

Partager



Email destinataire :

Vous devez renseigner un email valide

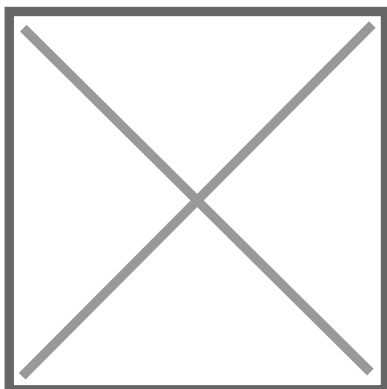
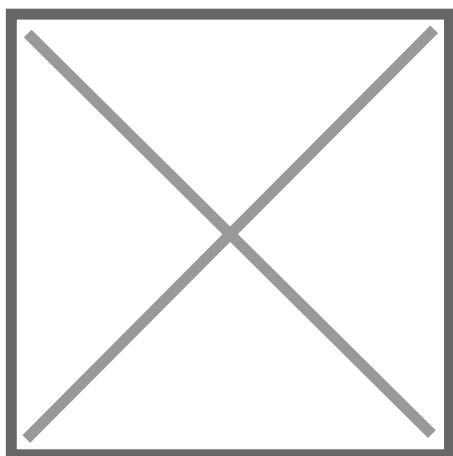
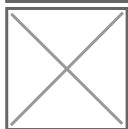
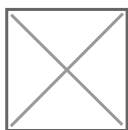
Envoyer

Une erreur est survenue. Merci de réessayer ultérieurement

Le mail de partage a bien été envoyé.

Ajouter au comparateur

M1 Nuclear Engineering



Master

Mention Ingénierie nucléaire

Régime(s) d'inscription

Formation initiale Formation continue

Langue(s) d'enseignement

Anglais

Un diplôme international de haut niveau, enseigné entièrement en anglais, qui forme les ingénieurs et chercheurs de demain dans le domaine du nucléaire civil.

Alliant **excellence scientifique**, **expertise technique** et **vision globale des enjeux énergétiques**, le Master prépare ses étudiants à relever les défis de la transition énergétique : production d'électricité bas carbone, sûreté et sécurité des installations, gestion des déchets, conception des réacteurs du futur.

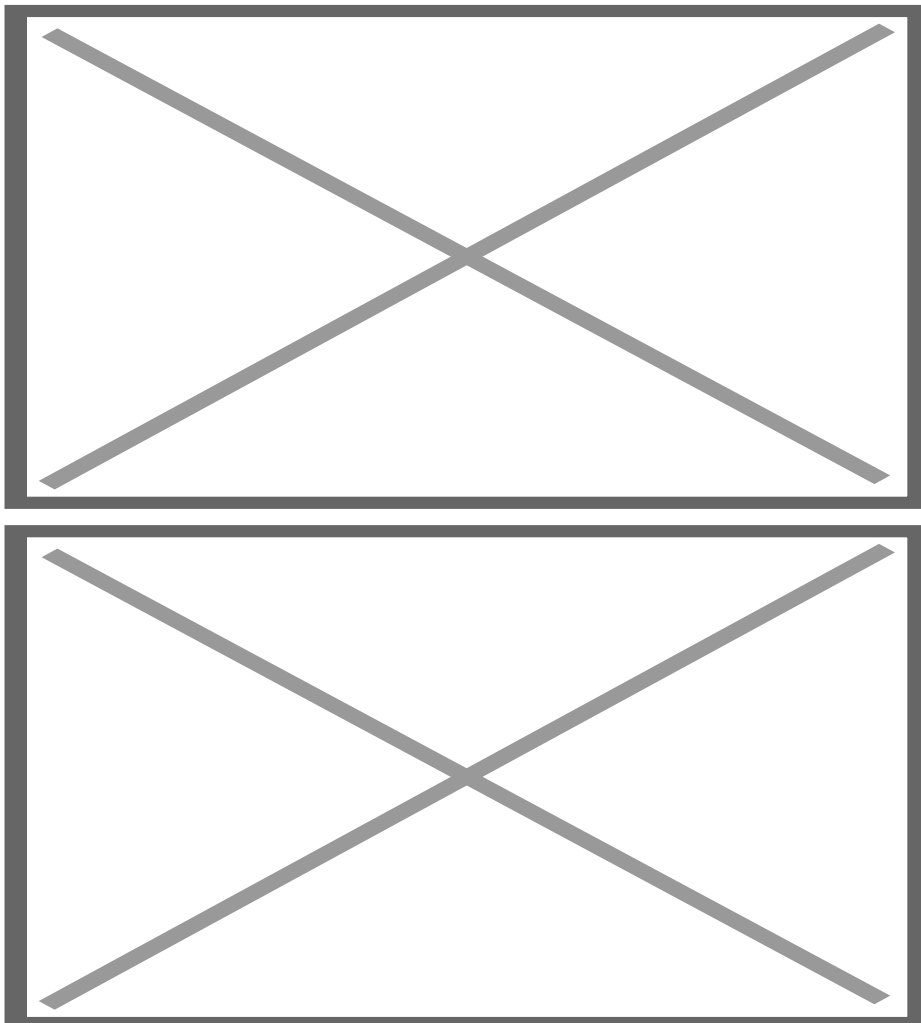
Le Master *Nuclear Engineering* est un diplôme international de haut niveau, entièrement dispensé en anglais. Destiné aux étudiants français et étrangers, il forme des ingénieurs et chercheurs capables de relever les défis liés à l'exploitation, la sûreté, la conception, le démantèlement et l'évolution des installations nucléaires, contribuant ainsi à la production d'électricité bas carbone.

