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Common-core syllabus

Life cycle analysis

Code: analyse-cycle-vie [life-cycle-analysis]

Description

Introduces the students to quantitative assessment methods for the environmental impacts of various activities (product, service, building).

Expected skill

- To know how to use ACV-dedicated tools: EQUER building ACV software ;
- To be able to apply their knowledge during practical classes, and a workshop on carrying out an ecological assessment of an individual house.

CAO/DAO - Building Information Modelling

Code: cao-dao-bim

Expected skill

- to have the basics of technical drawing
- to identify the main graphical representations of building projects,
- to use 2D (AUTOCAD) and 3D – BIM (REVIT) software.

Project steering (Methods and tools)

Code: conduite-projets [project steering]

Description

To acquire the fundamental methods and tools for project management in order to successfully steer a project, and create a tool-box.

Expected skill

- To become familiar with the key-concepts of project management;
- To identify the role and the responsibilities of a project manager;
- To steer a project by implementing an operational method and operational tools;
- To identify the key-steps of a project and its implementation process;
- To find solutions difficult situations in project management.
- To define the circumstances and players in a project;

Mathematics 1

Code: mathematiques-1

Description

This course is meant to review basic mathematical skills

Expected skill

- to know how to use matrices and tensors
- to be able to differentiate and integrate
- to know how to apply major theorems

Health and safety at work 1

Code: sante-securite-1-poste-travail [health-safety-1-work-station]

Description

To understand, in a transferable and inter-disciplinary manner, the different aspects of risk management, of health and safety at work, and of environment protection, within companies and administrations.

Expected skill

To make students aware about the different points relating to safety in companies.

Statistics

Code: statistiques

Description

This course is an introduction to statistics knowledge of which is essential for modern engineering jobs. After essential reviews, this course will present the mathematical framework (counting, discrete and continuous probability spaces), and then a few basic statistical tools for analysing experimental data and random functions (e.g. sampling theory, estimates, confidence interval, hypothesis testing).

Expected skill

- to know the classical laws of counting
- to know how to use a few statistical tools,
- to know the main random phenomena transferable to scientific disciplines.

Thermodynamics

Code: thermodynamique

Description

This course is meant to teach the fundamental tools required for approaching the different states of matter, and the energy exchanges which depend on them. We shall discuss: systems and principles, exchanges of matter, work, heat. Standard transformations: isothermal, isobaric, isentropic, cycles. Heat engines. S-T, H-T, H-S diagrams and applications. Phase diagrams for

pure substances. Real gases. Changes of phase. Phase-change materials. Bi-phase binary mixtures: isotherm and isobar diagrams. Ideal and real mixtures, and applications. Bi-phase ternary mixtures. Thermodynamic quantities of reactions, influence of temperature and pressure. Free enthalpy of a system and evolution. Characteristic quantities of chemical equilibrium. Applications to industrial processes.

Expected skill

- to analyse and quantify energy exchanges,
- to characterise the states of matter, changes of state, phase-change materials,
- to give the selection criteria for phase-change materials,
- to use binary diagrams,
- to explain and use chemical equilibria,
- to differentiate an ideal system from a real system, and to use the corresponding thermodynamic relations (fugacity, activity, chemical potential, etc.),
- to know the characteristics of the different states of matter, Clapeyron's relations,
- to use binary diagrams,
- to qualify the evolution of a chemical equilibrium

Algorithmics and Programming

Code: algo-prog

Description

After a few **reviews** on coding (numbers, images, sound), the different algorithmic structures will be reviewed (variables, test, loops, functions).

Then, relying on Python (programming language), several general concepts will be discussed: recursion, calculating complexity, use of complex types (lists, associative arrays, sets). A few standard exercises are solved during tutorial classes.

During practical classes, certain exercises seen during tutorial classes are programmed, then different topics can be discussed: fractal images, cryptography, image processing, cellular automata, etc.

Link to course and practical class documents

Expected skill

- numerical coding of data
- designing simple algorithms
- solving various problems through programming

English 1

Code: anglais-1 [English-1]

Description

this course teaches general English. After having distributed the students into level groups following a test, the work is aimed at achieving a B1 - B2 level, as defined by the CEFRL scale (Common European Framework of Reference for Languages: Learning, Teaching, Assessment) in the 5 language skills. Depending on levels, work is based on linguistic reviews and/or deepening the knowledge of the English-speaking world

Expected skill

- to express yourself fluently,
- to use the right intonation, the right tonic accent and the right phonemes,
- to use the grammar concepts required for a proper understanding,
- to use the vocabulary for the TOEIC,
- to be able to speak and write,
- to know about the English-speaking world.

Digital skills

Code: competences-numeriques [digital skills]

Description

This module follows the development of the PIX national volume in order to provide a solid basis of digital skills Work related to bibliographic searching and monitoring, and to the management and or protection of personal data will be discussed face-to-face. Working alone, the students will deal with questions of digital identity, licenses, and creating digital documents.

Expected skill

- To know the problems relating to the accessibility of digital tools
- To know how to control their traces and manage the personal data in order to protect their privacy and that of the others. To adopt an informed practice: confidentiality parameters, regular monitoring of traces through alerts and other tools, etc.
- To carry out a search and information monitoring, using a search engine, within a social network, by subscribing to streams or newsletters, or any other means.
- To control their private, institutional or professional digital identity.
- To know the questions on author rights, licenses, and to apply them.
- To structure and format a document
- To produce a composite document
- To use data in spreadsheets

Introduction to electrotechnology

Code: intro-electrotechnique

Description

the course will present the main power generation methods (power plant), will describe high-voltage transformation methods for transport, and will introduce a few operating principles (induction motor and DC motors). An introduction on power electronic components will be given in order to be able to discuss rectification in the continuation of the programme.

Expected skill

- to solve simple electricity problems with strong currents,
- to know the principles for the generation (alternator, power plant), the transport (transformation, power factor) and the use of electricity (rotating machines) under strong currents.

Fluid mechanics 1

Code: mecanique-fluides-1 [fluid-mechanics-3]

Description

The integral form of the fundamental conservation equations of a fluid's movement (mass conservation, momentum conservation and energy conservation) will be presented. The first applications which derive from there will be discussed: statics for a fluid at rest, local theorems for perfect fluids (Euler's equation, Bernoulli's equation), flow-rate and velocity measurements. The momentum-flow theorem will be established, and its use to estimate resultant forces applied by fluids on surfaces, will be presented.

Expected skill

- To learn the fundamental elements and general concepts of fluid mechanics;
- to know how to apply the general laws to a moving fluid;
- to master the essential elements for studying the movements of an ideal fluid.

Continuum mechanics

Code: mecanique-milieux-continus [continuum-mechanics]

Description

1. To define and establish links between the conceptual objects required for a balance equation:
    - To describe the evolution in time and space of a continuous deformable medium: to explain and make the link between the concepts of a material system, particle speed, and the concepts of transport, displacement, deformation.
    - To put in mathematical form the conservation of mass principle and to link it to the particle velocity field.
    - To described the forces applied to a continuous medium, locally and overall.
    - To link the causes to the effects of a transformation, i.e. to express the dynamics

fundamental principle as a momentum balance

2. To handle the mathematical tools concerning conservation equations within the context of continuum mechanics
    - To operate with vectors, second-order tensors, and momenta
    - To handle many variable functions, and functions with scalar, vector and tensor variables in order to put hypotheses and boundary conditions into mathematical form, .
    - To calculate multiple integrals in order to determine flow-rates, resultant forces, etc.
    - To apply and invert partial differential operators for expressing stress, velocity, pressure, fields etc.

Expected skill

- to interpret and handle the terms of a balance equation.
- to describe the movement of a continuous medium
- to deal with the concepts of deformation, stress, kinematics, mass conservation
- to know how to establish a momentum balance, to write the balance equation

English 2

Code: anglais-2 [English-1]

Description

this course is almost exclusively dedicated to speaking activities: presentations, debates and communication activities. Work will be done on scientific English: the presentations and debates are based on scientific research on science history and philosophy in English-speaking countries, and notes have to be taken; individual exam at the end of the year.

Expected skill

- to interact fluently,
- to know about the English-speaking world.
- To write a summary note using English-speaking media.

Management 1

Code: gestion-1 [management 1]

Description

This course will make the students discover the inter-relations between functions of a company: commercial, financial and accounting, and to develop a strategic behaviour. It is also an awareness-raising regarding company problems, through management simulation: grouped together in a management team, the students manage restaurants, taking rich marketing decisions and including many commercial investigations. Arkhé's teaching software will be used

Expected skill

to know the inter-relations between company functions

Introduction to numerical methods

Code : intro-methodes-numeriques

Description

This course is an introduction to numerical methods, essential for studying many physical phenomena. The teaching is divided intoto three parts: a theoretical course (theorems and mathematical tools), exercises and practical classes (application under MatLab). These three components are constantly called upon to interact. We shall discuss, in particular, suitable methods for solving equations, linear systems, polynomial interpolation, numerical integration and ordinary differential equations.

Expected skill

- to master the course (theorems and definitions)
- to know the main numerical methods introduced as exercises, and to study their properties
- to have the ability to propose algorithms for solving problems in pseudo-code and under MatLab.

Mathematics 2

Code: mathematiques-2

Description

This course is aimed at laying the basis of skills in the field of differential equations and partial differential equations, and at discovering distributions. The classical methods for analytical solving of ODEs and PDEs are studied, in particular using Fourier series, Fourier transformations and Laplace transformations. Distributions (Dirac, Heaviside) will also be discussed.

Expected skill

- to know how to solve a differential equation
- to know how to solve a partial differential equation
- to know how to use Fourier series, Fourier transformations and Laplace transformations.

Signals

Code: signaux [signals]

Description

Signal processing mathematical tools will be introduced and studied (decomposing into Fourier series, Fourier transform, Dirac's unit impulse symbol and comb, time and frequency convolutions, sampled signal models, Shannon's theorem, notion of anti-aliasing filter), and will lead to the fast Fourier transform and spectral analysis by computer. The information transmission-reception and signal frequency change methods are also discussed.

Expected skill

- to classify signals,
- to calculate the Fourier transform of an analytical signal, and represent its spectrum,
- to transpose a signal spectrum at different frequencies,
- to understand a modulation or spectral analysis block diagram.

Application work

Code: tap

Description

Supervised by a tutor, students, in groups, carry out personal work on very varied subjects that they propose themselves, or proposed by the teacher. Besides a bibliographic part, and possibly a theoretical part, the application work includes a practical part.

Expected skill

- to learn how to manage a project
- to understand group management
- to write a report
- to present in front of a jury

Communication

Code: communication-2

Description

This teaching is aimed at making adaptation in companies easier, while allowing for an effective search for work. Through speaking exercises in front of a group (work on the voice, language, posture) and drafting and correcting CVs and motivation letters. Moreover, using, as a support, application work (written dossier, speaking training and oral presentation) enables students to make videos as a tool for self-assessment, to master various supports and to manage stress.

Expected skill

- to communicate a message to different discussion partners
- to use tools essential for looking for work or internships.

Science history and philosophy

Code : histoire-philo-sciences

Description

After presenting the objectives of the history of science course, an illustrated bibliography of the history, philosophy and epistemology of science, will be proposed. Relations between science and techniques, science and religion, and science and politics, will be discussed. Chapter 1 begins with the place of women, the grand ideas in philosophy and epistemology of science, and thinking about the notion of scientific progress. Chapter 2 discusses the scientific revolution during the XVII-th century. Chapter 3 deals with the history of thermodynamics, in particular through the reading of Sadi Carnot's work. Chapter 4 is dedicated to the life and work of Albert Einstein. Chapter 5 tells the story of the thinking which led to major ideas of the Big Bang theory. The last chapter on the voyage and work of Charles Darwin is subject to a presentation in English, in the presence of the English teacher.

Expected skill

- to explain the development of scientific concepts,
- to justify the scientific developments thorough eras, knowledge and needs,
- to explain scientific progress in terms of success and errors.

Introduction to databases

Code: intro-bdd

Description

This course is an introduction to relational databases. After a general presentation justifying the introduction of DBMSs, the association entity and relational models will be described. The fundamental elements of SQL will then be discussed from the point of view of modelling and requests.

Expected skill

- understanding of the relational schema of a database, the relation between tables, primary and foreign keys.
- algebraic and SQL expression of requests on a given schema.
- interrogating a database.

Fluid mechanics 2

Code: mecanique-fluides-2 [fluid-mechanics-3]

Description

The extension of the application of general laws and principles of mechanics to the motion of a

real (viscous) fluid, will be presented. The mathematical modelling associated with Stoke's hypothesis which enables the stress tensor and the deformation velocities to be linked, will be shown. The local form of conservation equations for an incompressible fluid will be established (Navier-Stokes equations), and the exact main solutions of the equations will be presented (Poiseuille and Couette flows). The approaches for determining linear and singular head losses in pipe flow, will be developed (generalised Bernoulli's principle). Finally, concepts of dimensional analysis (PI theorem) and similarity, will be introduced.

Expected skill

- to know the basic mathematical modelling apt to provide solutions for different fluid flow problems,
- to know how to solve basic problems of incompressible fluid flows,
- to calculate head losses,
- to define all characteristics of a hydraulic network.

Materials science

Code: resistance-materiaux [materials-science]

Description

After having described the main mechanical systems (reading a drawing), their links, and having justified the form of the screw of the mechanical actions transmissible by each of them, the main principle of rigid body dynamics is reviewed and applied. Hypotheses are then made in order to characterise a deformable solid (elastic deformation field) and to define the beam in the sense of materials science. Writing the cohesion screw in the straight section of a beam leads to studying stress and deformation for the main simple forces (extension, compression, shearing, torsion, in-plane bending). Iron-carbon alloy will be studied, from steel making to the mechanical characteristics of metallurgical products. The main mechanical tests will be presented. The simplified theoretical study of materials is supplemented by an experimental approach: - traction and hardness testing of alloys, relating to heat treatments,
- relations between stresses and deformations, - numerical calculation tool (RDM 6).

Expected skill

- to design machine parts and structure elements,
- to write explicitly the design criteria for resistance and deformation,
- to calculate the components of the screws of mechanical actions transmissible via mechanical links,
- to calculate the components of the cohesion screw of the straight section of a beam
- to measure and inspect the mechanical characteristics of metal samples,
- To transpose graphically and in numerical form a simple technical choice (use of AUTOCAD software).

English 3

Code: anglais-3 [English-1]

Description

Groups 2 and 3: preparation for TOEIC (Listening, Reading) Group 1: briefly review the TOEIC Development of language skills in English for the professional world: CV drafting, and even motivation letter models.

Expected skill

- Deepening expression and understanding skills through varied, cultural subjects.
- Writing professional documents in English

Meeting steering - Conflict management

Code : conduite-reunion-gestion-conflits [steering-meeting-management-conflicts]

Description

Concepts and definitions, the different types of meeting, meeting and interview, success conditions, quality of persons involved.

Expected skill

- to be able to steer a meeting.
- to be able to identify personalities present.
- To know the constituent elements of a crisis, the contextual elements favouring them, and the possible response strategies.

Health and safety at work 2

Code: sante-securite-2-encadrement [health-safety-2-supervision]

Description

Using the Impact MOOC from *Ecole des Mines* in NANTES

Expected skill

- To identify, in the company, the economic, legal, social and human issues for health and safety at work;
- To integrate health and safety at work to the management of its activities and to the steering of its projects;
- To contribute the management of health and safety at work in a company.

Systems

Code: systemes

Description

Defining and studying the properties of the Laplace transform is followed by its application to solving differential equations. Transient and frequency response analysis (Bode plot, Black locus and Nyquist locus) of linear systems will then be considered. First- and second-order systems, and the study of integrator system and systems with delay, will be more particularly studied. After having defined the properties of the closed loop and the performance criteria of 1st and 2nd order closed-loop systems, system stability is studied via Nyquist's criterion, by defining gain and phase margins. The lead-lag compensator will then be introduced. The PID control study will concern the analysis of actions and the synthesis methods.

Expected skill

- to apply the performance criteria of closed-loop systems,
- to study system stability,
- to apply the principle of stabilising corrections,
- to tune a PID controller to a 1st and 2nd order system (whether with delay or without) by controlling monitoring and adjustment objectives,
- to analyse a simple control scheme.

Turbomachinery

Code : turbomachines

Description

This first part of the turbomachinery course is an introduction which addresses both specialities E/GC and E at the ENSIP in the same way. After a presentation describing the universe of turbomachinery and the basic concepts (Euler's theorem, velocity triangle), the operation of a centrifugal pump (or fan), is described in detail. Similitude theory and Rateau's coefficients for being able to choose a pump (for example) in an installation, are then introduced. The course will finish with a brief description of axial machinery, illustrated by the study of a fan or a pump of this type. It should be noted that a practical class on centrifugal pumps is included in the series of practical classes relating to the course on heat engines.

Expected skill

- to master the basic vocabulary and concepts of this discipline,
- to acquire the essential tools for designing elementary turbomachinery,
- to master the choice and the installation of a pump or a fan in a circuit,
- to acquire the English vocabulary specific to the subject.

English 5

Code: anglais-5 [English-1]

Description

The absolute priority of this course is for the student to take over communication situations as close as possible to professional reality: conducting / participating in professional meeting situations, round tables and scientific, international and ethical case studies, based on hot topics in the engineering world.

Expected skill

- to conduct (having prepared it) and actively participating in a professional meeting in English,
- to be able to give professional presentations on scientific and/or hot topics,
- to carry out a logical analysis on a moral and/or ethical question raised in the engineering world,
- to make the link between the language course and the scientific and professional training of ENSI Poitiers.

Management 2

Code: gestion-2 [management 1]

Description

this course discusses the initiation to reading and analysis of financial statements (balance, income statement, interim financial reports) through the presentation of data contained in the statements, and training for solving simple exercises of general accounting. Moreover, general accounting will be developed here: raw material of the analysis. Data contained in the balance and in the income statement. Characteristics quantities of the activity: the interim financial reports.

Expected skill

to analyse financial statements (balance, income statement, intermediate management balances) through the presentation of data contained in the statements, and training for solving simple exercises of general accounting, and through studying general accounting.

End of studies project

Code: pfe

Description

end of studies projects consist of an in-depth study bringing an original contribution to the development of techniques in fields relating to a professional speciality. This study is carried out

within a project in partnership with a company or within a research laboratory.

Expected skill

- to know how to work in a team,
- to conduct a project with different partners and discussion partners,
- to carry out a technology watch.

Quality

Code: qualite

Description

quality is fundamental to any production. For this reason, this course discusses the following points: human positioning with regard to the quality function; knowledge of performances, relation to objectives, cause-and-effect relation; the indicators measured and their use, preventive responsiveness. Process management, associated analysis tools; total quality management TQM, quality function deployment QFD; ISO 9000 standard, version 2000 approach; continual improvement system; quality approach sustainability.

Expected skill

- To explain human positioning with regard to the quality function,
- to know the performances, the relation to objectives,the cause-and-effect relation, the indicators measured and their use, the preventive responsiveness.
- to manage the processes and the associated analysis tools,
- to manage via quality TQM, quality deployment QFD
- to apply the ISO standards
- to comprehend continual improvement systems,
- to make the quality approach sustainable.

Health and safety at work 3

Code: sante-securite-3-csr [health-safety-2-csr]

Expected skill

to develop a managerial approach, technical and strategic at the same time, to CSR, to sustainable development and to QSE risk control in a company.

Corporate life

Code: vie-entreprise [corporate-life]

Description

Presentation given, for every group of specialities, by a head of personnel or head of human

resources from various companies. Training for setting up a company Training on the steps to take in preparing the setting up of a small-medium size company on territorial authorities and sustainable development: The actions implemented by territorial authorities within the framework of sustainable development.

