

Year 1 (M1)

Year 2 (M2)

Track MADI

Track MAGIS

Track microfluidics

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MASTER'S PRESENTATION

Master Materials Science and Engineering – Université Paris Sciences et Lettres

Master's program managers : Vincent Guipont & Lola Lilensten (contact.master-sgm@psl.eu)

This master's degree is part of the **graduate program in Engineering (ISAI)**

General presentation

The Master in Materials Science and Engineering (MSE) from Université PSL provides the experimental and theoretical knowledge required to **conceive and design the materials** of tomorrow and to **improve the performance** of existing materials and predict their lifespan. **Co-sponsored by Chimie ParisTech, MINES ParisTech and ESPCI Paris**, this program aims to establish a link between the processes of development, synthesis and layout, (micro) structures and structural and/or functional properties of various materials such as polymers, metal alloys, ceramics and biomaterials.

The first year of the Master in Materials Science and Engineering is common to the three tracks offered for the second year:

- Track "Materials for the Future: Design and Engineering"
- Track "Materials and Engineering Sciences in Paris"
- Track "Microfluidics"

The Master in Materials Science and Engineering aims at training **high-level scientists** with an integrative view of materials and their functionalities all along their life cycle. The experimental approach is favored with more than 150 hours of experimental work during the two years of the master's program and at least 6 months of internship either in the academic field or in high-technology industries. The classes are entirely taught in English.

Objectives of the program

The program follows an educational progression in order to acquire, during the second year, an in-depth expertise in a given field of materials science.

At the end of the four semesters, the students will have acquired:

- Scientific knowledge allowing them to analyze a scientific issue in their field of expertise;
- Methodology to analyze a scientific problem: literature search, design and monitoring of experiment protocols...;
- Tools to develop academic or industrial research projects;
- Skills to analyze and reconstitute scientific data.

Master's year 1:

The first year of the master aims to give a common base of theoretical and experimental knowledge in the field of materials science, necessary before any specialization. A broad-based program in chemistry, physics and mechanics of materials is proposed to all the students, mostly during the first semester. During the second semester, a **first specialization** occurs through optional courses. Part of the courses is shared with the engineering graduate program of the partner engineering schools and/or with the master "Energy".

Initiation to **research and innovation** is proposed as early as the first semester with the literature search project and the group innovation project led all along the year. The literature search project can be associated to the internship of the second semester.

The "cultural openness week" corresponds to either the "PSL week" or a MOOC, to offer an opening to other scientific domains. These half-yearly meetings offer PSL students a great opportunity to enrich their career, develop skills and explore many topics by following a one-week module of their choice in one of the partner institutions or online.

At last, mandatory language courses as well as career development and soft skills modules are proposed during the two years of the master.

Master's year 2:

The second year of the master is a year of specialization with an offer of three tracks. Whatever the track, the third semester consists of core and optional units. Initiation to research and innovation is pursued through research / industrial / design projects as well as soft skills courses. The fourth semester is devoted to an internship of 5 or 6 months either in an academic institution or in an industrial group.

At last, various programs are offered by PSL to students interested in innovation and entrepreneurship will benefit from (PSL i-Teams, PSL-Pepite, PSL-Lab...).

The tracks MAD1 and microfluidics can be followed in apprenticeship.

Who should apply ?

Master's year 1

Bachelor of Science degree in Chemistry, Physical Chemistry, Mechanics (equivalent to 180 ECTS).

Master's year 2

Students who have:

- completed a M1 year in science,
- successfully completed their 2nd year of engineering school.

Students with a Bachelor of Science degree might be also accepted.

Job opportunities

- PhD in one of the doctoral schools (DS) of PSL (DS Systems Engineering, Materials, Mechanics, Energetics; DS Physics and chemistry of materials, DS Physical and analytical chemistry), elsewhere in France or abroad;
- High-technology industries (transports, aircraft, biotechnologies, chemistry, optics...)
- Advanced Master's degree (for example: Design of Materials and structures from MINES ParisTech, etc)

CURRICULUM

Master 1 :

The first year is entirely taught in English.

Teaching units in italics are mandatory. Teaching units in normal style are optional.

