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1EL1010 – Radiation and propagation

Instructors: Dominique Lecointe
Department: DÉPARTEMENT ÉLECTRONIQUE ET ÉLECTROMAGNÉTISME
Language of instruction: French
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

Maxwell's theory has been a source of innovation and technological progress for more than a century and it is remarkable to note the extent of the industrial sectors impacted by the applications of this theory :
- the telecommunications sector at the heart of the information society,
- the aeronautics, automobile and transport sector,
- the electrical energy sector,
- the defense and security sector,
- the health and environment sector,
- the building and public works sector,
- the internet and connected objects sector.

For the 21st century engineer, the mastery of electromagnetic theory can not be ignored. But in an environment where the technological challenges are more and more complex, how does the engineer deal with the problems, what are the means at his disposal to solve them? This approach will be the thread of this course of electromagnetism. Starting from varied and concrete applications, this course presents the approach of an engineer to move from a real scene to the equation setting in the form of an electromagnetic problem, then the transition to resolution by use most often of specialized digital tools. The presented problems and their theoretical formulations will cover a broad spectrum of frequencies: from the continuous, via radio frequencies and microwaves to optics. The focus will be on the different types of problems, in particular, free and guided propagation and radiation. The small classes will allow a practical application on a wide variety of problems: free propagation and interference, guided propagation and optical fiber, radiation and antennas ... The rise of digital tools has radically transformed the methodology for solving electromagnetic problems. Several small classes will use industrial electromagnetic software to illustrate the current approach of an engineer for solving electromagnetic problems.

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)
None

Syllabus
1. Introduction
presence of electromagnetism in many industrial sectors
diversity of applications of electromagnetism
importance of digital simulation - state of the art for digital tools
course content and links between parties - course situation throughout the course

2. Equations of an electromagnetic problem: the 3 pillars
from the real scene to the setting in equation: phase of modeling study in temporal or in harmonic regime
first pillar: Maxwell's equations general case
second pillar: constitutive equations of media - most classical models - linearity, homogeneity, isotropy, dispersion
third pillar: equations of passage from one medium to another - writing according to the choice of medium models
link with digital tools (CST example)
Application: Digital TD: CST Presentation and Getting Started

3. Synthesis: the different types of problems: objective, associated hypotheses and simplification, iconic applications
quasi-stationary states
spread
influence
diffraction

4. Free propagation
plane wave
polarization of a plane wave
example of another solution - Gaussian bundles
propagation in a conductive medium - skin thickness
transmission of a wave from one medium to another
application: TD: duplexer
application: TD: polarimetry

5. Guided Propagation: Theory of Guides
physical approach of the modes through the parallel blade guide
theoretical development - TE, TM, TEM mode
example of the rectangular guide
example of the coaxial guide
application: TD: optical fiber
Application: Digital TD: Coaxial Line Transition - Rectangular Guide

6. Guided Propagation: Line Theory

from the TEM mode to the line theory
line theory
adaptation
application: TD: realization of an adaptation circuit for micro-ribbon line

7. Radiation and antennas
radiated field - far field
antenna technology
antenna characteristics (experimental approach) - gain and directivity
radiation pattern - input impedance
link budget
application: TD: antenna
application: TD digital: realization of a Yagi antenna

Class components (lecture, labs, etc.)

11 lessons of 1h30, 5 TD of 1h30, 3 Digital TD of 1h30, and 1 final exam written of 2h00.
All occurrences are presented in French.

Grading

1 final exam written without documents of 2h00.
The skills acquired will be validated during the final check. Identified questions will validate milestones 1 of competences C1 and C2. At least two questions per skill. The student who obtained the average on the questions associated with the competency assessed will validate milestone 1.

Course support, bibliography

Course and Exercises books.
Slides projected during the course (EDUNAO)
Techniques micro-ondes de Marc Hélier, édition Ellipses

Resources

Teaching staff (instructor(s) names): Dominique Lecointe, Dominique Picard
Maximum enrollment (default 25 students): In general, 2 groups in digital TD will alternate with 2 groups in traditional TD.
Software, number of licenses required: MWS software.
Workroom (department and capacity): Computer rooms (2 computer rooms with 25 workstations) for digital TD

Learning outcomes covered on the course

At the end of this lesson, the student will be able to:
- put in equations a realistic problem by the choice of more or less complex models.

- to judge the relevance of the models and their limitations.
- choose a resolution methodology that includes modern simulation tools.
- to master, from theory to practice, the structures of electromagnetic waves propagating in a given medium.
- to master, from theory to practice, the systems allowing the propagation of an electromagnetic signal.
- to master, from theory to practice, systems radiating an electromagnetic signal.

These different learning outcomes validate milestone 1 of competency C1.2 (Knowing how to use a model presented in class in a relevant way (model describing a phenomenon, without couplings) Choosing simplifying hypotheses adapted to the studied problem .).

Description of the skills acquired at the end of the course

The different learning outcomes validate milestone 1 of skill C1.2 (Knowing how to use a model presented in class in a relevant way (model describing a phenomenon, without any coupling) Choosing simplifying hypotheses adapted to the studied problem .).
Also, the different learning outcomes make it possible to validate milestone 1 of competency C2.1 (knowing how to define the notion of a scientific field)

1EL1500 – Physics of Waves

Instructors: Mohammed Serhir
Department: DÉPARTEMENT PHYSIQUE
Language of instruction: French, English
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

This course provides students with basic elements necessary to understand the physics of waves through the examples of ectromagnetism and acoustics. Many disciplines rely on those concepts: seismology, telecommunications, guided waves, imaging techniques, photonics, etc. The notions introduced in this course are basic concepts usefull to several “dominantes”.
Master Fourier analysis, understand concepts of waves and their applications in different domains :
1) spatial filtering methods, such as 4f Fourier optical assembly, for image processing
2) approximations according to the wavelength, the size of the system and the distance at which the phenomenon is observed: diffraction and radiation
3) directivity of an antenna.
4) relatioship between dielectric or optical properties and behaviour of a medium (transparent, absorbent or opaque)
5) Calculation of the reflection and transmission coefficients of a wave through an interface.

