



**MASTER'S DEGREE IN ENERGY**

**UNIVERSITÉ PSL**

**Master Energy**  
**Energy Technology Options for a Carbon Free Future**

*Master 1*



## Programme Content

- Data Science
- Process design 1
- Electro-chemistry and corrosion
- Machine Learning
- Literature Review Project
- Modeling industrial processes
- Nuclear
- Metrology
- Thermodynamics
  
- Electronic Properties of Solids
- Heat and Mass Transfer
- CV and motivation letter writing
- Mechanics of fluids
- PSL WEEK
- Process design 2
  
- 2- 4months internship
  
- English Course
- French Course

<b>Energie M1</b>	<b>S1</b>	<b>Course Title: Thermodynamics</b> <i>Keywords: thermal cycles, Carnot cycles, refrigeration</i>			
Instructor(s), Coordinator	Assaad Zoughaib Assaad.zoughaib@minesparis.psl.eu				
<b>ECTS</b>	<i>Lectures</i> 8 h	<i>small classes</i> 6 h	<i>Experimental teaching</i> 0 h	<i>Tutoring</i>	<i>rating: exam (100%)</i>
<i>The course aims to introduce thermodynamics applied to energy conversion systems.</i>					
<b>Learning goals</b> The student should be able to: <ul style="list-style-type: none"> <li>- Analyze and Visualize the correlation between any two variables in a dataset</li> <li>- Apply Polynomial interpolation (Lagrange and Newton)</li> <li>- Apply Gradient descent</li> <li>- Apply linear and multiple regression methods (manually and python libraries)</li> </ul>					
<b>Pre-requisites :</b> Basics in statistics and python					
Teaching language: English Lecture notes: yes					

<b>Energie M1</b>	<b>S1</b>	<b>Course Title: Metrology</b> <i>Keywords: Sensor placement, Error propagation, Monte Carlo</i>			
Instructor(s), Coordinator		Hala RAMEH halarameh@gmail.com			
ECTS	Lectures 9 h	small classes 0 h	Experimental teaching 0 h	Tutoring	rating: final project (100%)
<p>The course is aimed at learning how to find the best instrumentation for an industrial process. This is done by compromising price and precision of each instrumentation scheme. You will learn how to describe your process and apply different methods to compute the precision of these schemes.</p>					
<p><b>Learning goals</b> The student should be able to:</p> <ul style="list-style-type: none"> <li>- Find valid instrumentation scheme for a process</li> <li>- Approximate the induced error of the key process variables</li> <li>- Draw the Pareto Curve to choose the best instrumentation</li> </ul>					
<p><b>Pre-requisites :</b> Derivatives, Taylor expansion and basics in python</p>					
<p>Teaching language: English Lecture notes: yes</p>					

<b>Energie M1</b>	<b>S1</b>	<b>Course Title: Data Analysis</b> <i>Keywords: Correlation, Gradient Descent, Linear Regression</i>			
Instructor(s), Coordinator		Hala RAMEH halarameh@gmail.com			
ECTS	Lectures 9 h	small classes 0 h	Experimental teaching 0 h	Tutoring	rating: final project (100%)
<p>The course is aimed at introducing data analysis (basic statistics, correlations and visualization) and learning how to solve regression problems (exact and approximate solutions).</p>					
<p><b>Learning goals</b> The student should be able to:</p> <ul style="list-style-type: none"> <li>- Analyze and Visualize the correlation between any two variables in a dataset</li> <li>- Apply Polynomial interpolation (Lagrange and Newton)</li> <li>- Apply Gradient descent</li> <li>- Apply linear and multiple regression methods (manually and python libraries)</li> </ul>					
<p><b>Pre-requisites :</b> Basics in statistics and python</p>					
<p>Teaching language: English Lecture notes: yes</p>					

