PSL UNIVERSITÉ PARIS

MASTER
MATERIALS SCIENCE AND ENGINEERING

2026-2027

Master 1
First year of the Master SGM-PSL

Master SGM
PSL UNIVERSITÉ PARIS
Materials Science & Engineering

MASTER PROGRAM: *MATERIALS SCIENCE AND ENGINEERING*

PRESENTATION OF THE MASTER

The Master of Materials Science and Engineering from Paris Sciences et Lettres University (PSL-SGM)

The PSL Master "Materials Science and Engineering", namely master SGM, allows students to acquire the experimental and theoretical knowledge necessary to imagine and design the materials of tomorrow, improve the performance of existing materials and predict their service life. Co-led by internationally renowned schools: Chimie ParisTech PSL, MINES Paris PSL and ESPCI Paris PSL, it aims to establish the link between elaboration, synthesis and forming processes, (micro) structure and structural and/or functional properties of materials as varied like polymers, metal alloys, ceramics or biomaterials.

During the first year (M1) of the Master, students develop skills to have an integrative vision of materials with their functionalities in their environment, in their use and in their elaboration. This first year serves as a common base of knowledge to allow students to specialize in the second year (M2). Three tracks are offered for the second year:

- Track "Materials of the Future: Design and Engineering" - MADI
- Track "Mechanics of Materials for Engineering and Structural Integrity" - MAGIS
- Track "Microfluidics" - MICROFLU

The experimental approach is particularly highlighted in this Master from the M1, with a training in research "through the practice of research", including literature review, 9 weeks of mandatory immersion in academic or industrial research laboratories, and hours of experimental work during the year of M1.

The M1 is fully taught in English.

Objectives of the M1 training

During the two semesters of M1, students must acquire:

- Scientific knowledge allowing them to analyze a problem in a field related to the improvement of the performance and durability of a material in connection with its structure and chemistry.
- The experimental and theoretical knowledge necessary to imagine and design innovative materials that meet precise specifications and to improve the performance of existing materials and predict their lifespan
- Methods of analysis of a scientific problem: information search and bibliography management; design of experimental protocols.
- Skills for presentation of scientific data and data interpretation (in English).
- The tools necessary for the development of industrial or academic research projects.

Conditions of access

The Master delivering courses in Chemistry, Mechanics and Materials, Physics, and Engineering Sciences, the conditions of access to the Master of Materials Science and Engineering in the first year are specified below:

Access to Master 1

Students must hold one of the following degrees:

- Licence (L3) scientifique (Chimie, Physique-Chimie, Mécanique) ;
- Bachelor of Science (Chemistry, Physico-chemistry, Mechanics) (equivalent to 180 ECTS) ;

Pedagogical and scientific tutoring

Scientific tutoring is an essential part of the training. From Master 1, each student benefits from a particular support by a doctoral student or senior scientist around a research project, with a first phase dedicated to learning bibliographic research in Semester 1, followed potentially by a second phase of laboratory practice in Semester 2.

As many apprenticeships are offered in the form of projects in Master 1 and Master 2, a pedagogical tutoring to learn about team working is also present.

ORGANIZATION OF TEACHING COURSES

Duration of teaching courses

Semester 1: 249 hours over 15 weeks of common base, constituting two blocks of courses:

- One 121-hours block “Basic knowledge in Material Science” counting for 17 ECTS
- One block “Scientific tools and communication” counting for 13 ECTS

Semester 2 : From 162 to 188 hours of specialization courses, constituting two blocks of courses:

- One block "Specialization in Material science” from 74 to 100h counting for 12 ECTS
- One block “Scientific tools and communication” of 88h counting for 10 ECTS
- A minimum 2-months internship counting for 8 ECTS

The start of the school year will take place in early September 2025 at Chimie ParisTech, 11 rue Pierre et Marie Curie, 75005 Paris. The schedule will be communicated to students via their personal online access once they have registered.

Language courses are scheduled in the evening from 18:15 to 20:15 at MINES Paris .

The English classes are mandatory and provided at MINES Paris. An English test (oral, written) is conducted at the beginning of the year by the Language teachers (mandatory for all). Students who can demonstrate a sufficient level at the end of this test (typically C1 level) can choose another language, with priority given to French, which is offered by the PSL Language Center.

Master 1: Common Courses

The courses shown in italics are the mandatory courses. Courses written in normal style are optional courses. The language of teaching at the M1 level is English.

