

ISMIN SYLLABUS

2024 – 2025

Master's Year 2	S10	Final Year Internship				Research Project Common Core	Workshop Common Core	Innovation Common Core
	S9	Languages & Cultures Common Core	Management Common Core	Biomedical Devices Tech. challenges OR Mobility & Security Tech. challenges OR Electronics & Energy Tech. challenges OR IT & Supply Chain Tech. challenges	Microelectronics Design Major OR Embedded Systems Major OR Computer Science Major			
Master's Year 1	S8	Languages & Cultures Common Core	Management Common Core	Electronics Microelectronics Elective	Computer Science Elective			Technical Internship in France or Abroad OR School Project
	S7	Languages & Cultures Common Core	Management Common Core	Electronics Microelectronics Common Core	Computer Science Common Core	IOT Project Common Core	Entrepreneurial Visa Common Core	
Bachelor Year	S6	Languages & Cultures Common Core	Management Common Core	Electronics Microelectronics Common Core	Computer Science Common Core	Prototyping Project Common Core	Robotics Project Common Core	ISA Project Common Core
	S5	Languages & Cultures Common Core	Management Common Core	Electronics Microelectronics Common Core	Computer Science Common Core			Observation & Analysis Internship of a Professional Situation

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Technological Challenges

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ISMIN SYLLABUS

2025 – 2026

Semester 5

Direction de la Formation - ISMIN
Mines Saint-Etienne
June 2024

Semester 5

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Educational Unit: General Physics

Educational Unit Director

Agnès ROUSSY

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B206

Number of ECTS credits (European Credit Transfer Scale)	5
In-person class time (in hours)	59.6
Individual work time (in hours)	36.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	7, 9, 10

General description

This Educational Unit provides students with the knowledge base they need to continue their studies in microelectronics.

Keywords

Basic electronics tools; Silicon physics; Material properties; Physics of passive components

Links between course sub-modules

At the end of the ‘Basic Electronics Tools’ and ‘Physics of Passive Components’ Educational Components, students will have acquired the theoretical foundations needed to continue learning about microelectronics, electricity and electromagnetism.

By the end of the ‘Silicon Physics’ and ‘Properties of Materials’ Educational Components, students will be familiar with the materials used in electronics: semiconductors and polymers.

Sub-modules

Basic Electronics Tools
Jean-Baptiste RIGAUD
Silicon Physics
Agnès ROUSSY
Properties of Materials
Esma ISMAÏLOVA
Physics of Passive Components
Roger DELATTRE

Educational Component: Basic Electronics Tools

Educational Unit: General Physics

Educational Component Director

Jean-Baptiste RIGAUD

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A225

In-person class time (in hours)	12
Individual work time (in hours)	20
Language(s) of instruction	French

General description

Review of fundamental concepts and methods for studying electrical circuits in continuous, sinusoidal and transient modes.

Keywords

Passive and active dipoles; Notion of impedance; Ohm's law; Superposition / Norton / Thévenin / Millman theorems; Kirchhoff's laws; Complex numbers; Permanent / transient / pseudo-periodic sinusoidal regime; Transfer function / Gain / Bode plot

Types or organisation of classes

1	Dipole definitions and reminders
2	Electrical circuit study methods
3	Transient electric circuits
4	Sinusoidal transfer functions

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Master the various methods of solving electrical circuits	4. Analyse	Tutorials	Written examination	Accuracy of answers
Use complex numbers	3. Apply	Tutorials	Written examination	Justification of choices
Analyse steady-state/transient/pseudoperiodic circuits	4. Analyse	Tutorials	Written examination	Relevance of argumentation
Apply the acquired knowledge to the study of sinusoidal filters	6. Create	Tutorials	Written examination	Rigour

Educational Component: Silicon Physics

Educational Unit: General Physics

Educational Component Director

Agnès ROUSSY

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B206

In-person class time (in hours)	12
Individual work time (in hours)	8.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Silicon is a key material in the world of semiconductors, thanks to its unique properties and widespread use in electronic devices. This course covers the fundamental principles governing the behaviour of silicon, from its crystalline structure to its electronic properties, including the concept of doping, conduction mechanisms and the effects of temperature. Students will be better prepared to design, optimise and innovate in the fields of silicon-based technologies.

Keywords

Semiconductor; Insulator; Metal; Charge carriers: electrons and holes; Doping; Electrical conduction

Types or organisation of classes

1	Microelectronics industry and reminder of crystallography basics
2	Reminder of solid state physics basics
3	Statistical physics and doping
4	Basic component: the PN junction

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Memorise the crystal structure of IV and III-V semiconductors	1. Remember	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Understand the links between crystallography and the properties of a solid material	2. Understand	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Analyse energy-band diagrams for different types of materials used in microelectronics	4. Analyse	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Describe the mechanisms of the two types of doping: P and N	2. Understand	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Explain the phenomenon of conduction in a semiconductor material	2. Understand	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Understand the concept of Fermi level alignment	3. Apply	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Apply the knowledge acquired in silicon physics to the study of PN junction operation	6. Create	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Evaluate the operation of a PN junction under polarisation	3. Apply	Lectures Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Raise awareness of the ecological impact of the microelectronics industry (consumption of water, energy and chemicals (acids, solvents, gases), recycling of consumables, air quality, extraction of rare minerals, etc.).	0.5
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Bibliography

Essential

O. Bonnaud, *Composants à semi-conducteurs, De la physique du solide aux transistors - Niveau C*. Ellipses, 2006

H. Mathieu & H. Fanet, *Physique des semiconducteurs et des composants électroniques*. Dunod, 2009

Useful

S. M. Sze & K. K. Ng, *Physics of Semiconductor Devices*. Wiley, 2006

Learn more

C. Kittel & J. Wiley, *Physique de l'état solide*. Dunod, 2019

Educational Component: Properties of Materials

Educational Unit: General Physics

Educational Component Director

Esma ISMAILOVA

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A345

In-person class time (in hours)	12
Individual work time (in hours)	12
Language(s) of instruction	French and English
Sustainable Development Goals (SDGs)	7, 10

General description

Provide an overview of the different properties of materials in new technologies, microelectronics and electronics. The aim of the course is to introduce students to the fundamentals of the chemical, physical, mechanical and electrochemical science of materials, covering the basic definition of material types, syntheses and processes, conformational structure and morphology, physicochemical properties and current applications.

Keywords

Organic materials; Inorganic materials; Polymeric materials; Electronic devices; Microelectronics manufacturing; Electrochemical reactions; Process vs. material properties; Additive manufacturing; Rapid prototyping; Redox reaction

Types or organisation of classes

1	Chemical physics of organic materials
2	Physical properties
3	Use of materials in microelectronics
4	Materials in devices
5	Materials for microelectronics
6	Mechanics of materials and rapid prototyping
7	Introduction to the fundamentals of redox reactions
8	Electrochemical thermodynamics
9	Kinetics of electrochemical reactions
10	Energy storage and conversion
11	Electrochemical characterisation techniques
12	Corrosion and protection mechanisms

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Recognise the different types of materials and associate them with their properties	1. Remember	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Understand the laws of polymer synthesis	2. Understand	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Memorise the conformational and morphological structure of polymers	1. Remember	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Understand the choice and role of materials in microelectronic components	5. Evaluate	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Apply more broadly the knowledge acquired on examples of new technology polymer-based manufacturing	3. Apply	1/4 group classes Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	IDFab prototyping
Assess the usefulness of materials science knowledge in rapid device prototyping using 3D printing	3. Apply	1/4 group classes Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	IDFab prototyping
Understand the role of redox reactions in various applications	2. Understand	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
Understand the principles of electrochemical processes	2. Understand	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Apply materials science concepts to microfabrication	1. Remember	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Evaluate energy solutions using electrochemical systems	5. Evaluate	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Develop expertise in electrochemical measurement techniques	3. Apply	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	
Develop expertise in corrosion prevention for industrial and structural applications	3. Apply	Lectures Tutorials	MCQs Written examination	Accuracy of answers Justification of choices Thinking-based approach	

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Presentation of the manufacturing and prototyping tools available on the IDFab platform as low-cost, fast, environmentally-friendly, low-energy and sustainable techniques	0.5
Goal 10: Reduce inequality within and among countries	Raise awareness of the ecological impact of the microelectronics industry, microfabrication processes, lithography, cleanrooms, current technological alternatives using printing and rapid prototyping processes, the appearance of plastics-polymers	0.5

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Essential

A. J. Bard, *Electrochemical Methods: Fundamentals and Applications*. Wiley, 2000

M. Fontanille, *Chimie et physico-chimie des polymères*. Dunod, 2021

V. K. A. Muniraj *et al.*, « High Performance Stretchable Wire Li-Ion Batteries », *Advanced Materials Technologies*, vol. 9, n° 21, p. 2302117, 2024, doi: [10.1002/admt.202302117](https://doi.org/10.1002/admt.202302117)

E. Noam & E. Gileadi, *Physical Electrochemistry: Fundamentals, Techniques, and Applications, 2nd Edition | Wiley*. Wiley, 2018

Educational Component: Physics of Passive Components

Educational Unit: General Physics

Educational Component Director

Roger DELATTRE

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A222

In-person class time (in hours)	18
Individual work time (in hours)	6
Language(s) of instruction	French

General description

Master the basic concepts of passive component electronics: physical principles, laws of behaviour, impedance. Introduction to the physical principles used in S6 Prototyping. Introduction to finite element modelling of electrostatic phenomena. Study and simulation of a conditioning circuit for an electrostatic sensor used in S6 Prototyping.

Keywords

Maxwell; Impedance; Finite element modelling; Electrical circuit simulation

Types or organisation of classes

1	Classes: Maxwell's equations for capacitive phenomena
2	Tutorial: Maxwell's equations for capacitive phenomena
3	Classes: Maxwell's equations for inductive phenomena
4	Tutorial: Maxwell's equations for inductive phenomena
5	Practical work: Finite element modelling of electrostatic phenomena
6	Practical work: Finite element modelling of electrostatic phenomena
7	Practical work: Partquest simulations of the electrostatic sensor conditioning circuit used in S6 prototyping

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Identify the role of passive components in electronics	2. Understand	Classes Tutorials	Oral Report	Relevant practical application of concepts	IDFab prototyping
Explain the physical principles involved in these components	2. Understand	Tutorials	Oral Report	Relevant practical application of concepts	IDFab prototyping
Create a circuit based on the physical principles learned	3. Apply	Tutorials	Oral Report	Relevant practical application of concepts	IDFab prototyping
Simulate an electrostatic sensor using the finite element method	3. Apply	Tutorials	Oral Report	Relevant practical application of concepts	IDFab prototyping
Simulate an electronic conditioning circuit for this sensor	3. Apply	Tutorials	Oral Report	Relevant practical application of concepts	IDFab prototyping
Characterise an electronic circuit	4. Analyse	Tutorials	Oral Report	Relevant practical application of concepts	IDFab prototyping

Educational Unit: Engineering Mathematics & Tools

Educational Unit Directors

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 A321 / B206

Number of ECTS credits (European Credit Transfer Scale)	5
In-person class time (in hours)	63
Individual work time (in hours)	57
Language(s) of instruction	French

General description

Mathematical concepts required for the ISMIN syllabus

Keywords

Signal processing; Signal mathematics; Robotics; Probability; Statistics

Links between course sub-modules

Mathematics for microelectronics and computer science

Sub-modules

Statistical Probability
Daniel OCHOA / Agnès ROUSSY
Signal Mathematics
David MOREAU
Signal Processing
David MOREAU
Linear Robotics
Bernard DHALLUIN

Educational Component: Statistical Probability

Educational Unit: Engineering Mathematics & Tools

Educational Component Directors

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A321 / B206

In-person class time (in hours)	15
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Master the statistical concepts required for the engineering profession

Keywords

Statistical test; Pairs of random variables (continuous/discrete); Confidence intervals; Estimator

Types or organisation of classes

1	Probability spaces and discrete random variables
2	Continuous random variables
3	Pairs of random variables (discrete and continuous)
4	Confidence intervals and estimators
5	Hypothesis testing

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Interpret data in statements	4. Analyse	Lectures Tutorials	Written examination	Critical analysis Thinking-based approach Relevance of argumentation
Analyse the problem in relation to an industrial case study	4. Analyse	Lectures Tutorials	Written examination	Critical analysis Thinking-based approach Relevance of argumentation
Choose the most suitable resolution method	5. Evaluate	Lectures Tutorials	Written examination	Achievement of goals Rigour Relevance of argumentation
Solve the problem at hand	3. Apply	Lectures Tutorials	Written examination	Justification of choices Methodology Accuracy of answers

Educational Component: Signal Mathematics

Educational Unit: Engineering Mathematics & Tools

Educational Component Director

David MOREAU

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A331

In-person class time (in hours)	19.5
Individual work time (in hours)	12
Language(s) of instruction	French

General description

The aim of this Educational Component is to introduce the tools of signal analysis and to study further the mathematical methods of signal representation and analysis.

Keywords

Signal mathematics; Convolution; Complex analysis; Fourier transform; Laplace transform; Z-transform; Signals

Types or organisation of classes

1	Classes: Introduction, Distributions, Convolution
2	Classes: Complex analysis, Fourier transform
3	Tutorial: Convolution and complex analysis
4	Classes: Fourier transform (continued), Laplace transform, Z-transform
5	Classes: Random signals (PSD of a stationary and ergodic signal)
6	Tutorial: Transforms
7	Assessment (1/2 session)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand signal analysis tools	2. Understand	Lectures Tutorials	Written examination	Command of the subject Accuracy of answers
Master signal analysis tools	4. Analyse	Lectures Tutorials	Written examination	Command of the subject Accuracy of answers

Educational Component: Signal Processing

Educational Unit: Engineering Mathematics & Tools

Educational Component Director

David MOREAU

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A331

In-person class time (in hours)	12
Individual work time (in hours)	8
Language(s) of instruction	French

General description

The aim of this Educational Component is to acquire the basics of digital signal processing.

Keywords

Signal processing; Signal digitalisation; Fast Fourier transform / Wavelet transform;
Analogue-to-digital conversion; Digital filters

Types or organisation of classes

1	Introduction, notions of signal and noise, characteristic quantities (autocorrelation, mean-variance...) digitalisation and sampling, fast Fourier transform and wavelet transform
2	Analogue-to-digital conversion, digital-to-analogue conversion, digital filters, adaptive filtering
3	Practical work: Python - ECG signal processing
4	Practical work: Python - Image compression using discrete cosine transform

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand signal processing tools	2. Understand	Lectures Tutorials	Practical work: assessed programming	Methodology Achievement of goals
Master signal processing tools	4. Analyse	Lectures Tutorials	Practical work: assessed programming	Methodology Achievement of goals

Educational Component: Linear Robotics

Educational Unit: Engineering Mathematics & Tools

Educational Component Director

Bernard DHALLUIN

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A229

In-person class time (in hours)	15
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Master the principles used to determine the performance (stability, accuracy, speed) of continuous linear systems. Master the tools for analysing these systems in the time and frequency domains. Apply theory to the study of electronic stability correction systems.

Keywords

Feedback loop; Servo systems; System performance; Control / Command

Types or organisation of classes

1	Classes: Generalities of robotics based on simple examples (Laplace formalism, Bode plot, etc.) of 1st and 2nd order system studies.
2	Classes: Study of the stability of linear servo systems (Black-Nichols, Routh table, stability criteria)
3	Classes and tutorials: Servo system performance (accuracy and speed)
4	Tutorial: Proportional corrector studies
5	Tutorial: Studies of Proportional-Integral and Proportional-Integral-Derivative correctors

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Render system performance criteria	1. Remember	Classes Tutorials	Written examination	Rigour
Use methods to analyse the stability of a linear system	3. Apply	Classes Tutorials	Written examination	Rigour Critical analysis
Analyse the stability, precision and speed of a servo system and select the appropriate corrector	4. Analyse	Classes Tutorials	Written examination	Rigour Critical analysis
Justify the choice of a linear system corrector	5. Evaluate	Classes Tutorials	Written examination	Rigour Critical analysis

Bibliography

Essential

M. Rivoire and J.-L. Ferrier, *Cours d'automatique 2 - Asservissement. Régulation*. Editions Eyrolles, 1998.

Useful

F. Maneville & J. Esquieu, *Electronique - 2 - Systèmes bouclés linéaires, de communication et de filtrage*. Dunod, 2004.

Learn more

G. F. Franklin, J. D. Powell & A. Emami-Naeini, *Feedback Control of Dynamic Systems*. Prentice Hall, 2005.

Educational Unit: Fundamentals of Electronics

Educational Unit Director

Bernard DHALLUIN

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A229

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	57
Individual work time (in hours)	39
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9, 12

General description

Acquire the basics of electronics required to understand the advantages, operation, identification and characterisation of mixed electronic circuits

Keywords

Electronic components; Electronic circuits and schematics: amplification, filtering; Mixed systems; Combinational and sequential logic; Binary number representation, state machine

Links between course sub-modules

The two courses in this Educational Unit provide the knowledge needed to understand complete electronic systems.

Sub-modules

Analogue electronics
Bernard DHALLUIN

Digital electronics
Olivier POTIN

Educational Component: Analogue Electronics

Educational Unit: Fundamentals of Electronics

Educational Component Director

Bernard DHALLUIN

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A229

In-person class time (in hours)	30
Individual work time (in hours)	16
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Understand the functioning of two basic semiconductor components in electronics (diode and MOS transistor) and an integrated circuit (operational amplifier), as well as common circuits: signal amplifier, signal adder/subtractor, impedance converter, integrator/deviator, hysteresis, filter.

Master the basic principles of amplifiers: linearity, input/output impedance, impedance matching, bandwidth.

