CHIMIE PARISTECH - PSL

Syllabus

1st year of the engineering cycle

The first year is dedicated to the training of multidisciplinary general science, to provide the student engineer with a complete level of scientific knowledge.

Teaching includes basic courses in mathematics, physics, computer science, courses oriented towards the theoretical foundations of chemistry (physicochemistry, structure of matter) and courses in organic and analytical chemistry. The courses are supplemented by one-day experimental works designed to teach the basic gestures of chemistry, starting with safety rules and risk management.

The engineering professions are introduced through management courses focused on the discovery of the business world and in the second semester, over a period of six months, a transdisciplinary project allowing students to learn to manage teamwork while being able to report to a client. At the end of the year, after the last exams which take place at the beginning of May, the students manage a three-week project in research laboratories.

The school year terminates with a one or two-months internship.

Semester 5 :	Semester 6 :
Mathematics and physics for the engineer (6 ECTS) Applied mathematics for engineers Quantum Mechanics Computer science and programming **Physical and analytical chemistry (6 ECTS)** Physico-chemistry of interfaces Experiments in Physical and analytical chemistry **Molecular chemistry 1 (6 ECTS)** Structure and reactivity Molecular Spectroscopy Chemical risk **Structure of the material (6 ECTS)** Solid chemistry Crystallography **Business knowledge, languages and culture 1 (6 ECTS)** Management English "Inclusion-team building" and "CSR-Responsible engineer" seminars **Optional courses** Sport Foreign language	**Material and interactions (5 ECTS)** Chemical bonding Matter-Radiation Interaction Experiments in Spectroscopy **Molecular chemistry 2 (5 ECTS)** Synthesis and reactivity Long experimental projects Experiments in molecular chemistry **Processes (5 ECTS)** Chemical engineering Numerical methods Experiments in chemical engineering **Analytical chemistry (5 ECTS)** Solution chemistry Separation methods Electrochemistry Experiments in Physical and analytical **Business knowledge, languages and culture 2 (6 ECTS)** Management English Transdisciplinary project "Innovation Days" seminars **Awareness of societal and professional environmental issues (4 ECTS)** Training in ecological transition Worker internship **Optional courses** Sport Foreign language

Possibility of taking a gap year

SEMESTER 5

1A S5	MH11ES.MAI	**Applied mathematics for engineer** *Key words :* algebra, Fourier transform, statistics

Responsible : Frédéric Wiame, Associate Professor
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ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* Written exam
	0 h	24 h	0 h		

Course outline :
This course provides students with the essential notions of mathematics allowing them to understand first-year courses and practical work (Physics I: Quantum Mechanics, Physics II: radiation-matter interactions, TP IRM and Materials ...). It is thus a teaching with applied purpose for which practicing of concepts is essential.
The course is divided into three parts:
1) Mathematics applied to quantum mechanics where are introduced the notion of Hilbert space, the Dirac notation, the computation of quantities in a complex vector space, and their application in the framework of the theory of measurement in quantum mechanics.
2) Mathematics applied to signal processing where are discussed the use of Fourier series and Fourier transforms as tools for processing and analysis.
3) Mathematics applied to data analysis where are presented the notions of probabilities, statistics and distributions. Essential concepts such as mean, standard deviation, and linear regression will be reported and applied to uncertainty calculations and data analysis.

Learning outcomes :
At the end of the course students will be able:
- to use Dirac's formalism and computation in a Hilbert space in the context of a quantum physics or quantum chemistry problem,
- to analyze and process a signal by using the properties of Fourier transform and Dirac distribution,
- to assess uncertainties in measured and calculated quantities and to use data analysis methods to judge the suitability of a model.

Prerequisites :

Algebra: finite-dimensional vector spaces (definition, basis, scalar product and norm in Euclidean space, dual space and dual basis, linear form), matrix algebra (matrix, operations on matrices, determinants, matrix of a linear application, diagonalization, change of basis).

Analysis: integration, integration by parts, usual primitives.
Probability: notion of event, probability of an event, independent events, conditional probabilities, Bayes' theorem, total probability formula, probability density.

Teaching language: french
Documents, website: textbook, slide presentation, corrected exercises, online quiz
https://moodle.psl.eu/course/view.php?id=14878

1A S5	MH11ES.MQ	**Physics I : Quantum Mechanics** *Key words :* fundamental concepts of quantum physics, model systems

Responsible : Laurent Binet, Professor
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ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* written examination
	12 h	12 h	0 h		

Course outline :
This course aims at introducing the conceptual tools necessary to address future technological innovations (e.g. quantum technologies) in which chemistry is to play a key role, to understand the functional properties of molecules and materials and to get into the advanced methods for the characterization of matter, including the spectroscopic methods. The course thus introduces the postulates of quantum mechanics, the Heiseng-berg's relations, the mathematical tools, the main model systems (potential wells and steps, the harmonic oscillator, the hydrogen atom), the angular momenta and the quantum properties of indiscernable particles.

Learning outcomes :
The student should be able to:
- Tell the conceptual differences between classical and quantum physics.
- Use the mathematical formalism of quantum mechanics.
- Apply the postulates in the context of a problem in quantum physics.
- Define the main features and properties of the model systems.
- Use appropriate approximations to change a complex system into a model system.
- Use his knowledge to solve a complex problem (AAG1).

Prerequisites :
Classical physics: momentum, angular momentum, kinetic and potential energies, Newton's laws, conservation laws of energy and angular momentum for isolated systems, angular momentum theorem, dynamics of 2 interacting particles, electric field and electrostatic potentiel of a point charge, magnetic field and microscopic currents, plane waves, wave-vector.

Mathematics: calculations with complex numbers, algebra in Hilbert spaces (calculation of scalar products, Dirac's otation, discrete or continuous bases, tensor product, linera operators, eigne values and eigne vectors, matrix calculations, diagonalisation), Fourier transform, Dirac's distribution, linear differential equations of 1st or 2nd order with constant coefficients, partial derivatives of multivariable functions, Laplacian, gradient, cartesian and spherical coordinates.

Teaching language : french (english on request)
Documents, website : https://moodle.psl.eu/

1A S5	MH11ES.IP				**Computer science and programming** *Key words :* programming, C
Responsible : Julien Ciaffi julien.ciaffi@chimieparistech.psl.eu					
ECTS :	*Course* 0 h	*Tutorials* 26 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* Computer-based evaluation

Course outline :
This module aims to train the engineering student in the basic concepts of programming, and to enable him/her to build an application independently using simple and familiar algorithms.
The programming language used is C, which is fundamental in industrial and academic fields. This makes it possible to introduce fundamental aspects of programming such as the choice of appropriate representations of data in memory, notions of numerical precision, the proper use of the results of numerical calculations or the structure or logic of a program when building an application to solve a given problem.
Particular attention is paid to the efficiency, quality and limitations of IT solutions, in order to make the student engineer able to communicate with the IT specialists of his future company or laboratory, and to remove the black box aspect generally associated with IT.
The training is based on course/TD sessions, based on examples mainly taken in the field of chemistry using the free software Code::Blocks, easily installed on any personal computer.