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

- Geometric optics (converging lens)
- Electrostatics, Magnetostatics
- Maxwell's equations in vacuum
- Electromagnetic plane wave.
- Decomposition of a periodic function in Fourier series
- Partial differential equations (Poisson's equation, d'Alembert's equation)

Syllabus

1-Introduction

We present concepts and applications that students will see in the lectures through selected examples (propagation, guidance, emission, different scales ...). The place of the course shall be exposed within the curriculum (present the courses where this course will be useful). Mathematical preliminaries: Fourier transform, Dirac distribution

2-Basic principles of imaging, Plane wave expansion
Propagation: near field, far field, evanescent waves, wave diffraction / self-diffraction, resolution limit
TD1: Propagation, diffraction, Earth-Moon distance measurement, antenna for a geostationary satellite
TD2: Optical image processing

3-Wave sources
Electromagnetic wave sources: retarded potentials, far-field approximation, dipole approximation
TD3: Radiation of a wire antenna / antenna array

4-Radiation
Radiated field: local plane wave structure. Radiated power
TD4: Radiation of a mobile-phone antenna (magnetic dipolar antenna)

5-Diffusion, diffraction by a periodic array
Introduction to diffusion by one or more ordered or disordered diffusers, Bragg diffraction
TD5: Diffusion and diffraction by a 2D photonic crystal

6-Maxwell equations in matter, from microscopic to a macroscopic scale
General Maxwell equations for any medium: transition to spatial averaging for the derivation of macroscopic Maxwell equations
TD6: Dielectric constant, attenuation and energy balance of a wave in an absorbent medium

7-Constitutive equations of matter, generalized Maxwell's equations, free propagation in matter
Effective (generalized) dielectric constant. Notions of homogeneity, linearity, isotropy, dispersion. Links between dispersion and inertia, between phase shift and dissipation. Definition of the optical index. Meaning of the real and imaginary parts of the index and dielectric constant. Energy balance. Definition of transparent, opaque and absorbent media
TD7: Anti-reflective coating, evanescent wave microscope

8-Field continuity relationships, reflection and refraction
Snell Descartes laws. Refraction and reflection phenomena at an interface, total reflection, evanescent wave, Brewster angle
TD8: Dielectric waveguide: application to optical fiber
TD9: Non-linear medium: second harmonic generation
TD10: Brillouin diffusion: coupling between acoustic and electromagnetic

waves

9-Negative refractive refraction engineering – Metamaterials:
Propagation in a double negative media. Perfect lens, invisibility

Class components (lecture, labs, etc.)
9 lecture sessions in the Amphitheatre
10 tutorial sessions in groups of 33 students

In the case of the **English version, the lecture is taught in English**, but only **one tutorial class is taught in English** (in the other two tutorial classes, the teaching is in French)
Occurrence 1.2 will be taught in English and occurrence 1.4 will be taught in French

Class components:
1 Lecture 1
2 Lecture 2
3 Tutorial 1
4 Lecture 3
5 Tutorial 2
6 Lecture 4 (Quizz 1)
7 Tutorial 3
8 Lecture 5
9 Tutorial 4
10 Lecture 6
11 Tutorial 5
12 Lecture 7 (Quizz 2)
13 Tutorial 6
14 Lecture 8
15 Tutorial 7
16 Tutorial 8
17 Tutorial 9
18 Lecture 9 (Quizz 3)
19 Tutorial 10
20 Final Exam

Grading
Continuous assessment (MCQ) with no documents : Test 1 of 15 min in session 6 during Lecture 4. Test 2 of 15 min at session 12 during Lecture 7. Test 3 of 15 min at session 18 during Lecture 9. Final exam (written exam) of 2 hours with documents (65%).
Each continuous assessment (MCQ) counts with a weighting of 0.35/3 of the mark, with the final assessment counting with a weighting of 0.65.
Skill C.1 is evaluated through one of the exercises of the final written exam. If the grade for this exercise is higher than 50%, the student will have

validated the C.1 skill in this course.
Skill C.2 is validated if the final average mark is higher than 10/20.

Course support, bibliography

Course and Exercises books. Corrections of exercises.

Resources

Teaching staff (instructor(s) names): Hichem Dammak, Pierre-Eymeric Janolin, Bruno Palpant, Thomas Antoni, Charles Paillard, Nicolas Mallick, Mohammed Serhir, Gaëlle Vitali-Derrien, Romain Pierrat (vacataire), Aurélie Bonnefois (vacataire)
Maximum enrollment (default 35 students): 4 TD rooms of 30 for TDs.
Software, number of licenses required: Python already installed on students' laptops
Equipment-specific classrooms (specify the department and room capacity): No

Learning outcomes covered on the course

1) **Apply** spatial filtering methods, such as 4f Fourier optical assembly, for image processing
2) **Apply** the required approximations according to the wavelength, the size of the system and the distance at which the phenomenon is observed: diffraction of a wave or radiation of an antenna
3) **Determine** the radiation area and directivity of an antenna.
4) **Describe** whether a medium is transparent, absorbent or opaque from its dielectric or optical properties.
5) **Apply** the boundary conditions for a system with one or more interfaces.
6) **Calculate** the reflection and transmission coefficients of a wave through an interface.

Description of the skills acquired at the end of the course

C1.1: Analyze the scientific aspects of the overall behavior of a small-scale system (e.g. isolated part of a complex system), including the identification of factors that influence its behavior (**diffraction, diffusion, reflection, transmission, absorption, interference**)
C1.2: Correctly use a model presented in class in its conditions of validity (model describing a phenomenon, without couplings) (**far field approximation, dipolar approximation, planar wave approximation, Fourier optics/image processing, antenna array, scattering by a periodic array, anti-reflection layer, Brillouin scattering**)
C1.3: Compare the results of a simulation with experimental measurements or approximate calculation results, taking into account measurement errors and uncertainties, or model approximations, based on the knowledge of orders of magnitude
C2.1: Deepen your knowledge of an engineering field or scientific discipline

1EL2000 – Electrical Energy

Instructors: Martin Hennebel
Department: DÉPARTEMENT SYSTÈMES D'ÉNERGIE ÉLECTRIQUE
Language of instruction: English, French
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

Electrical energy is indispensable to the functioning and development of society all across the globe. Over 100 years of continuous progress has allowed its integration into new sectors (ground, maritime, and aerial transport, onboard systems, renewable energy, spatial). Presently, environmental and sustainable development objectives have motivated further progress in the technology at different power levels. This course on electrical energy aims to provide students with the fundamentals and methods used for the analysis of systems using electricity as an energy vector. The course associates knowledge of physics and magnetic materials for the characterization of the elements which constitute electrical energy systems. To start with, the course touches on major actors and global issues associated with the use of electrical energy for the functioning of society, with an emphasis on the pertinence of different scientific disciplines. Next, the course presents the principal concepts and tools needed for the analysis of electrical systems along with examples for their application. The course focuses on the importance of understanding magnetic coupling in electrical systems using the laws of electromagnetism. The behavior of the associated magnetic materials and their analysis is then applied to establish models for the systems in order to better understand their performance at different levels of excitation or frequency. The representation of typical magnetic circuits is then used to give students better understanding of how the physics associated with elements of the systems may be used to develop a system model. The natural application of the principals learned by students in the first parts of the course is the study of transformers and inductively coupled systems. Afterward, the conversion of electrical into mechanical energy will be formalized using the principal of virtual work based on magnetic energy associated to magnetic coenergy for the formulation of forces and torques produced by motors and generators. An application of electrical to mechanical energy conversion, the direct current machine, will then be presented in order to provide students with the basis for understanding the principals of motorization or electrical generation at variable speed.