Expected skill

- To become aware of the topic of looking for an internship or a 1st job
- To simulate a collective interview
- To learn the basics of setting up a company,
- To understand a work contract and corporate collective social relations
- To discuss ethics in the framework of the company
- To carry out a speed meeting simulation
- To make use of their skills

2nd year internship

Code: stage-2a [internship-1a]

Expected skill

To acquire new professional skills and to reinforce those already acquired at ENSI Poitiers.

3rd year internship

Code: stage-3a [internship-1a]

Expected skill

To acquire new professional skills and to reinforce those already acquired at ENSI Poitiers.

1st year internship

Code: stage-1a [internship-1a]

Energy diploma

Sensors

Code: capteurs [sensors]

Description

To comprehend, quantify or identify a physical quantity, an appropriate measurement system is fundamental. This course aims at presenting the main measurement techniques used in engineering, mainly insisting on their implementation. Given the variety of the quantities to measure or to detect, this course will be mainly limited to a few families of sensors often met in engineering, e. g., position sensors, motion sensors, acceleration sensors, force sensors, torque

sensors, temperature sensors, pressure and flow-rate sensor, to name only a few. In each case, after describing the operating principle and the technical characteristics used in the industry, special attention will be given to the problems of sensitivity, calibration, acquisition, selection and measuring chain.

Expected skill

- to know the operating principles of the main families of sensors;
- to read and extract the main characteristics of the technical documentation on sensors;
- to integrated a sensor into a measuring system;

- to characterise and calibrate the main sensors of the instrumentation chains.

Energies (professional seminars)

Code: conferences-energies

Description

This course module will consist of a cycle of seminars on general knowledge and applications to different engineering professions in the energy field. The seminars (general information, professions, R&D, etc.) will discuss different present and future topics and issues, such as: fossil energy, renewable energy, nuclear energy, energy policies, the French energy mix, the international context and issues, regulations, energy storage, energy management system, energy saving certificates, smart grids, etc.

Expected skill

To become aware of the energy context and policies in France, in Europe and throughout the world, of energy geopolitics, of the energy mix.

Optics and materials

Code: optique-materiaux

Description

The objective of this teaching is to show the link between types of materials (metal, dielectric, semi-conductor), their electronic and optical properties and the way they can be used in technical devices: mirrors, glasses, radiation detection, etc. The teaching is divided intoto 3 chapters where different concepts are discussed:

Chapter 1 “Structure des solides” [Structure of solids]:

- Photelectric effect
- Bohr’s atomic model
- Atom and quantum mechanics
- Atomic bonds
- Solids / Theory of energy bands.

Chapter 2 “Propriétés électroniques & optiques des solides” [Electronic and optical properties of solids]:

- Dielectric permittivity
- Index & transmission, reflection, absorption
- Part A: Metals (Drude’s model)
- Part B: Dielectrics (Lorentz’s model and Cauchy’s law)
- Part C: Semiconductors (concept of holes, - FERMI DIRAC function - Intrinsic SC, N-type extrinsic SC, P-type extrinsic SC, transport phenomena, PN junction, metal/semiconductor junction, optical properties).

Chapter 3 “Les photodétecteurs” [Photo-detectors] :

- Dark current, Spectral sensitivity
- Bandwidth
- Optical sensor noise
- Signal to noise ratio
- Detectivity & NEP
- Quantum efficiency
- Passive detector (Photo-resistor of photoconductive cell)
- Active detector (Photoemissive sensors: Photomultiplier, photo-diode)
- Thermal detectors (thermistor, thermocouple or thermopile, pyroelectric detectors)

Students (in groups of 3 or 4) will have to carry out a bibliography summary on a subject relating to the use of materials with specific properties in the field of energy, from an article published in the collection *“Techniques de l’ingénieur”*.

Expected skill

To be able to explain the differences in electronic, and hence optical properties, between metal/isolator/semiconductor; to be able to explain the operation of thermal and photonic photodetectors; to know how to choose a suitable light detector (UV-Visible-near-IR) for practical applications, depending upon their technical characteristics; to be able to produce a review on a bibliographic subject and to present it in an organised, clear manner to an initiated public.

Risks in the professional environment

Code: risques-milieu-professionnel [risks-environment-professional]

Vibrations

Code: vibrations

Description

This course present mechanical vibrations. The analysis of phenomena is progressive: study of systems with 1 degree of freedom, then with several degrees of freedom. The notion of damping is also discussed. In the second part of the course, continuous systems (beams, strings, plates and membranes), are discussed. Practical classes support the theoretical course, allowing the students

to apply directly the physical concepts mentioned during the course and the tutorial classes.

Expected skill

- to predict the evolution of a vibrational mechanical system whose characteristics vary in time, from the basic equations of continuum mechanics,
- to recognise a equation of motion for a vibrational mechanical phenomenon,
- to use circular functions and complex exponential functions,
- to apply the concepts of damping and resonance,
- to solve the equation of motions for various oscillating physical systems,
- to interpret the equations.

Electromagnetism

Code: electromagnetisme

Description

The course will start with a review of Gauss' and Ampère's theorems for treating electrostatics and magnetostatics problems in a vacuum. It will continue in the same chapter with a study of Maxwell's general equations and solving particular cases (in particular of EMC). The second chapter of the course is dedicated to Maxwell's general equations in material media. Applications to optics, energy and electrical engineering illustrate this part.

Expected skill

To adapt Maxwell's general equations to solving simple problems of electromagnetism.

Electronics

Code: electronique

Description

After having presented a brief history of electronics and the emergence of telecommunication systems, the elementary laws of electrical circuits are discussed. The main components of analogue electronics will be studied through their equivalent models and their applications. The diode is first studied in classical rectification applications which involve the "large-signal" model. Linearisation of its current-voltage characteristic is then carried out around a rest point, in order to introduce the "small-signal" model which will then be widely used when studying the transistor. After having modelled the bipolar transistor from an analogue viewpoint, this will be studied through its main applications. The analysis of passive and active filters and the synthesis of active filters using Butterworth's frequency response and Sallen-Key structure, are discussed. The study of the main properties of feedback enables us to discuss the oscillation function by studying a Wien bridge oscillator. After a presentation of digital electronics, counting systems, logic gates, combinational logic circuits, binary arithmetic and the notion of multiplexing form the first part of the course on digital electronics, the study of combinational logic. Finally, the

main functions of sequential digital electronics such as latches, registers, counters and a summary of logic circuits form the second part of the digital electronics course.

Expected skill

- to use components such as diodes, transistors, operational amplifiers in the main functions of analogue electronics,
- to summarise simple electronic functions such as amplification, filtering and signals generation,
- to know binary arithmetic, logic gates, combinational logic, latches, registers, counters,
- to summarise logic functions in digital electronics.

Heat engines

Code: machines-thermiques [heat-engines]

Description

This course is aimed at acquiring skills in the thermodynamics of open systems, as applied to heat engines. It is divided into two parts. The first part presents the general structure of conservation equations relating to extensive quantities and the application to open systems: first and second principle of thermodynamics seen from the point of view of matter, energy and entropy, and then impulse, angular momentum, energy conservation equations. This part is supplemented by a theoretical analysis of flows through machines and ducts, of unsteady flows. The second part concerns the introduction of the main thermodynamic characteristic diagrams (Clapeyron, Mollier, entropic, refrigeration) and the initiation to thermodynamic cycles (Joule, Brayton, Rankine, Hirn). This theoretical knowledge will be applied to various heat engines: definitions, energy efficiency, Coefficient of Performance, exergetic (available work) efficiency of compressors, pumps, turbines, internal combustion engines, steam engines, refrigerating machines, heat pumps, absorption machines, industrial systems.

Expected skill

- To acquire the basic concepts for understanding thermodynamics applied to machines;
- To know the operating principles and performance of elementary heat engines;
- To know how to qualify and quantify the evolutions of elementary real-world heat engines: compressors, pumps, turbines;
- To know how to qualify and quantify the evolutions of thermodynamic cycles in complex real-world, industrial heat engines: steam engines, refrigerating machines, etc.

Experimental design

Code: plans-experience [experimental-design]

Description

This course is aimed at acquiring skills in terms of strategy for determining key-factors, for

optimising the control of a process or of an apparatus, and the prediction through modelling of a process behaviour. Experimental design is used in many industrial fields because it belongs to a general approach to the improvement of quality. Its principle is the possibility of interpreting results with a minimum effort at the experimental level: minimising the number of required experiments in order to save time and money. After presenting a basic vocabulary (controllable factors, inputs, responses), the different steps of a study through experimental design, are carried out. The concepts of multilinear regression, coded or centred variables, and those of experimental matrix, effects matrix and the design matrix of factorial plans, are discussed through examples from different fields.

Expected skill

To know how implement an experimental design and interpret its results.

Heat transfer - Conduction

Code: transfert-chaleur-conduction [heat-transfer-conduction]

Description

This course presents one the three modes of heat transfer, “thermal conduction”, and is intended for second-year students in the “Energy” speciality at ENSI Poitiers. The course will start by an introduction, and then a presentation of a few useful, essential definitions. Then, a detailed description of thermal conduction in a material, in the steady and transient regime, will be given. The emphasis will especially be on solid materials. The central element is the heat equation obtained by combining Fourier’s law with the principle of energy conservation. The basic concepts associated with each of the regimes, are developed, and appropriate calculations are used to emphasize the problems met in many applications. The concept of electrical analogy is especially interesting. After presenting this concept in a steady regime, it is generalised to the transient regime by applying the thermal quadrupole method. A second important concept is heat conduction through fins, and its study emphasizes the interaction of heat conduction as first mode of transfer with the second mode, namely convection which is treated in a separate course. A series of tutorial classes allows the students to comprehend the concepts acquired during the course.

Expected skill

To acquire general knowledge and the basic concepts on heat conduction through materials in the steady and transient regime; to know how to use different approaches and calculation concepts for quantifying the heat transfer rates via conduction through materials; to know how to identify and describe problems which involve this mode of heat transfer.

Distribution and conversion of electrical energy

Code: distribution-conversion-energie-electrique [distribution-conversion-electrical-energy]

Description

This course presents electrical networks starting from the major generation and distribution grids down to electrical installations at the scale of a building, and for street lighting. Within this framework, the different functions of static power converters are presented, while reviewing the basics of electricity. The concepts of power balance, line losses, power factor, harmonics, etc., are introduced. Electrical hazards, the different grounding systems (EE, EN, LE), electrical safety, the standards to comply with, and the different types of electrical devices, are also reviewed. Moreover, design elements for installations in building, street lighting, and the industrial sector, are given in order to determine the rated power, the design current, the choice of protective devices, the cable gauges, etc.

Expected skill

- to know the electrical hazards, the regulations and the standards in vigour to comply with,
- to know the generation, distribution and transport principles for electrical power,
- to know the basic circuits for converting electrical power, using power static converters,
- to be able to design low-current and high-current installations for a building.

Wind power

Code : energie-eolienne-1 [wind-power-2]

Description

This introductory teaching concerning wind power is organised around 5 topics: 1) wind energy amongst renewable energies ; 2) the wind: measurement, modelling, resource assessment; 3) horizontal-axis wind turbine: geometric description, modelling, performances; 4) other types of wind turbine: Darrieus, Savonius, biomimetic design; 5) location: administrative framework, noise and visual impact, production assessment This teaching is supplemented by a seminar given by a specialist in the field, and by a site visit.

Expected skill

- to know the main issues relating to the development of wind power,
- to be able to design a wind turbine,
- to master the field installation specificities (regulations, laws, etc.) for a wind turbine.

Estimation

Code: estimation

Description

After having introduced the definition of time-dependent data, the main tools for treating data (covariance, correlation, etc.), and methods such as least squares, will be presented for determining regression models.

Expected skill

To analyse time-dependent data, to determine models through approaches such as linear regression

Heat transfer - Convection

Code: transfert-chaleur-convection [heat-transfer-convection]

Description

This course is organised around forced convection. The first chapter introduces the basics of convection as mode of heat transfer, and identifies the different convections: natural, mixed and forced. Transfer mechanism by convection are then described from a microscopic point of view (advection, diffusion). The conservation equations discussed in fluid mechanics (mass, Navier-Stokes, energy) are reviewed and adapted to forced convection problems under laminar, steady or transient regimes, for incompressible fluids. The notion of laminar thermal boundary layer is introduced: concept, analysis of orders of magnitude, approximations, characteristic numbers (Pr, Nu, St). Two topics are treated in detail: flat plate (Blasius's solution, Karman-Polhausen integral solution, characteristic quantities: thickness of the boundary layer, flow density, exchange coefficient, general correlations) and pipe problems (notion of dynamic and thermal establishment, mean temperature, influence of the inlet zone, practical correlations). This first topic finally introduces forced convection in the turbulent regime, and the interest of this type of exchange (intensification, friction), etc. This module is supplemented by practical classes: study of a water jet in free space, TGV ejecto-convector (transport), study of coupled transfers in a refrigerated window (food industry), cooling of power electronic components (electronics), etc.

Expected skill

- to acquire supplementary knowledge on forced convection mechanisms,
- to know how to calculate the characteristics quantities of thermal boundary layers (Nusselt, Grashof, exchange coefficient, power, etc.),
- To know how to identify appropriate correlations for solving real-world industrial problems (heat exchanger, heat engines, electronic components, cooling, ovens, building, etc.).

Heat transfer - Heat exchangers

Code: transfert-chaleur-echangeurs [heat-transfer-heat-exchangers]

Description

This first "Heat exchangers" module is aimed at providing the required training basics to engineers in this field. Heat exchangers are present everywhere in industry, housing environment (solar heating, geothermics, heat recovery, storage, etc.), energy (refinery, nuclear power plant, electronics, etc.). This module is divided into several complementary parts. General aspects and the identification of architectures (industrial heat exchangers: tube, shell, plates, sealing strips,

coils, compact, phase-change heat exchangers), are first discussed. The second part focuses on the design and performances of single-phase heat exchangers (logarithmic mean temperature difference DTlm, NUT, efficiency) co-currents, counter-current, in series, in line, in parallel series.

Expected skill

- to identify the different topologies of heat exchangers or heat exchanger networks,
- to be able to choose and design compatible heat exchangers appropriate to a targeted industrial sector.

Heat transfer - Radiation

Code: transfert-chaleur-convection [heat-transfer-radiation]

Description

This course presents heat transfer by thermal radiation, and is intended for the second-year students in the “Energy” speciality at ENSI Poitiers. Thermal radiation is one of the three modes of heat transfer, along with thermal conduction and convection. The course will start with an introduction, and then a presentation of a few useful definitions essential for understanding the physics of heat transfer by radiation. After having defined the nature of thermal radiation, the quantities relating to the spectral character of radiation and those relating to the direction of propagation, we shall present the notion of a black body, which is a reference body in the field of thermal radiation. Radiative properties of real-world bodies will then be defined. Secondly, we shall spend some time determining radiative exchanges between black bodies, using form factors, and then we shall extend the calculations to grey bodies by using, in particular, the radiosity method. This course will contain many practical examples (green-house effect applied to the solar thermal sensor, calculation of the solar constant, radiative balance in an oven, etc.). A series of tutorial classes will allow the students to put in practice and understand the concepts presented during the course.

Expected skill

- General knowledge and basic concepts of thermal radiation
- To know how to identify the physical mechanisms associated with this mode of heat transfer
- To know how to quantify radiative exchanges between black and grey surfaces

Solar power

Code: energie-solaire-1 [solar-power-2]

Description

This module is an introductory course on solar power. First, we shall identify the global energy issues, the environmental issues, and we shall present a carbon balance. It is supplemented, on

the one hand, by advanced concepts of solar thermal power: identifying and describing different solar sensors (flat sensors, vacuum sensors) and operating principle. On the other hand, the course described existing systems and those under development on photovoltaic conversion: photodiode, new generations of detectors, tandem cells, concentrating photovoltaic systems, thermophotovoltaic conversion. A last aspect of this module relates more particularly to thermoelectricity: the principle of the thermoelectric effect, thermoelectric modules, efficiency of a thermoelectric generator, performance coefficient of a thermoelectric refrigerator, figure-of-merit, design and manufacturing of thermoelectric modules.

Expected skill

- to acquire basic concepts relating to solar power conversion into electricity (photovoltaic) or into heat (thermal),
- to know how to identify and describe various types of solar sensors and their components,
- to know and understand the thermoelectricity field,
- to know how to describe the different elements of thermoelectric modules.

Numerical methods 1

Code: intro-methodes-numeriques

Description

This course discusses the general concepts of simulation engineering and numerical calculation. The basic methods for solving ordinary differential equations (ODE) and partial differential equations (PDE), are presented. The finite difference method is implemented. The concepts discussed are illustrated by examples relating to the field of energy and to the different training programmes: solving the heat equation, solving, fluid mechanics equations, solving linear systems by direct methods and by iterative methods, introduction of optimisation, integration, digital signal processing. The focus is on putting these in practice throughout the teaching sessions.

Expected skill

To master the essential concepts of numerical analysis and the main basics of scientific calculation; to create codes implementing numerical methods; to know how to look critically at the relevance of a numerical result.

Programming

Code: programmation

Description

This module is a continuation of the first-year algorithmic and programming module. It is more based on **practical usages**. After a few tutorial classes in the computer room, on advanced data structures (dictionaries, sets, etc.), and examples of applications (data analysis, data recovery

from the Internet, design of graphical interfaces), the module will end with practical classes. Programming is done in Python, with a focus on real-world applications.

Expected skill

- advanced concepts on certain specific points of Python (data structures, etc.)
- data analysis
- creating graphical interface
- open data recovery

Turbomachinery - Turbines

Code : turbomachines-turbines

Description

This second course on turbomachinery is deliberately oriented towards turbines which in practice constitute the main way of producing electrical power. The concepts discussed within the framework of the previous module are quickly reviewed, through the study of hydraulic turbines: general aspects, Francis turbines, Pelton turbines, Kaplan turbines. Gas turbines or steam turbines are the subject of a second section of this module: axial turbines, steam turbines and gas turbines. This is an occasion to study the theory of turbomachinery in more detail on the one hand, and of internal aerodynamics and thermodynamics on the other, while using the concepts taught in the other courses. Finally, the operation of axial compressors is discussed and illustrated by a brief description of a turbojet.

Expected skill

- to understand the operation of turbines and know how to describe it,
- to know how to estimate the main parameters relating to this form of electrical power production,
- to know how the carry out a mean-line analysis of a turbine or of an axial compressor,
- to acquire the English technical vocabulary specific to this subject.

English 4

Code: anglais-4 [English-1]

Description

During this semester, groups will be heterogeneous, and the course focuses on the English-speaking world and on the scientific world. The students will develop their practise of English in relation with new technologies, in order to be able to use it in the professional world. They will have to prepare two substantial talks: research will be carried out so that they can extend their language and professional skills in English, on a hot topic; another review work will be presented on international scientific research, in front of a jury.

Expected skill

- to prepare a professional presentation in English (speaking proficiency + written comprehension),
- to carry out research work (extension of language skills and know-how in civilisation) in order to be able to carry out a review of scientific journals.

Water engineering and civil engineering diploma

Natural water chemistry

Code: chimie-eaux-naturelles [natural-water-chemistry]

Description

This course will present the main parameters for characterising natural waters: dissolved salts and gases, suspended matter, natural organic matter. These different parameters will be introduced through a prior presentation of the great biogeochemical processes at the origin of the composition and evolution of natural waters (alteration-precipitation, biological processes, air-water exchanges). We shall focus on the calcium carbonate equilibria and their role in the chemistry of natural waters, natural organic materials, the chemistry of metal and redox reactions. This module is an occasion to use the main methods for water analysis (pH, alkalinity, hardness, dissolved oxygen, redox potential, conductivity, etc.), and to introduce methods such as chromatography and atomic spectroscopy. The different physical and chemical parameters and their evolution will also be presented within the framework of case studies (eutrophic lake and quarry acid lakes) illustrating theoretical concepts. This course is also an occasion to introduce the Visual MINTEQ software for solving chemical equilibria.