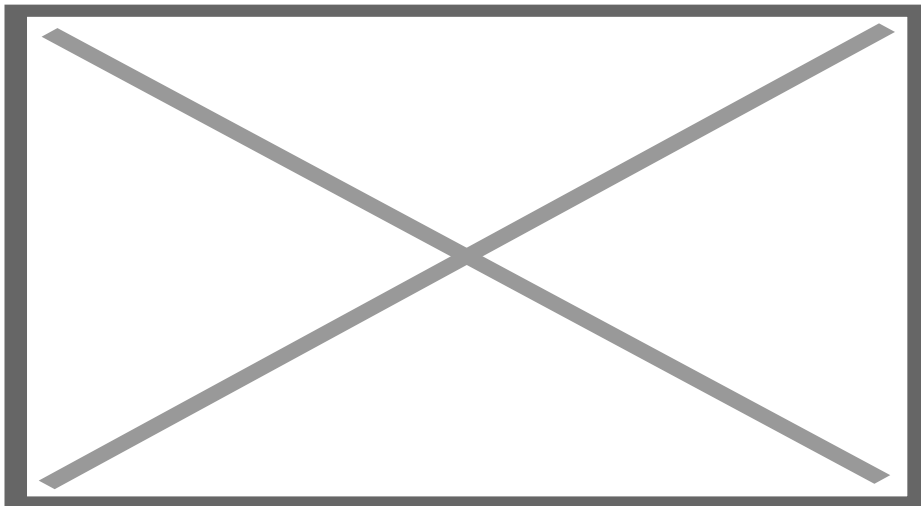
Le cursus, sur deux ans, comprend :

- **M1** : deux parcours, **Physique** et **Chimie**, pour acquérir les bases indispensables à la spécialisation.
- **M2** : cinq spécialisations couvrant les grands domaines du nucléaire civil : **Cycle du combustible**, **Démantèlement et gestion des déchets**, **Exploitation**, **Conception des installations nucléaires**, **Physique et ingénierie des réacteurs nucléaires**.

Cette organisation progressive permet aux étudiants de développer une expertise scientifique et technique solide, ainsi qu'une vision globale des enjeux industriels, environnementaux et sociétaux de l'énergie nucléaire.

[Télécharger la fiche détaillée](#)
[Je candidate](#)





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Informations

- [Présentation](#)
- [Admission](#)
- [Programme](#)

Présentation

Compétences

À l'issue du Master, les étudiants seront capables de :

- Identifier les connaissances et outils nécessaires à l'analyse et à la résolution de problèmes complexes liés au nucléaire.
- Maîtriser les principales disciplines impliquées dans la mise en œuvre industrielle de l'énergie nucléaire.
- Comprendre et expliquer les impacts de l'énergie nucléaire sur l'homme et l'environnement, en situation normale ou accidentelle.
- Travailler efficacement en équipe, en collaboration avec des acteurs d'origines culturelles, scientifiques et professionnelles diverses.
- Connaître, comprendre et appliquer les principes fondamentaux de la **culture de sûreté** (prudence, questionnement, transparence, responsabilité).
- Situer l'énergie nucléaire dans le mix énergétique mondial, en comparaison avec les autres filières, sous l'angle environnemental, économique et géopolitique.

Objectifs pédagogiques de la formation

Le Master vise à :

- Former des spécialistes dotés de solides connaissances scientifiques et techniques, capables de contribuer à l'exploitation sûre et durable de l'énergie nucléaire.
- Préparer les étudiants à une carrière industrielle dans le secteur nucléaire ou à un parcours de recherche dans les domaines de la physique des réacteurs, de la modélisation, de la radioprotection ou encore de la chimie nucléaire.
- Développer la compréhension des enjeux de sûreté, de sécurité et d'impact environnemental associés aux installations nucléaires.
- Donner une vision comparative et critique de l'énergie nucléaire face aux autres sources de production énergétique, en termes de durabilité, d'économie et d'indépendance énergétique.

Débouchés

Professionnels

Après un Master ou Master + Doctorat : ingénieur (R&D, contrôle, production...)

Après un Master ou Master + Doctorat : chercheur ou enseignant-chercheur

Après un Master ou Master + Doctorat : ingénieur (recherche-développement, contrôle, production...) dans les domaines santé, pharmacie, agroalimentaire, biotechnologies, instruments et réactifs, cosmétique, dépollution et environnement

Après Master + Doctorat : chercheur ou enseignant-chercheur

Après un Master ou Master + Doctorat : ingénieur (recherche et développement, contrôle, production...)

Après un master : Chargé(e) d'études

Ingenieur R&D

Chargé d'affaire

Ingénieur de sûreté

ingénieur étude conception

ingénieur chimie-environnement

Ingénieur R&D Nucléaire

Chef de projet

Consultant

Ingénieur d'études dans les domaines de l'industrie

Ingénieur d'études dans les domaines de la recherche

Ingénieur d'études industrie / recherche publique

Chargé.e de recherche et innovation

Chargé.e de projet

Ingénieur de recherche ou d'études

enseignant.e-chercheur.se (après un doctorat)

Chargé de mission / projets

Chef de projet prévention

Poursuite d'études

Doctorat

Master 2

Agenda

Début de la formation (date indicative)

01/09/2026

Fin de la formation (date indicative)

09/07/2027

Admission

Voie d'accès

Physique

Chimie

Physique, chimie

Mécanique

Génie civil

Sciences pour l'ingénieur

Double Licence Mathématique - Physique

Capacité d'accueil

Places

45

Public visé et prérequis

Licence de Physique et licence de chimie et équivalent.

Période(s) de candidature

Plateforme Inception

Du 15/01/2026 au 16/03/2026

Plateforme MonMaster

Du 17 février au 16 mars 2026

Pour connaître la plateforme sur laquelle vous devez candidater, vous trouverez plus de renseignements sur la page [Candidater à nos masters](#). Vous trouverez ci-dessous la liste des pièces justificatives demandées sur la plateforme Inception.

Pièces justificatives

Obligatoires

Copie du dernier diplôme.

Copie du passeport.

Lettre de motivation.

Tous les relevés de notes des années/semestres validés depuis le BAC à la date de la candidature.

Attestation de niveau d'anglais (obligatoire pour les non anglophones).

Curriculum Vitae.

Attestation de niveau d'anglais (obligatoire pour les non anglophones) ou Résultats test GMAT/GRE.

Moyenne générale des 3 années de Licence (moyenne à indiquer DANS LE TITRE DU DOCUMENT).

Facultatifs

Attestation de niveau d'anglais.

Dossier VAPP (obligatoire pour toutes les personnes demandant une validation des acquis pour accéder à la formation) <https://www.universite-paris-saclay.fr/formation/formation-continue/validation-des-acquis-de-lexperience>.

D'éventuelles lettres de recommandation.

Document justificatif des candidats exilés ayant un statut de réfugié, protection subsidiaire ou protection temporaire en France ou à l'étranger (facultatif mais recommandé, un seul document à fournir) :

- Carte de séjour mention réfugié du pays du premier asile
- OU récépissé mention réfugié du pays du premier asile
- OU document du Haut Commissariat des Nations unies pour les réfugiés reconnaissant le statut de réfugié
- OU récépissé mention réfugié délivré en France
- OU carte de séjour avec mention réfugié délivré en France
- OU document faisant état du statut de bénéficiaire de la protection subsidiaire en France ou à l'étranger.

