self-fulfilment.

Evaluation

- Attendance compulsory throughout the five days
- Personal involvement of each trainee in the role play exercises proposed
- Final grade based on the quality of the survey and the feed-back produced

SH3205
Management — Sociology, Organizations and Risks

Professor: Cynthia Colmellere

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Understand the "risk society"
- Identify stakes in high-risk organizations (nuclear power-plant, hospital, and chemical industry): high-risk and other risks, humans in high-risk industries, risk management and efficiency, ethics and sustainable development, the manager, the citizen and risks
- Understand and analyse risky situations
- Understand the role of the manager facing those situations: foresee, assess, inform, organize
- Manage complex situations within the organization in connection with civil society

On completion of the course, students should be able to

- understand how high-risk organizations work
- understand construction of risks
- understand how catastrophes happen
- understand how to foresee, assess and manage risks

Course Contents

- **Risk society**: social construction of risks, risks management, sociology in high-risk environments
- **High-risk organizations**: basics, actors of risks, prevention and risks management, control, regulation and everyday matters
- **Understand how catastrophes happen/ tools**: human errors, organizational failures, can accidents be avoided?, new risks

Evaluation

Continuous assessment based on skills of acquisition, capacity to progress and teamwork

SH3206
Management — Management in Action

Professor: Corinne Goetz

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- **Understand tomorrow challenges for the manager**: ethics and sustainable development, change management, globalization, mobility and remote management, results-oriented and understanding the human dimension
- **Understand the environment and know how to adapt**
- **Develop different skills for the manager**: anticipate, inform, organize, motivate, and assess
- **Identify her/his own style and position it within the organization**
- **Manage difficult situations**: tensions, conflicts, power games, and force of inertia or lack of motivation

On completion of the course, students should be able to

approach the different missions of the future manager:

- anticipate
- inform and inquire
- mobilize
- manage conflicts
- negotiate objectives and means
- assess results

Course Contents

- **Context**: key-management trends, long-term vision, theory of sensemaking
- **Management style**: the three dimensions - human, organization, environment, personal style (self-assessment), adaptation to the team and company environment
- **Understanding how the team operates**: stages of group dynamics, the emergence of roles, motivation dynamics - approach through neurosciences
- **Management of difficult situations - the tools**: crisis, conflict and negotiation, change - inform, identify and treat resistance, team support, lack of motivation and inertia - handling delicate performance assessment meetings, manipulation and power games

Evaluation

Continuous assessment based on skills of acquisition, capacity to progress and teamwork

SH3207
Management — Negotiation

Professor: Thierry Gadaud, Eric Le Deley

Language of instruction: English – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Increasing your awareness about the complexity of negotiation
- Becoming a better analyst of negotiation behavior, your own and others
- Enhancing your negotiation skills and broadening your repertoire
- Learning to deal more efficiently with tensions, differences, and conflicts
- Improving your working relationships with others
- Learning how to make better deals and contracts
- Learning how to learn effectively from your own experience

Course Contents

- Negotiation strategy (preparation and process)
- Difficult negotiation
- Creating and claiming value
- Emotions, body language, gestures, and communication
- Complex negotiation
- Mediation
- International mediation
- Synthesis: mediation management

Course Organization

Movie "Our Bank's friends"

Quiz

SH3208
Management — Effective Public Speaking in a Corporate/ Multi-Cultural Environment

Professor: Philippe Wuppermann

Language of instruction: English – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

To promote effective public speaking skills in a corporate/ multi-cultural environment

On completion of the course, students should be able to

- communicate efficiently
- define public speaking objective
- invite action
- use of influencing language
- better manage time

Course Contents

The students will be taught the fundamentals of effective public speaking and communication skills, via the use of multi-media supports and refernces to thought leaders in communications.

Teaching Material and Textbooks

- I Hate Presentations: Transform The Way You Present With A Fresh And Powerful Approach - James Caplin
- Words that Change Minds - Shelle Rose Charvet (1995)
- Transform Your Business by Being Remarkable - Seth Godin (2003)
- 4MAT in Action: Right/Left Mode Techniques - Bernice McCarthy
- A Whole New Mind - Daniel Pink (2009)
- Positioning: The Battle for Your Mind - Al Ries Jack Trout (2001)

Evaluation

The students will be expected to present a speech (Impro or prepared) with a clearly defined objective and invite their audience to action.

SH3209
Management — Integrating Human Factor and Social Stakes in Corporate World

Professor: Omid Kohneh-Chahri, Benoït Dugenêt

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Better understanding of human factor complexity in corporate world
- Sharing thoughts and reflections on corporate social responsability as future leaders
- Getting insights around long-term impacts of decisions

On completion of the course, students should be able to

- be much more efficient as managers, able to mobilize, motivate and create group dynamics
- increase their global environment (stake holders) responsibility awareness

Course Contents

- How to engage and mobilize human resources in corporate world?
- What is a responsible manager? And what is CSR (Corporate Social Responsibility)?
- How to drive collective intelligence to support business performance (Group Dynamics in corporate world)?
- How to better manage individual and collective decision making mechanisms and their long-term impacts?

Evaluation

Case study in sub-groups

SH3300
Seminar Series: Innovation and Complexity

Professor: Patrick Obertelli

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Complexity: get familiar and be at ease with complex problems.
- Multireferentiality: increase ability and act along several reference frames to take into account real situations.
- Innovation: develop individual and collective abilities to react based on innovative ideas and behaviors.
- Diversity of social actors: identify points of references in social and human complexity.