Expected skill

- to know the characterisation parameters of a water and know how to analyse a natural water,
- to solve chemical equilibria in solution,
- to use speciation software,

- to interpret and comment critically on results

Engineering geology

Code: geologie-ingenieur [engineering-geology]

Description

Geology concepts concern first the principle of rock classification, their formation, and the study of the main families of minerals which form them. Minerals are studied through the analysis of crystalline systems (symmetry elements), and their chemical compositions (structural formulae and solid solutions). Secondly, understanding spatial distribution is discussed through the study

of France's geology and the analysis of geological maps, in particular by using Infoterre.

Expected skill

- to identify the main types of rocks and the minerals which form them
- to know their chemical composition and the conditions of formation
- to know the great geological formations in France
- to carry out a geological cross-section from the analysis of a geological map
- to use Infoterre for a search of geological data.

Geotechnics 1: Basic concepts

Code: geotechnique-1-basics

Description

Natural material structure: densities, porosities, particle size distribution. Soil identification and classification. Water characteristics and soil clayeyness. Water in soils. concepts of in situ exploration, mechanical probing, in situ testing (dynamic penetrometer, pressuremeter).

Expected skill

To know how to characterise a natural material and its state: to measure and calculate porosities, void ratios, concentrations of water, clay, etc. To carry out the main tests for GTR classification. To understand the importance of water in the behaviour of geomaterials.

Concrete and use

Code : beton-mise-en-oeuvre [concrete-installation]

Description

Concrete is a composite material consisting of a mixture of cement, aggregates, mixing water, addition, additive and fibres. The first two chapters of this course describe these different constituents. For each constituent, we shall give its composition, manufacturing, properties, standardisation and fields of application. Concrete is an industrial material which needs to have constant properties to used in building structures and ensure that they last. The third chapter discusses the European standardisation of concrete. The NF EN 206-1 standard defines the different types of concrete that can be used on construction sites, concrete specifications as a function of the environment classes of the future structures, classification of concretes depending on their properties, and concrete conformity. The formulation of a concrete depends on the expected properties in its fresh state and in its hardened state. In the fresh state, concrete's consistency is involved in its workability which characterises its capacity to fill formworks and to envelop steels. In its hardened state, concrete's porosity has an influence on its mechanical resistance and its durability. In the fourth chapter, the description of these different properties is used for explaining the so-called Dreux Gorisse formulation method. Structural elements made of reinforced concrete or pre-stressed concrete can be produced in factories, we then talk about

prefabricated elements, or elements fabricated on-site, and then about elements cast in place. In both cases, concrete is cast in a mould called a formwork which will give concrete its permanent form. The different techniques for using concrete are presented in the fifth and last chapter.

Expected skill

- To be able to select and control the different components of concrete.
- To be able to formulate and control concrete following technical specifications while complying with the regulations.
- To be able to carry out production monitoring, to use and inspect concrete on construction sites.

Geotechnics 2: Applications

Code: geotechnique-2-applications

Description

This course discusses a number of topics relating to environmental geotechnics: the risk of soil movements, the seismic risk, the risk of torrential rain and geosynthetics. The first part of the course presents the concepts of hazard and vulnerability for defining the concept of risk. We then present the management and prevention of natural risk studied here. The second part of the course discusses the different statistical and geostatistical methods used to quantitatively treat the natural variability of soils and rocks.

Expected skill

- To know the different principles associated with the analysis and management of geotechnical risks;
- To know the different uses of geosynthetics (in particular waste storage facilities).

Hydrogeology

Code: hydrogeologie

Description

Water cycle: water resources on the planet - different uses of water. Annual hydrological balance: rain - flow-rate relations and structure design. Modelling rain for designing spillways, rainwater networks and for flood risk assessment. Hydrodynamic principles: physical properties of water, water table and aquifer typology, hydrostatics in saturated and unsaturated environment, interpretation of piezometric surface maps, Darcy's law (applications and limits).

Expected skill

- To use Darcy's law in simple cases (homogeneous media).
- To measure the permeability of porous media.
- Three-dimensional flows: well and flow network hydraulics.

- To carry out hydrological balances.
- To interpret hydrogeological maps.

Pollutants in natural environments

Code: polluants-milieux-naturels [pollutants-natural-environments]

Description

This course describes the large pollutant classes of anthropic origin found in different water and soil compartments of the natural environment. After a description of the type and origin of pollution supported by examples, we shall present the transfer and evolution modes (by hydrolysis, photolysis or biodegradation) for pollutants in a natural environment. The impact of pollution in terms of environmental and health hazards is also described, along with the regulations associated with environmental monitoring.

Expected skill

- to know the origin and the modes of evolution of pollutants in different environments
- to assess the impact of pollutions on environments, and their uses

Advanced office automation

Code: bureautique-avancee [advanced-office-automation]

Description

This course first describes the use of a spreadsheet for data analysis: presenting results, dynamic cross tables, using a solver, etc.

Expected skill

to use office tools for presenting data or calculations.

Technology and regulatory watch

Code: veille-technologique-reglementaire [technology-regulatory-watch]

Description

This course is aimed at training engineering students in writing scientific reports and using on-line search tools for bibliographies and patents. We shall introduce the rules for citing references. We shall also give the report writing standards.

Expected skill

- To use bibliography tools (Zotero, Mendeley, etc.)
- To know the rules for citing references
- To use bibliographic search tools

Polluted site and soil decontamination

Code: decontamination-sols-pollues [polluted-site-soil-decontamination]

Description

After having presented the regulations on the management of polluted sites, this course will describe diagnostic and monitoring methods for polluted sites (drilling techniques, sampling and analysing of different phases, site instrumentation and equipment, etc.) This course then lists the different treatments (biological, physical, chemical or thermal) used in the case of polluted sites and soils. We shall present in detail widely used methods, and we shall introduce methods under development. The focus will be on the existing link between the technology chosen and the pollution to be treated. Finally, the course is illustrated by several case studies.

Expected skill

- to use a methodology for assessing the state of a polluted soil or site,
- to design treatment programmes for polluted soils or remediation methods for polluted sites.

Soil investigation and management

Code: etudes-gestion-des-sols [Soil-investigation-management]

Description

The teaching concerns the physical, chemical, physical-chemical and biological properties of soil, aiming at understanding its functioning and its management as resource. This multi-disciplinary teaching is structured in 4 main topics: soil constituents and formation, soil constituent organisation and reactivity, water in soil and shrink-swell problems in soil. This teaching also discusses on-site description of soils and soil analysis interpretation. The concepts developed during this course are put in practice through a project on a reasoned choice of building plot implantation at a municipality level.

Expected skill

To identify soils on site, and to give their main characteristics - To interpret soil analyses - To differentiate the main physical, chemical and physical-chemical factors and processes governing soil functioning

Waste management and repurposing

Code: gestion-valorisation-dechets [waste-management-recycling]

Description

After having presented the environmental and societal context of waste management, the course discusses their classification, and provides characterising elements. The policy and regulatory

framework of waste management will be presented, along with the collection, recycling and re-purposing depending on the type of material concerned. Finally, the course describes the design and the functioning of recycling, incineration, composting, anaerobic digestion facilities and storage centres for waste, from the perspective of reducing their environmental impacts. The treatment methods for hazardous waste will also be discussed.

Expected skill

to know how to design and size environment-friendly treatment programmes, to assess a corporate or community policy relating to waste management, and to analyse its conformity with the regulations, and its environmental and economic relevance

Supervised project

Code : projets-encadres [supervised-project]

Description

Visits of industrial facilities for waste treatment and re-purposing (waste recycling, composting, storage or energy recovery) or for polluted soil decontamination, illustrate the concepts discussed during the course, and provides in-depth knowledge through case studies and independent individual work.

Expected skill

to know how to write a visit report, to identify infrastructures and to understand, the operation of industrial facilities on site

Water resource and transfers of pollutants

Code: ressources-eau-transferts-polluants [water-resource-transfers-pollutants]

Description

Establishing steady and transient flow equations, hydrodynamic characteristics (transmissivity and storativity), flow networks, structure hydraulics, superposition principle, initiation to hydrodynamic modelling, initiation to pollutant transfer into water sheets.

Expected skill

- To draw flow networks graphically.
- To interpret hydraulic tests (test pumping and hydraulic shocks) in simple cases (homogeneous media).
- To understand the diffusion equation.
- To determine hydro-dispersive characteristics.

BIM Building Information Modelling

Code: bim

Description

BIM is a working method, a process which uses a 3D smart digital scale model as central element of the exchanges between the different persons involved in construction. To this end, a visit to a construction site or a building (e.g.: STEP) will be carried out, then 2D drawings will be provided to the engineering students who will have to model the building, and thus create its 3D digital scale model. In parallel with this work, acquisition tools for 3D point clouds (3D scanner) will be presented and used in the case of old buildings.

Expected skill

Advanced knowledge on a BIM-oriented software (REVIT)

Network hydraulics 1

Code: hydraulique-reseaux-1 [network-hydraulics-1]

Description

Within the urban life cycle, this course will give the tools for designing full pipe hydraulic networks (drinking water distribution networks) and free surface flows (waste water and rainwater collection network). Starting from needs to be met (demand for drinking water or quantities of waste water and rainwater to be stored or discharged), we shall assess the regimes due to flows in terms of flow-rate and piezometric line. Taking into account the distribution and operation restrictions of the systems, we calculate the diameters of optimum piping and the structures which would fulfil the medium-term needs in terms of quantity, and the long-term needs in terms of mechanical and physical-chemical resistance. We shall also discuss the heritage management of the two networks, drinking water supply and collective sewerage, in order to provide better functioning of these two networks.

Expected skill

- To design and size a drinking water, waste water and rainwater network.
- To choose flow equipment.
- To know the construction techniques and the network operation restrictions.

Road infrastructures 1

Code: infrastructures-routieres-1 [road-infrastructures-1]

Description

This first section of the course concerns road and earth-moving methods from a regulatory environmental and technical point of view. The objectives are (1) to present techniques:

materials, constituents and the GTR and (2) initiation into a few practical rules: cubatures, progression of a earth-moving work site, checks (bearing capacity, compactness, etc .). Technology of viability materials, standardisation and classification of aggregates and soils (GTR)

Expected skill

to define the main road earth-moving tasks - to participate in a construction site meeting - to calculate the excavated material-filling equilibrium - to check the installation and compaction of the different structure layers of a pavement

Metrology

Code: metrologie

Description

This course is aimed at defining all aspects relating to metrology, and more particularly starting from the sensor for the value to be measured (measurand) to the user (displayed). This course will rely on basic mathematical concepts, and will offer the students the means to make appropriate choices of sensors for the different applications they will meet in their job. For this reason, the course has to be divided into four parts devoted to:

1. Defining the metrology vocabulary, and the mathematical tools required for assessing sensor performances (example: accuracy, fidelity, standard deviation)
2. Presenting the different types of sensors providing only one measured quantity, whether direct or indirect (example: concept of probes). Presenting the technologies used depending on the types of sensors, and a list of sensors widely used within the framework of professions relating to mechanics, civil engineering and water treatment (examples: manometer, flow-meter, pH meter, strain gauge, probe)
3. The concepts of analogue/digital conversion of signals will also be discussed. This will allow us to introduce the concepts of resolution and the basics of space measurement. This will also be used in extending the course toward the concepts of time resolution for simple sensors (one measured quantity).
4. The last part will concern an extension to the concepts of sensors providing measurement fields (example: Camera, SEM), discussing 2D, 2D ½ and 3D measurement issues through specific examples from the fields concerned (mechanics, civil engineering, water treatment).

GIS Geographic Information System

Code: sig [gis]

Description

This geomatics teaching makes it possible to acquire basics required for using geographic information systems. The concepts of spatial data, digital mapping, creation and building a spatial picture, are discussed through the use of GIS software, and directly applied to real cases

from the environmental field.

Expected skill

To know how to use a GIS - To create and return spatial data as an answer to a practical question

Topography

Code: topographie

Description

Topography is a method for describing a field configuration with all its characteristic points. The elements to be collected have to make it possible to position in space each of these points, aiming at creating a graphical representation, a topographic map. By extension, topography is used to transfer the characteristic elements of a future construction to the field with the aim of building it. We then talk about the layout of structures. Finally, topography is used to follow in time the evolution of elements, whether natural or not, through comparisons between periodically performed topographic readings. This course consists of four sections: 1- General aspects: description of the activity of a geomatics/land surveyor, of the positioning techniques on land and of topography. 2- Levelling: altimetry description, to know how to carry out a direct levelling by using a level, or an indirect levelling using a tacheometer from a closed traverse. 3- Polygonal surface: planimetric description, to know how to create a polygonal surface using the tacheometer from a closed traverse. 4- Project design: reading and establishing a topographic map, carrying out a road layout, estimating the cubatures applied to quarries, to earth-moving and water dams.

Expected skill

- To know the activity of a geomatics/land surveyor.
- To master the field survey techniques (direct or indirect levelling, traverse and polygonal surface).
- To use to topographic instruments, the level and the tacheometer.
- To know how to use Lambert's coordinates.
- To read and establish a topographic map.
- To calculate cubatures (application to road earth-moving, quarry operations, retentions in hydrogeology)
- To regulate a drinking water supply network or a rainwater and waste water sewerage network.

Road networks and various networks

Code : voirie-reseaux-divers [road-networks-various-networks]

Description

The teaching on *voirie et réseaux divers (VRD)* [road networks and various networks] is

provided around four topics: initiation to VRD environment presenting the constituent elements of road networks and the participants in the public domain, a regulatory section on the authorisation for work on road networks (road networks rules, permit, etc.), a supplementary section on the execution of road network work, which presents the different types of existing work, and the methods and the professional rules for carrying them out, and a last part dedicated to financial resources, especially those allocated to communities.

Expected skill

- to understand and decipher the notable elements of road networks and public participants
- to know road networks work and the execution methods
- to know the regulatory authorisations and the financial resources needed for carrying out road work

Alteration of construction materials

Code: alteration-materiaux-construction [Alteration-construction-materials]

Expected skill

- Knowledge on the physical-chemical aspects of hydraulic binders
- To assess pathologies and investigation methods
- Risk assessment
- Preserving and curative methods depending on the severity of disorders

English 4

Code: anglais-4 [English-1]

Description

During this semester, groups will be heterogeneous, and the course focuses on the English-speaking world and on the scientific world. The students will develop their practise of English in relation with new technologies, in order to be able to use it in the professional world. They will have to prepare two substantial talks: research will be carried out so that they can extend their language and professional skills in English, on a hot topic; another review work will be presented on international scientific research, in front of a jury.

Expected skill

- to prepare a professional presentation in English (speaking proficiency + written comprehension),
- to carry out research work (extension of language skills and know-how in civilisation) in order to be able to carry out a review of scientific journals.

Public contract code - MOA [Owner], MOE [general contractor]

Code : code-marches-publics [public-contracts-code]

Description

Public authorities represent major players for implementing purchase policies in the field of public works and water (work, services and provisions). Within this framework, a first part of the course is dedicated to public contracts, and will also present the regulations governing public orders, the different participants (powers and counterpowers), the law regarding public contracting authorities [*loi MOP*], the organisation of competition and the obligations of the Contractors and service providers, general and special contractual documents. Secondly, the execution and contractual management modes for contracts, are discussed; this second part is supported by a constant reference to the repository containing the main French regulations and European jurisprudence. For each part, examples of applications in the fields of civil engineering and water are presented, and a case study shows a concrete example for the content of this course.

Expected skill

- to understand and to know the purchasing rules and modes for public authorities (+ state)
- to discover the repository governing public orders (CMP, CCAG, CCTG, MOP law, etc.)
- to comprehend the legal rules applicable to the public contracts for work and services
- to provide the tools for assessing the regularity of a procedure
- to respond to a call for bids in line with the public contract code
- to become familiar with the decision-making and legal context for granting and executing public contracts
- to anticipate and manage execution and management disputes in public contracts

Environmental law and sustainable development

Code: droit-environnement-developpement-durable [environmental-law-sustainable-development]

Description

This course presents the issues and the objectives of sustainable development. It gives concepts of environmental law by presenting the different players and regulatory texts on the protection of sites, landscapes, natural spaces and certain geographic spaces, on urban planning control, on the general regime of classified installations for environment protection, the law on water and the prevention of natural and technological hazards. This course also discusses the methods used for impact investigations and diagnostic investigations, and environmental management.

Expected skill

- to understand and implement interactions relating to sustainable development
- to interpret regulatory texts and the issues of land use through an interdisciplinary approach to environmental, economic and social parameters
- To learn how to define the technical programmes and the country and town planning to carry out depending on the priority issues of land use, while applying the regulatory texts,

Rainwater management

Code: gestion-eaux-pluviales [rainwater-management]

Description

Rainwater and surface run-off management is an important issue for local authorities in their town and country planning, both for public health reasons (risk of deterioration of surface water quality) and for safety reasons (flood risk). Within a sustainable development approach, industries are also concerned because reusing rainwater for certain purposes saves drinking water. This course discusses the regulatory framework relating to rainwater (town planning, rainwater reuse), rainwater characterisation (pollution), possible depollution treatments, and presents the different methods of quantitative control of rainwater (swales and ditches, draining trenches, infiltration wells, cell structures, dry basin, tank-structure , water retaining roads, storing roofs, etc.). Reusing rainwater in housing (private or collective) is also discussed.

Expected skill

- To know the different alternative techniques in rainwater sanitation

Cross-field project

Code: projet-transversal [cross-field project]

Description

This project is aimed at validating the pedagogic skills of the 1st and 2nd year (speciality and GMC-GTS/TEN study path) of the GEGC diploma. The project will concern the water treatment plant (STEP) (La Folie site) in Poitiers. This project will start by visiting the site, and then the students (in groups of 2/3) will work on a part of the site, in relation to their skills acquired in their speciality and through their study programmes. The groups of students will be able to approach different fields and to complete their knowledge on topography, building, geotechnics, VRD, waste water treatment, the management and maintenance of a STEP, etc.

Heat transfer

Code: transfert-chaleur [heat-transfer]

Description

This course brings general knowledge on the different modes of heat transfer and the associated physical mechanisms. The first part concerns conduction: Fourier’s law, the heat equation, concepts of thermal resistances, contact thermal resistance, thermal capacity. The problems treated concern plane geometries (semi-infinite wall) and cylindrical geometries (pipe insulation, optimisation, etc.). The transient aspect of conduction is treated by introducing appropriate methods (the method of separation of variables). The second part is an introduction to convective phenomena: notion de convective exchange coefficient, Nusselt’s number (forced convection),

Grashof's number (natural convection), most common correlations. The third part concerns thermal radiation transfers: thermal radiation of surfaces, black and grey surfaces. PLANCK's and STEFAN-BOLTZMANN's laws, the concept of form factors, of energy exchange between surfaces with diffuse emission and reflection. De Poljak's method will be presented. The fourth part concerns heat exchangers: introduction to heat exchangers: heat exchanger technology, flow direction, modes of transfer, efficiency and design using the DTlm and NUT methods.

Expected skill

- to qualify heat exchanges by studying a physical phenomenon,
- to quantify heat exchanges,
- to justify the choice of materials from a thermal point of view,
- to design thermal systems,
- to give solutions corresponding to technical specifications,
- To design a heat exchanger depending on the characteristics of a process.

MEE study path

Power electronics 1

Code: electronique-puissance-1 [power-electronics-1]

Description

This course module is aimed at studying DC/DC converters (step down choppers, step up choppers, four-quadrant choppers, flyback and forward power supplies) with their waveforms and their characteristics, and the AC/DC converters (diode bridge, thyristor bridge) with the associated waveforms and characteristics. We shall also discuss a few imperfections of AC/DC converters, such as the overlap phenomenon. The choice of power electronics technology and components (switching diodes, bipolar transistor, the thyristor family (including the GTO and the TRIAC), the MOSFET, the IGBT and the integrated products, etc.), their design, their control and their protection will be studied depending on the intended application.

