Handbook - CMI H3E

Thermal Track

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femto-st

UNIVERSITÉ MARIE & LOUIS PASTEUR

Contents

CMI 1

1.1 Semester 1

1.1.1 Mathematics

1.1.1.1 Algebra

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Algebra	FD	10	26	0	0	0	41	36	39	75	3

Content

· Systems of linear equations: solving using Gauss's pivot method,
· Complex numbers: the set C of complex numbers, operations in C,
Algebraic form, conjugate, modulus of a complex number,
Quadratic equations in C, the binomial formula,
Arguments, trigonometric and exponential forms of a complex number,
nth roots, Euler's and Moivre's formulas,
Geometric interpretation,
· Applications: injective, surjective and bijective functions,
Direct image and inverse image,
· Introduction to matrix calculus: definition, operations on matrices,
Elementary transformations, row-echelon form of a matrix, rank of a matrix,
Calculation of the inverse of a matrix.
· Analytical geometry in the plane.

Module objectives/intended learning outcomes

Consolidation of the fundamentals of algebraic calculation, including the ability to express a physical phenomenon as an equation, then simplify and solve it.
Ability to manipulate a harmonic signal represented in complex form.

Language English

Relation to curriculum Compulsory

Responsible Emmanuel Cote

Examination form Written tests in tutorials, a final exam.

Prerequisites Null

Code Y4ESI111

1.1.1.2 Analysis

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Analysis	FD	10	26	0	0	0	41	36	39	75	3

Content

· Inequalities in R, absolute value, the triangle inequality, upper and lower bounds.
· Study of the infinite branches of a function,
· Reciprocal functions of a continuous and strictly monotonic function,
Derivation of the reciprocal,
· Classical functions: arcsin, arccos, arctan, hyperbolic functions and their reciprocals, power functions,
· Limit series, Taylor's formula,
· Integration of continuous functions, properties, calculation techniques (integral of a product of powers, change of variables, integration of rational functions),
· Differential equations: general principles,
Solving first-order linear differential equations,
Solving second-order linear differential equations with constant coefficients,

Module objectives/intended learning outcomes

Acquiring the fundamentals of analysis for practical applications in physics, chemistry, mechanics, environmental engineering, etc.

Language English

Relation to curriculum Compulsory

Responsible Emmanuel Cote

Examination form Written questions

Prerequisites Null

Code Y4ESI112

1.1.2 Physics

1.1.2.1 Electricity

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Electricity	FD	8	10	8	0	0	30	26	49	75	3

Content

* Series and parallel connections of dipoles
* Star-delta transformation
* General theorems of electromagnetics in steady-state conditions (Ohm's and Pouillet's laws – voltage and current dividers – node and loop theorems – Millman's, Thévenin's and Norton's theorems)
* Power in steady-state conditions

Module objectives/intended learning outcomes

Master
* calculations of equivalent resistances and circuit transformation

* calculations of potential differences in DC circuits comprising several branches
* the determination of voltages, currents and power in circuits comprising several branches with resistors, voltage sources and current sources by applying the various general theorems of DC electrodynamics.

Language English

Relation to curriculum Compulsory

Responsible Didier Chamagne

Examination form Written tests in tutorials, practical reports and final exam

Prerequisites Null

Code Y4ESI121

1.1.2.2 Thermodynamics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Thermodynamics	FD	8	10	9	0	0	31	27	48	75	3

Content

Thermodynamics:
* Thermodynamic systems, ideal gases, isobaric, isochoric and isothermal processes. Clapeyron diagram.
Heat transfer:
* Conduction: Fourier's law, thermal conductivity, thermal resistance, rectangular prism structures, cylindrical structures.
* Convection: Newton's law, convective heat transfer coefficient.
* Radiation: the electromagnetic spectrum of light, Planck's law, Wien's law, emittance, luminance, illuminance, emissivity, black bodies, real bodies (grey, opaque, etc.), absorptivity, radiative exchange between two surfaces, shape factors.

Module objectives/intended learning outcomes

This provides students with an introduction to thermodynamics, combined with the general and highly simplified laws of heat transfer.
This useful combination enables them to perform thermal modelling of simple structures in steady-state conditions in order to predict internal temperatures in straightforward cases.
The areas of application are multi-layer walls (insulation, plaster, concrete) to which convective boundary conditions are applied.

Language English

Relation to curriculum Compulsory

Responsible Raynal Glises De La Riviere

Examination form Written tests in tutorials and the final exam

Prerequisites Null

Code Y4ESI122

1.1.3 Engineering Sciences

1.1.3.1 EEA discovery

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	EEA discovery	CDS	6	4	9	0	0	22	19	31	50	2

Content

* Number systems and encoding: why binary (base 2); octal; hexadecimal; ASCII code; binary encoding; BCD encoding; one's-complement and two's-complement codes; Gray code; representation of integers and fractional numbers

* Combinational logic: basic laws of Boolean algebra; properties; NAND, NOR and XOR gates; writing logical functions; first and second canonical forms; implementation; simplification of logical functions; multiplexer

* Comparator, adder...

Module objectives/intended learning outcomes

To acquire a basic understanding of digital electronics as an introduction to industrial computing and automation

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form Written tests in tutorials, practical reports and the final exam covering lectures, tutorials and practicals

Prerequisites Null

Code Y4ESI131

1.1.3.2 Mechanical discovery

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Mechanical discovery	CDS	6	4	9	0	0	22	19	31	50	2

Content

The aim is to explore aspects of mechanics through a few key concepts:

· The concept of force and its implications
· The concept of the motion of a material point and its implications
· The concept of a material's rigidity and its implications

Module objectives/intended learning outcomes

To understand the importance of mechanics in design.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form Written tests in tutorials, practical reports, final exam

Prerequisites Null

Code Y4ESI132

1.1.3.3 Programming basics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Programming basics	CDS	6	6	15	0	0	30	27	23	50	2

Content

* How computers work (internal structure, different components, binary coding)

* Programming basics: predefined types, variables, operators, expressions, simple and control statements (conditional and iterative); language used: Python

* Basics of algorithms through examples covered in practical sessions (array manipulation, sorting algorithms, etc.)

Object-oriented programming will not be covered (in Year 2)

Module objectives/intended learning outcomes

The aim of this module is to explain how a computer works
and to provide students with the basics of algorithms and programming in Python.

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Written tests in tutorials, practical work programmes, final exam

Prerequisites Null

Code Y4ESI133

1.1.4 Chemistry

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Chemistry	FD	10	26	15	0	0	56	51	99	150	6

Content

* Atoms: atomic structure, electronic structures, the periodic table, formation of simple ions, etc. Molecules: covalent bonding, bond polarisation, Lewis structures, molecular geometry, etc.

* Gaseous state: the laws of gases.

* Chemical reactions: molar and mass balance, reaction progress, example of redox reactions, chemical kinetics, etc.

* Practical work: quantitative analysis using acid-base titration and redox titration.

Module objectives/intended learning outcomes

Determine the nuclear composition and electronic structure of an element based on its position in the periodic table.

Determine the stoichiometric ratios of a reaction based on its balanced equation. Predict the expected

masses of the products. Be able to convert between amount of substance, mass and volume, depending on the physical state of the reactant or product.
Recognise a redox reaction from its balanced equation and know how to balance it using oxidation numbers.
Recognise, based on monitoring the progress of the reaction, reactions of order 0, 1 and 2.
Practical work: know how to determine a molar concentration, a mass fraction, etc. from a precise titration. Record results with the correct number of significant figures.

Language English

Relation to curriculum Compulsory

Responsible Jean-Luc Sanner

Examination form Written tests in tutorials, practical reports, final exam covering lectures, tutorials and practicals

Prerequisites Null

Code Y4ESI1M4

1.1.5 Methodology of science and academic work

1.1.5.1 PIX

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	PIX	SECO	0	0	24	0	0	24	24	26	50	2

Content

* Understanding some legal aspects relating to IT (data protection regulations, etc.)
* Being proficient in using your workstation and the network (directories, file formats, file permissions, file compression, viruses, etc.)
* Introduction to word processing (managing single-page documents, formatting text, paragraphs and lists, inserting images, headers and footers, etc.)
* Introduction to spreadsheets
* Proficiency in the digital learning environment (ENT), online courses and activities, and the University's email system

Module objectives/intended learning outcomes

To be able to use the available IT resources in a considered manner.

Language English

Relation to curriculum Compulsory

Responsible Eric Duverger

Examination form practical tests and final exam

Prerequisites Null

Code Y4ESI151

1.1.5.2 English

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	English	SECO	0	6	0	0	0	6	6	44	50	2

Content

Self-study English

Exercises to consolidate the basics and maintain language skills, using online learning platforms: working with a variety of audio and written materials [lessons to brush up on your English, read about world news, understand more about what is happening in the world of technology, and learn some useful tech vocabulary, etc.]; strengthening grammar skills at B1-B2 level

Module objectives/intended learning outcomes

Learning objectives

¿ To activate linguistic resources (lexical, phonological, syntactic and grammatical) through oral and written practice of the language

¿ To understand, analyse and summarise information with a view to using it in written and/or oral communication

Language English

Relation to curriculum Compulsory

Responsible Fanny Lalevee

Examination form B1 placement test at the start and end of the term.

Prerequisites Null

Code Y4ESI152

1.1.5.3 Scientific methodology

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Scientific methodology	SECO	0	0	10	0	0	10	10	40	50	2

Content

dimensional analysis, uncertainty analysis, graphical representations,

writing a practical report.

Module objectives/intended learning outcomes

To equip students with the tools and methods of scientific research

Language Not specified

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form

Prerequisites Null

Code Y4ESI153

1.1.5.4 Documentation

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
1	Documentation	SECO	0	0	0	0	0	0	0	0	0	0

Content

Tour of the University Library

Module objectives/intended learning outcomes

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form No rating

Prerequisites Null

Code Y4ESI154

1.2 Semester 2

1.2.1 English and professional integration

1.2.1.1 English CMI1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	English CMI1	SECO	0	12	0	0	0	12	12	13	25	1

Content

* Recognise, use and expand everyday vocabulary / vocabulary related to major societal issues / current affairs / issues relating to higher education and student life
* Recognise, use and expand basic vocabulary (descriptive, argumentative, scientific)
* Expand subject-specific lexical knowledge related to science and energy, and technology (fields of application of Engineering Sciences, design and production of innovative industrial products, etc.)
¿ Apply basic grammar (verb phrases, modal expressions, etc.)
¿ Demonstrate a basic level of oral and written comprehension (identifying information, inference, reading strategies, etc.)

Module objectives/intended learning outcomes

Objectives: to master the language of general communication; to be able to understand and use subject-specific vocabulary in context

Language English

Relation to curriculum Compulsory

Responsible Fabienne Halm

Examination form Continuous assessment and final exam

Prerequisites Null

Code Y4ECH161

1.2.1.2 Professional integration CMI1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Professional integration CMI1	SECO	0	8	0	0	0	8	8	42	50	2

Content

* Implementing the PEC approach
* Introduction to research at the FEMTO Laboratory (Department of Electrical Engineering)

Module objectives/intended learning outcomes

Discover what makes the CMI H3E unique

Language English

Relation to curriculum Compulsory

Responsible Daniel Hissel

Examination form project progress report

Prerequisites Null

Code Y4ECH162

1.2.2 L1 or L2 work placement

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	L1 or L2 work placement	CDS	0	0	0	0	0	0	0	75	75	3

Content

The immersion placement takes place in the first or second year of the degree and should preferably be undertaken abroad and conducted in English. To make things easier, students may work in pairs to facilitate the organisation of a placement abroad.

Module objectives/intended learning outcomes

For the immersion placement, students are expected to give a presentation during an oral defence, using a presentation format such as PowerPoint or PDF.

* Use the various registers of written and spoken English with ease

* Report and communicate orally and in writing, adapting to the relevant audience (professionals, the general public, academics)

* Analyse and summarise data for practical application

* Develop an argument with a critical mindset

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Assessments: oral presentation; report; assessment form

Prerequisites Null

Code Y4ECH1M7

1.2.3 Mathematical tools 1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Mathematical tools 1	FD	12	40	0	0	0	58	52	98	150	6

Content

· Plane and spatial geometry: scalar product, vector product, determinant,
Standard coordinate systems (Cartesian, polar, cylindrical and spherical),
Change of basis
· Scalar functions of several variables: continuity, differentiability, partial derivatives, gradient
· Vector functions of several variables: continuity, differentiability, partial derivatives,
Differential operators: divergence, rotational, Laplacian,
· Double and triple integrals, line and surface integration,
Circulation of a vector field, flux of a vector field, scalar potential,
Classical theorems of multiple integrals (Green's, Stokes', divergence),

Module objectives/intended learning outcomes

- To familiarise students with the various coordinate systems in the plane and in space (Cartesian, polar, cylindrical and spherical), and with the manipulation of the scalar product, the vector product, determinants and their geometric applications.
- Understand the definition and properties of differentiable functions of two or three variables (partial derivatives, gradient, differential, directional derivative, tangent plane to the graph, etc.). First-order limit expansions.
- Master the properties of vector fields: circulation along a path, flux through an oriented parameterised surface, calculation of curl and divergence.

Be able to use vector calculus as a tool in solving practical engineering problems.

Language English

Relation to curriculum Compulsory

Responsible Emmanuel Cote

Examination form Written tests in tutorials, an individualised homework assignment, and a final exam.

Prerequisites Null

Code Y4ESI2M6

1.2.4 Engineering Sciences 1

1.2.4.1 Automatic

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Automatic	CDS	8	8	12	0	0	32	28	47	75	3

Content

* History of automation; concepts of systems and control; differences between control inputs and disturbance inputs in a system.
* Continuous-time linear systems; differential equations; complex form; transfer function.
* Frequency representation of systems; Bode plots.
* Time response of systems: examples of first- and second-order systems.