Quarter number
SG1 and SG3

Prerequisites (in terms of CS courses)
None

Syllabus
Introduction to electrical power engineering Omnipresence of electrical engineering: production, transport, conversion, utilization and control of electrical energy. Multi-physical and economic aspects.

Transport and consumption of electrical energy
Single phase and three phase systems, definition and calculation of electrical power. Equipment sizing and power factor.

Physics associated with electrical power engineering
Electromagnetism applied to electrical power engineering. Magnetic materials, creation and channeling of magnetic fields, permanent magnets. Modeling methods, magnetic circuits, reluctance and electromotive force. Taking into account power losses associated with magnetic circuits.

Principals of magnetic coupling
Notions of magnetic flux and leakage flux. Partial and total leakage inductance. Modeling of magnetic coupling.

Single and three phase transformers
Function and structure; ideal transformer; modelling of a real transformer, transformer operation at 50 Hz and influence of variable frequency; construction of magnetic circuit, insulation and conductors.

Electro-mechanical conversion
Link between electrical, magnetic, and mechanical energy. Systems with moving parts; calculation of forces and torques; resistive torque.

Direct Current machine
Principal and structure/construction. Fundamental equations. Excitation modes. Problems associated with operation. Principles of control with variable speed. DC brushless motor.

Class components (lecture, labs, etc.)
Lectures (CM), tutorials (TD). Pratical works (TP) would be organized depending on the avilability of the laboratory during the works in Building Bréguet.
The objective repartition is :
CM (13h30)

TD (9h)
TP (6h)

Grading

The evaluation will be done by a written examination of 2h. The pratical works will be taken into account in the final grade of the module for 20%. Absence at a pratical work session will give the mark 0/20 to the TP. Practical work is compulsory assessment (EO)

Course support, bibliography

Text provided by the teaching group.
Electrical Machines, Drives and Power Systems (Theodore Wildi, Prentice-Hall Intl)

Resources

Teaching staff : Martin Hennebel - Michael Kirkpatrick - Romaric Landfried – Mohamed Bensetti
• Maximum enrollment : 25
• Software, number of licenses required:
• Equipment-specific classrooms (specify the department and room capacity): Electrical Energy System departmentq teaching laboratory for practical work.
Occurrence 1.1 is taught in English, occurrences 1.2, 1.3 and 1.4 are taught in French.

Learning outcomes covered on the course

At the end of this course, the student will be able to:
- Modelling electrical devices and equipment based on magnetic coupling

- Make the choice of an adapted model of behaviour (integral form of Maxwell's equations, equivalent diagram of type circuit ...)
- Identify the parameters of this model using experimental data and / or geometric and physical properties
- Validate the quality of the model

- Predefining an AC power transmission system (three-phase) with its main elements

- Analyse and evaluate a motorisation based on AC or DC actuators

- Analyse the electrical, magnetic and mechanical behaviour of the actuator
- Compare to nominal behaviour
- Evaluate the performances and criticise the results obtained

Description of the skills acquired at the end of the course

- This course validates milestone 1 of skills C1 and C2:

The course, and in particular the practical work sessions allow to develop the C1 competence, i.e. the analysis, the modeling and resolution, as well as the design of complex systems. These skills apply to the three-phase power systems, magnetic systems (transformers, magnets) and electromechanical actuation systems (actuators, motors).
This course develops an in-depth competence in the field of electrical power systems engineering, which corresponds to milestone 1 of competence C2.

1EL3000 – Industrial Engineering

Instructors: Ludovic-Alexandre VIDAL
Department: DÉPARTEMENT GÉNIE INDUSTRIEL ET OPÉRATIONS
Language of instruction: French English
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

• Know the issues and stakes of firms and organisations, their products and services, and their relationships with innovation, economy and human societies.
• Understand the multidisciplinary and complex character of firm-oriented systems along the lifecycle of an organization (design, industrialisation, production, distribution, reliability and return on experience,…).
• Understand how the choices made to determine the strategy for products/services development is a compromise between many constraints : availability of resources and skills, competition, environmental impact, organizational culture and strategy,…
• Understand and use the fondamental concepts, models and tools (and their application through several examples) which are used internationally in the field of industrial enginnering (academic world and industrial practitioners).

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

None

Syllabus

This course presents to the students the essential concepts and tools of industrial engineering, helping them to understand the stakes of product and organisation lifecycles. Thanks to the tutorials (with a ratio of about 1h theory for 2h tutorial), this course will offer the students a very exhaustive introduction to industrial and organisational systems, as well as their interdependences.

Sessions :
Session 1 (Introduction 1h30) : Life Cycle of an Organization / a Product / a Service Life Cycle Concept, Stakeholders and Values, Systems Thinking, Main Phases and Processes.
Sessions 2&3 : Design Processes - Design Processes and Activities,

Functional Analysis, Specifications, Life Cycle Analysis, V-Cycle, Design Flexibility, Product-based FMECA.
Session 4&5 : Production Processes - Make-to-Order Approaches, MRP and Associated Mathematical Models, Make-to-Stock Approaches, Kanban, Associated Mathematical Models.
Session 6&7: Distribution Processes - Stakes of Distribution Activities, Distribution Monitoring and Control, Distribution Performance, Stock, DRP, Warehouses and Cross-Docking Models, Flows & Vehicle Route Optimisation, Supply Chain Sustainability and Performance, Tracking.
Session 8&9 : Quality Processes Product Reliability, Reliability Funcitons, Reliability and Safety Analysis Parameters, Bathtub Curve, Reliability of Parallel or Series Components. Maintenance Processes, Introduction to Statistical Process Control. Introduction to 6 Sigma. Control Charting. Capability Measures.
Session 10 : Industrial Conference (3h) Synthesis of all sessions with an industrial conference.
Session 11 : Final Test (2h) Final Test.

Class components (lecture, labs, etc.)

Some of the sessions will be carried out in reverse pedagogy mode in distance mode for the lectures (to promote proactive and flexible learning of the concepts), followed by on-site tutorials to answer all questions before adressing the exercises of the tutorials.

Occurrences of this course will be taught in the following languages :
Occurrence 1.1. English
Occurrence 1.2. French
Occurrence 1.4. French

Grading

2 continuous controls will take place during the course.
Final exam duration : 2h.
Documents authorized, calculator authorized. No Internet access or computer.
The score of continuous (intermediate) controls will be worth 40% (20% each continuous control) and that of the final exam 60%.

Course support, bibliography

Given Lesson after Lesson (specific references).