Expected skill

- to know the operating principles of circuits with choppers and rectifiers,
- to know how to draw the waveforms of output currents and voltages for choppers and rectifiers, and to know how to determine their characteristic quantities (mean value, rms values, etc .).

Identification 1 - Data analysis

Code: identification-1-analyse-donnees [identification-1-data-analysis]

Description

In order to be identified, data acquired by a real-world system have to be analysed beforehand in

order to study their properties and relevance for the intended objective. Thus, after having defined the notion of noise, we shall look at tools for studying the links which could exist between the variables involved, i.e. the correlation and the principal component analysis.

Expected skill

To master the correlation tools, the principal component analysis and spectral analysis.

Data processing

Code: informatique [data-processing]

Description

This module is both a more in-depth study of the first-year and common-core syllabus concepts, and a link with industrial data processing Several types of contents are considered:

- introduction to C language (link between industrial data processing and Arduino)
- advanced concepts of algorithmics and data structure
- advanced use of Python
- introduction to Linux

Expected skill

- to chose the computer tools (equipment, language, OS) in an informed manner
- to have an overall view of data processing and know how to implement it

Mathematics and automatic control

Code : mathematiques-automatique [mathematics-automatic-control]

Description

This module is aimed at reviewing a few concepts required for following the other MEE modules. We shall thus repeat concepts of linear algebra, normalised spaces, probabilities and statistics. We shall also discuss non-linear optimisation basics.

Expected skill

To master classical tools of linear algebra, normalised spaces, statistics and optimisation, aimed at system identification and control.

Electrical engineering 1

Code: electrotechnique-1 [electrical-engineering-1]

Description

This course module repeats in its first part, fundamental concepts of electromagnetism enabling us to study elementary magnetic circuits, and then to present the modelling and the operating

characteristics of single-phase and three-phase transformers. We shall also discuss unbalanced three-phase regimes. Then, in the second part, this course will discuss the modelling and operation of AC rotating machines (asynchronous and synchronous motors). An introduction to the different steps from design using client's technical specifications to the manufacturing of electrical motors is also given, and the characteristics of a few special motors will be presented: stepper motor, variable-reluctance motor, piezoelectric motor, micro motors, magnet synchronous motors.

Identification 1 - Continuous-time identification

Code : identification-1-temps-continu [continuous-time-identification-1]

Description

After presenting a few graphical approaches used to estimate parameters, this part will be first concerned with identification using the linear least squares method, and more particularly the method of state variable filters. Secondly, we are interested in the non-linear least squares method for which the gradient, Newton and Levenberg-Marquardt algorithms will be studied. Finally, the association of the two approaches provides an efficient tool for estimating the performances of systems governed by differential equations.

Expected skill

To know how to estimate the parameters of system governed by differential equations.

Control methods 1

Code: methodes-commande-1 [control-methods-2]

Description

This module is divided into three parts. We are first interested in studying discrete systems using the z-transform. We shall then study different control methods which make it possible to reach, for certain systems, objectives that are unreachable with a simple PID controller. Finally, system representation by a state model is introduced, leading to a full state feedback. Z-transform: this part discusses the study of systems with discrete representation via the z-transform (definitions, theorems, properties, discrete transfer function of a continuous system, linear difference equations), the analysis of discrete representation systems (stability, performance), and the synthesis method for PID-type digital controllers. Study of the different control systems: this course looks at the different control systems currently met. After a short overview on PID-type controller synthesis graphical methods, it discusses the self-tuning principle for these controllers, and that of anti-windup devices. Different control schemes are then studied such as internal model control, Smith predictor and feedforward control. Finally, in the case of discrete systems, we shall study the control by pole placement associated with an RST controller. State-space representation: this course will introduce a new representation of systems: the state space model. More precisely, we will explain its origin, its interest and its main properties. Its links with other classical representations in automatic control such as the transfer function or the differential

equation, will be presented. Once this model is introduced, we shall consider the study of the time-dependent response of state models. We shall thus show how to analyse the stability of such a model. The much less familiar concepts of controllability and observability of state-space representation are then analysed leading us to the control and observation of these systems in the single-variable case. The study of discrete state model will also be briefly discussed.

Expected skill

- To master the z-transform tool and its properties, to calculate the transfer function of a computer-controlled continuous system, to summarize and implement different controller functions (digital PID, RST controller, internal model, Smith predictor, feedforward, etc.).
- To model a linear system as state-space representation, to consider a few linear approximations, to change a base in the state space (change from one realization to another) and change from a realization to the transfer function, to analyse system properties (stability, steady and transient performances) based on a realization, to study controllability and observability of a state space model (according to Kalman's criterion), to apply a state feedback pole placement algorithm.

Industrial data processing

Code: informatique-industrielle [industrial-data-processing]

Description

We shall first examine the basic elements of GRAFCET, its evolution rules and its extensions. The concepts of sequential automatic systems are then applied to programmable logic controllers. After studying the constituent parts of a logical controller, we shall see how to configure and program it using dedicated software. Secondly, we shall study, in the form of a mini-project, the problems linked to micro-controller programming. Finally, a more advanced project will be carried out, in order to emphasise problems relating to data acquisition, quantification and sampling, analogue/digital and digital/analogue converters, etc.

Expected skill

To know the rules of GRAFCET programming; to program a logical controller; to design a rapid prototype based on micro-controller card; to manage a whole industria computing project.

Automatic control project 1

Code : projet-auto-1

Description

The automatic control project 1 is an opportunity to apply the second-year teaching to real-world systems, with a certain autonomy with regard to choosing the methods to implement for controlling these systems. The project will be carried out in three steps: • modelling the process to control, and estimating its parameters • to simulate different control schemes for this system, •

to integrate these control laws into the system by means of rapid prototyping software.

Expected skill

To know how to model the process to control, and estimate its parameters, to simulate different control schemes for this system, to integrate these control laws into the system by means of rapid prototyping software.

Hybrid vehicle/ electrical and automatic

Code: vehicule-hybride [hybrid-vehicle]

Description

This course is an application of modelling and simulation techniques to electrical and hybrid vehicles. We shall present modelling issues, modelling methods and simulation methods for automatic control.

Expected skill

- to know the hybrid vehicle architectures, energy management and modelling,
- to know their components, and especially about energy storage in a battery,
- to simulate hybrid vehicle operation under Matlab/Simulink.

Electromagnetic compatibility

Code: compatibilite-electromagnetique [electromagnetic-compatibility]

Description

After having defined the notion of electromagnetic compatibility (EMC) and the standards, this course introduces conducted, radiated and electrostatic disturbances. We shall then study the couplings associated with different disturbances. This course will then continue with studying protection techniques in the field of EMC (special wiring, various shieldings, harmonic characterisation, active filters, passive filters), immunity tests and equipment performances with regard to EMC;

Expected skill

- to know the standards used in EMC,
- to know the different solutions of EMC protection.

Electrical engineering 2

Code: electrotechnique-2 [electrical-engineering-1]

Description

This course is aimed at presenting the speed control principle of a DC machine and AC

machines. This course introduces dynamic-regime modelling of AC electrical machines (synchronous and asynchronous machines) and the vector control principle used in speed control. To this end, we are shall review the concepts of energy conversion and we shall define the direct-quadrature-zero transformation applied to asynchronous and synchronous machines. Finally, we shall discuss a few special applications to speed control in AC electrical machines.

Expected skill

- to know the speed control principle of a DC machine
- to know the dynamic-regime modelling of synchronous and asynchronous machines
- to master the direct-quadrature-zero transformation
- to know the automatic piloting and vector control principle of a synchronous machine
- to know the scalar control and vector control principle of an asynchronous machine

Identification 2

Code: identification-2

Description

The study carried out in the Identification 1 module related to the least squares approach for systems governed by differential equations. This second part will discuss discrete systems governed by difference equations. After reviews and definitions on the identification methods with equation-error and output-error, this course is devoted to studying the properties of estimators, especially the estimation error, the bias and the estimation variance. The study of these different properties is used to introduce bias reduction or elimination techniques using equation-error approaches such as residue filtering techniques (generalised least squares (GLS), extended least squares (ELS), maximum likelihood estimation (MLE) approaches, etc .) and the method of instrumental variables. Finally, we shall look at the estimators' precision.

Expected skill

- To master the analysis tools used for studying algorithms,
- to master the present of the algorithms presented, and their implementation,
- to analyse an algorithm which was not studied in class.

Power electronics 2

Code: electronique-puissance-2 [power-electronics-1]

Description

This course is aimed at studying single-phase and three-phase DC/AC converters with their different controls (full wave, Pulse-width modulation (PWM), space-vector PWM), AC/AC converters with their structures and controls (wave form and phase angle dimmers), the influences of conduction losses in DC/DC converters, at using average equivalent models in DC/DC converters, the principle and characterisation of soft switching in static conversion

(quasi-resonant switched-mode power supplies, resonance inverters).

Expected skill

- to know the operating principle of DC/AC and AC/AC circuits,
- to know how to draw the waveforms of output currents and voltages for DC/AC and AC/AC circuits, and to know how to determine their characteristic quantities
- to know the operating principle of quasi-resonant switched-mode power supplies.

Control methods 2

Code: methodes-commande-2 [control-methods-2]

Description

Optimum control: this course will present the theoretical basics of optimum control, focusing more specifically on a case relatively widespread in practice: the optimum control theory of multivariable linear systems. In order to introduce this special case of a more general theory, the course firstly discusses optimum control as it was initially stated. This approach is used to emphasise the main mathematical tools used by the calculus of variations, and to introduce optimality required and sufficient conditions. We shall then consider the problem of linear system control in the hypothesis of a space state vector measured in a deterministic context. We shall then discuss the problem of the state space vector estimation in a stochastic context. More specifically, we shall present the continuous (and discrete) Kalman filter. Finally, we shall discuss the linear-quadratic- Gaussian control. Predictive control: this course will present the theoretical basics of model predictive control. After having introduced the preliminary concepts required for implementing this technique, the course will define the four principles on which it relies, namely the internal model, the reference trajectory, the calculation of control algorithmics and the notion of automatic compensator. We shall study the implementation of model predictive control, in particular the determination of an explicit solution, taking into account constraints in the control law, obtaining an implicit solution, the equivalent linear regulator, the adjustment properties underlying the performance and stability criteria, and the performance/robustness compromise. The second section of the course discusses system modelling (V-model, modelling approach, hierarchical decomposition of a system, the different representations of a physical system, numerical simulation, validation, etc.) Application of automatic control to electrical engineering this course discusses energy control in electrical networks and presents more particularly FACTS (Flexible Alternative Current Transmission System) modelling and control for electrical networks.

Expected skill

To design a Luenberger observer (minimum order) or a full order (Kalman) observer, to combine pole placement and full order observer methods in order to propose a state feedback control law. To state a quadratic control problem, i.e. to specify the form of the cost function to minimise, corresponding to the control problem considered, to solve finite- and infinite-horizon LQ problems using Ricatti’s differential and algebraic equations, to build a continuous-time Kalman

filter. To know the basic principles of a model predictive control, to implement this technique into academic examples, to adjust its parameters at least in the nominal case, to position the method with respect to other control methods, to apply these approaches to numerical simulation.

Automatic control project 2

Code : projet-auto-2

Description

The automatic control project 2 is an opportunity to apply the teaching received during the previous year to real-world systems, with a certain autonomy with regard to choosing the methods to implement for controlling these systems. The project will be carried out in three steps:

- to model the process to control and estimate its parameters,
- to simulate different control schemes of this system,
- implement these control laws into a system using a rapid prototyping software.

Expected skill

- to model the process to control and estimate its parameters,
- to simulate different control schemes of this system,
- implement these control laws into a system using a rapid prototyping software.

Electrical energy management and quality

Code: gestion-qualite-energie-electrique [electrical-energy-management-and-quality]

Description

This course module is divided into two parts. The first part consists in analysing energy transfers taking place within a mini-network consisting of stand-alone electrical system including various means of production (photovoltaic generator, portable generators, wind turbine, even a fuel cell) and stand-alone, and in giving design elements for these means of production and storage aimed at improving their reliability while increasing their energy efficiency. After having introduced the main disturbances that could degrade the quality of electrical power in a network, the second part of the course is devoted to describing the phenomena involved and to presenting the standards and regulations on electrical power quality and environmental protection. Finally, it will present solutions for improving the quality of electrical power (power factor correction, active filter, etc.).

Expected skill

- to know the different means of energy storage.
- to master the design of these means of production and storage,
- to know the control strategies of multi-source systems,
- to know the different sources of disturbances for electrical networks,

- to know the different solutions for improving the electrical power continuity and quality
- to know the standardisation in vigour and the verification procedures for electrical power quality.

Electrical accreditation

Code: habilitation-electrique [electrical-accreditation]

Description

Raising awareness of electrical hazards. Theoretical and practical training for electrical accreditation for the B1V (worker) and BR (qualified manager) levels.

Expected skill

B1V and BR accreditation levels.

Computer and industrial networks

Code: reseaux-informatiques [computer-networks]

Description

This course is organised around two main themes: Local industrial networks and TCP/IP networks.

Within the framework of **local industrial networks**, we shall look at network architecture, transmission supports and data transmission methods. We shall also discuss the access modes to these supports and the means of management of transmission errors. Finally, we shall study communication protocols in vehicles and field networks in industrial environments.

The course on **TCP/IP networks** will present the OSI reference model and the TCP/IP layer model, and internet protocols (TCP/IP family: IP, TCP, UDP, etc.). The application layer protocols (POP, SMTP, HTTP) will be studied, along with network interconnection, routing, network security and encryption methods.

A few seminars given by external guests complete this course.

Expected skill

- To know the communication protocol for vehicles and field networks
- To know the TCP/IP stack
- To program network applications (client or server)

EI study path

Power-to-Heat

Code: electrothermie [power-to-heat]

Description

This course is an introduction to power-to-heat. After a review of electromagnetic waves and Maxwell's equations, we shall discuss the following different methods: heating by electrical conduction, heating by electromagnetic induction, heating by infrared radiation, high-frequency and microwave heating, laser beam heating. The course will be supplemented by numerical projects on practical subjects, done in small working groups. This course will enable the students to discuss multi-physics and multi-scale modelling.

Expected skill

- to raise awareness with regard to the different existing power-to-heat methods.
- to see through to its end, a numerical project based on multi-physics and multi-scale modelling.

Fluid mechanics 3

Code: mecanique-fluides-3 [fluid-mechanics-3]

Description

The course consists of three parts. The first part reviews conservation concepts seen during the first year, and it extends to energy balances. The second part is dedicated to studying the laminar boundary layer. After analysing the mechanisms involved, writing their equations leads to Prandtl's and integral equations. The rest of the chapter is dedicated to studying the characteristics of boundary layers (thickness, displacement thickness, momentum) thickness and refined solutions (Blasius solution without pressure gradient). Finally, we shall study in detail the analysis of a pressure gradient. The last part of the course is an introduction to turbulent flows. Reynolds equations are discussed in detail, and a few applications are presented (flows through pipes, boundary layers).

Expected skill

- to acquire knowledge about laminar or turbulent viscous fluids
- to be able to determine the size of the forces applied by a fluid on a solid, using conservation equations,
- to analyse the properties of near-wall flows,
- to be able to establish Reynolds equations.

Moist air course

Code : physique-air-humide [moist-air-course]

Description

This teaching is about studying air in the presence of humidity. The introduction will show the necessity of taking into account air humidity when we want to treat it in different environments. We shall then describe moist air physics and the different quantities used in air treatment.

Conservation equations (mass/humidity/energy) and moist air diagrams will then be presented. In a second part, we shall study the characteristic evolutions of moist air: heating, cooling, humidification, dehumidification, etc. These concepts will then be applied to air handling units.

Expected skill

- To acquire basic knowledge on moist air.
- To be able to describe the thermodynamic evolution of moist air for all types of transformations
- To master the use of a moist air diagram

Thermodynamics of reactive mixtures

Code: thermodynamique-melanges-reactifs [thermodynamics-of-reactive-mixtures]

Description

This course on the thermodynamics of reactive mixtures is the basis of combustion. It is thus aimed at introducing concepts for:

- defining an overall reaction: chemical species (fuels, oxidants), reagents, products, stoichiometry, equivalence ratio and smoke-developed index.
- to characterise a reactive mixture: dilution, richness, excess air, etc.
- to calculate the energy properties of a fuel; reaction enthalpy, heating values, adiabatic flame temperature.
- to determine the concentration of minority species (pollutants) in combustion products: combustion diagrams, chemical equilibrium.

The application of these concepts is carried out by using numerical tools: calculations of chemical equilibria, of adiabatic flame temperature, and during practical classes (overall analysis of the operation of a chemical equilibrium boiler, calculation of the powers involved, smoke analysis, use of combustion diagrams).

Expected skill

- to balance a combustion reaction and to determine its characteristics: stoichiometry, equivalence ratio and smoke-developed index.
- to calculate the composition of a reactive mixture and its characteristics: richness, excess air.
- to estimate the quantity of energy and the chemical species involved in a combustion,
- designing an industrial burner and a household boiler.

Solar power [advanced course]

Code: energie-solaire-2 [solar-power-2]

Description

This course is a supplement to the initiation course on solar power. It is aimed at training students in renewable energy of solar origin: overview of the solar resource, measurement of the solar flow with pyranometers and pyrheliometers, comparison with semi-empirical relations. The students will then choose a subject for a project. This can be studying a flat solar panel, an enclosed trough, a parabolic trough, a solar chimney or a distiller, etc. This type of project includes a modelling part and a practical part which can go as far as producing the installation.

Expected skill

To install devices converting solar energy into heat.

Fluid mechanics - Turbulence

Code: mecanique-fluides-turbulence [fluid-mechanics-t]

Description

This course is dedicated to studying turbulence: a first part presents the instability mechanisms present in fluid flows. The main part of the course will first present the use of Reynolds equations governing turbulent flows. Secondly, a physical analysis will be used on examples of generic flows (channel flow, jets, wakes, boundary layer, etc) for deriving the characteristic properties of these flows (profiles, friction, etc.) The last part of the course is devoted to modelling: after establishing the different balances, we shall present the main turbulence models, insisting on their particularities of each of them. The teaching is supplemented by practical classes in a wind tunnel, enabling students to put into practice the acquired knowledge and to be initiated in metrology in fluid mechanics (hot wires, LDV, Pitot tube, etc.)

Expected skill

- to analyse the stabilising or destabilising effects within a flow,
- to analyse a turbulent flow by comparing it with its laminar equivalent,
- To know the advantages and disadvantages of the different turbulence models and to chose one depending of the problems studied.

Heat transfer - Natural and mixed convection

Code: transfert-chaleur-convection-naturelle-mixte [heat-transfer-natural-mixed-convection]

Description

This course is an introduction to heat transfer by natural and mixed convection (housing, people, fins, etc .). The first part will set the phenomenological basics of natural convection on a vertical flat plate under laminar flow: equations, Boussinesq’s approximation, orders of magnitude, characteristic numbers (Gr, Ra), resolution by refined methods, resolution by integral methods, exchange coefficient, main correlations at constant temperature of flow density. This aspect is supplemented by an analysis under turbulent flow: turbulence effect, turbulent boundary layer,

effects and applications. Other geometries will be studied in free space: inclined walls, horizontal plates, cylinders, spheres, turbulent thermal plume, etc or in a confined space (heat exchanger fins, housing). Finally, the module will end with an introduction to mixed convection (phenomenology, characteristic number, Ar, Ri), either external (cylinder, immobile flat plate, flat plate in motion), or internal (vertical or horizontal tube).