Learning outcomes :
The student must be able to:
- analyse a problem and translate it into a general programming language
- imagine and design an application using a modular structure and an appropriate representation of the data in memory
- evaluate, control and validate algorithms and programs

Prerequisites :
None

Teaching language : french
Documents, website : handouts, documents

1A **S5**	**MH11ES.PCI**	**Physico-chemistry and interfaces** *Key words :* mixing, ideality, non-ideality of physico-chemical systems, interfaces and colloids

Responsible : Virginie LAIR Professor
virginie.lair@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* Final written exam
	12 h	12 h	0 h		

Course outline :
The Physical Chemistry and Interfaces course provides engineering students with the skills to characterise the phenomena that occur at the core of chemical reactions and to predict their behaviour. It constitutes an indispensable basis for the understanding of the characteristics of mixtures and interactions as well for specialists in material science, biochemistry or chemical engineering.

Based on known thermodynamic concepts (enthalpy, free enthalpy, entropy, chemical potential, molar quantities,...), the student will be able to relate theoretically independent properties and express the effects of intensive variables such as the temperature and the pressure. This course includes the application of these concepts to gases, ionic solutions and binary mixtures (liquid/gas), emphasising the notion of ideality and non-ideality. We will show how, from model laws of ideality, to build valid models for real behaviour (van der Waals, Debye-Huckel models, regular solutions for instance). The notion of activity and activity coefficients will be at the heart of this part while relying on concrete applications of measurements and determination. The application to the molecular weight measurement of macro molecules will be illustrated using the colligative properties.
The thermodynamics of interfaces, especially for liquid surfaces, will be described. The basic notions essential to the understanding of interface phenomena will be described, explained and illustrated (surface tension, capillarity, contact angle and adsorption). Surfactants and their properties will also be described, with emphasis on emulsion applications. Then, the thermodynamic and kinetic basis of colloid stability will also be presented, illustrating the phenomena with examples from everyday life, medical imaging, environmental and industrial applications. This part constitutes the indispensable basis for the study of soft matter.

Learning outcomes :
- Define and identify the parameters of a gaseous, ionic or binary system, using thermodynamic concepts.
- Analyse and build a model by comparing its predictions with experimental results or an ideal behaviour.
- Evaluate the limits of validity of the selected models
- Identify and describe phenomena at interfaces.
- Explain and appreciate the notion of metastability (e.g. emulsions and colloids).

Prerequisites : Basics of thermodynamics, chemical equilibrium, solution chemistry

Teaching language : french
Documents, website : pdf documents, exercices handouts, Moodle website

1A S5S6	MH11FECP et MH12FECP	**Laboratory course in physical and analytical chemistry** *Key words :* physical and analytical chemistry, electrochemistry, chromatography and separation sciences

Responsible : Laura Trapiella, Associate Professor
laura.trapiella@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* Practical examination, bibliographic report, experimental reports, oral presentations, daily involvement
	0 h	0 h	67.5 h		

Course outline :
The practical work in this module is in harmony with the courses of physical chemistry and interfaces, chemistry of reaction media, electrochemistry and separative methods. They allow to illustrate and to put into practice the theoretical notions of the course as well as to apprehend their fields of application in the industry. The first part of the course concerns the analysis of traces / ultratraces in relation to the fields of quality control, industrial process control and environmental protection: liquid/liquid extraction methods for metal cations (downstream of the nuclear cycle); separative methods (ion chromatography, high-performance liquid chromatography, capillary electrophoresis) for the determination and quantification of inorganic or organic pollutants; electrochemical methods (complexation or pulse polarography, selective electrodes) for the determination and quantification of pollutants in environmental matrices (water, soil) as well as for decontamination (ultrafiltration). A second component concerns studies at interfaces to better understand the synthesis and characterization of new materials and processes using interfaces: synthesis of materials by electrochemical way (electrodeposition); study of corrosion and additives allowing to control this phenomenon; electrokinetic characterization of membranes and application to electrodialysis (water purification); thermodynamics of surfaces (surface tension, contact angle) for the characterization of a formulation of detergents and functionalized surfaces (design of windshields, for example) ; characterization of complex media (hydrogen electrode, densimeter, UV-visible spectroscopy, cyclic voltammetry) for the understanding and prediction of phenomena in industrial processes involving hydro-organic and micellar media, catalytic processes. ..

Learning outcomes :
Following this practical training, students should be able to:
- Follow health and safety guidelines
- Get pratical laboratory skills
- Fill out a laboratory workbook
- Analyse, exploit and discuss experimental data
- Use appropriate theoretical concepts and models
- Undertake a literature search
- Write experimental and bibliographic reports
- Present experimental results and conlusion to an audience

Prerequisites :
thermodynamics of solutions and interfaces

Teaching language : french
Documents, website : handouts, self evaluation quiz, tutorials

1A S5	MH11ES.SR	**Functional Groups: Synthesis and Reactivity** *Key words :*			
Responsible : Sylvain Darses sylvain.darses@chimie-paristech.fr					
ECTS :	*Course* 12 h	*Tutorials* 12 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* Written exam

Course outline :
The course MH11ES.SR "Functional groups: synthesis and reactivity" addresses the chemistry of carbon compounds through the study of the characteristic reactions of the main functional groups. In this first part of a teaching given over two semesters, the formation and reactivity of the carbon-carbon bonds will be mainly tackled: chemical bonding, hybridization, halogenated derivatives (substitution, elimination, ...), alkenes and alkynes (addition, oxidation, ...), dienes ([4+2]-cyclo-addition, ...), aromatics (electrophilic substitution, reduction, reactivity at the benzyl position, …), alcohols (activation, protection, oxidation, etc.) , amines (formation, protection).

Learning outcomes :
At the end of the MH11ES.SR module, the students will have acquired some essential basics in organic chemistry and will be able to apprehend the realization of simple synthesis. They will be in possession of the necessary tools to understand and analyze the mechanisms and the reactivity of the molecules, allowing them to deepen their knowledge with the MH12ER.SR module.