Programme

Tronc commun (bloc 1)

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Thermodynamique	3	Semestre 1	18	9							

Thermodynamique

ECTS : 3

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 18

Travaux dirigés : 9

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Good knowledge of mathematics, derivatives, linear algebra and calculus. Basic knowledge of classical thermodynamics would be helpful.

Programme / plan / contenus

The course content is divided into 4 main chapters:

1. 1st and 2nd laws of thermodynamics

System and process (reminder of terminology and definitions), state functions properties, basic notions of temperature, pressure, heat and work, 1st law and energy conservation, concept of irreversibility, 2nd law and entropy creation.

2. Differential formulation, calorimetric and thermo-elastic coefficients

How to use these to solve a problem of thermodynamics, ideal gas model and real gases, Joule expansions.

3. Phase changes and phase diagrams of pure substances

Clausius-Clapeyron equation, reading and handling different diagrams [(P,T), (P,V), (T,S), and Mollier diagrams].

4. Heat engines, refrigerators and heat pumps

Operating principle, Raveau diagram, Carnot cycle, efficiency calculations, studying thermal cycles with chap. 3 diagrams, operating cycles (Otto, Diesel, Brayton, Rankine, Stirling).

Objectifs d'apprentissage

The objective of this course is to provide a clear view of the principles of Thermodynamics and its applications relevant to physics and engineering. The aim for the students is to acquire a valuable understanding of the fundamental concepts of Thermodynamics (such as energy exchange, reversible and irreversible processes, entropy creation etc.) and a good knowledge of the calculation method associated.

Organisation générale et modalités pédagogiques

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Méthodes mathématiques pour l'ingénierie	4	Semestre 1	18	0							



Méthodes mathématiques pour l'ingénierie

ECTS : 4

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 18

Travaux dirigés : 0

Projet tutoré 24

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Bachelor level in Mathematics

Notions of algorithmics

Notion of Python

Notions in Linux

Programme / plan / contenus

Introduction to Python

The language and existing numerical libraries.

Part 1 : Simple functions

Elements of floating point numbers : IEEE 754 format, relative uncertainty, single / double precision.

Catastrophic cancelation, examples with solving the quadratic equation and computing geometric quantities

Evaluating elementary and special functions : interval reduction, Taylor's expansion

Estimating statistical quantities : variance in particular, critical to uncertainties estimations

Part 2 : Linear algebra

Linear systems, Cramer's rule and why one should avoid it,

Gaussian elimination (simple and full pivot), LU factorization, elements of error propagation ; why one should rely on factorization to evaluate determinants and geometric quantities

Eigenvalues and Eigenvectors

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
<u>Interaction et détection des rayonnements ionisants</u>	3	Semestre 1	9	3	21						

Interaction et détection des rayonnements ionisants

ECTS : 3

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 9

Travaux pratiques : 21

Travaux dirigés : 3

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

The prerequisites for this module are:

- converting electromagnetic energies into wavelengths, speeds, and frequencies
- explaining atomic structure and its reactions when energy below the ionization threshold is transferred to it
- explaining the organization of atoms into molecules and crystals and citing the binding energies involved
- explaining all the origins of ionizing radiation emitted at the end of a nuclear reaction (spontaneous or induced by a particle or radiation)
- list the energy ranges conveyed by ionizing and non-ionizing radiation
- calculate the energy balance of a nuclear reaction and the kinetic energy of the products of this reaction
- explain the different modes of spontaneous nuclear transitions: radioactivity

Programme / plan / contenus

- Sources of ionizing radiation: kinetic energy spectra according to the origin of the radiation
- Energy losses of ionizing radiation in matter:
 - Directly ionizing radiation: charged particles: linear energy transfer, range, penetration, energy losses through ionization, excitation, heat transfer, and bremsstrahlung
 - Indirectly ionizing radiation: electromagnetic radiation:
 - scattering, absorption, cross section, mean free path, attenuation laws
 - Indirectly ionizing radiation: neutrons:
 - scattering and slowing down, captures and induced nuclear reactions
 - (radiative capture, activation, fission, (n,alpha) reactions, etc.),
 - cross sections, mean free path, attenuation laws
- Measurement uncertainties: estimation and propagation. Special case of uncertainties associated with

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Notions de Physique Nucléaire	4	Semestre 1	18	18							

Notions de Physique Nucléaire

ECTS : 4

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 18

Travaux dirigés : 18

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

None

Programme / plan / contenus

1. Discovery of the Atomic Nucleus

- From early atomic models to Rutherford's experiment and the discovery of subatomic particles.
- Identification of protons, neutrons, and isotopes; scale of atomic and nuclear dimensions.
- Introduction to natural nuclear units (energy, mass, charge).

2. Nuclear Masses and Binding Energy

- Mass defect, binding energy, and nuclear cohesion.
- Liquid-drop model and Bethe–Weizsäcker formula.
- Nuclear stability, mass parabolas, and reaction energetics (Q-value calculations).

3. Nuclear Structure and Models

- Mean-field potential and shell model concepts.
- Quantum numbers, spin, parity, and magic numbers.
- Collective vs single-particle models of nuclear behavior.

4. Nuclear Reactions and Cross-Sections

- Classification and notation of nuclear reactions.
- Definition of cross-sections, reaction rates, and mean free path.
- Compound nucleus formation and reaction mechanisms.

5. Nuclear Kinematics

- Kinematics of two-body reactions in laboratory and center-of-mass systems

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
<u>Chemical Engineering</u>	4	Semestre 2	15	15	6						

Chemical Engineering

ECTS : 4

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 15

Travaux pratiques : 6

Travaux dirigés : 15

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

None

Programme / plan / contenus

1. Fundamentals of chemical engineering (i) Mass and energy balances (ii) Ideal reactors (CSTR, BSTR, PFR) Reactor analysis and design (iii) Purification unit operations: example of solvent extraction in the spent fuel treatment process
2. Thermodynamics: i) Calculation of chemical equilibrium and phase equilibrium: models based on excess free enthalpies or equations of state ii) Thermodynamics of electrolyte solutions
3. Thermodynamics: i) Diagram and phase equilibrium of pure substances: chemical potential ii) thermodynamic models and equations of state, iii) energy and entropy balances with application to thermodynamic cycles (Rankine) and energy storage

Objectifs d'apprentissage

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

1. List the modes of mass transfer.
2. Identify the different modes of mass transfer (diffusion/convection) at work in a given configuration.
3. Write mass balances, taking into account chemical reaction kinetics if necessary.
4. Translate phenomena into equations using fundamental balances.
4. Translate phenomena into equations using fundamental balances,
5. Calculate chemical equilibrium and phase equilibrium
6. Apply thermodynamic fundamentals to electrolyte solutions
7. Understand a phase equilibrium diagram for pure substances
8. Perform energy and entropy balances with application to thermodynamic cycles and energy storage

Tronc commun d'ouverture (Bloc 2)

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Technologies de Production d'Énergie	3	Semestre 1	9	18							

Technologies de Production d'Énergie

ECTS : 3

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 9

Travaux dirigés : 18

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Students in mechanical engineering, chemical engineering, energetics. Good basis in thermodynamics is required, basic knowledge in chemistry is preferable.