Resources

Teaching staff : Ludovic-Alexandre Vidal and Julie Le Cardinal for courses. Loïc Pineau, Ludovic-Alexandre Vidal & Julie Le Cardinal for exercises and case studies. Some industrial conferences.

Learning outcomes covered on the course

At the end of this course, the student will be able to: (Skills)

C1.1 Analyze: Study a system as a whole, the situation as a whole. Identify, formulate and analyze a system within the framework of a transdisciplinary approach with its scientific, economic, human dimensions, etc.

C1.2 Model: use and develop suitable models, choose the right modeling scale and the relevant simplifying assumptions

C1.4 Design: Specify, build and validate all or part of a complex system

C2.1 Deepen a field of engineering sciences or a scientific discipline (adapted to industrial engineering)

Description of the skills acquired at the end of the course

At the end of this course, the student will be able to: (Skills)

C1.1 Analyze: Study a system as a whole, the situation as a whole. Identify, formulate and analyze a system within the framework of a transdisciplinary approach with its scientific, economic, human dimensions, etc.

C1.2 Model: use and develop suitable models, choose the right modeling scale and the relevant simplifying assumptions

C1.4 Design: Specify, build and validate all or part of a complex system

C2.1 Deepen a field of engineering sciences or a scientific discipline (adapted to industrial engineering)

1EL4000 – Materials

Instructors: Véronique Aubin
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: French English
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

- To make 1st year students aware of materials issues and their importance in society, economy and innovation
- Open them to the multidisciplinary nature of the world of materials and make them aware of the scientific and technological barriers around materials (e.g. aeronautics, fuel cells, ITER, electronics beyond Moore's law, energy recovery and transformation, materials for health, biomaterials, MEMS-NEMS,...)
- To give students the ability to read scientific and technical documents on any material, to extract the characteristics important for a targeted application, and to interpret these elements in relation to the structural, physical and mechanical characteristics of the material
- Show that the choice of a material results from a compromise within a set of constraints: availability of resources, production processes, use properties, life cycle, environmental impact and cost
- To make understand the physical phenomena at the origin of the properties of materials, to propose, through some examples, simple models which capture the essential of the physics of the phenomena and tools which make it possible to apprehend these phenomena, and to give the desire to deepen in more fundamental courses thereafter

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

None

Syllabus

• Introduction: current importance of materials, challenges associated with materials in major societal issues, taking into account the constraints related to sustainable development
• Introduction to the main families of materials: definition based on the nature of the chemical bond, resulting and use properties, introduction to the choice of materials
• Structures and phase transformations of materials :
o Order-disorder concepts: from crystal to amorphous via polymers and liquid crystals and how to describe and measure order and disorder
o Defects (0D to 3D): crucial role of the defect in the materials, illustration by various couples defect / property
o Thermodynamic balances and phase diagrams, their role in materials development
• Material properties :
o Mechanical properties related to the structure: plastic deformation mechanisms
o Functional properties related to the structure: thermal and electrical conduction, ferroelectricity, magnetism, optics

Class components (lecture, labs, etc.)

(1 session = 3 hours lesson) except session 1 of 1:30 and session 12 that will be 2 hours

- Sessions 1: lecture
- Session 1 to 9: lecture + directed study session
- Session 10: 3 hours working session
- Session 11: exam

Grading

Continuous monitoring during the course (25% of the final grade) by MCQ

Mandatory evaluation:
- summary document produced at the end of the study session on a material and its application (mandatory evaluation): 25% of the final grade.
- Final written exam (2 hours): 50% of the final grade

Skill C1 is validated if the grade is higher than 12 in the final exam or in the case study
Skill C2 is validated if the course is validated (global grade > 10)

Course support, bibliography

Materials of M. Ashby and D. Jones, Introduction to Solid State Physics of C. Kittel

Resources

• Teaching staff (instructor(s) names): Véronique Aubin, Brahim Dkhil, Camille Gandiolle, Jan Neggers, Elsa Vennat
• Maximum enrollment (default 35 students): 35 students
• Software, number of licenses required: CES Edupack, 100 licenses
• Equipment-specific classrooms : computer classrooms
Sessions 1.1 and 1.3 are given in French, session 1.4 in English.

Learning outcomes covered on the course

At the end of this course, the student will be able to:
- Analyze the scientific aspects of the overall behavior of a limited-scale system (e.g., isolated part of a complex system), including identification of factors that influence its behavior
How:
o For a given application, describe the constraints and the loadings imposed by that application. Prioritize these constraints to make a choice of materials. Make a multi-criteria material selection.
o For a given material, explain the macroscopic properties according to its atomic arrangement, its defects and its microstructure at different scales
o Read scientific and technical documents on a material, extract important characteristics for a targeted application, interpret these elements in relation to the structural, physical and mechanical characteristics of the material

- Correctly use a model presented in class, in its conditions of validity (model describing a phenomenon, without couplings)
How to:
o use a phase diagram to predict the microstructure of a material according to its thermomechanical history
o use a diffractogram to identify the structure and the atomic arrangement of the analyzed material
o use the model of interaction of dislocations with the microstructure to explain the mechanical behavior of a crystalline material
o interpret the electronic properties of a material to deduce its functional properties, semiconductivity and ferroelectricity

Description of the skills acquired at the end of the course

C1: Analyze, design, and build complex systems with scientific, technological, human, and economic components
C2: Develop in-depth skills in an engineering field and a family of professions

1EL5000 – Continuum Mechanics

Instructors: Guillaume Puel
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: English French
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

The student should be convinced of the ubiquity of the concepts and tools of mechanics in any industrial project implying either basic or advanced technology. The basic concepts are introduced in a common unified framework for tridimensional deformable solids and slender structures. Problems involving mechanics at different scales illustrate the course, with some applications to civil engineering, transportation, biomechanics and nanotechnology typically.

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

None

Syllabus

- Strains: Lagrangian description of movements, Green-Lagrange strain tensor, infinitesimal strain tensor (1h30)
- Stresses: global equilibrium equations for a material medium, Cauchy stress tensor, local equilibrium equation
- Strength criteria: mechanical tests, brittle fracture criteria, Tresca and von Mises criteria, stress concentrations
- Material behaviour: diversity, linear elastic isotropic behaviour, thermoelasticity
- Elasticity: properties of the mechanical solution, exact and approximate solutions, simplifications of an elastic problem (flipped classroom with a 3h-tutorial)
- a) Intermediary examination (analysis of numerical solutions: 30 min) / b) Beam approximation: demonstration of the assumptions of the beam model, definition of the internal loadings
- Beam approximation: approximate kinematics, constitutive relations, connections
- Beam approximation: solution methods, buckling phenomenon
- Summary problem on beams (2h)

- Engineering study: design problem, with graded report (3h)
- Final examination (2h)

Class components (lecture, labs, etc.)

