Handbook - CMI H3E

Electrical Track

P. Baucour
FEMTO-ST, ENERGY Department
philippe.baucour@umlp.fr

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 Applied physics

3.1.2.1 Electronics

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

Content

Review of the operational amplifier:
linear and non-linear operation;
dynamic operation
Review of the bipolar transistor Passive and active filters: - characteristics (type, order, response), specific responses (Butterworth, Legendre, Cauer, etc.), structure (single-stage, multi-stage, source-controlled, universal))
- switched-capacitor filters
- filter synthesis

Measurement chain:
design of analogue circuits for sensor conditioning.

Analogue controllers:
design of electronic circuits for P, PI, PD and PID-type analogue controllers

Module objectives/intended learning outcomes

The student will master the basic components of analogue electronics. They will be able to interpret technical specifications for the design of a filter.
They will be able to design and build a filter, a regulator or a sensor conditioner, and put them into operation.

Language Not specified

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form - Written theory test

- Written examinations, an oral test, or a report on practical work or annotated programmes of numerical simulations.

Prerequisites Null

Code Y4ESE521

3.1.2.2 Electromagnetism

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

Content

Syllabus:
- Magnetic fields and magnetic circuits
- (Magnetically) coupled electrical circuits
- Energy, magnetic energy and magnetic forces
- Magnetic materials

Module objectives/intended learning outcomes

- Be able to calculate the magnetic field by applying Ampère's theorem, or by using a reluctance network, or by using basic finite element analysis software (such as FMM)
- Be able to calculate the inductance and mutual inductance of electrical circuits and apply these concepts when formulating electrical equations for coupled circuits
- Be able to theoretically calculate the magnetic force acting within an electromagnetic device using the concepts of magnetic energy and magnetic co-energy
- Be able to calculate the magnetic force acting in an electromagnetic device using basic finite element analysis software (e.g. FMM)
- Be able to define the magnetic characteristics of hard magnetic materials (permanent magnets) and soft magnetic materials (magnetic sheets) used in electrical machines based on data provided by the manufacturers of these materials

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form - Theory test

- Practical test, or a report on practical work or numerical simulations, or an oral or written test.

Prerequisites Null

Code Y4ESE522

3.1.3 Electrical energy conversion

3.1.3.1 Power electronics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Power electronics	CDS	20	14	12	0	0	56	46	29	75	3

Content

Understanding of the four main functions of power electronics:
- DC-DC conversion, DC-AC conversion, AC-DC conversion and AC-AC conversion;
Ability to calculate the main characteristics of these circuits;
Ability to design and analyse controlled and uncontrolled AC-DC conversion circuits, in both single-phase and three-phase configurations;
Ability to size and analyse DC-DC conversion circuits;
Ability to size and analyse basic DC-AC conversion circuits;

Module objectives/intended learning outcomes

The aim is to examine a number of fundamental power electronics circuits, understand their benefits and learn about their main applications.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form - Written exams (final and/or continuous assessment)
- Reports on practical work.
- Possibly assignments and/or reports to be submitted.

Prerequisites Null

Code Y4ESE531

3.1.3.2 Electrical engineering

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Electrical engineering	CDS	14	14	9	0	0	44	37	38	75	3

Content

To study ideal electrical systems (static and dynamic components), specifically by neglecting losses that are not essential to operation and assuming linear operation:
- single-phase and three-phase transformers.
- DC machines,
- AC machines.
Emphasis will be placed on the methodology for both voltage modelling and stability analysis.

Module objectives/intended learning outcomes

To be able to analyse ideal electrical systems, disregarding losses that are not essential for operation

in a linear regime. Formulation of voltage equations and analysis of stability.

Language English

Relation to curriculum Compulsory

Responsible Didier Chamagne

Examination form - Written theory test.
- Practical test, oral test or report on practical work.