Course Contents

Students may choose among the following modules:

- SH 3301. Sociology of Innovation
- SH 3302. Science and Society
- SH 3303. Design: Understanding and Testing Out Another Methodology
- SH 3304. Communication, Innovation, Entrepreneurship
- SH 3305. Bioethics
- SH 3306. Synchrotron
- SH 3307. Group Creativity and Innovation

SH3301
Innovation and Complexity — Sociology of Innovation

Professor: Mickaël Nelson

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Giving the keys for enabling a better understanding of innovation as an individual, collective and pluri-disciplinary phenomenon
- Explaining the paths and patterns from conception to innovation
- Simplifying the analysis of situations where innovation is implemented and its failures, beyond the technological issues
- Increasing the awareness of the difficulties of innovation, and especially on the transgression of rules

On completion of the course, students should be able to

- analyze innovation mechanisms
- support innovation around the technological invention

Course Contents

- Challenges for innovation in the 21st century
- Main approaches to innovation as a subject of sociology study
- Innovation : beyond strictly technological points of view
- Focus on conception which is at the heart of innovation
- How to innovate, how to organize innovation?

Course Organization

Throughout the seminar, case studies based on real or fictions experiences will be examined in small groups.

Evaluation

Case study

SH3302
Innovation and Complexity — Science and Society

Professor: Étienne Klein

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

The aim of this lecture is to make the students think collectively about the role played today by science in the structure of our society, in our intellectual conceptions and in the work organization.

Course Contents

We will invite the students to discuss the following argument:

During the last fifty years, the way of doing science has changed: there has been a transition from a regime where techniques and science were linked by complex relationships to a new situation, called the “techno-science”, where techniques and science have lost their autonomy. This techno-science being quite efficient, it has become the main engine of innovation. But everyone can notice that its power deeply modifies the exercise and the aims of the scientific activity, that is the way of working of engineers and researchers: those have now to claim that their researches will surely lead to useful results. Does this new situation mean that the value of any new knowledge has now to be evaluated only by its possible concrete outcomes?

Course Organization

One lecture followed by discussions.

SH3303
Innovation and Complexity — Design: Understanding and Testing Out Another Methodology

Professor: Joseph Mazoyer

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Discover the "design" approach and the creative process in a specific project
- Ensure that the engineering student takes the end-user into account in his/her project

Course Contents

Students will be faced with a problem for a development project that requires design. They must approach it as an "end-user" and choose the axes for innovation that they consider realistic within the complex framework of the company. They must show creativity and company vision.

Each student should develop a product/service concept or a proposal using the designer's tools:

- Analysis and challenge set by the problem, documentary research and "state of the art", identify key arguments to be able to steer the project, choice of a personal option
- Look for innovative and humanising solutions: group brainstorming and creation of situations for usage
- Conceptualisation by drawing (knowing how to draw is not a pre-requisite, the important point is to be understood)
- Finalising a project, mini-plan, outline layout

Course Organization

As this seminar will be held in a design school, engineering students will be able to discuss with student designers, see the methodologies and practices in situ and thus be motivated for their project.

Resources

Joseph Mazoyer is a designer and lecturer at ENSCI (Ecole Nationale Supérieure de Création Industrielle).

Evaluation

- Monitoring participation throughout the seminar
- Final submission of project developed during the seminar

SH3304
Innovation and Complexity — Communication, Innovation, Entrepreneurship

Professor: Franck Amiach

Language of instruction: English – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

The main goal is to train students to entrepreneurship behaviors. The training will enable participants to build and present an executive summary. This process will include several brainstorming about management, innovation as well as entreprenarial basics and theatrical simulations.

On completion of the course, students should be able to

- ✧ list the main topics needed in a business plan
- ✧ adopt the appropriate behaviors when lauching an innovative venture
- ✧ manage and communicate: public speaking, risk taking, negociating, team work

Course Contents

- ✧ entrepreneurial behaviors: building an executive summary from a personal idea
- ✧ innovation, leadership, international business development brainstorming sessions
- ✧ how to build a business plan?
- ✧ communication: public speaking, negotiation, management theatrical sessions
- ✧ theater workshop: dealing with creativity, relationship, risk taking through small scenes creation
- ✧ venture creation business cases study

Course Organization

A few parts of the lecture will be in French.

Evaluation

- ✧ Executive summary and pitch
- ✧ Grading will also take individual communication, work and progresses into account.

SH3305
Innovation and Complexity — Bioethics

Professor: Marie-Laure Théodule

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: PR5950 or equivalent.

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- To understand the impacts of biological research on human beings and mankind's identity and integrity
- To understand the issues at stake concerning the problems linked to aspects of genetic manipulation and engineering
- To acquire a framework of reference in order to ascertain and grasp the central issues involved in bioethics in order to be competent and operational in this field
- To identify the players and protagonists involved in the various different levels of the process of joint consultation and reflection
- To reflect on and take stock of the situation following the 2009 overhaul and upgrade of the 2004 law on bioethics

Course Contents

Ethical issues for society raised by breakthroughs and progress in research into biology

Alternation between theoretical phases, documentary research and lectures and debates

Work in teams - class subdivided into small groups - work on a topic chosen from the themes of the official report on OPECST's "Law on Bioethics of 2004"

Lectures given by:

- Ségolène Aymé, Director of research at INSERM: ethical aspects of genetic testing.
- Elena Ceccarelli, Research engineer at the CEA: Ethical implications and considerations associated with stem cell work.
- Emmanuel Hirsch, Director of the department of Ethical Research at Paris-Sud and ethical considerations of AP-HP: From Nurenberg to gene therapy.
- Jacques Testart, Director of research at INSERM, the scientific pioneer and "father" of the first test-tube baby in France.
- Patrick Verspieren, Professor in the Department of Biomedical Ethics of Centre Sèvres Paris.

Group oral presentation and defense of work on the 2009 overhaul and upgrade of the 2004 law on bioethics.

Course Organization

This module is intended for the students taking the Cellular and Molecular Biology Lab (PR5950).

SH3306
Innovation and Complexity — Synchrotron

Professor: Lisa Carrière, André Angotti

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: PH2200

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Contents

This seminar is fully coupled with the PH2200 course: “X-ray Beamline Design”.

The coupling of this Humanities and Social Sciences module with the “X-ray Beamline Design” course has two objectives: develop the students' abilities to work in a team, help develop oral expression for the final defense.

The “Beamline Design” project teams are built after the “Belbin inventory” method, a tool that enables to identify and dispatch roles according to the team needs, with regard to everyone's personality.