Programme / plan / contenus

Introduction to renewable energies - Cleantech - Legal aspects

Solar energy

Wind energy

Energy storage

Energy efficiency

CO2 capture sequestration and valorisation

CO2 capture technologies

Oil and Gas

Combustion for energy production

Objectifs d'apprentissage

The objectives of the course are to:

have acquired a global knowledge of the current and future situation of power generation, essentially focused on fossil and renewable sources; possess an overview on current global market of oil and gas and its prospects for the future in the medium and long term; have acquired good technological and economical notions on wind and solar farms for renewable energy production; have acquired an advanced knowledge on the current and future generations of bio fuels, and the formation of atmospheric pollutants during their combustion; be able to understand the challenges of energy efficiency in buildings and industry; have acquired a knowledge of the main technologies of energy storage; possess an insight into the future of low carbon power generation via the development of CO2 capture, sequestration and valorisation (CCS/V) technologies

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Gestion de Projet	3	Semestre 2	12								

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
■											

Gestion de Projet

ECTS : 3

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 12

Projet tutoré 18

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

none

Programme / plan / contenus

This course is an introduction to project management. It will provide the students with the essential milestones of project management.

(1) Identification of needs and drafting of specifications

(2) Organization and management of the project team

(3) Identification and analysis of risks

(4) Construction and monitoring of the schedule

(5) Quality management (customer satisfaction and management of difficulties encountered)

(6) Cost analysis and budget implementation

(7) Choice of development model

(8) Resistance management

(8) Project monitoring and dashboard creation

Objectifs d'apprentissage

Managing a project: meeting customer expectations while staying within the allocated budget and schedule.

Organisation générale et modalités pédagogiques

Students form groups of 3-4 people. They choose a project they want to implement and work on: the skills required, the management approach they plan to use, the development model they want to follow, the potential risks, the schedule, how to ensure customer satisfaction, cost analysis, managing potential resistance, and the monitoring dashboard. The objective is to put into

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Économie de l'énergie	2	Semestre 2	24								

Économie de l'énergie

ECTS : 2

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 24

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

none

Programme / plan / contenus

The course is organized around 11 topics and chapters as follow:

- 1 Introduction and Background: Review of the Basics of Supply, Demand and Price Formation in Competitive Markets
- 2 Energy Demand: Short Run and Long Run Price and Income Elasticity's
- 3 Energy Supply and the Economics of Depletable Resources
- 4 World Oil Markets and Energy Security
- 5 Natural Gas Price Regulation, Deregulation and Markets
- 6 Electricity
- 7 Energy and Climate Change
- 8 Internalizing Environmental Externalities with a Focus on CO2 Emissions Cap and Trade Mechanisms
- 9 Coal
- 10 Nuclear Power
- 11 Renewable Energy Policies analysis

Objectifs d'apprentissage

This course explores the theoretical and empirical perspectives on individual and industrial demand for energy, energy supply, energy markets, and public policies affecting energy markets. It discusses aspects of the oil, natural gas, electricity, and nuclear power sectors and examines energy tax, price regulation, deregulation and policies for controlling emission.

Bibliographie

Jean-Pierre Hansen, Jacques Percebois, Énergie, Économie et politiques de Boeck.

MIT « The Future of the Electric Grid » An Interdisciplinary MIT

study : <http://mitei.mit.edu/publications/reports->

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
<u>Notion de Physique des Réacteurs</u>	1	Semestre 1	9								

Notion de Physique des Réacteurs

ECTS : 1

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 9

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Mathematics : resolution of first order differential equations

Programme / plan / contenus

The following elements will be seen:

- Brief review of nuclear physics for reactor physics: mass defect, binding energy, fission (spontaneous/induced), neutron/matter interactions, definition of cross-sections, radioactivity (natural/artificial).
- Neutron induced fission and self-sustaining chain reaction: introduction of the concept of criticality, definition of the multiplication factor. Focus on thermal neutron reactors with the four factor formula.
- Neutron energy spectrum in reactors: comparison of fast and thermal neutron reactors.
- Introduction of the different reactor types: different possible combinations of coolant, moderator, fuel and neutron spectra.
- Definition and impacts of the feedback: temperature effects (Doppler and moderator), expansion effects. Explaining their importance for the reactor stability.
- Fuel depletion: fission product poisoning (Xenon and Samarium effects), isotopic depletion, Bateman equations, definition of the burn-up to characterize the fuel depletion.
- Fuel management: brief review of the different strategies (fuel reprocessing vs. storage).

Objectifs d'apprentissage

The objective of the course is to provide a basic overview of reactor physics and the phenomena at work in the core of a reactor.

Organisation générale et modalités pédagogiques

All lectures are given by UE coordinator. Exercises are included in the lectures to help students assimilate the concepts covered in a more direct and concrete way.

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
UE libre catalogue S1 et S2	2.5	Semestre 2									
■											

UE libre catalogue S1 et S2

ECTS : 2.5

Semestre calendaire : Semestre 2

Langue d'enseignement

Français

Enseignement à distance

non

Nature de l'évaluation

Evaluation Terminale

Cours de Spécialité Physique (Bloc 3)

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Notion de Neutronique	1	Semestre 1	12	0							



Notion de Neutronique

ECTS : 1

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 12

Travaux dirigés : 0

Projet tutoré 0

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Mathematics : resolution of first order differential equations

Follow the course "Basic Reactor Operation"

Programme / plan / contenus

The following elements will be seen:

- Notion of neutron density, neutron flux, neutron current. Derivation of the full neutron balance equation (Boltzmann equation).
- Focus on spatial effects: monokinetics diffusion equation, external and internal boundary conditions, effect of a reflector, critical condition (critical size and critical mass).
- Time evolution of the neutron population: point-kinetics approximation, definition and importance of delayed neutrons, inhour equation.
- Understanding of neutron spectrum: neutron slowing down by elastic and isotropic scattering, lethargy variable, slowing down power of moderator materials, slowing down equation, notion of resonant absorption, thermalization.

