MASTER
MATERIALS SCIENCE AND ENGINEERING

Track MADI

Ver. 2024/06/05

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, tutored project), gathering students with various backgrounds, is essential.

The track MADI is built around a specialization elective to be chosen among 5, focusing either on an 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…). Additional innovation and application classes can be chosen among two groups. At last, two classes of communication and scientific openness complete the curriculum.

This track can be followed in apprenticeship for all electives.

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

Elective « Sustainable Processes and Materials » - E1

The elective « 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).

Elective « Innovative metal materials » - E2

The elective ” Innovative Metal Materials” focuses on the physical-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.

Elective « Design and Innovation of Materials » - E3

The elective “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 elective, 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 elective, 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…)

Elective « Soft Matter Formulation » - E4

The elective « 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 elective, 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.

Elective « Sustainable Energy and Materials » - E5

The elective “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.

MASTER MATERIALS SCIENCE AND ENGINEERING

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Semester 3 **5 mandatory units (14 ECTS) + 4 optional units (16 ECTS)**		**ECTS**	**E1**	**E2**	**E3**	**E4**	**E5**
MATERIAL SCIENCE SPECIALIZATION (ELECTIVE)	**117 h**	**20**					
Selection and design of materials for a sustainable city	39h		M	M	M	M	M
Materials and Environment	39 h		M		O	O	O
From ecodesign to recycling	39 h		M	O	M		O
Materials for everyday life: scientific challenges	39 h		O		M	O	O
Endurance and durability of metal materials	42 h		O	M			O
Physical metallurgy	42 h			M			
Physicochemistry and formulation of colloidal dispersions	39 h				O	M	
Formulation and processing of soft matter	39 h					M	
Bioresources valorization	39 h		O				O
Processes and coatings	39 h		O	O	O	O	O
From mechanical tests to constitutive laws	39 h			O			
Materials of the cultural heritage and durability	39 h		O	O			O
Sustainable Energy and Materials	60 h						M
INNOVATION APPLICATION CLASSES: Group 1 OR Group 2		6					
Group 1		**6**	O	O	O	O	O
Managing the unknown	30	**3**	M	M	M	M	M
Tutored project	27	**3**	M	M	M	M	M
Group 2		**6**	O	O	O	O	O
Design Thinking		**3**	M	M	M	M	M
Design Project		**3**	M	M	M	M	M
COMMUNICATION AND SCIENTIFIC OPENNESS	**57 h**	**4**					
Langage (NC)	20 h	2	M	M	M	M	M
History of sciences and technologies in the society (NC) (mandatory for Group 1 students)	20h	2	M	M	M	M	M
PSL week (NC) (mandatory for Group 2 students)	30h	2	M	M	M	M	M
Total S3	**294**	**30**					
Semester 4 mandatory internship (5 to 6 months), 30 ECTS *		30					
Total S4		30					
Total M2	294	60					

MASTER MATERIALS SCIENCE AND ENGINEERING

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

M : mandatory course for the given elective
0: optional course for the given elective (2 courses to be chosen)

Courses are taught in English.

MASTER MATERIALS SCIENCE AND ENGINEERING

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

In case of professionalization contract:

Semester 3 Pro **5 mandatory units (14 ECTS) + 4 optional units (16 ECTS)**		**ECTS**	**E1**	**E2**	**E3**	**E4**	**E5**
MATERIAL SCIENCE SPECIALIZATION (ELECTIVE)	**117 h**	**20**					
Selection and design of materials for a sustainable city	39h		M	M	M	M	M
Materials and Environment	39 h		M		O	O	O
From ecodesign to recycling	39 h		M	O	M		O
Materials for everyday life: scientific challenges	39 h		O		M	O	O
Endurance and durability of metal materials	42 h		O	M			O
Physical metallurgy	42 h			M			
Physicochemistry and formulation of colloidal dispersions	39 h				O	M	
Formulation and processing of soft matter	39 h					M	
Bioresources valorization	39 h		O				O
Processes and coatings	39 h		O	O	O	O	O
From mechanical tests to constitutive laws	39 h			O			
Materials of the cultural heritage and durability	39 h		O	O			O
Sustainable Energy and Materials	60 h						M
INNOVATION APPLICATION CLASSES: Group 1bis		**6**					
***Group 1**bis*		**6**	M	M	M	M	M
Managing the unknown	30	**3**	M	M	M	M	M
Tutored project	27	**3**	M	M	M	M	M
COMMUNICATION AND SCIENTIFIC OPENNESS	**57 h**	**4**					
Langage (NC)	20 h	2	M	M	M	M	M
Report on the first period in the company (NC)	20h	2	M	M	M	M	M
PSL week (NC) (mandatory for Group 2 students)	30h	2	M	M	M	M	M
Total S3 Pro	**294**	**30**					
Semester 4 Pro - mandatory internship (5 to 6 months), + UE		30					
Mandatory internship (from the end of the semester to the end of the professionalization contract)		28					
History of sciences and technologies in the society	20h	2					
Total S4 Pro		30					
Total M2	294	60					

