MASTER
MATERIALS SCIENCE AND ENGINEERING

Track MADI

Ver. 2022/10/24

TRACK M2 Materials for the future : Design and Engineering : MADI

Master 2 : Track « Materials for the future : Design and Engineering » - MADI

The track “Materials for the future: Design and Engineering” provides an “integrated” perspective of various materials of the future, including synthesis processes, desired structure or architecture, eco-design and lifespan. It delivers strategies to properly design a material from a technical point of view and to answer precise economics and environmental requirements specifications. In such multidisciplinary approach, team work on joint projects (design project, industrial project), gathering students with various backgrounds, is essential.

The track MADI is built around core courses and a specialization sub-track to be chosen among 5, focusing either on a engineering or design approach, on one or several families of materials (metal materials, soft matter…) and/or the environmental impact (sustainable processes, sustainable materials, sustainable energy…).

This track can be followed in apprenticeship.

Sub-track « Sustainable Processes and Materials » - C1

The sub-track « Sustainable Processes and Materials” focuses on the elaboration of materials in the framework of sustainable development. It covers a field of techniques starting from the most ancient ones (materials of the cultural heritage) to the most recent ones (materials for housing, for recycling systems). It aims to analyse the constraints associated with resources and environment, social acceptance in order to deliver to the students the technical and scientific knowledge necessary to the fabrication of materials for our everyday life. It analyses the behaviour of materials all along their lifetime (eco-design, durability, recycling).

Sub-track « Innovative metal materials » - C2

The sub-track « Innovative Metal Materials” focuses on the physic-chemical and mechanical properties of metal materials with the aim to either improve the performance of existing materials or design new materials for structural or functional applications. Characterization and uses of materials employed under severe conditions (mechanical loading, aggressive environments) will be emphasized.

Sub-track « Design and Innovation of Materials » - C3

The sub-track “Design and Innovation of Materials” provides an “integrated” perspective of various materials for the future including synthesis and elaboration processes, desired structure and architecture and associated physical properties. In this sub-track, the physical and chemical properties of the main classes of materials (metals, ceramics, inorganic materials, polymers…) are addressed in a synergistic approach. After following this sub-track, students will be able to imagine a relevant and innovative material for a given application that respects specifications defined in relationship with other fields of design (marketing, designer…)

Sub-track « Soft Matter Formulation » - C4

The sub-track « Soft Matter Formulation” focuses on the formulation of colloidal dispersions, surfactant solutions, polymer solutions found in various applications such as detergency, cosmetics, food industry or building materials. In this sub-track, students will learn how the physic-chemical nature of these compounds controls the interfacial properties (foams, emulsification, wetting) as well as the rheology and mechanical properties of formulations through a monitoring of the interactions at the microscopic scale.

Sub-track « Sustainable Energy and Materials » - C5

The sub-track “Sustainable Energy and Materials” focuses on the phenomena occurring within conversion devices (battery, fuel cell, photovoltaic conversion...). Student will learn how (i) to recognise the typical responses of a device according to the chemistry involved, and its specific material (ii) to calculate the energies and powers supplied from the results of conventional electrochemical tests (iii) to adapt a device according to the specifications of the application address. Issues, challenges, modelling contributions, and recycling approaches will be developed.

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Semester 3 (16 ECTS) 5 mandatory units (14 ECTS) + 4 optional units		ECTS	C1	C2	C3	C4	C5
COMMON CORE	**117 h**	**10**					
Selection and design of materials for a sustainable city	39 h						
Managing the unknown or Design Thinking	39 h						
Industrial project or Design project	39 h						
SCIENTIFIC TOOLS AND COMMUNICATION	**57 h**	**4**					
Language	20 h						
Cultural openness week / MOOC	35-40 h						
SUB-TRACK	**117 h**	**16**					
Materials and Environment	39 h		O		X	X	X
From ecodesign to recycling	39 h		O	X	O		X
Materials for everyday life : scientific challenges	39 h		X		O	X	X
Endurance and durability of metal materials	42 h		X	O			X
Physical metallurgy	42 h			O			
Physicochemistry and formulation of colloidal dispersions	39 h				X	O	
Formulation and processing of soft matter	39 h					O	
Bioresources valorization	39 h		X				X
Processes and coatings	39 h		X	X	X	X	X
From mechanical tests to constitutive laws	39 h			X			
Materials of the cultural heritage and durability	39 h		X				X
Sustainable Energy and Materials	60 h						O
Total S3	**294 h**	**30**					
Semester 4 * mandatory internship (5 to 6 months), 30 ECTS		30					
Total S4		30					
Total M2	294 h	60					