Expected skill

- to analyse physical phenomena and to determine convective flow,
- to identify correlations appropriate to the problem encountered,
- to accurately calculate characteristic parameters: mean temperature, exchange characteristics, exchanged power, etc.
- to solve actual problems: cooling in micro-electronics, thermal comfort in housing, etc.

Energy storage and conversion

Cod : conversion-stockage-energie [energy-storage-conversion]

Description

This teaching is dedicated to renewable energy conversion and storage by the hydrogen carrier. Indeed, renewable energies, intermittent by their nature, require the development of an energy storage infrastructure appropriate in size and need. One of the ideas considered is the conversion of solar- or wind-origin origin electricity into hydrogen. We shall present the advantages and disadvantages of the hydrogen carrier. The different elements of the chain are presented in detail, from the electrochemical cell scale (component materials, structuring, electrochemical potential, heat transfer, charge transfer and material transfer) to the system scale (electrolysis principle, fuel cell, gas, liquid and solid storage of H2)

Expected skill

- Operating principle of electrolysis and fuel cells,
- Energy balances of electrochemical systems,
- Design calculations of a hydrogen carrier chain,
- Analysis/Critical comment on the present and future energy mix.

Machines using inert fluids

Code : machines-fluides-inertes [machines-inert-fluids]

Description

This teaching supplements the knowledge acquired in the Heat engines module. The analysis of cycles is deepened in order to illustrate the energy issues of machines using inert fluids (without combustion), gas or steam and with change of state, in particular by a thorough exergy analysis: specific cycles are analysed (overheating, sampling, with sliding, etc.). This course thus concerns machines such as steam engines, dryers, air conditioners, refrigerating machines and

compression heat pumps, absorption machines. Gas and steam cycles are subject to energy and exergy studies (efficiency, specific consumption, etc .).

Expected skill

- To know how to identify and analyse the cycles of machines using inert fluids (without combustion), gas or steam, whether with our without change of state,
- To quantity the energies involved, and to assess the energy issues of these real-world machines by an thorough exergy analysis.

Machines using reactive fluids

Code: machines-fluides-reactifs [machines-reactive-fluids]

Description

This course is supplementing the modules, Thermodynamics of reactive mixtures and Heat engines. Based on combustion, it discusses the details of the operation of internal combustion engines: general aspects, block diagram, classification, schematic operation, 2-stroke cycles, 4-stroke cycles. Theoretical and applied cycles, simple or mixed internal combustion motors [MACI] are described in detail: Beau de Rochas, Sabathé, and Diesel cycles, calculation of energy and exergy efficiencies, specific consumption and mean pressure. Combustion gas turbines will also be presented in a separate chapter: operation analysis, calculation of effective work, thermal and energy efficiency, specific consumption - estimated depending on the different parameters such as pressure ratio and fuel mixture dilution. Recovery cycles will be reviewed and analysed, and we will assess the different cogeneration methods from these turbines. This course will finally discuss the problems of turbine cycles in aeronautics.

Expected skill

To know how to understand and how to describe the operating steps of an internal combustion engine, to quantify the elementary steps of MACI's cycles: energy, power, mechanical work, to calculate the overall characteristic parameters of MACIs (efficiencies, consumption) in terms of energy and exergy, to solve real-world industrial problems using combustion gas turbines, cogeneration methods.

Material transfer

Code : transfert-matiere [material-transfer]

Description

Conservation equations are presented in their integral form, and then in local form. The main modes of transfer will then be presented: permanent flow diffusion in different media (solid, liquid, gaseous) without any chemical reaction; diffusion in the presence of homogeneous chemical reactions (volume reactions); diffusion in the presence of heterogeneous chemical reactions (surface reactions); diffusion in under non-permanent flow (concentration jump and

diffusion impedance); diffusion in a non-isothermal medium. We shall then discuss material transport in electrolytes, especially the mode of transfer by migration. The second part of this module will discuss material transport by convection using semi-empirical correlations. We shall also present concepts on turbulent material transport. The similarity between material transport phenomena and heat transfers will also be discussed. The third part will be devoted to studying the formation of diffusion layers by solving diffusion-convection equations. The different problems discussed are the following: gas solubility in a flowing liquid film, material transfer in tubes (established hydrodynamics) and near a plate (non-established hydrodynamics). These concepts will be applied during practical classes.

Expected skill

- to acquire knowledge about the main mechanisms of material transfer,
- to identify the different transfer modes and the associated physical phenomena, whether with or without a chemical reaction,
- to master the use of semi-empirical correlations,
- to understand how to solve diffusion-convection equations in the boundary layer approximation, and master the hypotheses used.

Fluid mechanics - Turbulent transfers

Code: mecanique-fluides-transferts-turbulents [fluid-mechanics-turbulent-transfers]

Description

In order to supplement the teaching of fluid mechanics in turbulent flows, we shall study turbulent flow transfers, theoretically and through applications. The course will thus discuss: turbulent thermal plumes, free turbulent flows under forced convection, turbulent transfers in near-wall flows. At the modelling level, the most advanced turbulence models and taking into account thermal effects will be presented in detail, emphasising their advantages and their disadvantages (stability, calculation time, precision, etc .).

Expected skill

- to calculate heat transfers generated by turbulent flow, using balance laws,
- to analyse the role of turbulence on these transfers, to know different classes of statistical models (RANS), the underlying simplifying hypotheses, their advantages and disadvantages,
- to understand the physical mechanisms governing the evolution of turbulence, and the reasonings leading to their modelling,
- to understand the modelling approach (physical and mathematical constraints) of turbulent heat flows and transport equations

Numerical methods 2 (EI) - Direct and inverse problems

Code : methodes-numeriques-2-ei [numerical-methods-2-ei]

Description

This teaching is aimed at teaching engineers to master various numerical methods and simulation techniques for solving realistic problems which cannot be solved by analytical methods. Applications consist of solving actual problems involving physical and mathematical concepts acquired from other courses. This course material relies on i) a lecture and ii) a set of problems to solve in the form of homework on computer (exercise sessions and individual work). Depending on the study paths followed, the topics treated discuss an introduction to optimisation, the state-space representation, solving diffusion equations, diffusion transport, Navier-Stokes, the wave equation, the discretisation methods in complex geometry, non-structured finite volumes, finite elements, etc .). Moreover, this course is an introduction to the methods used to solve inverse problems in conduction and thermal radiation. Regularisation techniques (SVD, Tikhonov, etc.) will also be discussed. The course is illustrated by examples taken from industrial applications (e. g., identifying boundary conditions in extreme situations).

Expected skill

- To know how to solve inverse problems in conduction and thermal radiation using regularisation methods and techniques.
- To know the numerical simulation techniques and programming in science calculus.

Heat transfer - Thermal radiation 2

Code: transfert-chaleur-rayonnement-thermique-2 [heat-transfer-thermal-radiation]

Description

This course is an introduction to thermal radiation in non-isothermal semi-transparent media. A first part concerns the introduction of fundamental concepts (luminance, absorption, diffusion, radiative flow vector, radiative transfer equation, etc.). Different solving methods are then discussed: semi-analytical methods, PN method, discrete ordinate method, Monte-Carlo method, etc. Finally, the coupling between radiation and conduction and/or convection is discussed.

Expected skill

- Skills:
- To acquire knowledge in the field of thermal radiation in semi-transparent media,
- To write and solve the equations for coupled transfer problems (radiation / conduction ; radiation : convection).

Promotion of innovating projects

Code: valorisation-projets-innovants [promotion-innovating-projects]

Description

This module is aimed at initiating the students in the development of an innovating technical, technological or scientific project. It is divided into two approaches. The first is oriented towards

feasibility studies, initiation in searching for research financing (Oseo, Feder, private funding, public funding), thinking about the industrial potential, company setting-up, budgeting, estimating the added value compared to an initial project, etc. The second consists in giving a general view on project management and methods for seeing an innovative project through to a successful end. The module is taught by a professional from the innovation field. The students are divided up into groups which carry out a mini-project in a given time, and then give a presentation on the result.

Expected skill

- to be able to implement and promote an innovative project in technical and technological fields,
- to be able to search for possible financing sources for the financial plan of the project, and provide sustainability for the project they will manage and lead.

Energy analysis

Code: analyse-energetique [energy-analysis]

Description

It concerns giving the basics of energy analysis. A first part will discuss energy balances in the present world, available sources of energy (primary sources of energy: present situation and trends; fossil and renewable energies). The second part is more oriented towards energy consumption: industrial needs, energy conservation and energy carriers, heat and cold production, analysis of the main consumption items, globally or regionally. Finally, a last part will be devoted to identifying the different approaches for carrying out an analysis of relevant data, and to implement an energy analysis: energy transport, energy storage, energy losses, exergy, life cycle analysis, energy risks, environmental constraints.

Expected skill

- to understand and identify the economic, scientific and environmental issues relating to energy,
- to carry out an effective energy analysis.

Combustion in industrial environment

Code: combustion-milieu-industriel [combustion-industrial-environment]

Description

This course is aimed at providing a knowledge base on the combined complexity of reactive system, relating to the coupling between many parameters, involving chemical, thermal and fluid dynamic aspects. We shall discuss the main types of flames: pre-mixed flames, diffusion flames, self-ignition mechanisms, detonation. We shall describe the chemical kinetics of a combustion reaction. Two scalar variables will be introduced: one passive (mixture fraction) describing the

state of the mixture between the fuel and the oxidant, and one reactive (completion rate) describing the evolution of the chemical reaction. We shall study the internal structure of flames: pre-mixture and diffusion. Flame behaviour in a flow is studied in detail: propagation, mixture, expansion, etc. The aim is to be able to describe the behaviour of a mixture of reagents in real-world situations (boilers, turbines, fires, accidental explosions) through the study of simplified flow. The equations describing the evolution of momentum, temperature, and chemical species, are introduced and implemented using numerical tools: 1D calculations of flame structures (whether pre-mixed or not), (0D) calculations of detailed reaction mechanisms, or CFD calculations for complex configurations: gas turbines, burners, etc. An introduction to turbulent flow combustion will be the final section of this course.

Expected skill

- to acquire understanding, modelling and metrology tools appropriate for often very complex turbulent reactive flows
- to quantify the thermal, chemical and dynamic effects of reactive flows in industrial environment,
- to optimise real-world industrial burners (emitted species, energy produced).

Heat exchangers - performances and optimisation

Code: echangeur-de-chaleur [heat-exchanger]

Description

We shall review first the general aspects and the identification of architectures (industrial heat exchangers: tube, shell, plates, sealing strips, coils, compact, phase-change heat exchangers). In the second part, we shall review the design and performances of single-phase heat exchangers (logarithmic mean temperature difference DTlm, NUT, efficiency) co-currents, counter-current, in series, in line, in parallel series. We shall then discuss the optimisation of a heat exchanger and of the means of intensifying exchanges: geometry, materials, clogging. Exchanger networks will also be studied: general aspects, meshed networks (application to tubular exchangers), concepts on multiple-current networks -application to a cogeneration heating circuit in the nuclear field, etc .) ; cross flow exchangers. Finally, the last part of this course will discuss phase-change exchangers: principle, evaporators, condensers, heat pipes, two-phase loops, etc ., and case studies will support these theoretical courses. An analysis of the available experimental devices within our research laboratories will be subject to application work. The teaching is supplemented by talks given by specialists (industry and research) and a project in the field.

Expected skill

- to identify the different topologies of heat exchangers or heat exchanger networks,
- to be able to choose and design compatible heat exchangers appropriate for the targeted industrial sector.

- to develop appropriate modelling tools.

Rational use of energy - project

Code: projet-ure

Description

In groups of two or three, the students will carry out a bibliography review around a topic relating to the rational use of energy. The project subject will be proposed, defined and supervised by teachers from the university, in relation to industry or applied research. This review will be the subject of a written dissertation and of a talk. As examples, we can cite a few recent dissertations: Carbon catching and storage; Cold plasmas: general principles and applications; Radioactive waste production and treatment; Smart glass: principle, use and perspectives; Micro-Electro-Mechanical Systems (MEMS); Vertical-axis wind turbines: concepts, problems, retained technological solutions.

Expected skill

- To know how to carry out a bibliographic search relating to a scientific or technical topic by finding relevant articles on a subject of interest for an engineer, through university, traditional or internet databases,
- To know how to implement a regulatory or technology watch,
- To draft a summary report on a subject proposed from a bibliographic search including at least 15 papers published in peer-reviewed journals,
- to know how to render the review work carried out in a multi-media presentation,
- students are expected to increase their speaking and arguing ability in a presentation on a scientific or technical subject.
- to master the tools required for scientific communication and information.

Wind power [advanced course]

Code : energie-eolienne-2 [wind-power-2]

Description

This second module on wind power will give more advanced concepts and extend the knowledge acquired in the general module. Two directions will be presented: the aerodynamics of a wind turbine and production assessment. For the first topic, the aerodynamics of a wind turbine is described in detail: motor disc, lifting-line, fluid/structure interaction, aeroacoustics, etc . For the second point, resource assessment needs: to carry out a wind assessment, to model a wind turbine, to assess the resource using Wasp software. This course will also present models, and will be supplemented by numerical modelling, practical applications on test benches, and talks on small wind turbines given by a specialist in the field.

Expected skill

- to have the culture required for designing a wind turbine (aerodynamic aspect),
- to know how to estimate the electrical production coming from the operation of a wind turbine,
- to know how to use modelling tools appropriate to these energy problems.

Geothermics

Code: geothermie

Description

This module consists of different talks and technical days of presentation and introduction to hydraulic and geothermal energies. As for the hydraulic energy, it supplements the teaching on turbomachinery devoted to turbines, it presents resources, the development of the industry, in particular in terms of micro-turbines, or presents innovation in terms of marine energies, etc .). As for geothermics, different modules will be presented: context, different forms, technical problems, resources, catchment, uses, outputs, etc. In both cases (hydraulics and geothermics), these talks are accompanied by case studies which can serve as a base for a project tutored by a industry person skilled in the field.

Expected skill

- To become aware about the production of hydraulic and geothermal energy, and about the methods used,
- To know how to integrate a development project on hydraulic or geothermal renewable energy.

Nuclear energy and safety

Code : energie-nucleaire-securite [nuclear-energy-safety]

Description

This module is divided into two parts. The first part is aimed at giving the engineering students the means of understanding the steps in producing nuclear energy: radioactivity mechanisms, radioactivity in the environment and effects on the living, reactor operation, nuclear energy industries, reactor safety, upstream of the fuel cycle (deposit and enriching), downstream of the fuel cycle (treatment and burying); reactors of the future, 4th generation reactor. The second part of the module is rather oriented towards fire safety in the nuclear field. This teaching is aimed at improving the basic knowledge in terms of fire safety of industrial facilities (warehouse, tunnel, air terminal, building, ventilation system, etc .) and more particularly in the nuclear sector. It is provided by specialists in the field (*Institut de Radioprotection et de Sûreté Nucléaire IRSN* and *CNRS*), concerning both experimental and modelling aspects. It concerns describing physical phenomena me in a compartment-divided fire, presenting experimental approaches and prediction and simulation tools. It is supplemented by a presentation of the codes appropriate for

this type of problem. This teaching consists of talks and a project assisted by a FDS (Fire Dynamics Simulator) field code.

Expected skill

- to know the principles of present and future technologies for nuclear energy productions,
- to know how to identify and analyse fire risk in a severe industrial environment like the nuclear environment,
- to know how to use a field code for simulating the potential development of a fire.

Initiation to CFD software

Code: initiation-cfd

Description

This module should serve as a support for showing the practical advantages numerical modelling has for engineers. It concerns the field of fluid mechanics and of heat transfers in a broad sense (conduction, convection, radiation). Talks given by specialists in the field of numerical modelling will complete the initiation in the so-called commercial steady-flow and transient-flow CFD software previously cited. The interest is to initiate students in one or more of these software (stability of numerical schemes, convergence criterion, influence of meshing, etc .) and to use them within the framework of a PFE module.

Expected skill

- to know how to develop a simplified modelling for an actual industrial problem,
- to be able to identify CFD commercial software and their specificities (mesh generator, required operation system, solving method, etc .), in the field of fluid mechanics, of thermal science in a broad sense or in combustion.

Heat transfers with change of phase

Code: transferts-thermiques [heat-transfers]

Description

After a general introduction and emphasising the interest of these problems (examples of application: thermal storage, interface materials, metal deposition, fusion at the reactor's core, freezing in dispersed environment, etc .), the course is divided into three parts: 1- analysis of transfers by solidification/fusion: fundamental aspects, concept of movable interface, change of state with purely conductive transfer or conduction/convection coupling, solidification of multi-component mixtures; 2- boiling: boundary conditions at the interface, thermophysical properties and adimensional number specific to boiling (Jacob, Bond, Weber), boiling modes (in a vessel, under external forced convection, under internal forced convection, two-phase flow); 3 condensation: different configurations and condensation modes: surface, volume, drops, jets, fog. etc . ; condensation on film on vertical plate in laminar flow (theory, simplified Nusselt) model ,

extension to wavy turbulent flows, condensation on radial systems: sphere or tube, condensation on film in horizontal pipes (application to exchangers), condensation in droplets.

Expected skill

- to know how to identify industrial problems involving heat transfer mechanisms with change of state or change of phase,
- to be able to qualify mechanisms during a change of state, to quantify its associated heat transfers (boiling, condensation, evaporation, solidification, fusion, etc.),
- to be able to solve using different methods (analytical, numerical, etc .) complex problems involving these phenomena.

EAT study path

Fundamental acoustics

Code: acoustique-fondamentale [fundamental-acoustics]

Description

This course will present the wave propagation equation and will define the speed of sound. Plane wave and spherical wave solutions will be specified. The concepts of acoustic impedance and transmission phenomena will then be discussed; the case of several media and the application derived from it (mass law) will be presented. The propagation of sound waves in a guided medium (pipes and cavities) will be discussed, first in the low-frequency approximation, and then without any frequency limitation, and the main applications will be studied: impedance tube, acoustic filters, resonators, transverse modes, cut-off phenomenon. This course will be supplemented and illustrated by practical classes and talks on environmental acoustics.

Expected skill

- to know the different physical quantities related to acoustics, and to know how to measure them,
- to master the basic concepts and concepts of acoustics,
- to know how to solve a problem of physical acoustics in an academic situation.

Fluid mechanics 3

Code: mecanique-fluides-3 [fluid-mechanics-3]

Description

The course consists of three parts. The first part reviews conservation concepts seen during the first year, and it extends to energy balances. The second part is dedicated to studying the laminar boundary layer. After analysing the mechanisms involved, writing their equations leads to Prandtl's and integral equations. The rest of the chapter is dedicated to studying the characteristics of boundary layers (thickness, displacement thickness, momentum) thickness and

refined solutions (Blasius solution without pressure gradient). Finally, we shall study in detail the analysis of a pressure gradient. The last part of the course is an introduction to turbulent flows. Reynolds equations are discussed in detail, and a few applications are presented (flows through pipes, boundary layers).

Expected skill

- to acquire knowledge about laminar or turbulent viscous fluids
- to be able to determine the size of the forces applied by a fluid on a solid, using conservation equations,
- to analyse the properties of near-wall flows,
- to be able to establish Reynolds equations.

Moist air course

Code : physique-air-humide [moist-air-course]

Description

This teaching is about studying air in the presence of humidity. The introduction will show the necessity of taking into account air humidity when we want to treat it in different environments. We shall then describe moist air physics and the different quantities used in air treatment. Conservation equations (mass/humidity/energy) and moist air diagrams will then be presented. In a second part, we shall study the characteristic evolutions of moist air: heating, cooling, humidification, dehumidification, etc. These concepts will then be applied to air handling units.