Module objectives/intended learning outcomes

Students will gain a historical overview of the development of automatic control: from simple system control to control systems. They will have acquired the mathematical foundations necessary for the study of linear control systems, which will be explored in greater depth.

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form Written tests in tutorials, practical session reports, final exam covering lectures, tutorials and practical sessions

Prerequisites Null

Code Y4ESI271

1.2.4.2 Electro-kinetics 1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Electro-kinetics 1	CDS	8	10	8	0	0	30	26	49	75	3

Content

* Laws governing steady-state operation
* Laws governing first-order transient response
* Laws governing steady-state sinusoidal operation applied to RLC circuits of all kinds

Module objectives/intended learning outcomes

Master

* Representation of sinusoidal quantities
* Complex impedance, Ohm's and Kirchhoff's laws in steady-state sinusoidal conditions
* Power in steady-state sinusoidal conditions
* Resonant and anti-resonant circuits

Language English

Relation to curriculum Compulsory

Responsible Didier Chamagne

Examination form written tests in tutorials, practical reports and final exam

Prerequisites Null

Code Y4ESI272

1.2.5 Newtonian physics

1.2.5.1 Newtonian physics 1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Newtonian physics 1	FD	10	8	15	0	0	38	33	67	100	4

Content

The mechanics discussed here relate exclusively to point mechanics. In practice, this concerns physical objects with a very small spatial extent

· Analysis of the most common forces
· The art of locating objects and kinematics
· The basic principles of point dynamics (Newton's laws)

Module objectives/intended learning outcomes

Be able to relate the motion of a system of points to the forces acting upon it.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form

Prerequisites Null

Code Y4ESI281

1.2.5.2 Newtonian physics 2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Newtonian physics 2	FD	10	10	0	0	0	25	20	30	50	2

Content

The mechanics discussed here relate exclusively to point mechanics. In practical terms, this concerns physical objects with a very small spatial extent.

This Part 2 builds on the concepts covered in Part 1.
· The moment of a force and angular momentum
· Energy

Module objectives/intended learning outcomes

Know how to use certain methods (conservation of angular momentum, conservation of mechanical energy) to solve certain problems more easily.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form 0

Prerequisites Null

Code Y4ESI282

1.2.6 Engineering Sciences 2

1.2.6.1 Electro-kinetics 2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Electro-kinetics 2	CDS	8	10	8	0	0	30	26	49	75	3

Content

* Continuous-current linear circuits; Transfer function; Operational amplifier.
* Types of filters: low-pass, high-pass, band-pass, band-stop.

Module objectives/intended learning outcomes

Understand the concept of a transfer function, know how to calculate and identify a transfer function, and recognise the type of filter.

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form Written tests in tutorials, practical session reports, final exam covering lectures, tutorials and practical sessions

Prerequisites Null

Code Y4ESI291

1.2.6.2 Mechanics and Engineering

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Mechanics and Engineering	CDS	6	6	15	0	0	30	27	48	75	3

Content

Mechanics is approached here from a technological perspective, explaining the criteria used in design:

· Real and ideal mechanical joints
· Contact pressure, work hardening and seizing
· Smooth joints and full-contact joints

Module objectives/intended learning outcomes

To be able to validate the design of a mechanical connection in a simplified context

Language Not specified

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form Written tests in tutorials, practical reports and final exam

Prerequisites Null

Code Y4ESI292

1.2.7 Cross-disciplinary

1.2.7.1 Socio-ecological issues

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Socio-ecological issues	SECO	10	10	0	0	0	25	20	30	50	2

Content

Presentation of key socio-ecological issues and group-based research based on a list of topics

Module objectives/intended learning outcomes

This module aims to develop an understanding of major socio-ecological challenges and the ability to address them in a multidisciplinary and systemic manner. The key issues covered are: climate change, biodiversity loss, resource availability, planetary boundaries, just transitions and social equity, environmental health, drivers and barriers to change, and transition scenarios.

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Multiple-choice questions, oral presentations

Prerequisites Null

Code Y4ESI2X1

1.2.7.2 Career planning workshop

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Career planning workshop	SECO	0	0	6	0	0	6	6	19	25	1

Content

* Professional written communication: writing a CV, an email, a letter, etc.
* Oral communication skills.

Module objectives/intended learning outcomes

Mastering spoken and written French

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form practical report, oral exam

Prerequisites Null

Code Y4ESI2X2

1.2.7.3 English

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	English	SECO	0	22	0	0	0	22	22	53	75	3

Content

General and specialised English, drawing on topics relevant to the students' core study programmes (SPI, energy and industry, technological innovations, environmental issues, etc.) and current affairs; activation of linguistic resources (lexical, phonological, syntactic, grammatical) through oral and written language practice, in both reception and production, notably through tasks based on audio and/or video materials; activities to enrich and put vocabulary into practice; practice in reading and understanding various articles; essay writing; structural/formal grammar exercises

Module objectives/intended learning outcomes

Learning objectives

· To activate linguistic resources (vocabulary, pronunciation, syntax and grammar) through spoken and written practice of the language

· To understand, analyse and summarise information for use in written and/or spoken communication

· To engage in simple conversation in English in everyday or subject-specific contexts, to rephrase, express an opinion and take a stance

Language English

Relation to curriculum Compulsory

Responsible Fanny Lalevee

Examination form Written and oral assessments in tutorials, final exam

Prerequisites Null

Code Y4ESI2X3

1.2.8 Professional integration CMI1

1.2.8.1 Experience and Skills Portfolio (PEC)

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Experience and Skills Portfolio (PEC)	SECO	0	0	6	0	0	6	6	19	25	1

Content

* Use the PEC tool
* Define the concepts of skills, occupations and sectors within the PEC tool and begin an assessment.

Module objectives/intended learning outcomes

Students must be able to master the PEC tool.

Language English

Relation to curriculum Compulsory

Responsible Daniel Hissel

Examination form report

Prerequisites Null

Code Y4ECH281

1.2.8.2 Expression Communication

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Expression Communication	SECO	0	12	0	0	0	12	12	38	50	2

Content

* Work independently when writing: think critically, express ideas clearly, organise knowledge, and structure a text.
* Use correct syntax and spelling
* Oral communication techniques.
* Identify non-verbal communication cues.
* Construct and illustrate a presentation suited to the subject, circumstances and audience.
* Professional written communication: drafting a CV, an email, a letter...

Module objectives/intended learning outcomes

Mastering spoken and written French

Language Not specified

Relation to curriculum Compulsory

Responsible Daniel Hissel

Examination form written and oral reports and tests

Prerequisites Null

Code Y4ECH282

1.2.9 Laboratory R&D CMI1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
2	Laboratory R&D CMI1	SC	0	16	0	0	0	16	16	59	75	3

Content

Laboratory-based R&D is a team-based project focusing on a topic related to the research activities of the CMI programme being studied.

The aim is to gain hands-on experience in project management, to familiarise students with the research challenges associated with the programme's discipline, and to organise a scientific dissemination event aimed at a specific audience.

Module objectives/intended learning outcomes

Three key objectives:

* To explore the challenges of R&D and innovation by organising a research project whilst working in different professional environments:

- small design offices (start-ups / SMEs / associations / organisations)
- R&D departments (major industrial groups), local authorities, government departments, etc.
- research laboratory (universities / national research bodies)

* Learn to manage, organise and successfully complete a project

* Acquire new skills (being open to others, interacting, etc.)

Language English

Relation to curriculum Compulsory

Responsible

Examination form

Prerequisites Null

Code Y4ECH2M9

CMI 2

2.1 Semester 3

2.1.1 Information Math Applied to Science 1

2.1.1.1 Mathematical tools 1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Mathematical tools 1	FD	7	18	0	0	0	28	25	50	75	3

Content

Matrix algebra and vector spaces,
Linear transformations, the matrix of a linear transformation and change of basis,
Determinants, characteristic polynomials, diagonalisation (and trigonisation) of a matrix, Gaussian reduction,
Examples of the application of diagonalisation to power calculations,
Examples of the application of diagonalisation to the solution of differential equations.

Module objectives/intended learning outcomes

Students will master the mathematical tools required to solve problems encountered in physics. The focus is on practical applications in conjunction with the specialised course content.

Language Not specified

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form Continuous assessment

Prerequisites Null

Code Y4ESI311

2.1.1.2 IT 1

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	IT 1	FD	10	10	10	0	0	35	30	45	75	3

Content

The aim of this module is to build on the foundations of algorithms and Python programming covered in the first year. Functional programming, object-oriented programming and recursion are explored within a scientific context.

Module objectives/intended learning outcomes

Students will master the basics of programming and will be able to reuse all or part of an existing library to solve a specific problem. The practical work focuses on a project defined in collaboration with the students.

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Continuous assessment

Prerequisites Null

Code Y4ESI312

2.1.2 Engineering Sciences 1

2.1.2.1 Structural design

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Structural design	CDS	10	11	7	0	0	33	28	46	75	3

Content

Strength and deformation in materials: the specific case of beams.
Cohesion tensor: relationship between external and internal forces.
Displacement, deformation: expansion and slippage.
Stresses: stress vector, components. Behavioural laws: longitudinal and transverse moduli of elasticity.
Results for specific cases of cohesion torques: simple stresses (tension, torsion, pure bending and simple bending).

Strength criteria.
Introduction to plane elasticity: Mohr's circle.
Introduction to strain gauging: strain gauge set-ups.

Module objectives/intended learning outcomes

The student will be able to calculate the displacements and deflections of a beam under load. They will have acquired the skills required to assess the strength and design a beam or similar structures.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form Questions in tutorials, practical report, practical exam
Final exam

Prerequisites Null

Code Y4ESI321

2.1.2.2 Solid mechanics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Solid mechanics	CDS	10	11	7	0	0	33	28	46	75	3

Content

Mechanics: the case of a material system, the special case of a rigid body.

Kinematics: equiprojectivity, velocity field, plane-to-plane motion in the case of a rigid body. Geometry of masses: centre of inertia, barycentric relation, inertia operator of a rigid body. Kinetic theory: kinetic torus, relations in the case of a rigid body, conservation of angular momentum. Dynamics: dynamic torque, relations between angular momentum and dynamic momentum, Galilean and approximate reference frames: PFD.

Energy: power, work, potential energy, kinetic energy, expressions in the case of a rigid body, kinetic energy theorem, first integral.

Module objectives/intended learning outcomes

The student will have a thorough understanding of parameterisation and the calculation of trajectory, velocity and acceleration.

They will be able to calculate forces acting on a body undergoing accelerated motion.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form quizzes in tutorials, practical report, practical exam

final exam

Prerequisites Null

Code Y4ESI322

2.1.3 Physics and Energy 1

2.1.3.1 Thermodynamics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Thermodynamics	CDS	12	10	9	0	0	37	31	44	75	3

Content

Definition of a thermodynamic system. Thermodynamic variables. The equation of state and its validity. Ideal gases and real gases. First law, heat, internal energy, enthalpy. Second law, concept of entropy. Applications to thermal machines (engines and refrigeration cycles), efficiency of thermal machines. Thermodynamics: thermal metrology. Calorimetry.

Module objectives/intended learning outcomes

The student will be able to define a thermodynamic system and carry out energy and entropy balances.

They will be able to analyse the operation of a simple heat engine and will have acquired a basic understanding of calorimetry

Language English

Relation to curriculum Compulsory

Responsible Raynal Glises De La Riviere

Examination form quizzes in tutorials, lab reports, lab exams

final exam

Prerequisites Null

Code Y4ESI331

2.1.3.2 Fluid mechanics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Fluid mechanics	CDS	13	14	0	0	0	33	27	48	75	3

Content

Fluid statics: Pressure at a point in a fluid; Fundamental equation of fluid statics: incompressible fluid in a gravitational field (hydrostatics); Pressure forces on a wall; Archimedes' forces; Compressible fluid in a gravitational field; Application to the atmosphere; Surface tension phenomena; Laplace's formula. Angles of connection. Jurin's law.

Fluid kinematics: Definitions; Lagrangian description; Eulerian description; Trajectory; Streamline; Planar flow of an ideal incompressible fluid: Solutions to Laplace's equation; Analytic functions; Examples; Superposition of multiple flows; Potential flows with circulation; Example of flow around a plane

Module objectives/intended learning outcomes

The student will have acquired a basic understanding of fluid mechanics

Language English

Relation to curriculum Compulsory

Responsible Jean-Claude Roy

Examination form quizzes in tutorials

final exam

Prerequisites Null

Code Y4ESI332

2.1.4 Physics and EEA 1

2.1.4.1 Automatic

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Automatic	CDS	10	9	9	0	0	33	28	47	75	3

Content

Study of continuous-time linear systems: definition, complex form, transfer function and associated representations (Bode, Black-Nichols, Nyquist), Laplace form, study of first- and second-order systems (frequency and time domain analysis).

Study of control systems:

structure: action chain, reaction chain, setpoint, comparator; accuracy of control systems: system class, static error, tracking error; stability of control systems

Module objectives/intended learning outcomes

The student will have acquired a basic understanding of continuous-time linear control systems.

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form quizzes in tutorials, lab reports, lab exams
final exam

Prerequisites Null

Code Y4ESI341

2.1.4.2 Electronics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Electronics	CDS	10	9	9	0	0	33	28	47	75	3

Content
Diode: characteristics, static behaviour and small-signal dynamics. Operational amplifier: characteristics, linear behaviour, non-linear behaviour, linear circuits.
Bipolar transistor: characteristics, linear and cut-off/saturation behaviour, biasing, dynamic model, amplifier circuits.

Module objectives/intended learning outcomes
The student will have acquired a basic understanding of analogue electronics.