O : mandatory course for the given sub-track
X : optional course for the given sub-track
Courses taught in English only if non-English-speaking students in the audience.

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The program starts beginning of September.

Typical week schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
Morning	*	MAD-BIO MAD-COAT	MAD-FORM MAD-AGE TECHREN1	MAD-CHO	MAD-MECA
Afternoon	MAD-THINK	MAD-PAT MAD-QUOT	MAD-PHYS MAD-PROS TECHREN2	MAD-ECO	MAD-MAT MAD-MECA

MAD-INNOV is scheduled during one week in November..
Project associated with MAD-INNOV and MAD-THINK takes place during the last week of January.

The cultural openness week is scheduled the last week of November via the PSL weeks. Students chosing Managing the unknown will validate this cultural openness week through a MOOC.

Language courses are scheduled one evening per week between 18h15 and 20h15.

MAD.CHO	**SELECTION AND DESIGN OF MATERIALS FOR A SUSTAINABLE CITY** *Tags :* composition-microstructure-property relationships, material design, material selection, performance
Teachers	Daniel Caurant, Nicolas Lequeux, Alba Marcellan, Cécile Monteux, Lola Lilensten, Frédéric Prima, Philippe Vermaut
Responsible	Frederic.prima@chimie-paristech.fr

ECTS	*Course*	*Tutorials*	*Exam*	*Oral*	
4	33 h			100%	

Course outline:

This course provides a method for selecting the most efficient material for a given application defined by specifications. Ashby's method of material selection strategy is presented in a theoretical way.
The composition-microstructure-property relationships are studied in general terms and through examples relating to housing and urban materials: cements, ceramics, glass and glass ceramics, metal alloys, polymers. Composite materials and architectural materials (whose characteristic dimension is in the order of mm) are approached as materials capable of associating properties that are a priori incompatible, and with the idea of encouraging the student to imagine new possibilities in a functional design approach.
The examples also illustrate the environmental functions of materials: lightening, thermal insulation in particular.

Learning outcomes:

At the end of this course the student must:

- Know the definition and concrete examples of composite or architectural materials
- Know how to design new materials, especially for sustainable cities
  Use the Ashby method of material selection
- Know how to compare the mechanical and thermal properties of the major classes of materials.

MAD.THINK	DESIGN THINKING *Tags :* **design, innovation**
Teachers	Faustine Vanhulle, Damien Ziakovic, Marc Dolger, Corinne Soulié, Hélène Montès
Responsible	Corinne.soulie@espci.fr, Helene.Montes@espci.fr

ECTS	*Course*	*Tutorials*	*Exam*	*Written*	*C.A.*	*Oral*	
3	11 h			30%	35%	35%	

Course outline:

During this course, the "Design Thinking approach is introduced and applied to a real innovative issue (e.g. "personalized care", topic suggested by LVMH). The issue of the year is first analysed and then positioned following an innovating approach. This methodology relies on ideation sessions, preparation of a trend book, tests and pools.

Intermediary sessions will be devoted to an iteration of the process, refinement of the positioning, definition of the technical feasibility and of the business model and control of the sustainability of the proposed solution.

The solution(s) selected for their innovative potential will be developed during the Design Project (MAD-DES) that will take place during the last week of January.

This course is built on both lectures and practical workshop conducted by coaches in innovation, designers and scientists.