Theoretical elements about Belbin roles, teamwork mechanisms, communication and meeting management, as well as experience feedback at critical moments of the process, help understand group dynamics and develop useful experience for the professional life.

For further information, see the “X-ray Beamline Design” topic at http://www.designworkshops.fr/

Course Organization

This course is part of the design workshop that combines PH2200 "X-ray Beamline Design" and SH3306. Students must thus sign for both courses concurrently. Students will work in project mode during the one-week module (approximately 50 hr) and will attend four half-day preparation and debrief sessions on prior and subsequent weeks.

SH3307
Innovation and Complexity — Group Creativity and Innovation

Professor: Alain Chevalier-Beaumel

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: EN2910

Period: S8 Humanities Module 14-21 May IN28SH2, SEP8SH2

Course Objectives

- Developing one's creative faculties within a group for problem resolution.
- Using group dynamics as a stimulus for imagination and generation of ideas.
- Setting up meetings that enable creative solutions to be found, providing a production hierarchy with a view to operational efficiency.

On completion of the course, students should be able to

- lead innovative group projects
- set up innovative and creative processes

Course Contents

- What is creativity? Difference between creativity and innovation
- Developing a state of mind conducive to creativity
- Creative characteristics: mental agility
- Flexibility (Koestler's bisociation)
- Fluidity/Fluency (Osborn's brainstorming)
- Humour and creativity as part of the same mental process (mind games, puns)
- Practical exercises
- Multiplying creativity through a group. Innovative practice in business
- Creative techniques for idea generation
- Applying creativity to objects that need improving
- Six stages of the Innovative process
- Case studies (Esso, Citroën, Valéo)

Course Organization

This course uses an interactive hands-on approach, with small groups working on concrete situations. Active participation required!

Evaluation

Report on group work

SH3400
Seminar Series: International Awareness

Professor: Patrick Obertelli

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Understand international major dynamics issues and functioning
- Identify professional levers

Course Contents

Students may choose among the following seminars:

- SH3401. How China is facing the world?
- SH3402. Being an Engineer in Europe
- SH3403. Intercultural Challenges and Methods: Socio-cultural Drivers in an International Environment

SH3401
International Awareness — How China is facing the World?

Professor: Alain Wang

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Make students reflect on the potential and difficulties for China in the 21st century and the challenges that it creates: China has become an indisputable international player but in 2012 a new team will take over a country which is socially and economically fragile
- Reflect on the journalistic treatment of Chinese events, as seen by the Chinese and Western press

On completion of the course, students should be able to

- acquire the keys to understand the modern world at the international level
- understand social phenomena in the specific context of the Chinese world
- understand the professional opportunities that may be available in China

Course Contents

- Society: the urban elite, the motor growth, what peasantry for tomorrow?
- Politics: the heirs to Hu Jintao, Taiwan, a bringing together without reconciliation
- Experiencing society - a day in Paris: press and censorship, visit to the 13th district
- International Relations: China, from Asia to the G20
- Economy : "China incorporated" for conquering the world

Course Organization

- Films: Made in China, Paradis perdus "Tempêtes sur la Chine", L'empire de l'ar*t*
- Meeting with the manager "Asie" of Reporters sans frontières at the NGO's headquarters
- Visit to Chinatown in Paris 13th

Evaluation

Oral presentation by groups of a thematic press review and written work on a chosen subject

SH3402
International Awareness — Being an Engineer in Europe

Professor: Jean-Christophe Dallemagne

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- Sensitise students to Europeanization and globalisation issues.
- Better understand relations between players, and public - private interactions.
- Better master institutional structures; better grasp the new professional issues at stake in the context of Europe and globalization.

Course Contents

- Definition of the concept of Community Regulation.
- The impact of community regulation on companies (macro approach).
- The impact of community regulation on company organisational behavior (micro approach).
- From economic intelligence to European lobbying.
- European support of enterprises.
- Strategic management of European information.

A two day study trip to Brussels is programmed aiming at professional contact making and validation of gained knowledge.

- First day: Institutional approach (Commission and European payment).
- Second day: Professional approach (Business Europe, employer's union and lobbying bureaux, Think tanks).

A trip into the heart of what Europe comprises of today.

Course Organization

- Lectures.
- Replies to students' questions (intuiti-personae).
- Practical cases from the European Commission cases database (DG Internal Market and Services and DG Trade).
- Practical application in the company of key-concepts presented to students who have followed the first year AOC. (No repeating).

Evaluation

Writing a strategic note

SH3403
International Awareness — International Challenges and Methods: Socio-cultural Drivers in an International Environment

Professor: Michel Sauquet, Martin Vielajus

Language of instruction: English – **Number of hours**: 32 – **ECTS**: 2

Prerequisites: None

Period: S8 Humanities Module 2-6 April IN28SH1, SEP8SH1

Course Objectives

- To foster an attitude of "mindfulness of the Other" ("intelligence de l'Autre") whereby the students, stepping away from their own cultural societal framework, accept that the Other may have for his/her methods and behavior reasons, logics that they themselves ignore. Invite them to question their own responses, a mindset they may not be aware they have.
- To develop among the students an awareness of the multiplicity of human, societal, professional cultures and thinking patterns they will encounter in the course of their professional life and which may affect it.
- Develop students' ability to handle with ease situations when they will have to respond to unexpected challenges and to account for their thinking both orally and on paper.

Course Contents

The course's methodology is based on an "Identification grid of socio-cultural drivers governing the Other's attitudes and operating modes", oriented towards professionals working abroad or, if in their own country, within a multicultural context. Its eleven series of questions are designed, whenever a cooperation action, a commercial transaction, a scientific or technical debate hits on unexpected difficulties, to ask "where did it all go wrong? What caused confusion? Where did the misunderstanding spring from?" Beneath the visible part of the proverbial iceberg of cultures (codes of communications and everyday manners, verbals and non-verbals et al, basic local professional behavior) what can, deep down, culturally, explain these codes and behaviors.