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form quizzes in tutorials, lab reports, lab exams
final exam

Prerequisites Null

Code Y4ESI342

2.1.5 Cross-disciplinary S3

2.1.5.1 Career planning workshop

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Career planning workshop	SECO	0	0	5	0	0	5	5	20	25	1

Content
Implementing the PEC approach Using the PEC tools Defining the concepts of skills and job roles, and refining the skills assessment

Module objectives/intended learning outcomes
The aim is to help students develop their career plans

Language Not specified

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form written report and/or oral presentation

Prerequisites Null

Code Y4ESI351

2.1.5.2 Documentary research project

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Documentary research project	SECO	0	0	4	0	0	4	4	21	25	1

Content

Methodological literature review supported by the University Library to assist with topics selected for supervised technical projects in the third and fourth semesters.
To develop skills in conducting literature reviews and familiarise oneself with the available research tools

Module objectives/intended learning outcomes

To provide students with methodological guidance and tools for conducting literature reviews.

Language Not specified

Relation to curriculum Compulsory

Responsible

Examination form Available

Prerequisites Null

Code Y4ESI352

2.1.5.3 Tutored technical project S3

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Tutored technical project S3	SECO	0	0	0	0	0	0	0	25	25	1

Content

A bibliographic, theoretical and experimental project of a general nature within a discipline chosen by the student (mechanics, energy, etc.). Topics are selected in such a way that students are encouraged to apply and build upon the knowledge covered in lectures. Practical implementation is strongly encouraged. Supervision is provided by lecturers and research staff. The project will be supplemented by a review of scientific literature.

Module objectives/intended learning outcomes

Develop the ability to analyse a problem and find solutions Learn how to search for scientific literature Work as part of a team

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form to be submitted in the form of a written report and an oral examination.

Prerequisites Null

Code Y4ESI353

2.1.5.4 English S3

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	English S3	SECO	0	25	0	0	0	25	25	50	75	3

Content

General and academic English; specialised English based on topics relevant to the student's field of study (SPI; energy and industry; technological innovations; environmental issues); activities focusing on comprehension and written and oral expression (individual continuous speech presentations and/or interactive debates on current affairs covering the major areas of discussion in our societies); understanding the requirements of language certification

Module objectives/intended learning outcomes

To master the skills required to understand and express oneself in everyday and professional situations (general, scientific and technical English); to apply these skills in comprehension, production and interaction (both oral and written)

Language English

Relation to curriculum Compulsory

Responsible Fanny Lalevee

Examination form Continuous assessment

Prerequisites Null

Code Y4ESI354

2.1.6 International relations

2.1.6.1 English CMI2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	English CMI2	SECO	0	12	0	0	0	12	12	38	50	2

Content

Developing proficiency in specialist English

§ Approach

· Teaching will be based on specialist texts

· Oral presentation (with submission of a portfolio)

· Preparation for the TOEIC exam, which will take place in semester 6

Module objectives/intended learning outcomes

§ Objectives

· To be able to read and analyse scientific literature in English

· To write and express oneself in English

Language English

Relation to curriculum Compulsory

Responsible Fabienne Halm

Examination form quizzes in tutorials

Prerequisites Null

Code Y4ECH361

2.1.6.2 Professional integration CMI2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Professional integration CMI2	SECO	0	8	0	0	0	8	8	17	25	1

Content

* Implementing the PEC approach
* Introduction to research at the FEMTO Laboratory (Department of Electrical Engineering)

Module objectives/intended learning outcomes

Discover what makes the CMI H3E unique

Language English

Relation to curriculum Compulsory

Responsible Daniel Hissel

Examination form project progress report

Prerequisites Null

Code Y4ECH362

2.1.7 Electrochemistry

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
3	Electrochemistry	SC	8	10	0	0	0	22	18	57	75	3

Content

First law: internal energy, enthalpy, heat capacity, latent heat of phase change

Second law: entropy, free enthalpy

Law of mass action, application to chemical equilibria: laws governing the shift of chemical equilibria

Module objectives/intended learning outcomes

Aim of the lesson: to understand the various factors that can influence a chemical reaction and to be able to predict how these factors will affect a chemical reaction.

Language English

Relation to curriculum Compulsory

Responsible Jean-Pierre Verovic

Examination form quizzes in tutorials
final exam

Prerequisites Null

Code Y4ECH3M7

2.2 Semester 4

2.2.1 Information Math Applied to Science 2

2.2.1.1 Mathematical tools 2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Mathematical tools 2	FD	10	32	0	0	0	47	42	83	125	5

Content

Numerical series, integer series, Fourier series, applications to physical systems; - Matrix exponential; - Fourier and Laplace transforms, applications to the solution of ODE and PDE; - Partial differential equations (Laplace's equation, the diffusion equation, the wave equation, etc.).

Module objectives/intended learning outcomes

Students will master the mathematical tools required to solve problems encountered in physics. The focus is on practical applications in conjunction with the specialised modules.

Language English

Relation to curriculum Compulsory

Responsible

Examination form tests in tutorials,
final exam

Prerequisites Null

Code Y4ESI461

2.2.1.2 IT 2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	IT 2	FD	0	0	10	0	0	10	10	15	25	1

Content

Advanced use of IT tools: word processing, spreadsheets, presentations Use of IT tools in the fields of mathematics and physics (mechanics, thermodynamics, control systems, etc.)

Module objectives/intended learning outcomes

The student will become proficient in various IT tools required in a range of fields: mathematics, physics

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form quizzes in tutorials, lab reports, lab exams
final exam

Prerequisites Null

Code Y4ESI462

2.2.2 Engineering Sciences 2

2.2.2.1 Industrial Computing

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Industrial Computing	CDS	10	10	8	0	0	33	28	47	75	3

Content

Combinational logic. Multiplexing, demultiplexing, encoding, decoding, adders, combinational circuits. Sequential logic: counters, flip-flops, shift registers. Programmable logic circuits (ASICs) and programmable logic devices (PALs, PLDs, CPLDs, FPGAs)

Module objectives/intended learning outcomes

The student will have acquired a basic understanding of logic, enabling them to go on to understand industrial automation

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form quizzes in tutorials, lab reports, lab exams
final exam

Prerequisites Null

Code Y4ESI471

2.2.2.2 Industrial Automation

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Industrial Automation	CDS	10	10	8	0	0	33	28	47	75	3

Content

Introduction to automated technical systems: Study and functional analysis of an automation system; Concepts of the Operational Unit (OU) and Control Unit (CU); Industrial Programmable Logic Controllers (PLCs) and PC/OU interfacing; PLC programming languages: Ladder, Grafcet; Study of Grafcet; Examples of applications and implementation of an automation system

Module objectives/intended learning outcomes

The aim is to master the functional analysis of an automated technical system, known as industrial automation, with a view to its implementation or maintenance.

Language Not specified

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form quizzes in tutorials, lab reports, lab exams
final exam

Prerequisites Null

Code Y4ESI472

2.2.3 Physics and Energy 2

2.2.3.1 Radiation physics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Radiation physics	CDS	10	8	0	0	0	23	18	57	75	3

Content

1/ From Maxwell's equations to electromagnetic waves in a vacuum2/ Vibration modes of a cavity 'filled' with vacuum3/ Radiated energy – spectra4/ The concept of a black body5/ Quantisation of energy – Planck's law6/ Thermal radiation: flux, intensity, exitance, luminance, illuminance7/ Exercises and application problemsThe applications cover fundamental topics such as the calculation of solid angles, radiative exchange between arbitrarily oriented surfaces, and the absorption/transmission of semi-transparent media. Practical exercises focusing on radiation sources (sun, radiator, electric bulb, oven, flame), propagation media (vacuum, vapours (CO2, H2O), solids (glass)) and receivers (surfaces, sensors) help students become familiar with basic definitions and concepts. Determining the temperature of planets, modelling the greenhouse effect, ocean absorption and albedo phenomena form a set of applied problems designed to provide the keys to understanding a significant part of the physical mechanisms at work in climate change.
Prerequisites: Maxwell's equations in a vacuum. Thermodynamics of ideal gases.

Module objectives/intended learning outcomes

Understanding the origin of thermal radiation and the physical laws that govern it. An introduction to quantum physics.

Language English

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form Written tests

Prerequisites Null

Code Y4ESI481

2.2.3.2 Heat transfer

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Heat transfer	CDS	10	12	15	0	0	42	37	38	75	3

Content

Overview of energy transfer. Heat generation. Introduction to heat transfer by convection, conduction and radiation. Heating and cooling of solids and fluids. Basic modelling of heat exchange in systems. Certain industrial and everyday problems will be addressed through textbook examples, enabling rapid and satisfactory results to be obtained for realistic orders of magnitude.

Module objectives/intended learning outcomes

Students will be able to create simplified models of phenomena and systems (machines, industrial processes) based on heat balances requiring basic mathematical formulations.

Language English

Relation to curriculum Compulsory

Responsible Laurent Thiery

Examination form quizzes in tutorials, lab reports, lab exams
final exam

Prerequisites Null

Code Y4ESI482

2.2.4 Physics and EEA 2

2.2.4.1 Electrical Engineering

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Electrical Engineering	CDS	12	10	8	0	0	36	30	45	75	3

Content
Single-phase transformer: principle, power balance and Kapp's law Induction motor: principle, equivalent electrical circuit, power balance

Module objectives/intended learning outcomes
To acquire a basic understanding of electrical engineering and to master the operating principles of common electrical machines (DC motors, single-phase transformers and induction motors).

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form quizzes in tutorials, lab reports, lab exams
final exam

Prerequisites Null

Code Y4ESI491

2.2.4.2 Electromagnetism

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Electromagnetism	CDS	15	16	0	0	0	38	31	44	75	3

Content
1/ The role of electromagnetism in physics: Fundamental interactions; Electric charge and current; Maxwell's equations 2/ Vacuum electrostatics: Force, field, potential and electrostatic energy; Generalisation: linear, surface and volume charge distributions 3/ Concepts of electrostatics in matter: Conductors at equilibrium; the phenomenon of influence; capacitanceElectrostatic dipoles Dielectrics: polarisation, depolarising field 4/Vacuum magnetostaticsOrigin of magnetism Force, field, vector potential and magnetic energyMagnetic dipole5/Concepts of magnetostatics in matter: Magnetised materials: magnetisation, magnetic field and excitation Concepts relating to magnetic materials: paramagnetic, diamagnetic and

ferromagnetic 6/Electrodynamics in the quasi-steady-state approximation: Induction phenomena, electromotive force, Lenz's law and applications

Module objectives/intended learning outcomes

The student will have gained an understanding of electromagnetic phenomena in a vacuum and in matter.

Language English

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form tutorial questions

final exam

Prerequisites Null

Code Y4ESI492

2.2.5 Cross-disciplinary S4

2.2.5.1 Corporate culture

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Corporate culture	SECO	0	10	0	0	0	10	10	15	25	1

Content

1. Introduction to Management: The Organisation and its Stakeholders. (15 hours)

The organisation, its objectives, its functions and how they interrelate

- Introduction to business strategy
- Different types of organisations, organisational structures and main legal forms
- The organisation and its stakeholders
- The organisation within its sector: the concept of the value chain
- Inter-firm relations: competition and cooperation

Module objectives/intended learning outcomes

Place a business or organisation within its socio-economic context; identify key contacts and the various roles within an organisation

Language English

Relation to curriculum Compulsory

Responsible Sasa Radosavljevic

Examination form tests

final exam

Prerequisites Null

Code Y4ESI4X1

2.2.5.2 General culture

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	General culture	SECO	0	10	0	0	0	10	10	15	25	1

Content

- Epistemology and history of science
- Ethics lectures
- Citizenship and environmental citizenship, professional ethics

Module objectives/intended learning outcomes

To provide students with general knowledge

Language English

Relation to curriculum Compulsory

Responsible Igor Agbossou

Examination form written report

Prerequisites Null

Code Y4ESI4X2

2.2.5.3 English S4

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	English S4	SECO	0	22	0	0	0	22	22	28	50	2

Content

Continuation of Term 3 activities: Expansion of vocabulary and language skills related to engineering sciences; individual or group presentations of scientific documents or projects; introduction to the requirements of the TOEIC certification

Module objectives/intended learning outcomes

TOEIC score of 720

Language English

Relation to curriculum Compulsory

Responsible Claire Greber

Examination form

Prerequisites Null

Code Y4ESI4X3

2.2.5.4 Tutored technical project S4

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Tutored technical project S4	SECO	0	0	0	0	0	0	0	50	50	2

Content

Continuation of the third-semester project: A broad-based bibliographic, theoretical and experimental study within a discipline chosen by the student (mechanics, energy, etc.). Topics are selected in such a way that students are required to apply and build upon the knowledge covered in lectures. A practical project is strongly encouraged. Supervision by lecturers and research staff. The project is complemented by a review of scientific literature.

Module objectives/intended learning outcomes

Develop the ability to analyse a problem and find solutions Learn how to search for scientific literature Work as part of a team

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form to be submitted in the form of a written report and an oral examination.

Prerequisites Null

Code Y4ESI4X4

2.2.6 Chemistry

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Chemistry	SC	8	10	0	0	0	22	18	57	75	3

Content

Redox equilibria in solution, electrochemical cells, potentiometry, E-pH diagram; Ellingham diagrams

Module objectives/intended learning outcomes

Students will have acquired the basic knowledge needed to understand fuel cells

Language Not specified

Relation to curriculum Compulsory

Responsible Jean-Luc Sanner

Examination form quizzes in tutorials

final exam

Prerequisites Null

Code Y4ECH4M8

2.2.7 Laboratory R&D CMI2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
4	Laboratory R&D CMI2	SC	0	16	0	0	0	16	16	59	75	3

Content

Laboratory-based R&D is a team-based project focusing on a topic related to the research activities of the CMI programme being studied.

The aim is to gain hands-on experience in project management, to familiarise students with the research challenges associated with the programme's discipline, and to organise a scientific dissemination event aimed at a specific audience.