Prerequisites :
Basic knowledge of organic chemistry

Teaching language : french
Documents, website : handouts

1A S5	MH11ES.SCM	**Basic principles of molecular spectroscopy** *Key words :* NMR, mass spectrosmetry, molecular spectroscopy, UV-vis, IR, Nuclear magnetic resonance

Responsible : Frédéric de Montigny, Associate Professor
frederic.de-montigny@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* written exam
	9 h	6 h	0 h		

Course outline :
The objective of the course is to present the usual analysis methods for organic molecules. The student should understand the fundamental bases of these methods and should be able to analyze different kinds of molecules. It is divided into three parts: NMR, mass spectrometry and molecular spectroscopy.
* Nuclear magnetic resonance spectroscopy:
- Analysis of 1H and 13C NMR spectra, determination of the covalent structure of organic molecules, NMR principles: spin concept, Zeeman effect, chemical shift, scalar coupling, spectrum recording techniques: 1H NMR: diastereoisotopy, 1st order and 2nd order spectra, … NMR 13C: 1D experiments, uncoupling, ...
* Mass spectrometry:
- The basic principles of mass spectrometry and the characteristics of this spectrometry method (Molecular mass, average, isotopy, resolution, etc.)
- The different ionizations strategies and mass analyzers and their application in the study of more complex compounds.
- General fragmentation rules allowing the analysis of spectra of various organic compounds presenting the main functions encountered in organic chemistry.
* Molecular spectroscopy:
- Reminder of the fundamentals governing IR, UV-vis with a short introduction on Raman, and optical activity....

Learning outcomes :
Acquisition of theoretical and practical knowledge of mass spectrometry (MS)and Nuclear Magnetic Resonance (NMR). In these lectures, the basic concepts of MS, spectroscopy and NMR are used to understand the applications of these two techniques to identify organic compounds. Exercise sessions will be used to become familiar with interpreting spectra of small molecules and macromolecules.

Prerequisites :

Teaching language : french
Documents, website : https://coursenligne.chimie-paristech.fr/enrol/index.php?id=16

1A S5	MH11ES.RC	**Chemical safety** *Key words :* safety, risk assessment, material safety data sheet, fires and explosion, industrial hygienes

Responsible : Michael Tatoulian Professor
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ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* written exam
	16 h	h	h		

Course outline :
This course aims first of all to provide the basic elements of chemical risks in order to know how to decipher a safety data sheet and to know all the parameters of toxicological and fire risk assessment. Particular attention will be paid to the physico-chemical properties (SDS) useful for understanding chemical risks. Different exposure scenarios will be presented to allow students to assess the chemical risks related to possible overexposure to chemicals that could lead to intoxication or explosion/fire risk; in particular, this approach will define good laboratory practices and ensure the safety of an operating station. Students will also be trained in the dangers of static electricity, and dust explosions. Finally, students will be introduced to the problem of inerting in chemical reactors and will set up prevention/protection barriers through the use of the What-if method in a process safety approach. The teaching will then be supplemented by the regulatory aspects related to the implementation of REACH, the regulation on explosive atmospheres (ATEX).

Learning outcomes :
At the end of the course, students must be able to :
- Be able to understand chemical risks (toxicological risks - fire risks) based on physico-chemical properties
- Be able to make exposure scenarios and assess their risks
- Be able to define the inerting processes of chemical reactors
- Perform a workstation analysis

Prerequisites :
general chemistry

Teaching language : french
Documents, website : handouts https://coursenligne.chimie-paristech.fr

1A S5	MH11ES.CS	**Solid State Chemistry** *Key words :* ionic model, reticular energy; ionic radius scale, crystal field theory, defects in solids, non stoechiometry

Responsible : Gerard Aka, Professor
gerard.aka@chimieparistech.psl.eu

ECTS :	*Course* 13.50 h	*Tutorials* 12 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* written exam integrating a documentary approach

Course outline :
The objective of this teaching is to allow the student to acquire skills on the structural description and the chemical and physical properties of a crystallized solid. A first part of the course is devoted to the description of the structural characteristics of different ionic solids. The thermodynamics of formation of these solids is then presented. Historical landmarks, relating to the design of the different ionic radius scales, are mentioned. Models, justifying the deviation from the perfect ionic model, are described, followed by the crystal field theory as well as its thermodynamic, structural and magnetic consequences.
In a second part, the model of the perfect crystalline solid is completed by the introduction of imperfections or defects existing in all real solids. It is the set "Perfect crystal + defects" which will constitute the model of the real solid. Emphasis on point defects and non-stoichiometry in solids. The point defect formation mechanisms are explained according to the nature of the type of defect. The remarkable physical properties that arise from defects in the real crystal are presented and discussed in the last part of this teaching.

Learning outcomes :
At the end of this teaching the student will be able to acquire following knowledge and skills:
1 - Know how to describe the main structural types characterizing solids
2 - Know how to calculate and interpret the lattice energy of a solid.
3 - Know how to use the ionic radius scale according to Shanon and Prewitt to better understand the structure of the solid.
4 - Know how to analyze the thermodynamic, structural or magnetic consequences linked to the existence of the crystalline field in a given solid.
5 - Knowing how to distinguish the different types of intrinsic and extrinsic defects in a solid
6 - Know how to write the mechanism of formation of point defects in a non-stoichiometric solid and deduce the remarkable properties (physico-chemical) associated with each type of defect..

Prerequisites :
License, Master 1 (L3/M1)

Teaching language : french
Documents, website : Course handout and digital version, visualization software for the structure of crystalline solids, slide show of the course and digital yearbook of corrected exercises.
https://moodle.psl.eu/

1A S5	MH11ES.CDS	**Crystallography** *Key words :* Geometric crystallography, lattices, symmetries, X ray diffraction

Responsible : Gilles Wallez, Associate Professor
gilles.wallez@upmc.fr

ECTS :	*Course* 12 h	*Tutorials* 12 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* final examination

Course outline :
Geometric Crystallography describes the crystalline solid through the periodic repetition and the invariance following symmetries of a chemical pattern at lattice points, hence the properties. Beyond, X ray Diffraction is the tool that allows determining the crystal structure at the atomic scale.

Learning outcomes :
This teaching unit aims at making the student able to apprehend by him/herself the symmetries and the atomic array of a crystal structure. These geometric considerations will be developed in narrow relation with X ray powder diffraction that will allow solving simple crystal structures. In a more general canvas, this unit is linked to teaching in solid state chemistry and is a basis for understanding the properties of materials.