Keywords

Analogue electronic circuit; Polarisation; Amplification; Diode; MOS transistor; Operational amplifier; Modelling

Type or organisation of classes

1	Elements of semiconductor physics: the PN junction. The diode: Models, examples of diodes in use, exercises: series/parallel, ON/OFF, logic gate.
2	Diode: signal diode (full-wave and half-wave rectification), Zener (clipping), LED (luminous intensity)
3	TP Diode: signal diode (full-wave and half-wave rectification), Zener (clipping), LED (light intensity)
4	The MOS transistor: Physical principle. Large signal modelling, polarisation, small signal modelling.
5	MOS transistor: DC/AC and MOS amplification studies - Common-source assembly MOS switching: LED or motor control exercise. Current source: exercises
6	MOS practical work: common-source circuit assembly: linear amplifier
7	Operational amplifier (op amp)
8	Op amp practical work: Inverting amplifier and bandpass filter assembly
9	Op amp practical work: Study of a PWM control circuit based on a hysteresis and an integrator

Intended learning and outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Explain the actual operation of a diode, a MOS transistor and an op amp	2. Understand	Lectures Practical work	Individual written examination Practical work reports in pairs	Justification of choices Media quality
Read an electronic diagram and understand how it works	2. Understand	Lectures Practical work	Individual written examination Practical work reports in pairs	Justification of choices Media quality
Choose the most appropriate schematic structure to meet specifications	3. Apply	Lectures Practical work	Individual written examination Practical work reports in pairs	Justification of choices Media quality
Perform DC and AC analysis of a simple analogue electronic circuit	4. Analyse	Lectures Practical work	Individual written examination Practical work reports in pairs	Justification of choices Media quality
Identify the current-voltage characteristics of the components studied	1. Remember	Lectures	Individual written examination	Accuracy of answers

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Raising awareness of the ecological impact of the microelectronics industry (water and energy consumption, consumption and recycling of chemicals - acids and solvents, extraction of rare minerals, etc.)	1
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S. Dusausay, *Comprendre l'électronique par la simulation*. Vuibert, 2000

Learn more

S. M. Sze & K. K. Ng, *Physics of Semiconductor Devices*. Wiley, 2006

Educational Component: Digital Electronics

Educational Unit: Fundamentals of Electronics

Educational Component Director

Olivier POTIN

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A225

In-person class time (in hours)	24
Individual work time (in hours)	24
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	12

General description

This Educational Component covers the concepts of digital systems:

- . representation of numbers in binary and arithmetic operations (unsigned, signed, real numbers, etc.)
- . digital design of basic combinatorial elements (Boolean logic gates, multiplexers, adders, etc.),
- . sequential (standard memory cells)
- . and Moore and Mealy finite-state machines

Keywords

Binary representation; Arithmetic operation in binary; Boolean algebra; Boolean equation and simplification; Basic real-valued functions; Memory point and sequential logic; Finite-state machine

Type or organisation of classes

1	4 sessions on combinatorial logic and arithmetic operators, sequential logic and the Moore or Mealy finite-state machine synthesis method
2	4 tutorial sessions

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify Boolean functions	1. Remember	Lectures Practical work	Written examination	Accuracy of answers
Determine the binary representation of numbers according to the expected precision	2. Understand	Lectures Practical work	Written examination	Accuracy of answers
Recognise arithmetical and sequential operators	2. Understand	Lectures Practical work	Written examination	Accuracy of answers
Define a finite-state machine according to the target application	3. Apply	Lectures Practical work	Written examination	Accuracy of answers

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 12: Ensure sustainable consumption and production patterns	Basic principle of power consumption in electronic systems	0.3
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Useful

M. M. Mano, *Digital Design*. Prentice Hall, 2002

Learn more

T. Lang & M. D. Ercegovac, *Digital arithmetic*. Morgan Kaufmann, 2003

Educational Unit: IT Concepts & Tools

Educational Unit Director

Pierre UNY

uny@emse.fr

B205

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	55.5
Individual work time (in hours)	40.5
Language(s) of instruction	French

General description

Fundamentals of algorithmics, programming and associated tools.

Keywords

C language; Linux; Git

Links between course sub-modules

The concepts and tools used to implement them.

Sub-modules

Algorithms and Programming 1

Pierre UNY

IT Tools

Pierre UNY

Educational Component: Algorithmics & Programming 1

Educational Unit: IT Designing & Tools

Educational Component Director

Pierre UNY

uny@emse.fr

B205

In-person class time (in hours)	42
Individual work time (in hours)	40.5
Language(s) of instruction	French

General description

Acquire technical skills in C Language programming for implementation of high-performance data structures and algorithms

Keywords

C Language; Programming; Algorithm

Types or organisation of classes

1	C Language Basics
2	Functions & Tables
3	Recursion
4	Algorithm Complexity
5	Pointers & Addresses
6	Structures
7	Character Strings
8	Files
9	Linked Lists
10	Heap Data Structure
11	Modularity

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Develop an application using C language	6. Create	Classes Project practical work	Practical examination Project	Accuracy of answers Achievement of goals
Define data structures and algorithms that are efficient in terms of memory space and time	6. Create	Classes Project practical work	Project	Achievement of goals
Write clean, legible code	4. Analyse	Classes Project practical work	Practical examination Project	Achievement of goals

Educational Component: IT Tools

Educational Unit: IT Concepts & Tools

Educational Component Director

Pierre UNY

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B205

In-person class time (in hours)	13.5
Individual work time (in hours)	0
Language(s) of instruction	French

General description

Become familiar with the fundamental tools used in IT projects

Keywords

Linux; Shell; Git

Types or organisation of classes

1	Linux: File hierarchy and commands
2	Linux: Shell scripts
3	Git: Zones, commits, branches
4	Git: Collaborative work, GitLab

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Use Linux via the command line and shell scripts	3. Apply	Practical work	Written examination	Accuracy of answers
Use Git commands to manage versions and collaborative work	3. Apply	Practical work	Written examination	Accuracy of answers

Educational Unit: Company Components

Educational Unit Director

Maxime MALAFOSSE

maxime.malafosse@mines-stetienne.fr

A319

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	49.5
Individual work time (in hours)	46.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	5, 7, 8, 9, 12, 16

General description

Experiment with the role of corporate functions and strategies in a responsible approach. Provide a global vision of the company through its players, culture, management and decision-making processes. Raise awareness of the fundamentals of collective intelligence to develop the team spirit essential to high-performance organisations.

Keywords

Organisation; Player; Managerial methods; Culture; Functions; Decision-making; Corporate functions; Corporate strategy

Links between course sub-modules

This programme combines an organisational and strategic approach to business. The first module covers the roles, culture, management and collective intelligence essential to teamwork. The second explores corporate functions and strategies, and puts these into practice via a serious game. Together, they provide a global vision of the workings and dynamics of corporate decision-making.

Sub-modules

Corporate functions and teamwork
Maxime MALAFOSSE
Corporate vision and strategies
Thibaut METAILLER

Educational Component: Corporate Functions and Teamwork

Educational Unit: Company Components

Educational Component Director

Maxime MALAFOSSE

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A319

In-person class time (in hours)	12
Individual work time (in hours)	4
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	5; 8; 16

General description

Provide students with a general overview of the components of a company and how it operates, from the point of view of its players, culture, functioning, managerial methods and decision-making processes. The focus on the fundamentals of collective intelligence (two sessions) is designed to raise students' awareness of the importance of teamwork and the development of a particular team spirit found in high-performance organisations, winning sports teams, well-functioning associations, communities working for the common good with convincing results, and so on.

Keywords

Organisation; Player; Managerial methods; Culture; Functions; Decision-making; Corporate function; Corporate strategy

Types or organisation of classes

1	Introduction, Social Sciences & Humanities for engineers
2	Corporate functions and roles
3	Culture and management styles
4	The fundamentals of collective intelligence
5	Decision-making methods and quality tools

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify the components of a company and how it functions, in terms of its players, culture, operations, management and decision-making methods.	2. Understand	Tutorials	Pass / Fail	Active participation
Evolve in different cultures and managerial modes	4. Analyse	Simulation	Pass / Fail	Active participation
Mobilise the fundamentals of collective intelligence	3. Apply	Tutorials	Pass / Fail	Active participation
Implement a decision-making process based on collective intelligence and quality tools	6. Create	Tutorials	Pass / Fail	Active participation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 5: Achieve gender equality and empower all women and girls	Collective intelligence is a useful skill to acquire in order to work towards this goal	3
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Mastering the components of the company and how it operates promotes shared, sustainable economic growth, full, productive employment and decent work for all.	6
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Collective intelligence is a useful skill to acquire in order to work towards this goal	3

Educational Component: Corporate Vision and Strategy

Educational Unit: Company Components

Educational Component Director

Thibaut METAILLER

thibaut.metailler@emse.fr

A316

In-person class time (in hours)	36
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	7, 8, 9, 12

General description

Understand, through experimentation, the role of different corporate functions and strategies in a responsible approach

Keywords

Corporate function; Corporate strategy

Types or organisation of classes

1	Different corporate functions and the foundations of corporate strategy
2	Serious game simulation of a company takeover

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the fundamentals of corporate strategic analysis	1. Remember	Lectures	MCQs	Accuracy of answers
Understand the roles and functioning of a company	3. Apply	Lectures Simulation	Self-assessment Participation in the simulation Group oral presentation	Critical analysis Clarity of presentation Creativity Commitment Justification of choices Active participation Relevance of argumentation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Reflecting on resource issues in innovation, critiquing technology-intensive approaches to innovation	36
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Designing a responsible development strategy	36
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Innovation and sustainable production approach	36
Goal 12: Ensure sustainable consumption and production patterns	Innovation and sustainable production approach	36

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R. Durand, P. Dussauge, & L. Lehmann-Ortega, *Strategor - La référence en stratégie, de la start-UP à la multinationale*. Dunod, 2024.

Essential

Educational Unit: Corporate Investigation

Educational Unit Director

Maxime MALAFOSSE

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A319

Number of ECTS credits (European Credit Transfer Scale)	6
In-person class time (in hours)	30
Individual work time (in hours)	10
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 5, 8, 16

General description

Deepen knowledge acquired on the general operation of a business and its main functions through a field study. Review the basics of interpersonal communication (key concepts, principles, techniques). Improve communication skills. Learn to take control of communication situations.

Keywords

CV; Cover letter; Observation; Integration; Understanding; Stepping back; Listening; Questioning; Relationships; Gestural / non-verbal communication

Links between course sub-modules

This programme combines communication and corporate immersion. The first three sessions develop the essential communication skills needed to interact effectively in the workplace. Preparing for an internship enables students to apply what they have learned to a real-life situation, by observing, integrating and understanding how the company works. Last but not least, the internship assessment enables them to take a step back from the experience and analyse the interactions and relational dimension observed, thus ensuring in-depth, concrete learning.

Sub-modules

Preparation, internship and feedback

Maxime MALAFOSSE

Relational development

Maxime MALAFOSSE

Educational Component: Preparation, Internship and Feedback

Educational Unit: Corporate Investigation

Educational Component Director

Maxime MALAFOSSE

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A319

In-person class time (in hours)	18
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	5, 8

General description

Deepen knowledge acquired on the general operation of a business and its main functions through a field study.

Keywords

CV; Cover letter; Observation; Induction; Understanding; Stepping back; Sharing experience

Types or organisation of classes

1	Preparation workshops
2	Internship presentation
3	Introduction to the business world' internship (1 month)
4	Internship report (3 sessions)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Deepen their knowledge of the company's general operations and its main functions through a field study	2. Understand	Internship	Academic tutor assessment	Commitment
Give an oral presentation of their experience	4. Analyse	Feedback	Group oral presentation	Quality of deliverables

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 5: Achieve gender equality and empower all women and girls	Students develop their ability to analyse the path to greater gender equality	8
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Students develop their ability to analyse the effective participation of companies in shared and sustainable economic growth, full and productive employment and decent work for all.	24

Educational Component: Relational Development

Educational Unit: Corporate Investigation

Educational Component Director

Maxime MALAFOSSE

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A319

In-person class time (in hours)	9
Individual work time (in hours)	4
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 5, 16

General description

Review the basics of interpersonal communication (key concepts, principles, techniques). Improve communication skills. Learn to take control of communication situations.

Keywords

Listening; Questioning; Relationships; Gestural / non-verbal communication; Palo Alto

Types of organisation or classes

1	Communication basics
2	Communicating in front of (and with) an audience
3	Recognising the importance of the relational dimension in any communication situation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify the basics of communication	2. Understand	Tutorials	Pass/fail	Active participation
Appreciate the relational dimension in any communication situation	3. Apply	Tutorials	Pass/fail	Active participation
Communicate in front of (and with) an audience	6. Create	Tutorials	Pass/fail	Active participation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Relational development is an essential skill to acquire in order to work towards this goal	3
Goal 5: Achieve gender equality and empower all women and girls	Relational development is an essential skill to acquire in order to work towards this goal	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Relational development is an essential skill to acquire in order to work towards this goal	3

Educational Unit: Languages & Cultures

Educational Unit Director

Samantha CHIN

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A106

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	42.5
Individual work time (in hours)	29.5
Language(s) of instruction	English, German, Chinese, Spanish, Japanese, Portuguese
Sustainable Development Goals (SDGs)	4, 8, 10, 13, 16

General description

Modern languages at the heart of engineering students' training

As part of their training, engineering students are taught modern languages with a strong professional and international focus. The aim is to complement their technical and scientific knowledge with the development of high-level linguistic and intercultural skills, essential for their development in a multicultural environment.

Requirements and certifications

Fluency in English (1st foreign language) is a priority, with a minimum requirement of 800 TOEIC points or 90 TOEFL IBT points, as well as a B2 level according to the Common European Framework of Reference for Languages (CEFR), certified by the School. A second modern language (Spanish, German, Chinese, Japanese, French or Portuguese) is also taught, with the aim of ensuring operational proficiency adapted to the needs of engineers in an international context.

Professional and intercultural skills

The language teaching takes a pragmatic approach, with a strong focus on communication needs in real-life professional situations. This course helps to equip our future engineers with the tools they need to collaborate effectively in a global and multicultural environment, facilitating their professional integration and international mobility.

Keywords

English; Chinese; German; Japanese; Portuguese; Spanish

Links between course sub-modules

Objectives common to all Educational Components

Sub-modules

English
Samantha CHIN

Modern Languages 2 (2nd foreign language)
Samantha CHIN

Educational Component: English

Educational Unit: Languages & Cultures

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	20
Individual work time (in hours)	15
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	4, 8, 10, 13, 16

General description

The main aim of this Educational Component is to prepare students for a study or work experience abroad, as part of their syllabus at ISMIN. The module aims to provide students with the tools they need to start thinking about their international project, help them identify destinations suited to their personal and professional goals, and initiate the first concrete planning steps (B1+/B2 level).

Keywords

International mobility; Intercultural awareness; Language skills; Employability; Cultural immersion; Adaptability; Intercultural communication; Study abroad; Soft skills; Multilingualism

Types or organisation of classes

1	10 classes
2	5 tutorials

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Search for information in English (level B1/B2) on a foreign country to identify available academic or career opportunities	2. Understand	Research work Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Analyse the cultural and educational differences between several countries in order to choose a suitable destination to meet personal and professional goals	4. Analyse	Teamwork Tutorials	Peer assessment	Thinking-based approach
Plan the logistical aspects of a stay abroad (budget, administrative procedures, accommodation) for a successful mobility experience.	5. Assess	Classes Tutorials Project	Written case study	Relevance of proposed plan: is it logistically realistic and adapted to the chosen destination (budget, accommodation, itinerary, visa, etc.)?
Communicate findings and conclusions orally in English at B1/B2 level in front of a group of people	6. Create	Classes Tutorials Project	Oral projects: Preparation and individual or group presentation of conclusions.	Clarity of presentation Language level Fluidity

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Develop the intercultural and linguistic skills needed to operate in an international academic or professional environment.	2
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Raising awareness of social, ethical and legal standards for internships and jobs in different countries, to promote successful integration.	1.5
Goal 10: Reduce inequality within and among countries	Analysis of cultural and economic inequalities between different countries to prepare students for diverse environments.	1.5
Goal13: Take urgent action to combat climate change and its impacts	Introduction to sustainable practices applied to international mobility (reducing the carbon footprint of travel, choosing eco-responsible destinations).	1
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Training on inclusive and ethical behaviour in international environments, promoting effective collaboration in multicultural teams.	1

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Useful

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A. Molinski, *Global Dexterity: How to Adapt Your Behavior Across Cultures Without Losing Yourself in the Process*. HBR, 2013.

R. Murphy, *English Grammar in Use*. Cambridge University Press, 2019.

Educational Component: Modern Languages 2

Educational Unit: Languages & Cultures

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	19
Individual work time (in hours)	14
Language(s) of instruction	Choice between: German Chinese, Spanish, Japanese, Portuguese
Sustainable Development Goals (SDGs)	4, 8, 10, 13, 16

General description

(Level B1/B1+/B2) The main aim of this Educational Component is to prepare students for a study or work experience abroad, as part of their syllabus at ISMIN. The module aims to provide students with the tools they need to start thinking about their international project, help them identify destinations suited to their personal and professional goals, and initiate the first concrete planning steps.

(Level A0/A1/A2) The main aim of this Educational Component, intended for levels A0/A1/A2, is to enable students to develop basic linguistic competence in their second foreign language. They will learn to understand and use simple expressions to meet basic communication needs in everyday situations. Students will be able to introduce themselves and exchange personal information, such as their name, nationality, language and hobbies, both in writing and orally. They will also acquire a good grounding in pronunciation and grammar, adapted to the language studied, to ensure comprehensible communication. In addition, they will be introduced to fundamental linguistic structures, and learn to recognise and use basic written forms. Lastly, this unit aims to introduce students to key cultural aspects of the target language, focusing on customs, social practices and cultural peculiarities in personal or professional contexts.