Semester 1	10 mandatory units (30 ECTS)		ECT S
BASICS IN MATERIALS SCIENCE		121 h	16
	<i>Corrosion</i>	24 h	
	<i>Physical properties of polymers</i>	24 h	
	<i>Crystallized materials</i>	32 h	
	<i>Metal materials</i>	24 h	
	<i>Introduction to mechanics</i>	24 h	
	<i>Electrochemistry (optional)</i>	12 h	
SCIENTIFIC TOOLS AND COMMUNICATION		121 h	14
	<i>Programming</i>	18h	
	<i>Experimental methods</i>	47h	
	<i>Literature Search project</i>	9h	
	<i>Group innovation project</i>	27h	
	<i>Language</i>	20h	
Total S1		249h	30
Semester 2	5 mandatory units (13 ECTS) + 3 optional units (9 ECTS) 2-months internship* (8 ECTS)		
PROPERTIES OF MATERIALS		92 - 118 h	14
	<i>Modeling</i>	18 h	
	<i>Elaboration of materials</i>	24 h	
	Electronic properties of solids	24 h	
	Inorganic chemistry : from molecules to materials	18 h	
	Surface properties and endurance of materials	24 h	
	Advanced fluid mechanics	30 h	
	From mechanical tests to constitutive laws	24 h	
	Mechanics of solid materials	34 h	
SCIENTIFIC TOOLS AND COMMUNICATION		85 h	8
	<i>Language</i>	30 h	
	<i>Group innovation project</i>	18 h	
	<i>Cultural openness week / MOOC</i>	37 h	
	<i>2-months internship*</i>		8
Total S2		177 -203 h	30
Total M1		439 - 465 h	60

* The internship may be longer than 2 months. It can be done in France or abroad.

Master 2 : Track « Materials for the future : Design and Engineering » - MAD1

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 MAD1 is built around core courses and a specialization sub-track 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...).

The teaching language is English. 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 at analysing the constraints associated with resources, 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.

Semester 3	5 mandatory units (14 ECTS) + 4 optional units (16 ECTS)		ECTS	C1	C2	C3	C4	C5
COMMON CORE		117 h	10					
	<i>Selection and design of materials for a sustainable city</i>	39 h						
	<i>Managing the unknown or Design Thinking</i>	39 h						
	<i>Industrial project or Design project</i>	39 h						
SCIENTIFIC TOOLS AND COMMUNICATION		57 h	4					
	<i>Language</i>	20 h						
	<i>Cultural openness week / MOOC</i>	37 h						
SUB-TRACK		117 h	16					
	<i>Materials and Environment</i>	39 h		O		X	X	X
	<i>From ecodesign to recycling</i>	39 h		O	X	O		X
	<i>Materials for everyday life : scientific challenges</i>	39 h		X		O	X	X
	<i>Endurance and durability of metal materials</i>	42 h		X	O			X
	<i>Physical metallurgy</i>	42 h			O			
	<i>Physicochemistry and formulation of colloidal dispersions</i>	39 h				X	O	
	<i>Formulation and processes of soft matter</i>	39 h					O	
	<i>Bioresources valorization</i>	39 h		X				X
	<i>Processes and coatings</i>	39 h		X	X	X	X	X
	<i>From mechanical tests to constitutive laws</i>	39 h			X			
	<i>Materials of the cultural heritage and durability</i>	39 h		X				X
	<i>Sustainable Energy and Materials</i>	90 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

Master 2 : Track « Materials and Engineering Sciences in Paris » – MAGIS

The objectives of this program are to provide students with a deeper understanding of materials science & engineering and solid mechanics fundamentals and to impart a better knowledge of recent developments in the field, for advanced industrial applications and innovative processes. This track provides an education in the mechanics of materials. It focuses on the relationships between processes, materials, microstructures, and mechanical properties for advanced industrial applications and innovative processes.

Track taught in English, in partnership with Arts & Métiers Paris and Université Paris Saclay

The track « MAGIS » is divided into core courses and the choice of one elective sub-track to choose among 4 :

- Elective 1 (E1) : Damage and fracture of materials and structures
- Elective 2 (E2) : Metal processing and additive manufacturing
- Elective 3 (E3) : Life cycle of polymers and composite materials
- Elective 4 (E4) : Machining and simulation