Module objectives/intended learning outcomes

Three key objectives:

* To be able to debrief as a group.
* To carry out an individual and collective review of the activity undertaken.
* To be able to present a written and oral review of the activity

Language English

Relation to curriculum Compulsory

Responsible

Examination form

Prerequisites Null

Code Y4ECH4M9

CMI 3

3.1 Semester 5

3.1.1 Applied mathematics

3.1.1.1 Numerical analysis

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Numerical analysis	FD	9	4	12	0	0	29	25	50	75	3

Content

Introduction, matrix operations, the concept of condition number

Solving specific systems, triangular systems, tridiagonal systems

Gauss's algorithm, LU decomposition, Ordinary Differential Equations, Problems: Initial conditions, Problems: Boundary conditions

Euler's method (Explicit, Implicit), Runge-Kutta method, Order 2 and 4

Multi-step methods (Adams)

Module objectives/intended learning outcomes

By the end of the course, students will be able to apply standard numerical methods to solve physics problems (thermal and electrical). Students will be able to select the appropriate method depending on the problem at hand. For example, in the case of ODE, they will favour implicit methods over explicit methods wherever possible. All the techniques covered are applied to practical problems in tutorials or practical sessions.

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST511

3.1.1.2 Mathematics for engineers

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Mathematics for engineers	FD	13	16	0	0	0	35	29	46	75	3

Content

First-order differential equations (revision)

Second-order linear differential equations with constant coefficients

Systems of first-order linear differential equations and differential equations of order higher than two

The Laplace transform, application to the solution of differential equations and systems of differential equations

Probability: general principles and random variables (revision)

Classical probability distributions, including the normal distribution and its application to subject-specific problems

Module objectives/intended learning outcomes

Solve first- and second-order differential equations analytically

Linearise physical phenomena around an equilibrium point and model them mathematically

Master various techniques for the analytical solution of differential equations or systems of differential equations

Understand the classical laws of probability

Understand the fundamental probabilistic concepts found in signal processing and reliability analysis

Master the probabilistic approach to solving equations (random variables, variance, standard deviation, etc.)

Language English

Relation to curriculum Compulsory

Responsible Emmanuel Cote

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST512

3.1.2 Thermodynamics and energy conversion

3.1.2.1 Thermal and mechanical energy conversion

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Thermal and mechanical energy conversion	CDS	7	8	0	0	0	18	15	35	50	2

Content

An overview of the global energy situation, fossil fuel consumption, calorific values and CO2 emissions. Conversion of heat into mechanical energy, mechanical systems for the conversion of process heat, and thermodynamic cycles.

Module objectives/intended learning outcomes

Understand and be able to work with the units used for different energy sources.

Estimate the amounts of heat released.

Work with conversion efficiencies from heat to mechanical energy.

Understand the basic principles of operation of the main devices that convert heat into mechanical energy (engines, turbines, etc.).

Language English

Relation to curriculum Compulsory

Responsible Jean-Claude Roy

Examination form Continuous assessment

Prerequisites Null

Code Y4EST521

3.1.2.2 Advanced thermodynamics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Advanced thermodynamics	CDS	15	10	8	0	0	40	33	17	50	2

Content

Firstly, the use of the differential and integral forms of the first and second laws of thermodynamics enables the derivation of the equations required to perform mechanical and thermal energy balances on solid and single-phase fluid systems. Secondly, the thermodynamics of open systems in steady-state and transient conditions is addressed. Phase-change phenomena in thermal machines are covered in the third part through thermodynamic balances (state functions, Clapeyron's and Rankine's laws) and the use of thermodynamic diagrams (T-s, h-s, h-logP).

Module objectives/intended learning outcomes

Be able to perform a thermodynamic analysis using differential and integral forms for a system (closed, open). Use thermodynamic tables for fluids. Interpret thermodynamic diagrams

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST522

3.1.2.3 ELC3 – Thermodynamics principles

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	ELC3 – Thermodynamics principles	CDS	15	10	4	0	0	36	29	21	50	2

Content

Thermodynamics of closed systems: Definition of thermodynamic systems. Temperatures and heat fluxes. Isobaric, isochoric, isothermal, adiabatic and polytropic processes. Thermodynamic cycles. First law. Second law of thermodynamics: Clausius's statement. Two-state and multi-state machines: thermodynamic efficiency, Carnot efficiency. Entropy of irreversible processes. Thermodynamics of open systems: Chemical potential, Gibbs energy, two-phase binary diagrams.

Module objectives/intended learning outcomes

Designing two-phase thermodynamic systems such as engines, heat pumps and refrigeration machines.
Understanding how to define efficiency in order to propose fundamental improvements.
Mastering the scientific tools required to design other types of thermodynamic systems, particularly for cogeneration applications.

Language English

Relation to curriculum Compulsory

Responsible Raynal Glises De La Riviere

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST523

3.1.3 Transfers and flows principles

3.1.3.1 Heat transfer - Stationary conduction

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Heat transfer - Stationary conduction	CDS	12	16	4	0	0	38	32	18	50	2

Content

Review, definitions and basic concepts; Fourier's law, Newton's law, the heat equation. One-dimensional and steady-state heat conduction problems in Cartesian, cylindrical and spherical coordinates. Concepts of thermal resistance and electrical equivalence. Conductive-convective coupling: fin theory. Solid-solid coupling: contact resistance.

Module objectives/intended learning outcomes

Understand how to draw up a thermal balance and solve it under steady-state conditions.

Language English

Relation to curriculum Compulsory

Responsible Laurent Thiery

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST531

3.1.3.2 Perfect fluid dynamics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Perfect fluid dynamics	CDS	17	10	8	0	0	43	35	15	50	2

Content

Study of ideal fluid flow:
Momentum balance in a fluid control volume; Euler's theorem
Applications to machinery
Bernoulli's equation
Study of internal flow, pressure losses

Module objectives/intended learning outcomes

Model a flow comprehensively and determine fluid-machine interactions
-Determine the characteristics of an internal flow using Bernoulli's equation
-Determine pressure losses in an internal flow
-Use Euler's equation to model fluid-machine interactions
-Design simple energy conversion devices (pumps, wind turbines, etc.)

Language English

Relation to curriculum Compulsory

Responsible Jean-Claude Roy

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST532

3.1.3.3 Heat transfer - Convection

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Heat transfer - Convection	CDS	7	8	4	0	0	22	19	31	50	2

Content

Physical phenomena, the concept of dynamic and thermal boundary layers, definition of the Nusselt number, correlations for flat plates and cylinders in external forced convection, Reynolds analogy. Practical case studies.

Module objectives/intended learning outcomes

Be able to calculate heat transfer by forced convection in simple cases. Determine a convective heat transfer coefficient for externally forced flow in standard geometries (flat plate, cylinder). Be able to select an appropriate correlation based on the data for the case study.

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Continuous and final assessment

Prerequisites Null

Code Y4EST533

3.1.4 Instrumentation and industrial computing

3.1.4.1 Instrumentation, measurement, sensors

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Instrumentation, measurement, sensors	CDS	10	9	15	0	0	39	34	41	75	3

Content

Sensors and the data acquisition system

Electrical and non-electrical quantities; Definitions and general principles of sensors; Different types of sensors (passive, active, digital, smart, composite); Physical phenomena used in sensors (law of electromagnetic induction, Hall effect, thermoelectric effect, magnetoresistive effect, photoelectric effect, piezoelectric effect, Doppler effect, etc.); Overall structure of a complete measurement chain: acquisition, processing, output.

Metrological characteristics

Sensitivity, linearity, calibration curve, resolution, speed, response time and bandwidth, operating limits, calibration-measurement range, nominal operating range, non-deterioration zone, measurement errors, criteria for selecting a sensor.

Passive sensor conditioners

General characteristics of passive sensor conditioners; Potentiometric circuit (measurement of resistances, measurement of complex impedances, disadvantages of the potentiometric circuit); Bridge circuit (Wheatstone bridge, complex bridges: Sauty bridge, Maxwell bridge); oscillators.

Introduction to sensor dynamics

Order 0, 1 and 2 sensors. Dynamic characteristics. Interpretation of measured quantities.

Module objectives/intended learning outcomes

The overall aim of this module is to explain the physical principles behind various sensors, to outline their characteristics and their application within a measurement chain.
By the end of this module, students will be able to:
-Select a sensor based on the physical quantity being measured and its order of magnitude
-Interpret a sensor's technical documentation
- Plot a sensor's calibration curve
- Condition a passive sensor
- Condition the measurement signal: filtering, amplification, linearisation
- Implement a reliable measurement using a sensor
- Interpret a sensor's technical documentation
- Programme measurement acquisitions in LabVIEW

Language English

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST541

3.1.4.2 Thermal and fluid metrology

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Thermal and fluid metrology	CDS	10	8	0	0	0	23	18	32	50	2

Content

Introduction to the measurement of physical quantities in thermofluidics: temperature, velocity (or flow rate) and pressure. Physical principles of sensors. Issues relating to errors inherent in thermal measurements, whether contact or non-contact.

Module objectives/intended learning outcomes

Understand how various sensors work in the fields of thermal engineering and fluid mechanics. Know how to use sensors in different industrial environments.

Language English

Relation to curriculum Compulsory

Responsible Laurent Thiery

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST542

3.1.4.3 Computer Science for Engineers

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Computer Science for Engineers	CDS	0	0	12	0	0	12	12	13	25	1

Content

Use of spreadsheet, word processing and presentation software to process, interpret and present measurement results.

Module objectives/intended learning outcomes

Report writing. Presentation of results. Interpretation of measurement results.

Language English

Relation to curriculum Compulsory

Responsible Dimitri Bonnet

Examination form Terminal control

Prerequisites Null

Code Y4EST543

3.1.5 Knowledge of the professional environment

3.1.5.1 Career planning workshop

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Career planning workshop	SECO	0	0	9	0	0	9	9	16	25	1

Content

Methodology of the Portfolio of Experiences and Skills (PEC)
PEC support, self-assessment, techniques for finding work placements and jobs

Module objectives/intended learning outcomes

Assessing your situation, developing a plan, understanding the job market

Language English

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form Formative assessment, summative assessment

Prerequisites Null

Code Y4EST551

3.1.5.2 English

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	English	SECO	0	30	0	0	0	30	30	95	125	5

Content

To develop students' ability to analyse and interpret audio and written materials by listening to and reading a variety of resources related to current affairs, everyday life or the student's field of study. To consolidate the correct use of syntactic, grammatical and phonological rules and to expand students' vocabulary (practical exercises + oral and written interaction)

Module objectives/intended learning outcomes

Recognise, use and expand general and academic vocabulary; - Understand the nuances and structure of written and audio materials; - Write in a structured manner; - Be able to speak in public with confidence (present and defend a viewpoint, discuss an argument or topic in a critical and organised manner)

Language English

Relation to curriculum Compulsory

Responsible Claire Greber

Examination form

Prerequisites Null

Code Y4EST552

3.1.6 Disciplinary reinforcement

3.1.6.1 Cogeneration

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Cogeneration	CDS	6	6	4	0	0	19	16	34	50	2

Content

Thermodynamic cycles of machines with external heat input (Stirling, Ericsson, thermoacoustic, magnetocaloric). Thermal and electrical balances applied to machines that simultaneously produce heat (hot, cold) and electricity.

Module objectives/intended learning outcomes

To familiarise oneself with the various cogeneration systems currently available on the market.

To understand their applications in residential settings, electricity generation and multi-source energy production.

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4ECH561

3.1.6.2 Similarity and dimensional analysis

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Similarity and dimensional analysis	CDS	6	4	0	0	0	13	10	40	50	2

Content

Concepts of dimensions and units

Concepts of similarity / dimensionless groups

Pi theorem / matrix approach

Application of the pi theorem: the Rayleigh, Huntley and Siano method

Module objectives/intended learning outcomes

Studying a phenomenon without prior knowledge

Being able to carry out experimental measurements that corroborate the dimensional analysis

Introducing the appropriate dimensionless groups

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Formative assessment, summative assessment

Prerequisites Null

Code Y4ECH562

3.1.7 Project management

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Project management	SECO	0	16	0	0	0	16	16	34	50	2

Content

This teaching unit takes the form of flipped learning, revisiting the topic of project management, given that students undertook an R&D project during their second year of the degree.

Project management:

- Driving change (Strebel's equation): incremental change and a shift in logic – Measuring progress and drafting an activity report
- Chairing meetings: distinguishing between types of meetings; why hold a meeting? Should you convene or invite?
- Using facilitation tools.
- Managing difficult situations.
- Producing a report and an action plan.
- Using techniques to facilitate larger groups (Phillips 6X6, World Café, etc.)
- Using a Metaplan, brainstorming or other creativity tools.
- Defining a problem, then setting up a project approach, the role of the project manager and an introduction to project methodology, the concept of a patent

Module objectives/intended learning outcomes

- Acquire and master management tools.

Language English

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form - Written or oral theory test.

- Continuous assessment in the form of written or oral tests, or practical exercises. In some cases, written reports or summaries.