Learning outcomes:

- Identify innovation in a given field (difference between innovation and invention)
- Use correctly the tools of Design thinking to generate innovating ideas, test them
- Use correctly the tools of the designer to confront ideas with the existing market (trend book)
- Confront ideas with technical feasibility
- Consider the development of ideas (marketing, target, sustainability for industry)

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MAD.INNOV	**MANAGING THE UNKNOWN** *Tags : innovation, engineering, design*				
Responsible	Pascal Le Masson Pascal.le_masson@mines-paristech.fr				
ECTS 3	*Course* 37 h	*Tutorials*	*Exam*	*Written* 100%	

Course outline

Innovative companies today are developing new methods for organizing and managing design. Companies can't wait for "flashes of insight" from creative geniuses; nor can the rely on risky and costly random trials. In this context, they have to redefine what is collective design: the activity, its reasoning, its organization. It requires joint thinking about the technical, scientific and managerial aspects. The course provides the basics for preparing the students to act in these new forms of organization of innovations design. The basics include:

- the modelling of design reasoning;
- familiarity with the industrial world so as to understand the origin and role of the various protagonists involved (marketing, research, technical departments, strategy and design);
- contemporary crises and developments in design organizations faced with new stakes and new forms of innovation.

The course bears on at twofold logic:

1. Design reasoning and the related systems are presented in terms of the major phases in the rationalization of design activities in companies. This presentation relies on various historical examples (hydraulic wheel, Baldwin Locomotive Works 1860, Edison 1880, Eiffel 1889) and contemporary evidence (aeronautics, motor vehicles, micro-electronics, mobile telephony, household electrical goods, DIY).

2. Design theories are gradually implemented through a "design workshop" the design of a household object. A preliminary phase focuses on an analysis of the competitive environment, distribution methods, uses, industrial property and technical developments. A second phase aims to design an innovative policy by organizing the joint exploration of values and skills areas.

This course is associated to the industrial project MAD-IND, that will take place during the last week of January.

MAD.MAT	**MATERIALS AND ENVIRONMENT** *Mots clés : energy processing, housing materials, mineral resources*						
Teachers	P. Barboux, T. Pauporté, V. Lair, S. Lebouil, D. Giaume						
Responsible	philippe.barboux@chimie-paristech.fr						
ECTS 4	*Course* 21 h	*Tutorials* 18 h	*Exam*	*Written* 50%	*C.A.*	*Oral* 50%	

Course outline:

The module covers new technologies applied to environmental materials and especially those for housing. The major problems of the sustainable world are linked to energy, the disappearance of many mineral resources and environmental pollution. The course will include a part of theoretical courses (12h), company visits and a part of tutored projects (20h) presented by the students themselves and covering the following aspects:

– Environment and energy: materials for energy storage and transformation (photovoltaics, batteries, thermoelectricity…) materials for housings

– Strategic resources: save, substitute, recycle

Learning outcomes:

The student should be familiar with the latest developments in materials for the environment and environmentally friendly processes. He knows how to manage a documentation project throughout the semester and present it to his classmates during several brainstorming sessions.

MAD-ECO	FROM ECODESIGN TO RECYCLING *Tags : circular economy, eco-design, life cycle analysis, recycling*						
Responsible	Anne Varenne, Chimie Paristech anne.varenne@chimie-paristech.fr						
ECTS 4	*Course* 15 h	*Tutorials* 15 h	*Exam*	*Written* 50%	*C.A.*	*Oral* 50%	

Course outline

This course is intended to raise awareness among students of the importance of taking into account the environmental impact, related to the use of a particular material or process, during the design stages of a finished or semi-finished system. It is based on a macroeconomic vision of the environmental problems to be taken into account when designing. The notions of the life cycle of materials will be addressed in order to acquire the knowledge essential to the realization of eco-audits. The different strategies for selecting materials or processes will then be applied, based as much as possible on concrete case studies.