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

The program starts beginning of September.
Typical week schedule :

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

Managing the unknown (MAD-INNO) is scheduled during a full week in November.
The project associated with MAD-DES 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.

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, Jean-Baptiste d'Espinose, Alba Marcellan, Fan Sun, Lola Lilensten, Frédéric Prima, Philippe Vermaut
Responsible	Frederic.prima@chimieparistech.psl.eu

ECTS	*Course*	*Tutorials*	*Exam*	*Written*	
4	39 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 + MAD-DES	DESIGN THINKING *Tags :* **design, innovation**
Teachers	Faustine Vanhulle, Majooran Kanthiah
Responsible	Majoorank@gmail.com

ECTS	*Course*	*Tutorials*	*Exam*	*Written*	*C.A.*	*Oral*
3	10.5h	10.5h + 7h of project work		50%		50%

Course outline:

During this course, we will introduce and apply the "Design Thinking" approach to a real issue proposed by a company (e.g. LVMH, Vicat …).

Design Thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology and the requirements for business success.

Hence, in the frame of the course, students will start from the initial formulation of the issue (challenge), observe and interact with stakeholders and potential users or customers in order to define their own "point of view". They will then find options to propose an innovative solution (MAD-THINK).
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 give the groups the opportunity to prototype and test their ideas, before presenting them.

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 the tools of Design thinking to generate innovative ideas, prototype and test them, and confront them to the market
- Evaluate technical feasibility, and business viability

MAD.HIST	**History of Science and Technology in Society** *Tags :*
Teachers	Emanuel Bertrand
Responsible	emanuel.bertrand@espci.psl.eu

ECTS	*Course*	*Tutorials*	*Exam*	*Written*	*C.A.*	*Oral*
2	18 h		*X*	X		

Course outline:

This course, entitled "History of Science and Technology in Society", takes an interdisciplinary approach in the humanities and social sciences (history, philosophy, sociology, political science) to the place of natural science and technology in society - past and present. The aim is to help Master's students take a step back from natural science and technology, and from the various issues involved in their deployment in society.

The "History of Science and Technology in Society" course involves a graded assessment of students (1.5-hour final table exam).

The following topics will be discussed:

- Can we define "science"? What is a scientific "proof"? *Illustration with the case of electromagnetic wave propagation (1888-1893)*.
- What influence does the social and historical context have on the establishment of a scientific statement? What is scientific "truth"? *An example of scientific controversy in society: spontaneous generation (1859-1864)*.
- A brief history of thermodynamics. *The emergence of a scientific discipline from industrial practice in the 19th century*.
- What are the links between hydrocarbon energies (coal, oil) and democracy in the 19th and 20th centuries? *How has oil gradually shaped the contemporary world?*
- Is science the ultimate cause of economic growth? *The economics of science since 1945*.

Learning outcomes:

The aim of this course is to contribute to the training of future Master's graduates who do not have a naive view of natural science and technology, and who have a professional (and personal) awareness that is open to the causes and consequences of scientific practices.

The course will develop students' critical thinking and intellectual autonomy.