Prerequisites Null

Code Y4ECH5M7

3.2 Semester 6

3.2.1 Information processing

3.2.1.1 Signal processing

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Signal processing	CDS	8	8	12	0	0	32	28	47	75	3

Content

Introduction to Signal Processing, Representation of Continuous Signals, Representation of Discrete Signals, Filtering

Module objectives/intended learning outcomes

The overall aim of this module is to equip students with the tools to understand and implement measurement signal processing, its programming and the analysis of its results. Throughout the course, the teaching will enable students to gradually develop the ability to: Distinguish between analogue and digital signal processing. Improve the quality of a measurement signal: amplification, analogue filtering, digital filtering. Analyse a periodic vibration signal and determine its frequency composition. Analyse a finite-energy transient signal using an FFT. Physically interpret the meaning of convolution and deconvolution. Describe the spectral consequences of sampling a signal. Justify the choice of sampling frequency based on the temporal or frequency analysis performed. Describe the different stages of the analogue-to-digital or digital-to-analogue conversion process. Program signal processing operations in LabVIEW and/or Python

Language English

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST661

3.2.1.2 Automatic

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Automatic	CDS	12	10	8	0	0	36	30	45	75	3

Content

Definition of a continuous-time linear system, representations (complex transfer function, Laplace transform), Time-domain analysis of a system, frequency-domain analysis (Bode, Black, Nyquist), first- and second-order systems
Closed-loop system:
different types of inputs (setpoint, disturbance), open-loop and closed-loop transfer functions
system class, accuracy, static error, tracking error
system stability, Routh criterion, Nyquist criterion, safety margin (gain margin, phase margin)
use of the Black-Nichols chart
trade-off between accuracy and stability: introduction to PID controllers

Module objectives/intended learning outcomes

Model a continuous-time linear system,
Identify the various components of a control system,
Calculate the system's time responses.
Possess the tools required to analyse and improve control systems
Be able to analyse a practical case study

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form Continuous assessment

Prerequisites Null

Code Y4EST662

3.2.2 Mechanical and electrical thermal systems

3.2.2.1 Electrical energy conversion

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Electrical energy conversion	CDS	8	6	8	0	0	26	22	28	50	2

Content

Single-phase transformer: operating principle, electrical equivalent circuit based on Kapp's law, power balance, efficiency. Three-phase induction motor: principle and construction of an electric actuator, electrical equivalent circuit, power balance, efficiency

Module objectives/intended learning outcomes

Acquire a basic understanding of electrical engineering
Carry out energy assessments incorporating various energy sources, such as mechanical, thermal and electrical
Explore the various physical systems and processes involved in energy conversion (e.g. wind turbines).

Language English

Relation to curriculum Compulsory

Responsible Didier Chamagne

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST671

3.2.2.2 Systems mechanics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Systems mechanics	CDS	12	12	12	0	0	42	36	39	75	3

Content

Force vectors, moment vectors, torques, equilibrium
Sliding friction, rolling friction. Application to clutches and brakes.
Mass geometry, inertial action, moments of inertia, Huygens' theorem
Transmitters, reduced torques, reduced inertia
Energy analysis, efficiency, total torque developed by friction on a given shaft
Balancing of rotors on the machine and in situ

Module objectives/intended learning outcomes

Be able to model the powertrain of a real-world system as a block diagram, calculate and plot the system's characteristics on a given axis.
Understand transient and steady-state conditions, and select an actuator based on the required performance.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST672

3.2.2.3 Thermal systems

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Thermal systems	CDS	0	14	0	0	0	14	14	11	25	1

Content

A review of thermodynamics, application to open systems, general polytropic thermodynamic processes, an introduction to exergy balances, energy conversion in machines: applications to positive-displacement compressors, internal and external combustion engines, gas turbines and steam turbines.

Module objectives/intended learning outcomes

Carry out performance calculations for systems that convert heat into mechanical energy, and prepare energy and exergy balances for the installations.

Language English

Relation to curriculum Compulsory

Responsible Laurent Thiery

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST673

3.2.3 Advanced transfers and flows

3.2.3.1 Heat transfer - Unsteady conduction

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Heat transfer - Unsteady conduction	CDS	14	8	0	0	0	29	22	28	50	2

Content

Time-domain solutions to problems with a small Biot number. The role of the Fourier number. Introduction to techniques for solving partial differential equations. Semi-infinite media, the integral solution of the contact problem. Finite media, the method of separation of variables, extension to non-homogeneous problems. The special case of solutions in periodic regime. Introduction to integral transforms, use of the Laplace transform.

Module objectives/intended learning outcomes

To grasp the concepts of thermokinetics and their mathematical foundations. To understand the laws governing the behaviour of materials in response to internal or external time-dependent stresses, such as periodic surface flow, and the characteristic dimensions associated with them.

Language English

Relation to curriculum Compulsory

Responsible Laurent Thiery

Examination form continuous assessment; end-of-term exam

Prerequisites Null

Code Y4EST681

3.2.3.2 Viscous fluid dynamics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Viscous fluid dynamics	CDS	14	14	0	0	0	35	28	47	75	3

Content

Relationship between stress and strain in a viscous fluid.
Flow equations: continuity equation, Navier-Stokes equations
Viscosity, fluid rheology
Study of the dynamic boundary layer

Module objectives/intended learning outcomes

Modelling viscous flow and determining velocity and pressure distributions in simple cases
Identifying the flow characteristics to be taken into account for numerical solution (simulation)

Language English

Relation to curriculum Compulsory

Responsible Jean-Claude Roy

Examination form Continuous assessment

Prerequisites Null

Code Y4EST682

3.2.3.3 Heat transfer – Radiation models

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Heat transfer – Radiation models	CDS	8	6	0	0	0	18	14	11	25	1

Content

Pure radiative heat transfer between surfaces: the concept of shape factors. Calculations of radiative heat transfer between two surfaces. Multiple surfaces: methods based on radiative resistances. Influence of radiation from gases and flames; numerical techniques for solving complex systems.

Module objectives/intended learning outcomes

The student will be able to select the radiation model best suited to the situation under study. They will be able to utilise the features of the radiation models available in multi-physics simulation tools.

Language English

Relation to curriculum Compulsory

Responsible David Ramel

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4EST683

3.2.4 Housing heat engineering and integrated projects

3.2.4.1 Housing heat engineering

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Housing heat engineering	CDS	4	4	12	0	0	22	20	30	50	2

Content

This course provides an introduction to building thermal performance. Heat losses through the building envelope and via ventilation are calculated.

Methods for making a building energy-efficient or even energy-positive are discussed. The various certification schemes and regulations are described. Practical case studies are analysed using software for calculating heat losses and compliance with regulations.

Module objectives/intended learning outcomes

By the end of this course, students will be able to calculate a building's heat loss and verify whether or not it complies with thermal regulations. They will be able to suggest energy-efficiency improvements.

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Continuous assessment

Prerequisites Null

Code Y4EST691

3.2.4.2 Project

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Project	CDS	0	0	0	0	0	0	0	100	100	4

Content

Application of the multidisciplinary skills acquired to a specific industrial, scientific or educational topic. The project may serve as preparation for the work placement

Module objectives/intended learning outcomes

Draw on scientific, technical and humanities knowledge and apply it to the subject under consideration

Language English

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form Assessments: oral defence; report

Prerequisites Null

Code Y4EST692

3.2.5 Industrial placement

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Industrial placement	CDS	0	0	0	0	0	0	0	150	150	6

Content

The placement enables students to gain an in-depth understanding of the company or laboratory by applying the knowledge and skills they have acquired to a specific project set by the company supervisor. It involves writing a report and giving an oral presentation in French or English.

Module objectives/intended learning outcomes

The ability to adapt to and thrive in a technical and economic environment
Strong written and oral communication skills
The ability to work both independently and as part of a team
Adherence to instructions and deadlines

Language English

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form Assessments: oral presentation; report; assessment form

Prerequisites Null

Code Y4EST6UX

3.2.6 English CMI3

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	English CMI3	SECO	0	20	0	0	0	20	20	55	75	3

Content

Module objectives/intended learning outcomes

Recognise, use and expand vocabulary relating to tools derived from new information and communication technologies

Speak in public, present and defend a point of view, a product or a project

Apply a broad range of listening and reading comprehension skills (locating information, making inferences, reading strategies, etc.)

Write fluently, without awkwardness that makes reading difficult; to this end, know how to utilise or adapt the available linguistic resources, ensuring they are as authentic as possible

Language English

Relation to curriculum Compulsory

Responsible Fanny Lalevee

Examination form Formative assessment; summative assessment

Prerequisites Null

Code Y4ECH6M8

3.2.7 Corporate culture

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Corporate culture	SECO	9	9	0	0	0	22	18	57	75	3

Content

Part 3: The accounting approach to business:
a) the concepts of expenses and income
b) recording accounting transactions
c) the profit and loss account
d) the balance sheet
Part 4: The financial approach to business
a) financial analysis of the profit and loss account
b) financial analysis of the balance sheet
Part 5: Calculating production costs:
a) Different types of cost
b) Calculating production costs using the full-cost method
c) Calculating production costs using the partial-cost method
Applying Job Search Techniques (JST) for the specialisation placement:
- Adapting your CV and cover letter (including for international opportunities)
- International outlook

Module objectives/intended learning outcomes

In-depth knowledge of the business world.

Language English

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form - Written or oral theory test.

- Continuous assessment in the form of written or oral tests, or practical exercises. In some cases, written reports or summaries.

Prerequisites Null

Code Y4ECH6M9

CMI 4

4.1 Semester 7

4.1.1 Industrial World 1

4.1.1.1 English

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	English	SECO	0	20	0	0	0	20	20	55	75	3

Content

Everyday, scientific and technical English, based on topics specific to the students' core course of study (electrical energy stream).

Module objectives/intended learning outcomes

Apply the tools required for effective written and oral comprehension and expression in the scientific and technical fields specific to the course or current topics;
Identify and articulate the key elements of an argument or a speech;
Analyse and summarise data for use in written or oral presentations;
Create and use visual aids (PowerPoint, diagrams, tables, etc.) appropriately and effectively;
Present a clear and well-researched argument in direct interaction and/or in front of a group, listen, debate, defend an opinion, and persuade (acquisition of technical and interpersonal skills);
Preparation for a B2-level certification exam (such as TOEIC) at the end of the Master's programme;
Individual work, in pairs or in small groups.

Language English

Relation to curriculum Compulsory

Responsible Fabienne Halm

Examination form

Prerequisites Null

Code Y4EEE711

4.1.1.2 Professional communication

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Professional communication	SECO	0	18	0	0	0	18	18	57	75	3

Content

Master the components of interpersonal communication;
Convey a message effectively, adapt to the recipient(s), understand different types of interlocutors, and know how to present a case;
Identify communication techniques useful in everyday situations;
Build relationships (with line managers, colleagues and clients);
Knowing how to deal with difficult interpersonal situations;
Developing assertiveness, optimising non-verbal communication, and enhancing self-image.

Module objectives/intended learning outcomes

Communicate effectively in everyday work situations;

Respond effectively to the main interpersonal challenges encountered in the workplace.

Language English

Relation to curriculum Compulsory

Responsible Lucia Tribouley

Examination form

Prerequisites Null

Code Y4EEE712

4.1.2 FLUID MECHANICS

4.1.2.1 Fluid dynamics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Fluid dynamics	CDS	26	14	15	0	0	68	55	45	100	4

Content

Phenomenology of fluid flow with a view to describing the aerodynamic forces exerted by a moving fluid on a body immersed in that fluid.?

Description of lift and drag.?

Expression of aerodynamic forces acting on a structure in terms of aerodynamic coefficients.?

Polar diagrams relating aerodynamic coefficients.?

Description of compressible flows.?

Review of fluid mechanics and thermodynamics equations for application to compressible flows.?

Illustration of compressible flows in one-dimensional cases (ideal fluid, with friction, with heating, with cross-sectional changes, etc.)?

Calculations of relevant quantities (pressure, velocity, heat transfer, etc.) in compressible flows and description of shock waves.?

Applications of compressible flows in nozzles.?

Description of turbulence phenomena in flows.?

Consequences of turbulence on flows and heat transfer.?

Principles of turbulence modelling (statistical treatment of transport equations, closure models).?

Introduction to the various turbulence models commonly used in CFD numerical simulation, detailing their concepts, specific features, strengths and limitations.?

Illustrations of the various phenomena in the form of practical sessions: wind tunnels, optical measurement bench, numerical simulations?

Module objectives/intended learning outcomes

To understand the principles of fluid dynamics in order to be able to predict, quantify or optimise pressure drops, heat transfer or certain phenomena in structures involving fluid flow (free, internal or external).?

Language English

Relation to curriculum Compulsory

Responsible Dimitri Bonnet

Examination form Continuous assessment and/or submission of work

Prerequisites Null

Code Y4ETT721

4.1.2.2 Introduction to CFD

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Introduction to CFD	CDS	0	0	12	0	0	12	12	38	50	2

Content

Phenomenology of fluid flow with a view to describing the aerodynamic forces exerted by a moving fluid on a body immersed in that fluid.
Description of lift and drag.
Conversion of aerodynamic forces acting on a structure into aerodynamic coefficients.
Polar diagrams relating aerodynamic coefficients
Description of compressible flows.
Review of fluid mechanics and thermodynamics equations for application to compressible flows.
Illustration of compressible flows in one-dimensional cases (ideal fluid, with friction, with heating, with change of cross-section, etc.).
Calculations of relevant quantities (pressure, velocity, heat transfer, etc.) in compressible flows and description of shock waves.
Applications of compressible flows in nozzles.
Description of turbulence phenomena in flows.
Consequences of turbulence in flows and on heat transfer.
Principles of turbulence modelling (statistical treatment of transport equations, closure models).
Introduction to the various turbulence models commonly used in CFD numerical simulation, detailing their concepts, specific features, strengths and limitations.
Illustrations of the various phenomena in the form of practical sessions: wind tunnels, optical measurement bench, numerical practical sessions

Module objectives/intended learning outcomes

To provide students with the foundational knowledge required to master the use and application of CFD numerical simulation software. This involves familiarising themselves with and understanding ANSYS tools, as well as any additional tools that may emerge on the market in the future.