The grid identifies several areas where similarities and differences might exist: the attitudes to tradition, history and religion; the attitudes to nature and human life; the attitudes to identity and difference; the relation to time ; the relation to space; the attitudes toward work; the attitudes toward money, wealth, poverty; the attitudes to authority, power and norms; the attitudes to knowledge and creativity; formal language, communication practices.

Expatriates or professionals immersed in a multicultural environment may seek mediators, persons who, because of their life experience in the country, their mixed origins, the knowledge acquired astride two cultures, are in a position to explain where differences might have impacted.

The checklist aims to stimulate an enquiring and questioning attitude. Not on the assumption that "difference is everywhere", or that every difference has cultural sources - we have to be able to distinguish purely cultural factors from simple social norms. Rather, it is about remaining alert to the relevance of discounted differences to how we work and live *in situ*.

Course Organization

A few parts of the course will be in French

Evaluation

Continuous assessment

Sports

SP1100
Sports and Physical Education

Professor: Stéphane Blondel

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 0

Prerequisites: None

Period: S5 between September and January IN15COM, FEP5COM

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, Golf (advanced students), Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis (advanced students), Track Field, Volleyball.

Course Organization

Physical activities: 36 hr

Evaluation

Continuous assessment, competitions

SP1200
Sports and Physical Education

Professor: Stéphane Blondel

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 0

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

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, Golf (advanced students), Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis (advanced students), Track Field, Volleyball.

Course Organization

Physical activities: 36 hr

Evaluation

Continuous assessment

SP2100
Sports and Physical Education

Professor: Stéphane Blondel

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 0

Prerequisites: None

Period: S7 between September and January IN27COM, FEP7COM

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, Golf (advanced students), Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis (advanced students), Track Field, Volleyball.

Course Organization

Physical activities: 36hr

Evaluation

Continuous assessment

SP2200
Sports and Physical Education

Professor: Stéphane Blondel

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 0

Prerequisites: None

Period: S8 between February and June IN28COM, SEP8COM

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, Golf (advanced students), Handball, Judo / Jujitsu, Rowing, Rugby, Squash, Soccer, Swimming, Table Tennis, Tennis (advanced students), Track Field, Volleyball.

Course Organization

Physical activities: 36 hr

Evaluation

Continuous assessment

Leadership and Engineering

WL1100
Workshops on Professional Development and Leadership

Professor: Serge Delle Vedove, Dimitri Dagot

Language of instruction: French – **Number of hours**: 51 – **ECTS**: 2.5

Prerequisites: Good level in French

Period: S5 October to January IN15CAA, FEP5CAA

Course Objectives

- Develop a set of key skills to become an innovative engineer: teamwork, communication, complex problem solving and creativity
- Move from a school paradigm into a professional one
- Build one's academic and career plan

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 problem solving
- develop their professional project

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
- Creativity: group creativity methods

Build one's academic and career plan

- Discover the work of an engineer
- Start anticipating one's professional career
- Understand Centrale's curriculum choices

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 2.5 days in groups of 40 students supervised by 2 professors, with the support of invited speakers. Activities are based on experiment, case studies, team work and group work.

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

WL1200
Workshops on Professional Development and Leadership

Professor: Serge Delle Vedove, Dimitri Dagot

Language of instruction: French – **Number of hours**: 34 – **ECTS**: 1.5

Prerequisites: WL1100 or equivalent.

Period: S6 March to May IN16CAA, SEP6CAA

Course Objectives

- Help students develop their leadership, and their innovative and entrepreneuring skills
- Help students build their academic and professional paths

On completion of the course, students should be able to

implement basic leadership, innovation and entrepreneurship skills

Course Contents

Help students develop their leadership, and their innovative and entrepreneuring skills

- innovation processes and business plan fundamentals
- fundamentals of leadership

Help students build their academic and professional paths

- Present oneself professionally (resumé, introduction letter, interview)
- Support in the choice of academic choices

Course Organization

2 seminars of 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 and team work.

Teaching Material and Textbooks

Lecture notes are provided for all topics. Example of suggested readings:

- 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

WL1300
Workshops on Professional Development and Leadership

Professor: Serge Delle Vedove, Dimitri Dagot

Language of instruction: French – **Number of hours**: 16 – **ECTS**: 1

Prerequisites: WL1100 and WL1200 or equivalent.

Period: S7 October to January IN27CAA, FEP7CAA

Course Objectives

- Basics on how to operate in multicultural environments
- Develop an attractive, sound professional project, building on the strengths of one's personality

On completion of the course, students should be able to

- understand the notion of Culture and the processes of integration in a different cultural universe
- develop an attractive and credible professional project

Course Contents

- Analysis of the dimensions underlying the notion of culture: the 5 dimensions of culture according to Hofstede; integration into a new culture
- Development of a Professional Project: preparation of a professional project

Course Organization

2 seminars (0.5 and 1.5 days), in groups of 40 students supervised by 2 professors, with the support of invited speakers.

Teaching Material and Textbooks

Lecture notes are provided for all topics. Examples of suggested readings:

- E.T. Hall, Understanding Cultural Differences, Intercultural Press, Inc, 1990
- G. Hofstede, Culture's Consequences, Sage Publications, 2001
- C. Gury, Les 5 clés pour rebondir et piloter sa carrière, A2C Media, 2009

Evaluation

Validation is based on quality of participation

WL1400
Workshops on Professional Development and Leadership

Professor: Serge Delle Vedove, Dimitri Dagot

Language of instruction: French – **Number of hours**: 8 – **ECTS**: 0

Prerequisites: WL1100, WL1200 and WL1300 or equivalent.