Energie	Sx	<p><b>Course Title : Nuclear Energy and Fuel Cycle</b></p> <p><i>Mots clefs : Electronuclear production, nuclear fuel cycle, nuclear wastes</i></p>
Coordinateur		Grégory Lefèvre
ECTS :	Total hours : <ul style="list-style-type: none"> <li>- Course – 24h</li> <li>- Practicals</li> <li>- Project.... – 6 h</li> <li>- Visits – 3h</li> </ul>	Evaluation : <ul style="list-style-type: none"> <li>- Exam 0%</li> <li>- Project 100 %</li> <li>- Practical 0%</li> </ul>
<p><b>Description</b></p> <p><i>The course is aimed at giving a global view of the electronuclear cycle. Teachers will present the nuclear power plant systems and the radioprotection approach, the uranium resources and extraction, the different steps of fabrication of nuclear fuel, the management, reprocessing and storage of nuclear wastes. A visit of an EDF or CEA site is planned. A part of the course will take place as group project works.</i></p>		
<p><b>Learning objectives</b></p> <p>Understanding the pros and cons of nuclear energy in a decarbonized system of production. Describing the chemical approaches to build nuclear fuel and to manage the safety of the nuclear wastes.</p>		
<p><b>Aquired compétences</b></p> <ul style="list-style-type: none"> <li>- Gaining perspective on the importance of nuclear energy in France and worldwide</li> <li>- Understanding the methods to produce nuclear fuel from natural uranium</li> <li>- Knowing the reprocessing of used fuel and the management of wastes</li> <li>- Understanding the steal cycles in a nuclear power plant</li> </ul>		
<p><b>Pre-requisites</b></p> <ul style="list-style-type: none"> <li>- Basics in solution and material chemistry, physics.</li> </ul>		
Teaching language : English Course material : copy of the teachers' slides.		
Teaching language : English Course material : copy of the teachers' slides.		

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: Internship</b> <i>Keywords: Research, R&amp;D</i>			
Instructor(s), Coordinator		Assaad Zoughaib Assaad.zoughaib@minesparis.psl.eu			
ECTS	Duration 2 to 4 months				rating: Report (50%) oral presentation (50%)
<p>The internship in the first year of the master is a research or research and development experience of 2 to 4 months. The students should work on a project that requires to do a literature review, define a work strategy and apply knowledge, use tools or experimental techniques in relation with the teachings they had. They have to write a comprehensive report and be able to present their work clearly.</p>					
<p><b>Learning goals</b> The student should be able to:</p> <ul style="list-style-type: none"> <li>- Perform a literature review</li> <li>- Define a work strategy to answer a research question</li> <li>- Apply knowledge to produce numerical or experimental results</li> <li>- Write a report</li> <li>- Present their work in a limited time</li> </ul>					
<p><b>Pre-requisites :</b> Basics in energy engineering</p>					
<p>Teaching language: English Lecture notes: yes</p>					

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: Heat and mass transfer</b> <i>Keywords: thermal conduction, convection, radiation, fick's law</i>			
Instructor(s), Coordinator		Assaad Zoughaib Assaad.zoughaib@minesparis.psl.eu			
ECTS	Lectures	small classes	Experimental teaching	Numerical tutorials	rating: exam (40%) experimental tutorials (20%) Mini project
	18 h	10 h	6 h	12h	
<p>The course aims to introduce heat transfer modes (conduction, convection and radiation). It introduces also the mass transfer fick's law and the coupling between heat and mass transfer. The aim is to allow students to write correctly an energy balance on a system and understand the different heat and transfer modes involved in this balance.</p>					
<p><b>Learning goals</b> The student should be able to:</p> <ul style="list-style-type: none"> <li>- Define a control volume and write an energy balance</li> <li>- Understand the different heat and mass transfer modes</li> <li>- Apply these notions on real industrial problems and systems</li> <li>- Observe experimentally these phenomenon and apply the theory to interpret the results</li> </ul>					
<p><b>Pre-requisites :</b> Basics in physics</p>					
<p>Teaching language: English Lecture notes: yes</p>					

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: Fluid mechanics</b>			
		<i>Keywords: momentum equation, bernouilli equation, Navier stockes, Euler theorem</i>			
Instructor(s), Coordinator	Assaad Zoughaib Assaad.zoughaib@minesparis.psl.eu				
<b>ECTS</b>	<i>Lectures</i>	<i>small classes</i>	<i>Experimental teaching</i>	<i>Numerical tutorials</i>	<i>rating: exam (50%) numerical tutorials (50%)</i>
	9 h	9 h	0 h	12h	
<p><i>The course aims to introduce fluid mechanics conservation equations. It gives an engineering approach to the application of these equations.</i></p>					
<p><b>Learning goals</b></p> <p>The student should be able to:</p> <ul style="list-style-type: none"> <li>- Define a control volume and write the mass, momentum and energy conservation equations</li> <li>- Understand the possible simplifications and the assumptions behind</li> <li>- Calculate pressure losses in a flow</li> <li>- Have notions of computational fluid dynamics</li> </ul>					
<p><b>Pre-requisites :</b> Basics in physics</p>					
<p>Teaching language: English Lecture notes: yes</p>					