Language English

Relation to curriculum Compulsory

Responsible Dimitri Bonnet

Examination form Continuous assessment and/or coursework

Prerequisites Null

Code Y4ETT722

4.1.3 Heat and fluid transfers / Transfer Phenomena

4.1.3.1 Forced and natural convection

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Forced and natural convection	CDS	14	10	8	0	0	39	32	18	50	2

Content

Chapter 1. Introduction and background, convection regimes, Newton's law, range of h values, factors affecting the calculation of h, boundary layer, general formulation, Nusselt number, local and average quantities

Chapter 2. External forced convection – Boundary layer, flat plate in laminar flow, solution of conservation equations under Prandtl's assumptions, flat plate in turbulent flow, flow around a bundle of tubes

Chapter 3. Internal forced convection – Steady state, inlet length, laminar flow in a tube, turbulent flow in a tube

Chapter 4. Natural convection - - Coefficient of thermal expansion. Archimedes' principle. Grashof and Rayleigh numbers ¿ Boundary layer. Vertical and horizontal plates - Cylinders

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Chapter 1. Introduction, convection regimes, Newton's law, range of h values, factors involved in the calculation of h, boundary layer, general formulation, Nusselt number, local quantities and mean quantities

Chapter 2. External forced convection – Boundary layer, flat plate in laminar regime, solution of conservation equations under the Prandtl hypothesis, flat plate in turbulent regime, flow around a sheet of tubes

Chapter 3. Internal forced convection – Fully developed flow regime, inlet length, laminar flow in a tube, turbulent flow in a tube

Chapter 4. Natural convection – Coefficient of thermal expansion. Buoyancy force. Grashof and Rayleigh numbers – Boundary layer. Vertical and horizontal plates – Cylinders

Module objectives/intended learning outcomes

Provide the necessary information to enable students to predict and quantify convective heat transfer between a wall and a moving fluid

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Provide the necessary information to enable students to predict and quantify convective heat transfer between a wall and a moving fluid

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Review and submission of deliverables following the practical sessions

Prerequisites Null

Code Y4ETT731

4.1.3.2 Heat exchangers

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Heat exchangers	CDS	12	4	4	0	0	26	20	30	50	2

Content

The plan of the course is :

1/ Introduction to Heat exchangers
Introduction
Heat exchanger principle
Classification
Heat transfer basics
Thermal Resistance
Fins
Exercices
Engine
Fuel Cell

2/ Log Mean Temperature Difference
Energy balance on a single tube
Energy balance
One tube calculations
Heat exchanger
Overall energy balance
Parallel flow heat exchanger
Counterflow heat exchanger

3/ The Effectiveness¿NTU Method
Effectiveness
Definition
Ideal counterflow heat exchanger
Function of the cold or hot side
NTU
Definition
Example of parallel flow heat-exchanger
Conclusion for PF heat-exchanger
Expressions for a variety of heat exchangers

4/ Heat Exchangers grids
Introduction
Series architecture
Architecture ?
Temperature ratio
Effectiveness
NTU
Parrallel - series architecture
Cold fluid in parallel and hot fluid in series

Hot fluid in parallel and cold fluid in series

Module objectives/intended learning outcomes

The student will acquire the ability to conduct an analysis of a heat exchanger, including a review of fin designs and calculations. The technology of heat exchangers will be explored.

Various criteria will be defined, such as effectiveness and NTU (Number of Transfer Units). Special attention will be given to the design of a heat exchanger based on available inputs, such as temperatures (inlet and/or outlet) or heat fluxes. The student will gain the capability to design and select the optimal heat exchanger for a specific scenario.

Furthermore, the final lecture will focus on heat exchanger grids.

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Final exam

Prerequisites Null

Code Y4ETT732

4.1.3.3 Two-phase heat transfer and mass transfer

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Two-phase heat transfer and mass transfer	CDS	12	8	8	0	0	34	28	22	50	2

Content

This course consists of 2 parts: 1) Two-phase heat transfer, 2) Matter transfer
1) Two-phase heat transfer 6CM, 4TD, 4TP
- introduction to the physical mechanisms of phase change
- boiling: Nukyama curve, nucleate and film boiling, critical flows, two-phase flows
- condensation: physical mechanisms, laminar and turbulent condensation, flat-plate and tube condensation
- heat exchange intensification, examples of two-phase heat exchangers
2) Mass transfer, 6CM, 4TD, 4TP
Lecture 1: Mass Transfer
Introduction
Objectives
Bibliography
Review
Quantifying Energy and Matter
Mass and Energy Balances
Mixture of Components
Flux Density for Binary Mixtures

Mass Diffusivity or Diffusion Coefficient
Fluid Flow Problems
Definitions
Expression of Mass Fluxes
Summary
Transient Regime
Formulation
Heat-Mass Analogy
Exercise

Lecture 2: Mass Transfer - Boundary Conditions
Gas/Liquid Equilibrium
Henry's Law
Raoult's Law
Gas/Solid Equilibrium
Solubility
Sorption
Sorption Isotherm
Boundary Conditions
Introduction to the Problem
Continuity of Variables

Lecture 3: Heat-Mass Analogies
Boundary Layer Analogy
Heat Convection/Mass Convection
Lewis Number
Synthesis
Evaporation
Convection and Evaporation
Link between Heat and Mass Fluxes
Thermal-Mass Equivalence

Module objectives/intended learning outcomes

- Gaining an understanding of the physical phenomena involved in phase change and mass transfer in industrial systems.
- Acquiring the ability to calculate heat transfers during different phase changes (thermal fluxes, fluid states, fluid temperatures).
- The student will gain the ability to comprehend and calculate mass transfer, with a specific focus on diffusion processes. Emphasis is placed on understanding boundary conditions. Mass transfer between fluids and gases is examined, highlighting the distinctions between solubility (S), Henry's constant (H), and sorption isotherms. Numerous applications will be presented, such as water mass transfer through a wall and the mechanisms allowing fishes to breathe underwater.
- In order to facilitate the understanding of phenomena, mass-thermal analogies will be employed. This will allow students to work with both heat transfer and mass transfer simultaneously.

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Final exam

Prerequisites Null

Code Y4ETT733

4.1.4 Engineering Sciences

4.1.4.1 Systems acoustics and vibration

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Systems acoustics and vibration	FD	20	10	9	0	0	49	39	36	75	3

Content

Acoustics: definitions, propagation in open and enclosed environments, applications to buildings and machinery, noise reduction techniques. Vibrations: discretisation of a structure, frequencies and vibration modes, beam vibrations, applications to rotating machinery, isolation, spectral analysis, faults, balancing, predictive maintenance.

Module objectives/intended learning outcomes

To understand vibration phenomena and the techniques used to mitigate or correct their harmful effects on machinery and users.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form written exam

Prerequisites Null

Code Y4ETT741

4.1.4.2 Refrigeration cycles and heat pumps

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Refrigeration cycles and heat pumps	FD	10	10	4	0	0	29	24	26	50	2

Content

This course covers the fundamental principles of refrigeration cycles and heat pump cycles

Module objectives/intended learning outcomes

- understand the main vapour-compression cycles (refrigeration machines and heat pumps)
- understand refrigerants (thermophysical properties)
- plot cycles on enthalpy diagrams (Mollier)
- calculate the power requirements of the main components (compressor, evaporator and condenser)
- determine the coefficient of performance of the systems

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT742

4.1.4.3 Fluid power technology

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Fluid power technology	FD	6	4	3	0	0	16	13	12	25	1

Content

Architecture of internal combustion engines, axial and radial piston hydraulic pumps and motors, and pneumatic compressors. Dynamic aspects: force balancing. Technological aspects: design criteria, contact pressure models in mechanical joints, pressing pressure, overheating and seizure.

Module objectives/intended learning outcomes

To understand vibration phenomena and the techniques used to mitigate or correct their harmful effects on machinery and users.

Language English

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT743

4.1.5 Integration Project

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Integration Project	SC	0	0	0	0	0	0	0	150	150	6

Content

The topics for supervised projects are set by academic staff or researchers, as well as by engineers or representatives from industry;
They are aligned with the research activities of the supporting laboratories and with industry's expectations;
The topics covered must allow for experimental implementation and/or simulation;
Joint projects between the EE and ITE programmes are carried out in teams of 2 to 8 students.

Module objectives/intended learning outcomes

Apply, in a comprehensive manner to a specific case study, the knowledge acquired during the Master's programme, thereby linking theoretical learning with the project;
Develop practical skills through practical scenarios that encourage observation and discussion within the group and within the organisation involved in the project;

Learn to work effectively and productively within a project group, with a dual focus on developing personal autonomy and the ability to work and organise oneself as part of a team;
Develop an awareness of the necessary distance required to engage in critical, constructive and relevant reflection, and learn to communicate this to the 'client';
Learn to research and synthesise information;
Master the key factors for a project's success and gain knowledge of the toolkit required to manage a project;
Know how to organise, direct, plan and manage a project.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form 0

Prerequisites Null

Code Y4ETT7U5

4.1.6 Hydrogen Energy & Energy Systems

4.1.6.1 Fuel Cell

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Fuel Cell	CDS	8	4	3	0	0	19	15	35	50	2

Content

Different technologies, thermodynamics, electrochemistry and mass transfer for fuel cells, polarisation curve, efficiency, basic calculations for PEMFCs and SOFCs
Different technologies, thermodynamics, electrochemistry and mass transfer for fuel cells, polarisation curve, efficiency, basic calculations for PEMFCs and SOFCs

Module objectives/intended learning outcomes

The student will be able to describe the phenomena involved in a fuel cell and write the operating equations for simple models
By the end of the module, the student will be able to describe the phenomena involved in a fuel cell and write the operating equations for simple models

Language English

Relation to curriculum Compulsory

Responsible Nadia Steiner

Examination form 0

Prerequisites Null

Code Y4EER751

4.1.6.2 Thermal Management of Electric Machines

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Thermal Management of Electric Machines	CDS	6	3	6	0	0	18	15	35	50	2

Content

Electrical machines have broadly been used in many industries including the transportation industry. Electrical machines with higher power density and higher efficiency are demanded and, thus, more stringent thermal management requirements are needed for electrified vehicle applications. Design considerations, challenges, and methods for enhanced thermal management concern this course. Fundamental thermal properties of common materials are presented and sources of losses in various parts of machines are explained. Furthermore, typical cooling techniques and thermal analysis approaches for electrical machines are reviewed in detail.

Module objectives/intended learning outcomes

Provide students a relative autonomy using the "project-based learning" method.
Develop a experience in the field of research and development.
Develop the need to work on coupled physical problems, especially magnetic and thermal.
Develop the ability to work in English.
Develop to work in a team with a designated team manager (switch roles during learning)
Develop the ability to work on a common topic while having different academic backgrounds/cultures

Language English

Relation to curriculum Compulsory

Responsible Raynal Glises De La Riviere

Examination form 0

Prerequisites Null

Code Y4EER752

4.1.6.3 Energy Branch

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Energy Branch	CDS	8	2	0	0	0	14	10	40	50	2

Content

Syllabus :
- Current (fossil, nuclear, hydraulic) and alternative (renewable, H2);
- Resource estimation methods and key figures.

Module objectives/intended learning outcomes

Competencies targeted:
- Classify and characterize the different energy sectors.

Language Not specified

Relation to curriculum Compulsory

Responsible Nadia Steiner

Examination form Exams, Practicals

Prerequisites Null

Code Y4EER753

4.1.7 The company

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	The company	SECO	10	8	0	0	0	23	18	32	50	2

Content

The 'Business' module is a course offered to students to help them gain a deeper understanding of the business world, covering topics relevant to the sectors in which they will work.
A presentation on in-company PhD programmes is also organised.

Module objectives/intended learning outcomes

The course will take the form of a serious game on business start-ups. A business plan developed by a group of students will be presented to a panel of industry representatives. This module is run by the Chamber of Commerce and Industry.

Language English

Relation to curriculum Compulsory

Responsible

Examination form

Prerequisites Null

Code Y4ECH7M7

4.2 Semester 8

4.2.1 Industrial World 2

4.2.1.1 English

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	English	SECO	0	20	0	0	0	20	20	30	50	2

Content

Everyday, scientific and technical English, based on topics specific to the students' core course of study (electrical energy stream).

Module objectives/intended learning outcomes

Apply the tools required for effective written and oral comprehension and expression in the scientific and technical fields specific to the course or current topics;
Identify and articulate the key elements of an argument or a speech;
Analyse and summarise data for use in written or oral presentations;
Create and use visual aids (PowerPoint, diagrams, tables, etc.) appropriately and effectively;
Present a clear and well-researched argument in direct interaction and/or in front of a group, listen, debate, defend an opinion, and persuade (acquisition of technical and interpersonal skills);
Preparation for a B2-level certification exam (such as TOEIC) at the end of the Master's programme;
Individual work, in pairs or in small groups.

Language English

Relation to curriculum Compulsory

Responsible Fabienne Halm

Examination form

Prerequisites Null

Code Y4EEE861

4.2.1.2 Economics of energy transition

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Economics of energy transition	SECO	18	0	0	0	0	27	18	32	50	2

Content

This course aims to provide an understanding of how electricity markets operate (price formation, marginal rents, the impact of the introduction of renewable energy sources, reserve mechanisms to ensure grid stability, demand response, NEBEF, capacity mechanisms, frequency control, etc.) and the link with the carbon market. The general structure of the electricity sector is explained, covering the roles of the regulator, transmission and distribution system operators, electricity generators and suppliers, aggregators, etc. The origins of the opening up of the electricity sector to competition are explained using the concepts of economies of scale, natural monopoly, and the evolution of technologies and costs within this industry.

A significant part of the course is also devoted to explaining how the European carbon market works, the factors that determine carbon pricing, and the strategies employed by electricity producers to reduce their CO2 emissions in response to carbon prices (reversing the dispatch order of power stations, co-firing wood in coal-fired power stations, hydrogen in gas-fired power stations, etc.).

Students are given numerous illustrative exercises to calculate the price of electricity at different times of day, the rents, and the remuneration of renewable energy operators benefiting from various support mechanisms (feed-in tariffs, contracts for difference, green certificates, etc.), etc. Exercises also highlight CO2 emission reduction strategies for companies facing a carbon price, in particular the calculation of fuel-switching prices for electricity producers (an indicator widely used by players in the electricity sector and financial markets).