Prerequisites :
geometry, trigonometry, scalar and vector products, matrices calculations, complex exponential

Teaching language : french
Documents, website : handouts moodle

1A **S5**	**MH11TC.CE2**	**Management economic and social sciences - knowledge of the company** *Key words :* engineer, company, management, organization, societal and ecological issues, responsible engineer and actor of transformations and transitions, CSR (Corporate Social Responsibility), governance, professional project

Responsible : Philippe Vernazobres and Delphine Bourland, Associate Professor and teacher
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ECTS :	*Course* 40 h	*Tutorials* 0 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* Summary note on a company + Articulation with the 1A internship where they will be in a participant observation posture

Course outline :
This UE aims to train and professionalize engineers capable of having a global and transdisciplinary vision of their environment. It is about giving them the tools to enable them to integrate into an organization and to understand the complex challenges of the company.
Course topics - 12h
- The contributions of SHS to the understanding of the company and management (economics, sociology...)
- Engineers and their professions within the organization.
- The major changes in managerial thinking.
- The fundamentals of management: managerial skills and leadership.

Workshop topics - 14h
- Professional project: career path, ambition, French-English CV, cover letters
- Economic approach of the company: definitions, actors, goals, organization, economic, societal and environmental performance
- Governance: awareness of the different modes of governance, identification of stakeholders

Seminar topics - 14h
- Team-building: inclusion-cooperation seminar (7h)
- Corporate Social Responsibility: the responsible engineer, exchanges with professionals (3.5h)
- Round tables: engineering professions, exchanges with professionals (3.5 hours)

Learning outcomes :
At the end of the modules, the student will be able to:
- Understand basic basic vocabulary of economic and managerial fields, useful to work in companies and organisations
- Understand the reality and complex challenges of the company: economic, social, societal and environmental performance; transition issues and ecological impacts
- Inserting and situating oneself in an organisation
- To fit in and take one's place in a group, taking into account group dynamics, collective intelligence and cultural differences
- Think and act responsibly and ethically
- Get to know yourself better, think about your career plan, master job search tools

Prerequisites :

Teaching language : french
Documents, website :

1A S5S6	MH11TC.ANG; MH12TC.ANG;	**General, scientific and business english** *Key words :* English, General, Scientific, Business, Intercultural Skills

Responsible : Daria Moreau, Head of Languages and Cultures Department
daria.moreau@chimieparistech.psl.eu

ECTS :	*Course* 0 h	*Tutorials* 79.5 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* evaluation reports validation of 5 skills (see CECRL grid) at least at B2 level

Course outline :
These courses are designed to improve English language skills and to teach linguistic autonomy in order to prepare students to work with technical and scientific English in an international or in an intercultural context.
Each student is required to participate in both General and Scientific English classes. The General English courses take place in level groups established at the beginning of the year on the basis of both a placement test and oral evaluations. Students can freely choose the theme-based classes independently on their levels in English. For the most advanced students (bilingual or C2 according to CECRL) it is possible to replace the classroom courses with research work supervised by a teacher from the Department. Low-level students can attend one-to-one tutoring sessions.
The classroom courses are complemented by an adapted and varied "e-learning" (the Yesmag application which aims to facilitate reading texts in their original versions; multiple linguistic activities on Moodle; self-study in the language lab).
General English courses are to master:
- speaking skills: presentations, debates, discussions on cultural topics specific to Anglo-Saxon countries,
- listening and comprehension of TV or radio news,
- synthesis and comparison of authentic documents from the current press,
- CV writing,
- role-playing in professional situations (negotiations, telephone conversations, job interviews),
- analysis of business cases with reference to authentic documents.
Scientific English courses are to:
- work on technical and scientific vocabulary,
- master writing reports, articles, essays,
- practice oral communication on technical, scientific and social subjects,
- discuss scientific articles.
Individual and group project work will also be proposed.

Learning outcomes :
The student will have a thorough knowledge of grammar and technical/scientific vocabulary to be able to communicate both in written and oral business English in a multicultural company / The student will be prepared to search for an internship or a job in an English-speaking country / The student will write his/her CV in English, taking into account the cultural rules of an English-speaking country / The student will be open to collaborative work / The student will have a strong culture of at least one English-speaking country / The student will learn to master a debate on an everyday life, technical or scientific subject / The student will be able to prepare in advance a clear presentation on a subject with a cultural, civilizational, technical or scientific content / The student will answer factual questions on a given subject / The student will be able to participate in a conversation and express himself/herself on a wide range of topics / The student will synthesize a scientific or general text or an audio, identify relevant information and present it to an audience.

Prerequisites : B1

Teaching language : english
Documents, website : audio and video documents, factual documents https://coursenligne.chimie-paristech.fr/course/view.php?id=76

1A S5/S6	**Sport** *Key words :* sport				
ECTS : 1					

Course outline :
Students at the school have a free half-day on Thursday afternoons for sports.

ECTS credits are awarded when regular practice is validated by a teacher or the person in charge of the sport.

ENSCP students form men's and women's handball and volleyball teams.

Other sports can be practiced within the wider framework of PSL University.

https://www.psl.eu/vie-de-campus/sport

1A S5/S6	**Foreign language** *Key words :*		
Responsible : Daria Moreau, Head of Languages and Cultures Department daria.moreau@chimieparistech.psl.eu			
ECTS : 1	*Course*	*Tutorials* 42 h	*Evaluation Method :* At the end of each semester, validation of the 5 competences of the CEFR grid and of: personal work, knowledge of culture and intercultural communication, motivation, course participation, attendance, etc.

Language options : German, Arabic, Chinese, Spanish, Italian, Japanese, Portuguese, Russian, Swedish

Course outline :
Linguistic and cultural training is an integral part of the curriculum at Chimie ParisTech-PSL. This training is designed to prepare them for internships or study stays abroad and a possible international professional career, as well as to familiarize them with other cultures.
LV2 language teachers also organize preparatory courses enabling students to take internationally-recognized language exams.
LV2 courses are optional at Chimie ParisTech-PSL.
The choice of LV2 is made at the beginning of the school year on the Moodle platform. A placement test is compulsory for German and Spanish courses.
Students can choose from the following courses
- German (4 groups of A1-C1 level),
- Spanish (4 groups of A1-C1 level),
- Chinese (2 groups of level A1-A2),
- Japanese (2 groups, level A1-A2),
- Italian (2 groups, level A1-A2),
- Swedish (1 group, A1 level).

Students can also take courses in Arabic, Portuguese or Russian offered by PSL.
Foreign language courses are designed to enable students to master :
Depending on the level as described in the CEFR:
- continuous oral expression and interaction on a wide range of topics from everyday life, professional life and the world of the language studied,
- acquisition of grammar and vocabulary,
- regular training in oral and written comprehension on a variety of topics,
- writing a variety of texts,
- interaction with a native speaker,
- argumentation through news and current affairs, songs, film extracts, etc.