Typical 1h30 lectures followed by 1h30 tutorial classes, except for session 1 (1h30 lecture) and sessions 5, 9 and 10 (3h-sessions of tutorial classes)
Occurrences 1.1 and 1.4 are in English; occurrences 1.2 and 1.3 are in French.

Grading

Overall grade = 20% intermediary examination (continuous assessment) grade + 20% engineering study report (session 10) (continuous assessment) grade + 60% final examination grade (written exam)
All documents are allowed, as well as non communicating calculators for the final examination

Course support, bibliography

Lecture notes

Resources

• Teaching staff (instructor(s) names): Andrea BARBARULO, Didier CLOUTEAU, Ann-Lenaig HAMON, Guillaume PUEL
• Maximum enrollment: 40 for each tutorial class
• Software, number of licenses required: Comsol Multiphysics (including the Structural mechanics module)
• Equipment-specific classrooms: none (numerical sessions with Comsol are taught in classical tutorial classes)

Learning outcomes covered on the course

Learning outcomes:
• Model the mechanical behaviour of a deformable solid

> Justify the relevant choice of model (2D or 3D, axisymmetry, slender structures, ...)
> Write the correct equations and boundary conditions corresponding to the loads and constraints applied to the domain and its boundaries
> Identify the mechanical properties of constitutive materials that are relevant to model the studied problem (e.g. rigidity, resistance, …)

• Determine the (stationary) mechanical response of a deformable solid

> Find the exact solution or an approximate solution (analytical or numerical) of the studied problem

Deduce from the obtained solution the quantities allowing to make design choices
Justify or criticize the validity of the obtained solution

Description of the skills acquired at the end of the course

The intermediate examination on the analysis of numerical solutions allows the evaluation of the milestone 1 of the subskills **C1.2** "Modeling: use and develop appropriate models, choose the right modeling scale and the relevant simplifying hypotheses" and **C1.3** "Solving: solve a problem with the use of approximation, simulation and experimentation".
The report of the engineering study (session 10) allows the evaluation of milestone 1 of sub-skills **C1.1** "Analyzing: study a system as a whole, the situation as a whole. Identify, formulate and analyze a system within the framework of a trans-disciplinary approach with its scientific, economic and human dimensions" and **C1.4** "Designing: specify, realize and validate all or part of a complex system".
These two elements allow the validation of milestone 1 of skill **C1**, while the validation of milestone 1 of skill **C2** is directly related to the final mark for this course.

1EL6000 – Networks and Security

Instructors: Pierre Wilke
Department: CAMPUS DE RENNES
Language of instruction: French English
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

This course aims to provide CentraleSupélec students with basic knowledge in computer networking, as well as a reasonable awareness of information security issues.
Regarding networking, the mechanisms allowing users like us to browse and use Internet services will be highlighted. Thus, the various network layers, from the physical to the applicative level, will be introduced, as well as additional network services such as DNS (Domain Name System). Hands-on and tutorial sessions will allow students to face the actual implementation of the various concepts covered, in realistic situations and systems.
Regarding information security, lectures will introduce fundamental concepts and will succintly present a few security mechanisms. They will be complemented by lab sessions illustrating various security risks and the associated countermeasures.

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

- Information systems and programming
- Basic Python programming

Syllabus

Part 1: Networking – lower layers
- Physical layer / data link layer (Ethernet)
- Address Resolution Protocol (ARP), Media Access Control (MAC) addresses

Part 2: Networking – intermediate layers

- IP protocol and addresses
- IP routing and routing protocols
- Transport protocols (TCP and UDP)
- Tutorial 1: Network traffic analysis (Wireshark)
- Tutorial 2: Specification of a communication protocol
- Lab 1: Networking equipment handling (routers / switches)
- Personal work: Border Gateway Protocol (BGP), peering, IPv4-IPv6 migration, congestion control, flow control, QoS...

Part 3: Networking – Applicative layers and services

- Domain name resolution (DNS)
- HTTP protocol, web technologies
- Tutorial 3: Implementation of the protocol specified in tutorial 2, in Python (socket programming)
- Personal work: e-mail protocols (IMAP, POP, SMTP), directories (LDAP)...

Part 4: Information security

- Introduction to information security, fundamentals
- Legal and social aspects
- Introduction to cryptography and cryptographic protocols
- Introduction to malware
- Lab 2: Virtual Private Networks (VPN)
- Lab 3: Web application security
- Personal work: IPSec, DNSSec, TLS, secure instant messaging...

Class components (lecture, labs, etc.)

Networking – lower layers: lecture (1h30)
Networking – intermediate layers: lecture (3h), tutorial (6h), lab (3h), personal work (9h)
Networking – Applicative layers and services: lecture (3h), tutorial (3h), personal work (9h)
Information security: lecture (3h), lab (6h), personal work (10h)
Written exam (2h)

Occurrences 1.2 and 1.4 are taught in French
Occurrence 1.3 is taught in English

Grading

The evaluation will be the average of a written examination at the end of the session (CF) lasting 2h and the evaluation of the labs 1 and 2 (mandatory evaluation)
- 50% final exam (written, multiple choice questions, no documents)
- 25% lab 1
- 25% lab 2

Lab grades always participate in the final grade, whether they improve it or not.

Course support, bibliography
Lecture slides provided in electronic format
Books:

- J.F. Kurose and K.W. Ross, *Computer Networking: A Top-Down Approach*, 7th ed. Eyrolles. Pearson. ISBN : 978-0133594140
- Ross J. Anderson, *Security Engineering: A Guide to Building Dependable Distributed Systems*, 2nd Edition. Wiley. ISBN : 978-0470068526 (available online on https://www.cl.cam.ac.uk/~rja14/book.html)

MOOC:

- Stanford Online: *Introduction to Computer Networking* (https://lagunita.stanford.edu/courses/Engineering/Networking-SP/SelfPaced/about)
- Coursera / Université du Maryland : *spécialisation Cybersécurité* (https://www.coursera.org/specializations/cyber-security)
- Cisco Networking Academy: CCNA1 and CCNA2 modules (https://netacad.centralesupelec.fr/)

Resources

- Teaching staff: Rennes/CIDRE team members, as well as Paris-Saclay teachers (computing and telecommunications departments);
- Most tutorials and lab sessions require a personal laptop;
- Software used: Wireshark, Python, VirtualBox, OpenVPN (all free/open source);
- Some tutorials and lab sessions involve specific networking equipment;
- Some lectures may be presented remotely from Rennes.

Learning outcomes covered on the course
After completion of this course, students will be able to:

- Know TCP/IP computer networking concepts, protocols and mechanisms;
- Analyse the network activity generated by web applications;
- Know the main types of cryptographic schemes;
- Know techniques used by malware;
- Set up and manage switched and routed computer networks;
- Design and implement an applicative communication protocol;
- Set up and configure a Virtual Private Network (VPN);
- Detect and analyse some web application vulnerabilities.