Semester 1 **10 mandatory courses (30 ECTS)**		**ECTS**
BASIC KNOWLEDGE IN MATERIAL SCIENCE	131 h	17
Corrosion	24 h	
Physical-Chemistry of polymers	24 h	
Crystalline materials	32 h	
Metallic materials	24 h	
Introduction to Mechanics	27 h	
Electrochemistry (optional)	12 h	
SCIENTIFIC TOOLS AND COMMUNICATION	121 h	13
Machine Learning	18h	+121
Experimental methods	47h	
Literature review: conducting and writing	9h	
Innovation Project in Group (PIG)	27h	
Language courses	20h	
Total S1	252h	30
Semester 2 **5 mandatory courses (13 ECTS)** **+ 3 Optional courses to choose (9 ECTS)** **Internship of 2 months* (8 ECTS)**		
Specialization in Materials science	92 - 118 h	14
Modeling	18 h	
Materials processing	24 h	
Electronic properties of solids	24 h	
Inorganic assemblies	18 h	
Surface properties and mechanical strength of materials	24 h	
Advanced fluid mechanics	30 h	
From mechanical testing to constitutive law	234 h	
SCIENTIFIC TOOLS AND COMMUNICATION	85 h	8
Language courses	30 h	
Innovation Project (in group)	18 h	
PSL week	37 h	
Internship		8
Total S2	177 -203 h	30
Total M1	439 - 465 h	60

** The duration of the internship indicated constitutes the minimum allowing validation. The internship can be done in France or abroad.*

Content of Teaching Courses

MHM1SGEC: CORROSION

Keywords: Pourbaix diagram, passivation, generalized and localized corrosion

Teachers	Cécilie Duhamel
Coordinator	cecilie.duhamel@minesparis.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	12 h	12h	3h		70%	20%	10%		Yes

Description of the teaching module:

The course focuses on aqueous corrosion of metals and metal alloys. First, the basic concepts of aqueous corrosion are presented: Pourbaix diagram, corrosion rate, passivity. These notions are then implemented to describe and explain the different forms of corrosion observed: uniform corrosion, galvanic coupling, localized corrosion.

Content:

- Definition and introduction to different forms of corrosion
- Electrochemical nature of corrosion
- Thermodynamic aspects: the Pourbaix diagram
- Corrosion rate: Butler-Volmer law, Tafel representation, reactions controlled by the transport of matter
- Passivation
- Uniform corrosion

Localized corrosion: intergranular corrosion, pitting, cavernous corrosion,...

Learning Objectives:

At the end of this Training Module, students:

- Will be able to understand the fundamental aspects of electrochemistry
- Will be able to establish the equations of current-potential characteristics under equilibrium conditions
- Will know how to use a Pourbaix diagram
- Will be able to determine a corrosion rate
- Will be able to recognize different forms of corrosion

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	12h course + 12h tutored exercises	English	English

MHM1SGEC-EC: ELECTROCHEMISTRY (optional)

Keywords : Oxidation-reduction, Nernst potential, electromotive force, battery, electrolysis, Potential intensity curves, electro-deposition

Teacher	Virginie Lair
Coordinator	virginie.lair@chimieparistech.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
0	8 h	4 h							no

Description of the teaching module:

The course aims to redefine the basics of electrochemistry in order to apply it to battery systems. The possibility of electrochemically deposition process for thin films will be presented. The establishment of potential intensity curves will be discussed.

- Reminder on the notions of oxidation-reduction, half-equations redox
- Nernst Potential
- Electromotive force
- Faraday's Law
- Potential intensity curves: reading, origin and application to energy systems
- Electrochemical techniques: application to thin film deposition

Learning Objectives:

At the end of this teaching module, students will be able to:

- understand the fundamental aspects of electrochemistry,
- apply and express basic formulas (Faraday's law, Nernst potential,...)
- read and draw curves i = f (E),
- digitize and describe the different electrochemical techniques
- determine the conditions for the deposition of a material

Language		*Documents*	*Literature*
English	Course, Exercises, Practical, Tutoring 8h course + 4h exercises	English	English

MHM1SGPOL: PHYSICAL-CHEMISTRY OF POLYMERS

Keywords: Polymers, vitreous transition, mecanics, thermodynamics

Teachers	Kawthar Bouchemal, Joshua McGraw
Coordinator	joshua.mcgraw@espci.fr

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	24h	Incl.	6h		60%	40%	-	-	yes

Description of the teaching module:

[1] Conformation of chains (Joshua)
- Ideal chains
- Entropy of ideal chains; free energy; Hooke's law for polymers
- Real chains : Flory
- solutions (concentration regimes)
- c*; blobs -> concentrated solutions

[2] Macroscopic consequences of random walk chains (Joshua)
- Rubber elasticity : affine network model, modulus of a network
- dynamics (Rouse, Zimm, Entanglement)
- rheology (G', G'')

[3] Polymeric gels (Kawthar)
- Introduction
- Classification

[4] Physical chemistry & formulation (Kawthar)
- Polysaccharide-based hydrogels
- Thermosensitive hydrogels
- Supramolecular hydrogels
- Cyclodextrin-based hydrogels

[5] Applications in life sciences (Kawthar)
- Medical devices
- Tissue engineering
- Cosmetology

Learning Objectives:

Students will be exposed to the basic principles governing polymer molecules and materials composed of these macromolecules. Starting from the characteristic dimension of monomers, and going through that of entire chains and networks thereof, along with polymer solutions, solid state materials, and their formulation, the students will acquire a basic knowledge of this important class of materials which are widespread in biology and industry.