Teaching is a continuum between courses, seminars (actors from the professional world of eco-design, recycling, circular economy), active participation of students around a project and a restitution of the acquisition of skills in the form of presentations. The project work will start with a product. A reflection of the upstream and downstream aspects of this product will lead the group to a description of the life cycle of this compound. The objective of this training is to deepen the concepts through criticism and the construction of a thorough and global reflection on eco-design, waste management, recycling and the circular economy in a more global way.

Learning outcomes:

Provide the main keys to tackle eco-design and recycling, through a scientific, technical, economic and societal vision, so that future chemical engineers become actors of innovation which is a challenge in this field. The working approach in project format will give rise to a critical reflection of the existing situation in order to identify innovative ways that need to be explored further.

MAD-QUOT	**MATERIALS OF EVERYDAY LIFE : SCIENTIFIC CHALLENGES** *Tags :.*				
Responsible	Hélène Montes, professeur, ESPCI Helene.Montes@espci.fr,				
ECTS 4	*Course* 39 h	*Tutorials*	*Exam*	*Written* 100%	

Course outline

This course aims to address present and future challenges in the field of material design through everyday life materials in various applications. Through some selected materials, this course shows the link between requirements of physical and chemical properties imposed by a given application or societal context and its translation in terms of scientific issues to solve to fulfil them. Fabrication processes are also addressed.

The course relies on examples of advanced formulations required to elaborate materials that respect multiple constraints that can by opposite (comfort, legislation, environment) to show materials evolution with time.

Examples of materials selected to illustrate the course :

- Building materials (cement)
- Glass and its optical properties
- Packaging : mechanical properties of polymers

Learning outcomes:

- Link physical properties to chemical structures and constraints on elaboration processes-
- Choose science levers that lead to evolutions of materials properties (chemistry, shaping)
- Propose scientific approaches that help to design materials with improved or combined properties, or even new properties.

MAD-AGE	**ENDURANCE AND DURABILITY OF METAL MATERIALS** *Tags : durability, damage, oxidation*				
Responsibles	Cécilie DUHAMEL / Anne-Françoise GOURGUES-LORENZON cecilie.duhamel@mines-paristech; anne-francoise.gourgues@mines-paristech.fr				
ECTS 4	*Course* 18 h	*Tutorials* 18 h	*Exam*	*Written* 100%	

Course outline

This course deals with mechanical and/or chemical phenomena that lead to the damage and failure of metal materials.

The first part of the course focuses on the interaction of metals and metal alloys with a corrosive environment at high temperature. First, the baseic concepts of high temperature corrosion are introduced: thermodynamics, oxidation kinetics, oxidation mechanisms. These concepts are then used to describe and explain various forms of oxidation observed in metal alloys. Damage modes associated with the formation of an oxide layer at the surface of a material are then treated. Finally, solutions of prevention and protection against high temperature corrosion will be introduced. The course mainly focuses on high temperature oxidation, i.e. corrosion by reaction with gaseous oxygen. However, other forms of corrosion will be addressed during tutorials and case studies.

The second part of the course focuses on the mechanisms of failure and failure analysis due to mechanical loading. The course starts by an initiation to an expertise process (approach, tools and case study) and reminders on simple mechanical tools (both experimental and numerical) available for the metallurgist. During lectures and tutorials based on real case studies, various modes of damage and fracture will be addressed: ductile fracture (deformable materials), brittle fracture (intra- and intergranular), time-dependent fracture due to cyclic (fatigue) or long-time (creep) loading. Each of these situations will be treated both from the viewpoint of the physical mechanisms and quantitative dimensioning criterion.

Learning outcomes:

The students will be able to identify failure modes of metal materials and to propose a process to follow to solve the problem.

They will be able to appreciate quickly the risks of failure that may be encountered by a given class of materials in given conditions of application and to conduct the preliminary studies necessary the select appropriate materials for a given application.