Module objectives/intended learning outcomes

Understanding how electricity prices are formed (merit order, marginal power plant, etc.) and how sub-marginal rents are used to finance investment costs;
Understanding the challenges for the electricity system posed by the growing integration of renewable energy: how support mechanisms work, the impact on electricity pricing (merit-order effect) and on investment returns (missing money), the need to establish reserve and capacity markets to manage intermittency and ensure the stability of the electricity system, etc.
Knowledge of the market mechanisms put in place to ensure the stability of electricity networks over different time horizons, ranging from the very short term (system services and balancing mechanisms) to the long term (capacity mechanisms);
Understanding how different types of services for the electricity grid operate: demand response (which can be valued through various market mechanisms depending on the relevant time horizon), upward or downward regulation, remuneration for activatable capacity and/or activated capacity, etc.
Ability to explain carbon pricing: the impact of changes in emission reduction targets set by the regulator or of exogenous events such as temperature variations or changes in the relative price of gas compared to coal;
Ability to calculate the indicators used by practitioners in the electricity industry to determine CO2 emission reduction strategies in response to the carbon price (e.g. fuel-switching prices).

Language English

Relation to curriculum Compulsory

Responsible Vincent Bertrand

Examination form

Prerequisites Null

Code Y4EEE862

4.2.1.3 Project management

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Project management	SECO	12	6	0	0	0	24	18	32	50	2

Content

Understand the key stages of project management;
Manage a project and use the appropriate tools: objectives, stakeholders, tasks, responsibilities, resources,

deadlines and scheduling, budget, specific constraints, risk assessment, etc.
Working as part of a project team: putting the team together, coordinating project progress, monitoring progress, collaborating and communicating, managing project issues, adapting to the company's specific tools,

Module objectives/intended learning outcomes

Be able to apply a project management methodology (from inception to evaluation);
Identify the tools used in project management.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EEE863

4.2.2 Energy production

4.2.2.1 Combustion

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Combustion	FD	12	6	0	0	0	24	18	32	50	2

Content

History of combustion (slow combustion, rapid combustion, oxidation-reduction, applications). Phenomenology of combustion and properties (diffusion and premixed flames, the fire triangle, liquid and solid fuels, different types of oxidation, spontaneous ignition, Le Chatelier's principle). Fuels. Thermodynamics of combustion and flames (activation energy, calorific value, flash point, combustion (P, T, V) and mixture ratio, deflagration and detonation, chemiluminescence, risks, oxidants other than air). Chemical kinetics. Pollutants and emissions. Application of combustion to the operation of gas turbines.

Module objectives/intended learning outcomes

To provide students with a clear, comprehensive and concise overview of combustion processes and their general principles. To establish a link between the thermodynamics of open systems and flame thermodynamics. To help them understand the concept of combustion efficiency, whilst emphasising the associated pollution and safety risks. To bridge the gap between academic combustion theory and the industrial operation of gas turbines.

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT871

4.2.2.2 Nuclear and hydrogen energy

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Nuclear and hydrogen energy	FD	16	8	8	0	0	40	32	18	50	2

Content

NUCLEAR Power station: history, operating principles and components of a nuclear power station. Electricity generation process: reactor vessel, primary circuit, steam generator, secondary circuit, steam turbine and generator coupling. Elements of nuclear physics: basic nuclear properties, mass, charge, angular momentum of the nucleus, dynamic properties, the de Broglie wave, Schrödinger's equation and its applications, nuclear binding energy, energy levels of nuclei, radioactive decays (alpha, beta), various nuclear reactions, cross-sections, fission... Elements of nuclear metallurgy.

HYDROGEN ENERGY: history, composition, uses of hydrogen, hydrogen as an energy carrier, various applications, particularly fuel cells. Storage, combustion of H2, oxidation in fuel cells, risks associated with hydrogen, manufacturing processes, current policy and developments in the field.

Module objectives/intended learning outcomes

Although these two courses are very different in nature, despite the similarities envisaged in terms of H2 production, their aim is to introduce two promising fields in the fight against global warming. Students will learn not only the general principles but also the detailed principles of these two technologies. They will be able to carry out a preliminary sizing of these systems with the aim of determining the net energy output. Thus, in the nuclear field, they will be able to calculate the fission rate required to meet a specified output power. Regarding hydrogen energy, they will be able to determine the thermodynamic efficiency of experimental systems and the energy consumption required to meet a specified output power. In both cases, they will have a thorough understanding of the three key aspects: risks, advantages and disadvantages.

Language English

Relation to curriculum Compulsory

Responsible Raynal Glises De La Riviere

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT872

4.2.2.3 Turbomachinery

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Turbomachinery	FD	18	10	0	0	0	37	28	22	50	2

Content

This course focuses on turbomachinery, specifically industrial compressors and turbines

Module objectives/intended learning outcomes

- definitions of impulse and reaction machines
- review of the thermodynamics of compressible and incompressible fluids
- definition of the speed triangle
- determination of turbomachine performance: power, efficiency, characteristic dimensionless numbers

(flow coefficient, power coefficient), efficiency curves
- study of industrial thermodynamic cycles: TS, HS and PV diagrams

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT873

4.2.3 Energy Modelling

4.2.3.1 Computational codes in fluid dynamics and finite elements

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Computational codes in fluid dynamics and finite elements	FD	0	0	30	0	0	30	30	45	75	3

Content

Training in COMSOL Multiphysics and FLUENT software (laminar and turbulent flow). Definition of the geometry under study and definition of study parameters (thermophysical parameters and boundary conditions). Meshing and optimisation. Solving and optimisation. Interpretation of results. Analysis of specific case studies involving steady-state and transient conditions. Special cases of coupled problem studies (e.g. thermofluidic, thermoelectric, etc.)

Module objectives/intended learning outcomes

Students will become proficient in the development, management and application of simple thermophysical models. They will be able to make the most of these modelling tools whilst interpreting the results accurately and reliably.

Language Not specified

Relation to curriculum Compulsory

Responsible Yannick Bailly

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT881

4.2.3.2 Numerical methods and mathematical tools for engineers

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Numerical methods and mathematical tools for engineers	FD	20	10	9	0	0	49	39	36	75	3

Content

Introduction to the classification of partial differential equations used in thermal and fluid mechanics: the characteristic method.

Parameters required for solution: domain, boundary conditions

Finite difference methods: selecting a method suited to the physical problem at hand: the Crank-Nicolson method, the alternating direction method.
Finite volume method: scope of application, description of the method for fluid dynamics equations. Selection of options available in CFD tools to optimise simulations

1/ Introduction to optimisation
Formulation of an optimisation problem
Example of linear programming
Local and global minima

2/ Optimisation methods
1D: Interval elimination, Powell's method, Newton-Raphson method
ND: Simplex method, Newton-Raphson method, conjugate gradient method, Davidon-Fletcher-Powell (DFP) algorithm, Broyden-Fletcher-Goldfarb-Shanno (BFGS)

3/ Solving ODE - matrix approach
Discretisation of space and time
Vector relation, Matrix representation
Formulation
Explicit formulation, Implicit formulation, Stability analysis

Module objectives/intended learning outcomes

Achieve the objective of a "well-defined" problem:
Define the elements required to simulate a thermal and/or fluid dynamics problem: domain, boundary conditions, appropriate numerical method, and critical analysis of numerical simulation results.
Prepare the problem elements to feed into a CFD tool, enabling simulations of the scenarios under consideration.

Able to formalise an optimisation problem by distinguishing between criteria and variables, and between methods with or without derivatives.
Through practical sessions, students will be able to write a Python programme to solve a transient heat transfer problem in a 2D geometry. The various methods (implicit, explicit, Crank-Nicolson, ADI) will be compared in terms of performance, accuracy and stability.

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT882

4.2.4 Energy efficiency

4.2.4.1 Energy efficiency in buildings and LCA

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Energy efficiency in buildings and LCA	CDS	16	4	6	0	0	34	26	24	50	2

Content

Module objectives/intended learning outcomes

To enable students to calculate a building's energy requirements and its emissions throughout its life cycle.

Language Not specified

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT891

4.2.4.2 Renewable energies

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Renewable energies	CDS	14	8	16	0	0	45	38	37	75	3

Content

Topic 1. Wind energy: Wind resources (Weibull distribution, data analysis), wind power (Betz limit), rotor aerodynamics, electricity generation from wind turbines. Topic 2. Solar thermal energy: solar resources, flat-plate and evacuated-tube solar thermal collectors: principles, efficiency.Topic 3. Photovoltaic solar energy: Photovoltaic conversion, solar panel technologies, cell and panel configurations, off-grid and grid-connected installations

Module objectives/intended learning outcomes

To enable students to assess wind and solar resources and calculate the corresponding energy output using conversion technologies.

Language Not specified

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Lectures, tutorials and practical case studies

Prerequisites Null

Code Y4ETT892

4.2.4.3 Refrigeration systems

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Refrigeration systems	CDS	8	5	0	0	0	17	13	12	25	1

Content

- A brief history of refrigeration
- Introduction: physical principles
- Refrigerants
- Single-stage compression systems: description of thermodynamic cycles, role of components, identification of losses
- Two-stage compression systems: open economiser, partial economiser, two-fluid cascade cycles
- Design of commercial systems

Module objectives/intended learning outcomes

- Understand the properties of refrigerants
- Select the mechanical and thermal components for a system
- Know how to size a commercial refrigeration system
- Determine a system's performance criteria: efficiency, coefficient of performance

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT893

4.2.5 Integration Project 2

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Integration Project 2	CDS	0	0	0	0	0	0	0	150	150	6

Content

The topics for supervised projects are set by academic staff or researchers, as well as by engineers or representatives from industry;
They are aligned with the research activities of the supporting laboratories and with industry's expectations;
The topics covered must allow for experimental and/or simulation-based implementation;
Joint projects between the EE and ITE programmes are carried out in teams of 2 to 8 students.

Module objectives/intended learning outcomes

Apply, in a comprehensive manner to a specific case study, the knowledge acquired during the Master's programme, thereby linking theoretical learning with the project;
Develop practical skills through practical scenarios that encourage observation and discussion within the group and within the organisation involved in the project;

Learn to work effectively and productively within a project group, with a dual focus on developing personal autonomy and the ability to work and organise oneself as part of a team;
Develop an awareness of the necessary distance required to engage in critical, constructive and relevant reflection, and learn to communicate this to the 'client';
Learn to research and synthesise information;
Master the key factors for a project's success and gain knowledge of the toolkit required to manage a project;
Know how to organise, direct, plan and manage a project.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form 0

Prerequisites Null

Code Y4ETT8UX

4.2.6 Hydrogen Energy & Energy Efficiency

4.2.6.1 Conversion and Energy Efficiency

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Conversion and Energy Efficiency	SC	12	4	4	0	0	26	20	30	50	2

Content

Energy conversion and energy efficiency: different sources (fossil fuels, fission and fusion, solar, wind and tidal, geothermal), different forms (chemical, nuclear, mechanical, electrical), conversion technologies and associated efficiencies,

Module objectives/intended learning outcomes

By the end of the module, the student will be able to
classify the different types of energy conversion,
write the basic equations,
calculate the efficiency

Language Not specified

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form 0

Prerequisites Null

Code Y4EER891

4.2.6.2 Energy Grids

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Energy Grids	SC	12	4	4	0	0	26	20	30	50	2

Content

Energy networks: hydrocarbon distribution networks, electrical networks (principles, technologies, losses), heating networks (principles, technologies, losses)

Energy networks: hydrocarbon distribution networks, electrical networks (principles, technologies, losses), heating networks (principles, technologies, losses)

Module objectives/intended learning outcomes

By the end of the module, the student will be able to

classify the various energy distribution networks,
identify the principles governing them,
calculate their losses in simple cases

Language English

Relation to curriculum Compulsory

Responsible Frederic Dubas

Examination form

Prerequisites Null

Code Y4EER892

4.2.6.3 Energy Storage

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Energy Storage	SC	12	4	4	0	0	26	20	30	50	2

Content

Energy storage: the need for storage, different technologies (electrochemistry, electrostatics, superconductors, flywheels, gravity storage, thermal storage with and without phase change, compressed air) and key figures

Energy storage: the need for storage, different technologies (electrochemistry, electrostatics, superconductors, flywheels, gravity storage, heat storage with and without phase change, compressed air) and key figures

Module objectives/intended learning outcomes

By the end of the module, students will be able to classify the different forms of energy storage, write the basic equations and calculate the efficiency

At the end of the module, students will be able to classify the different forms of energy storage, write the basic equations and calculate the efficiency

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EER893

CMI 5

5.1 Semester 9

5.1.1 Industrial World 3

5.1.1.1 English

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	English	SECO	0	20	0	0	0	20	20	30	50	2

Content

Business English.

Module objectives/intended learning outcomes

Apply the tools required for effective written and oral comprehension and expression in the scientific and technical fields specific to the course or current topics;
Identify and articulate the key elements of an argument or a speech;
Analyse and summarise data for use in written or oral presentations;
Create and use visual aids (PowerPoint, diagrams, tables, etc.) appropriately and effectively;
Present a clear and well-researched argument in direct interaction and/or in front of a group, listen, debate, defend an opinion, and persuade (acquisition of technical and interpersonal skills);
Preparation for a B2-level certification exam (such as TOEIC) at the end of the Master's programme;
Individual work, in pairs or in small groups.

Language English

Relation to curriculum Compulsory

Responsible Fabienne Halm

Examination form

Prerequisites Null

Code Y4EEE911

5.1.1.2 Legal and economic culture

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Legal and economic culture	SECO	6	12	0	0	0	21	18	32	50	2

Content

This course aims to achieve two main objectives:
To provide an insight into the professional world from a legal perspective, through a general introduction to law, contract law and employment law.
It will also explore the legal aspects of business: types of business, intellectual property, etc.