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	English	English	English/French

MHM1SGMC: CRYSTALLINE MATERIALS

Keywords: structure, diffraction, symmetry

Teachers	Vanessa Pimenta, Sandrine Ithurria
Coordinator	vanessa.pereira-pimenta@espci.fr; sandrine.ithurria@espci.fr

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
4	14 h	14 h	8h		100%				non

Description of the teaching module:

The aim of this course is to provide students basic tools to describe the structure and properties of crystalline materials. The course starts by the study of symmetries and the classification of crystals. Then, a detailed review of the investigations methods by X-ray diffraction is proposed. The last part of the course deals with the structures of ionic and covalent crystals as well as deviations from the perfect crystal, in order to understand the relationships between the structure of the main crystalline solids and their physical properties.

Content :

- Crystallography: periodic lattices - symmetry - point and space groups
- Radiocrystallography: reciprocal lattice - structural factor - structure resolutions - diffuse scattering - experimental methods
- Crystal structures: ionic and covalent crystal
- Point defects - extended defects - non-stoichiometry - ionic conductivity Disorder in crystals
- Quasi-crystals
- Structure-property relationships: Curie principle
- Piezoelectric and ferroelectric materials

Learning Objectives:

At the end of this course, students:

- will be able to classify crystals according to their symmetry;
- will be able to find structural information from experimental data;
- will be able to recognize different deviations from the perfect crystal;
- will be able to make a link between the structure and properties of crystalline materials.

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	English	English	English

MHM1SGMM: METALLIC MATERIALS

Keywords: structure, reactivity, phase diagram, solidification

Teachers	Frédéric Prima
Coordinator	frederic.prima@chimieparistech.psl.eu

ECTS	Course	Exercises	Practical	Tutoring	Written Exam	Continuous Eval.	Practical Exam	Oral Exam	Mixed Eval.
4	24 h	4.5 h	6h		100%				

Description of the teaching module:

This course aims to give students a basics in structural metallurgy. It addresses different related aspects

- Microstructures of metal alloys: structural aspects (defects), chemical aspects (diffusion), thermodynamic aspects
- Study of structure/property relations (introduction)
- Solidification of alloys (the genesis of these microstructures)
- Phase diagrams (binary and ternary)
- Phase transformations: kinetic, thermodynamic and crystallographic aspects
- Industrial processes for the manufacture of metallic materials (thermomechanical treatments).

The course is completed by practical work on metallurgy illustrating the relationship between microstructure and mechanical properties (quenching and tensile studies)

Learning Objectives:

At the end of this course, students:

- Will master the different concepts of metallurgy.
- Will know how to relate the thermodynamic aspects to the microstructures of metallic materials.
- Will understand the relationship between the microscopic aspects of a material and its macroscopic properties in terms of mechanical behaviour.
- Could develop a synthesis strategy in relation to the expected properties of an alloy.

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	21h course, 3h supervised exercises	English	English

MHM1SGMEC: INTRODUCTION TO MECHANICS

Keywords: deformation; elasticity; plasticity; damage; mechanical modelling

Teachers	Cristian Ovalle
Coordinator	cristian.ovalle_rodas@minesparis.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	15 h	9 h	3h		80%	20 %			yes

Description of the teaching module:

The course begins with the study of the generalities of material properties and the mechanical tests commonly used to characterise their mechanical response. It continues with the study of the construction of material response models and stress state criteria. Then, we focus on linear elastic, thermoelastic and viscoelastic response, followed by the modelling of the plastic domain. The last part of the course deals with the main damage and failure models of materials.

Content

- Experimental observations: Microstructure – Mechanical Testing – Mechanics
- Introduction to mechanics: Material properties – Mechanical properties – Basic formalisms
- Elasticity: linear elasticity – non-linear elasticity – viscoelasticity
- Plasticity: experimental results – theoretical background – mechanical modelling – elastoplastic response
- Damage and fracture: description – Introduction to Fracture mechanics

Learning Objectives:

- Know how to recognize different mechanical tests,
- Know how to build models of behavior,
- know the mechanical behavior of materials to a given stress.

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	English 15h course, 9h supervised exercises	English	English

MHM1SGML : MACHINE LEARNING									
	Keywords: Machine Learning, Python, Data Analysis, Supervised Learning, Neural Networks								
Teachers	Michael KHAIRALLAH								
Coordinator	michael.khairallah@minesparis.psl.eu, assaad.zoughaib@minesparis.psl.eu								
ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
2	9 h		9 h		40%	10%	50%		no

Description of the teaching module:

The field of machine learning is rapidly transforming industries and research, offering powerful tools to extract insights, make predictions, and automate complex decision-making processes. This module provides a comprehensive introduction to the principles, techniques, and practical applications of machine learning. An emphasis will be placed on hands-on implementation using Python, a popular adopted language in the data science community. Students will learn to navigate the Python environment, mastering key scientific libraries (such as NumPy, Pandas, Scikit-learn, Keras/TensorFlow) to pre-process data, build, train, and evaluate various machine learning models. The curriculum covers a broad spectrum of topics, including supervised learning (regression and classification), unsupervised learning (clustering and association rule mining), and an in-depth exploration of artificial, convolutional, and recurrent neural networks. This module aims to equip students with the essential skills to not only understand the theoretical notions of machine learning algorithms but also to confidently apply them to real-world problems, transforming raw data into actionable intelligence.