Keywords

International mobility; Intercultural awareness; Language skills; Employability; Cultural immersion; Adaptability; Intercultural communication; Study abroad; Soft skills; Multilingualism

Types or organisation of classes

1	10 classes
2	5 tutorials

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Level B1/B2				
Communicate orally in everyday and professional situations.	3. Apply	Role play Professional conversation simulations	Oral assessment during simulations	Fluency, Precision Correct grammatical structure
Write a structured text to describe experiences or defend a point of view.	4. Analyse	Written essays or reports on specific topics	Correction of written texts	Consistency Vocabulary used Spelling Clarity of ideas
Understand authentic documents to identify key information.	2. Understand	Analysis of written documents (articles, emails, brochures) or audio material (podcasts, videos)	Multiple-choice questions or written summary based on the documents studied	Overall understanding Accuracy in identifying information
Take an active part in a debate, expressing opinions clearly and responding to those of others.	5. Assess	Organisation of debates on cultural or professional topics	Teacher observation and feedback	Relevance of arguments Interaction Use of vocabulary

Intended learning and outcomes

Intended learning and outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Level A0/A1/A2				
Understand and using simple expressions to communicate in everyday situations	1. Recognise	Role play Guided dialogue on everyday topics (introducing oneself, shopping, travel)	Classroom observation Oral exercises	Pronunciation Understanding Correct use of words
Introduce themselves and exchange personal information orally and in writing	2. Understand	Interactive activities such as mock interviews and questionnaires	Oral presentation Individual writing	Clarity Fluency Accuracy of information provided
Recognise and reproduce simple grammatical structures in the language studied	3. Apply	Practical grammar exercises (simple sentences, conjugations).	MCQs Written exercises	Grammatical accuracy Correct basic structures
Discover and apply the basic cultural aspects of the language studied	2. Understand	Analysis of images, videos or discussions on local customs and traditions	Group presentation on a cultural theme	Relevance of examples Understanding of cultural aspects

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Develop the intercultural and linguistic skills needed to operate in an international academic or professional environment.	
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Raising awareness of social, ethical and legal standards for internships and jobs in different countries, to promote successful integration.	
Goal 10: Reduce inequality within and among countries	Analysis of cultural and economic inequalities between different countries to prepare students for diverse environments.	
Goal 13: Take urgent action to combat climate change and its impacts	Introduction to sustainable practices applied to international mobility (reducing the carbon footprint of travel, choosing eco-responsible destinations).	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Training on inclusive and ethical behaviour in international environments, promoting effective collaboration in multicultural teams.	

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ISMIN SYLLABUS

2025 – 2026

Semester 6

Direction de la Formation - ISMIN
Mines Saint-Etienne
June 2024

Semester 6

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Educational Unit: Electronics 1

Educational Unit Director

Jean-Max DUTERTRE

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A226

Number of ECTS credits (European Credit Transfer Scale)	5
In-person class time (in hours)	63
Individual work time (in hours)	41
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

The aim of the Electronics 1 Educational Unit is to train students to set up analogue signal processing chains with a view to digitising them. The lessons also cover digital servo systems (control, command and correction). The final objective is to train students to design complex digital systems using a hardware description language.

The overall aim of the course is to provide a coherent whole, with all the conceptual tools and know-how needed to acquire an analogue signal (e.g. from a sensor), use it in a digital servo system and describe the hardware of a digital circuit that can implement it.

Keywords

Acquisition chain; Active analogue filter; Analogue-to-digital conversion; Digital servo control; System control; Hardware description language (HDL); SystemVerilog

Links between course sub-modules

The Electronics 1 Educational Unit continues the electronics training begun in the previous semester with classes in analogue and digital electronics. It builds a bridge between these two fields through the Acquisition Chain class which deals with the shaping and digital conversion of an analogue signal. The digitised signal can typically come from a sensor and be used by a digital servo system. This is the topic of the Digital Robotics Educational Component, which covers the control, command and correction aspects of digital servo systems. Finally, the third Educational Component, Digital System Designing, introduces the use of a hardware description language (SystemVerilog) for modelling digital circuits. The concepts introduced are applied in a supervised project to design a hardware cryptographic accelerator.

Sub-modules

Digital Robotics

Bernard DHALLUIN

Acquisition Chain

Alexandre HABIB

Digital System Designing

Jean-Baptiste RIGAUD

Educational Component: Digital Robotics

Educational Unit: Electronics 1

Educational Component Director

Bernard DHALLUIN

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A229

In-person class time (in hours)	15
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Acquire the analytical tools and principles used to determine the performance (stability, accuracy, speed) of continuous and discrete linear systems. Apply theory to the study of electronic stability correction systems.

Prerequisites

Linear Robotics – 1st and 2nd order systems analysis. Matrix computing elements

Keywords

Digital servo control; State feedback control; System performance; Control / Command; Corrector

Types or organisation of classes

1	Classes. Digital servo control (paradigm, Z-transform, limits, stability study, methods, model), sampled transfer functions
2	Classes. Sampled systems, correction, corrector synthesis, control accuracy analysis, standard controllers, digital PID
3	Classes. State space: paradigm, canonical forms, controllability and observability of a system, links between linear and digital representations, state feedback control, state reconstructor
4	Tutorial. Application of basic skills in digital servo control methods
5	Tutorial. Application of basic skills in state space-specific methods

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Identify the behavioural parameters of a linear or digital state system	1. Remember	Classes Tutorials	Written examination	Rigour Critical analysis
Calculate a servo system to improve system performance	3. Apply	Classes Tutorials	Written examination	Rigour Critical analysis
Assess performance in terms of accuracy, stability and speed of a corrected system	5. Evaluate	Classes Tutorials	Written examination	Critical analysis Thinking-based approach

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Useful

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Educational Component: Acquisition Chain

Educational Unit: Electronics 1

Educational Component Director

HABIB Alexandre

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A227

In-person class time (in hours)	21
Individual work time (in hours)	10
Language(s) of instruction	French

General description

The aim of this Educational Component is to teach the main principles used to implement a signal acquisition chain, from the conditioning to the digitisation of an analogue signal. It consists of theoretical sections to enable students to master the concepts, and experimental sections for their practical application. By the end of the course, students will be able to implement the various components of a sensor signal processing chain: nth-order analogue filtering via an active filter, use of analogue-to-digital converters, increased accuracy (effective number of bits) by oversampling and decimation.

Keywords

Active analogue filters; Instrumentation amplifier; Analogue-to-digital converter (ADC); Digital-to-analogue converter (DAC); Sampling; Oversampling; Effective number of bits (ENOB)

Types or organisation of classes

1	Class on the data acquisition chain, presentation of concepts (filtering, sampling, data digitisation)
2	Tutorial on active analogue filter synthesis, synthesis methods (analytics, abacuses and software)
3	Practical work on building and characterising an active analogue filter
4	Class on analogue-to-digital and digital-to-analogue conversion
5	Session including a tutorial and practical work on the implementation of an oversampling converter
6	First session of practical application to the case of postal scales implementing a complete acquisition chain and using an oversampling and decimation technique
7	Second practical session with postal scales, involving noise filtering and resolution enhancement (ENOB)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Design and analyse an nth-order active analogue filter	6. Create	Lecture Tutorials Practical work	Written assignment Practical work report	Accuracy of answers Rigour and critical analysis
Select and implement analogue-to-digital converter (ADC) technology	6. Create	Lecture Tutorials Practical work	Written assignment Practical work report	Accuracy of answers Rigour and critical analysis
Analyse the signal processing chain from sensor to digitisation	4. Analyse	Lecture Tutorials Practical work	Written assignment Practical work report	Accuracy of answers Rigour and critical analysis
Use oversampling techniques to increase the resolution (ENOB) of an ADC	5. Evaluate	Lecture Tutorials Practical work	Written assignment Practical work report	Accuracy of answers Rigour and critical analysis

Educational Component: Digital System Designing

Educational Unit: Electronics 1

Educational Component Director

Jean-Baptiste RIGAUD

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A225

In-person class time (in hours)	27
Individual work time (in hours)	21
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Understand and implement the fundamental concepts of a hardware description language for designing large-scale digital systems, in this case SystemVerilog, through a course followed up with a project.

Four sessions of lectures and tutorials will cover the key concepts: design units, libraries, concurrent processes, signals and variables, simulation paradigms, dataflow, structural and behavioural modelling, configuration, test bench, genericity, description of Moore and Mealy finite state machines.

Five project sessions will put these concepts into practice on the design of an encryption algorithm with associated data (Ascon), the standard for lightweight cryptographic algorithms (LWC).

Keywords

Register Transfer Level, RTL; SystemVerilog; Structural; Finite State Machine (FSM); Genericity; Logic simulation; Process; Sequential; Combinatorial; Lightweight encryption

Types or organisation of classes

1	General information on hardware description languages, HDL. First example of a circuit modelled in SystemVerilog
2	Structural (hierarchical) circuit modelling and logic simulation
3	Notion of genericity and behavioural modelling
4	SystemVerilog modelling of a machine with a finite number of states.
5	Presentation of the Ascon lightweight encryption algorithm and the working environment
6	Modelling basic permutation functions
7	Continuation of basic permutation modelling
8	Final permutation and data path control via FSM
9	Final circuit assembly

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Produce a circuit design report	6. Create	Project-based learning	Design report Technical report	Document structure Accuracy of answers Quality of diagrams Quality of illustrations Command of tools and language
Apply a hierarchical design methodology	3. Apply	Tutorials	Academic assessment	Command of tools and language
Design/model the various parts of an integrated digital circuit	6. Create	Project-based learning	Design report Technical report	Command of the subject Relevance of choices
Generate/analyse test programs to validate circuit function	4. Analyse	Tutorials	Academic assessment	Relevance of choices Justification of choices

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation		1
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Learn more

IEEE SystemVerilog standard

Educational Unit: Electronic System Designing 1

Educational Unit Director

Acacio MARQUES

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D103

Number of ECTS credits (European Credit Transfer Scale)	8
In-person class time (in hours)	103.5
Individual work time (in hours)	40
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	8, 13, 15

General description

Introduction to the architecture and programming of microcontroller systems, followed by a more in-depth understanding of the concepts through various programming and hardware projects.

Keywords

Arithmetic logic unit; Registers; Von Neumann architecture; STM32; ARM core; Peripherals; Timers; ADC; UART

Links between course sub-modules

The Processor Architecture Educational Component enables students to discover the internal structure of a microprogrammed system and its low-level operation. The Microcontroller-Based System Educational Component introduces the concepts needed to program, in high-level language, the specific STM32 architecture. The robot project extends this learning process, providing experience through the creation of an on-board program for driving a terrestrial robot. Finally, the overarching project dedicated to prototyping offers a global vision of embedded systems, from the initial idea to its design, including hardware production and programming.

Sub-modules

Processor architecture 1

Olivier POTIN

Microcontroller-Based Systems 1

Acacio MARQUES

Applied Robotics

Acacio MARQUES

Prototyping

François BERNIER

Educational Component: Processor Architecture 1

Educational Unit: Electronic System Designing 1

Educational Component Director

Olivier POTIN

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A225

In-person class time (in hours)	15
Individual work time (in hours)	19
Language(s) of instruction	French

General description

The aim is to study computer architecture and processor designing based on an open-source RISC-V instruction set.

The course includes:

- understanding the levels of abstraction from application to microarchitecture,
- microarchitecture design choices for executing assembler routines
- and the identification of data and control dependencies in the pipeline architecture.

Keywords

Computer architecture; ISA; RISC microarchitecture; Compilation; Binary encoding of assembler instructions; Single-cycle, multicycle, pipeline microarchitecture; Memory organisation (Von Neuman, Harvard); EABI; LOGISIM schema editing tool

Types or organisation of classes

1	Introduction to processor architectures
2	RISCV ISA
3	Flow break instructions and exceptions
4	Multicycle and pipeline architecture
5	RISCV ABI

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Characterise a processor architecture	2. Understand	Lecture-style classes	Written assignment	Accuracy of results
Assemble digital microarchitecture components	2. Understand	Tutorials	Technical report	Media quality
Identify the data and control management path	1. Remember			
Complete or modify a RISC microarchitecture	3. Apply			
Write a technical report	3. Apply			

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A. S. Tanenbaum, *Structured Computer Organization*, 6th edition. Pearson India, 2016.

Educational Component: Microcontroller-Based Systems 1

Educational Unit: Electronic System Designing 1

Educational Component Director

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D103

In-person class time (in hours)	24
Individual work time (in hours)	20
Language(s) of instruction	French

General description

Acquire complete mastery of the hardware architecture of a specific microcontroller, from the ARM core to the basic STM32 peripherals. Learn how to develop drivers to operate these peripherals efficiently, using modern, high-level hardware and software tools. Also develop the ability to debug an application using these same tools.

Keywords

Flash; Cache; Interrupts; Clock; Timers; ADC; uART; Step; Breakpoint

Types or organisation of classes

1	ARM-Cortex architecture
2	STM32CubeIDE and GPIO tool
3	GPIO practical work
4	Interrupts
5	Timers
6	PWM generation and input capture measurement
7	ADC
8	uART serial link

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Program basic microcontroller peripheral drivers	3. Apply	Practical work	Machine test	Compliance with specifications
Debug their application using the tools provided by the development platform	3. Apply	Practical work	Machine test	Functional application
Choose and configure their microcontroller	3. Apply	Practical work	Machine test	Optimised solution
Understand the vocabulary of embedded systems	2. Understand	Classes	Questionnaire	Accuracy of answers
Methodical approach to embedded problems	3. Apply	Example-based approach	Machine test	Code structure
Read an electronic/digital schematic or synoptic diagram	2. Understand	Example-based approach	Machine test	Compliance with input/output specifications
Read and extract information from a data sheet	2. Understand	Inquiry-based approach	Questionnaire	Accuracy of answers
Draw up a flow chart of the proposed solution	3. Apply	Example-based approach	Written exercise	Compliance with representation standards Compliance with specifications

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Educational Component: Applied Robotics

Educational Unit: Electronic System Designing 1

Educational Component Director

Acacio MARQUES

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D103

In-person class time (in hours)	24
Individual work time (in hours)	20
Language(s) of instruction	French

General description

Gain experience in embedded C programming. Respect specifications when designing and building software. Know how to draw up flow charts during the design phase corresponding to the proposed solution. Optimise a solution using the interrupt concept. Know how to use debugging tools effectively.

Keywords

Sonar; Infrared; Caterpillar; Quadrature encoder; Chopper bridge; PWM; ST-link; STM32 Nucleo; Bluetooth; Servo motor

Types or organisation of classes

1	Presentation
2	Flow chart
3	Flow chart assessment
4	Project
5	Project
6	Project
7	Project
8	DEMO

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Select and program drivers for the peripheral devices required for the project	4. Analyse	Project	Demonstration and questions	Correct functioning and accuracy of answers
Debug their application using the tools provided by the development platform	3. Apply	Project	Demonstration	Correct functioning
Communicate with customers Coordinate work within the team	3. Apply	Project in pairs Individual work sessions	Participation score	Level of participation and relevance of questions
Conduct a demonstration for a customer.	2. Understand	Real-life situation	Demonstration	Demonstration quality
Methodical approach to embedded problems	3. Apply	Project	Questions	Code structure
Read an electronic/digital diagram or chart	2. Understand	Project	Questions	Compliance with specifications
Read and extract information from a data sheet	2. Understand	Project	Questions	Accuracy of answers
Produce a flow chart of the proposed solution	6. Create	Project	Written assessment	Compliance with standards, consistency, feasibility, optimisation of the solution
Test their application to the limit	4. Analyse	Project	Report	Quality of measurements, relevance of tests

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Educational Component: Prototyping

Educational Unit: Electronic System Designing 1

Educational Component Director

François BERNIER

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D102

In-person class time (in hours)	36
Individual work time (in hours)	24
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	8, 13, 15

General description

This Educational Component has a twofold objective:

Imagine, design and build an application, unsupervised, using the building blocks acquired in Semester 5 (Explore and understand the development stages of a sensor and its acquisition chain)

Following 9 supervised sessions, students then build their own complete acquisition system independently over 3 sessions. This work is done in pairs.

To build their systems, students have access to all the available IDFab facilities (3D printer, welding station, PCB milling tools, simulation tools, etc.)

Prerequisites

Analogue electronics, sensors and actuators, finite elements, microcontroller systems

Keywords

Electronic circuit designing, Schematics; Routing; Datasheet; Electronic assembly/manufacturing; Capacitive interface; Use case; Prototype/prototyping

Types or organisation of classes

1	KICAD class 1
2	KICAD class 2
3	PCB design 1
4	PCB design 2
5	Production
6	Assembly/TEST 1
7	Measures
8	Programming
9	Independent Project 1
10	Independent Project 2
11	Independent Project 3
12	Defence

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
----------------------------	----------------------	---------------------------	--------------------	---------------------	----------

Upon completion of the Educational Component, students will be able to:

Identify the components used in electronic circuit designing	2. Understand	Lectures		Achievement of goals	
Draw an electronic circuit diagram based on the simulations carried out in Semester 5	1. Remember	Lectures		Achievement of goals	
Associate routing design rules with the components used	2. Understand	Lectures	Peer assessment	Achievement of goals	Prototyping IDFab
Assemble the various components to create the conditioning circuit	6. Create	Tutorials		Achievement of goals	
Characterise an electronic circuit	1. Remember	Tutorials		Achievement of goals	
Collect analogue signals using a microcontroller	1. Remember	Tutorials		Achievement of goals	
Imagine a use case implementing the capacitive phenomenon	6. Create	Project-based learning (PBL)		Achievement of goals	IDFab prototyping

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
Draw and produce an electronic/digital synoptic diagram of the developed concept	1. Remember	Practical work		Achievement of goals	
Make the various components required for proof of concept	6. Create	Practical work		Achievement of goals	IDFab prototyping
Test the entire system before assembly	5. Evaluate	Practical work		Achievement of goals	
Estimate corrections to be made, if any	5. Evaluate	Practical work		Achievement of goals	
Design 3D models to assemble the various components	6. Create	Practical work		Achievement of goals	IDFab prototyping
Assemble the various components to produce the final prototype	6. Create	Practical work		Achievement of goals	IDFab prototyping
Produce a final report describing all the theoretical and practical steps taken to complete the project	5. Evaluate	Practical work	Project report Oral presentation		

Sustainable Development Goals

SDGs	Contribution
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This Educational Component contributes to achieving the following goals:

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Create a prototype that can be industrialised
Goal 13: Take urgent action to combat climate change and its impacts	Produce soil moisture monitoring systems for the purposes of agriculture
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably, manage forests, combat desertification, halt and reverse soil degradation and halt biodiversity loss	Ecosystem monitoring using capacitive interfaces

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Educational Unit: Computer Science 1

Educational Unit Director

Elodie SUZANNE

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B205

Number of ECTS credits (European Credit Transfer Scale)	6
In-person class time (in hours)	75.5
Individual work time (in hours)	68.5
Language(s) of instruction	French

General description

The 'Computer Science 1' is a continuation of the 'IT Concepts & Tools' Educational Unit (Semester 5), building on the scientific culture and skills acquired in algorithms, programming and computing in general. Upon completion of the Educational Unit, students will be able to:

- Tackle and solve concrete engineering problems: (i) analyse requirements, (ii) formalise the problem at hand, (iii) structure and represent data, (iv) propose, design and implement solution algorithms/programs;
- Demonstrate a solid scientific background in computer science and programming fundamentals.