Prerequisites Null

Code Y4ESE532

3.1.4 Instrumentation and industrial IT

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 Industrial computing

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
5	Industrial computing	CDS	21	8	15	0	0	54	44	31	75	3

Content

- Representation and processing of information in a computer system
- Microprocessor architecture.
- Communication between the microprocessor and the external environment.
- Introduction to microcontrollers.
- Microcontroller programming: from assembly language to C.
- Integrated development environment for embedded applications.
- Wireless communications, IoT concepts
- LabView/Arduino interfacing

Module objectives/intended learning outcomes

- Be able to select a microcontroller component for a given application.
- Be able to develop the software component of a given application.
- Be able to program a microcontroller in C and/or assembly language.
- Be able to acquire and process data remotely.

Language English

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form - Written theory exam.
- Practical exam: oral test, report on practical work, report and/or annotated computer programs

Prerequisites Null

Code Y4ESE542

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 buildings, 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 Signals and systems

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

3.2.1.3 Linear control systems

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Linear control systems	CDS	10	8	12	0	0	35	30	20	50	2

Content

The accuracy-stability trade-off, the need to control a system Phase-lag controller, proportional and integral Phase-lead controller, proportional and derivative Generalisation to PID controllers Secondary-loop compensation Identification of continuous-time linear systems Empirical method for synthesising a PID controller: the Ziegler-Nichols method,

Module objectives/intended learning outcomes

Students will be able to model a continuous-time linear system, identify the various components of a control system, and calculate the system's time responses. They will have the necessary tools to analyse and improve control systems

Language English

Relation to curriculum Compulsory

Responsible Roger Bedu

Examination form - Written theory exam.
- Continuous assessment in the form of written tests, oral tests, reports or accounts of practical work or numerical simulations

Prerequisites Null

Code Y4ESE663

3.2.2 Thermal and mechanical systems

3.2.2.1 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

3.2.2.2 Component thermics

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

Content

Syllabus: - Conduction: Fourier's law, thermal conductivity, thermal resistance, applications to rectangular prism structures, the general heat equation, application to cylindrical structures in electric motors
- Convection: Newton's law, natural convection, forced convection, the dimensionless Prandtl, Grashof, Nusselt and Reynolds numbers. Characteristic lengths, hydraulic diameter, convective thermal resistance.
- Radiation: the electromagnetic spectrum of light, Planck's law, Wien's law, emittance, luminance, existence, illuminance, emissivity, black bodies, real bodies (grey, opaque, etc.), absorptivity, radiative exchange between two surfaces, shape factors.

Module objectives/intended learning outcomes

The student will be able to determine temperature profiles in solid structures, primarily those comparable to electric motors.
They will be able to determine convective and radiative heat fluxes on the surfaces of structures subjected to internal heat sources.

Language Not specified

Relation to curriculum Compulsory

Responsible Raynal Glises De La Riviere

Examination form - Written theory exam
- Continuous assessment in the form of written or oral tests, or reports on practical work or numerical simulations.

Prerequisites Null

Code Y4ESE672

3.2.3 Electrical energy technology and storage

3.2.3.1 Electrical energy storage

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Electrical energy storage	CDS	8	8	8	0	0	28	24	51	75	3

Content

- Batteries: types, operating principles, modelling, applications and constraints, battery charging.

Module objectives/intended learning outcomes

This course focuses on battery-based electricity storage systems. The aim is to understand how this common technology works and to learn about its main applications.

Language English

Relation to curriculum Compulsory

Responsible Nadia Steiner

Examination form - Written theory exam

- Continuous assessment in the form of written and oral tests, as well as reports on practical work or numerical simulations.

Prerequisites Null

Code Y4ESE681

3.2.3.2 Electrical technology

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
6	Electrical technology	CDS	10	10	0	0	0	25	20	55	75	3

Content

The aim is to provide high-quality teaching materials that enable students to find, in a clearly organised and structured manner, all the essential elements required for a sound understanding of the fundamental technological principles of electrical engineering.

They will then be able to adapt to and contribute to future developments and to grasp, in broad terms, new technical challenges.

Reading electrical diagrams (single-line and multi-line).

Procedures for working on an electrical switchboard.

Identification of the various components.