This Teaching Module is organized in 6 sessions of 3 hours. Most of the sessions take place in two parts: the first devoted to the presentation of concepts and theories and the other to practical work on Python.

The Teaching Module assessment is done in two parts:
- 10% continuous evaluation: participation, involvement in the practical work…
- 40% written exam: multiple choice questions, open questions…
- 50% Python exam: realization of a programming assignment covering some topics.

Learning Objectives:

The objective of this course is to provide students with the necessary knowledge elements in Machine learning, which will subsequently enable them to: Achieve Python expertise for data tasks and utilize key machine learning libraries, Effectively prepare datasets for model development using various techniques, Construct ML pipelines, train models, and evaluate their performance with appropriate metrics, Apply and evaluate regression and classification algorithms, interpret clustering, and gain foundational knowledge of artificial neural network like CNNs (for images), and RNNs/LSTMs (for sequences).

Prerequisites:

This course requires a basic prior knowledge and practice of Python programming. To help you prepare, here are some useful internet links:

How to install Anaconda

- https://www.youtube.com/watch?v=s49fbb1qlE8

MOOC Python

- https://programming-24.mooc.fi/

Python tutorials from Youtube

- Python Full Course – Learn Python in 12 Hours
  - https://www.youtube.com/watch?v=WGJJIrtnfpk
- Python Tutorial for Beginners – Learn Python in 5 Hours
  - https://www.youtube.com/watch?v=t8pPdKYpowI
- Python Basics | Python Tutorial For Beginners | Learn Python Programming from Scratch |
  - https://www.youtube.com/watch?v=woVJ4N5nl_s
- Python for Beginners – Learn Python in 1 Hour
  - https://www.youtube.com/watch?v=kqtD5dpn9C8

Websites for Python Learning

- Python Tutorial
  - https://www.w3schools.com/PYTHON/

Exercises:

- https://www.w3schools.com/python/python_exercises.asp
- https://www.w3schools.com/python/python_quiz.asp

Language English	Course, Exercises, Practical, Tutoring 9 h course,9h exercises	*Documents* English	*Literature* English

MHM1SGTEX : EXPERIMENTAL METHODS

Keywords : Characterization techniques , Image analysis, Metrology

Teachers	Prof. Anouk GALTAYRIES, Frank N'GUYEN, Hala RAMEH
Coordinator	anouk.galtayries@chimieparistech.psl.eu, frank.nguyen@minesparis.psl.eu, hala.rameh@gmail.com

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	24 h		6 h	1h	100%				no

Description of the teaching module:

The aim of this Teaching Module is to introduce experimental methods conventionally used in the field of materials.

A first part of the Teaching Module will be devoted to the introduction of experimental techniques for micro-characterization of materials (microstructure, chemistry and chemical bondings). After an introductory course, two half-days of visits/demonstrations are organized in two PSL laboratories.

A second part will introduce the concepts associated with image analysis.

An introduction to metrology and data analysis will conclude this Teaching Module.

Learning Objectives:

- Know experimental techniques for characterization of materials
- Be able to choose the most relevant technique(s) to obtain the information sought
- Have the basics in image analysis and data analysis

Language		*Documents*	*Literature*
English	Course, Exercises, Practical, Tutoring	English	English

MHM1SGBIB : LITERATURE REVIEW: CONDUCTING AND WRITING

Keywords : bibliography, state of the art, references…

Teachers

Coordinator Heads of the SGM Master's program

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	3 h				66%			33%	no

Description of the teaching module:

This Teaching Module consists of an introduction to the use of digital tools, in particular to carry out a bibliographic study around a defined subject. In order to allow the student to understand the interest of such a work, this bibliographic project might be coupled with a period of experimental work in the laboratory in semester S2 if an internship position is available.

After an introductory session on bibliographic research tools, the student is expected to complete the work on their own time. However, four half-days have been set aside in the schedule to allow the student to work on their bibliographic project and to arrange follow-up meetings with the tutor who proposed the topic. The student is expected to actively engage and interact with this tutor. Work in group to share experince might be also benificial for students

Learning Objectives:

The objective for the student is:

- To learn how to search for existing and available data on a topic;
- To extract relevant information from a scientific paper;
- To know how to transcribe correctly and without plagiarizing general ideas emanating from several sources;
- To have an overall perspective and synthesize the information collected

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	6h introduction to data search	English	English

MH23TC.PIG and MH24TC.PIG: INNOVATION GROUP PROJECT

Keywords: creativity, innovation, project management, prototype

Teachers	Frederic de Montigny
Coordinator	Frederic.de-montigny@chimieparistech.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3				27h+18h	50%			50%	yes

Description of the teaching module:

The goal of these innovation group projects is to continue learning project management and teamwork through the development of a technological innovation project. A technological project is a study designed to develop an idea initiated by a client. This must proceed from an innovation approach aimed at creating a new product, a new service, a new good, adding that we can include a new process, a new recipe closer to chemistry.