MAD-INNOV	**MANAGING THE UNKNOWN** *Tags : innovation, engineering, design*			
Responsible	Pascal Le Masson Pascal.le_masson@mines-paristech.fr			
ECTS	*Course*	*Practicals/case studies*	*Exam*	*Written*
3	15 h	15h	*X*	100%

Course outline

This 30-hour face-to-face course, held during PSL Week in November 2024 (25.11 to 29.11), is an in-depth introduction to managing the unknown with the support of design theory. Contemporary issues of managing transitions (climate, energy, mobility, digitial…) and managing crisis (pandemia, inflation, energy prices, war…) call for a capacity to organize collective action in the unknown – this capacity is expected from all kinds of managers, and in particular scientists, engineers, and designers. The capacity is today more easily acquired thanks to the advances in design theory. Design theory brings solid foundation for designing transition and designing resilient solutions to face contemporary crises. These approaches are essential today for those who wish to train in the management of innovation, scientific entrepreneurship, and the management of contemporary transitions.
The course alternates between theoretical lessons in the morning and practical workshops in the afternoon. Practitioners are invited to speak about their experience of design in various areas (business, science, art).

Main notions:

In the end of the course, participants should have acquired the following capacities:

- On design reasoning: capacity to build a simple C-K; capacity to evaluate a C-K (main notions: C-space, K-space, operators, double expansion)
- On knowledge for generativity: capacity to learn and develop knowledge for generativity (main notions: independent knowledge, splitting knowledge)
- On leadership for defixation: capacity to give relevant input to help team members to overcome their own fixation (main notions: fixations, defixation)
- On economic evaluation in design: capacity to rely on economics criteria for improved exploration (main notions: design of decision, design for genericity, the value of knowledge in design activity)
- On organization of collective design: capacity to rely on and make relevant use of R&D capacities in companies, capacity to organize innovative design processes (main notions: organization principles of rule-based and innovative design, dominant design, KCP processes)
- On design and ecosystems: introduction to “double impact” research and “mission-driven” companies.

Updated June 2024

MAD-MAT	MATERIALS AND ENVIRONMENT *keywords : energy processing, housing materials, mineral resources*
Teachers	A.-L. Joudrier, O. Majerus, A. Galtayries, P. Volovitch, D. Giaume
Responsible	Anne-laure.joudrier@chimieparistech.psl.eu

ECTS	*Course*	*Tutorials*	*Exam*	*Written*	*Contrôle continu*	*Oral*
4	36h			25% (QCM)	25%	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.

Updated June 2023

MAD-ECO	**FROM ECODESIGN TO RECYCLING** *Tags : circular economy, eco-design, life cycle analysis, recycling*
Responsible	Anne Varenne, Chimie Paristech anne.varenne@chimieparistech.psl.eu

ECTS	*Course*	*Tutorials*	*Exam*	*Written*	*C.A.*	*Oral*
4	24 h	12 h		50%		50%

Course outline

The main challenges of the 21st century require a global thinking on the management of natural resources and the impact of products and processes on the environment, and therefore an important innovation around eco-design, waste management and recycling. This course is thus intended to make students aware of the environmental impact of a product or process, during its design and with a view to its recycling.

The teaching is a continuum between courses, seminars (given by professional actors in the field of eco-design, recycling, life cycle analysis, circular economy), as well as a project (group of 6 students) on a theme (product, process) chosen by the students after a feasibility study. The different themes addressed (circular economy, eco-design, waste management, recycling) are closely linked in the global vision of life cycle analysis. This training aims to (1) provide a "macro-economic" vision of the various environmental dimensions to be taken into account from the design of a product to its end of life, and (2) deepen the concepts by criticizing and building a thorough and global thinking on eco-design, waste management, and recycling.
It provides the main keys around eco-design and recycling, through a scientific, technical, economic and societal vision, so that future engineers can be the actors of the systematic implementation of life cycle analysis and innovation in this field.

Learning outcomes:

The project work allows the students to apply the acquired notions and to use them, to model them, to criticize them, in order to detect innovative ways in this field. The deliverable will be representative of the skills acquired during this training, demonstrating an in-depth and global reflection of eco-design, waste management, recycling and the circular economy in a more global way. The project work approach will result in a critical reflection of the existing in order to identify innovative ways that should be further explored.

Prerequisites

Notions in all fields of chemistry at the level of a M1 in chemistry

Updated June 2023

MAD-QUOT	**MATERIALS OF EVERYDAY LIFE : SCIENTIFIC CHALLENGES** *Tags :.*				
Responsible	Corinne Soulié-Ziakovic, professeure, ESPCI corinne.soulie@espci.psl.eu				
ECTS 4	*Course* 36 h	*Tutorials*	*Exam*	*Written (reports)* 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.