Objectifs d'apprentissage

The objective is to deepen the knowledge covered in Basic Reactor Operation course. We will seek to gain a more precise understanding of neutronics in nuclear reactor cores. We will focus in particular on the energy, spatial, and temporal behavior of the neutron population.

Organisation générale et modalités pédagogiques

All lectures are given by UE coordinator. Exercises are included in the lectures to help students assimilate the concepts covered in a more direct and concrete way.

Bibliographie

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
<u>Material Science and mechanics</u>	4	Semestre 1	17	16	6						

Material Science and mechanics

ECTS : 4

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 17

Travaux pratiques : 6

Travaux dirigés : 16

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Bases of Solid mechanic

Notions of Chemistry

Programme / plan / contenus

At the end, student must be able to determine the mechanical properties of the materials, to describe and understand the physical phenomena leading to its failure, have a first approach to structural design.

Objectifs d'apprentissage

Materials play a major role in reliability and sustainability of nuclear power plant. The aim of this course is to provide a knowledge base for students to understand how material is generated and what is the impact on its mechanical behavior. Relationships between microstructure, deformation mechanisms or failure and mechanical properties and behavior are highlighted here. The problem of structure dimensioning is also discussed. The aspects studied here are crystallography, phase diagrams, mechanical behavior (tension, creep, relaxation, Low cycle fatigue, High cycle fatigue, fatigue cracks growth rate) the origin of the damage (plasticity, initiation and crack propagation). The various points are processed separately in form of lectures and tutorials classes. The link between the different courses is highlighted at each end of the lesson.

Bibliographie

Ashby and Jones: Engineering Materials

Baralis & Maeder: Precis de métallurgie

Cornet & Hlawka : Propriétés et comportement des matériaux

Dowling: Mechanical Behaviour of Materials.

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Ingénierie Électrique	3	Semestre 1	21	6							



Ingénierie Électrique

ECTS : 3

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 21

Travaux dirigés : 6

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Basics in magnetism and electricity ; principles of automatic control

Programme / plan / contenus

Fundamentals in electrical power systems

Basic element models. Formal calculation for sinusoidal steady state at fixed frequency. Boucherot theorem.

Three phase systems.

Transformers

Principle, magnetic coupling, modelling.

Application to single phase and three phase systems

Principles of AC Machines

Description and utilization of alternating current machines based on rotating magnetic fields.

Induction machines

Constitution, principles. Steady state model. Torque characteristics. Starting issues. Asynchronous machines utilization.

Synchronous machines

Alternator structure. Simplified model. Performances of the coupling to an infinite power transmission network. Reactive power production capacity.

Electrical energy transmission grid

Line characteristics. Modelling. Power flow on the line. Reactive power role. Maximum transmission capacity. Elements about the voltage plan collapse.

Power transmission network

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Notions de Mécanique Quantique	3	Semestre 1	17.5	12.5							

Notions de Mécanique Quantique

ECTS : 3

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 17.5

Travaux dirigés : 12.5

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Good knowledge of:

- Classical mechanics (forces, kinetic and potential energy, classical particle motion, rotations...)
- Oscillation and waves (harmonic oscillator wave propagation, interference, diffraction...)
- Linear algebra and calculus
- Basic knowledge of electromagnetism: electric and magnetic fields

Programme / plan / contenus

Programme détaillé / Course program

1. Classical physics shortcomings and the birth of quantum mechanics
2. Foundation of quantum mechanics
 - a. Linear algebra and operators
 - b. Shrödinger equation
3. One dimensional piece-wise constant potentials
 - a. Square well potential and discrete energy spectrum
 - b. Potential step and potential barrier: the tunnel effect
4. Quantum Harmonic oscillator
5. Spin and the two level systems
6. Special relativity : a brief introduction
7. Quantum entanglement and quantum cryptography , an introduction

Objectifs d'apprentissage

This is a medium level course covering non-relativistic quantum physics. The course starts by a brief review of

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Mécanique des Fluides et Transferts thermiques	4	Semestre 2	24	12							



Mécanique des Fluides et Transferts thermiques

ECTS : 4

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 24

Travaux dirigés : 12

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Math and calculus (derivatives, integrals, solution to equations, some ordinary differential equations)

Mechanics of particles: the original theory of motion (kinematics) and forces (dynamics)

Basic thermodynamics: First and second principles

Programme / plan / contenus

The program combines fluid mechanics and heat transfer, and is sequenced as follows:

2.1 Introduction to fluid mechanics, 5*3h, Nicolas

Mallick, Lecturer, CentraleSupélec (CS)

1. Introduction. Conservation and diffusion of a physical quantity. Continuum hypothesis. Introduction to the study of fluid flow. Material derivative. Example of particles (Fick's law) and moderation of nuclear reactions.

2. Navier-Stokes equation. Stress and strain tensors in Newtonian fluids. Establishment of Navier-Stokes and Euler equations. Simple examples (Couette and Poiseuille flows).

3. Bernoulli's equation and applications. General mechanical energy balance. Efficiency.

4. Macroscopic balance equations. Application to the determination of hydrodynamic forces and moments. Propulsion applications.

5. Physics of boundary layers. Various types of shear flows. Approximations and boundary layers modelisation.

2.2 Conduction and radiation, 4*3h, Mike Kirkpatrick, Assistant professor (CS)

6. Intro to heat transfer : 3 modes: conduction, convection (to be treated in more detail by Salvatore), and radiation. Fourier's Law in 1D - example of temperature profile in a finite rod between two plates. Thermal resistance and analogy to Ohm's Law.

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Détection appliquée à la physique	2	Semestre 2	2		16						

Détection appliquée à la physique

ECTS : 2

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 2

Travaux pratiques : 16

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Basic Nuclear Physics knowledge (provided in the first semester)

Interaction of particle in matter (provided in the first semester)

Statistical analysis (provided in the first semester)

Programme / plan / contenus

1. Introduction à la radioactivité

- Définitions et rappel des grandeurs nucléaires (A , Z , J , π).
- Les processus α , $\beta^\pm$, capture électronique, désexcitation γ , conversion interne.