Project progress:

The projects are carried out in five phases in semester 1 and semester 2:

1. Search for topics and organization of the team and project
2. Study of the state of the art and analysis of resources (patents, publications, internet, customer visit
3. Elaboration of the project and proposal phase to the steering committee. Critical discussion and defense of the project. Possible ordering of the material
4. Technical realization, development
5. Restitution (written report and oral defense of the project.

Learning Objectives:

The goal of learning is to learn how to develop interdisciplinary skills

- in the field of project management (schedule, schedule, programming)
- in the scientific and technical field (state-of-the-art analysis, bibliography, initiative, design and development of an innovative product)

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	27h + 18h tutored project	En/Fr	En

MHM1SGANG : LANGUAGES

Keywords:

Teachers

Coordinator: Claire Allman (claireallmanbazin@gmail.com): English
Javier Casas (Javier.casas@minesparis.psl.eu): French

ECTS	Course	Exercises	Practical	Tutoring	Written Exam	Continuous Eval.	Practical Exam	Oral Exam	Mixed Eval.
2 + 2	20h+20h				50%			50%	no

Description of the teaching module:

This Teaching Module allows students to learn a foreign language and thus open their horizons to be able to communicate effectively in the scientific world and within a company in France.

This Teaching Module is running during the two semesters

Learning Objectives:

The objective of this Teaching Module is that each student has a minimum level in English or French.

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
En/Fr	2x20h course	En/Fr	En/Fr

MH24OP.MOD: MODELLING

Keywords: molecular modeling

Teachers	Frédéric Labat
Coordinator	frederic.labat@chimieparistech.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
2	3h		12h		100%				no

Description of the teaching module:

This Teaching Module aims to train the student to quantum and classical modeling of complex systems (molecules, solids, biomolecules) of industrial interest. Methods for describing spectroscopic properties (IR, Raman, UV-Vis, NMR and RPE) and chemical reactivity are particularly targeted. Particular interest is given to simulation methods currently used in the industrial and application field.The training is based on alternating courses and practical work sessions, which allow students to put into practice the methods described in class using software of academic and industrial interest.

Learning Objectives:

- know how to choose the most suitable method according to the properties and the system
- know how to interpret the results obtained and their limits

Language		*Documents*	*Literature*
En	Course, Exercises, Practical, Tutoring	En/Fr	En

MH24OP.ELA : INORGANIC MATERIALS ELABORATION

Keywords: inorganic synthesis, ceramic, monocristalline synthesis ; thin films

Teachers	Gérard Aka ; Domitille Giaume ; Odile Majerus
Coordinator	domitille.giaume@chimieparistech.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
2	22h	2h			100%				no

Description of the teaching module:

This course presents the fundamentals of materials elaboration.
A first part presents the basics of monocrystalline synthesis, starting from reflexion based on phase diagrams, nucleation-growth concepts and illustrations with various hot-temperature monocrystalline routes. Such routes are predominant in the optic and photovoltaic domains. A second part deals with the physical and chemical principles underlying the solid-state densification and sintering of powders to obtain technical ceramics. Technical ceramics are a wide family of high-value materials for structural or functional applications (magnetic, optic, dielectric…). On the other hand, glass and glass-ceramics are materials prepared from the liquid state. Their elaboration is briefly presented at the end of this part. . The third part concerns the synthesis of such small inorganic materials by low temperature routes. Basics of aqueous precipitation, sol-gel condensation, high-boiling solvent synthesis are thoroughly described. The last part presents the different opportunities and methods for a chemist concerning the specific elaboration of thin or thick films.

Learning Objectives:

At the end of this course, the students will be able to:

1. Identify and understand the various synthesis routes used to elaborate inorganic materials;
2. Evaluate the advantages and limitations of specific synthesis routes;
3. Choose the most appropriate synthesis route for their study;
4. Understand the mechanisms involved in the different synthesis routes;
5. Propose consistent modifications to a given synthesis process.

Language		*Documents*	*Literature*
English	Course, Exercises, Practical, Tutoring	En/Fr	En/Fr

MH24OP.PES : ELECTRON PROPERTIES OF SOLIDS: FROM MACRO TO NANO SCALE

Keywords: electron band structure, semiconductors, devices, nanosciences

Teachers	Laurent Binet, Pascal Loiseau, Frédéric Wiame
Coordinator	Laurent.binet@chimieparistech.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	18 h	4.5h			100%	0%	0%		

Description of the teaching module:

The objective of this course is to describe the electronic structure of solids, the main properties and applications resulting from them, with an overview of the current technological developments.
In the first part, the course introduces the basic concepts (free electron gas and tight-biding models, dispersion curves, density of states) to describe the electronic band structures of solids and shows how these concepts explain the main classes of properties, namely electrical, optical and chemical pf solids.
In the second part, the course focuses on an important class of materials, semiconductors. It thus introduces the specific crystal and electronic structures of the elemental, III-V and II-VI semiconductors, the n-type and p-type dopings and their electrical and optical behaviors. The course then describes in detail the phenomena occuring in a p-n junction. The applications of the p-n junction are described, solar cells, photo-diodes and light-emitting diodes.