Semester 3		ECTS	E1	E2	E3	E4
EQUALIZATION TEACHING UNITS (common to all students, optional but highly recommended)	30 h	0				
CORE COURSES (common to all students)	150 h	18				
<i>Material Sciences</i>	30 h	3				
<i>Materials constitutive equations and thermodynamic of solids</i>	30 h	3				
<i>Numerical methods for continuum mechanics</i>	30 h	3				
<i>Advanced experimental methods</i>	30 h	3				
<i>Research project</i>		3				
<i>Scientific communication in foreign language</i>		3				
OPTION (3 mandatory units + 1 unit to be chosen)	120 h	12				
<i>Fracture mechanics</i>	30 h	3	O			
<i>Damage and fracture of polymers and composites</i>	30 h	3	O			
<i>Continuum damage mechanics</i>	30 h	3	O	X	X	X
<i>Plastic strain processing</i>	30 h	3	X	O	X	O
<i>Metal additive manufacturing</i>	30 h	3		O		
<i>Numerical simulation for metal processing</i>	30 h	3		O		
<i>Durability and recycling of polymers and composite materials</i>	30 h	3			O	
<i>Processing of polymers and composites</i>	30 h	3	X	X	O	X
<i>Mechanical behavior of polymers</i>	30 h	3			O	
<i>Multi-physical approach of cutting, materials and material integrity</i>	30 h	3				O
<i>Advanced machining and its applications</i>	30 h	3				O
<i>Dynamic behaviour and failure of materials</i>	30 h	3	X	X	X	X
<i>Algorithmic modelling of physical processes</i>	30 h	3	X	X	X	X
<i>Fatigue of materials</i>	30 h	3	X	X	X	X
<i>Eco-materials</i>	30 h	3	X	X	X	X
Total S3	300 h	30				
Semester 4	Internship (minimum 5 months) 30 ECTS *	30				
Total du M2	300 h	60				

O : mandatory teaching unit for the given option

X : optional teaching unit for the given option

Master 2 : Track « Microfluidics »

The objective of the track "Microfluidics" is to prepare students for a career in the field of microfluidics but also in any area involving fluids and micro/nanotechnologies.

This is why the training is very open-ended: fluid dynamics, physical chemistry, opening to biology, biotechnology, and many practicals in micro/nanofabrication. The courses are provided by leading professors, experts in their field, opened to academic research at the highest level and offer an attractive profile for many companies involved in these matters.

The number of areas of interest in microfluidics (either academic or industrial ones) is considerable: medicine, energy, green chemistry, cosmetics, food industry... Tomorrow, the technologies currently developed will allow:

- In BIOLOGY: to process a large number of samples, conduct experiments on the scale of the cell and understand the interactions between cells, improve the accuracy and timeliness of diagnosis as HIV, reduce experimental volumes...
- In CHEMISTRY: to test thousands of reactions, encapsulate chemical reactions in microfluidic drops...
- In PHYSICS: to create controlled automated systems and experimental set-ups...

Thus, this track opens to great opportunities in a new field, with strong international growth in a multidisciplinary spirit, yet avoiding a premature specialization.

This track is in partnership with Sorbonne University, the University Paris Saclay and the University of Paris.

Semester 3		ECTS
EQUALIZATION TEACHING UNITS in physics, chemistry and biology		
MICROFLUIDICS ET MICROFABRICATION	63h	6
<i>Micro- and nanofabrication techniques</i>		
<i>Surface functionalization with molecules and biomolecules</i>		
FLUID MECHANICS	90h	12
<i>Hydrodynamics and transport at the micro and nanofluidic scale</i>		
<i>Capillarity and wetting phenomena, soft matter, physics of interfaces</i>		
<i>Flow chemistry</i>		
LAB ON CHIPS	42h	6
<i>Continuous Flow and Segmented Flow Chemistry</i>		
<i>Organs on chips</i>		
<i>Bioassays, analytical microdevices</i>		
INTRODUCTION TO BIOLOGY AND BIOCHEMISTRY	34h	3
<i>Droplet-based biochemistry and single cell analysis</i>		
<i>Behavior of individual and collective cells in and on microfabricated devices</i>		
PROJECT		3
<i>Research project</i>		
<i>PSL week</i>		
ADVANCED COURSES (to choose)		
<i>Advanced hydrodynamics and nanofluidics</i>		
<i>Advanced statistical mechanics</i>		
<i>Advanced flow chemistry</i>		
<i>Analytical chemistry</i>		
<i>Physics and measurements</i>		
<i>Synthetic biology</i>		
<i>Medical imaging</i>		
<i>Statistics and data science</i>		
<i>Biophysics</i>		
<i>Machine learning</i>		
Semester 4	Internship (5 months)	30

PRACTICAL INFORMATION

Institution for registration

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

Teaching institutions

Most of the courses are held in three partner institutions of the master's program: Chimie ParisTech, MINES ParisTech, ESPCI Paris.

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

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

All these institutions are located in the center of Paris.



For the track MAGIS, some teachings will occur at Arts & Métiers ParisTech - Boulevard de l'Hôpital (Paris 13^e arrondissement) and at the University Paris Saclay (1 day / week).

Contacts

Master in Material 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 : Domitille Giaume, Cécilie Duhamel, Corinne Soulié, Cécile Monteux, Virginie Lair

Track MAGIS : Thilo Morgeneyer

Track microfluidics : Jacques Fattaccioli

<https://microfluidics-master.fr/>

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

The Welcome Desk helps international 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!