Keywords

Algorithms; C programming; Databases; System programming

Links between course sub-modules

This Educational Unit comprises 3 Educational Components:

1. Algorithms and Programming 2
2. System Programming
3. Databases

It continues to develop knowledge of computer systems and a scientific culture of computing.

The 'Algorithms & Programming 2' Educational Component uses the programming concepts covered in Algorithms 1 (S5) to propose algorithms for solving application problems. This Educational Component covers and implements several different data structures.

The 'System Programming' Educational Component requires the C implementation skills acquired in the 'Algorithms & Programming 1' and 'Algorithms and Programming 2' Educational Components to implement system-related algorithms.

The 'Databases' Educational Component provides an opportunity to discuss the storage and structure of data in databases prior to their use in algorithms.

Sub-modules

Algorithms and Programming 2

Elodie SUZANNE

System Programming

Pierre UNY

Databases

Olivier POTIN

Educational Component: Algorithms and Programming 2

Educational Unit: Computer Science 1

Educational Component Director

Elodie SUZANNE

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B205

In-person class time (in hours)	27
Individual work time (in hours)	27
Language(s) of instruction	French

General description

This Educational Component follows on from the S5 Algorithms and Programming 1 Educational Component. The main aim of Algorithms and Programming 2 is to apply the concepts studied previously (data structures, reading and writing to files, etc.) to more extensive algorithms responding to application problems, and thus consolidate C programming skills.

Keywords

Algorithms; C programming; Graphs; Hash tables; Pseudocode; Binary search trees

Types or organisation of classes

1	Basics of graphs (adjacency matrix, adjacency lists)
2	Pseudocodes
3	Graph traversal
4	Shortest path (Dijkstra and Bellman-Ford)
5	Spanning trees and forests (Prim and Kruskal)
6	Maximum flow (Ford-Fulkerson)
7	Binary search trees
8	Hash tables
9	Backtracking (sudoku solving)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Implement and analyse data structures	2. Understand	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers
Write and explain a pseudocode	2. Understand	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers
Use an existing code	5. Evaluate	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers
Consolidate their C programming skills	4. Analyse	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers
Analyse needs and formalise the problem at hand	2. Understand	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Organise and represent data	5. Evaluate	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers
Propose and implement resolution algorithms	6. Create	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers
Evaluate the complexity of an algorithm	2. Understand	Lecture Practical work	Written assignment	Achievement of goals Thinking-based approach Accuracy of answers

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Essential

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Useful

T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, *Introduction to Algorithms, third edition*, Third edition. Cambridge, Massachusetts London, England: The MIT Press, 2009.

C. Delannoy, *Programmer en langage C, 5e édition : Cours et exercices corrigés*. Paris: EYROLLES, 2016.

Educational Component: System Programming

Educational Unit: Computer Science 1

Educational Component Director

Pierre UNY

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B205

In-person class time (in hours)	28.5
Individual work time (in hours)	24
Language(s) of instruction	French

General description

Linux system programming in C.

Keywords

Operating system; Programming; C language; Linux

Types or organisation of classes

1	Universal Inputs/Outputs. File descriptor.
2	Processes.
3	Threads.
4	Tube communication.
5	Communication via TCP/IP sockets.
6	Synchronisation: Mutex and Semaphore.
7	Some system algorithms: producer-consumer, etc.

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Create a multi-tasking application.	6. Create	Classes Practical work Project	Written assignment Project	Accuracy of answers Achievement of goals
Make tasks communicate locally.	6. Create	Classes Practical work Project	Written assignment Project	Accuracy of answers Achievement of goals
Make tasks communicate via the network.	6. Create	Classes Practical work Project	Written assignment Project	Accuracy of answers Achievement of goals
Synchronise tasks.	6. Create	Classes Practical work Project	Written assignment Project	Accuracy of answers Achievement of goals

Educational Component: Databases

Educational Unit: Computer Science 1

Educational Component Director

Olivier POTIN

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A225

In-person class time (in hours)	18
Individual work time (in hours)	6
Language(s) of instruction	French

General description

Be able to understand the structure of a database and use an existing DB (this does not involve analysing or designing a DB).

Use SQL queries to extract, add, modify and delete data from a database.

Keywords

Data query (SELECT), PostgreSQL server and phpPgAdmin prerequisites; Data manipulation (Insert, Update, Delete); Recursion; OLAP; Procedural SQL

Types or organisation of classes

1	Lecture and Practical session 1: Data handling
2	Recursion, OLAP and procedural SQL
3	Practical session 2: Recursion and OLAP
4	Practical session 3: Procedural SQL

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse the structure of a database in order to exploit it	4. Analyse	Lecture-style classes	MCQs	Accuracy of answers
Consolidate data from the database for statistical calculations	2. Understand	Practical work	Written assignment	Justification of choices
Execute SQL queries for data extraction and manipulation	3. Apply	Practical work		
Choose the appropriate SQL syntax for a given need	3. Apply	Practical work		
Execute SQL queries to browse a table containing hierarchical data	3. Apply	Practical work		

Educational Unit: Sustainable Development - Social Responsibility - Sustainable Transition

Educational Unit Director

Daniel OCHOA

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A321

Number of ECTS credits (European Credit Transfer Scale)	3
In-person class time (in hours)	30
Individual work time (in hours)	49
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	Potentially 17 SDGs

General description

The 2021 UNESCO report, ‘Engineering for Sustainable Development’, highlights the essential role of engineering in achieving each of the 17 Sustainable Development Goals (SDGs)

“These 17 goals represent an integrated approach to addressing the imperatives of poverty alleviation, the urgent need for basic amenities for many (including education, health and sanitation), gender equality, the impacts of climate change and the rapid depletion of the world’s resources.”

With this in mind, the ‘Sustainable Development, Social Responsibility and Sustainable Transition’ Educational Unit aims to provide future engineering students with an overview of the challenges facing humanity and the planet, and the potential individual and collective levers of transformative action to address them.

Keywords

Climate issues; IPCC; Environment; Sustainable development; Health; Societal issues; Citizenship; Adaptability; Collective intelligence; Cooperation; Player; Action; Project management; Technology; Digital technology; Energy; Energy storage; Biodegradability

Links between course sub-modules

This Educational Unit will raise students' awareness of climate issues through the **Climate Fresk** Educational Component, a collective workshop that will enable them to identify individual and collective levers of transformative action to become players in the ecological transition.

In addition, as part of the **ISA Project** Educational Component, students will learn about collaborative work and project management through action, by leading projects proposed by a partner, with a social, civic or solidarity dimension.

The **Fair Tech Day** Educational Component will encourage them to reflect on their role as engineers and scientific players acting for a sustainable world.

Finally, the **Biodegradable Systems for Green Energy Storage** Educational Component will raise awareness of the need to design energy storage systems that are free of all elements that are harmful or toxic to the environment and health.

Sub-modules

Climate Mural

Thierry CAMILLONI

ISA Project (Solidarity Engineers in Action)
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Thierry RICORDEAU

Fair Tech Day

Sylvain BLAYAC

Biodegradable Systems for Green Energy Storage
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Thierry DJENIZIAN

Educational Component: Climate Fresk

Educational Unit: Sustainable Development - Social Responsibility - Sustainable Transition

Educational Component Director

Thierry CAMILLONI

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D014

In-person class time (in hours)	3
Individual work time (in hours)	0
Language(s) of instruction	French/English
Sustainable Development Goals (SDGs)	13

General description

At the end of the "Climate Fresk" collaborative workshop, students will be able to explain the causal links of climate change and identify individual and collective catalysts to become players in the ecological transition.

Keywords

Climate change, Climate challenges; Scientific data; IPCC; Collective intelligence; Cooperation; Mobilisation; Action

Types or organisation of classes

1	Collective intelligence workshop (3h)
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Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Explain the causal links of global warming	2. Understand	Collective intelligence workshop	Active participation
Systemically understand the scale of climate challenges	4. Analyse	Collective intelligence workshop	Active participation
Compare the impact of the various catalysts imaginable, make constructive criticism and defend their choices and ideas	4. Analyse	Collective intelligence workshop	Active participation
Become players in the ecological transition	6. Create	Collective intelligence workshop	Active participation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 13: Take urgent action to combat climate change and its impacts	The Climate Fresk helps students grasp the scope of climate challenges and pass on their acquired knowledge among personal and professional circles	3
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- A. Boutaud & N. Gondran, *Les limites planétaires*. Paris: La Découverte, 2020.
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- Sciences Po, *Leçon inaugurale de Jean-Marc Jancovici - rentrée 2019 campus de Paris*, (30 August 2019). Accessed on: 28 March 2025. [Online Video]. Available on: https://www.youtube.com/watch?v=h9SuWi_mtCM

Educational Component: ISA Project (Solidarity Engineers in Action)

Educational Unit: Sustainable Development - Social Responsibility - Sustainable Transition

Educational Component Director

Thierry RICORDEAU

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A317

In-person class time (in hours)	12
Individual work time (in hours)	39
Language(s) of instruction	French
Format	Hybrid
Sustainable Development Goals (SDGs)	1, 2, 3, 4, 5, 8, 10, 11, 12, 15, 16, 17

General description

“Solidarity Engineers in Action” is a series of civic projects carried out by first-year ISMIN students. The aim is to introduce students to collaborative project management through action with:

- One or more defined objectives
- Obligations to be met (deadlines, costs and expected specifications).
- An approach structured around joint processes.
- A team whose roles are defined at varying degrees.
- Activities that mobilise resources and are broken down into actions to be taken.
- Continuous, proactive steering of project progress

Students work in teams on a project based on a partner’s request. The team must identify and meet the partner's expectations, and achieve concrete implementation of the project through various project management phases:

1. Work organisation and distribution
 - Identify the objectives to be achieved.
 - Identify and allocate tasks (those responsible for the various jobs, and final summary).
 - Define mechanisms to adjust the group's functioning in the event of unforeseen circumstances (alert and emergency procedures, decision-making methods).

2. Identify the available skills and experience that will contribute to the project’s success
 - Detail the tasks to be carried out.
 - Identify the knowledge and experience contributed by all the players involved in the project (stakeholders).

- Allocate functional responsibilities (the functions of each member of the team) and editorial responsibilities (who writes what document for whom, and when).

3. Implementation of the project or actions

- Carry out work individually and collectively in close collaboration, exchanging useful information in real time.
- Regular progress briefings at group level and with the customer.

4. Assessment and presentation of the work done

- The final project report should show the work carried out by the project members. It is to be presented to both the tutor and the customer.
- Although the success of the project itself must remain an objective, the students' pedagogical efforts and assessments focus primarily on project management and group work.

Students are expected to show proper commitment to their project. They may, therefore, choose their project. The topics can be scientific, social, humanitarian or cultural. The proposed projects offer them the opportunity to open up to others, interact with a variety of players, become interculturally aware and progress in a social, civic or solidarity dimension.

Keywords

Citizenship; Project management; Listening; Human relations; Societal aspects; Communication; Empathy/tolerance; Management; Open-mindedness; Adaptability

Types or organisation of classes

1	Presentation of ISA project expectations and objectives
2	Presentation of ISA projects by partners
3	Workshops on scoping memos, team charters and project management
4	Actions with partners and beneficiaries
5	Oral presentation of progress with a focus on SDGs and engineering ethics
6	Drafting of a report for each project and of individual feedback

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Master the tools and methods of collaborative work	3. Apply	Project-based learning	Collective written report	Active participation
Conduct a project	3. Apply	Project-based learning	Collective written report	Active participation
Satisfy customer needs	6. Create	Project-based learning	Collective written report	Active participation
Identify the objectives to be met	5. Evaluate	Project-based learning	Collective written report	Active participation
Identify the skills available	6. Create	Project-based learning	Collective written report	Active participation
Allocate functional responsibilities	4. Analyse	Project-based learning	Collective written report	Active participation

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Assess the work done	4. Analyse	Project-based learning	Collective written report	Active participation
Position themselves in relation to the group	4. Analyse	Project-based learning	Collective written report	Active participation
The engineer's role in society	4. Analyse	Project-based learning	Collective written report	Active participation
Popularisation of new technologies	2. Understand	Project-based learning	Collective written report	Active participation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	Depending on the project proposed by the partner	0 to 39
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Depending on the project proposed by the partner	0 to 39
Goal 3: Ensure healthy lives and promote well-being for all at all ages	Depending on the project proposed by the partner	0 to 39
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Depending on the project proposed by the partner	0 to 39

SDGs	Contribution	Volume in hours
Goal 5: Achieve gender equality and empower all women and girls	Depending on the project proposed by the partner	0 to 39
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Depending on the project proposed by the partner	0 to 39
Goal 10: Reduce inequality within and among countries	Depending on the project proposed by the partner	0 to 39
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Depending on the project proposed by the partner	0 to 39
Goal 12: Ensure sustainable consumption and production patterns	Depending on the project proposed by the partner	0 to 39

SDGs	Contribution	Volume in hours
Goal 13: Take urgent action to combat climate change and its impacts	Depending on the project proposed by the partner	0 to 39
Goal 15: Preserve and restore terrestrial ecosystems, ensuring that they are used sustainably, manage forests sustainably, combat desertification, halt and reverse soil degradation and halt biodiversity loss	Depending on the project proposed by the partner	0 to 39
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Depending on the project proposed by the partner	0 to 39
Goal 17: Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development	Depending on the project proposed by the partner	0 to 39

Bibliography

Essential

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Useful

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A. Carlier, *Management des projets collaboratifs : Construire, développer, mettre en oeuvre*. La Plaine-Saint-Denis: AFNOR, 2020.

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P. Scharnitzsky & P. Scharnitzky, *Être soi en entreprise : Estime, confiance, engagement et reconnaissance*. Mardaga, 2021.

G. B. Wilson & P. Molho, *La communication non violente, c'est malin : En famille, en couple, au travail... Comment parler et écouter pour désamorcer*, Illustrated édition. Paris: LEDUC, 2016.

Educational Component: Fair Tech Day

Educational Unit: Sustainable Development - Social Responsibility - Sustainable Transition

Educational Component Director

Sylvain BLAYAC

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D202

In-person class time (in hours)	21
Individual work time (in hours)	20
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	2, 3, 6, 9, 12, 14, 15, 16, 17

General description

As part of the effort to raise awareness on sustainable development, future ISMIN engineers working in the fields of microelectronics, computer science and, more generally, information science and technology, are invited to reflect on their future role as engineers and scientific players in a sustainable world. Emphasis is placed on themes related to the research topics of the Centre of Microelectronics in Provence, and on links with the socioeconomic world. The final deliverable is a synthesis of their work, to be presented at Fair Tech Day, a forum that brings together students, faculty members and public and private players.

Keywords

Digital; Sustainable development; Societal impact

Types or organisation of classes

1	Plenary session, opening debate and presentation of objectives and organisation
2	Introduction to the 4 topics, testimonials from professionals, problematisation in groups of 4 to 5 students, choice of presentation format
3	Initial presentation and work session
4	Presentation training
5	Assessment session and selection of the winning group for each topic
6	Presentation practice
7	Fair Tech Day (full day): presentations in 4 sessions including presentations by professionals, business forum, prize for best presentation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Link the digital engineering profession to major societal and environmental challenges	2. Understand	Evolving debate	Relevance of analysis work
Establish a problem in relation to social and environmental issues	4. Analyse	Seminar	Commitment to producing the deliverable
Explain the problem in precise, well-defined terms	6. Create	Activity by project	Presentation originality
Derive a technical-scientific approach from this problem	6. Create	Teamwork	Quality of presentation format
Analyse the positive and negative impacts of technological developments	4. Analyse	Informal presentation of work	
Assess technical-scientific actions with regard to sustainable development goals	5. Evaluate		
Summarise the reflection process in a suitable and intelligible form	3. Apply		

Intended learning outcomes	Classification level	Type of teaching activity	Assessment criteria
Gather information and testimonials from the socio-economic world	4. Analyse		
Create a suitable presentation of the analysis work	6. Create		
Contribute to debates based on scientifically validated knowledge	4. Analyse		

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Topic: Air, Water, Agroecology	
Goal 3: Ensure healthy lives and promote well-being for all at all ages	Topic: Health and Bioelectronics	
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Topic: Air, Water, Agroecology	
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Topic: Ecodesign, Recycling, Circular Economy	
Goal 12: Ensure sustainable consumption and production patterns	Topic: Ecodesign, Recycling, Circular Economy; Topic: Air, Water, Agroecology	

SDGs	Contribution	Volume in hours
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Topic: Air, Water, Agroecology	
Goal 15: Protect, restore and promote sustainable use of territorial ecosystems, sustainably manage forests, combat desertification, halt and reverse soil degradation and halt biodiversity loss	Topic: Air, Water, Agroecology	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Topic: Data and Cybersecurity	
Goal 17: Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development.	Topic: Data and Cybersecurity	

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Useful

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Learn more

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Educational Component: Biodegradable Systems for Green Energy Storage

Educational Unit: Sustainable Development - Social Responsibility - Sustainable Transition

Educational Component Director

Thierry DJENIZIAN

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A325

In-person class time (in hours)	5
Individual work time (in hours)	1
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	3, 9, 12

General description

Raise awareness of the need to manufacture electrochemical energy storage systems free of elements that are harmful or toxic to the environment and human health. Description of new technologies based on the development of fully biodegradable and/or bioresorbable Na-ion and K-ion batteries for green applications.