Learning outcomes :
At the end of the course, students will be able to:
- develop linguistic and intercultural skills,
- integrate into professional, academic and social life abroad,
- work collaboratively in LV2,
- argue orally on an everyday, technical or scientific subject,
- answer factual questions and argue on a given subject,
- hold a conversation and express oneself fluently on a wide range of subjects,
- synthesize a scientific or general text or an audio document, extracting the relevant information and presenting it to an audience,
- compare the cultural, social and historical particularities of a foreign country,
- understand everyday language through cinema, radio or television programs.

SEMESTER 6

1A S6	MH12ES.LC	**Chemical Bonding** *Key words :* chemical bonding			
Responsible : Carlo Adamo, Professor carlo.adamo@chimieparistech.psl.eu					
ECTS :	*Course* 12 h	*Tutorials* 12 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* Written exam

Course outline :
This module is an introduction to the main basic concepts encountered in quantum chemistry for the determination of the electronic structure of systems ranging from hydrogen atoms to single multi-electronic molecules.
The main concepts covered are: molecular orbital theory, resolution of the Schrödinger equation, electronic correlation, perturbation or variational approaches, approximate methods for calculating the electronic structure, study of reactivity using boundary orbital theory and characterization of an energy profile.
The training is based on alternating course and TD sessions.

Learning outcomes :
The student must be able to:
- understand the basic concepts of quantum chemistry
- to be able to describe a multi-electronic atomic or molecular system
- select and use the approximate methods for calculating the electronic structure
- understand the basic concepts of molecular system reactivity

Prerequisites :

Teaching language : french
Documents, website : handouts

1A S6	MH12ES.IRM	**Matter-Radiation Interaction** *Key words :* atomic and molecular physics, processes of interaction with radiation

Responsible : Laurent Binet, Professor
laurent.binet@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* written examination
	15 h	9 h	0 h		

Course outline :
The interaction processes between matter and electromagnetic radiation are the basis of spectroscopic techniques in analytical chemistry as well as major technological applications (imaging techniques, photovoltaics, optoelectronics, quantum technologies,...). The objective of the course is to make a general presentation of these processes and to explain the spectroscopic properties in relation to the quantum descriptions of atoms, molecules, and matter in general. The course starts with describing the fundamental processes (absorption, stimulated and spontaneous emissions and 2nd order processes) induced by an electromagnetic wave onto a quantum system and the notion of selection rules. Then the dipolar approximation for the coupling between light and matter is explained, allowing to introduce electric and magnetic dipole transitions. Then the electronic transitions in atoms are addressed, including the effects of the electron-electron and spin-orbit interactions. The last part addresses the rotational, vibrational and electronic spectroscopies of molecules (separation of electronic and nuclear motions, energy diagrams in configuration coordinates, Franck-Condon principle, specific selection rules). The course is illustrated by examples from variuous fields (environmental and earth sciences, biology, astrophysics, heritage sciences,…).

Learning outcomes :
The student must be able to:
- describe the different ways in which radiation and matter interact,
- describe the different interactions that exist in atoms and molecules,
- explain the different levels of approximation in the quantum description of atoms and molecules,
- determine the spectroscopic terms or multiplets of atoms
- predict possible transitions in atoms and molecules and to interpret absorption or emission spectra on this basis,
- use his knowledge to solve a complex problem (AAG1).

Prerequisites :
Quantum physics : Schrödinger’s equation, Dirac’s notation, electron states in single electron atoms / ions, properties of angular momenta in quantum physics, quantum harmonic oscillator

Classical electromagnetism: electromagnetic plane waves, vector potential, electric and magnetic dipole moments

Teaching language: french (english on request)
Documents, website: https://moodle.psl.eu/

1A S6	MH12FE.IRM	**Practical Work in Spectroscopy: Interaction of Radiation with Matter** *Key words :* quantum mechanics, spectroscopy, signal processing, cristallography, X ray diffraction

Responsible : Pascal Loiseau, Associate Professor
pascal.loiseau@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* report
	0 h	0 h	30 h		

Course outline :
Pratical work about interaction of radiation with matter happens in first year. It focuses on characterization techniques of matter mobilizing knowledge either in crystallography, for the study of any crystallized material, or in spectroscopy based on dipolar electric interactions as well as dipolar magnetic ones, by covering a large range of energy from microwave to visible radiation.
The experimental techniques examined in depth are : X-ray diffraction, electron paramagnetic resonance, Fourier-transform infrared spectroscopy, molecular emission, UV-visible absorption, laser oscillation.

Learning outcomes :
This practical teaching emphasizes the importance of the operating principles of any experimental techniques on measurement, and applies skills in crystallography-X ray diffraction, interaction of radiation with matter and applied mathematics.
From this practical work, the student will be able to:
- optimize acquisition parameters by considering resolution and signal to noise ratio, in accordance with the signal processing embedded in a measuring equipment
- apply a systematic method of structural analysis, notably by the use of Fullprof software
- identify and classify the nature of electronic transition on a spectrum as a function of energy
- criticize a physical model depending on used hypotheses

Prerequisites :
crystallography-X ray diffraction, interaction of radiation with matter, applied mathematics

Teaching language : french
Documents, website : handouts https://coursenligne.chimie-paristech.fr/course/view.php?id=22

1A S6	MH12ES.SR	**Functional groups: synthesis and reactivity** *Key words :* functional group, reactivity, mechanism, multi-step synthesis

Responsible : Jean-François Soulé, Professor
jean-francois.soule@chimieparistech.psl.eu

ECTS :	*Course* 12 h	*Tutorials* 12 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* Written examination

Course outline :
UE CMB.SR.1.2 is a continuation of UE CMB.SR.1.1 and covers the reactivity of carbonyl functions (aldehydes and ketones) and carboxylic acids and their derivatives. The different reactions involving these functions will be studied in detail, with an emphasis on their mechanisms to better understand the reactivity of the carbonyl bond. A particular emphasis is placed on the application of these transformations in multi-step synthesis of complex molecules, such as natural products and drugs. Concrete examples will be given to illustrate these applications.

Course program:
1) Organometallic derivatives: preparation, properties
2) Carbonyl derivatives:
    Nomenclature and physico-chemical properties, preparation
    Reversible nucleophilic addition reactions (water, alcohols, amines, thiols, ...)
    Irreversible nucleophilic addition reactions (organometallics, ylides, ...)
    Reduction to alcohols and alkanes
    Formation and reactivity of enols, enolates, enamines, silyl enol ethers
    Aldol condensation, alkylation, halogenation, Mannich reaction
    Michael addition, Robinson annulation
    Oxidation and reduction reactions
3) Carboxylic acids and derivatives:
    Nomenclature and physico-chemical properties, preparation
    Nucleophilic addition of organometallics
    Curtius, Arndt Eistert, Knoevenagel, Reformatsky, Darzens, Baylis-Hillmann reactions
    Wolff rearrangement
    Claisen and Dieckman condensations
    Reduction reactions.