Learning Objectives:

The sudent must be able:

To define the features of the two main models of electronic structure of solids and to know in which context to apply them.

To explain the main parameters that govern the electrical and optical properties of materials and the factors that have a positive or negative effect on these properties.

To interpret a band structure diagram of a solid and deduce its electrical and optical behavior.

To describe in detail the electronic processes in the main semiconductor devices and explain the factors controlling their performance.

To establish a structure-property relationship for a given application.

Language		*Documents*	*Literature*
English	Course, Exercises,	En/Fr	En/Fr

MH24OP.NOR : INORGANIC ASSEMBLIES: FROM MOLECULES TO MATERIALS

Keywords:

Teachers	Domitille Giaume, Pascal Loiseau
Coordinator	domitille.giaume@chimieparistech.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	10.5h	7.5h			100%				no

Description of the teaching module:

The objective of this course is to give the rules of construction of all inorganic and mineral systems but also to show how much this inorganic chemistry is alive and has many applications in current problems (energy, environment, information storage, nanotechnologies...). An introduction to the industrial mineral chemistry industry completes the course (cements, glasses, aquatic chemistry, batteries). The theoretical part focuses on transition metal and lanthanide complexes and describes their optical and magnetic properties.

Learning Objectives:

At the end of the course:

- The student knows the periodic table and the trends of the different elements (ionization, complexation, orbital levels).
- He can describe a mineral system and choose between two simple approaches to describe inorganic complexes according to two ion binding or covalent binding models.
- He can explain the stability and reactivity of inorganic molecules based mainly on transition elements or elements of the p-block.

Language		*Documents*	*Literature*
English	Course, Exercises, Practical, Tutoring		

Mh24OP.MM: SURFACE PROPERTIES AND ENDURANCE OF MATERIALS

Keywords: surface characterization, electronic spectroscopies, reactivity

Teachers *Philippe Vermaut, Frédéric Wiame, Anouk Galtayries*

Coordinator frederic.wiame@chimieparistech.psl.eu

ECTS	Course	Exercises	Practical	Tutoring	Written Exam	Continuous Eval.	Practical Exam	Oral Exam	Mixed Eval.
3	18h	4.5h			100%				no

Description of the teaching module:

What is a surface? What are the specificities of surfaces compared to bulk? Why and how to study these surfaces? In this course we will try to answer these questions. The concepts of surface energy and stress will be introduced and their effects on the structure and properties of the surface will be studied. The initial stages of reactivity will be characterized in the framework of the adsorption theory. The course will be illustrated by practical examples which will highlight the different information that can be obtained using surface characterization techniques such as photoelectron spectroscopy.

After having seen the relationship microstructure-mechanical properties of metals, we propose to go further by studying the mechanisms that lead to the failure of materials when they are exposed to static, or cyclic mechanical stresses, combined with high temperatures or an aggressive environment. This will allow us to address the issue of the durability of metallic materials under the conditions of use and the solutions to improve their lifetime.

Learning objectives:

At the end of the course the student will be able to:

- identify and explain the main technological issues of the study of surfaces,
- describe the fundamental differences between the properties of a surface and those of the bulk material,
- determine the structure, characteristics and basic properties of a surface of given orientation,
- describe the different adsorption mechanisms and give their main characteristics,
- justify the usefulness of ultra-high vacuum and electronic spectroscopies to answer a given problem,
- highlight, by means of examples, the importance of the structure and the surface composition on the mechanisms and the kinetics of reactivity.
- solve basic problems related to the dimensioning of parts exposed to various conditions of use (fatigue, creep, …)
- propose treatments to improve the life of parts in operation
- choose the appropriate non-destructive testing technique

Language		Documents	Literature
English	Course, Exercises, Practical, Tutoring	En/Fr	En/Fr

M1FLOWCHEM: ADVANCED FLUID MECHANICS

Keywords: microfluidics, Reynolds number, heat transport, hydrodynamic instability

Teachers: Nicolas Bremond, José Bico, Laurent Duchemin

Coordinator

ECTS	Course	Exercises	Practical	Tutoring	Written Exam	Continuous Eval.	Practical Exam	Oral Exam	Mixed Eval.
3	30 h				100%				no

Description of the teaching module:

A first part of the course (10h) deals with Microfluidics (AFM-MIC) and focuses on the mechanics of fluids at low Reynolds number in confined systems where interfaces play a major role. The properties of mono-phasic and bi-phasic flows and dispersions, colloidal or otherwise, are presented. The possibility of modifying these flows by controlling pressure, temperature or electromagnetic fields is also discussed. One of the objectives of this course is to show how the combination of microfabrication technologies and basic and applied sciences leads to innovations in areas such as biotechnology or chemistry.