Expected skill

- To acquire basic knowledge on moist air.
- To be able to describe the thermodynamic evolution of moist air for all types of transformations
- To master the use of a moist air diagram

Radiometry and photometry

Code: radiometrie-photometrie

Description

The course will present different quantities (flux, intensity, illuminance, luminance), and their units. Changing from radiometric to photometric quantities makes it possible to define the luminous efficiencies of a radiation, of a source of light, or more generally of source of lighting. The metrology aspects, in particular measuring devices (lux meter, luminance meter, spectrophotometer, goniophotometer, integrating sphere) will also be presented. We shall also discuss the usage factor and the UGR. A significant part of the tutorial classes will be devoted to the application of Beer-Lambert (Bouguer) law, i.e. to illuminance calculations knowing the intensity polar diagram for point sources or the polar luminous intensity graph for wide sources.

The particular case of Lambertian secondary sources will be studied.

Expected skill

- to be able to identify and use photometric data in technical documentation (spectrum, total flux, luminous efficiency, intensity polar diagram);
- to know how to carry out any type of photometric calculations in the field of lighting;
- to know the hypotheses used by lighting design software (point primary sources, Lambertian secondary sources), to be able to check and discuss results provided by such software;
- to know how to draft technical specifications and propose technical solutions for lighting projects.

Building acoustics

Code: acoustique-bâtiment [building-acoustics]

Description

The course is devoted to presenting acoustic materials and the concepts of acoustic absorption, insulation and correction in housing and industry, and of structure-borne noise. We shall then discuss exterior propagation of acoustic waves, and we shall do application exercises with Acoubat (software). This course is divided into 6 sections:

1. The first section will review the definitions and issues of acoustics in building: sound, noise, sound production, acoustic pressure, decibel, scale of sound levels, frequency, spectrum, octave, frequency weighting, white noise, pink noise, measurement of acoustic pressure.
2. Absorption: absorption mechanisms, absorbing materials, absorption coefficients, reverberation, acoustic correction, equivalent absorption area, Sabine's formula, noise reduction.
3. Insulation: general information on acoustic materials, rate of acoustic transmission, examples of R values, theoretical mass law - normal incidence & oblique incidence, experimental mass law, simple walls - critical frequency, multiple walls - critical frequencies & resonance frequencies, wall linings, walls with opening, acoustic insulation, sound reduction index, unique in-situ indices, pink noise - roadway noise, calculation of DnTw and of the C and Ctr terms, provisional calculation of DnTw+C.
4. Structure-borne noise: measurements & impact machine, calculation method for L'nTw, prediction of L'nTw, transmission channels, floating screed, floor coatings, structure-borne noise from equipment & sound-borne transmission, railway structure-borne noises.
5. Environment & Regulations
6. Simulations

This programme is supplemented by three talks given by specialists on environmental acoustics and noise-control policy.

Expected skill

To be able to treat a problem of building acoustics.

Colorimetry

Code: colorimetrie [colorimetry]

Description

Colour temperature and the colour rendering index of source lights are important parameters in the field of lighting, and they give an indication of the quality of light. This course is aimed at defining different concepts relating to colour measurement such as: reference illuminants, chromaticity diagrams ((x,y), (u',v')), the dominating wavelength and the excitation purity, CIELAB and CIELUV colour spaces. We shall present the methods for determining the colour temperature and the colour rendering index for sources of light, and the new emergent methods (IES) for defining the fidelity index (Rf) and the gamut index (Rg) of the current light sources. This programme is illustrated by four practical classes focusing on: photometric measurements (luminance, illuminance, reflection index measurements), colorimetric measurements (colour temperature, CRI, Rg, Rf) for different types of lamps (fluorescent tubes, discharge lamps, LEDs), for different object colours (colour discrimination), and finally by the use of an image editing software (Photoshop) for lighting rendering and the presentation of lighting projects. The programme will be supplemented by talks given by professionals on light design and interior lighting.

Expected skill

- to determine the three-colour coordinates of a colour stimulus;
- to calculate the difference in calculated between two coloured objects;
- to determine the colorimetric characteristics of light sources -colour temperature, colour rendering index, fidelity index, Gamut index)

Lighting technology

Code : technologie-eclairage [lighting-technology]

Description

From a technology point of view, LEDs surpass traditional electrical sources of light. However, renewal is rather slow, and the different technologies will co-exist for several years. A first part of this course is thus devoted to presenting the different processes of light emission: incandescence, photoluminescence, electrical discharge in gases, electroluminescence. To every physical principle, artificial sources of light are associated: incandescent lamps, discharge lamps, fluorescent tubes and compact florescent lights, electroluminescent diodes. In the second part, we will focus on LED lamps and on their control. We shall present communication protocols, focusing on the DALI protocol which is currently the most used in lighting. The programme is partly carried out by speakers from the industry. The latest lighting problems (non-visual effects

of light, web control by Ethernet, Li-fi communication, etc.) are partially presented by students themselves in the form of bibliography data sheets and talks. The programme will be illustrated by 4 practical classes: photometric measurements on LEDs, electrical measurements and lighting management (DALI protocol) for different light sources, DMX lighting control, measurements by video luminance meter for visual ergonomy and determining the UGR. The programme will be supplemented by two talks given by professionals, on LED technology (advantages, comparison with the other traditional sources, limits of use and substitution), and lighting management.

Expected skill

- To know how to explain the physical and technological sources of lighting, and to know their main characteristics;
- To know how to analyse and compare the characteristics of light sources from manufacturers' catalogues;
- To propose technical solutions in an (indoor and outdoor) lighting project;
- To be able to carry out a technology watch on new lamps and communication protocols.

Indoor climate systems

Code: ambiances-climatiques [indoor-climate-systems]

Description

This course discusses indoor climate systems in buildings. This teaching consists of designing ventilation, heating and cooling elements which are needed for providing a specific indoor climate inside a building. A first part of the course will concern heat production by combustion. Heat engines will be reviewed, as applied to heat and cold production in buildings. Tutorial classes will illustrate the theoretical concepts discussed in this course, and also in the courses on heat engines and moist air. Four practical classes are associated with this teaching. The programme will be supplemented by two talks given by industry professionals, on air permeability, ventilation systems, heat production systems and smart materials and systems for the building industry.

Expected skill

- To know how to acquire general knowledge and basic concepts for heat production by combustion.
- To know how to design the different elements forming an air handling unit
- To know how to design elements for heat and cold production

Indoor and outdoor lighting

Code : eclairage-interieur-exterieur [indoor-outdoor-lighting]

Description

Indoor and outdoor lamps: optical, electrical and mechanical characteristics. The different steps of in an indoor and outdoor lighting project. Comparison between manual and computer-assisted calculation - analysis - understanding. Completing a project using software (Dialux or Relux): parameter setting for the room or the traffic area, choosing objects and textures, choosing and installing lamps, illuminance, luminance UGR or GR calculation. The students will have to work on a public lighting design or indoor lighting project (they can chose). Industry professional speakers supplement the teaching on outdoor lighting (new standards and regulations for outdoor lighting, power supply grids for public lighting, public lighting management).

Expected skill

- to have the fundamental concepts on indoor or outdoor lighting
- to know how to carry out lighting calculations using lighting software in the service sector/industry world or in public lighting.

Construction systems

Code: systemes-constructifs [construction-systems]

Description

The main construction systems in building will be presented, along with their thermal and acoustic problems. We shall discuss the technical vocabulary and the knowledge of materials from reading plans for new projects and rehabilitation projects. Interior and exterior insulation methods will be presented in detail, as well as the calculation of surface and linear losses. Actual cases will be treated in the form of projects.

Expected skill

- to identify the components of an existing structure,
- to propose compatible insulation solutions,
- to calculate spot heat losses.

Thermal science for buildings 1

Code: thermique-batiment-1 [thermal-science-buildings-1]

Description

This is an initiation course in thermal science for buildings, to current and future thermal regulations. This course discusses more particularly envelopes, losses (thermal bridges, ventilation, windows and doors, etc.) and introduces the concepts of level of technical performances in buildings (Labels, E+/C-) as per the regulations in vigour. We shall initiate students in the minimisation of the energy needs and optimisation toward the passive or even zero-energy or “positive-energy” building. A project is proposed, using commercial software for treating the thermal static cases for buildings and the impact of the energy systems retained, on

the level of performance.

Expected skill

To know how to choose and design energy installations for a building, for heating during winter and air-conditioning during summer.

CAD/CADD 2 - BIM

Code : cao-dao-2 [cad-cadd-2]

Description

The frequent use of CADD software during internships in companies requires revising and deepening the work carried out on AUTOCAD during the 1st year. The subjects proposed during practical classes help students to acquire knowledge in the field of architectural drafting and design of specialised technical models, starting from recent construction projects.

Expected skill

- to know and to use the main AUTOCAD commands,
- to diension a drawing,
- to manage blocks,
- to configure a printing format.

Energy performances

Code: performances-energetiques [energy-performances]

Description

Concept of building performance: from classic to low-energy houses, passive houses, or “positive-energy” houses. Technological aspects: ventilation, filtration, air permeability. Technological aspects of energy production: fossil energy, renewable energies (geothermics, photovoltaic, etc.), micro-installations. Environmental aspects: greenhouse gas emission; % CO2, carbon balance in an industrial thermal environment. Labels: Effinergie, PassivHaus, etc .

Expected skill

- to know how to take into account the ecological and environmental concerns during the design, execution, servicing and maintenance phases, and know how to assess the technological feasibility considering the economic aspects,
- to be able to minimise the energy needs and to seek a high level of energy performance in building: aiming at low-energy houses, passive houses, or even “positive-energy” house.

Thermal science for buildings 2

Code: thermique-batiment-2 [thermal-science-buildings-1]

Description

This course is aimed at acquiring skills in terms of dynamic thermal modelling. In order to meet the requirements relating the the energy transition, transient heat transfer models will be considered for a building. After entering the numerical scale model of the building, simulations of the transient thermal behaviour will be carried out using the commercial Comfie-Pléiades code which includes material conduction and inertia, wall radiation, fluid medium (air) convection, external sunshine additions and internal sources, variable parameters in time (process, computers, lighting, persons). The aim is to carry out a dynamic optimisation of the energy systems needed for the winter-time, and also summer-time, thermal comfort of persons or for the proper state of processes. Application to individual houses, to the commercial sector (offices, housing, large volume room, etc.) and studying the influence of building location and orientation, of the type of walls whether with or without interior or exterior thermal insulation, of windows and doors, etc. The programme is supplemented by talks given by professionals, on: dynamic thermal science, energy renovation of existing buildings, thermal regulations.

Expected skill

To know how to solve dynamic conservation equations, to be able to dynamically optimise an energy system, to know how to analyse results coming from numerical simulations (hypothesis consistency, critical approach to the results obtained, proposing appropriate technical solutions).

Ventilation and Indoor air quality

Cod : ventilation-qualite-air [ventilation-air-quality]

Description

People spend between 80 and 90% of their time in a closed space, and breathe 26,000 times a day, i.e. 15,000 litres of air. Along with the evolution of thermal regulations (200, 2005, 2012) and that forecast for 2020, buildings became more and more insulated and “hermetic” to outdoor conditions. In these conditions, ventilation becomes a sustainability issue due to possible developments of local humidity zones (condensation, mould, etc.), and also a public health issue, for the same reasons. This course will be structured around 5 successive topics: a) initiation to comfort, hygiene, well-being in an enclosed environment) ; b) identification, analysis and sizing of existing ventilations systems (single flow mechanical ventilation, double flow mechanical ventilation, fans, filters, dehumidifiers, blowing systems, return air systems, duct networks, etc.) ; c) regulatory aspects (RT2012, standards in vigour…, duct noise acoustic standards, etc.) ; d) Mechanical ventilation installation software (BBS Slama, ANJOS, ALDES…) ; e) energy aspects of technical solutions, optimisation. This course will be supplemented by: on the one hand, practical work concerning this subject (mechanical ventilation, etc.), on the other, a project on the risk analysis of condensation in a building using WUFI software will help to perfect the understanding of the links between materials (envelope) and air circulating inside a building.

Expected skill

- To know how to identify ventilation problems depending on the type of building (office,

industrial, individual).
- To know how to quantify ventilation needs (air renewal, hygiene, well-being, standards applied).
- To know and to identify ventilation systems to be installed.
- To know and to use the main dimensioning tools for ventilation systems.
- Energy management of systems (mechanical ventilation, fans, filters, etc.).

Natural and combined lighting

Code: eclairage-naturel-mixte [natural-combined-lighting]

Description

Part of this teaching is devoted to indoor lighting projects aiming at coordinating natural and artificial lighting within an environmental approach (use of control systems for the technical management of buildings). We shall discuss the concepts of daylight factor (DF), of autonomy in natural light, and solar protections. The thermal regulations will be presented from the point of view of lighting. We shall introduce visual ergonomy applied to work-stations, and the regulatory standards and texts on lighting in work places. The programme is illustrated by project sessions during which the students will carry out in-situ DF measurements which they will compare with natural lighting numerical simulations using classical software from engineering engineering design firms (e.g. Dialux, DialuxEvo, Relux, Dial+). The second part will be devoted to museum and stage lighting: lighting as an interpreting factor of the work exhibited (means of expression), comfort and visitors' well-being (visual ergonomy element), degradation factor on a large number of materials. Commented visits of a museum and of a theatre will be organised for illustration. The last part will be dedicated to sports and large space lighting, thus supplementing the teaching on (indoor and outdoor) lighting: lighting providing proper visual conditions both for the parties on the playing field, and for the spectators and media.

Expected skill

- to draft technical specifications and propose technical solutions for:
  - the indoor lighting of buildings (natural lighting, energy constraints, thermal regulations in vigour, environment, working conditions for users, standards and labels),
  - museum lighting (museum, exhibition, etc.) using light as a means of communication and staging,
  - sports lighting.

Numerical methods 2 (EAT)

Code : methodes-numeriques-2-eat [numerical-methods-2-eat]

Description

This course discusses the general principles of simulation engineering and numerical calculation. We shall present methods for solving partial differential equations, as applied to Navier-Stokes

equations, for natural convection and propagation in complex geometries (non-structured finite volumes, finite elements, etc.). Part of the teaching relies on the use of multi-physics software during practical classes-projects closely related to the topics discussed during the curriculum.

Expected skill

- to know the big concepts implemented during the simulation of physical laws into the commercially available software;
- to write codes implementing numerical methods;
- to assess the relevance of a numerical result.

Acoustic sources and propagation

Code: sources-acoustique-propagation [acoustic-sources-propagation]

Description

Phenomenology of acoustic sources; Time-dependent, frequency and directional aspects; measurements of acoustic sources; Establishment of the equations of acoustics with sources; Canonic sources (monopoles, dipoles, quadrupoles); Introduction to solving equations with sources (integral equations); Introduction to the ray method; Application to exterior propagation; including the atmospheric refraction and screen diffraction effects. The programme is supplemented by talks given by professionals, and illustrated by practical classes.

Expected skill

- to know how to analyse and model an acoustic source
- to solve problems on exterior propagation
- to know the methods of source measurements

Electroacoustic systems

Code : systemes-electroacoustiques

Description

Acoustic modelling using localised elements (low-frequency hypothesis); Principle of electroacoustic transducers (electrodynamics, electrostatics); Application to modelling diffusion systems using loudspeakers; Radiation model from a 2D piston; Modelling sound reinforcement and measurement microphones; basic principles of acoustic measurements. The programme is illustrated by practical classes.

Expected skill

- to know how to analyse an electroacoustic system (loudspeaker or microphone)
- to be able to design an electroacoustic source,
- to know the main acoustic sensors and their use within a measuring chain.

Room acoustics

Code: acoustique-des-salles [room-accoustics]

Description

This course discusses room acoustics by presenting the wave, geometrical and statistical approach. We shall define the concepts of diffuse field, reverberation time, direct/reverberated field. One of its aims is to understand the effects of reverberation on listening intelligibility and comfort. We shall present quality criteria for rooms, on the basis of an impulse response or echogram, and the Speech Transmission Index. We shall also discuss coupled rooms. This programme will be illustrated by four practical classes on: acoustic transparency of construction elements, the measurement of the absorption coefficient under diffuse incidence, the decrease of the acoustic pressure level emitted by a source in a room, the study of a multi-purpose room using ray tracing software.

Expected skill

To be able to approach a problem of room acoustics.

Architecture

Code: architecture

Description

This course will bring a series of fundamental references in architectural culture in order to enable students to understand and find their place in the game of the future players in the building trade. Its purpose is to help understand the ongoing practical mutations on the constructed environment; to help understand the technical and architectural solutions retained; to help understand the issues met by architecture professionals. The course consist of 6 workshops: History of architecture, The architect and the architectural professions, The steps of a project (case study), The life of a project, Designing and building: a team work, The execution. A visit of the projects built or under completion is also included in this course.

Expected skill

- to be able to give the major references in architecture and to know what characterises them,
- to know how to identify the different phases of an architectural project,
- to be able to place the role of an engineer in an architectural project.

Communicating objects and buildings

Code : objets-batiments-communicants [communicating-objects-buildings]

Description

Building automation, intelligent building management took off thanks to recent technology

innovations: communicating sensors, smart meters, energy monitoring, smart grids, etc. It makes it possible, for instance, to control, depending on the needs and use context of buildings, the lighting, the heating/air-conditioning, the opening/closing of doors and windows, the power supply of certain equipment, etc. This teaching is aimed at giving students, the concepts relating to the different protocols for communication between different network components (TCP/IP, KNXt, BACNet, LonWorks et LonTalk, DALI, ZigBee, etc.) and at raising their awareness to network security problems. The course is supplemented by a talk given by a professional.

Expected skill

- To know how to identify the different elements of centralised management of a building or of a public lighting network,
- To know the different communication protocols.

Option 1: Aeroacoustics

Code: aeroacoustique

Description

Introduction and examples of flow-generated noise - Propagation of waves in a flow, linearised Euler equations - Guided propagation in a flow, absorbent materials, singularity effects - Noise of a turbulent flow: Lighthill analogy, power low for a free jet noise and for a pipe jet noise - Wall effect: Fowcs-Williams and Hawkings analogy - Vortex approach and acoustic potential. We shall also present applications to complete the picture: noise from fans, industrial mufflers, numerical simulations, etc. (outside speakers).

Expected skill

To understand the fundamental problems of applied aeroacoustics applied to building sectors (noise from air-conditioning systems, from flow around buildings), to transport, etc. To master the physical concepts and the elementary quantitative tools in aeroacoustics.

Option 2: Visual appearance

Code : apparence-visuelle [visual-appearance]

Description

This course will show links between the intrinsic optical properties of materials (complex refractive index) and their visual appearance (colour, gloss, translucency). By adopting an electromagnetic approach first, then a radiometric approach, the first part is devoted to light/matter interactions at interfaces (surface reflection, refraction and diffusion) and in the volume of a material (volume absorption and diffusion). The second part will present the measurement and modelling methods for the visual appearance of materials. The programme will be supplemented by talks given by professionals, on the promotion of urban areas (implementation of the master plan of lighting planning and of the lighting plan) and on the

lighting up, as well as on the numerical simulation of lighting scenes.

Expected skill

- to know how to describe the general concepts for simulating lighting scenes in a realistic way;
- to be able to qualify and quantify the visual appearance of the illuminated materials.

Town planning

Code: urbanisme [town-planning]

Description

This course is aimed at raising the awareness of future engineers to town and country planning (professions, situations, issues, players, tools). - Theoretical input for better defining town and country planning and inferring the big issues: Defining town planning and its professions. The different scales of town and country planning. The players and the management of a planning project. The (modern) issues of town planning (Town and town equipment development/renewal; Social balance of housing; Town organisation and greenhouse gases). - Workshop work for approaching the essential issue of the densification of urban areas: Household location policy, densification policy in a residential area.

Expected skill

- to be able to understand the practical elements of town planning
- to be able to identify the main current issues of town planning and the main issues of social housing in France.