Module objectives/intended learning outcomes

In accordance with standards NF C 15 100 and NF C 18 510, the targeted skills are:

- electrical safety and authorisation

- distribution of electrical energy and various protective measures
- use of electrical energy for motive power
- safety and maintenance of electrical installations and equipment
- commercial and technical aspects of the electrical engineering profession
- selection and sizing of protective and control equipment and wiring.

Language English

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form - Written or oral theory test

Prerequisites Null

Code Y4ESE682

3.2.4 Integrative project

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

Content

The aim of the project is to study, design and build a pre-production product or prototype that applies skills acquired in electronics, electrical engineering, signal processing and industrial computing. This work is partly supervised, and the student's active involvement in the various stages of the project is essential. Traffic light control at a junction, the up and down movement of a lift, an autonomous weather station, an audio signal spectrum analyser, instrumentation and data acquisition on an engine test bench, a signal and harmonic generator, etc., are examples of projects completed in previous years. Computer programming is involved in all topics. This work is the subject of a written report produced in Word and a 20-minute oral presentation prepared using PowerPoint.

Module objectives/intended learning outcomes

- Managing and leading a small-scale project
- Designing a technological solution in line with a set of specifications
- Researching technical documentation
- Drafting interim and final reports
- Giving an oral presentation of a project's results

Language English

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form - Written report
- Oral presentation followed by a question-and-answer session.

Prerequisites Null

Code Y4ESE6U9

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

- This substantial work placement (minimum 6 weeks – 10 weeks recommended), which takes place at the end of the sixth semester, aims to immerse the student in the professional environment, to give them an understanding of the realities of the workplace and to provide an initial insight into the duties expected of them by the company.
- The placement must take place within a company, preferably in a department related to electrical engineering, and may be carried out in a foreign country.

Module objectives/intended learning outcomes

Targeted skills: Knowledge:
- of the business world
- of the industrial working environment
- of constraints: deadlines, results, costs, staff
- independence and teamwork, rigour, scientific integrity.

Language Not specified

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form - Written internship report
- Presentation in the form of an oral presentation followed by a Q&A session.

Prerequisites Null

Code Y4ESE6UX

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 Electrical Actuators

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Electrical Actuators	CDS	24	24	36	0	0	96	84	66	150	6

Content

Synchronous machine with smooth or salient poles: Modelling, choice of Park coordinate system, operating equations in the d- and q-axes, voltage diagram, torque as a function of angular displacement and stability with the effect of dampers, behaviour under saturated conditions and Potier and Blondel diagrams, loss and efficiency tests, behaviour under an asymmetrical load;
Asynchronous machine: Formulation of equations, choice of reference frame and operating equations in various coordinate systems, operating equations in complex variables, equivalent circuits and power balance, torque as a function of slip and effect of stator resistance, operation at constant and variable frequency and voltage respectively, constant flux operation, principle of vector control, tests, losses, normalised current diagram, squirrel-cage and double-cage motors, single-phase operation;
Self-controlled synchronous motor: Principle of control based on rotor position, machines with sinusoidal or trapezoidal field distribution, different power supplies, brushless motors, torque ripple and operational adjustment, advantages and economic considerations;
Variable reluctance motors: Principle, advantages and limitations, requirements regarding the number of teeth and poles, hybrid motors, advantages and disadvantages, variable frequency and self-controlled power supply, stepper motor operation.

Module objectives/intended learning outcomes

To study the behaviour of real machines, taking into account various losses and the saturation of magnetic materials;
To analyse their behaviour depending on the power supply (mains or inverter);
To provide the fundamentals for control (e.g. self-controlled synchronous machines or vector control);
Be able to characterise electric machines experimentally: measurement of electrical and energy characteristics;
Be able to analyse the operation of electric machines based on an analysis of the magnetic field distribution;
Outline the characteristics of each type of motorisation in relation to potential applications.