Energie	Sx	<p><b>Course Title: Electronic Properties of Solids</b></p> <p><i>Mots clefs : band structure, electrical and optical properties, semiconductors, devices</i></p>	
Coordinateur		Laurent Binet, Professor, Chimie-ParisTech, laurent.binet@chimieparistech.psl.eu	
ECTS :	<p><i>Total hours :</i></p> <ul style="list-style-type: none"> <li>- Course 22.5h</li> <li>- Practicals 0h</li> <li>- Project....0h</li> </ul>	<p><i>Evaluation :</i></p> <ul style="list-style-type: none"> <li>- Exam 100%</li> <li>- Project 0%</li> <li>- Practical 0%</li> </ul>	
<p><b>Description</b></p> <p>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 current technological developments.</p> <p>In the first part the course introduces the basic concepts (free electron gas and tight-binding 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 of solids.</p> <p>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 that occur in a p-n junction. The applications of the p-n junction are described, in particular solar cells, photo-diodes and light-emitting diodes.</p>			
<p><b>Learning objectives</b></p> <p>The student must be able:</p> <ul style="list-style-type: none"> <li>- to define the characteristics of the two main models of electronic structure of solids and to know in which context to apply them,</li> <li>- 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,</li> <li>- to interpret a band structure diagram of a solid and deduce its electrical and optical behaviour,</li> <li>- to describe in details the electronic processes occurring in the main semiconductor devices and explain the factors controlling their performance</li> <li>- to establish a structure-property relationship for a given application.</li> </ul>			

**Acquired skills**

- Ability to interpret a band structure and to predict the electrical and optical properties of solid based on it.
- Ability to constrain the design of a material for targeted electrical and optical properties
- Ability to understand the functioning of semiconductor-based devices

**Pre-requisites**

- Classical mechanics: Newton's laws, momentum, force and potential energy, kinetic energy, work done by a force.
- Quantum physics: Schrödinger equation, De Broglie and Planck-Einstein relations, Dirac notation, eigenfunctions and eigenvalues and their physical meaning, scalar product in a Hilbert space, energies and wavefunctions of a free particle and of a particle in a quantum well.
- Quantum chemistry: atomic and molecular orbitals, linear combinations of atomic orbitals, bonding and antibonding molecular orbitals, Born-Oppenheimer and single electron approximations.
- Crystallography: crystal systems, normal and reciprocal lattices, relation between basis vectors of these lattices.
- Electromagnetism: plane waves, wave vector, electrostatic potential, electric field, Poisson's equation.
- Thermodynamics: Boltzmann and Fermi-Dirac statistics, Ficks' law.
- Mathematics: gradient, Laplacian, divergence, partial derivative, differential.

Teaching language : English

Course material : <https://moodle.psl.eu/>

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: CV writing and job interview simulations</b>			
		Keywords: Research, R&D			
Instructor(s), Coordinator		Assaad Zoughaib Assaad.zoughaib@minesparis.psl.eu			
ECTS	Lectures 2 h	Individual interview 2 h			Validated upon participation to the exercise
The course is a training on how to write a cv and a motivation letter. It includes also simulated interviews with HR qualified trainer.					
<b>Learning goals</b>					
The student should be able to:					
<ul style="list-style-type: none"> <li>- Write a cv</li> <li>- Write a motivation letter</li> <li>- Have hints on job interviews</li> </ul>					
<b>Pre-requisites :</b>					
Teaching language: English					
Lecture notes: yes					

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: Process design</b>			
		- Keywords:			
Instructor(s), Coordinator					
ECTS	Lectures	Individual interview			Validated upon participation to the exercise
<b>Learning goals</b>					
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<b>Pre-requisites :</b>					

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: Electro-chemistry and corrosion</b>			
		- Keywords:			
Instructor(s), Coordinator					
ECTS	Lectures	Individual interview			Validated upon participation to the exercise
<b>Learning goals</b>					
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<b>Pre-requisites :</b>					

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: Machine Learning</b>			
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<i>Keywords:</i>					
Instructor(s), Coordinator					
<i>ECTS</i>	<i>Lectures</i>	<i>Individual interview</i>			<i>Validated upon participation to the exercise</i>
<b>Learning goals</b>					
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<b>Pre-requisites :</b>					

<b>Energie M1</b>	<b>S2</b>	<b>Course Title: Literature Review Project</b>			
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<i>Keywords:</i>					
Instructor(s), Coordinator					
<i>ECTS</i>	<i>Lectures</i>	<i>Individual interview</i>			<i>Validated upon participation to the exercise</i>
<b>Learning goals</b>					
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<b>Pre-requisites :</b>					