Period: S8 between February and June IN28CAA, FEP8CAA

Course Objectives

Help students develop their skills in operating and innovating in complex environments and challenges

On completion of the course, students should be able to

implement basic skills in a systemic approach, with the development of a shared vision and the creative framing of a complex problem

Course Contents

Help students develop their ability to deal with complex issues in a creative manner:

- frame the issue in a creative manner
- develop a systemic vision of the issue (stakeholders, stragegies, interactions, what is at stake)
- learn how to develop a shared vision from diverging points of view

Course Organization

This one-day seminar may take different formats depending on the topic (groups of 30 to 100 students)

Teaching Material and Textbooks

Lecture notes are provided for all topics. Examples of suggested readings:

- M. Crozier, L'Acteur et le Système, Seuil, 1977
- P.M. Senge, The 5th discipline, Currency, 1994
- D. Genelot, Manager dans la complexité, INSEP Consulting ed., 2001
- R. Heifetz, Leadership on the Line, Harvard Business Press, 2002
- L. de Brabandere, The Forgotten Half of Change, Dearborn Trade Publishing, 2005

Evaluation

Validation is based on quality of participation

WL2100
Engineering Leadership on Projects

Professor: Luc Roullet

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: WL1100, WL1200 and WL1300 or equivalent. Be involved in a project (innovation, student organization or other) with passion

Period: S8 Elective 11 March to June IN28IE4, SEP8IE4

Course Objectives

Main Objective

Develop your leadership talents and strengthen your capabilities to lead complex projects and implement innovative and robust solutions.

Secondary objectives

1. Refine the rigor of your thinking and the quality of your decision-making, thanks to a higher creativity in the underlying hypothesis and purpose.

2. Understand and intervene with accuracy in human dynamics, thanks to better abilities to mobilize:

- your determination and your personal talents
- the collective intelligence of various stakeholders
- all the stakeholders needed for implementation till completion

On completion of the course, students should be able to

- express complex problems in a simple and articulate form
- create a robust innovation dynamic, with scientific rigor and fun in the collective work
- inspire a spirit of shared leadership and appropriately use authority
- identify the most efficient leverage points thanks to a systemic approach
- think out of the box to look for the right information with rigorous investigation methods
- make the right decisions in unstable environments, for more efficiency and impact
- better know oneself professionally and strengthen self-confidence

Course Contents

The course is based on "creative problem solving" that was introduced in the Workshops on Professional Development and Leadership; on the concepts of "learning teams and organizations" developed at MIT; and on "adaptive leadership" developed at Harvard University.

The main topics are :

- Frame a problem in a creative manner, linking it to the team values
- Create a mobilizing vision and enroll new allies (microfinance in Bangladesh case study)
- Ensure robustness of innovative solutions (testimony of an engineer, Centrale alumnus)
- Make the right decisions in real time in a project (with case studies)
- Develop innovation as a scientist in a company (testimony of an engineer, Centrale alumnus)
- The art of leadership, a perspective outside of France
- Listen and listen to oneself to overcome mental models that limit creativity
- Survive in the exercise of leadership

Course Organization

The course is built to present leadership models and provide you with a space to reflect on your own practices and capabilities, experienced in your project. Theory, case study, testimonies and group work will nurture the participants and help them realize how to evolve and improve their impact in the exercise of leadership.

- Twelve 3-hr courses with a balanced mix of pedagogic forms
- Regular papers on your project (2 to 3 pages)
- Final paper (5 to 10 pages) on your personal and collective learning, and on the next steps of the project

Teaching Material and Textbooks

Course material will be provided for each topic. Sample of readings:

- *The structure of scientific revolutions*, Thomas Kuhn
- *Leadership without easy answers*, Ronald Heifetz
- *Objective knowledge*, Karl Popper
- *Actors and systems*, Michel Crozier
- *The fifth discipline*, Peter Senge

Evaluation

- 1/3 class participation
- 1/3 periodic papers
- 1/3 final paper

WL2200
Ethics and Responsibility in Engineering

Professor: Jean-Marc Camelin

Language of instruction: French – **Number of hours**: 36 – **ECTS**: 3

Prerequisites: Be aware of these issues individually, through associations, hobbies, or a related innovation project

Period: S8 Elective 12 March to June IN28IE5, SEP8IE5

Course Objectives

High level engineers have a key role in the evolution of society. This course is designed for both students intending to pursue either a career 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 students to the ethical, social, societal, economical and political consequences of their actions as an engineer, in an increasingly multicultural environment
- help students develop awareness of ethical and societal issues in their future professional career, whether in engineering, research, or management

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, and face the challenges of the system
- transform challenges and constraints into opportunities to conduct their career in accordance with their personal ethics

Course Contents

- Introduction to ethics: responsibility, concept, history, reference texts, tangible actions involved, meaning. Multicultural link with Ecole Centrale Beijing.
- Illustration of the problem: labor and work (concept, role, suffering at work, empowerment), environment (sustainable development, decisions, impact), world global issues (e.g. Food: issues, aberrations, choices)
- Understanding the System: the current system (capitalism, economic regulation,impact on the actions of decision makers, measures, GDP), alternatives (anti-globalization, its limits, freedom to think the world differently, alternatives such as micro-credit or 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).
- Action: ethics is an action. Individual issues (I make my decisions 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 an engineer (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 following seminars, based on students's expectations and context (in particular, certain student projects may interact with the course).

The following seminars will illustrate practical examples on the importance of the problem (3 workshops), devote time to work on understanding the overall system within which the issue arises (3 seminars), and finally lead the students to concrete action and potential projections for their professional career (individually and as a group).

Each seminar includes a theoretical pars, an illustrative part (case study, documentary analysis, talk by an expert), and a discernment part.

Teaching Material and Textbooks

- 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
- 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

Evaluation

- Oral presentation of group project conducted throughout the seminars
- Production of a group paper
- Participation

WL4100
Blue Collar Internship

Professor: Angela Minzoni-Deroche

Language of instruction: French – **Number of hours**: 210 – **ECTS**: 0

Prerequisites: None

Period: S7 between September and January IN27COM

Course Objectives

The objective of this internship is to help students 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 Contents

Cf. Section 5 of the "Règlement des Etudes"

Course Organization

The internship must be at least 6-weeks long.