Keywords

Energy storage; Biodegradability; Bioresorbability; IPCC; Environment; Health

Types or organisation of classes

1	Class on current systems involving toxic materials
2	Class on emerging systems involving eco-friendly materials (recyclable, biodegradable, bioresorbable)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify environmentally toxic systems	1. Remember	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Evaluate the actions required to recycle systems	2. Understand	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Propose fully biodegradable energy storage systems	3. Apply	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 3: Ensure healthy lives and promote well-being for all at all ages	Use of bioresorbable batteries for temporary medical implants to avoid second surgery	NA
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Raising awareness of the ecological impact of the battery industry	NA
Goal 12: Ensure sustainable consumption and production patterns	Development of entirely green, biodegradable batteries	NA

Educational Unit: Career Path Customisation Workshops

Educational Unit Director

Thierry DJENIZIAN

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A325

Number of ECTS credits (European Credit Transfer Scale)	24
In-person class time (in hours)	21
Individual work time (in hours)	3
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9, 11, 12

General description

Introduction to the electronics and IT courses offered in the second and third years of the ISMIN cycle. The aim is to help students make the right choice for their future career, through courses and independent work. Presentation of the international Hybrid Electronics Master's degree, co-accredited with Aix-Marseille University, to inform students about the possibility of earning an internationally recognised dual degree that opens up academic career opportunities.

Keywords

Electronics; Computing; Career path

Links between course sub-modules

An overview of teaching activities in electronics and IT to help with specialisation choices.

Sub-modules

Electronics

Thierry DJENIZIAN

Computer Science - Optimisation Challenge

Dominique FEILLET

Educational Component: Electronics

Educational Unit: Career Path Customisation Workshops

Educational Component Director

Thierry DJENIZIAN

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A325

In-person class time (in hours)	9
Individual work time (in hours)	1.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Lessons in the main topics of electronics at 2A, 3A and master's levels. Introduction and overview of electronic devices, manufacturing processes and fields of application

Keywords

Biomedical electronic devices; Semiconductors; Non-conventional electronics; Basic techniques for making microelectronic devices; Internet of Things (IoT)

Types or organisation of classes

1	Introductory class on biomedical electronic devices
2	Introductory class on emerging semiconductors
3	Class to present academic pathways in electronics
4	Introduction to IoT for the ecological transition
5	Tutorials on the use of lithographic techniques to produce microelectronic devices

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Choose an electronics specialisation	2. Understand	Lecture Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Assess an interest in microelectronics	2. Understand	Lecture Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Explain basic technologies	1. Remember	Lecture Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Discover the main topics taught in microelectronics	2. Understand	Lecture Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach
Choose an electronics specialisation	2. Understand	Lecture Tutorials	Written examination	Accuracy of answers Justification of choices Thinking-based approach

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Raising awareness of the ecological impact of the microelectronics industry	0.5
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Educational Component: Computer Science - Optimisation Challenge

Educational Unit: Career Path Customisation Workshops

Educational Component Director

Dominique FEILLET

feillet@emse.fr

A312

In-person class time (in hours)	12
Individual work time (in hours)	0
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	11, 12

General description

Use the optimisation challenge to study concrete decision-aid problems. Design and develop algorithms to deal with them. Understand the computer science topics proposed in 3A.

Keywords

Operational research; Combinatorial optimisation; Decision support; Algorithms; Heuristics

Types or organisation of classes

1	One-day optimisation challenge
2	A 1½-hour session to put into perspective the work done

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand a complex combinatorial optimisation problem	2. Understand	Problem-based approach	Comparison of the results obtained by each group	Quality of results
Understand the complexity of decision-making problems	2. Understand	Problem-based approach	Comparison of the results obtained by each group	Quality of results
Code a complex algorithm	3. Apply	Problem-based approach	Comparison of the results obtained by each group	Quality of results
Analyse algorithm behaviour	4. Analyse	Problem-based approach	Comparison of the results obtained by each group	Quality of results
Design an optimisation algorithm	6. Create	Problem-based approach	Comparison of the results obtained by each group	Quality of results

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	According to the subject defined each year for the challenge	10.5
Goal 12: Ensure sustainable consumption and production patterns	According to the subject defined each year for the challenge	10.5

Educational Unit: Career Guidance Cycle

Educational Unit Director

Maxime MALAFOSSE

maxime.malafosse@mines-stetienne.fr

A319

Number of ECTS credits (European Credit Transfer Scale)	3
In-person class time (in hours)	26.5
Individual work time (in hours)	46.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 5, 8, 9, 12, 16

General description

Explore professions and sectors to refine career choices and facilitate the search for an internship. Build an ISMIN-specific professions database. Strengthen written and oral communication skills. Draw on feedback to better understand the realities of the professional world.

Keywords

Professions; Skills; Experience; Career opportunities; Sectors of activity; International context; Listening; Questioning; Relationships; Gestural/non-verbal communication

Links between course sub-modules

This programme combines business exploration, communication and feedback for a coherent and rewarding approach. The profession investigation enables students to refine their career plans and build up a database of benefit to all. Feedback from our alumni provides constructive insights with regard to possible career paths, in line with international and sectoral realities. At the same time, revisiting the fundamentals of communication and improving interpersonal skills will enable students to interact effectively during their profession investigations, internships and working lives. Finally, the cycle closes with a post-internship analysis of what has been learned on the ground, thus ensuring continuous and consistent progress.

Sub-modules

Investigation of Professions and Sectors
--

Maxime MALAFOSSE

Alumni Feedback: International and Business Sectors

Maxime MALAFOSSE

Relational Development, Occupational Health

Maxime MALAFOSSE

Post-Internship Feedback

Thibaut METAILLER

Educational Component: Profession and Business Sector Investigations

Educational Unit: Career Guidance Cycle

Educational Component Director

Maxime MALAFOSSE

maxime.malafosse@emse.fr

A319

In-person class time (in hours)	12
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	16

General description

This Educational Component aims to help you to:

- answer your questions or confirm your choice of first job;
- thanks to your commitment, create an ISMIN-specific business database;
- take advantage of the opportunity to find a better internship;
- put into practice your communication skills, both written and oral.

Keywords

Professions; Skills; Experience; Job opportunities; Sectors of activity; International context

Types or organisation of classes

1	Investigations
2	International workshop
3	Business sector workshops

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Conduct an investigation	6. Create	Investigation	Oral presentation	Quality of deliverables
Prepare for interviews	3. Apply	Tutorials	Oral presentation	Quality of deliverables
Create an ISMIN-specific professions database	4. Analyse	Video editing	Oral presentation	Quality of deliverables
Make career choices	5. Evaluate	Investigation	Oral presentation	Quality of deliverables

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Reflecting on these societal issues in your career choices. Taking a stance when faced with the dilemma of business sectors such as armament, fossil fuels or finance.	8
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Educational Component: Alumni Feedback - International and Business Sectors

Educational Unit: Career Guidance Cycle

Educational Component Director

Maxime MALAFOSSE

maxime.malafosse@emse.fr

A319

In-person class time (in hours)	6
Individual work time (in hours)	3
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	16

General description

This Educational Component aims to help you to:

- answer your questions or confirm your choice of first job;
- take advantage of the opportunity to find a better internship;
- put into practice your communication skills, both written and oral.

Keywords

Professions; Skills; Experience; Job opportunities; Sectors of activity; International context

Types or organisation of classes

1	Investigations
2	International workshop
3	Business sector workshops

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Conduct an investigation	6. Create	Investigation	Oral presentation	Quality of deliverables
Prepare for interviews	3. Apply	Tutorials	Oral presentation	Quality of deliverables
Create an ISMIN-specific professions database	4. Analyse	Video editing	Oral presentation	Quality of deliverables
Make career choices	5. Evaluate	Investigation	Oral presentation	Quality of deliverables

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Reflecting on these societal issues in your career choices. Taking a stance when faced with the dilemma of business sectors such as armament, fossil fuels or finance.	8
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Educational Component: Relational Development

Educational Unit: Career Guidance Cycle

Educational Component Director

MALAFOSSE Maxime

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A319

In-person class time (in hours)	6
Individual work time (in hours)	0
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 5

General description

Review the basics of interpersonal communication (key concepts, principles, techniques). Improve communication skills. Learn to take control of communication situations.

Keywords

Listening; Questioning; Relationships; Palo Alto; Gestural/non-verbal communication

Types or organisation of classes

1	Develop interview skills
2	Improve knowledge and command of meetings

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Develop their interview skills	2. Understand	Tutorials	Pass/fail	Active participation
Improve their knowledge and command of meetings	3. Apply	Tutorials	Pass/fail	Active participation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Relational development is an essential skill to acquire in order to work towards this goal	3
Goal 5: Achieve gender equality and empower all women and girls	Relational development is an essential skill to acquire in order to work towards this goal	3

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Educational Component: Post-Internship Feedback

Educational Unit: Career Guidance Cycle

Educational Component Director

Thibaut METAILLER

thibaut.metailler@emse.fr

A316

In-person class time (in hours)	9
Individual work time (in hours)	50
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	8, 9, 12, 16

General description

Develop skills in communication (written and oral) and critical thinking

Keywords

Written communication; Oral communication; Feedback; Critical analysis

Types or organisation of classes

1	Presentation of instructions
2	Delivery of results

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Produce an experience feedback document	6. Create	Internship report writing and tutorial	Individual written report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation
Critique company operations and their own experience	5. Evaluate	Internship report writing and tutorial	Individual written report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation
Problematise and analyse a situation using SSH concepts	5. Evaluate	Internship report writing and tutorial	Individual written report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Thinking-based practice on business activities and the engineering profession	NA
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Thinking-based practice on business activities and the engineering profession	NA
Goal 12: Ensure sustainable consumption and production patterns	Thinking-based practice on business activities and the engineering profession	NA
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Thinking-based practice on business activities and the engineering profession	NA

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Educational Unit: Languages and Cultures

Educational Unit Director

Samantha CHIN

samantha.chin@emse.fr

A106

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	56
Individual work time (in hours)	40
Language(s) of instruction	English, German, Chinese, Spanish, Japanese, Portuguese
Sustainable Development Goals (SDGs)	4, 5, 8, 10, 13, 16

General description

Modern languages at the heart of engineering students' training

As part of their training, engineering students are taught modern languages with a strong professional and international focus. The aim is to complement their technical and scientific knowledge with the development of high-level linguistic and intercultural skills, essential for their development in a multicultural environment.

Requirements and certifications

Fluency in English (1st foreign language) is a priority, with a minimum requirement of 800 TOEIC points or 90 TOEFL IBT points, as well as a B2 level according to the Common European Framework of Reference for Languages (CEFR), certified by the School. A second modern language (Spanish, German, Chinese, Japanese, French or Portuguese) is also taught, with the aim of ensuring operational proficiency adapted to the needs of engineers in an international context.

Professional and intercultural skills

The language teaching takes a pragmatic approach, with a strong focus on communication needs in concrete professional situations. This course helps to equip our future engineers with the tools they need to collaborate effectively in a global and multicultural environment, facilitating their professional integration and international mobility.

Keywords

English; Chinese; German; Japanese; Portuguese; Spanish

Links between course sub-modules

Objectives common to all Educational Components.

Sub-modules

English
Samantha CHIN

Modern Languages 2 (2nd foreign language)
Samantha CHIN

Educational Component: English

Educational Unit: Languages and Cultures

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	26
Individual work time (in hours)	21
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	4, 8, 10, 13, 16

General description

(level B1+/B2)

Develop advanced language and communication skills: understand and write professional documents (CVs, cover letters) and take an active part in discussions or simulated interviews in English.

Improve professional skills in English: highlight experiences, defend opinions and effectively present an academic or professional project in an international context.

Understand and adapt to international corporate culture: integrate notions of ethics, diversity and intercultural communication into concrete situations, such as negotiations or presentations.

Keywords

Professional portfolio; CV; Cover letter; Job interview; Corporate culture; Diversity and inclusion; Professional ethics; Intercultural communication; TOEIC; Language skills

Types or organisation of classes

1	15 classes
2	7 tutorials

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Produce a CV and cover letter in English (minimum level B1) highlighting relevant skills and experience in an international professional context.	3. Apply	Feedback	Internship report	Thinking-based approach Structure Appropriate vocabulary Compliance with professional conventions
Take part in a mock interview in English, highlighting their academic and professional background, and answer questions in a structured way (minimum level B1)	6. Create	Role play Tutorials	Oral presentation Self-assessment	Language fluency and accuracy Clarity of answers Ability to justify choices
Take part in a mock interview in English, highlighting their academic and professional background, and answer questions in a structured way (minimum level B1).	6. Create	Role play Tutorials	Oral presentation Self-assessment	Language fluency and accuracy Clarity of answers Ability to justify choices
Prepare and present a professional portfolio containing documents in English (CV, cover letter, job offer analysis), in line with their professional project (minimum level B1)	6. Create	Flipped classroom Individual project	Project assessment Peer feedback	Organisation and relevance of documents Specialised vocabulary Consistency with the project
Explain cultural differences and their impact on organisational behaviour, using concrete examples (minimum level B1)	2. Understand	Thematic workshops Group discussions	MCQs Oral presentation	Precision of ideas Ability to compare Use of appropriate vocabulary

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	The creation of CVs, cover letters and participation in internships encourage practical learning and equal access to professional opportunities.	2
Goal 5: Achieve gender equality and empower all women and girls	Discussions about diversity, inclusion and ethical behaviour in business promote empowerment and gender equality.	1
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	The development of professional competency and language skills enables students to compete in the international marketplace and contribute to a sustainable economy.	1
Goal 10: Reduce inequality within and among countries	By integrating cultural diversity and an understanding of international standards into training, the programme prepares students to work in multicultural environments and reduce inequalities in access to opportunities.	1
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Modules on corporate culture and ethics raise students' awareness of responsible practices and inclusive work environments.	1

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Educational Component: Modern Languages 2 (2nd foreign language)

Educational Unit: Languages and Cultures

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	26
Individual work time (in hours)	20
Language(s) of instruction	Choice between: German, Chinese, Spanish, Japanese, Portuguese
Sustainable Development Goals (SDGs)	4, 8, 10, 13, 16

General description

Level B1/B1+/B2: The main aim of this teaching unit is to prepare students to integrate into international academic and professional environments, by enhancing their employability and intercultural skills. Students will develop effective written and oral communication in professional contexts (presentations, negotiations, drafting documents). This module will also enable them to analyse and adapt to intercultural situations, while planning study or work opportunities abroad in line with their personal and professional goals.

Level A0/A1/A2: The main aim of this teaching unit is to establish the linguistic and cultural foundations essential to interaction in simple everyday and professional situations. Students will learn to introduce themselves, exchange basic information and understand key cultural practices related to the language studied. The module also promotes integration into multicultural environments by introducing students to intercultural communication and adaptability.

Keywords

Employability; Intercultural awareness; Professional communication; Adaptability; Language skills; Cultural practices; Oral interaction; Written communication; International planning; Multicultural collaboration

Types or organisation of classes

1	16 classes
2	7 tutorials

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Level B1/B1+/B2				
Communicate effectively in international professional and cultural situations	3. Apply	Role play Intercultural business conversation simulations	Classroom observation and oral exercises	Fluency Precision Use of appropriate vocabulary
Write complex documents for professional purposes, such as reports or formal letters	4. Analyse	Report writing Essays or letters on employability topics	Correction and feedback on written texts	Consistency Content quality Correct formal structures
Analyse intercultural situations to better adapt to different international contexts	5. Evaluate	Cultural case studies Interactive discussions or debates	Teacher observation and feedback	Relevance of analysis Ability to propose appropriate solutions
Participate actively in multicultural presentations or negotiations, presenting ideas clearly	4. Analyse	Organisation of presentations Simulation of professional meetings	Observation during presentations or simulations	Clarity Impact Ability to interact and respond

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Level A0/A1/A2				
Understand and use simple expressions to manage basic, everyday exchanges	1. Recognise	Role-playing activities and guided dialogues in everyday situations	Simple oral assessment (introducing oneself, asking for information)	Correct pronunciation Comprehension and fluency
Introduce themselves and exchange personal information in a specific cultural context	2. Understand	Interactive activities, mock interviews or conversation in pairs	Individual oral and written presentation	Consistency of information Clarity and cultural adaptation
Recognise and reproduce simple grammatical structures to express basic ideas	3. Apply	Practical grammar exercises and contextualisation (simple sentences, conjugations)	MCQ or written assignment on grammatical structures	Grammatical accuracy Correct basic structures
Discover and apply fundamental cultural elements related to the language studied	2. Understand	Analysis of videos, images or discussions on local customs and traditions	Presentation or quiz on the cultural themes studied	Understanding of cultural aspects Relevance of examples given

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	(Depending on level) Develop the intercultural and linguistic skills needed to operate in an international academic or professional environment	
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	(Depending on level) Raise awareness of social, ethical and legal standards for internships and jobs in different countries, to promote successful integration.	
Goal 10: Reduce inequality within and among countries	(Depending on level) Analysis of cultural and economic inequalities between different countries to prepare students for diverse environments.	
Goal 13: Take urgent action to combat climate change and its impacts	(Depending on level) Introduction to sustainable practices applied to international mobility (reducing the carbon footprint of travel, choosing eco-responsible destinations).	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	(Depending on level) Training on inclusive and ethical behaviour in international environments, promoting effective collaboration in multicultural teams.	