MAD.PHYS	**PHYSICAL METALLURGY** *Tags : diffusion, phase transformation, plasticity, dislocations*				
Responsible	Vladimir ESIN vladimir.esin@mines-paristech.fr				
ECTS 4	*Cours* 18 h	*Tutorials* 18 h	*Exam*	*Written* 100%	

Course outline

This advanced course of physical metallurgy deals (i) on phase transformation and microstructure evolution of metal alloys, (ii) the mechanism of plastic deformation in these alloys.

The first part of the course focuses on the basic concepts of physical metallurgy such as diffusion and thermodynamics of phase equilibrium that allow the description of phase transformations during solidification and precipitation. Nucleation, growth and maturation of precipitates as well as displacive transformations are addressed from various angles: thermodynamics, kinetics, physical mechanisms). The specificity of microstructures of solidification (dendritic microstructure) will be presented. The mechanism of restoration and recrystallization will complete the notions required to understand the evolution of microstructures.

In a second part, the concepts of the theory of dislocations in crystals will be developed to allow the description of the physical aspects of plastic deformation in crystalline materials. Thus, the physical principles of lattice friction, interactions between dislocations or with a foreign atom, or with the interface with a precipitate or another grain are used to interpret the yield strength first for a single crystal of a pure metal, then for a polycrystalline and multiphase material. The various hardening mechanisms can then be correlated to the composition and the microstructural characteristics of the metal alloys such as precipitate distribution (volume fraction, size, distance between precipitates) or grain size. The optimization of a metal alloy in terms of yield stress is then obtained by monitoring the parameters of the thermal treatment of the alloy.

Learning outcomes:

Handle the concepts of physical metallurgy that are at the origin of the constitution of the microstructure and of the plastic deformation of metal alloys

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MAD-FORM	**PHYSICO-CHEMISTRY AND FORMULATION** *Tags : dispersions, émulsions, foams, formulation, polymers, surfactants*						
Responsible	Patrick Perrin, Professeur, UPMC patrick.perrin@espci.fr						
ECTS 4	*Course* 39 h	*Tutorials*	*Exam*	*Written* 60%	*C.A.*	*Oral* 40%	

Course outline

This course introduces the concepts necessary to understand the complex formulated systems of colloidal dispersions, surfaces/interfaces and self-organized systems that are part of soft matter. The multi-scale approach will allow us to understand how the control of interactions occurring at the interface scale often determines the properties of dispersed systems.
This course is intended for students interested in the scientific and technical basics of soft matter formulation. It is used in cosmetology but also in many other fields of application such as pharmaceuticals, food processing, petroleum, detergents, bitumen and materials in general…

Learning outcomes:

At the end of the EU, the student must be able to identify the scientific aspects behind a recipe for formulating a complex system (principles of colloidal scale interactions, mixing and stabilization methods).
He masters physical phenomena, in particular those at mesoscopic scales that allow him to move from his knowledge as a chemist to the development of complex industrial systems.

MAD.PROS	**FORMULATIION AND PROCESSING OF SOFT MATTER** *Tags : formulation, polymers, colloidal dispersion*						
Responsible	Cécilie Monteux cécile.monteux@espci.fr						
ECTS 4	*Course* 39 h	*Tutorials*	*Exam*	*Written*	*C.A.*	*Oral*	

Course outline

In most of the shaping processes of materials, whether traditional or innovative, steps exist where the materials are in the state of complex fluids, like concentrated colloidal dispersions or melt polymers that flow and then solidify. To obtain the final material with the desired performance and to develop non-pollutant green processes with a low energy cost, it is necessary to master these steps that are very susceptible to the used formulations.

For example, in the 3D printing of biomaterials, the flow properties of the used hydrogel have a very important effect. Similarly, during the drying process of building materials, it is fundamental to control the formulation to impede crack initiation and to obtain an homogeneous material.
In this course, we'll show that playing with the formulations has a direct effect on the interactions between constituents at the molecular scale and allows the monitoring the flow properties as well as the transfer phenomena. The main shaping processes (emulsification, encapsulation, 3D printing, polymer extrusion and injection, filtration, drying) will be addressed.