Learning outcomes :
At the end of UE CMB.SR.1.2, students will have acquired the fundamental concepts necessary to understand the reactivity between two chemical entities. They will be able to analyze the mechanisms of the main reactions and apply them to concrete examples. They will also be able to use this knowledge to analyze a multi-step reaction sequence and construct a reaction scheme for the synthesis of a target molecule.

Prerequisites :
Basic course in organic chemistry (preparatory class, L2)

Teaching language : french
Documents, website : handouts

1A S6	MH12FE.CMB	**Experimental training in molecular chemistry** *Key words :*			
Responsible : Sylvain Darses, Associate Professor sylvain.darses@chimieparistech.psl.eu					
ECTS :	*Course* 0 h	*Tutorials* 0 h	*Practical work* 60 h	*Mentoring*	*Evaluation method :* report and laboratory behavior

Course outline :
In this laboratory experimental work module, through multi-step syntheses in relation with the course and the tutorials, the students approach the classic techniques of synthesis and purification and put into practice the knowledge acquired in the spectroscopy module (IR , NMR, ...) to analyze the synthesized compounds. Students are gradually brought to work autonomously, to determine themselves, by means of a bibliographical research, the most suitable synthesis routes and to implement them. This work is the subject of a professional situation (compliance with the rules of hygiene and safety and implementation of special measures, keeping a laboratory notebook, writing reports).

Learning outcomes :
The objective of this practical work is to train engineering students in the basic techniques of organic synthesis (conventional assemblies, low-temperature reactions, reactions under inert atmosphere, distillation, recrystallization, column chromatography, etc.). analysis (GC, FT-IR, NMR, ...) and raise awareness of health and safety issues.

Prerequisites :
none

Teaching language : french
Documents, website : handouts

1A S6	MH12ES.GC	**Chemical Engineering** *Key words :* fluid mechanics , mass and heat transfer, unit operations of fluid mixtures

Responsible : Frédéric Rousseau, Associate Professor
frederic.rousseau@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* written exam with documents and calculators
	19.5 h	4.5 h	30 h		

Course outline :
This training aims to present the steps to operate a process of transformation of the material with or without chemical reactions (for the traditional chemical industry and for the new ways of recycling).
A chemical process consists of a reactor in which chemical reactions take place, and, downstream of the devices (distillation, extraction...) intended to separate and/or purify the products obtained. Depending on the application sought, these processes operate in continuous or discontinuous mode.
Faced with this complexity, it is first necessary to understand the transfer processes at the local scale: the mechanics of fluids, energy transfers and in particular heat transfers (conduction, convection and radiation) and finally the transfers of matter in single-phase and two-phase media.
To optimize these transfer processes, very often coupled, in steady state or transient, softwares are available to students in practices. To simulate the operation of the process, the setting in equation of the processes is necessary and the resolution of the complex system of equations is possible thanks to data processing. Thus, if the use of mathematics is a means and not an end, the mathematical tool is essential. It must be understood and mastered so that these softwares are not black boxes. The sessions of course and TD are devoted to the comprehension of the concepts of transfers brought into play. This approach is completed by experimental teaching in the laboratory on pilots, which allows theory and practice to be compared.
This knowledge and know-how are very useful and even essential to understand the functioning of a process studied in research, development or production in an academic or industrial environment.

Learning outcomes :
At the end of this training, the student has understood that in order to be able to manage and optimize an industrial manufacturing unit for classical chemistry or for recycling, it is necessary to carry out the material and energy balances. The student mobilizes his skills to adapt and respond to the technical and economic constraints by seeking in particular energy efficiency (by reducing pressure and heat losses, by using pumps at their best operating point, by optimizing the number of stages of unit operations...).
The student remembers that the adjustment of the parameters of a process and / or a unit operation (flow rates, heat flows, reflux rate of the columns...), often dependent, is not empirical but the result of a rigorous scientific analysis.

Prerequisites :
thermodynamic solutions / partial derivatives

Teaching language : french
Documents, website : books, Power Points

1A S6	MH12FE.GC	**Experimental training in chemical engineering** *Key words :* heat and mass transfer, unit operation, simulation

Responsible : Frédéric Rousseau, Associate Professor
frederic.rousseau@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* Continuous monitoring :written reports and oral presentation
	0 h	0 h	30 h		

Course outline :
The practical exercises followed by each student engineer must allow him to apply the concepts discussed in class and in lectures (unit operations and heat transfers) and to complete his experimental training in fluid mechanics, in transfer phenomena and in unit operations. The work is done in pairs and must allow students to report their results and their interpretations in writing and orally.

Learning outcomes :
To give the future engineer a base of knowledge, complementary to his training in fluid mechanics and heat transfer (Fourier law). The future engineer will be able to :
- Know how to describe and estimate linear and singular pressure losses in a network where a fluid is flowing.
- Observe, interpret and dimension the operation of a pump.
- Define, explain and determine the different types of heat transfer by conduction, convection and radiation.
- Be able to understand and describe the phenomena involved in unit operations and to dimension such a system.
- To acquire notions of simulation on chemical engineering software such as Aspen Hysys and COMSOL.
- Combine the phenomena of momentum, heat and matter transfer to predict the operation of a chemical reactor.
- Build and validate a model by comparing its predictions to experimental results and appreciate its limits of validity.

Prerequisites : *Physic and mathematics level Licence 1*

Teaching language : french
Documents, website : handouts https://coursenligne.chimie-paristech.fr/enrol/index.php?id=21

1A S6	MH12ES.MN	**Numerical methods** *Key words :* Algorithmics, programming, C

Responsible : Julien Ciaffi, Lecturer
julien.ciaffi@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* Written report
	0 h	26 h	0 h		

Course outline :
This module aims to train the engineering student in the classical techniques of numerical methods commonly encountered in various scientific fields, in order to enable him/her to choose an algorithm adapted to a given problem and to implement it by making an application in C language.
The algorithms introduced cover problems regularly encountered in various scientific fields, such as the solution of linear and non-linear equations, derivation and numerical integration, the calculation of eigenvalues and vectors, the minimization of functions, the solution of differential equations or partial differential equations.
Particular attention is paid to the efficiency, quality and limitations of the IT solutions that can be used.
The training is based on course/TD sessions, based on examples mainly taken from the field of chemistry, using the free software Code::Blocks, easily installed on any personal computer.