TEN study path

Coagulation-flocculation

Code : coagulation-floculation [coagulation-flocculation]

Description

This course will present coagulation-flocculation, preliminary step to the liquid/solid separation operations. We shall show the treatment goals, we shall specify the fields of application, and we shall present the implementation into a water treatment outlet. The theory of coagulation and flocculation is described in detail, and the different usable reagents; the associated technical aspect is also developed along with the presentation of the technologies implemented.

Expected skill

- to know the main physical-chemical aspects involved during the coagulation and flocculation steps
- to choose the appropriate reagent and to define a level of treatment depending on the

quality of raw water

Decanting and floatation

Code: decantation-flottation

Description

This course is aimed at introducing the main sizing principles for individual liquid-solid separation operations, by sedimentation and by floatation. We shall present the operating conditions which make this separation possible, and the different existing methods.

Expected skill

- To know the principles of sedimentation and floatation,
- To know how to design an installation,
- To know how to choose a method appropriate for the quality of the water to be treated

Depth and membrane filtration

Code: filtration

Description

This course will introduce the different mechanisms involved in liquid-solid separation in membrane and depth filtration. We shall present a comparison between technologies, and give design methods.

Expected skill

- To know the principles of depth and membrane filtration,
- To know how to design an installation,
- To know how to choose a method appropriate for the quality of the water to be treated

Waste water metrology

Code: metrologie-eaux-residuaires [waste-water-metrology]

Description

This course is aimed at presenting the different tools for characterising complex environments such as rainwater, urban wastewater and industrial effluents. In addition to waste water origin and composition, the course is largely devoted to the description of the overall assessment criteria for particle, organic, carbon, nitrogen, phosphorous pollution, and pollution by halogenated compounds (TSS/VSS, TOC, COD, BOD, nitrogen quantity determined by Kjeldahl's method, TP, AOX, etc.). The impact of the different types of pollution in terms of environmental and health hazards will be systematically described. We shall also discuss toxicity tests.

Expected skill

- To know the origin and the different types of pollution of urban waste water.
- To know the principle, the implementation and the fields of application of analysis methods for waste water.
- To assess the impact of pollution on environments.
- To interpret and critically comment on analysis results.

Environmental microbiology

Code: microbiologie-environnement [Environmental-microbiology]

Description

After reviewing the biological diversity of microorganisms in the water environment, this course is devoted in its first part to bacteriology: we shall characterise the bacterial cell, we shall describe the influence of chemical and physical factors on bacterial growth, and we shall present the different methods for counting bacteria. In the second part of the course, we shall focus on health hazards linked to the presence of pathogenic microorganisms in the water environment, in relation to water treatment and use. We shall give examples of parasitic, bacterial and viral pathologies linked to water. Finally, we shall present the legal context of the indicators of faecal contamination.

Expected skill

- to carry out bacteria cultures and counting,
- to identify the major metabolic pathways,
- to analyse the microbiological hazards linked to the different uses of water

Reactors

Code: reacteurs

Description

After classifying the different types of chemical reactions, this course will present the theory of perfect (continuous and discontinuous) reactors applied to the simple kinetics of single-phase reactions. This teaching will also introduce the description of reactive flows (residence time distribution) and their effects on conversion. For every reactor, design methodology will be shown through all fundamental principles (material balances) making it possible to solve the problems met in this field.

Expected skill

- To solve the equations governing material balances within reaction environments,
- To carry out an investigation for finding the residence time distribution of a real-world reactor, and to model the real-world reactor with a combination of ideal reactors/

Analysis techniques for the environment

Code: techniques-analyses-environnement [analysis-techniques-environment]

Description

This course will use the context of environmental analysis for presenting techniques for sample preparation, for pollutant identification and quantification in water, soil and air environments, as supplements to the methods presented in the courses on the “Chemistry of natural environments”, “Pollutants in natural environments” and “Metrology of urban waste water”. We shall present the methods aimed at analysing metal elements (atomic absorption spectrometry, inductively coupled plasma associated with different types of detectors) and trace organic micropollutants such as disinfection by-products, drug or pesticide residues (liquid or gas chromatography coupled with mass spectrometry). The course will be illustrated by many examples of water analyses, and we shall establish a close link with the aspects of water treatment.

Expected skill

To chose an appropriate method, to prepare samples, to implement atomic spectroscopy, and liquid and gas chromatography methods, to know how to interpret analysis results and assess the performances of an analytical method

Practical classes 1

Code: tp-1-ten

Description

Practical classes will make use of the techniques, processes and methods discussed in the UE079 TEN module.

Expected skill

- to have autonomy in carrying out experiments in the field of water chemical and microbiological analysis, and in the field of process engineering applied to water treatment
- to use the results obtained

Activated carbon adsorption

Code: adsorbtion-cag

Description

After presenting the characteristics of activated carbon (texture, structure) and of adsorption (kinetics and adsorption equilibrium in a discontinuous reactor, filtration on granular activated carbon), the course will present the various applications of drinking water treatment (history, methods involving powder and granular activated carbon, expected performances, case study).

Biological treatment and design of treatment stations for activated sludge

Code : epuration-biologique-dimensionnement-stations [biological- treatment-design-stations]

Description

After a short reviewing of bacterial metabolism and enzyme kinetics, the course will treat the kinetics of bacterial growth and the modelling of bioreactors using free bacteria, in order to show the influence of fundamental parameters on substrate removal and biomass production, by successively examining discontinuous reactors, continuous reactors without recirculation, single reactors, reactors in series, and piston with recirculation. The course will then discuss the biological pathways of transformation of organic pollution in aerobic and anaerobic environments, of nitrogen pollution and phosphorous pollution in waste water and sludge, and will specify, for every major type of reactions, the main reactions involved and the optimum conditions of implementation of these reactions. This teaching will then present the basics for designing all structures of an urban activated sludge treatment plant (pretreatment, primary decanter, bioreactor and clarifier, etc.), the calculation of oxygen consumption and the design of aeration systems, the estimation of sludge production and the methods for diagnosing and improving the operation of the existing installations. We shall also briefly present the various activated sludge sequencing batch reactors.

Expected skill

- To carry out material balances for a bioreactor or a treatment plant,
- To understand the influence of operating parameters on the performances of a bioreactor,
- To understand the biological pathways of transformation of organic, nitrogen and phosphorous pollutions, in order to apply them to water treatment,
- To design an activated sludge treatment plant, a lagooning and a reed bed filter (design of each structure, calculation of reagent and energy consumption, etc.),
- To diagnose the performances of a waste water treatment plant using the above methods, in order to solve malfunctioning problems and optimise performances.

Calcium carbonate equilibria

Code: equilibres-calco-carboniques [calcium-carbonate-equilibria]

Description

After a review of theory, we shall present the classical methods for solving calcium carbonate equilibria according to HALLOPEAU and DUBIN and LEGRAND and POIRIER, along with examples of actual cases. Legrand-Poirier method is applied using the LplWin software. At the end of this course, the students will be able to assess the impact of treatment (coagulation/flocculation, aeration, remineralisation, decarbonation, etc.) on composition and more particularly on the aggressive or hard character of water in the process of being made drinkable.

Expected skill

To solve calcium carbonate equilibria using graphical methods applied to water treatment, to use the Hallopeau and Dubin calibration graph, to use the LpLwin software

Drinking water production outlet

Code: filiere-production-eau-potable [drinking-water-production-outlet]

Description

After presenting the European and French legislation context on drinking water production, distribution and quality, this course is devoted to describing the different treatment outlets which can be considered for treating underground water or surface water. In relation to the quality of the resource and the treatment objectives (removing suspended solids, turbidity, natural organic materials, mineral or organic micropollutants, algae, pathogenic germs, etc.), this course will expose in a summary manner, the criteria for choosing an appropriate treatment method. Illustrated by many examples of treatment method for drinking water, this course is aimed at being a practical guide for designing drinking water production plants.

Expected skill

- to choose a complete treatment method for drinking water production depending on the quality of raw water and the treatment objectives,
- to design all the structures of a classic drinking water plant,
- to diagnose the performances of a waste water treatment plant, in order to solve malfunctioning problems and optimise performances.

Chemical oxidation - Disinfection

Code: oxydation-chimique-desinfection [chemical-oxidation-disinfection]

Description

Introduced through general concepts on disinfection and the regulations applied to drinking water production, oxidation in an aqueous environment by chlorine and its by-products, chlorine dioxide and ozone, will be described: reactivity with mineral and organic compounds, place within the treatment outlets, industrial implementation, analysis.

Expected skill

- to understand the chemical processes governing the oxidation reactions of the dissolved compounds
- to know the oxidation by-products potentially formed and their risks to human health
- to be able to chose the best appropriate oxidizer for the quality of the water to be treated, and for the treatment objectives

Precipitation - Decarbonation - Equilibration

Code: precipitation-decarbonatation

Description

We shall present the technological aspects of calcium carbonate equilibration for the production of drinking water, and the design data. We shall also discuss in detail the methods for precipitating dissolved salts, particularly decarbonation and lime softening operations.

Expected skill

to design and size precipitation and remineralisation units

Practical classes 2

Code: tp-2-ten

Description

Practical classes will make use of the techniques, processes and methods discussed in the UE12 TEN module.

Expected skill

- to have autonomy in carrying out experiments in the field of water analysis, and in the field of process engineering applied to water treatment
- to use the results obtained

Drinking water

Code: eau-potable [drinking-water]

Description

This is an advanced course over the 2nd year teaching. It is aimed at providing specialised teaching on specific treatments for removing iron, manganese, arsenic, selenium, fluoride, nitrogen and organic micropollutants. It is supplemented by the presentation of water disinfection methods using UV radiation, water desalination methods, and eco-methods applied to the production of drinking water. The course compare, according to technical and economic criteria, the different technologies which can be considered, and gives the basics of structure sizing. We shall study many examples of installations. The problems of malfunctioning and non-conformities in a drinking water unit or the problems of drinking water management during crises will be discussed by professionals. Finally, a drinking water treatment unit will be designed through two projects presented by industry people: from a given water resource and production constraints, a choice has to be made and the dimensioning of a method for drinking water treatment has to be carried out.

Expected skill

- to design and size treatment structures for drinking water
- to diagnose treatment methods for drinking water

Air pollution

Code: pollution-air [air-pollution]

Description

This module will describe sources of atmospheric pollution (transport, large combustion installations, incineration, industries, etc .) along with their associated pollutants (SO2, NOx, O3, VOCs, CO, particles, etc .) and the main targets (human health, climate impact, material goods and biological resources, odour pollution). It will then present the European and French regulations and the organisation of the inspection of industrial installations and air quality monitoring in France (Atmo network). It will then describe the manual and automated methods of analysis for different atmospheric pollutants. After a brief presentation of gas-liquid equilibrium and of the writing conventions, this module will also present the different types of gas-liquid contactors that can be used, namely in the water and gaseous effluent treatment industry. The course will then discuss the material conservation equations, the concepts of theoretical stages for tray columns, and of transfer unit for packed columns, and the sizing of gas-liquid transfer reactors. We shall present a few concepts of material transfer with chemical reaction in the liquid phase. This course will then synthetically present the treatment methods for gaseous emissions from static and mobile sources. It will thus present the main available depollution technologies, specific industrial applications to the major classes of pollutants, and finally a few emergent methods or those under development .

Expected skill

To chose and implement air analyses, to comment and interpret results, to know the different methods for air purification, to design and size a gas treatment installation

Network hydraulics 2

Code: hydraulique-reseaux-2 [network-hydraulics-1]

Description

This course is an initiation in the use of software for flow modelling in full pipe networks (Porteau software, with a case study on drinking water) and in a pipe with free surface (Infoworks software with a case study on sewage). This course will also discuss the evolution of water quality in a drinking water network, and the topic of asset management of drinking water and sewage networks;

Expected skill

- to know the data and methods associated with modelling tools.

- to know how to enter this data, how to calculate flow regimes,
- to simulate operation, - to think critically and to use results,
- to know how to use numerical tools for sizing and drawing up a master plan.

Water and health

Code: eau-sante [water-health]

Description

This course will discuss several aspects: toxicology (general concepts, mechanism of action of toxic substances, assessment of the toxic risk, establishing standards); sanitary inspection of drinking water and swimming water (regulations, players, result distribution) in France; management of the risk of Legionella (regulatory context, measures of prevention, maintenance of inspections).

Expected skill

- to be able to understand the effects of toxic substances and to asses a toxic risk
- to know the issues of sanitary inspection

Urban waste water

Code: eaux-residuaires-urbaines [urban-waste-water]

Description

This course is divided into 4 parts: 1- Fixed-film of biomass treatment. This course is aimed at presenting the operational principles, the technological aspects, the basics for sizing, and the performances of the treatment methods using a fixed film of biomass: bacterial beds, rotating biological contactors, biofilters and activated sludge reactors with mobile supports. 2- Extensive methods. This teaching will present the operating principle, the basics for sizing and the performances of the treatment methods for small communities, such as natural lagooning, infiltration-percolation and reed bed filters. Bamboo plantations, short rotation coppices, revegetated discharge zones, etc. will also be discussed in this course. 3- On-site sewage facility. This course will present the regulations concerning an On-site sewage facility (OSSF), the operating principles and the performances of the various treatment systems used by an OSSF. 4- Reuse of treated urban waste water. After a presentation of regulatory aspects of the different fields reusing treated waste water, the course will present, through actual cases from France and abroad, post-treatment outlet for reusing urban waste water in green space irrigation, groundwater recharging and drinking water or industrial water production. Finally, designing, sizing and installing a STEP will be carried out through two projects presented by industry people.

Expected skill

- to design and size treatment stations

- to diagnose a treatment station in order to propose solutions for malfunctioning problems or to optimise performances.

Natural environment

Code: milieu-naturel [natural-environment]

Description

This course will discuss the quality of the water resource, in relation to the biology of aquatic media. This course will provide an overview on aquatic ecosystems, especially relating to running water. We shall present the different biological indices (saprobic index, biotic index, standardised biotic index (French standard: *indice biologique global normalisé*, diatomic index) and we shall describe the use of bioindicators for the search of toxic substances in the natural environment. This course is also an occasion to present in detail the phenomenon of eutrophication due to human activity: it shows in rivers, seas, lakes or reservoirs, and has consequences in terms of modification of aquatic ecosystems and resources used to fight against this phenomenon. Finally, we shall present the classification of water courses using assessment grids for the quality of water.

Expected skill

to diagnose the quality of water courses from biological analyses

Sludge treatment

Code: traitement-boues [sludge-treatment]

Description

This course is divided into 2 parts:

1. Liquid sludge treatment. This course describes the operating principle, the technological aspects, the basics of sizing and the performances of various treatment methods for liquid sludge such as sludge static and dynamic thickening, dehydration (press filter, filter strips, centrifugation), conditioning and stabilisation.
2. Treatment and recycling of dehydrated sludge. This course will discuss, more particularly, outlets for treating and recycling treated sludge. After reviewing the data related to sludge production and composition, the course will present the different recycling outlets: recycling to land (fertilizer), composting, sludge incineration and anaerobic digestion (regulatory and technological aspects). The different treatment facilities for sludge will also be described by presenting in more detail certain operations such as sludge drying and the methods for reducing sludge production.

Expected skill

To design and size sludge treatment facilities

Industrial water

Code: eaux-industrielles [industrial-water]

Description

This course consists of three sections: 1 - Water use and treatment in the industry. This course will discuss how water is used in different sectors of industrial activity. For certain industries, the course will describe the main manufacturing operations in order to define the water needs, the required water qualities, and will present the main characteristics of the produced waste water. 2 - Production of process water. This course will discuss the different process water production facilities, from industrial water quality to ultra-pure water quality. 3 – Treatment water from boilers and cooling circuits. After describing the water cycle in a boiler room, and the different constraints relating to boiler operation, this course will present treatment and conditioning possibilities for boiler waters. The treatment of cooling circuit water will then be discussed, with a focus on the main problems met (scaling, corrosion, biological clogging).

Expected skill

- to design process water treatment facilities and to be able to assess the advantages and limits of each of the facilities proposed,
- to diagnose industrial installations aiming at proposing solutions in case of malfunctioning or to optimise the performances of installations.

Industrial waste water

Code: eaux-residuaires-industrielles [industrial-waste-water]

Description

The course describes the different treatment methods for industrial waste water (and in particular methods more specifically implemented in this field: advanced oxidation, evapoconcentration, electrocoagulation, etc.) and presents many treatment facilities. We shall present the different possibilities for saving water (reusing water, using rainwater, clean technologies) through actual examples.

Database management

Code : gestion-basics-donnees [database-management]

Description

This course is aimed at introducing database management methods. We shall present statistical analyses and teach how to use the R software.

Expected skill

- To know how to use Big Data analysis tools

- R software

Remote management

Code: telegestion [remote-management]

Description

This course will present the principles and the implementation or remote management applied to a water treatment installation or to water network: specific instrumentation, operation and maintenance of the different equipment, organisation of the remote management network, supervision.

Expected skill

- to know the structure of remote management systems
- to know the functions of the different equipment

Swimming pool water treatment

Code : traitement-eaux-piscine [swimming-pool-water-treatment]

Description

This course on the treatment of public swimming pool water will successively examine the regulatory aspects, the classical treatment facilities, the formation of chlorination by-products, the risks to health and the new methods implemented for reducing the concentration of unwanted by-products (UV dechlorination, stripping, ozone treatment).

GMC study path

Professional environment 1

Code: environnement-professionnel-1 [professional-environment-1]

Description

Presentation of the professional environment and of the different steps of a building and planning project (e.g.: the law regarding public contracting authorities [*loi MOP*] Presentation and definition of the parties involved in the project: general contractor, client, companies, subcontractors.

Expected skill

To understand the role of the different participants in implementing a building project - To determine a project phasing

Rock formation and identification

Code: formation-identification-roches [rock-formation-identification]

Description

This teaching concerns the identification and description of igneous, metamorphic and sedimentary rocks: petrography (macroscopic and microscopic identification), mineralogy, texture. We shall present the genesis of endogenous rocks from petrography and petrochemistry, and from associated deposits. We shall present metamorphic rocks taking into account parageneses and structural evolutions. They are interpreted in terms of overall dynamics. Sedimentary rocks will be understood from sedimentary processes. The teaching includes: rock classification and identification, reconstruction of sedimentation media and identification of formations.

Expected skill

To macroscopically identify different rocks - to associate modes of formation with forms of deposits - to provide petrographic analysis.

Geotechnics 3: Soil mechanics

Code: geotechnique-3-mecanique-sols (geotechnics-3-soil-mechanics]

Description

This course focuses on soil mechanics and rheology. concepts of shift, deformation, main deformation and stress. Reminders from continuum mechanics; (Vertical and horizontal) stress expression in a rock mass. Drawing MOHR's circles. Soil resistance to shearing (CASAGRANDE's shear box , triaxial shear testing apparatus). Definition of the intrinsic curve and of MOHR-COULOMB criterion. Extension of BOUSSINESQ's results. Concepts of soil compressibility and consolidation. Practical determination of subsidence (elasticity and oedometer test). Soil bearing capacity. Subsidence calculation by pressuremeter testing. Slope and embankment stability using TALREN (software). Sizing shallow foundations with FOXTA (software).

Expected skill

- To understand soil mechanics in saturated media
- To know and master laboratory tests
- To know and use Eurocode 7 (shallow foundations)

Rock mechanics 1: Structural geology

Code: mecanique-roches-1-geologie-structurale [rock-mechanics-1-structural-geology]

Description

Basics of rock mechanics: stresses, deformations, rheology, rupture and fractures. Application to geological structures: brittle tectonics (faults) and ductile tectonics (folds). Application of structure stability to rock, in particular with a mini-project.

Expected skill

To interpret a landscape and geological structures. To understand the mechanical behaviour of rocks, at different time and space scales. To understand the link between structural geology and structure behaviour in a rock.