A second part (10 h) deals with Physics of Transport (AFM-PT) of mass and heat. It will answer a wide variety of questions such as: why does my coffee cool much faster than the sugar diffuses into the cup? How long can I stay on top of Everest without gloves? How to design a microfluidic chip to effectively capture biomolecules? How many showers can I take per day with a 10 square meter solar water heater? What do cetaceans and heat exchangers have in common? Why is mixing in turbulent flows so effective?

The last part (10h) is a course on Hydrodynamic Instabilities (AFM-HI). After the introduction of the general concepts of stability study, we will focus on the instabilities occuring in a fluid initially at rest: in particular, we will treat the so-called Rayleigh-Taylor instabilities related to gravity and that of Rayleigh-Bénard observed in a fluid heated from below. Next, we will describe the instabilities of parallel flows, from which large structures can emerge (Kelvin-Helmholtz). Finally, we will focus briefly and phenomenologically on isotropic homogeneous turbulence (Kolmogorov theory).

Learning Objectives:

- Identify the different microfabrication techniques and select the most relevant
- Solving low Reynolds number problems and electrohydrodynamic problems
- Identify heat and mass exchange mechanisms
- Compare different modes of transport using dimensionless numbers
- Model a diffusion, radiative, or convection transport problem
- Identify the mechanisms of instability of a fluid at rest or flow
- Formulate a linear stability problem with or without a free surface, and establish the dispersion relationship

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English		En	En/Fr

MHM1SGESS : FROM MECHANICAL TESTING TO MATERIALS BEHAVIORS

Keywords: mechanical behavior, mechanical testing, numerical simulation

Teachers	Pierre Arnaud, Matthieu Rambaudon
Coordinator	pierre.arnaud@minesparis.psl.eu

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
3	12 h		12 h		100%				

Description of the teaching module:

This Teaching Module aims to be an introduction to the design and dimensioning of structures. It is aimed at students with a material profile but wishing to open up to the mechanical behavior of metallic materials and the relationship between microstructure and properties. Its purpose is to provide sufficient bases in materials mechanics and numerical simulation to be able to exchange on these subjects with specialists in the field.

The design and sizing of structures require knowing the mechanical behavior of materials under given conditions but also being able to model it in order to be able to predict it via numerical simulations. For this reason, an introduction to finite element calculations will be proposed.

This Teaching Module will take place in a laboratory over 5 whole days. It will be structured around lectures, tutorials and practical work during which students will be required to instrument, carry out and analyze various mechanical tests. The experimental results obtained will serve as input data for finite element calculations that will make it possible on the one hand to reproduce the experimental tests carried out (identification of laws of behavior), on the other hand, to predict the behavior of the material for other external stresses.

Learning Objectives:

Language		*Documents*	*Literature*
English	Course, Exercises, Practical, Tutoring	En/Fr	En/Fr

MHM1SGSTG: INTERNSHIP IN LABORATORY

Keywords: laboratory training period

Teachers

Coordinator Heads of the master SGM

ECTS	*Course*	*Exercises*	*Practical*	*Tutoring*	*Written Exam*	*Continuous Eval.*	*Practical Exam*	*Oral Exam*	*Mixed Eval.*
8			44 days min.		33%	33%		33%	Yes

Description of the teaching module:

A teaching unit is dedicated to a laboratory internship with a minimum duration of two months in the field of materials science. This internship offers students practical immersion at the heart of research units related to a scientific issue.

This internship can be linked to the bibliographic project of the first semester but can also be on a different topic.

The laboratory internship has a minimum duration of two months. It is possible to extend this duration according to the signed internship agreement, but the evaluation is based on a written report and an oral presentation at the end of the first two months. For your information, beyond two months, the internship must be obligatorily compensated for the entire duration. When the internship is two months long, compensation is not mandatory, which can facilitate its acceptance by a laboratory.

In cases where the bibliographic project does not lead to an internship, the student must independently and voluntarily search for an M1-level internship, potentially based on their project and scientific interests. A platform called "JobTeaser" is available to facilitate this search. However, it is highly recommended to actively seek opportunities by contacting professors involved in the SGM Master's program (M1 and M2) and expanding efforts to numerous laboratories in the Paris region, both within and outside PSL. It is also advisable to anticipate this search.

Learning Objectives:

The main objective of this internship is to allow students to gain hands-on experience in the laboratory by working on real projects and using state-of-the-art equipment. This internship aims to strengthen students' technical and analytical skills while developing their ability to work in a team and manage research projects.

At the end of the two months, students will have to write a detailed report and present their results during an oral defense, which will also allow them to develop their scientific communication skills.