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ISMIN SYLLABUS

2025 – 2026

Semester 7

Direction de la Formation - ISMIN
Mines Saint-Etienne
June 2024

Semester 7

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Educational Unit: Electronics 2

Educational Unit Director

Marc RAMUZ

ramuz@emse.fr

A203

Number of ECTS credits (European Credit Transfer Scale)	6
In-person class time (in hours)	77.5
Individual work time (in hours)	66.5
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	9, 12, 15

General description

This Educational Unit explores autonomous objects, particularly in the Internet of Things (IoT), focusing on their key components. It covers the wireless transmission technologies (Wi-Fi, LoRa, Zigbee) used in data transfer. The study of sensors provides an understanding of how environmental information (temperature, humidity, movement, etc.) is collected. Particular attention is paid to autonomous power supply systems, including batteries, and optimising consumption. Reliability and energy efficiency are also addressed. Practical work includes the design and analysis of autonomous IoT devices, with simulations and tests under real conditions, in connection with the Educational Component on Prototyping (S6) and the IoT Project (S7).

Keywords

Wireless transmission; Sensors; Energy for mobile systems; IoT

Links between course sub-modules

This Educational Unit ensures the vital consistency in the design of autonomous connected objects by integrating three complementary aspects. Wireless communications enable the efficient transfer of data collected by sensors, which monitor the environment and trigger actions via actuators. To guarantee the autonomy of these devices, energy and battery management optimises component consumption and power supply. This synergy makes it possible to design high-performance, sustainable IoT systems tailored to real-life constraints.

The Educational Unit Electronics 2 is closely linked to the Educational Component on Prototyping (S6), where students build a sensor and develop the signal acquisition chain. It also forms part of a pedagogical continuity with the IoT Project (S7), which provides an in-depth look at the integration of communicating and autonomous systems in practical applications.

Sub-modules

Actuator Sensors

Sylvain BLAYAC

Energy Management

Marc RAMUZ

Wireless Communications Solutions for the IOT

Marc RAMUS

Educational Component: Sensors and Actuators

Educational Unit: Electronics 2

Educational Component Director

Sylvain BLAYAC

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D201

In-person class time (in hours)	24
Individual work time (in hours)	20
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9, 15

General description

The first step is to acquire a basic understanding of the physics of coupling between electronics and electromagnetic, mechanical and thermal fields in order to understand how the transducers used in sensors and actuators work. The second objective is to establish compact transducer models which, combined with conditioning electronics, can be used to design complete sensors. Ultimately, students should be able to understand, calculate and optimise the factors influencing the behaviour of the object produced.

Keywords

Sensors; Actuators; Quadrupole modelling; Mechanical; Thermal; Electromagnetic; Transducers; Conditioners; Multiphysics simulation

Type or organisation of classes

1	Fundamentals of multiphysics coupling in electronics - Quadrupole modelling workshop
2	Principles of quadrupole modelling - Workshop for calculating complex transfer functions
3	Electromagnetic coupling and transmission line modelling - Transmission line workshop and application to detection of physical parameters
4	Mechanical-electrical coupling and electrostatic actuators - Accelerometer workshop I
5	Accelerometers and open/closed loop conditioning - Accelerometer workshop II
6	Mechanical-thermal coupling and equivalent thermal modelling - Workshop on thermal modelling of a chip
7	Thermal sensors and actuators, thermoelectricity - Hot wire anemometer workshop
8	Practical work - modelling and simulation of a transmission line
9	Design project: Sensor for in situ, real-time measurement of the quality of prestressed concrete in civil engineering structures

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the fundamentals of coupling electronics with its environment	1. Remember	Lecture	Written examination	Ability to rephrase Understanding of concepts
Understand the physical phenomena involved in sensors	2. Understand	Tutorials Simulation	Written examination	Ability to reason abstractly
Analyse a physical environment	4. Analyse	Tutorials Simulation	Written examination Project report	Ability to extrapolate
Model systems and propose an equivalent circuit diagram	4. Analyse	Tutorials Simulation	Written examination Project report	Appropriation of methods
Calculate contributions within a transduction pathway	3. Apply	Tutorials	Written examination	Accuracy of answers
Know the principles of conditioners and their different types	1. Remember	Lecture	Written examination	Ability to rephrase Understanding of concepts
Design an acquisition system integrating the transducer and conditioner	6. Create	Project-based learning (PBL)	Project report	Ability to extrapolate Methodology
Calculate a constitutive equation for a sensor	4. Analyse	Tutorials Simulation	Written assignment	Accuracy of answers
Summarise work in a structured manner in a design report	2. Understand	Project-based learning (PBL)	Project report	Careful and structured report

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	The project focuses on the creation of an innovative connected object for real-time monitoring of road engineering structures	6
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	The module provides a foundation for designing environmental monitoring systems (e.g. efficient irrigation management)	6

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Learn more

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Educational Component: Energy Management

Educational Unit: Electronics 2

Educational Component Director

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A203

In-person class time (in hours)	18
Individual work time (in hours)	15
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	12

General description

This Educational Component aims to provide students with an in-depth understanding of the operating principles of batteries and energy management techniques for mobile systems. It consists of two main blocks: the study of batteries and energy management electronics.

Study of batteries: operation and manufacture. Covers mainly Li-ion batteries, their structure, life cycle and electrochemical principles. Other battery types are also presented.

Keywords

Batteries; Li ion; Voltage regulators; Mobile systems

Type or organisation of classes

1	<ul style="list-style-type: none"> • Study of battery operating principles • Battery capacity • Oxidation/reduction reactions
2	<ul style="list-style-type: none"> • Battery performance: Energy density (Wh/kg); Number of cycles, Cost per cycle (\$) • Li-ion batteries: Principle and Applications • Choice of electrodes, electrolyte, separator in batteries • Flexible & stretchable batteries
3	<ul style="list-style-type: none"> • Nomadic systems • Choosing batteries: advantages/disadvantages • Charging and discharging batteries
4	<ul style="list-style-type: none"> • Electronics for mobile systems: Voltage management: Rectification and filtering • Regulators: <ul style="list-style-type: none"> - Linear: LDO - Pulse: BUCK, BOOST

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand how batteries work: structure (electrodes, electrolyte, interface)	4. Analyse	Classes Tutorials	Written assignment	Command of the subject
Understand the different options in batteries	2. Understand	Classes Tutorials	Written assignment	Command of the subject
Design voltage regulator circuits (linear & pulse)	3. Apply	Classes Tutorials	Written assignment	Command of the subject Methodology

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 12: Ensure sustainable consumption and production patterns	In certain respects, the use of batteries reduces greenhouse gas emissions	
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Educational Component: Wireless Communications Solutions for the IOT

Educational Unit: Electronics 2

Educational Component Director

Marc RAMUZ

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A203

In-person class time (in hours)	30
Individual work time (in hours)	25
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	12

General description

Know and understand the principles, fundamental issues and architectures of modern radio transmission systems in order to be able to specify a complete radio system in an Internet of Things, wireless sensor network or embedded system application.

This Educational Component explores wireless communication technologies for the Internet of Things (IoT). It covers the current protocols (Wi-Fi, Bluetooth, LoRa, Zigbee, NB-IoT), their operating principles, advantages and constraints. Practical work includes implementing IoT solutions and analysing protocol performance (in connection with UP IOT).

Part of this Educational Component is a mini-project on different transmission protocols.

Keywords

IoT (Internet of Things); Wireless communication; Wi-Fi; Bluetooth; Zigbee; LoRa; NB-IoT; Sigfox; Communication protocols; Device interoperability

Type or organisation of classes

1	<p>Introduction</p> <ul style="list-style-type: none"> - Presentation of the generic architecture of an IoT solution - the different layers and components <p>The Network-Connectivity layer</p> <ul style="list-style-type: none"> - Different classifications: use, flow, distance, - Parameters affecting connectivity solutions <p>IoT market drivers. Features of connectivity protocol families for the IOT</p> <ul style="list-style-type: none"> - Wireless - IP-based - Sensor-oriented - Location - Mobile Networks <p>Application: group work analysing 3 IOT application contexts (Health, Energy Management, Agriculture and Livestock) and proposing connectivity solutions</p>
2	<p>Common features of IOT connectivity protocols</p> <ul style="list-style-type: none"> - Energy efficiency - Bandwidth - Connectivity management - Security <p>Launch of group work on the study report</p>
3	<p>Wireless protocols (Wifi, BTLE, Zigbee, Z-Wave, NFC, RFID + LPWAN (LoRaWan and SigFox, Weightless, Ingenu)</p> <p>Group work on the study report</p>
4	<p>Overview of IP-based protocols (IPV6 for IoT, 6LoWPAN, CoAP, MQTT)</p> <p>Group work on the study report</p>
5	<p>Presentation of sensor protocols (MQTT for SN), CoCoA, DDS, AMPQ, TinyOS Messaging) and location protocols (GPS and similar)</p> <p>Group work on the study report</p>
6	<p>Group work: finalisation of study report and development of slideshow for oral presentation</p>
7	<p>Presentation of work</p>

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Characterise the general principles and operating modes of communications protocols	3. Apply	Classes	Project report Oral presentation	Characterise the general principles and operating modes of communications protocols
Understand radio transmission	5. Assess	Project-based learning	Project report Oral presentation	Understand radio transmission
Understand Connectivity protocol layers	5. Assess	Project-based learning	Project report Oral presentation	Understand Connectivity protocol layers
Develop a “solution-based approach” for the deployment of a communications protocol	6. Create	Project-based learning	Project report Oral presentation	Develop a “solution-based approach” for the deployment of a communications protocol

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 12: Ensure sustainable consumption and production patterns	In certain respects, the use of batteries reduces greenhouse gas emissions	
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Educational Unit: Electronic System Designing 2

Educational Unit Director

Acacio MARQUES

marques@emse.fr

D103

Number of ECTS credits (European Credit Transfer Scale)	6
In-person class time (in hours)	69
Individual work time (in hours)	75
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

Deepen knowledge of microprogrammed architectures and their programming. Discovery and implementation of an IoT system.

Keywords

Arithmetic and logic unit; Registers; MMU; RISC architecture; STM32; Network server; LORA; DMA; Low power; Watchdog

Links between course sub-modules

The Educational Component Microcontroller-Based Systems 2 allows students to continue exploring the advanced peripherals and techniques specific to embedded systems. The Educational Component on Processor Architecture opens up possibilities for other advanced architectures that are also programmable. The IOT project is designed to apply these concepts to the new environment of the Internet of Things.

Sub-modules

Processor Architecture 2

Olivier POTIN

Microcontroller-Based Systems 2

Acacio MARQUES

IOT Project

Élias KHARBOUCHE

Educational Component: Processor Architecture 2

Educational Unit: Electronic System Designing 2

Educational Component Director

Olivier POTIN

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A225

In-person class time (in hours)	15
Individual work time (in hours)	33
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

The course addresses processor performance optimisation:

- Description of pipeline microarchitecture,
- Management of dependencies related to pipeline architecture (INTERLOCK and FORWARDING),
- Branch prediction mechanisms,
- optimisation of memory access through the use of caches.

Keywords

RISC-V processor; Pipeline architecture; Data dependency; Control dependency; Memory hierarchy; Branch prediction; SystemVerilog

Type or organisation of classes

1	Managing data and control dependencies
2	Branch prediction
3	Cache hierarchy
4	Design project (2 sessions)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse a microarchitecture developed in SystemVerilog	2. Understand	Lecture	Collective written report	Critical analysis
Implement a solution for managing data and control dependencies	3. Apply	Practical work		Justification of choices
Develop a RISC-V processor functionality	3. Apply	Teamwork		Achievement of goals
Simulate the solution developed	3. Apply	Teamwork		Quality of deliverables

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Educational Component: Microcontroller-Based Systems 2

Educational Unit: Electronic System Designing 2

Educational Component Director

Acacio MARQUES

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D103

In-person class time (in hours)	24
Individual work time (in hours)	24
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

Gain a deeper understanding of microcontroller peripherals, with a focus on energy efficiency, security and application performance. Improve debugging skills in embedded C with current software and hardware development tools.

Keywords

Low power; Standby mode; RAM data retention; Sleep mode; Stop mode; Watchdog; DMA; PC bus; SPI bus; CAN bus;

Type or organisation of classes

1	Power Control
2	Watchdog
3	DMA
4	DMA
5	I ² C bus
6	SPI bus
7	CAN bus
8	CAN bus

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Program advanced microcontroller peripheral drivers	3. Apply	Practical work	Machine test	Compliance with specifications
Debug their application using the tools provided by the development platform	3. Apply	Practical work	Machine test	Functional application
Optimise application performance, power consumption and security	3. Apply	Practical work	Machine test	Optimised solution
Understand the vocabulary of embedded systems	2. Understand	Classes	Questionnaire	Accuracy of answers
Take a methodical approach to embedded problems	3. Apply	Example-based approach	Machine test	Code structure
Read an electronic/digital schematic or synoptic diagram	2. Understand	Example-based approach	Machine test	Compliance with specifications
Read and extract information from a data sheet	2. Understand	Inquiry-based approach	Questionnaire	Accuracy of answers
Draw up a flow chart of the proposed solution	4. Analyse	Practical work	Written exercise	Compliance with representation standards, functional solution

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Essential

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Useful

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Educational Component: IoT Project

Educational Unit: Electronic System Designing 2

Educational Component Director

Élias KHARBOUCHE

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D104

In-person class time (in hours)	27
Individual work time (in hours)	10
Language(s) of instruction	French/English
Sustainable Development Goals (SDGs)	3

General description

Design a sensory connected object to meet the needs of an Internet of Things (IoT) application, and produce a proof of concept.

Keywords

Internet of Things (IoT); Connected Autonomous Sensitive and Secure Object (OCASS); Environmental monitoring; Sensors; Microcontrollers; Wireless transmission; Embedded systems; Air quality analysis; Solution prototyping

Type or organisation of classes

1	General introduction to the project and course on LoRa modulation
2	Introduction to the OCASS platform and a basic sensor (temperature measurement)
3	Introduction to the LoRa MAC In C (LMIC) library
4	Data exchange with the server The Things Network (TTN) and the IoT platform Datacake
5	Introduction to the air monitoring card
6	Independent work on the chosen application
7	Independent work on the chosen application
8	Independent work on the chosen application
9	Final demonstration of the solution developed

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Define the requirements of an IoT application	2. Understand	Lecture	Project report	Accuracy of answers	
Implement an Internet of Things (IoT) solution for environmental monitoring	3. Apply	Practical work	Self-assessment	Achievement of goals	Prototyping IDFab
Implement, configure and optimise LoRa long-range communications	3. Apply	Practical work	Self-assessment	Commitment	Prototyping IDFab
Implement a machine learning algorithm to determine the output of a sensor	3. Apply	Practical work	Self-assessment	Commitment	Prototyping IDFab
Interpret error and warning messages from a firmware development environment	4. Analyse	Practical work	Self-assessment	Commitment	Prototyping IDFab
Check the performance of firmware for an IoT application	5. Assess	Practical work	Self-assessment	Commitment	Prototyping IDFab
Summarise the results obtained in a structured technical report	2. Understand	Case study	Project report	Methodology	
Produce a proof of concept independently	6. Create	Teamwork	Group oral presentation	Creativity	Prototyping IDFab

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 3: Ensure healthy lives and promote well-being for all at all ages	Presentation of the stakes for the IoT in relation to air quality in cities	1.5
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Educational Unit: Computer Science 2

Educational Unit Director

Pierre UNY

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B205

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	51
Individual work time (in hours)	75
Language(s) of instruction	French

General description

IT development using object programming and UML.

Keywords

Object-oriented programming; C++ language; UML

Links between course sub-modules

Project-based approach

Sub-modules

Object-Oriented Programming
Pierre UNY
UML
Pierre UNY

Educational Component: Object-Oriented Programming

Educational Unit: Computer Science 2

Educational Component Director

Pierre UNY

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B205

In-person class time (in hours)	30
Individual work time (in hours)	27.5
Language(s) of instruction	French

General description

Understand the concepts of object-oriented programming using the C++ language.

Keywords

Object-oriented programming; C++ language

Type or organisation of classes

1	Non-object extensions
2	Class and object: encapsulation, constructor and destructor, data and member functions
3	Object copies
4	Composition relationship
5	Friend functions
6	Functions and static data

7	Breakdown into modules
8	Operator overloading
9	Inheritance and virtual functions
10	Class templates
11	Exceptions
12	STL

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Develop a C language application++	6. Create	Classes Practical work	Practical examination	Accuracy of answers
Separate interface from implementation	4. Analyse	Classes Practical work	Practical examination	Accuracy of answers
Use STL	6. Create	Classes Practical work	Practical examination	Accuracy of answers

Educational Component: UML

Educational Unit: Computer Science 2

Educational Component Director

Pierre UNY

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B205

In-person class time (in hours)	15
Individual work time (in hours)	23.5
Language(s) of instruction	French

General description

Understand application modelling using UML.

Keywords

UML; Modelling; Software engineering

Type or organisation of classes

1	The need for modelling
2	Diagrams: classes, objects, uses, sequence, communication, state transition, activity, components, deployment.
3	The link with C++.

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Use UML to model a software application	4. Analyse	Classes Practical work Project	Project	Achievement of goals Quality of deliverables
Implement modelling in C++ language	6. Create	Classes Practical work Project	Project	Achievement of goals Quality of deliverables

Educational Unit: Intelligent and Secure Systems

Educational Unit Director

Olivier POTIN

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A225

Number of ECTS credits (European Credit Transfer Scale)	5
In-person class time (in hours)	66.5
Individual work time (in hours)	53.5
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	16

General description

The importance of data in industrial Information Systems (IS) leads to three paradigms: data analysis using artificial intelligence tools, data confidentiality using encryption algorithms, and data communication over networks. The courses in this Educational Unit demonstrate how encryption tools facilitate the deployment of security solutions in these IS on the network. The Educational Component on IT Network Security for Businesses addresses the fundamentals of network communication according to the OSI model, and enables the vulnerabilities of infrastructures to be measured in order to implement a security policy using encryption algorithms studied in the Introduction to Encryption. The study of Machine Learning makes it possible to analyse these data for decision support or classification.