Learning outcomes :
The student must be able to:
- analyze a scientific problem and determine the appropriate numerical methods for its resolution
- implement the main resolution algorithms
- analyze with a critical mind the results obtained, aware of the limits of the methods used

Prerequisites :
C programming : basics

Teaching language : french
Documents, website : handouts

1A S6	MH12ES.CS	**Solution chemistry** *Key words :* Chemistry of aqueous and non-aqueous solutions, chemical separations, complexation, solubilization, precipitation, extraction

Responsible : Anne Varenne, Professor
anne.varenne@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* Article study, multiple choice questions, and terminal exam
	7.5 h	4.5 h	0 h		

Course outline :

Aqueous solutions

- Diluted, concentrated, complex solutions
- Activity, activity coefficient (Debye and Hückel models, Davies, Theory of specific interactions, Pitzer model).
- Complexing: successive or global formation constants, complexing coefficient, distribution diagram, action of acidity on the complexing coefficients.
- Types of ligand (H, OH, L), multi-ligand complexation,.....

Chemical separations

- Solubilization / precipitation
- Liquid/liquid extraction: principle, simple or complex equilibria
- Extraction phenomenon: co-extraction / ion exchange
- Synergism, release
- Liquid/solid extraction: ion exchange resins, distribution equilibria, complexing effect

Non-aqueous reaction media

- Micellar media (presentation, micelles for separations, three-phase system, cloud point, liposomes, microemulsions for extraction)
- Molecular solvents (solvation, acid-base properties, ion pairs...)
- Molten salt media: molten salts at high temperature (presentation, oxoacidity, extraction applications) and ionic liquids (presentation, some properties, extraction applications)
- Supercritical fluids (presentation, some properties, extraction applications)

Articles from the scientific literature (in French and English) are exploited, interpreted and criticized in the light of the course concepts. The module ends with an intervention by a professional from the socio-economic world who exploits these processes in solution for selective separations.

Learning outcomes :

Mobilize knowledge to solve a problem of selective separation of compounds in aqueous or non-aqueous solution for depollution, recovery and/or recycling. Define and interpret the interactions in solution that can be implemented to design a selective separation from samples in complex matrices. Exploit literature data and theoretical equations with a critical mind to justify the experimental conditions to be implemented for a selective separation with the least impact on the environment.The applications presented are varied with a link to the fields of the environment and bioanalysis.

Prerequisites :

Solvents, acidity in aqueous medium, properties of ions, simple complexation, basic notions of electrochemistry

Teaching language : french
Documents, website : handouts in french, articles in english

1A **S6**	**MH12ES.MS**	**Separation Sciences** *Key words :* chromatography, capillary electrophoresis, solid phase extraction, sample preparation, analytical separation

Responsible : Fanny d'Orlyé, Associate Professor
fanny.dorlye@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* continuous control (MCQs and participation) and a final written exam with documents
	6 h	6 h			

Course outline :
Generalities on chromatographic separation methods: principles (interactions and separations), purposes, classification of methods, thin layer and column implementation, instrumental aspects, fields of application Chromatographic interactions and physico-chemical mechanisms controlling separations: volatility, differential interactions, choice of stationary and mobile phases Fundamental quantities and optimization parameters : Retention magnitudes, selectivity, dispersion, resolution On-line and coupled detections to chromatographs: characteristics of detectors, main detection modes, application to qualitative and quantitative analysis (calibration methods) Comparison of liquid and gas chromatography and positioning of chromatographic methods in relation to other separative methods. Introduction to capillary electrophoresis.

Learning outcomes :
The aim of this course is to introduce 1st year students to analytical chromatographic methods before they start practicing in laboratory classes or internships. At the end of this course the students should have a good overview of the different chromatographic approaches and their fields of application. They should have enough knowledge on technological and methodological elements to implement all types of chromatography and optimize separation performances from an analytical point of view.

Prerequisites :
Basics of thermodynamics, solution chemistry, spectroscopy, analytical chemistry, organic chemistry, hydrodynamics, mathematical

Teaching language : french
Documents, website : handouts, self evaluation quiz, simulation software

1A S6	MH12ES.EC	**Electrochemistry** *Key words :* Electrochemistry, microelectrolysis, voltammetry, analysis, effect of the chemical medium, electrochemical kinetics, generators

Responsible : Sophie Griveau, Professor
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ECTS :	*Course* 15 h	*Tutorials* 9 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* A final exam (80%) + a project (20%)

Course outline :
This course is addressed to engineer students that already have some notions on electrochemical potentials. As a first step, we will describe the fundamental principles of electrochemistry at equilibrium, in particular microelectrolysis and the current-potential characteristics I=f(E), that constitute a basis for the approach in analysis and the comprehension of mass and charge transfer at the electrodes. We will largely introduce the effect of the chemical medium on I=f(E) curves. Afterwards, we will develop the notions of electrochemical kinetics and coupled reaction to charge transfer, through cyclic voltammetry that enables to analyse electrochemical processes with short lifetime. We will finally give a panorama of the applications of electrochemistry to electrolysis and electrochemical generators, such as fuel cells and batteries.

Learning outcomes :
- The student will be able to understand the fundamental aspects of electrochemistry;
- He will understand the interest and implementation of microelectrolysis;
- He will know how to establish equations of current-potential characteristics under equilibrium conditions;
- He will integrate the effect of the chemical medium (acidity, complexation, precipitation) in the establishment and plot of I = f (E) curves;
- He will assimilate the basic equations of electrochemical kinetics;
- He will be able to interpret the reactions coupled to charge transfer through cyclic voltammetry.
- He will have basic knowledge and good vision of the applications of electrochemistry to electrolysis and electrochemical generators.

Prerequisites :
Notions on electrochemical potentials end equilibria, basis in thermodynamics and solution chemistry

Teaching language : french
Documents, website : pdf documents, handouts

1A S6	MH12TC.CE	**Management economic and social sciences - knowledge of the company - Intro. to economics and innovation management** *Key words :* innovation, design thinking, entrepreneurship, intellectual property, sustainable dvp, market, circuit, return on investment

Responsible : Philippe Vernazobres, Associate Professor
philippe.vernazobres@chimieparistech.psl.eu

ECTS :	*Course* 42 h	*Tutorials* 0 h	*Practical work* 0 h	*Mentoring*	*Evaluation method :* Final written evaluation for economics and conferences + Industrial jury for innovation week

Course outline :
This EU aims to train engineers capable of innovating and understanding the economic environment and the challenges facing the company to be an actor in the ecological, energy and digital transitions.
Economics course topics - 6 hours
- Purpose of the economic analysis and basic concepts : markets, competition, prices, externalities
- Introduction to macroeconomic analysis: circuits, economic actors and indicators
- Introduction to the economic analysis of money
- Introduction to the planetary boundaries and to the circular economy

Topics of managerial conferences (examples) + preparation for the internship - 11 hours
- Sustainable development end CSR, energy ans climate, energy transition
- Business intelligence, crisis communication, compliance
- Patents and intellectual property protection, Artificial Intelligence