2. Notions de détection

- Détection γ : principe de la scintillation, structure du spectre, efficacité.
- Détection de particules chargées : principe de la jonction P-N, précautions d'utilisation.

3. Modules électroniques

- Preamplificateur, amplificateur, discriminateurs, unité de coïncidences, convertisseurs analogique-numérique.
- Chaîne électronique complète pour mesures nucléaires.

4. Travaux pratiques

- **Expérience 1 : Spectrométrie γ**
 - Étude de spectres γ avec détecteurs NaI.
 - Calibration en énergie, résolution, efficacité, étude de schémas de désintégration.
- **Expérience 2 : Conversion interne**
 - Étude des électrons de conversion interne avec un détecteur silicium.
 - Détermination des coefficients de conversion partiels, multipolarité et parité des niveaux excités.

5. Annexe : Traitement des incertitudes

- Erreurs statistiques et systématiques,

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Contrôle des systèmes dynamiques	3	Semestre 2	21	6	3						



Contrôle des systèmes dynamiques

ECTS : 3

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 21

Travaux pratiques : 3

Travaux dirigés : 6

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Background in mathematics (real analysis, algebra, Laplace transform).

Programme / plan / contenus

Introduction – Generalities and basic concepts

Definitions – Fields of application – Historical data -

Motivations - Classification: regulation and tracking -

Structure of continuous and discrete time controlled systems – rejection and tracking dynamics – Block diagram of a feedback system.

Closed loop analysis

Notion and interest of feedback – Relations between open and closed loop – Closed loop stability: Nyquist criterion

– Stability margins – Robustness and sensitivity functions

– Relation between open loop frequency behavior and closed loop time domain behavior – Steady state error.

Regulation and P.I.D. controllers

Time domain features – Frequency domain features –

Continuous time domain implementation: derivative action, anti wind-up mechanism...

Industrial regulation strategies

Cascaded control – Feed-forward actions – Control of delayed systems: Smith predictor – Conditioning of controllers

Numerical control

Sampler and zero-order hold devices – Continuous to discrete time transformations – Resulting algorithms and calculation time.

Objectifs d'apprentissage

Most physical systems involve the fundamental concept of a feedback loop, which allows them to be controlled and to exhibit behavior that is as insensitive as possible to environmental disturbances. The overall objective of this course is to provide students with the concepts and skills needed to understand the structure and interactions within existing or newly designed dynamic systems, to process

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Mécanique des milieux continus	1	Semestre 1	11	4							



Mécanique des milieux continus

ECTS : 1

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 11

Travaux dirigés : 4

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Mathematics (vector and tensor calculus, , differential equations integral theorem, linear algebra..)

Classical mechanics (newton's law motion, static equilibrium, concepts of energy , work and Power..)

Physics (density, velocity field)

Elementary Thermodynamics

Programme / plan / contenus

At the end of this module, students will be able to understand and formulate the continuum hypothesis and its limits, model the mechanical behaviour of solid and fluid media, describe the fundamental quantities (stress, strain, deformation, velocity, energy, understand the notion of tensors (stress, strain, rotations, etc.), using conservation principles (mass, momentum, energy) and use the fundamental equations of motion of continuous media.

Objectifs d'apprentissage

The course of Continuous Media Mechanics aims to provide students with the theoretical and methodological basis necessary to model, analyse and understand the mechanical behaviour of materials considered as continuous media.

Organisation générale et modalités pédagogiques

From September to January at INSTN

Course assessment will be made based on a final exam

Bibliographie

Jean SALENCON, Mécanique des Milieux Continus, Edition de l'école Polytechnique

Philippe Germain, Jean-Louis Lemaître, Mécanique des milieux continus, Dunod

Jean Coirier et Carole Nadot-Martin, Mécanique des

Cours de Spécialité Chimie (Bloc 3)

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Solution Chemistry 1: Speciation and process	3	Semestre 1	20	10							

Solution Chemistry 1: Speciation and process

ECTS : 3

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 20

Travaux dirigés : 10

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Properties of chemicals: Elements, Oxidation state,

Complexation of cations and ligands,

Chemical reaction: stoichiometry, ICE chart

Mass Action Law, Gibbs free Energy, Chemical activity,

Acido-basic reaction,

Dissolution-precipitation reaction, solubility,

Redox reaction, Nernst Law

Programme / plan / contenus

The following sessions cover a wide range of the fuel cycle, including mining industry, cooling circuit of PWR, waste management, environmental speciation, f-elements.

Session n°1: Chemical equilibria, Acid/base,

n°2: Multiphasic Equilibria, High T/P,

n°3: Equilibrium shifts and complexation,

n°4: Activity coefficients, High salinities,

n°5: Oxydoreduction & corrosion,

n°6: Applications & scientific articles,

n°7&8: Uranium chemistry,

n°9&10: Chemistry of Actinides.

Objectifs d'apprentissage

The objective is to describe the mechanisms driving speciation in solution chemistry and introduce to a numerical tool simulating chemical systems. Classical physico-chemical concepts are reviewed: thermodynamic equilibrium, reactivity, multi-phasic systems. Lectures go into more detail on these concepts and the underlying models & equations. Analytical reasoning allowing to put in an equation practical macroscopic variables which characterize an aqueous equilibrium are given. Training to new concepts & tools is based on exercises. The use of the scientific software PhreeqC, to calculate speciation, is also taught through tutorials. They illustrate the necessity of numerical tools to describe real systems, importance of thermodynamic databases, and limitations of calculations.

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
<u>Radiolysis</u>	2	Semestre 1	13	4	4						

Radiolysis

ECTS : 2

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 13

Travaux pratiques : 4

Travaux dirigés : 4

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Bachelor level in Chemistry or Chemical Physics

Programme / plan / contenus

The program allows students to understand how water is broken down under ionizing radiation such as energetic photons and accelerated particles and which radicals are formed. The radiolytic yield of radicals as a function of time after energy deposition and as a function of the type of ionizing radiation are explained. In addition, the reactivity of some of these radicals as electron donors and acceptors is described. In practical work, the principles of chemical dosimetry are used to determine the dose in a ^{60}Co source.