Evaluation

Written report and oral defense

Global Challenges and Projects

WP1100
Challenges of the 21st Century: Introduction

Professor: Anne Spasojevic, Jean-François Gallouïn

Language of instruction: French – **Number of hours**: 50 – **ECTS**: 3

Prerequisites: None

Period: S5 between September and January IN15COM, FEP5COM

Course Objectives

The objectives of the course are to help students:

- 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
- Work in team on a real project

The seven thematics studied are the following:

- Economic mutations
- Energy
- Environment
- Health and biotechnologies
- Information and knowledge
- Territory: sustainable construction
- 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

Course Organization

- General introduction seminars to each of the challenges (six 3-hr seminars)
- Conferences on one of the challenges (eight to ten 1.5-hr conferences)
- Bibliographic study on one of the challenges
- A team project, continued over semester 6

Each challenge is directed by professionals from academia (*Référent Enjeu Interne* or REI) and industry (*Référent Enjeu Externe* or REE).

Evaluation

- Bibliographic study with report and oral defense at mid-semester
- Report and oral defense on the problem statement of the project to be continued over semester 6

WP1200
Challenges of the 21st Century: Team Project

Professor: Anne Spasojevic, Jean-François Gallouïn

Language of instruction: French – **Number of hours**: 50 – **ECTS**: 3

Prerequisites: None

Period: S6 between February and June IN16COM, SEP6COM

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 project is evaluated based on two series of written reports and oral defenses:

- midway through Semester 6,
- at the end of Semester 6.

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 and Technologies

Professor: Pascal da Costa, Estelle Iacona

Language of instruction: French – **Number of hours**: 32 – **ECTS**: 3

Prerequisites: None

Period:	S6	Elective 01	February to March	IN16DE1, SEP6DE1
	S8	Elective 08	February to March	IN28IE1, SEP8IE1

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)

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), water
- Vegetal resources and use of soil
- Waste management and recycling
- Technical state-of-the-art and new technologies for energy and water management

Course Organization

Lectures: 33 hr, Final exam: 3 hr

Teaching Material and Textbooks

- Résumés of the lecturers
- E. Iacona, J. Taine, B. Tamain, Les enjeux de l'énergie, Dunod 2008

Resources

This multidisciplinary course is taught by specialists of the various dimensions of sustainable development:

- Estelle Iacona (Ecole Centrale Paris): Energy and fossil resources
- Pasca Da Costa (Ecole Centrale Paris): Economics and development
- Dominique Pareau (Ecole Centrale Paris): Water
- Marc Dufumier (INRA, Agro): Vegetal resources
- Gilles Pison (INED, EHESS): Demographics
- Valérie Masson-Delmotte (CEA - University Paris Sud): Climate
- Jean-Pierre Chevalier (CNAM) - Resources

Evaluation

3-hr written final exam (exercises, questions on the lecture material, essay)

WP5100
Innovation Project S7

Professor: Éléonore Mounoud, Christophe Laux

Language of instruction: French – **Number of hours**: 75 – **ECTS**: 4

Prerequisites: None

Period: S7 between September and January IN27COM, FEP7COM

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 processes and organizations
- ✧ Design of products and services
- ✧ Scientific research
- ✧ Technological development

Topics:

- ✧ Mathematics
- ✧ Physics
- ✧ Mechanical and Civil Engineering
- ✧ Energy Science
- ✧ Chemical Engineering
- ✧ Industrial Engineering, Management and Economic Systems

- Human and Social Sciences
- Information Technologies and Advanced Systems

Course Organization

120 hr of personal and teamwork, including 75 hr reserved on the time schedule.

Deliverables:

- Mission statement
- Midterm report
- 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:
   - 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)

WP5200
Innovation Project S8

Professor: Éléonore Mounoud, Christophe Laux

Language of instruction: French – **Number of hours**: 150 – **ECTS**: 9

Prerequisites: None

Period: S8 between February and June IN28COM, SEP8COM

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.

WP5210
Innovation Project S8 (short)

Professor: Éléonore Mounoud, Christophe Laux

Language of instruction: French – **Number of hours**: 75 – **ECTS**: 4.5

Prerequisites: None

Period: S8 between February and June IN28COM, SEP8COM

Course Contents

The short S8 Innovation Project (WP5210) is for those students who do in parallel a short S8 Student Organization Project (WP6210).

The short Innovation Project S8 is usually the continuation of the S7 Innovation Project (WP5100). Students who chose the S7 Student Organization Project (WP6100) may either join an existing Innovation Project started in S7, or propose a new Innovation Project.

Course Organization

120 hr of personal and teamwork, including 75 hr reserved on the time schedule

Evaluation

Same as for WP5100

WP6100
Student Organization Project S7

Professor: Hélène Delpuech, Claire Bordes

Language of instruction: French – **Number of hours**: 75 – **ECTS**: 4

Prerequisites: Validation by the Committee on Student Organization Projects before the start of the project

Period: S7 between September and January IN27COM, FEP7COM

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 projects from previous years: Forum (job fair), Parrainage (sponsoring activities).

Course Organization

120 hr of personal and teamwork, including 75 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.

Evaluation

Written report and oral defense, evaluated by a Jury

NB: students who choose to continue their project during semester S8 (WP6210) must prepare an intermediate report at the end of semester S7. The final report is due at the end of semester S8.

WP6200
Student Organization Project S8

Professor: Hélène Delpuech, Claire Bordes

Language of instruction: French – **Number of hours**: 150 – **ECTS**: 9

Prerequisites: Not open to students having already taken WP6100. Validation by the Committee on Student Organization Projects before the start of the project

Period: S8 between February and June IN28COM, SEP8COM

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), Gala, Tour de France à la Voile.

Course Organization

240 hr of personal and teamwork, including 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.

Evaluation

Intermediate report + final report and oral defense, evaluated by a Jury

WP6210
Student Organization Project S8 (short)

Professor: Hélène Delpuech, Claire Bordes

Language of instruction: French – **Number of hours**: 75 – **ECTS**: 4.5

Prerequisites: Validation by the Committee on Student Organization Projects before the start of the project

Period: S8 between February and June IN28COM, SEP8COM

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 Ecole Centrale Paris.