Learning outcomes:

At the end of this course, the students will be able to the formulation processes that can be used to monitor the shaping processes and properties of soft matter.

MAD-BIO	**VALORIZATION OF BIORESOURCES** *Tags : biofuels, biomass, biomater, biosourced platform molecules, lignocellulose pre-treatment, other molecules of biosourced interest*
Responsible	Frederic de Montigny, Chimie ParisTech frederic.de-montigny@chimieparistech.psl.eu

ECTS	*Course*	*Tutorials*	*Exam*	*Written*	*C.A.*	*Oral*	
4	39 h	10 h		50%		50%	

Course outline

Presentation of the issues related to plant chemistry and concepts ranging from biomass to biomaterials and platform molecules.
Presentation of the concepts of plant chemistry allowing to replace fossil carbon by plant carbon, either by a substitution strategy or by the development of new biosourced materials.
The concepts covered will include: biomass, biofuels, lignocellulose pre-treatment, biosourced platform molecules, other molecules of biosourced interest, biomaterials

Learning outcomes:

Presentation of tools for the design and the implementation of industrial processes that meet the challenges of sustainable development: use of renewable materials from biomass, improvement of eco-compatibility of processes, development of industrial synthesis strategies considering all sustainability criteria.

MAD-COAT	**PROCESSES AND COATINGS** *Tags : coatings, thin films, surface treatments*				
Responsible	Frédéric Rousseau, Chimie ParisTech frederic.rousseau@chimie-paristech.fr				
ECTS 4	*Course* 27 h	*Tutorials* 9 h	*Exam*	*Oral* 100%	

Course outline

Examples of surface treatments as well as organic and inorganic coatings are introduced to the students. These examples come from literature data, industrial processes or research activities led by the research teams of the three engineering schools.
Properties and techniques of surface treatments either by wet (sol gel, electrochemistry, colloidal dispersion) or dry (physical or chemical techniques of coating by vapour or plasma deposition) processes. The course includes quick demonstrations and illustrated case studies (e.g. electrodes for solar cells). Additional practical work in the lab is proposed: reactor driving, surface treatments or coatings / thin films, physic-chemical characterizations of the as-treated materials…). At last, a training to a simulation software (COMSOL) used to model coating processes is proposed.

Learning outcomes:

The students will:

- understand the importance of surface treatments to provide new propertiesto a material (resistance to corrosion, insulation, electrical conductivity, wetting, catalytic properties…)
- know the physical and chemical phenomena involved during deposition for various wet and dry processes
- be able to choose a type of coating (thin, thick) depending on the application
- be able to propose relevant techniques to diagnose to study and characterize the coupling process / surface treatments
- be able to select techniques of analysis of the material that allow to validate the surface modification or the coating that was produced.

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MAD-MECA	**FROM MECHANICAL TESTS TO CONSTITUTIVE LAWS** *Tags :.mechanical behavior, experimental tests, numerical simulation*				
Responsibles	Alain KÖSTER & Djamel MISSOUM-BENZIANE alain.koster@mines-paristech.fr; djamel.missoum-benziane@mines-paristech.fr				
ECTS 4	*Course* 21 h	*Tutorials* 18 h	*Exam*	*Wrtten* 100%	

Course outline

This course is an introduction to structure design and dimensioning. It addresses to students with a materials science background that want to acquire basic knowledge on the mechanical behaviour of metal materials and to the microstructure / properties relationship. It aims to give the basis in mechanics and numerical simulation to be able to discuss with experts of these fields.

To design and dimension structures, it is necessary to know but also to simulate the mechanical behavior of materials in given conditions to be able to predict it. That's why an introduction to finite element calculation will be made.

This course will take place in a laboratory during 7 full days. It is built on lectures, tutorials and practical work during which students will instrument, perform and analyse various mechanical tests. The experimental results obtained will be used as input data for finite element calculations that will be done (i) to reproduce the experimental tests, (ii) to predict the material behaviour for other types of mechanical loadings.