Updated June 2024

MAD-AGE	**ENDURANCE AND DURABILITY OF METAL MATERIALS** *Tags : durability, damage, oxidation*				
Responsibles	Cécile DUHAMEL / Anne-Françoise GOURGUES-LORENZON cecilie.duhamel@minesparis.psl.eu; anne-francoise.gourgues@minesparis.psl.eu				
ECTS	*Course*	*Tutorials*	*CC (25%)*	*Final exam : Written*	
4	18 h	18 h		75%	

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 basic 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 due to mechanical loading, and on failure analysis methods. The course starts by an initiation to the failure analysis process (approach, tools and case studies) 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 by considering both the physical mechanisms and quantitative design criteria.

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.

Updated June 2024

MAD-PHYS	**PHYSICAL METALLURGY** *Tags : diffusion, phase transformation, plasticity, dislocations*			
Responsible	Cécile DUHAMEL , Mathias LAMARI Cecilie.duhamel@minesparis.psl.eu			
ECTS 4	*Cours* 18 h	*Tutorials* 18 h	*CC (25%)*	*Final exam : Written* 75%

Course outline

This advanced course of physical metallurgy deals (i) with phase transformations and microstructure evolution in metal alloys, (ii) the mechanisms of plastic deformation and hardening.

The first part 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 coarsening of precipitates as well as displacive transformations are addressed from various aspects: thermodynamics, kinetics, physical mechanisms. The specificity of solidification microstructure (dendritic microstructure) is discussed as well. The mechanism of recovery 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 advanced concepts of physical metallurgy that are at the origin of the microstructure formation and of the plastic deformation of metal alloys

Updated June 2024

MAD-FORM	**PHYSICO-CHEMISTRY AND FORMULATION OF COLLOIDAL DISPERSIONS** *Tags : dispersions, émulsions, foams, formulation, polymers, surfactants*						
Responsible	Patrick Perrin, Professeur, Sorbonne Université patrick.perrin@espci.fr						
ECTS 4	*Course* 39 h	*CC : 20%*	*Exam*	*Written* 40%	*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	**FORMULATION AND PROCESSING OF SOFT MATTER** *Tags : formulation, polymers, colloidal dispersion*						
Responsible	Cécile Monteux cécile.monteux@espci.fr						
ECTS	*Course*	*Practicals*	*Exam*	*Written*	*Contrôle continu*	*Oral*	
4	39 h			20%	30%	50%	

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 4	*Course* 30 h	*Tutorials* 9h	*Exam*	*Written* 50%	*C.A.*	*Oral* 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.

Updated June 2023

MAD-COAT	**PROCESSES AND COATINGS** *Tags : coatings, thin films, surface treatments*				
Responsible	Frédéric Rousseau, Chimie ParisTech frederic.rousseau@chimieparistech.psl.eu				
ECTS 4	*Course* 33 h	*Practicals* 3h + 3h of project	*Exam* *Poster : 50%*	*Oral* 50%	

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…). In addition, a training to a simulation software (COMSOL) used to model coating processes can be proposed.

Learning outcomes:

The students will:

- understand the importance of surface treatments to provide new properties to 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.

MAD-MECA	**FROM MECHANICAL TESTS TO CONSTITUTIVE LAWS** *Tags : mechanical behavior, experimental tests, numerical simulation*
Responsibles	Pierre Arnaud Pierre.arnaud@minesparis.psl.eu

ECTS	*Course*	*Tutorials*	*Travaux pratique*	*Written*	
4	39 h		+ *Exam*	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 or the stress/strain relationship in plasticity. 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.

MAD-PAT	**MATERIALS OF THE CULTURAL HERITAGE AND DURABILITY** *Tags : alteration, complex materials, conservation, cultural heritage, elaboration, multi-scale analytical methods*					
Teachers	O. Majérus					
Responsible	Odile.majerus@chimie-paristech.fr					
ECTS 4	*Course* 27h	*Practicals* 3h	*Tutorials* 3h	*Exam*	*Written* 50%	*Oral* 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.