Description of the skills acquired at the end of the course

- C1.1 - Examine a problem in full breadth and depth, within and beyond its immediate parameters, thus understanding it as a whole. This whole weaves the scientific, economic and social dimensions of the problem. Examine a problem in full breadth and depth, within and beyond its immediate parameters, thus understanding it as a whole. This whole weaves the scientific, economic and social dimensions of the problem
- C1.4 - Design, detail and corroborate a whole or part of a complex system
- C2.1 - Thoroughly master a domain or discipline based on the fundamental sciences or the engineering sciences.

1EL7000 – Transport Phenomena

Instructors: Ronan Vicquelin
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: English, French
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

The objective of this course is to teach the basic notions of mass, species, momentum and heat transfer necessary to the characterization and scaling of multiple systems. Due to the strong analogy between species transfer and heat transfer on the one hand and the intimate coupling between fluid dynamics and heat transfer inherent to the convection phenomenon on the other hand, this set of engineering sciences is very consistent and is part of the basic academic core in a large variety of industrial sectors covering energy (nuclear, fossil, renewable), transport (automobile, aircraft, aerospace), industrial processes (chemical, biomedical), health, building, … Moreover, a good knowledge of these transfer sciences is absolutely necessary in the booming domain of the optimization of industrial processes. Finally, several current environmental issues and challenges for society such as the reduction, the dispersion or the sequestration of pollutants or the climate change involve physical phenomena partly based on transfer sciences. To solve all the serious problems that humanity is facing in the beginning of this 21st century, many important developments and breakthroughs will have to be achieved in the domains of technology, health and environment. In this context, a good background in mass, species, momentum and heat transfer is a major advantage for engineering students, and this set of sciences is essential for the training of high level engineers. The course is composed of a dense theoretical content (mass and species transfers, fluid dynamics, heat transfer by conduction, convection and radiation in diverse configurations: steady-state or transient, isolated or coupled phenomena, boundary layers), and after each lecture a practical engineering problem illustrating the notions introduced is solved in tutorial classes.

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

Basics of mathematics and thermodynamics (studied during the first 2 university years)

Syllabus

- THE BASICS OF RADIATION HEAT TRANSFER:
  Notions of opaque body and of transparent medium. Notions of emitted, absorbed, reflected, leaving, incident and radiative heat fluxes. Writing boundary conditions involving radiative heat exchanges. Notion of spectral directional intensity. General expression of a radiation heat flux. Notion of equilibrium radiation – Properties of the associated spectral intensity.
- RADIATIVE PROPERTIES AND RADIATIVE TRANSFER:
  Characterization of the surface of an opaque body: notions of emissivity, absorptivity and reflectivity. Notions of gray body, black body, and diffuse body. Simple models of radiative transfer between 2 opaque bodies separated by a transparent medium: (1) opaque, convex and isothermal body surrounded by an isothermal black body; (2) opaque, convex, isothermal and small body surrounded by an opaque isothermal enclosure.
- INTRODUCTION TO THE STUDY OF FLUID FLOW:
  Theorem Pi. Types of flows. Description of motion and material derivative. Velocity and acceleration of a fluid particle. Transport theorems. General local balance of mass. Description of species mixtures.
- SPECIES MASS TRANSFER – DIMENSIONAL ANALYSIS:
  Local balance equation of species mass. Species absolute velocity, mixture mass-average velocity, diffusion velocity. Analogy between heat and mass transfers (diffusion and convection). Fick's law (binary mixture, dilute gas or liquid). Physical origins, order of magnitude of the mass diffusivity. Boundary conditions – Discontinuous concentrations at interfaces. Dimensional analysis to carry out a priori approximations. Characteristic time and length scales. Link with Pi theorem. Similitude conditions.
- BALANCE OF MOMENTUM:
  General motion of a fluid particle. Strain rate tensor. Stresses in fluids. Relation between stress and strain rate tensors in Newtonian fluids. Local balance equation of momentum. Euler equations. Navier-Stokes equations. Dimensional analysis of Navier-Stokes equations. Local balance equation for kinetic energy.
- ENERGY BALANCE EQUATIONS:
  Local balance equation of energy. General formalism and similarities of transport equations for mass, species concentrations, momentum and energy.Bernoulli theorem and applications. Macroscopic balance of mechanical energy. Study of incompressible flows in pipes. Friction head losses. Moody diagram. Singular head losses. Pump and turbine efficiency.
- MACROSCOPIQUES BALANCES:
  Macroscopic balance of mass and species. Momentum theorem in steady flows. Moment of momentum theorem. Application to the determination

of hydrodynamic forces and moments. Thrust of turboengines and rockets. Macroscopic balance of thermal energy.

- INTRODUCTION TO THE PHYSICS OF BOUNDARY LAYER: Boundary layer theory. A priori estimates of the laminar boundary layer thickness. Separation and transition. Definition of boundary layer thicknesses. The boundary layer equations for a laminar flow over a flat plate. Numerical solutions of equations of a laminar boundary layer on a flat plate without pressure gradient.
- EXTERNAL FORCED CONVECTION – 2D MECHANICAL AND THERMAL BOUNDARY LAYER MODEL:
  Approximate solutions of the boundary layer equations for a laminar flow over a flat plate with the integral method. Effects of pressure on boundary layers. Thermal boundary layer in external forced convection. General form of correlation formula for external forced convection. Simplifying hypotheses and simplified heat transport equation. Integral method applied to thermal boundary layer.
- NOTIONS OF INTERNAL FORCED CONVECTION:
  Elementary notions on the mechanical and thermal entrance zones and on the fully developed mechanical and thermal regimes. Notion of bulk velocity and bulk (or mixture) temperature. Determination of the velocity profile in fully-developed laminar regime. Expressions of the Nusselt number for laminar and turbulent flows and for a duct of circular cross-section. Internal convection in laminar and turbulent regimes. Notion of hydraulic diameter.

Class components (lecture, labs, etc.)

The course is given several times in French or English during the SG1 and SG3 sequences.
Sequence SG1

- Occurrence 1.1 (French) : Hervé Duval
- Occurrence 1.2 (English) : Gabi Stancu
- Occurrence BCPST (French) : Julien Colin

Sequence SG3

- Occurrence 1.3 (French) : Fabien Bellet
- Occurrence 1.4 (French & English) : Ronan Vicquelin, Antoine Renaud
  - Amphitheater + TD (French) : Ronan Vicquelin
    - *Default affectation in occurence 1.4 is in the French course*
  - One classroom (English) : Antoine Renaud
    - *Once the students are enrolled in occurence 1.4 (displayed as tough in French in the MyWay poll), they can choose afterwards to follow the English class.*

The course is scheduled over 19 slots of 1h30 each, 3 remote preparation elements (3 x 1h30) and a 2h exam session.