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MAD-PAT	**MATERIALS OF THE CULTURAL HERITAGE AND DURABILITY** *Tags : altération, complex materials, conservation, cultural heritage, élaboration, multi-scale analytical methods*					
Teachers	O. Majérus, G. Wallez					
Responsible	Odile.majerus@chimie-paristech.fr					
ECTS	*Course*	*Tutorials*	*Exam*	*Written*	*Oral*	
4	35 h	6 h		50%	50%	

Course outline

The dominance of materials contributes to drive human civilizations. The materials of Cultural heritage have been first produced by humans in a given historical context, then they have evolved in their conservation environment. These materials keep the memory of their origin and of their evolution, which is printed in their multi-scale structure (nano to macro). They are witnesses of our history and should be conserved for the future generations. Studying these materials also helps in anticipating the evolution of current modern materials. This course is multi-materials and multi-disciplinary, encompassing the domains of materials sciences, analytical physical chemistry, human and social sciences. It enriches the general knowledge of students about materials and gives to them tools and examples to predict and evaluate the durability of materials in a given environment. It consists in interactive lectures relying on the basic knowledge of students on materials, in a 3 hours tutorial and in a series of research conferences.

Learning outcomes:

At the end of the course, students :

– Have a consolidated knowledge of the specificities of different classes of materials (composition domain, chemical bond, structure, microstructure, elaboration process),
– Have developed their culture of materials, thanks to the historical point of view,
– Are able to propose an analytical approach adapted to a specific material,
– Are able to anticipate the probable evolution of a material in a given environment.

These abilities are evaluated by a final written examination containing general questions on materials and the resolution of a case study from the literature. In addition, students conduct an interview with a specialist of Cultural Heritage, and they have to report on the experimental approach and results of a study of this specialist.

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TECHREN1 and 2	***SUSTAINABLE ENERGY AND MATERIALS*** *Tags :photovoltaics, fuel cell, hydrogen, batteries, Thermoelectricity, piézoelectricity…*				
Responsible	Armelle Ringuedé Armelle.ringuedé@chimieparistech.psl.eu				
ECTS 8	*Course* 90 h	*Tutorials*	*Exam*		

Course outline

The increase of the global demand in energy needs to find alternatives to fossil resources. The request for sources of natural but sporadic energies (solar with photovoltaics, wind, hydrodynamics…) is increasing. It is thus necessary to couple these sources with systems allowing the recycling and storage of these energies (batteries, supercapacitors). The strong environmental constraint leads to the development of clean systems of storage such as fuel cells. However, it is time to stop ths race towards more and more energy and to limit our consumption. In this module, we'll see which materials can be used to store and recycle energy for the various as-mentioned systems.
For each of them, the mature technologies, new approaches and environmental challenges will be addressed.

Learning outcomes :

Students wiil be able to :

- understand the phenomena occurring inside batteries
- recognize typical responses of a storage device as a function of the involved chemistry
- calculate the provided energy and power from results of classical electrochemical tests
- adapt a storage device as a function of the requirements of the application

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Practical information

Host institution

Chimie ParisTech
11 rue Pierre et Marie Curie
75005 PARIS
www.chimie-paristech.fr