- Ionizing radiation matter interaction: photon and neutral and charged particles. Energy deposition, clusters, traces, TEL (5h)
- Radiolysis of water, radical and molecular yields TEL effect (5h)
- Radiolysis of aqueous solutions, influence of concentration, temperature, pressure, pH, chemical dosimetry TEL. In particular Fricke dosimeter and super-Fricke dosimeter and the Cerium (2h)
- Practical course: dosimetry of gamma source (Fricke dosimeter) (5h)
- Radiolysis other solvents (polar and nonpolar, ionic liquid, ...) (2h)
- Radiolysis and processes of the nuclear industry: Purex process, radiolysis under the conditions of the reactors (2h)
- Gas Radiolysis (1h)
- solid Radiolysis : induced disorder, curing, concrete

Organisation générale et modalités pédagogiques

Lecture, practical work and tutorial will take place at INSTN.

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
<u>Chemistry of Nuclear Materials</u>	4	Semestre 1	15	9	12						

Chemistry of Nuclear Materials

ECTS : 4

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 15

Travaux pratiques : 12

Travaux dirigés : 9

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Bachelor level in solid state chemistry, fundamentals in physics: classical mechanics, electromagnetism.

Programme / plan / contenus

The course of Chemistry of Materials addresses inorganic materials from a structure versus property treatment, with a peculiar emphasis put on relevant materials for nuclear applications both during and after in-reactor operations. Nuclear materials encompass virtually all classes of materials – metals, ceramics, glasses – that are used as structural materials, fuels, transmutation matrices, as well as immobilization matrices. Nuclear materials exhibit the fascinating feature of their radiation tolerance far from any thermodynamically stable condition. The topic is tackled from the Chemist's viewpoint. Lectures are organised in four main chapters, which concentrate in structures and bonding in solids, on the interplay between crystal and electronic structure in determining their properties. Imperfection in solids plays a considerable role in nuclear materials. Finally, the exciting field of radiation-induced defects and processes by which solids tolerate a large amount of structural disorder whilst preserving their crystalline structure is discussed. This course also includes labworks at the MOSAIC accelerator facility at IJCLab, Orsay campus.

Content

1 – Solid state chemistry

Atomic bonding in solids: bands formed from overlapping of atomic orbitals; primary interatomic bonding; secondary atomic bonding; classification of solids (ionic, covalent, metallic, molecular): Arkel-Ketelaar triangle. Structure of crystalline solids: fundamentals (crystalline and amorphous states); lattice, unit cell, basis, type of lattice, crystal systems, Bravais lattice, planes and directions; description of crystal structures (ccp, hcp, bcc): close packing of spheres, interstices in closed-packed and

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Solution Chemistry 2: Separation Chemistry	3	Semestre 2	12	12							

Solution Chemistry 2: Separation Chemistry

ECTS : 3

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 12

Travaux dirigés : 12

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

Aqueous solution chemistry reviewed in 1st semester:
Thermodynamic equilibria: Gibbs, energy, chemical reactions, equilibrium constant, ICE charts,
Reactivity: Acid/base, redox, dissolution/precipitation (solubility), complexation,
Quantification of the effects of secondary reactions on the primary reaction,
Speciation of ions, including actinides and f-elements.

Programme / plan / contenus

Sessions n°1-4 : Solvent Extraction (SE):

To remind the operational variables used to optimize the extraction system,
To underline the drawbacks of single-stage operation & detail counter-current cascade,
To introduce the chemical phenomenon influencing extraction system,
To justify the usual classification of the extraction systems & write a global reaction for each,
To quantify the distribution ratio for each class, highlighting the factors effects & optimization

Sessions n° 5-8: Ion Exchange (IE):

To extend Gibbs thermodynamic to surface-solution systems & describe equilibria
To introduce the theoretical background & characteristics of ion exchange resins (IER)
To introduce IER implementation, from laboratory to industrial scale
To illustrate IER application in various fields (analysis, purification, synthesis, waste management, etc.) with a focus on fuel cycle and on nuclear radiochemistry.

Objectifs d'apprentissage

The 2nd semester module S2_X_SQL follows the 1st

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Chimie Analytique des Éléments Radioactifs	4	Semestre 2	6	3	30						

Chimie Analytique des Éléments Radioactifs

ECTS : 4

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 6

Travaux pratiques : 30

Travaux dirigés : 3

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

This course unit consists of 9 hours of lectures and 30 hours of practical work. It is therefore a very experimental course. To take this course unit, it is preferable that students have previously had practical training (preparation of samples at given concentrations, use of laboratory equipment, precision balances, micropipettes, etc.). They must have a basic understanding of solution chemistry and know how to calculate pH values, concentrations, dilution factors, etc.

Programme / plan / contenus

Cet UE comprend 3 cours de 3h et 5 séances de TP de 6h. Les cours sont les suivants : Radiation safety (C1), The analytical chemistry: application to the radioelements (C2) et Nuclear Energy: The nuclear fuel cycle from the chemical point of view (C3). Les TPs sont les suivants : Introduction to radioactivity and radiation protection (TP1), PERALS spectrometry for U and Th analysis (TP2), Uranium target preparation (TP3), UV-visible spectroscopy for U and Th analysis (TP4), Thorium fluoride synthesis (TP5).

Objectifs d'apprentissage

To introduce the different analytical methods which take place in the nuclear industry and research
To classify these methods considering their applications, detection limit, accuracy, repeatability
For each method : to describe the physic and chemistry involved in the measurements
To introduce the industrial processes and environmental applications of these methods.

Organisation générale et modalités pédagogiques

Practical sessions take place in the IJCLab research laboratories in a supervised area. Practical sessions are

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
Spectroscopie Atomique et Moléculaire	3	Semestre 2	15	15							

Spectroscopie Atomique et Moléculaire

ECTS : 3

Semestre calendaire : Semestre 2

Détail du volume horaire

Cours magistraux : 15

Travaux dirigés : 15

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

The prerequisites for this course are Atomistics (electronic configuration, orbital representation); Valence Electron Pair Reputation (VSEPR) theory; Group theory; Quantum mechanics (Molecular orbital model).

Programme / plan / contenus

Group theory contribution to crystal field/ligand field model (spectroscopic terms/states, crystal field levels). Perturbation methodology. Electronic transitions/selection rules. Spectroscopy of d and f elements. Orgel and Tanabe/Sugano diagrams. Nephelauxetic and Jahn Teller effects. Single configuration-coordinate diagram. Electron/vibration coupling. Spectroscopy and speciation of 5f elements (introduction).

Objectifs d'apprentissage

This course aims to provide the various tools needed to describe transition metal complexes. These transition metal complexes will be described from the perspective of their electronic structure. Particular emphasis will be placed on the effects of ligands and the orbital chemistry of transition metal complexes. The goal will be to understand the spectra of these complexes and to assign the observed electronic transitions.