Field school: rock identification

Code: ecole-terrain-reconnaissance-roches [field-school-rock-identification]

Description

The skills acquired in geology will be used in practice by integrating the size of the land in the case of the geological investigation in the Sables d'Olonne sector, in a context combining magmatism and metamorphism. The expected large-scale mapping will be carried out on the basis of rigorous descriptions of the different outcrops met, including rock identification, and the analysis and measurement of geological structures. The students' work is supplemented by teaching based on the cases met on field.

Expected skill

To use field equipment in order to identify the different types of rocks and to carry out measurements for analysing geological structures - To identify the different geological systems taking into account the chronology of formation and/or of settling - To provide a report on the field observations and measurements, and on the interpretations of the geological context investigated.

Geotechnics 4: Foundations

Code: geotechnique-4-fondations [geotechnics-4-foundations]

Description

Reviews on laboratory tests and presentation of in-situ testing. The first part of this course presents the type of foundations (well, raft, strip footing, piles, micro-piles, etc.) and their sizing (briefly). A project on a real-world situation of geotechnical investigation (G1, G2 AVP [in French: *avant-projet* = draft phase of a project]): mineralogy investigation, analysis of laboratory tests (Attenberg's limits, MBT (methylene blue test), particle size distribution, etc.), in-situ tests (penetrometer, pressuremeter, etc.), choice of the type of foundations. All infrastructure calculations, foundations and underground work require in-situ upstream investigations: surveys using an excavator or trenches, drill holes and boreholes. The second part of the course focuses on the different methods of investigation through boreholes and drill holes using hammer drills

and rotary drills, as well as equipment elements (tubes, strainer), and on the properties/use of sludge from drill holes. The presentation of in-situ tests: “water” tests - infiltration and geotechnical tests: pressuremeter, hand vane tester, penetrometer, phicometer, is accompanied by practical classes and/or demonstration on construction sites. We shall also discuss in-situ equipment, dilatometer, inclinometer, settlement plate.

Expected skill

- To know Eurocode 7 (deep foundations)
- Definitions and knowledge of the types of foundations (shallow, deep and special)
- To master geotechnical missions (G1 and G2AVP)
- To know the in-situ tests.

Road infrastructures 2

Code : infrastrutures-routieres-2 [road-infrastructures-2]

Description

This second part on road techniques and earthwork is an application of the French directives *Recommandations pour les Terrassements Routiers* and the technical guide *Réalisation de Remblais et couches de forme*, for determining the categories of roads, traffic, levelling courses and platforms with applications to different geological fields, platform and compaction inspection tests. We shall also discuss the choice of earth-moving equipment, the optimisation of outputs (Q/S) and excavated material / filling.

Expected skill

To define a road structure - to define technical specifications for installation and inspection

Rock mechanics 2: Rock masses

Code: mecanique-roches-2-massifs-rocheux [rock-mechanics-2-rock-masses]

Description

This course will present the basics of rock mechanics and of the methods for pre-sizing underground structures (AFTES recommendations, Bieniawski’s RMR method, Barton’s Q-system). We shall also discuss the mechanical role of water present in rocks and rock masses.

Expected skill

- to propose characterisation methods for the discontinuities of a rock mass,
- to carry out a pre-sizing of an underground structure (tunnel, underground gallery).

Professional environment 2

Code: environnement-professionnel-2-gmc [professional-environment-2-gmc]

Description

A professional project, conducted by professionals, will enable students to be involved in different stages of a project, and in different positions and situations. The participation of professionals who work in the fields for which skills and missions are taught. Actual case study: a planning operation combined with a building operation. Using real-life scenarios in which the students will be asked to react professionally and to take positions according to their theoretical knowledge.

Expected skill

- The students will have to know how to find their way in a professional environment for a planning / building operation, and to find their place depending on their missions.
- To know the functions and responsibilities of the main players
- To know the content of the different phases of a planning / building operation, and how to approach them.
- To have general knowledge of the investigation methods and of the building techniques
- To have basic knowledge on the organisation of an operation through an actual case study.

Concrete structures

Code: structures-beton [concrete-structures]

Description

Structure calculation needs a review on the definition of actions, the fundamental principle of statics, forces (N, V and Mf), and elementary iso- and hyperstatic systems applied to constructions. The principle of lowering of loads is stated, and after a brief history, we shall present calculation methods for reinforced concrete and for prestressed concrete according to the rules of EUROCODE 2, both for the ultimate limit state and for the serviceability limit state. Tutorial classes will be devoted to elementary, actual cases of building projects. They will discuss beams, floors, piles and shallow foundations.

Expected skill

- To master the fundamental concepts governing the behaviour of a reinforced concrete and/or pre-stressed concrete section, * to master the basic calculations for designing reinforced concrete and/or pre-stressed concrete structures.

Civil engineering calculations and models

Code: calculs-modeles-genie-civil-gmc [civil-engineering-calculations-models]

Description

An engineer from an engineering consulting firm uses calculation codes based on solving partial differential equations. This course is aimed at presenting the most widely used analytical and numerical methods in civil engineering for solving partial differential equations (finite

differences and finite elements methods). For each method, special attention will be paid to the convergence criteria and to the stability of the implemented schemes. This course is also an introduction to the theory of plasticity which is widely used in geomechanics. This theory is illustrated in the course by applications coming from problems in geotechnics (Cam-Clay model). The teaching includes tutorial classes using the finite elements software Plaxis. The students following the GMC study path will have 15 tutorial classes devoted to Plaxis.

Expected skill

- to carry out calculations using a finite elements code
- To built, from a real-world case, a simplified numerical model (using the symmetries of the problem, creating a meshing, boundary conditions, choosing a behaviour law) for a finite elements code.

Advanced geotechnics

Code: geotechnique-approfondie [advanced-geotechnics]

Description

This course is the continuation of the first- and second-year geotechnics courses. It discusses three fields: foundations pathology, deep foundations and retaining structures. This teaching will be essentially provided by professionals from geotechnical consulting firms. Whether relating to sizing or foundations pathology, the courses and tutorial classes will be associated with engineering projects on real-world cases. The following subjects will be treated: Digging - Retaining structure. Analyses of the actions on excavation walls (moulded walls, prefabricated walls, Jet Grouting, Berlin wall, anchoring) - Catalogue of flexible retaining structure types and technologies. Retaining structures, theory of the push-pull limit equilibrium, pre-sizing methods, and reaction coefficient method (using the KRéa software). Sizing of deep foundations, special foundations, design and construction of underground structures, actions of forces on excavation walls, using the FOXTA software - calculations using the reaction coefficient. Soil reinforcement (tie rod bolting), stone columns.

Quarries: identification, exploitation, blasting

Code: carrieres [quarries]

Description

The teaching discusses the exploitation of deposits: legal aspects (legislation on the opening and layout of quarries and impact investigations), economic aspects and type of exploitations of aggregates (quarries - sand quarries). From a technical point of view, it concerns starting exploiting a quarry, optimising the extraction technical chains, cutting down, crushing, screening massive rocks in the quarry, extracting, washing, screening and crushing running rocks. In the second part, the teaching will discuss blasting techniques and their regulations: characteristics, classification and packaging of explosives. We shall also discuss the use of low explosives and detonating explosives, the choice of detonators - detonation relays and boosters, types of priming

and safety, the installation of firing and mine loading, and firing incidents. The last part of the teaching includes the description of a deposit through a field survey on different geological layers present in the context of sedimentary rocks (stratigraphic column).

Expected skill

- To know the regulations on the exploitation of a deposit (opening, exploitation, remediation, etc.)
- To draft a blasting firing plan
- To read the stratigraphic column in the field in order to assess the resource

Geophysics and petrophysics

Code: geophysique-petrophysique

Description

Soil and rock massive identification uses more and more non-intrusive geophysical methods. This course is aimed at presenting the different geophysical methods used in civil engineering. For every method, we shall show how petrophysical measurable data can be quantitatively related to a state parameter of a geomaterial (porosity, water concentration, density, salinity, clay concentration).

Expected skill

- To be a capable contact person for geophysics companies and consulting firms.
- To identify the geophysical method appropriate for the target involved.
- To organise a very basic campaign of geophysical exploration.

Road infrastructures 3

Code : infrastructures-routieres-3 [road-infrastructures-3]

Description

The objective is to learn how to characterise the different layers forming road structures, and to calculate these structures. The inventory and the properties of the different materials used in a road structure concern both the wearing courses and the underlying layers right to the upper earthwork platform. Material characterisation starts by the definition and composition of hydrocarbons; the properties and the nomenclature of hydrocarbon binders (asphalts, bitumens, and cut backs). The teaching includes the formulation of bituminous concrete, the inspections and laboratory testing. Based on case studies, road structure calculations will be supplemented by structure modelling using ALIZE. Prerequisite: road geotechnics, geological materials and GTR French classification.

GTS study path

Professional environment 1

Code: environnement-professionnel-1 [professional-environment-1]

Description

Presentation of the professional environment and of the different steps of a building and planning project (e.g.: the law regarding public contracting authorities [*loi MOP*] Presentation and definition of the parties involved in the project: general contractor, client, companies, subcontractors.

Expected skill

To understand the role of the different participants in implementing a building project - To determine a project phasing

Rock formation and identification

Code: formation-identification-roches [rock-formation-identification]

Description

This teaching concerns the identification and description of igneous, metamorphic and sedimentary rocks: petrography (macroscopic and microscopic identification), mineralogy, texture. We shall present the genesis of endogenous rocks from petrography and petrochemistry, and from associated deposits. We shall present metamorphic rocks taking into account parageneses and structural evolutions. They are interpreted in terms of overall dynamics. Sedimentary rocks will be understood from sedimentary processes. The teaching includes: rock classification and identification, reconstruction of sedimentation media and identification of formations.

Expected skill

To macroscopically identify different rocks - to associate modes of formation with forms of deposits - to provide petrographic analysis.

Geotechnics 3: Soil mechanics

Code: geotechnique-3-mecanique-sols (geotechnics-3-soil-mechanics]

Description

This course focuses on soil mechanics and rheology. concepts of shift, deformation, main deformation and stress. Reminders from continuum mechanics; (Vertical and horizontal) stress expression in a rock mass. Drawing MOHR’s circles. Soil resistance to shearing (CASAGRANDE’s shear box , triaxial shear testing apparatus). Definition of the intrinsic curve

and of MOHR-COULOMB criterion. Extension of BOUSSINESQ's results. Concepts of soil compressibility and consolidation. Practical determination of subsidence (elasticity and oedometer test). Soil bearing capacity. Subsidence calculation by pressuremeter testing. Slope and embankment stability using TALREN (software). Sizing shallow foundations with FOXTA (software).

Expected skill

- To understand soil mechanics in saturated media
- To know and master laboratory tests
- To know and use Eurocode 7 (shallow foundations)

Rock mechanics 1: Structural geology

Code: mecanique-roches-1-geologie-structurale [rock-mechanics-1-structural-geology]

Description

Basics of rock mechanics: stresses, deformations, rheology, rupture and fractures. Application to geological structures: brittle tectonics (faults) and ductile tectonics (folds). Application of structure stability to rock, in particular with a mini-project.

Expected skill

To interpret a landscape and geological structures. To understand the mechanical behaviour of rocks, at different time and space scales. To understand the link between structural geology and structure behaviour in a rock.

Field school: rock identification

Code: ecole-terrain-reconnaissance-roches [field-school-rock-identification]

Description

The skills acquired in geology will be used in practice by integrating the size of the terrain in the case of the geological investigation in the Sables d'Olonne sector, in a context combining magmatism and metamorphism. The expected large-scale mapping will be carried out on the basis of rigorous descriptions of the different outcrops met, including rock identification, and the analysis and measurement of geological structures. The students' work is supplemented by teaching based on the cases met on field.

Expected skill

To use field equipment in order to identify the different types of rocks and to carry out measurements for analysing geological structures - To identify the different geological systems taking into account the chronology of formation and/or of settling - To provide a report on the field observations and measurements, and on the interpretations of the geological context investigated.

Geotechnics 4: Foundations

Code: geotechnique-4-fondations [geotechnics-4-foundations]

Description

Reviews on laboratory tests and presentation of in-situ testing. The first part of this course presents the type of foundations (well, raft, strip footing, piles, micro-piles, etc.) and their sizing (briefly). A project on a real-world situation of geotechnical investigation (G1, G2 AVP [in French: *avant-projet* = draft phase of a project]): mineralogy investigation, analysis of laboratory tests (Attenberg's limits, MBT (methylene blue test), particle size distribution, etc.), in-situ tests (penetrometer, pressuremeter, etc.), choice of the type of foundations. All infrastructure calculations, foundations and underground work require in-situ upstream investigations: surveys using an excavator or trenches, drill holes and boreholes. The second part of the course focuses on the different methods of investigation through boreholes and drill holes using hammer drills and rotary drills, as well as equipment elements (tubes, strainer), and on the properties/use of sludge from drill holes. The presentation of in-situ tests: "water" tests - infiltration and geotechnical tests: pressuremeter, hand vane tester, penetrometer, phicometer, is accompanied by practical classes and/or demonstration on construction sites. We shall also discuss in-situ equipment, dilatometer, inclinometer, settlement plate.

Expected skill

- To know Eurocode 7 (deep foundations)
- Definitions and knowledge of the types of foundations (shallow, deep and special)
- To master geotechnical missions (G1 and G2AVP)
- To know the in-situ tests.

Road infrastructures 2

Code : infrastrutures-routieres-2 [road-infrastructures-2]

Description

This second part on road techniques and earthwork is an application of the French directives *Recommandations pour les Terrassements Routiers* and the technical guide *Réalisation de Remblais et couches de forme*, for determining the categories of roads, traffic, levelling courses and platforms with applications to different geological fields, platform and compaction inspection tests. We shall also discuss the choice of earth-moving equipment, the optimisation of outputs (Q/S) and excavated material / filling.

Expected skill

To define a road structure - to define technical specifications for installation and inspection

Rock mechanics 2: Rock masses

Code: mecanique-roches-2-massifs-rocheux [rock-mechanics-2-rock-masses]

Description

This course will present the basics of rock mechanics and of the methods for pre-sizing underground structures (AFTES recommendations, Bieniawski's RMR method, Barton's Q-system). We shall also discuss the mechanical role of water present in rocks and rock masses.

Expected skill

- to propose characterisation methods for the discontinuities of a rock mass,
- to carry out a pre-sizing of an underground structure (tunnel, underground gallery).

Underground structure design

Code: conception-ouvrages-souterrains [underground-structure-design]

Description

The module starts with complements of rock mechanics for underground work. We shall then present the typology, the framework and the history of underground work. The next step concerns land survey, both before digging and during progress, and the inspection of structures. An important part of the module is dedicated to digging methods (explosive, roadheader machine, tunnel boring machine) and retaining structures for underground structures.

Expected skill

To know the different traditional digging and retaining techniques for underground structures, and to be able to chose the best amongst them for a specific structure.

Professional environment 3

Code: environnement-professionnel-2-gts [professional-environment-2-gts]

Description

This module will present the application of the *MOP* law regarding public contracting authorities and its relation to private general contractors within the framework of underground work. We shall define the main players (client, general contractor, work company) and state their roles and responsibilities (technical and administrative monitoring of construction sites, etc.) and the regulations, in particular for the devolution of underground public contracts. We shall also discuss the contract practices in underground work.

Expected skill

To master the code of public contracts and its specificities in the case of underground structures.

Concrete structures

Code: structures-beton [concrete-structures]

Description

Structure calculation needs a review on the definition of actions, the fundamental principle of statics, forces (N, V and Mf), and elementary iso- and hyperstatic systems applied to constructions. The principle of lowering of loads is stated, and after a brief history, we shall present calculation methods for reinforced concrete and for prestressed concrete according to the rules of EUROCODE 2, both for the ultimate limit state and for the serviceability limit state. Tutorial classes will be devoted to elementary, actual cases of building projects. They will discuss beams, floors, piles and shallow foundations.

Expected skill

- To master the fundamental concepts governing the behaviour of a reinforced concrete and/or pre-stressed concrete section, * to master the basic calculations for designing reinforced concrete and/or pre-stressed concrete structures.

Civil engineering calculations and models (GTS)

Code: calculs-modeles-genie-civil-gts [civil-engineering-calculations-models-gts]

Description

An engineer from an engineering consulting firm uses calculation codes based on solving partial differential equations. This course is aimed at presenting the most widely used analytical and numerical methods in civil engineering for solving partial differential equations (finite differences and finite elements methods). For each method, special attention will be paid to the convergence criteria and to the stability of the implemented schemes. This course is also an introduction to the theory of plasticity which is widely used in geomechanics. This theory is illustrated in the course by applications coming from problems in geotechnics (Cam-Clay model). The teaching includes tutorial classes using the finite elements software Plaxis. The students following the GMC study path will have 15 tutorial classes devoted to Plaxis.

Expected skill

- to carry out calculations using a finite elements code
- To build, from a real-world case, a simplified numerical model (using the symmetries of the problem, creating a meshing, boundary conditions, choosing a behaviour law) for a finite elements code.

QSE approach to underground work

Code: demarche-qse-ouvrages-souterrains [QSE-approach-underground-work]

Description

This module is dedicated to the application of the quality, safety, environment approach to underground works and to the specificities of the latter within this approach. We will discuss, in particular, the management and reuse of excavation materials, and health and safety protection in underground work-sites.

Expected skill

To know how to adapt the QSE approach to underground work in order to improve the quality and safety of underground work and risk management.

Underground space

Code: espace-souterrain [underground-space]

Description

This module is dedicated to accessory structures to major underground structures. We include the case of equipment (ventilation, lighting, electricity, etc.) and making underground structures safe. Special attention is paid to underground structures in urban environment and to their interactions with this urban environment.

Expected skill

To know how to integrate a structure into its environment by taking into account all constraints, especially in an urban environment.

Leak-tightness and coating

Code: etancheite-revetement [leak-tightness-coating]

Description

In this module, we shall present the different sealing and coating techniques for underground structures, and the treatment for stopping water ingress into underground structures.

Expected skill

To know how to treat water conditions in an underground structure.

Underground work at small depth

Code: travaux-souterrains [underground-work]

Description

This module is dedicated to soil improvement techniques such as jet grouting, injections and ground freezing. We shall also present in detail digging into running ground using ground

improvement techniques at the front of the face (pre-vaults, umbrella vaults), and the use of shields for digging tunnels. We shall also discuss the management of aquifers. In this module, we shall also discuss the techniques of covered trenches.

Expected skill

To be able to adapt underground work methods to unfavourable conditions.

Underground space exploitation and layout

Code: exploitation-amenagement-espace-souterrain [underground-space-exploitation-layout]

Description

This module is a series of talks given by professionals about underground work and structures in different fields of application: hydraulic galleries, radioactive waste storage, gas storage, tunnels and urban infrastructures.

Expected skill

To understand the specificity of the different underground structures, and their related societal issues.

Geophysics and petrophysics

Code: geophysique-petrophysique

Description

Soil and rock massive identification uses more and more non-intrusive geophysical methods. This course is aimed at presenting the different geophysical methods used in civil engineering. For every method, we shall show how petrophysical measurable data can be quantitatively related to a state parameter of a geomaterial (porosity, water concentration, density, salinity, clay concentration).

Expected skill

- To be a capable contact person for geophysics companies and consulting firms.
- To identify the geophysical method appropriate for the target involved.
- To organise a very basic campaign of geophysical exploration.

Underground mining

Code: minage-souterrain [underground-mining]

Description

This module is devoted to work using explosives, from a technical and regulatory point of view. Part of the module is common to the GMC study path. The teaching will discuss blasting

techniques and their regulations: characteristics, classification and packaging of explosives. We shall also discuss the use of low explosives and detonating explosives, the choice of detonators - detonation relays and boosters, types of priming and safety, the installation of firing and mine loading, and firing incidents. The second part of the module is more specifically dedicated to the underground use of explosives.

Expected skill

To know the regulations in terms of work using explosives and to know how to set up an underground firing plan.