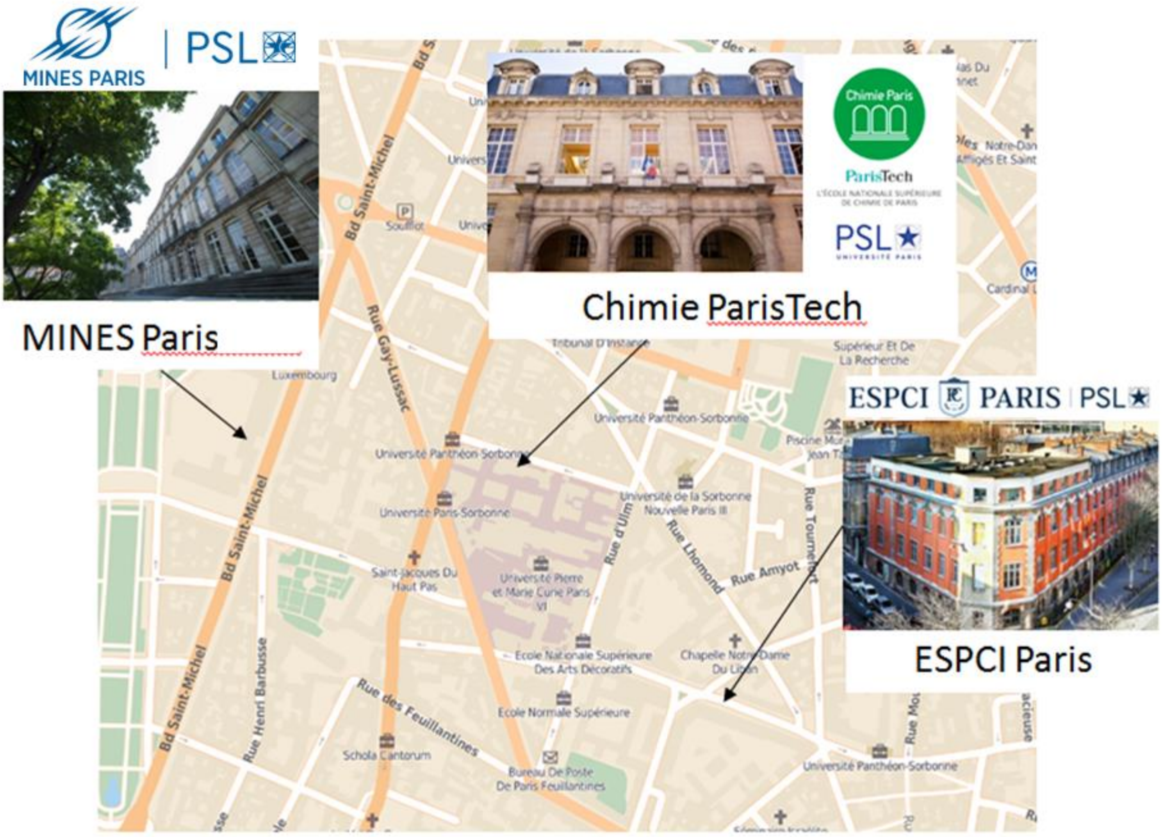
Teaching places

Most of the courses take place in the three engineering schools : Chimie ParisTech, MINES Paris, ESPCI Paris.

MINES Paris
60 boulevard Saint-Michel
75006 Paris
www.mines-paristech.fr

ESPCI Paris
10 rue Vauquelin
75005 PARIS
www.espci.fr

Part of the courses is common o the graduate engineering program of the partner schools.



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Contacts

Mention Materials Science and Engineering :

Vincent Guipont & Lola Lilensten, heads (contact.master-sgm@psl.eu)

https://www.psl.eu/formation/master-sciences-et-genie-des-materiaux

Track MADI :

- Sub-track « Sustainable Processes and Materials » : Domitille Giaume
- Sub-track « Innovative Metal Materials » : Cécilie Duhamel
- Sub-track « Design and Innovation of Materials » : Corinne Soulié
- Sub-track « Formulation of Soft Matter » : Cécile Monteux
- Sub-track « Sustainable Energy & Materials » : Virginie Lair

Welcome Desk PSL : welcomedesk@psl.eu / 01 75 00 02 91

The Welcome Desk helps internaitonal students for administrative procedures and boosts up their everyday life.

A bilingual team organizes different activities throughout the year. Touristic joggings, cultural visits...there is something for everyone! At these events international students meet other students, both internationals and Parisians who are part of the PSL network, improve their French and discover the different parts of Paris.

For more information, Facebook page: Welcome to Paris and to PSL!