Keywords

Cybersecurity; Machine learning; Encryption

Links between course sub-modules

The use of data is the central topic of this Educational Unit. The three 3 Educational Components provide an understanding of the concepts of confidentiality, authentication and integrity, enabling relevant analysis of classes and their communication.

Sub-modules

IT Network Security for Businesses

Raphael VIERA

Machine Learning

Olivier POTIN

Introduction to Encryption

Nadia EL-MRABET

Educational Component: IT Network Security for Businesses

Educational Unit: Intelligent and Secure Systems

Educational Component Director

Raphael VIERA

raphael.viera@emse.fr

C203

In-person class time (in hours)	24
Individual work time (in hours)	12
Language(s) of instruction	French/English

General description

This Educational Component will explore the essential foundations of data networks, focusing on key concepts such as IP addressing, subnetting, Ethernet, ports and protocols, and the OSI model. This model will serve as a framework for strengthening understanding of the essential basics of computer networks. Learning will be geared towards practical application, particularly in the context of pentesting (penetration testing). The skills needed to analyse, identify and test potential vulnerabilities in network infrastructure will be developed. This knowledge is indispensable in the field of ethical hacking and cybersecurity.

The aim of this course is to provide the theoretical and practical tools needed in enhancing the security of IT systems, while complying with current ethical and legal standards.

Keywords

Cybersecurity; Networks; Pentesting; Penetration testing; Ethical hacking

Type or organisation of classes

1	The fundamentals of computer networks
2	Network Security Principles
3	Setting up the framework for penetration, recognition and footprint testing
4	Network scanning
5	Enumeration attack on a vulnerable server
6	Gaining access to a vulnerable server
7	Capture the flag
8	Streamlining tasks through automation via programming

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the fundamental concepts of computer networks to explain OSI architecture, describe the main network protocols, and configure IP addresses adapted to different network environments	2. Understand	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Understand the principles of network security (confidentiality, integrity and availability) and ethical hacking	2. Understand	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Understand the methodologies and tools required to set up a penetration testing framework, including recognition and footprinting stages	2. Understand	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Understand and apply network scanning techniques as part of a penetration test	2. Understand	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Understand and apply an enumeration attack on a vulnerable server, identifying exploitable vulnerabilities and using the appropriate tools	2. Understand	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Understand and apply the techniques needed to gain access to a vulnerable server	2. Understand	Lecture Tutorials	Written assignment	Accuracy of answers Justification of choices Thinking-based approach
Apply computer security and problem-solving concepts using techniques related to the game "Capture the Flag"	3. Apply	Practical work	Practical work report	Justification of choices Quality of deliverables
Apply automation concepts to streamline a specific task using a programming script	6. Create	Practical work Project-based learning	Practical work report Project in pairs	Justification of choices Quality of deliverables

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Essential

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- J. Kurose et K. Ross, *Computer Networking: A Top-Down Approach*, 7th edition. Boston Munich: Pearson, 2016.

Useful

- E. Cole, *Network Security Bible*, 2nd edition. Indianapolis, Ind: Wiley, 2009.

Learn more

- J. Erickson, *Hacking: The Art of Exploitation, 2nd Edition*, 2nd edition. Heidelberg: No Starch Press, 2008.
- J. Forshaw, *Attacking Network Protocols: A Hacker's Guide to Capture, Analysis, and Exploitation*, 1st edition. Erscheinungsort nicht ermittelbar: No Starch Press, 2017.

Educational Component: Machine Learning

Educational Unit: Intelligent and Secure Systems

Educational Component Director

Olivier POTIN

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A225

In-person class time (in hours)	21
Individual work time (in hours)	25.5
Language(s) of instruction	French/English

General description

This Educational Component outlines the basic concepts of machine learning, including learning mechanisms, neural network topology and modelling using programming languages, and the underlying mathematical tools.

Keywords

Machine Learning (ML); ML Definitions and mathematics basics; Perceptron; Multilayer Perception (MLP) and Convolutional Neural Networks (CNN); Language models; Generative AI; Program language for AI: Python, Jupyter Notebook, etc.; AI platforms: Google Colab, etc.

Type or organisation of classes

1	ML introduction: context and theory
2	Un/supervised ML
3	Deep learning #1: Multilayer Perceptron and Convolutional Neural Networks
4	Deep learning #2: Natural Language processing and Attention Mechanisms
5	Deep learning #3: Generative, Foundation models
6	TP1
7	TP2

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the main supervised and unsupervised machine learning methods	1. Remember	Lecture	MCQs	Accuracy of answers
Understand the mechanisms of machine learning, particularly Deep Learning	2. Understand	Practical work	Written assignment	Media quality
Understand the steps to create a modern chatbot system (ChatGPT)	1. Remember		Individual technical report	Thinking-based approach
Develop a machine learning model to perform a supervised classification or unsupervised clustering task	3. Apply			Relevance of argumentation
Apply neural network model optimisation methods to correct overfitting issues	3. Apply			
Analyse learning results to detect data or algorithm problems	4. Analyse			
Assess the complexity of a machine learning task based on available data, the complexity of the task and state-of-the-art models.	5. Assess			

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K. P. Murphy, *Probabilistic Machine Learning: An Introduction*. Cambridge, Massachusetts London, England: The MIT Press, 2022.

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Educational Component: Introduction to Encryption

Educational Unit: Intelligent and Secure Systems

Educational Component Director

Nadia EL MRABET

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A216

In-person class time (in hours)	15
Individual work time (in hours)	5
Language(s) of instruction	French

General description

Introduce students to concepts related to encryption: securing digital communications and data, protection against hardware attacks.

Keywords

Symmetric encryption; Asymmetric encryption; Security; Post-quantum encryption

Type or organisation of classes

1	Session 1: 3-hour lecture introducing definitions and main protocols for conventional and post-quantum encryption
2	Session 2: 3-hour lecture introducing attacks on conventional and post-quantum encryption and distribution of topics for student presentations
3	Session 3: 3-hour flipped classroom, presentation of encryption-related topics by students
4	Session 4: 3-hour practical session on symmetric encryption
5	Session 5: 3-hour tutorial on asymmetric encryption

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Choose the encryption protocol best suited to the problem	4. Analyse	Lecture	Written assignment	Accuracy of answers
Assess the vulnerabilities of an encryption system	5. Assess	Tutorials	Group oral presentation	Clarity of presentation
Understand encryption protocols and standards	2. Understand	Practical work		Media quality
Apply encryption protocols and standards	3. Apply	Flipped classroom		Relevance of argumentation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Developing digital security and ensuring personal data protection for all	
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Essential

National Institute of Standards and Technology (US), *Advanced Encryption Standard (AES)*, NIST FIPS 197-upd1, Washington, D.C., 9 mai 2023. doi: [10.6028/NIST.FIPS.197-upd1](https://doi.org/10.6028/NIST.FIPS.197-upd1).

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H. Cohen, G. Frey, R. Avanzi, C. Doche, et T. Lange, *Handbook of Elliptic and Hyperelliptic Curve Cryptography: Theory and Practice*. Boca Raton: Chapman & Hall/CRC, 2005.

Educational Unit: Managerial Tools and Methods

Educational Unit Director

Thibaut METAILLER

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A316

Number of ECTS credits (European Credit Transfer Scale)	2
In-person class time (in hours)	27
Individual work time (in hours)	22.5
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	4, 8, 10, 12, 16 1 to 17 to be chosen

General description

Discover the management tools and methods that support engineers in their professional activities

Keywords

Project management; Teamwork; Collaborative work; Innovation; Intellectual property

Sub-modules

Project Management 1

Thibaut METAILLER

Teamwork

Maxime MALAFOSSÉ

Intellectual Property and Innovation

Maxime MALAFOSSÉ

Educational Component: Project Management 1

Educational Unit: Managerial Tools and Methods

Educational Component Director

Thibaut METAILLER

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A316

In-person class time (in hours)	9.5
Individual work time (in hours)	30
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	1 to 17 (to be chosen)

General description

Identify a need in society and create a project. Analyse and mobilise project management tools and methods. Learn to work in a team

Keywords

Project management; Project management methods and tools; UX design; Market (segments, competition, etc.)

Type or organisation of classes

1	Introduction to project management: a critical approach
2	Methods and tools
3	From idea to project

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify and analyse project management methods and tools	2. Understand	Lecture Flipped classroom Project	Oral presentation Group report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Methodology
Develop a responsible and sustainable methodology for the company and society	3. Apply	Lecture Flipped classroom Project	Oral presentation Group report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Methodology
Translate a need into a project	4. Analyse	Lecture Flipped classroom Project	Oral presentation Group report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Methodology

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 3: Ensure healthy lives and promote well-being for all at all ages	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	All projects must be in line with the SDG chosen by the group of students	30.5

Goal 5: Achieve gender equality and empower all women and girls	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 6: Ensure availability and sustainable management of water and sanitation for all	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	All projects must be in line with the SDG chosen by the group of students	30.5

Goal 10: Reduce inequality within and among countries	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 12: Ensure sustainable consumption and production patterns	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 13: Take urgent action to combat climate change and its impacts	All projects must be in line with the SDG chosen by the group of students	30.5
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	All projects must be in line with the SDG chosen by the group of students	30.5

<p>Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</p>	<p>All projects must be in line with the SDG chosen by the group of students</p>	<p>30.5</p>
<p>Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels</p>	<p>All projects must be in line with the SDG chosen by the group of students</p>	<p>30.5</p>
<p>Goal 17: Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development.</p>	<p>All projects must be in line with the SDG chosen by the group of students</p>	<p>30.5</p>

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Essential

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A. de Baynast, J. Lendrevie, et J. Lévy, *Mercator : Tout le marketing à l'ère de la data et du digital*. Malakoff: Dunod, 2021.

Educational Component: Project Teamwork

Educational Unit: Managerial Tools and Methods

Educational Component Director

Maxime MALAFOSSE

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A319

In-person class time (in hours)	6
Individual work time (in hours)	0
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	17

General description

This course aims to enable students to continue their exploration of collective intelligence by applying it in a practical context within industrial projects. It revisits the fundamental principles of generative collaboration and puts them into practice across three pillars: resonance, to establish a shared understanding and strengthen team cohesion; synergy, to effectively combine individual skills and contributions; and emergence, encouraging the emergence of innovative solutions. This framework aims to equip students with the skills they need to optimise group dynamics and meet the challenges of complex collaborative environments.

Keywords

Collective intelligence; collaboration

Type or organisation of classes

1	Literary and artistic property
2	Industrial Property

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Develop the ability to interact within a project	2. Understand	Tutorials	Pass/fail	Active participation	Develop the ability to interact within a project
Improve knowledge and command of meetings	3. Apply	Tutorials	Pass/fail	Active participation	Improve knowledge and command of meetings

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 17: Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development	Develop project teamwork skills in order to strengthen the means of implementation and revitalise the Global Partnership for Development.	6
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Bibliography

R. Forrester et A. B. Drexler, "A model for team-based organization performance", *AMP*, vol. 13, n° 3, p. 36-49, août 1999, doi: [10.5465/ame.1999.2210313](https://doi.org/10.5465/ame.1999.2210313).

D. Sibbet, *Visual Teams: Graphic Tools for Commitment, Innovation, and High Performance*, 1er édition. Wiley, 2011.

Educational Component: Intellectual Property and Innovation

Educational Unit: Managerial Tools and Methods

Educational Component Director

Maxime MALAFOSSE

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A319

In-person class time (in hours)	9
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	8, 6

General description

Understand the main legal standards applicable within companies concerning information and communication technologies.

Keywords

Industrial and intellectual property; Patents; Trademarks; Copyright; Image rights; Internet law; Data protection

Type or organisation of classes

1	Literary and artistic property
2	Industrial Property

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the main legal standards applicable within companies concerning information and communication technologies	2. Understand	Tutorials	MCQs	Accuracy of answers
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Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Understand the law in order to promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Understand the law in order to promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	6

Educational Unit: Management and Strategy 1

Educational Unit Director

Thibaut METAILLER

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A316

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	56
Individual work time (in hours)	44
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	4, 8, 10, 12, 16 1 to 17 potentially

General description

As part of the ISMIN programme, students will learn the fundamentals of strategic management through the following disciplines: finance, marketing, production management, organisational management, human resources and innovation. The exploration and exploitation phases, as defined by March (1991), will therefore be explored throughout the curriculum. In semester 7, the objective is to focus initially on financial aspects by experimenting with business creation or business development through a cross-disciplinary project that runs throughout the year (exploration phase). This teaching method allows this Educational Unit to be linked to the Educational Unit on management methods and tools, thereby developing technical knowledge in finance and the tools and working methods that will support engineers in their practice. Subsequently, training in production management introduces students to the industrial environment and its various production constraints (exploitation phase). This Educational Unit complements the knowledge acquired in the third year.

Keywords

Strategy; Finance; Marketing; Production management

Links between course sub-modules

As stated above, the Educational Components on Strategy and Finance and Strategy and Marketing introduce students to business creation, thereby enabling them to develop a project from the idea stage to the production phase (exploitation phase). The Educational Component on Production Management enables students to understand the production constraints of organisations (exploration phase). These two modules therefore enable engineering students to develop their ambidextrous skills.

Sub-modules

Strategy and Finance

Thibaut METAILLER

Strategy and Marketing

Thibaut METAILLER

Production Strategy

Claude YUGMA

Educational Component: Strategy and Finance

Educational Unit: Management and Strategy 1

Educational Component Director

Thibaut METAILLER

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A316

In-person class time (in hours)	9
Individual work time (in hours)	50
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	1 to 17 (potentially)

General description

Understand and apply key tools in corporate finance and project management through the creation of entrepreneurial/intrapreneurial activities.

Keywords

Fundamentals of general accounting; Balance sheet and income statement analysis; Financial analysis; Budget management; Introduction to cost accounting; Investment choices; BP

Type or organisation of classes

1	General accounting basics
2	Balance sheet and income statement
3	Financial analysis: Working capital, WCR, interim financial statement, net cash position
4	Budget management
5	Introduction to cost accounting
6	Investment choices
7	BP

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify key concepts in corporate and project finance	2. Understand	Lecture Project-based learning	MCQs Individual written report Oral presentation	Accuracy of answers Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Anticipation Methodology
Develop a responsible entrepreneurial or intrapreneurial project	5. Assess	Project-based learning	Collective written report Oral presentation	Accuracy of answers Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Anticipation Methodology
Mobilise the tools of finance	3. Apply	Lecture Project-based learning	Collective written report Oral presentation	Accuracy of answers Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Anticipation Methodology

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	Topic to be addressed will depend on the project developed	
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Topic to be addressed will depend on the project developed	
Goal 3: Ensure healthy lives and promote well-being for all at all ages	Topic to be addressed will depend on the project developed	
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Topic to be addressed will depend on the project developed	

Goal 5: Achieve gender equality and empower all women and girls	Topic to be addressed will depend on the project developed	
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Topic to be addressed will depend on the project developed	
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Topic to be addressed will depend on the project developed	
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Topic to be addressed will depend on the project developed	
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Topic to be addressed will depend on the project developed	

Goal 10: Reduce inequality within and among countries	Topic to be addressed will depend on the project developed	
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Topic to be addressed will depend on the project developed	
Goal 12: Ensure sustainable consumption and production patterns	Topic to be addressed will depend on the project developed	
Goal 13: Take urgent action to combat climate change and its impacts	Topic to be addressed will depend on the project developed	
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Topic to be addressed will depend on the project developed	

<p>Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</p>	<p>Topic to be addressed will depend on the project developed</p>	
<p>Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels</p>	<p>Topic to be addressed will depend on the project developed</p>	
<p>Goal 17: Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development.</p>	<p>Topic to be addressed will depend on the project developed</p>	

Educational Component: Strategy and Marketing

Educational Unit: Management and Strategy 1

Educational Component Director

Thibaut METAILLER

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A316

In-person class time (in hours)	6
Individual work time (in hours)	12
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	1 to 17 (potentially)

General description

The aim is to address and experiment with the fundamental principles of marketing in the context of a business creation or development project.

Keywords

Marketing; Strategy; Communication; Positioning strategy; Digital marketing; Persona; Brand strategy; Marketing tools

Type or organisation of classes

1	Marketing: the fundamentals
2	Practical case study

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Define the key marketing concepts	4. Analyse	Lecture Flipped classroom	Group oral presentation Written report	Critical analysis
Experiment with and evaluate marketing strategy issues and practices	6. Create	Case study Project-based learning	Group oral presentation Written report	Thinking-based approach

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	Topic to be addressed will depend on the project developed	18
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Topic to be addressed will depend on the project developed	
Goal 3: Ensure healthy lives and promote well-being for all at all ages	Topic to be addressed will depend on the project developed	
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Topic to be addressed will depend on the project developed	

Goal 5: Achieve gender equality and empower all women and girls	Topic to be addressed will depend on the project developed	18
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Topic to be addressed will depend on the project developed	
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Topic to be addressed will depend on the project developed	
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Topic to be addressed will depend on the project developed	
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Topic to be addressed will depend on the project developed	

Goal 10: Reduce inequality within and among countries	Topic to be addressed will depend on the project developed	18
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Topic to be addressed will depend on the project developed	
Goal 12: Ensure sustainable consumption and production patterns	Topic to be addressed will depend on the project developed	
Goal 13: Take urgent action to combat climate change and its impacts	Topic to be addressed will depend on the project developed	
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	Topic to be addressed will depend on the project developed	

<p>Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</p>	<p>Topic to be addressed will depend on the project developed</p>	<p>18</p>
<p>Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels</p>	<p>Topic to be addressed will depend on the project developed</p>	
<p>Goal 17: Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development.</p>	<p>Topic to be addressed will depend on the project developed</p>	

Educational Component: Production Strategy

Educational Unit: Management and Strategy 1

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	24
Individual work time (in hours)	10
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 8, 10, 12, 16

General description

The objective is to gain an understanding of production, starting with the challenges and importance of stock management and moving on to planning and scheduling. This is done in a formal way, presenting basic models.