Innovation Week - 24h
- Creativity and innovation seminar with design thinking (2 days), on a brief from an industrial client
- Visit of the Chimie ParisTech research laboratories (1 day)
- Conferences (1/2 day), presentation of school’s innovation ecosystem in PSL, testimonials from entrepreneurs

Learning outcomes :
At the end of the modules, the student will be able to:
- Understand the basic mechanisms of economics
- Understand the managerial subjects essential to the engineer actor of ecological dans digital transformations
- To be involved in an innovation process, the core business of engineers, modules extended in the 2nd and 3rd year
- Experiment and understand a design thinking approach, question the uses, the needs, the value proposition, create a prototype, iterate, cooperate in a team
- Defend an innovative project in competition before an industrial jury

Prerequisites :

Teaching language : french
Documents, website : handouts

1A S6	MH12TC.PTD	**Transdisciplinary project** *Key words : Team, project management, project manager, planning, deadlines, specifications, deliverable, customer relationship.*

Responsible : Philippe Vernazobres Associate Professor
philippe.vernazobres@chimieparistech.psl.eu

ECTS :	*Course* h	*Tutorials* h	*Practical work* h	*Mentoring*	*Evaluation method :* Writing a project report and oral defense

Course outline :
This module consists of putting students in a project mode teamwork situation, in the service of a client, to help them acquire the methods and postures of project management.
The work is organized in groups of seven students for one semester (January-June), half a day a week. It deals with real subjects proposed by industrial and institutional clients. These subjects focus on transversal themes: technological and/or social, societal and environmental dimensions; accompanying changes and transitions. The groups are tutored by teacher-researchers from the school, and the students experiment in a rotating way with the posture of project leader. Conferences provide project management tools and processes.

Learning outcomes :
At the end of the module, the student will be able to:
- Work in a team and open up to the practice of collaborative work.
- Manage the relationship with a client, from demand analysis to project delivery.
- Organize, plan a project, respect deadlines and develop specifications.
- Assume the role of project manager.
- Identify, model and solve unusual and incompletely defined problems.
- Take into account the transversal challenges of companies and society (economic, social, ethical, environmental...) and develop a critical spirit and approach to these challenges.
- Take into account the issues of labour relations, ethics and social responsibility at work.
- Find relevant information to respond to the customer's request, evaluate and implement it.
- Report on this experience and produce a deliverable, both written (report) and oral (presentation to clients).)

Prerequisites :

Teaching language : french
Documents, website :

1A S6	MH12ST.SDE	**INTERNSHIP TO DISCOVER THE COMPANY** *Key words :* company, work organization, organization chart, labour relations, corporate social responsibility, safety

Responsible : Philippe Vernazobres Associate Professor
philippe.vernazobres@chimieparistech.psl.eu

ECTS :	*Course*	*Tutorials*	*Practical work*	*Mentoring*	*Evaluation method :* Internship report
	0 h	150 h	0 h		

Course outline :
Internship of one to two months, of first discovery of the company as a worker or technician.
It is a question of being part of a participatory observation logic in order to, on the one hand, carry out field work and, on the other hand, communicate in writing to report on this experience in a professional way.
The internship report:
- mobilizes first year management courses to situate themselves in the company and understand its challenges.
- Invites to observe the organization of human resources, which will be the subject of management courses in the second year.

Learning outcomes :
At the end of the internship, the student will be able to:
- Integrate and position him/herself in an organization
- Be an actor and responsible for the tasks entrusted to him/her
- Observe and take a step back on the organization, labour relations, productivity, quality, safety, sustainable development, the environment...
- Report this experience regarding to :
o the company's challenges
o the tasks performed
o the construction of the professional project : knowing yourself, making choices

Prerequisites :
Management modules for the 1st and 2nd semester

Teaching language : french
Documents, website : grid for writing the internship report

1A S6	TRECO	**Training in the ecological transition** *Key words :* Planetary limits, New modes of production (industrial ecology, circular economy, decarbonization), Impact analysis, Transition scenarios

Responsible : Odile Majérus, Professor
odile.majerus@chimieparistech.psl.eu

ECTS :	*Cours* 12 h	*TD* 3 h	*TP*	*Tutorat*	*Evaluation method :* a written exam without documents : an MCQ (30 minutes) and one or two open-ended questions (1 h)

Course outline :

Today, our societies are confronted with planetary limits, defined by the conditions for maintaining the major natural cycles and balances that have enabled our development. These cycles and balances ensure the renewal of resources, climate stability and the regulatory services provided by biodiversity. The challenge now is to become aware of these services, understand how they work and mobilize the means to restore and preserve them.

New modes of production will have to be invented in the years to come, based on the principles of industrial ecology (linking players in a given area), the circular economy and the need to decarbonize all processes. Multi-sector dialogue and exchange, between trades and between professional sectors, will be the key to inventing this new global organization.

The aim of this course is to build a common understanding of these major challenges, to accelerate awareness and encourage multi-sector dialogue - in short, to help our engineers play their full part in the transformations that will mark their professional lives.

Learning outcomes :

The objectives of this module are as follows:

- Understand the major issues relating to nature's services and planetary limits: three sessions will focus on climate, biodiversity and chemical pollution,
- Understand the foundations of today's society in terms of energy and resources, and the orders of magnitude involved,
- Be able to refer to the main principles of new production organizations put in place at political and regulatory level: industrial ecology, circular economy, national low-carbon strategy,
- Be familiar with the main principles and quality standards of impact analysis methods (LCA and carbon footprint), and know how to read and criticize impact analyses produced by other players,
- Find your bearings in the panorama of technologies for renewable energies, process decarbonization (including CO_2 capture) and recycling. Become aware of technology-resource couplings,
- Understand, criticize and refer to ecological transition scenarios (energy, production, territories, professions).

Prerequisites :

Science degree level

Teaching language : french

Documents, website : Resources and links will be posted on Moodle

1A S6	**The gap year** *Key words :* gap year				

Course outline :
In exceptional circumstances, a student engineer may be authorized to interrupt his or her studies by taking a full year off (i.e. two semesters). This gap year is voluntary.
The student-engineer can take advantage of this period to do an internship or volunteer work, or to take a course in a field other than chemistry.
The gap year can only be taken at the end of the first or second year.
The gap year starts at the beginning of the academic year (September of the current year).
The gap year can only take place once during the academic year.
At the end of the gap year, the student-engineer returns to normal schooling.
MENESR circular 2015-122 of July 22, 2015 defines the terms and conditions of the Césure, as well as the types of Césure (Césure in a professional environment, other training, student-entrepreneur) that can be carried out.