Language English

Relation to curriculum Compulsory

Responsible Frederic Dubas

Examination form

Prerequisites Null

Code Y4EEE7U2

4.1.3 Power Electronics

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Power Electronics	CDS	28	28	18	0	0	88	74	76	150	6

Content

In-depth knowledge and understanding of various static converters (rectifiers, choppers, inverters, dimmers, etc.);
The latest technological developments in these converters (multi-level structures, interleaving, isolated structures);

Design of a voltage-to-voltage electronic power conversion system based on a specified set of requirements;

A comprehensive approach to the design of a complex system (electronic components, power conversion structure, control, real-time aspects, etc.), in response to a set of specifications;
Knowledge of the electronic power conversion structures used for speed control of DC motors and AC motors;
Ability to control an electronic power conversion structure.

Module objectives/intended learning outcomes

To deepen students' knowledge of power electronics;
To examine the various types of electronic power conversion systems in terms of their specifications, performance and control;
To develop practical skills in this field.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EEE7U3

4.1.4 Automatic control

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
7	Automatic control	FD	24	28	21	0	0	85	73	77	150	6

Content

Modelling and control of dynamic systems: Modelling and identification of dynamic systems, Analysis of the response of dynamic systems (stability, response time, accuracy and damping), State-space analysis of dynamic systems (internal stability, controllability and observability), Extension to multivariable systems, Observer synthesis (e.g., Luenberger observer), Pole placement via state feedback (separation principle), Concepts of optimal control and robust controllers, Handling non-linearities in dynamic systems;
Control of sampled systems: Introduction to sampled-data systems and digital systems, Description of signal sampling, Z-transform, sampled transfer function of a system, Study of the stability and performance of sampled-data systems, Modelling and analysis in state space, Synthesis of correctors for digital control systems via error signal correction or pole placement.

Module objectives/intended learning outcomes

The ability to model and formulate equations for system dynamics;
Proficiency in simulation software tools;
Rapid prototyping and digital controllers;
The world of microcontrollers and DSPs;
Real-time control.

Language English

Relation to curriculum Compulsory

Responsible Youcef Ait-Amirat

Examination form

Prerequisites Null

Code Y4EEE7U4

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

Prerequisites Null

Code Y4EEE7U5

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 H2 and Energy Storage

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	H2 and Energy Storage	CDS	28	28	18	0	0	88	74	76	150	6

Content

In-depth knowledge of conventional electrochemical electrical energy storage systems (i.e., electrochemical batteries);
In-depth knowledge of electrostatic electrical energy storage systems (i.e., supercapacitors);
In-depth knowledge of hydrogen-based electrical energy storage systems (i.e., electrolyser/H2 storage/fuel cell combination);
In-depth knowledge of other electrical energy storage systems (i.e., SMES, STEP, CAES, inertial storage, etc.);
Hybridisation of energy storage systems.

Module objectives/intended learning outcomes

Sizing an electrical energy storage system;
Designing a hybrid electrical system combining hydrogen energy and renewable energy sources;
Possessing scientific and technological knowledge of electrical energy storage systems for stationary and transport applications.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EEE8U7

4.2.3 Electric and Hybrid Drivelines

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Electric and Hybrid Drivelines	FD	24	18	36	0	0	90	78	72	150	6

Content

Environmental and economic context;
Basic principles of transport systems;
The internal combustion engine;
Electric vehicles;
Hybrid vehicles;
Hydrogen-powered vehicles;
Project-based module: carrying out a project with a schedule and deliverables based on a case study.

Module objectives/intended learning outcomes

Be able to calculate the energy balance of electric and hybrid powertrains;
Determine the appropriate size of on-board energy generation and storage systems;
Determine the appropriate size of electric and hybrid powertrains and validate them through simulation;
Be able to determine the energy and environmental balance from well to wheel.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EEE8U8

4.2.4 Power plants and renewable energies

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
8	Power plants and renewable energies	FD	28	42	0	0	0	84	70	80	150	6

Content

Study of the operating principles and technologies of conventional power stations: combustion plants, gas turbines and combined cycle plants, and nuclear power stations;
Study of the operating principles and technologies of renewable energy sources: hydroelectricity, photovoltaic panels, wind turbines, conventional power stations (combustion plants, gas turbines and combined cycle plants, nuclear power stations);
Economic and environmental issues relating to electricity generation systems.