WP6210 may be the continuation of a student organization project started in semester S7 (WP6100).

Course Organization

120 hr of personal and teamwork, including 75 hr reserved on the time schedule

Evaluation

Final report and oral defense, evaluated by a Jury

WP7100
Directed Studies

Professor: Staff

Language of instruction: French or English – **Number of hours**: 90 – **ECTS**: 5

Prerequisites: None

Period: S7 between September and January FEP7COM

Course Contents

This project is for international students registered at Ecole Centrale for a semester or a year of studies. The project is of a scientific nature and must be conducted under the supervision of a professor of Ecole Centrale. The project can be done individually or in a group. The duration may vary from 0 to 90 hours, for a total of 0 to 5 ECTS.

Course Organization

Please contact Mr. François-Xavier Alzuyeta, Academic Officer for International Students, to set up a Directed Studies Project

WP7200
Directed Studies

Professor: Staff

Language of instruction: French or English – **Number of hours**: 90 – **ECTS**: 5

Prerequisites: None

Period: S8 between February and June SEP8COM

Course Contents

See WL7100

Course Organization

Please contact Mr. François-Xavier Alzuyeta, Academic Officer for International Students, to set up a Directed Studies Project

Course list by period

Semester 5

EN1100 Heat Transfer
EN1101 Extra Tutorials in Heat Transfer
EN1920 Aerodynamics and Energy Science Laboratory
IS1110 Information Systems
IS1210 Algorithms and Programming
IS2950 Electronics Laboratory
LC0000 Modern Languages, Culture, 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
LCB000 Swedish
MA1100 Real Analysis
MA1200 Probability
MA1300 Statistics
MG1100 Mechanics
MG1960 Civil Engineering Laboratory
MG1970 Design of Mechanical Structures Laboratory
PH1910 Physics Laboratory
PR1930 Materials and Corrosion Laboratory
PR2940 Chemical and Environmental Engineering Laboratory
SE1100 Corporate Accounting and Finance
SE1200 Management
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
IS2110 Embedded Control Systems
IS2950 Electronics Laboratory
LC0000 Modern Languages, Culture, 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
LCB000 Swedish
MA1400 Simulation and Optimization
MG1960 Civil Engineering Laboratory
MG1970 Design of Mechanical Structures Laboratory
PH1100 Quantum and Statistical Physics
PH1102 Physics Tutorials
PH1910 Physics Laboratory
PR1920 New Technologies Laboratory
PR1930 Materials and Corrosion Laboratory

PR2940 Chemical and Environmental Engineering Laboratory
PR5100 Biology
SE1950 Reverse Engineering and Rapid Prototyping Laboratory
SE2100 Industrial Engineering
SE3100 Law
SH1100 Cultural Awareness Activities — Session 1
SH1200 Cultural Awareness Activities — Session 2
SH1300 Philosophy of Sciences
SH1400 Personal Development Seminar
SP1200 Sports and Physical Education
WL1200 Workshops on Professional Development and Leadership
WP1200 Challenges of the 21st Century: Team Project

Elective 01
EN1200 Fluid Mechanics
IS1310 Graph Theory for Computer Science: Algorithms and Applications
IS1410 Digital and Collaborative Engineering
IS2130 EE and CS Complex Systems
MA2500 Signal Processing
MA2822 Advanced Statistical Methods
MG1200 Civil Engineering
PR1100 Structure and Properties of Materials
PR3100 Chemical Engineering and Sustainable Development
PR4200 Electric Energy Networks
SE2750 Stochastic Modeling and Theory of Queues and their Applications
WP2100 Sustainable Development and Technologies

Semester 7

LC0000 Modern Languages, Culture, 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
LCB000 Swedish
SE1400 Economics
SE2900 Project Management
SE3100 Law
SH2100 Business Games
SP2100 Sports and Physical Education
WL1300 Workshops on Professional Development and Leadership
WL4100 Blue Collar Internship
WP5100 Innovation Project S7
WP6100 Student Organization Project S7
WP7100 Directed Studies

Elective 02
IS1220 Advanced Programming
IS1410 Digital and Collaborative Engineering
MG1200 Civil Engineering
PH2100 Waves
PR3100 Chemical Engineering and Sustainable Development

SE1300 Corporate and Market Finance

Elective 03
EN1200 Fluid Mechanics
MA2300 Random Modeling
MG1500 Biomechanics
MG1600 Nanomechanics
PH2300 The Structure of Matter: from Solid-State Physics to Nano-Materials
SE2200 Design and Innovation of Products and Services
SE2600 Enterprise Architecture and Modeling

Elective 04
EN1110 Applied Heat Transfer
IS1510 Digital Communications and Networks
MA2100 Financial Risk Modeling
MG1300 Structural Dynamics and Acoustics
PR1300 Introduction to Materials
PR4200 Electric Energy Networks
SE2400 Production and Distribution Management

Elective 05
IS2120 Control Systems
MA2200 Advanced Optimization
MG1400 Plasticity and Fracture: Mechanical Behavior of Materials
PH2500 A Crash Course in Modern Mathematical Physics
PR5210 The Genome
SE2300 Strategy and Marketing

Elective 06
MA2400 Conception - Simulation
MA2500 Signal Processing
PH2300 The Structure of Matter: from Solid-State Physics to Nano-Materials
PR5300 Biotechnology: Applications and Modeling
SE1600 Economics 2
SE3300 Entrepreneurship: A First Approach

Elective 07
SH2200 Coaching for Student Organizations
SH2201 Coaching for Student Organizations — Teamwork
SH2203 Coaching for Student Organizations — Introduction to Negotiation, Management and Teamwork
SH2300 Seminar Series: Management
SH2324 Management — Human Phenomena in Project Management
SH2327 Management — Negotiating
SH2329 Management — From Authority to Responsibility in Working Oganizations
SH2330 Management — Develop Leadership Skills (Daring and Creativity)
SH2331 Management — Taking One's Place in a Professional Context
SH2332 Management — Risks and Crisis Management
SH2333 Management — Teamwork and Running a Meeting
SH2334 Management — Negotiation and Management
SH2400 Seminar Series: International and Intercultural
SH2403 International and Intercultural — Being an Engineer in Europe
SH2404 International and Intercultural — Managing across Cultures
SH2406 International and intercultural — The Cultural Environments to Engineering Careers
SH2500 Seminar series: SHS Perspective on Key Social Issues
SH2504 SHS Perspective on Key Social Issues — European Geopolitics International Crisis Management

SH2505 SHS Perspective on Key Social Issues — Health at work: are Well-being and Efficiency Compatible?