This internship is an excellent opportunity for students to familiarize themselves with the challenges and opportunities in materials science while preparing for their second year of the SGM Master's program

Language	Course, Exercises, Practical, Tutoring	*Documents*	*Literature*
English	Practical work in laboratory	English	English

PRACTICAL INFORMATION

Registration institution

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

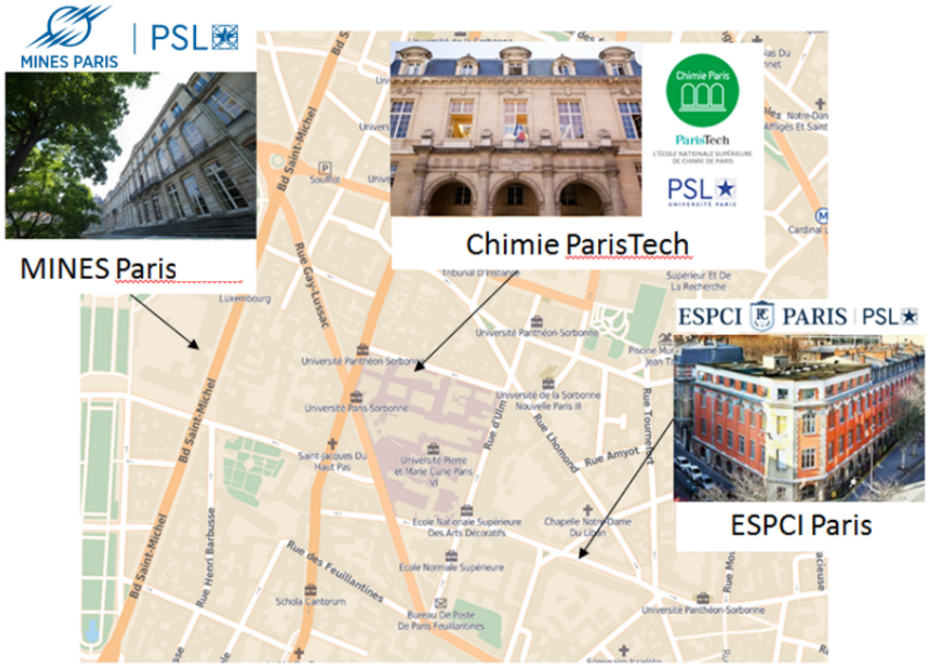
Places for Courses

The vast majority of the courses take place in the three partner institutions of the master's degree: Chimie ParisTech, MINES Paris, ESPCI Paris.

Chimie ParisTech	MINES Paris	ESPCI Paris
11 rue Pierre et Marie Curie 75005 PARIS www.chimie-paristech.fr	60 boulevard Saint-Michel 75006 Paris www.mines-paristech.fr certain courses and practical work sessions are scheduled on the Mines Paris- Versailles Campus site	10 rue Vauquelin 75005 PARIS www.espci.fr

Part of the first year of the M1 is shared with Teaching Courses of the engineering cycles of the partner institutions. Some courses are also transversal to other PSL Masters (in particular the PSL Energy Master), and will be mutualized for a greater richness of the profiles.

- The establishments where the courses are held are all located in the heart of the Paris Latin Quarter.



- Some courses may be offered at the MINES Paris campus in Versailles (4 to 5 days per semester). This campus is easily accessible by public transportation.

Contacts

Materials Science and Engineering (SGM) Master Program:

Jolanta Swiatowska & Loïc Assaud, co-directors (contact.master-sgm@psl.eu)

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

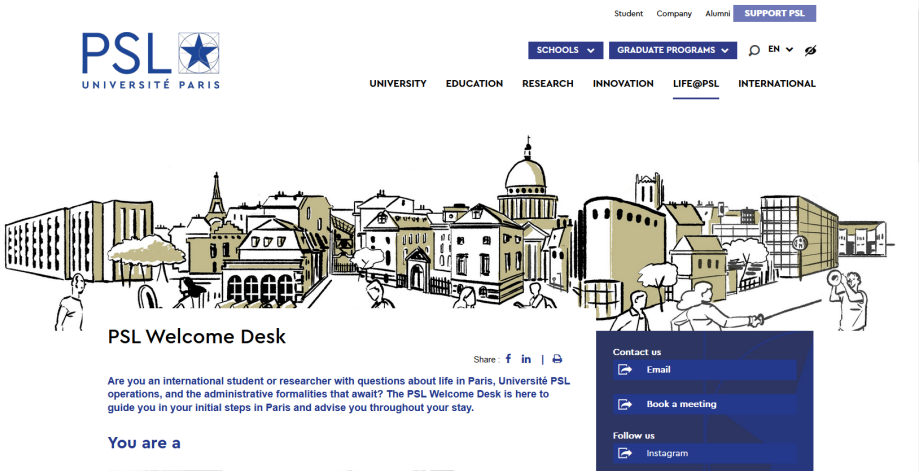
Welcome Desk PSL: welcomedesk@psl.eu / +33 (0)1 75 00 02 91

The Welcome Desk supports newcomer international students in their administrative procedures.

Throughout the year, the PSL Welcome Desk team, composed of bilingual students, also organizes many activities: language tandems, culinary workshops, group jogging, visits to Paris, student evenings, etc.

Every week, the Welcome Desk newsletter will inform you of available activities.

Rejoignez-les sur Facebook : PSL Welcome desk



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