MAD.ENE	***SUSTAINABLE ENERGY AND MATERIALS*** *Tags : photovoltaics, fuel cell, hydrogen, batteries, Thermoelectricity, piézoelectricity…*				
Responsible	Armelle Ringuedé armelle.ringuede@chimieparistech.psl.eu				
ECTS 8	*Course* 90 h	*Tutorials*	*Exam* *Written 100%*		

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 this 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

Practical information

Host institution

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

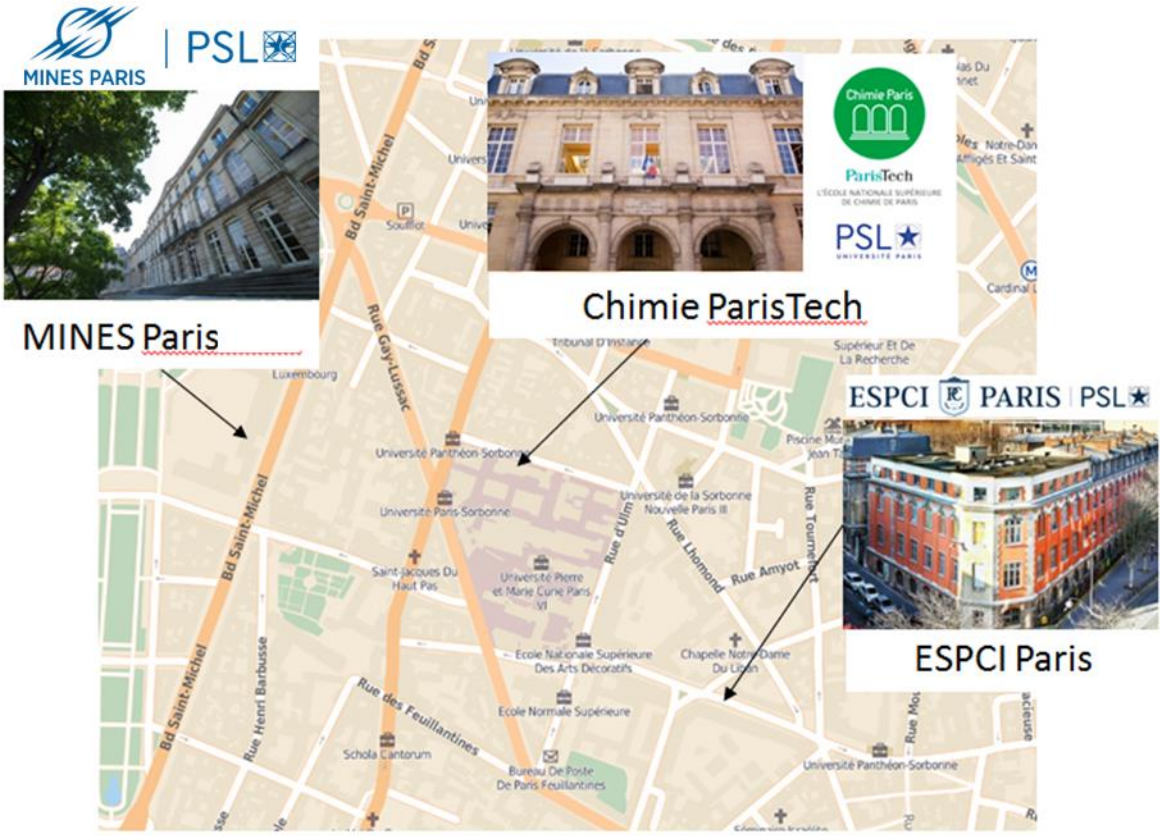
Teaching places

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.minesparis.psl.eu

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

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



MASTER MATERIALS SCIENCE AND ENGINEERING

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

Contacts

Mention Materials Science and Engineering :

Vincent Guipont & Jolanta Swiatowska, heads (contact.master-sgm@psl.eu)

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

Track MADI :

- Elective « Sustainable Processes and Materials »: Domitille Giaume
- Elective « Innovative Metal Materials »: Cécilie Duhamel
- Elective « Design and Innovation of Materials »: Corinne Soulié
- Elective « Formulation of Soft Matter » :Cécile Monteux
- Elective « 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!