Not offered in 2011-2012
PH2400 Chemistry: Matter Modeling and Design

Semester 8

LC0000 Modern Languages, Culture, 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
LCB000 Swedish
SP2200 Sports and Physical Education
WL1400 Workshops on Professional Development and Leadership
WP5200 Innovation Project S8
WP5210 Innovation Project S8 (short)
WP6200 Student Organization Project S8
WP6210 Student Organization Project S8 (short)
WP7200 Directed Studies

Elective 08
EN1200 Fluid Mechanics
IS1310 Graph Theory for Computer Science: Algorithms and Applications
IS2130 EE and CS Complex Systems
MA2500 Signal Processing
MA2822 Advanced Statistical Methods
MG1200 Civil Engineering
PR1100 Structure and Properties of Materials
PR3100 Chemical Engineering and Sustainable Development
PR4200 Electric Energy Networks
SE2750 Stochastic Modeling and Theory of Queues and their Applications
WP2100 Sustainable Development and Technologies

Elective 09
EN1500 Nuclear Engineering
IS1230 Introduction to Databases
MA2600 Numerical Optimization and Applications
MA2811 Computational Analysis, Algebra, and Geometry
MA2817 From Colorimetry to Visual Appearance – Spectral Simulation for Physically Realistic Image Synthesis
MG2814 Economy and Design of Dams
PH2812 Introduction to Atomic and Molecular Physics
PH2813 Advanced Materials and Novel Devices for Information Technologies
SE1500 Enterprise Modeling
SE1650 Modern Macroeconomics Modeling
SE2500 Demand Forecasting and Inventory Management
SE2550 Introduction to Purchasing

Elective 10
EN1400 Combustion Modeling and Simulation
EN1700 Introduction to Neutronics and Nuclear Reactor Physics
IS1320 Mathematical Foundations of Computing
MA2818 Introduction to Computer and Artificial Vision
MA2820 Probabilistic Safety Assessment in Nuclear Power Plants
MG2815 Industrial Processing of Soils and Granular Materials
MG2816 Micro-Electro-Mechanical Systems (MEMS)
PH2814 Science-Fiction and Physics
PR4300 Cogeneration and Energy Production
SE2700 Modeling for Decision Making
SE3200 Law 2

Elective 11
EN1600 Renewable Energy
IS1130 Systems Engineering
IS1240 High Performance Computing for Engineering and Finance
IS2310 Radio Communication Systems
MA2819 Advanced Numerical Simulation
MG2812 Introduction to Acoustics: Industrial and Musical Acoustics
PH2815 Quantum Correlations. Is Universe Separable? Schrödinger's Cats
PH2819 Structure, Chemical Properties and Molecular Symmetry
PR1950 Multiscale Surface Analysis
SE2650 Risk Assessment and Management
WL2100 Engineering Leadership on Projects

Elective 12
EN1120 Heat Transfer
MA2814 Discrete Time Stochastic Processes
MA2815 Mathematical Modeling for Biology
MA2821 Multi-agent Modeling of Complex Systems
MG2811 Urbanism and Tall Buildings
MG2817 Applications of the Finite Element Method
PH2817 Particle Physics
PH2820 Optoelectronic Technologies
PR2100 Water Treatment and Underground Water Protection
SE2800 Production Planning and Scheduling
WL2200 Ethics and Responsibility in Engineering

Elective 13, 5 Tuesdays
IS2960 Electronics Laboratory
MG2920 Civil Engineering Laboratory
PH2930 Nuclear Physics Laboratory

Elective 13, One-week module 1
EN2910 Aircraft Design
PH2200 X-ray Beamline Design

Elective 13, One-week module 2
EN2910 Aircraft Design
MG2818 Introduction to Petroleum Exploration and Production
PR3910 Biotechnologies Laboratory
PR5950 Cellular and Molecular Biology Laboratory
SE2850 Llenroc Plastics: Market-Driven Integration of Manufacturing and Distribution Systems

Humanities Module

SH3200 Seminar Series: Management
SH3201 Management — GlobStrat
SH3203 Management — Preparation for Playing a Role of Leader in the Industrial World
SH3204 Management — Assuming Responsibility in one's Duties
SH3205 Management — Sociology, Organizations and Risks
SH3206 Management — Management in Action
SH3207 Management — Negotiation
SH3208 Management — Effective Public Speaking in a Corporate/ Multi-Cultural Environment
SH3209 Management — Integrating Human Factor and Social Stakes in Corporate World
SH3300 Seminar Series: Innovation and Complexity
SH3301 Innovation and Complexity — Sociology of Innovation
SH3302 Innovation and Complexity — Science and Society
SH3303 Innovation and Complexity — Design: Understanding and Testing Out Another Methodology
SH3304 Innovation and Complexity — Communication, Innovation, Entrepreneurship
SH3305 Innovation and Complexity — Bioethics
SH3306 Innovation and Complexity — Synchrotron
SH3307 Innovation and Complexity — Group Creativity and Innovation
SH3400 Seminar Series: International Awareness
SH3401 International Awareness — How China is facing the World?
SH3402 International Awareness — Being an Engineer in Europe
SH3403 International Awareness — International Challenges and Methods: Socio-cultural Drivers in an International Environment

Not offered in 2011-2012

PR3300 Chemical Engineering and Sustainable Development 2
PR3400 Smart Experimentation

Courses with bold codes may be taken in English. See the corresponding course description for more information.

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