Module objectives/intended learning outcomes

Understand how conventional power stations and renewable energy sources work;
Be able to calculate the capacity requirements and carry out an energy assessment for these sources.

Language English

Relation to curriculum Compulsory

Responsible David Bouquain

Examination form

Prerequisites Null

Code Y4EEE8U9

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

Prerequisites Null

Code Y4EEE8UX

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 Modelling and Control of Energy Systems

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Modelling and Control of Energy Systems	FD	20	24	18	0	0	72	62	88	150	6

Content

This module aims to provide students with a solid foundation of knowledge in the field of energy flow management within complex systems. It will draw on examples of multiphysical systems from the fields of electrical energy generation, storage and utilisation, for both transport and stationary applications.
By the end of this module, students should be able to:
Understand the formalisms and tools for representing and analysing complex multiphysical systems;
Apply previously acquired concepts and principles of control engineering and industrial computing to complex energy systems;
Effectively model and simulate a complex multiphysical system;
Be able to propose control strategies for these multiphysical systems, as well as hardware and software sensors, in accordance with defined specifications.

Module objectives/intended learning outcomes

Modelling and simulating a complex energy system;
Controlling a complex energy system.

Language English

Relation to curriculum Compulsory

Responsible Daniel Hissel

Examination form

Prerequisites Null

Code Y4EEE9U2

5.1.3 Applied Artificial Intelligence for Energy Systems

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Applied Artificial Intelligence for Energy Systems	CDS	20	24	18	0	0	72	62	88	150	6

Content

To introduce students to artificial intelligence methods (neural networks, fuzzy logic, stochastic optimisation);
Be able to implement energy management methods for electric vehicles and hybrid stationary systems using fuzzy logic;
Introduce students to the programming of optimisation methods using genetic algorithms or particle swarms, applied to energy systems.

Module objectives/intended learning outcomes

To deepen students' knowledge of modelling and control/management of energy systems;
Experimental skills in these areas.

Language English

Relation to curriculum Compulsory

Responsible Daniel Hissel

Examination form

Prerequisites Null

Code Y4EEE9U3

5.1.4 Development of (Semi-)Analytical and Numerical Multi-Physical Models

Semester	Module	Type	CM	TD	TP	AMSP	AMSE	TD eq.	Contact	Self-study	Total time	ECTS
9	Development of (Semi-)Analytical and Numerical Multi-Physical Models	CDS	24	24	36	0	0	96	84	66	150	6

Content

State of the art in (semi-)analytical and numerical modelling in 2D or 3D;
(Semi-)analytical modelling based on the formal solution of Maxwell's equations: classical and advanced (subdomain method);
(Semi-)analytical modelling using the Magnetic Equivalent Circuit (MEC): classical and advanced (generic automation method).

Module objectives/intended learning outcomes

To provide students with scientific training in the field of (semi-)analytical modelling (i.e., the subdomain method and MEC) which is emerging in the field of electrical energy;
To be able to apply electromagnetic concepts relating to Maxwell's equations;
Be able to develop (semi-)analytical models for 2D or 3D devices.

Language English

Relation to curriculum Compulsory

Responsible Frederic Dubas

Examination form

Prerequisites Null

Code Y4EEE9U4

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

Prerequisites Null

Code Y4EEE9U5

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

1/ Within a company, the aim of this work placement is:
to give the student the opportunity to apply the knowledge acquired during their studies to the practical demands of working life;
to enable them to test their communication, integration and teamwork skills;
to provide them with a genuine first professional experience that will maximise their chances of finding their first job.
2/ In a laboratory or R&D department, the aim of this placement is:
to discover the world of research through a genuine first-hand experience in a laboratory or R&D department;
to put into practice the knowledge acquired throughout their studies;
to test their communication, integration and teamwork skills, as well as their ability to carry out research work independently.

Module objectives/intended learning outcomes

24 weeks in a company, a laboratory or an R&D department.

Language English

Relation to curriculum Compulsory

Responsible Frederic Dubas

Examination form

Prerequisites Null

Code Y4EEEXU6

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