Module objectives/intended learning outcomes

Possess the economic, legal and managerial knowledge required to understand the issues and challenges facing businesses;

Gain a thorough understanding of the economic, legal and managerial framework relevant to one's professional activity.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EEE912

5.1.1.3 Entrepreneurship

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Entrepreneurship	SECO	0	12	0	0	0	12	12	38	50	2

Content

This learning unit is covered in stages and then consolidated (into a practical group project):
¿ defining a product/service (using the 'Golden Circle' approach) within an integrated market perspective (sectoral and/or product/service benchmarking);
the fundamentals of an agile industrial and/or service organisation (such as deep dive, scrum, etc.);
drafting a marketing plan for the positioning of the product/service (range, pricing and sales channels, product lifecycle and version updates, etc.);
pricing of the product/service (calculation of their cost price, operating costs, etc.);
the development of a management structure for their project (based on the group's aptitudes and psycho-social profiles);
a summary presentation of the project (including a detailed FAQ for the promotion).

Module objectives/intended learning outcomes

learning the basics of drawing up a business plan covering product, organisational and financial aspects, etc. (using the Business Model Canvas);
learning the basics of presenting and promoting their business project (in groups).

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EEE913

5.1.2 Digital Engineering

5.1.2.1 Thermal and fluid dynamics calculation codes

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Thermal and fluid dynamics calculation codes	FD	0	0	33	0	0	33	33	17	50	2

Content

Advanced use of CFD tools – geometry optimisation – mesh optimisation – modelling of real-world scenarios.

Module objectives/intended learning outcomes

Be able to use CFD software to identify and optimise solutions to specific problems in fluid mechanics and/or heat transfer. Understand and apply best practices in CFD. Be able to interpret simulation results.

Language English

Relation to curriculum Compulsory

Responsible Dimitri Bonnet

Examination form Available

Prerequisites Null

Code Y4ETT921

5.1.2.2 Dynamic thermal simulation

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Dynamic thermal simulation	FD	0	0	18	0	0	18	18	32	50	2

Content

Principles of dynamic thermal simulation applied to buildings, 'free' heat gains (solar, metabolic, appliance losses), heat losses through transmission and ventilation, summer comfort, bioclimatic architecture, building optimisation to ensure both low heating requirements and summer comfort

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Principles of dynamic thermal simulation applied to buildings, "free" inputs (solar, metabolic, losses from appliances), losses through transmission and ventilation, summer comfort, bioclimatic architectures, building optimisation to ensure both low heating requirements and summer comfort.

Module objectives/intended learning outcomes

- be proficient in the use of dynamic thermal simulation software
- simulate an existing building for the purposes of energy assessment and optimisation
- simulate a new building to ensure its design meets current requirements

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- master the use of dynamic thermal simulation software
- simulate an existing building with a view to energy diagnostics and optimisation
- simulate a new building with a view to designing it in line with current expectations

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT922

5.1.2.3 CAD-DA

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	CAD-DA	FD	0	0	12	0	0	12	12	38	50	2

Content

- 3D modelling of a domestic hot water tank / 3D modelling of a sprinkler system
- 3D modelling of a heating system using a boiler or solar panels / 3D modelling of a ventilation system / Production of connectable "smart" modules

Module objectives/intended learning outcomes

- Proficiency in CAD software (building/process applications)
- Ability to create and modify fluid systems (air/water) from an existing plan

Language Not specified

Relation to curriculum Compulsory

Responsible Cyrille Verna

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT923

5.1.3 Thermal Systems

5.1.3.1 Conventional thermal power plants

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Conventional thermal power plants	CDS	16	12	0	0	0	36	28	22	50	2

Content

- Energy market
- Fossil fuels
- Power station thermodynamics
- Technology for coal-fired power stations and solid fuel boilers
- Section on CO2 capture

Module objectives/intended learning outcomes

- Design and assess the performance of a conventional thermal power station.
- Understand the different types of boiler technology

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT931

5.1.3.2 Fluid and energy management

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Fluid and energy management	CDS	12	4	0	0	0	22	16	34	50	2

Content

Calculation and sizing of fluid and energy systems. Calculation of system pumps and operating points. Calculation of pressure drop in a complex system. Sizing of a fan and ensuring it is suitable for its intended use.

Module objectives/intended learning outcomes

Acquiring the correct methodology for calculating fluid networks

Developing the ability to understand a complex network as a whole and to calculate its installation and operating costs

Gaining a thorough understanding of turbomachinery technology (axial and centrifugal)

Language English

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT932

5.1.3.3 Technological practical work

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Technological practical work	CDS	0	0	32	0	0	32	32	18	50	2

Content

To determine the performance of industrial-scale energy conversion systems on test benches

Module objectives/intended learning outcomes

Performance analysis of the following thermal machines and systems:
- pellet boilers, condensing boilers
- CO2 heat pumps
- steam generation
- climate simulation system for a living space
- positive-temperature cold room
- compressor

Language English

Relation to curriculum Compulsory

Responsible Thierry Laudet

Examination form Continuous assessment

Prerequisites Null

Code Y4ETT933

5.1.4 Advanced Energy Systems (Choice 1)

5.1.4.1 Innovative energy machines

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Innovative energy machines	CDS	12	6	0	0	0	24	18	32	50	2

Content

- Alternating flow, consideration of porous and/or structured media (cogenerators)
- Machines with external heat input (cogenerators, thermoacoustic systems, Stirling engines, Ericsson engines),
- Innovative cooling systems (magnetocaloric systems).

- Alternating flows, consideration of porous and/or structured media (cogenerators)
- Machines with external heat input (cogenerators, thermoacoustic systems, Stirling, Ericsson),
- Innovative cooling systems (magnetocalorics).

Module objectives/intended learning outcomes

Understanding alternating flow patterns and associated heat transfer
Understanding the underlying physical phenomena and how these machines operate
Performing preliminary design calculations for an energy converter
Determining the energy performance of such systems

Mastering alternating flows and associated heat exchange
Mastering the physical phenomena and understanding how these machines work
Pre-dimensioning calculation of an energy converter
Determining the energy performance of such systems

Language English

Relation to curriculum Compulsory

Responsible Sylvie Begot

Examination form Continuous assessment

Prerequisites Null

Code Y4ET4941

5.1.4.2 Advanced metrology

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Advanced metrology	CDS	19	11	9	0	0	48	39	11	50	2

Content

- Dynamic temperature measurement
- Thermal micrometry in fluids (temperatures and flows): principles and applications
- Infrared spectroscopy for temperature and concentration measurements in semi-transparent media
- Radiative Transfer Equation
- Principles and experimental set-ups
- Data processing (inversion method)
- Optical measurements in flows
- Flow visualisation techniques (tomography, ombroscopy, strioscopy).
- Velocimetry techniques (Laser Doppler Velocimetry, Particle Image Velocimetry, data processing).
- Methods for measuring other quantities (Pressure Sensitive Paints, Fluorescence, Granulometry).
- Intrusive measurement methods using wired microsensors.

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- Dynamic temperature measurements
- Thermal micro-measurements in fluids (temperatures and fluxes): principles and implementations
- Infrared spectroscopy for measuring temperatures and species concentrations in semi-transparent media
- Radiative Transfer Equation: RTE
- Principles and experimental setups
- Data processing (inversion method)
- Optical measurements in flows
- Flow visualisation techniques (tomography, shadowgraphy, striography).
- Velocimetry techniques (Laser Doppler Velocimetry, Particle Image Velocimetry, data processing).
- Methods for measuring other quantities (Pressure-Sensitive Paints, Fluorescence, Particle Size Analysis).
- Intrusive measurement methods using wired microsensors

Module objectives/intended learning outcomes

- understand the physical principles of fluidics diagnostic methods and tools
- be familiar with the metrological performance and application constraints of the various techniques
- be able to define the methods to be used to characterise a system or flow
- know how to use measurement results to obtain precise information
- Processing experimental data
- Basic knowledge of lasers and laser safety
- Notions of granulometry

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- understand the physical principles of fluidics diagnostic methods and tools
- understand the metrological performance and application constraints of the various techniques.
- be able to define the methods to be used to characterise a system or flow.
- know how to use measurement results to obtain precise information.
- Processing experimental data

- Basic knowledge of lasers and laser safety
- Notions of particle size analysis

Language English

Relation to curriculum Compulsory

Responsible Dimitri Bonnet

Examination form Continuous assessment

Prerequisites Null

Code Y4ET4942

5.1.4.3 Exergy analysis

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Exergy analysis	CDS	12	6	0	0	0	24	18	32	50	2

Content

1. Introduction
2. Fundamental transforms
3. Exergetic analyse of the compression processes
4. Exergetic analyse of the expansion processes
5. Exergetic analyse of the heat exchanges
6. Applications

Module objectives/intended learning outcomes

Enable the students to analyze energy and exergy flow in thermal energy systems, and calculate the flow of energy cost. To give understanding of the importance of exergy as the foundation of energy cost calculation, and to use systematic methods for energy system performance improvement.

Language English

Relation to curriculum Compulsory

Responsible Francois Lanzetta

Examination form Continuous assessment

Prerequisites Null

Code Y4ET4943

5.1.5 Integration Project 3

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Integration Project 3	SC	0	0	0	0	0	0	0	150	150	6

Content

The topics for supervised projects are set by academic staff or researchers, as well as by engineers or representatives from industry;
They are aligned with the research activities of the supporting laboratories and with industry's expectations;
The topics covered must allow for experimental implementation and/or simulation;
Joint projects between the EE and ITE programmes are carried out in teams of 2 to 8 students.

Module objectives/intended learning outcomes

Apply, in a comprehensive manner to a specific case study, the knowledge acquired during the Master's programme, thereby linking theoretical learning with the project;
Develop practical skills through practical scenarios that encourage observation and discussion within the group and within the organisation involved in the project;
Learn to work effectively and productively within a project group, with a dual focus on developing personal autonomy and the ability to work and organise oneself as part of a team;
Develop an awareness of the necessary distance required to engage in critical, constructive and relevant reflection, and learn to communicate this to the 'client';
Learn to research and synthesise information;
Master the key factors for a project's success and gain knowledge of the toolkit required to manage a project;
Know how to organise, direct, plan and manage a project.

Language English

Relation to curriculum Compulsory

Responsible Frederic Dubas

Examination form 0

Prerequisites Null

Code Y4ETT9U5

5.1.6 Clean Sustainable Energy Production

5.1.6.1 Advanced Cogeneration

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Advanced Cogeneration	CDS	10	4	6	0	0	25	20	30	50	2

Content

Analysis of oil, gas, solar and fuel cell cogeneration and trigeneration systems
Energy balance for a cogeneration plant: adjustment of thermal and electrical power

Optimal operating conditions
Case study
Analysis of oil, gas, solar and fuel cell co-generation and tri-generation systems
Energy balance for a cogeneration plant: adjustment of thermal and electrical power
Optimal operating conditions
Case study

Module objectives/intended learning outcomes

- Knowledge of the various technologies for the simultaneous production of electricity, cooling and heating
- Ability to propose a technological solution tailored to a competitive market

- Knowledge of the various technologies for the simultaneous production of electricity, cooling and heating
- Ability to propose a technological solution tailored to a competitive market

Language English

Relation to curriculum Compulsory

Responsible

Examination form

Prerequisites Null

Code Y4EER931

5.1.6.2 Advanced Fuell Cell Technologies

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Advanced Fuell Cell Technologies	CDS	10	4	6	0	0	25	20	30	50	2

Content

Fuel cell systems: definition, limits, constraints, optimisation
Modelling of different energy management strategies in transport applications

Fuel cell systems: definition, limits, constraints, optimisation
Modelling of different energy management strategies in transport applications

Module objectives/intended learning outcomes

- Provide students with advanced technical knowledge of how fuel cells and fuel cell systems operate - Skills in the experimental characterisation of fuel cells

- Provide students with advanced technical knowledge of how fuel cells and fuel cell systems operate
- Skills in the experimental characterisation of fuel cells

Language Not specified

Relation to curriculum Compulsory

Responsible

Examination form 0

Prerequisites Null

Code Y4EER932

5.1.6.3 Electrolyzis Hydogen Production

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Electrolyzis Hydogen Production	CDS	10	4	6	0	0	25	20	30	50	2

Content

Learning about different technologies, thermodynamics, electrochemistry and mass transfer in relation to electrolysers. Study of polarisation curves and efficiency. Basic calculations

Module objectives/intended learning outcomes

The student will be able to describe the phenomena involved in an electrolyser and write the operating equations for simple models

By the end of the module, the student will be able to describe the phenomena involved in an electrolyser and write the operating equations for simple models

Language English

Relation to curriculum Compulsory

Responsible

Examination form

Prerequisites Null

Code Y4EER933

5.2 Semester 10

5.2.1 UE6 – Internship

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
10	UE6 – Internship	CDS	0	0	0	0	0	0	0	750	750	30

Content

0

Module objectives/intended learning outcomes

0

Language Not specified

Relation to curriculum Compulsory

Responsible Philippe Baucour

Examination form - end-of-placement report
- oral presentation

Prerequisites Null

Code Y4ETTXU6

5.2.2 Management, Engineering, Environment, Society

5.2.2.1 Management

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
10	Management	SECO	0	12	0	0	0	12	12	63	75	3

Content

Module objectives/intended learning outcomes

Language English

Relation to curriculum Compulsory

Responsible Christian Arbez

Examination form

Prerequisites Null

Code Y4ECH961

5.2.2.2 Engineering, environment, society

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
10	Engineering, environment, society	SECO	0	12	0	0	0	12	12	38	50	2

Content

The 'Engineering, Environment and Society' module is a seminar focusing on the subject areas covered by the various CMI pathways. The aim is to give students the opportunity to discuss projects or assignments related to research activities, and to present these within the context of a day of lectures.

Module objectives/intended learning outcomes

The event will be organised in a similar way to a conference, with the establishment of a steering committee, a scientific organising committee and a logistics organising committee. These committees will be shared across all CMIs. A website for submitting abstracts, followed by guidance on whether to present as a
poster or an oral presentation, will be set up. Prizes for the best contributions may be offered.

* Identify the scope of inter-CMI collaboration in training and research
* Organise a scientific event
* Communicate in writing and orally
* Develop a professional network

Language English

Relation to curriculum Compulsory

Responsible

Examination form

Prerequisites Null

Code Y4ECH962