Grading

The Final Examination, held over 2 hours in the last session, can be carried out with documents. Students receive the grade denoted as CF.

Continuous assessment through a minimum of two optional quizzes and tests taken in class, with documents allowed. For each test, the student obtains a CCi mark: CC1 for test n°1, CC2 for test n°2, etc...

Ncc is the number of tests (minimum 2). Continuous assessment thus accounts for a maximum of 33% of the final grade, and final assessment for a minimum of 67%.

Course support, bibliography

• Provided course material
• Polycopié CentraleSupélec « Mécanique des Fluides» ; Tome I ; Sébastien Candel.
• « Transferts thermiques - Introduction aux transferts d'énergie » ; 5ème édition ; auteurs : Jean Taine, Franck Enguehard et Estelle Iacona ; Dunod, Paris, 2014.

Resources

• Teaching staff (instructor(s) names): Fabien Bellet, Julien Colin, Hervé Duval, Antoine Renaud, Gabi Stancu, Ronan Vicquelin
• Maximum enrollment (default 35 students): 100-120 per session, and 35 per tutorial class, which means 3 tutorial classes per session.

Learning outcomes covered on the course

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

1. Identify different modes of heat and mass transfer taking place in a given configuration,
2. Write appropriate balances (mass, species, momentum, energy), jump conditions at interface, to determine the evolution of different fields (species concentrations, velocity, pressure, temperature),
3. Compute stresses, heat fluxes, forces, mechanical and thermal powers, efficiencies, head losses.
4. Model complex systems, a necessary step to their conception and optimization:
   - Make approximations and estimations,
   - Simplify an apparently complex system
   - Use fundamental balances to solve practical problems

Description of the skills acquired at the end of the course

The course is part of the C1 and C2 competencies of the CentraleSupélec engineering curriculum.

C1: Analyse, design and build complex systems with scientific, technological, human and economic components
C1.1: Analyse: study a system as a whole, the situation as a whole. Identify, formulate and analyse a system within the framework of a transdisciplinary approach with its scientific, economic, human dimensions, etc.
C1.2: Model: use and develop appropriate models, choose the right scale of modelling and relevant simplifying assumptions
C2 : Develop an in-depth competence in an engineering field and in a family of professions
C2.1 : Go deeper into an engineering field or scientific discipline

Core skills in CentraSupélec curriculum:

- C1 (C1.1, C1.2) and C2 (C2.1)

C1 is validated if CF >= 10.
C2 is validated if NF >= 10.

1EL8000 – Electronic Systems

Instructors: Pietro Maris Ferreira
Department: DÉPARTEMENT ÉLECTRONIQUE ET ÉLECTROMAGNÉTISME
Language of instruction: English, French
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

Analog and digital electronic systems are today ubiquitous in our lives, whether in the use of connected objects for domotic applications, in the areas of communication, transport and health, in the fields of defense and space, or in the billions of computers connected across the WEB.
Despite a constantly evolving domain (Moore's law), there are a number of constant fundamentals that are common to most systems no matter their complexity:
- interfaces with the physical world (sensors) and persons (display devices, HMI),
- processing of analog signals (filtering, wavelets, ... and soon neuromorphic systems),
- analog-to-digital conversion (with or without data compression) and digital-to-analog (transducers)
- digital processing units onboard or remote (HPC, cloud ...).
This course is conducted in a top-down approach to prepare students to specify and develop electronic systems from existing hardware components (OpAmps, microcontrolers, FPGA).
Also, the principles and physical quantities related to the operation of these components are covered. Nevertheless, the microelectronic design and realization (i.e. Computer Aided Design and microelectronic technologies) will be addressed in more advanced courses to students who want to develop their skills in that field.

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

None

Syllabus

Analogue electronics :

- lecture 1: Historical and Economic Panorama of Electronic Systems; Linear Circuits

- lecture 2: Non-Linear Circuits - Distortion; Modulation; Saturation; Modeling
- tutorial class 1: Linear Amplifier Assemblies - Instrumentation Amplifier, TIA, 2nd Order Active Filter
- lecture 3: Semiconductor Components - PN Junction; Transistor MOS
- tutorial class 2: Non-Linear Systems Modeling - Analog Voltage Multiplier; Voltage Rectifier; Sample and hold; OTA
- lecture 5: Interface and sensors
- tutorial class 3: Instrumentation Chain LTSPICE Simulation: Radar Ultrason
- LAB : Instrumentation Chain Assembly: Ultrasonic Radar

Analogue to digital conversion :

- lecture : sampling and quantizing, non idealities and characterization, ADC specification
- Homework : ADC families,

Digital electronics :

- lecture 1: Introduction to logic and digital components, Complex system design: software vs. hardware solutions, design methodology
- homework : Discovering the Arduino
- lecture 2: Data representation, logic, gates, flip-flops
- lecture 3: Advanced functions, operators, state machines
- lecture 4: Introduction to VHDL language
- tutorial class 1: Initiation to VHDL language using FPGA
- lecture 5: Processing unit architecture
- tutorial class 2: digital processing of FPGA, lab preparation
- LAB : Implementation of a digital processing of a FPGA

Class components (lecture, labs, etc.)

The course is divided into 3 parts: Analogue, digital, and conversion.
Each analog and digital part is composed of classes, tutorials, homework and one laboratory.

The analog electronics tutorials are essentially modeling and calculations. One of the digital tutorials is around an electronic board DE10 Altera in initiation to design in VHDL language.

The two labs are a single project comprising a sensor, an analog stage, an ADC and a digital processing. The aim of the first lab is to design, simulate and test the analog stage, while the 2nd lab will focus on the design of the digital part using VHDL language.

The course is given in French for the occurrences 1.1, 1.2 and 1.3. It is given in English at occurrence 1.4

Grading

The course is evaluated on the basis of 2 laboratories and a written exam lasting 2 hours with document.
Final Evaluation = 75% written exam score, 25% analog lab and digital lab.
Labs are compulsory assessment (EO)
The 'analog' labs are prepared by a tutorial which allows to pre-determine the functions that will be tested. The supervisors will check that this preliminary work has been done and will take into account in their notation.
The Labs are evaluated on the basis of the report written in real time and the simulation and measurement elements produced, as well as the observation by supervisors of students in situation.
The 2-hour written exam poses an engineering problem for an electronic system for which students must provide a solution by choosing a sensor, an analog processing system, an analog-to-digital converter digital and digital processing.
Assessment of learning outcomes: The skills mentioned above are all assessed at a level 1, that is to say in the case of simple, relatively closed problems, and in a way guided by the professors. The skills will be assessed in 2 ways: - theoretically by means of the written exam and practically by laboratories.