Organisation générale et modalités pédagogiques

The EU is divided into lectures and tutorials. Written exam (70%) + consideration of participation in tutorials (30%)

Bibliographie

Sutton, D. (1969). Electronic Spectra of Transition Metal Complexes. Journal of The Electrochemical Society, 116(8), 310C. <https://doi.org/10.1149/1.2412267>;

Orgel, Leslie E. An Introduction to Transition-Metal

Matières	ECTS	Semestre	Cours	TD	TP	Cours- TD	Cours- TP	TD- TP	A distance	Projet	Tutorat
<u>Chimie dans le cycle électro-nucléaire</u>	2	Semestre 1	24								

Chimie dans le cycle électro-nucléaire

ECTS : 2

Semestre calendaire : Semestre 1

Détail du volume horaire

Cours magistraux : 24

Langue d'enseignement

Anglais

Enseignement à distance

non

Programme / plan / contenus

Modul content :

1) Lectures :

\- Intro Nuclear Fuel cycle (The essential role of chemistry in controlling waste),

\- Nuclear Fuel reprocessing

\- non conventional solvents + intro molt salts for nuclear fuel reprocessing (Chemistry, for fourth-generation reactors)

\- The chemistry of water in its various stages of use

\- Basics Corrosion

\- Radionuclides in Environment (intro Nuclear toxicology) (Lecture)

\- Numerical Simulation Radiolysis (Lecture)

\- Numerical Simulation DFT (structure of actinide complex), Numerical simulation in Nuclear Chemistry

2. Group work on one of the topics

Objectifs d'apprentissage

This module aims to introduce the chemical engineering aspects related to the Nuclear industry. Through reading, lectures, problem solving and class debates.

Organisation générale et modalités pédagogiques

Lectures and project

Nature de l'évaluation

Evaluation Continue non Intégrale

Stage (Bloc 4)



Stage

ECTS : 10

Semestre calendaire : Semestre 2

Détail du volume horaire

Projet tutoré 300

Langue d'enseignement

Anglais

Enseignement à distance

non

Prérequis

none

Nature de l'évaluation

Evaluation Continue non Intégrale

Lieu(x) d'enseignement

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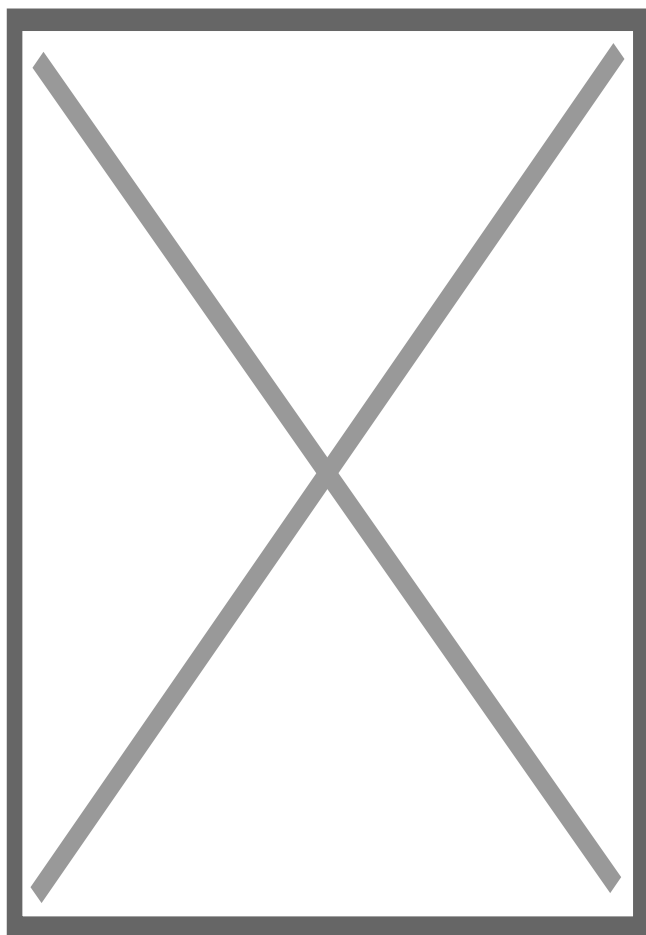
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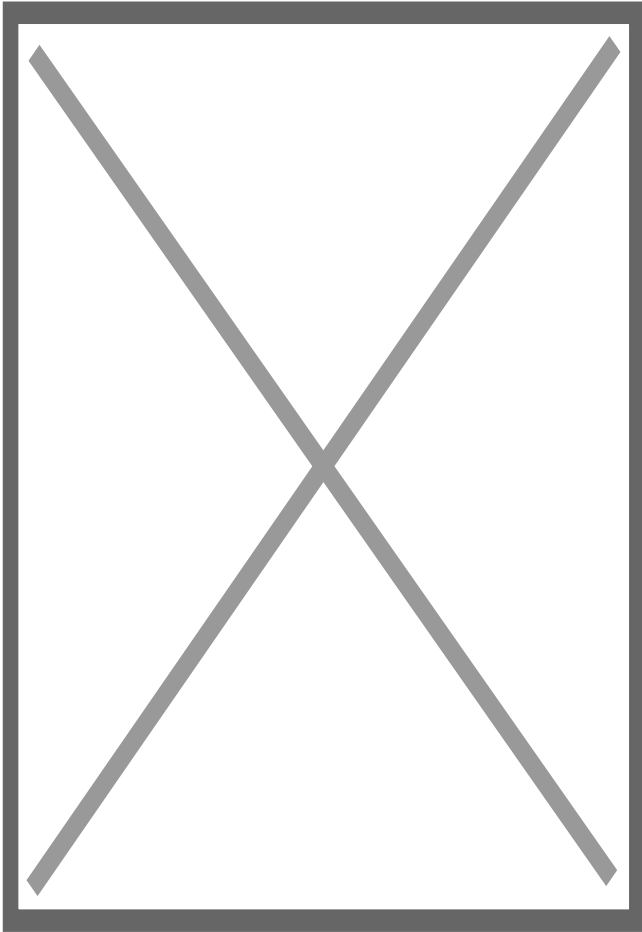
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Equipements sportifs

Résidence étudiante

Contact(s)

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MCF

<http://www.universite-paris-saclay.fr/formation/master/ingenierie-nucleaire/m1-nuclear-engineering>