C1 is validated if the average of the 2 labs is greater than 12 and the average of the questions marked C1 during the written exam is greater than 10
C2 is valid if the average of the questions marked C2 during the written exam is greater than 10

Course support, bibliography

"Digital Design and Computer Architecture"
David and Sarah Harris
Morgan Kaufmann Publishers

« Foundations of analog and digital electronic circuits »
Anant Agarwal and Jeffrey H Lang
Morgan Kaufmann Publishers

Resources

• Teaching staff (instructor(s) names):
- Digital : P. Bénabès, C. Lelandais, A Kolar, E. Libessart
- Sensors : J. Juillard & L. Bourgois
- Analogue: E. Avignon, P. Maris, M. Roger.

• Maximum enrollment (default 35 students): 100 students for classes, 35 for tutorials, ans 16-18 for laboratories

• Software, number of licenses required: Quartus Student edition (Free softwares)

• Equipment-specific classrooms (specify the department and room capacity)

2 laboratories in the department of electronic systems and telecommunications, 32 students by laboratory (4 assistants).

Learning outcomes covered on the course

The "Electronic Systems" course will provide students with a basic understanding of:

• A) Specify an analog processing chain
- Understand the different electronic technologies (integrated circuits vs printed circuits) and their evolutions (traditional technologies towards 'more than Moore' or 'beyond CMOS'), Systems on Chip, packaging, interconnections
- Design analog architectures from simple models (Laplace block for example) up to AOP-based circuits, capacitors, resistors, inductors.
- Analyze in matrix form the simple Kirchoff networks (RLC + AOP circuits).
- Determine if the limitations of the AOPs are respected (bandwidth, Gain-band product, input and output impedances, sweep rate) with respect to a given application
- Choose a sensor interface between the physical world and electronic signals

• B) Simulate and test a simple circuit
- Take control of Spice simulation software (schematic input, AC, DC, and transient simulation)
- Set up a simulation efficiently: simulation time and not adapted, solving possible convergence problems in simple cases (RLC + AOP circuits).
- Make clean montages on test plates (simulation versus measurement)
- Measure currents, voltages, impedances with the appropriate equipment (oscilloscopes, impedance meters, ...).
- Choose the appropriate component from its documentation (AOP limitations)

• C) Specify and select the correct analog-to-digital converter adapted to a given problem in terms of sampling frequency, resolution, family, and analyze the effect of sampling and quantification on the signal to be processed (effects of aliasing, saturation or non-linearity).

• D) Specify and choose a digital processing architecture adapted to a given problem
- Type of processing unit adapted to the problem (processor, microcontroller, DSP, programmable circuit, dedicated ASIC)
- Choice of the development tools necessary for the implementation of these components

• E) Implement a simple application with a microcontroller or a FPGA.
- Available peripherals in a microcontroller according to their potential use, and their simple implementation in C language
- Program, download and test a simple application on a microcontroller or FPGA in VHDL language

Description of the skills acquired at the end of the course

This course allows you to validate certain skills of type C1 - Analyze, design and build complex systems.
This validation is done by means of practicals (C13 Solve, C14 design) and the written exam (C11-Analyze, C12 Model).
The written exam also makes it possible to validate C2-type skills (C21-Deepen an engineering field, C22-Import knowledge from other fields)

So we will learn during this course who to:
A) Specify a simple analogue processing chain
B) Simulate and test a simple circuit
C) Specify and choose the right analogue-to-digital converter
D) Specify and choose a digital processing architecture adapted to a given simple problem
E) Implement a simple application with a micro-controller or a programmable logic device

Some basic concepts will need to be learned or reviewed independently (the basics of logic, Arduino microcontrolers, ADC converters families), and we will use
mathematical concepts studied elsewhere (sampling theory, filtering, signal processing)

1EL9000 – Thermodynamics

Instructors: Marie-Laurence Giorgi
Department: DÉPARTEMENT MÉCANIQUE ENERGÉTIQUE PROCÉDÉS
Language of instruction: English French
Campus: CAMPUS DE PARIS - SACLAY
Workload (HEE): 60
On-site hours (HPE): 30,50

Description

The objective of this course is to provide the theoretical bases, tools and good practices necessary for engineers to understand and design systems that transform raw energy into useful energy, and /or that modify the physicochemical properties of matter through controlled transformations.
The knowledge acquired in this course will allow for the design of these systems by determining their optimal operating points (for example by using phase transitions) in order to optimize their energy efficiency.
In particular, the course will show how thermodynamic concepts can be used to meet the challenges of the 21^{st} century (conventional and renewable energy production, energy efficiency of engineering processes, smart materials, recycling, water and waste treatment, etc.) and how recent scientific advances can help predict multiphysical couplings in complex systems.

Quarter number

SG1 and SG3

Prerequisites (in terms of CS courses)

None

Syllabus

1) Energy efficiency
General description of the fundamental concepts (open systems, state functions)
Open systems of energy transformation (energy, entropy and exergy balance)
Efficiency of energy recovery cycles (design of thermodynamic cycles)
2) Phase transitions
Thermodynamic properties of pure substances and solutions
Phase equilibria, phase diagrams
Phase transitions (equilibrium and departure from equilibrium, chemical

reactions, germination / growth)

Class components (lecture, labs, etc.)

The course will be divided into 3 hour periods (1.5 hours of lecture and 1.5 hours of tutorials).
At the end of each part of the course, students will carry out a project by 2 or 3 students (2 x 3 hours to realize the projects and write the reports).
A final evaluation (2-hour written test) will complete the course.
The second session will be an individual assessment of 2 hours.

The language of instruction is French for occurrences 1-1 and 1-2 and English for occurrence 1-3.

Grading

Two projects with two reports (40%) and an individual final assessment (60%)

Course support, bibliography

D. Kondepudi, I. Prigogine, Modern Thermodynamics – From Heat Engines to Dissipative Structures, John Wiley and sons, England, 1998.
C.H.P. Lupis, Chemical Thermodynamics of Materials, Elsevier Science Publishing, New York, 1983.

Resources

• Teaching staff (instructor(s) names): Marie-Laurence Giorgi, Sean Mc Guire
• Maximum enrollment: 35
• Software, number of licenses required: open source software

Learning outcomes covered on the course

At the end of the course, students will be able to:
1. Write energy, entropy and exergy balances
2. Designing and optimizing energy recovery cycles
3. Propose and evaluate solutions to optimize the energy efficiency of systems
4. Understand and use phase diagrams for material design
5. Construct thermodynamic models describing phase equilibria
6. Work as a team independently and interdependently towards a common team objective

Description of the skills acquired at the end of the course

C1.1, C1.2, C1.3, C2.1