This Educational Component is also an opportunity for students to develop IT skills in the context of scientific research (topics related to production strategy) that are transferable to a professional setting.

Keywords

Supply chain; Production; Stocks; Scheduling; Planning; Research question; Information; IST; Reliability; Communication; Information, scientific, technological, regulatory, economic and social monitoring

Type or organisation of classes

1	Supply chain
2	Stocks and basic models
3	Scheduling and basic models
4	Forecasting
5	Information and documentation research (on-site and remote classes)
6	Oral presentation of information research on an issue relating to production strategy

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Describe conventional and traditional production processes	2. Understand	Lecture	Written assignment	Justification of choices
Identify a problem	3. Apply	Problem-based approach	Written assignment	Justification of choices
Find solutions efficiently	6. Create	Problem-based approach	Written assignment	Justification of choices
Identify a need for information, define its nature and scope	4. Analyse	Lecture Flipped classroom	Summary: Introduction and conclusion written, detailed outline Oral presentation	Research question clearly defined Need for information clearly defined
Identify relevant sources and access information efficiently	3. Apply	Lecture Flipped classroom	Summary: Introduction and conclusion written, detailed outline Oral presentation	Use of appropriate research tools Quality of sources Access to documents
Critically evaluate the information obtained (sources, approaches, results)	5. Assess	Lecture Flipped classroom	Summary: Introduction and conclusion written, detailed outline Oral presentation	Pertinence of results obtained in relation to needs Reliability of information
Use results to produce and communicate	6. Create	Lecture Flipped classroom	Summary: Introduction and conclusion written, detailed outline Oral presentation	Use of the information obtained to write the summary Quoting sources Understanding of bibliography conventions Consistency and clarity of presentation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Developing information skills contributes to the lifelong learning process	3
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Information skills enable people to adapt to technological change and obtain high-quality jobs, thereby contributing to economic growth	3
Goal 10: Reduce inequality within and among countries	The development of information skills fosters the development of critical thinking, and the reduction of inequalities in access to information and disparities between social groups	3
Goal 12: Ensure sustainable consumption and production patterns	Optimising production in a sustainable manner	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Information skills promote transparency and access to information They enable citizens to obtain information and take an active part in democratic life	3

Learn more (Information skills)

A. Boulogne, Comment rédiger une bibliographie. ADBS, 2005.

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Educational Unit: Languages and Cultures

Educational Unit Director

Samantha CHIN

samantha.chin@emse.fr

A106

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	42.5
Individual work time (in hours)	29.5
Language(s) of instruction	English, Chinese, French as a Foreign Language, German, Japanese, Portuguese, Spanish
Sustainable Development Goals (SDGs)	4, 5, 8, 9, 10, 13, 16

General description

Modern languages at the heart of engineering students' training

As part of their training, engineering students are taught modern languages with a strong professional and international focus. The aim is to complement their technical and scientific knowledge with the development of high-level linguistic and intercultural skills, essential for their development in a multicultural environment.

Requirements and certifications

Fluency in English (1st foreign language) is a priority, with a minimum requirement of 800 TOEIC points or 90 TOEFL IBT points, as well as a B2 level according to the Common European Framework of Reference for Languages (CEFR), certified by the School. A second modern language (Spanish, German, Chinese, Japanese, French or Portuguese) is also taught, with the aim of ensuring operational proficiency adapted to the needs of engineers in an international context.

Professional and intercultural skills

The language teaching takes a pragmatic approach, with a strong focus on communication needs in concrete professional situations. This course helps to equip our future engineers with the tools they need to collaborate effectively in a global and multicultural environment, facilitating their professional integration and international mobility.

Keywords

English; Chinese; French as a Foreign Language; German; Japanese; Portuguese; Spanish

Links between course sub-modules

Objectives common to all Educational Components.

Sub-modules

English

Samantha CHIN

Modern Languages 2 (2nd foreign language)

Samantha CHIN

Educational Component: English

Educational Unit: Languages and Cultures

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	19.5
Individual work time (in hours)	15
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	4, 8, 9, 10, 16

General description

(Level B1+/B2) The English programme in Semester 7 focuses on entrepreneurship, practicing pitching skills in English and acquiring vocabulary relevant to the TOEIC exam, while offering activities tailored to students' needs.

Assessments include written tests (TOEIC-style) and oral activities, as well as tutorials focusing on participation and preparation. Skills covered include professional communication, mastery of advanced grammar, and preparation for international contexts such as interviews and negotiations.

Keywords

Entrepreneurship; Start-ups; Oral presentation; TOEIC; Negotiation; Professional interview; Cover letter; Hypotheses; Passive voice; Reported speech

Type or organisation of classes

1	10 classes
2	5 tutorials

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to (target: B1+/B2 level):

Create and present a clear and convincing professional pitch in English	4. Analyse	Group work and oral presentation with feedback	Graded oral presentation	Clarity Structure Use of appropriate vocabulary
Use vocabulary specific to entrepreneurship and international business contexts.	3. Apply	Interactive games, case studies and vocabulary files	Online quizzes and in-class exercises	Accuracy Variety and relevance of terms used
Write a cover letter that is structured and tailored to a job application in English.	5. Assess	Writing workshop with proofreading in pairs	Written evaluation (homework)	Structure Relevance of arguments Grammar
Actively participate in a mock interview in English, highlighting experience and skills.	3. Apply	Role-playing with assessment by peers and teacher	Oral assessment on the quality of the performance	Relevance of answers Fluency Overall impact
Analyse and answer TOEIC-type questions correctly.	2. Understand	Practical exercises and timed tests	Multiple-choice questions and mini tests under real-life conditions	Fast, accurate responses

Sustainable Development Goals

SDGs	Contribution	Volume in hours
------	--------------	-----------------

This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	The S7 program focuses on language learning (B1+/B2 level), preparing students for international requirements such as the TOEIC exam, while reinforcing their professional skills (writing, negotiation, interviewing).	1
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	The focus on entrepreneurship and the development of professional skills (pitching, interviews, cover letters) helps prepare students for productive, decent work, while promoting sustainable economic growth.	2
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	The theme of entrepreneurship encourages students to think about innovation, particularly in relation to start-ups, which is in line with the promotion of sustainable industrialisation and resilient infrastructure.	2
Goal 10: Reduce inequality within and among countries	The programme helps students integrate more easily into international environments and reduces language barriers, thereby helping to reduce inequalities between countries.	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	By focusing on communication and intercultural skills, the programme encourages effective and inclusive dialogue, promoting responsible interactions on a global scale.	2

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Educational Component: Modern Languages 2 (2nd foreign language)

Educational Unit: Languages and Cultures

Educational Component Director

Samantha CHIN

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A106

In-person class time (in hours)	19.5
Individual work time (in hours)	14
Language(s) of instruction	Chinese, French as a Foreign Language,
Sustainable Development Goals (SDGs)	German, Japanese, Portuguese, Spanish
	4, 8, 9, 13, 16

General description

Level B1+/B2/B2+: The main objective of this Educational Unit is to prepare students to navigate international academic and professional environments with ease, while strengthening their employability and intercultural skills. Students will develop advanced written and oral communication skills tailored to professional contexts, including presentations, negotiation and writing complex documents. The module also trains students in the ability to analyse and adapt in a variety of intercultural situations, by supporting them in planning study or work projects abroad in line with their personal and professional goals.

Level A1/A2/A2+: The main aim of this teaching unit is to provide the linguistic and cultural foundations required for interaction in simple everyday and professional situations. Students will learn to introduce themselves, exchange basic information and understand the essential cultural practices of the target language. This module also focuses on the development of intercultural communication to help students integrate into multicultural environments.

Keywords

Intercultural communication; Professional skills; Adaptability; Oral presentations; International negotiation; Writing documents; Cultural practices; Cultural integration; Critical analysis; Project planning

Type or organisation of classes

1	10 classes
2	5 tutorials

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Level B1+/B2/B2+				
Communicate effectively in professional and intercultural contexts.	3. Apply	Role play Intercultural meeting simulations	Classroom observation Oral exercises	Fluency, Precision Contextual appropriateness
Write professional documents (reports, emails, letters).	4. Analyse	Writing reports or letters for professional purposes	Correction and feedback on written texts	Consistency Using formal conventions
Analyse intercultural situations to solve problems.	5. Assess	Case studies Interactive debates	Observation during discussions	Relevance of solutions Depth of analysis
Participate actively in multicultural presentations, presenting ideas clearly.	4. Analyse	Preparing and presenting professional presentations	Observation during presentations	Impact Clarity Interaction

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to (target: B1+/B2 level):

Level A1/A2/A2+				
Use simple sentences for everyday interactions	1. Recognise	Role-playing everyday scenarios	Simple oral assessment (introducing oneself, asking for information)	Correct pronunciation Understanding
Introduce themselves and exchange basic information	2. Understand	Guided dialogues and interactive activities	Individual oral or written presentation	Clarity Fluency Cultural adaptation
Reproduce simple grammatical structures	3. Apply	Practical grammar exercises	Multiple-choice questions or written exercises	Grammatical accuracy Correct use of basic rules
Discover and assimilate fundamental cultural elements	2. Understand	Discussion and analysis of local customs	Quiz or presentation on a cultural topic	Cultural understanding Relevance

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Develop the intercultural and linguistic skills needed to operate in an international academic or professional environment.	
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Raising awareness of social, ethical and legal standards for internships and jobs in different countries, to promote successful integration.	
Goal 10: Reduce inequality within and among countries	Analysis of cultural and economic inequalities between different countries to prepare students for diverse environments.	
Goal 13: Take urgent action to combat climate change and its impacts	Introduction to sustainable practices applied to international mobility (reducing the carbon footprint of travel, choosing eco-responsible destinations).	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Training on inclusive and ethical behaviour in international environments, promoting effective collaboration in multicultural teams.	

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ISMIN SYLLABUS

2024 – 2025

Semester 8

Direction de la Formation - ISMIN
Mines Saint-Etienne
June 2024

Semester 8

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Educational Unit: FPGA Security (Electronics Elective course - ELEC 1)

Educational Unit Director

Jean-Baptiste RIGAUD

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A225

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	48
Individual work time (in hours)	16
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

Implementation of an integrated circuit design flow on reprogrammable Xilinx FPGA components. Instrumentation of the circuit using serial communication, and control of the development board’s inputs and outputs using a program written in Python.

Keywords

Logic synthesis; Hardware prototyping; Placement routing; Simulation with delay feedback annotation; Integrated logic analyser; Python; Serial communication; Machines with a finite number of states

Sub-modules

FPGA Hardware Design
Jean-Baptiste RIGAUD
Interface and Acquisition
Raphael VIERA

Educational Component: FPGA Hardware Design

Educational Unit: FPGA security (Electronics Elective course - ELEC 1)

Educational Component Director

Jean-Baptiste RIGAUD

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A225

In-person class time (in hours)	36
Individual work time (in hours)	12
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

This Educational Component is dedicated to the application and implementation of the fundamental concepts of a hardware description language for the design of large-scale digital systems.

Here, the entire design flow of an integrated circuit is applied to a reprogrammable target (FPGA).

Five lectures and tutorials will cover the following topics: general information on FPGA technology, introduction to the design flow associated with Xilinx FPGAs, intellectual property (IP) block library, review of finite state machines (FSMs), and use of the integrated logic analyser (ILA). These introductory sessions are based on the university training programme offered by Xilinx.

The remaining sessions apply these concepts to a project and illustrate certain topics covered in the third year of the programme and related issues. For example, aspects related to bioelectronics (ECG trace acquisition), personal data security (Ascon lightweight cryptography), and the instrumentation of development boards (UART communication).

Keywords

Field Programmable Gate Array (FPGA); Xilinx Vivado hardware design flow; Hardware Description Language (HDL); Implementation of ASCON cryptographic protocol; Debugging; Implementation of serial communication protocol (UART); Synthesis, Place and route; Timing constraints, Clock frequency, Synchronisation

Type or organisation of classes

1	Sessions 1, 2: Overview and FPGA technology / Xilinx Vivado tutorial #1
2	Sessions 3, 4, 5: IP integration, synthesis of finite state machines and integrated logic analyser (ILA) / Xilinx Vivado tutorials
3	Sessions 6, 7: UART protocol and finite state machines (FSM), theory and implementation
4	Session 8: Presentation of the project to be carried out (ECG traces, ASCON cryptographic algorithm, etc.)
5	Sessions 9, 10: Implementation of protocol and communication
6	Sessions 11, 12: Assembly, implementation on PYNQ Z2 board and testing

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Master a hardware design flow	3. Apply	Lectures	Technical report	Achievement of goals
Develop digital components	3. Apply	Practical work	Individual oral presentation	Media quality
Assemble a set of digital components	2. Understand	Project-based learning		Justification of choices
Use a UART-type serial communication protocol	3. Apply			Clarity of presentation
Implement a state machine to orchestrate the operation of an application	3. Apply			
Testing and debugging hardware	4. Analyse			
Simulating digital components	3. Apply			
Making hardware design choices	5. Assess			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
------	--------------	-----------------

This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	ECG applications (full session by D. Moreau)	
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Educational Component: Interface and Acquisition

Educational Unit: FPGA security (Electronics Elective course - ELEC 1)

Educational Component Director

Raphael VIERA

raphael.viera@emse.fr

C203

In-person class time (in hours)	18
Individual work time (in hours)	6
Language(s) of instruction	French

General description

This Educational Component guides students through programming an FPGA development board, encrypting ECG waveform data using an ASCON engine via UART, transmitting and receiving encrypted data, and analysing the results. The final task involves plotting ECG waveforms and calculating BPM and other aspects of electrocardiography (ECG). This Educational Component requires prior knowledge of FPGA fundamentals.

Keywords

Python; Serial communication (UART); ECG; Instrumentation; Data processing; Graphic visualisation

Type or organisation of classes

1	Loading a precompiled binary stream into the FPGA.
2	Transmitting ECG waveform data in clear text via UART.
3	Data encryption using ASCON with specified parameters.
4	Receiving and decrypting the encrypted waveform.
5	Analysing and plotting the ECG waveform.
6	Merging multiple waveforms to calculate BPM.

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Use a UART-type serial communication protocol	3. Apply	Tutorials	Oral presentation	Achievement of goals
Send commands to control a development board	3. Apply	Tutorials	Summary	Clarity of presentation
Receive and store a flow of information	3. Apply	Tutorials	Final demonstration	Quality of deliverables
Analyse and represent a set of information	4. Analyse	Tutorials		Media quality
Develop an instrumentation application in a programming language such as Python	3. Apply			

Educational Unit:

ECG - Human-Machine Interface (Electronics Elective course - ELEC 2)

Educational Unit Director

Sébastien SANAUR

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A324

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	60
Individual work time (in hours)	36
Language(s) of instruction	French; English
Sustainable Development Goals (SDGs)	3, 9

General description

- Practical application of course theory (materials, physics, fundamental electronics, analog electronics, microcontrollers, signal processing, etc.)
- Acquiring knowledge and skills in cleanroom technologies
- In synergy with: Prototyping, analog electronics, microcontroller programming, etc.
- Practical project in embedded systems & IoT: manufacturing a demonstrator similar to the everyday “connected” object
- Preparing for third year: E&E, BMD, Microelectronics Design, Embedded Systems

Keywords

Semiconductor component technologies; Microelectronics cleanrooms; Embedded systems; Practical application & prototyping; Tutored project, Demonstrators

Links between course sub-modules

This Educational Unit takes the form of a tutored project in which students design, manufacture and put into operation their own prototype of an embedded system. The embedded system acts as an interface between Humans and Machines: Human measurement of an ECG signal -> signal conditioning and acquisition electronics -> software processing in microprocessor -> multiplexing and display on passive matrix OLED.

Educational Component 1: Manufacture of conditioning and multiplexing electronics,

Educational Component 2: Manufacture of ECG electrodes and passive matrix OLEDs in a microelectronics cleanroom,

Educational Component 3: Programming a microcontroller to process and organise incoming and outgoing information.

Sub-modules

Design and Manufacture of Semiconductor Components in a Microelectronics Cleanroom
--

Marc RAMUZ

Electronics ECG + Multiplexer & Demonstrator Assembly

François BERNIER

Microcontroller programming

Raphael VIERA

Educational Component: Design and Manufacture of Semiconductor Components in a Microelectronics Cleanroom

Educational Unit: ECG - Human-Machine Interface (Electronics Elective course - ELEC 2)

Educational Component Director

Marc RAMUZ

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A203

In-person class time (in hours)	10.5
Individual work time (in hours)	0
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	9

General description

As part of the Educational Unit on Human-Machine Interfaces, this Educational Component focuses on the manufacture of two components in a cleanroom: an electrode on a flexible substrate and OLEDs. The main objective is to familiarise students with microelectronics manufacturing techniques. This involves spin coating, photolithography, metal evaporators, etc. Students will use various pieces of equipment. In terms of application, a flexible 'dry' electrode will be manufactured that can measure an electrocardiogram signal (measurement taken in the other Educational Component of this Educational Unit). The measurements are displayed using OLEDs manufactured as part of this Educational Component.

Keywords

Cleanroom; Photolithography; Thin film evaporation; OLED; ECG electrodes on flexible substrate

Type or organisation of classes

1	<p>Good practice in a cleanroom:</p> <ul style="list-style-type: none"> • The rules and regulations for cleanroom work, including those inherent to microelectronics • Environmental rules, clean concept / Good practice • Safety
2	<p>Designing a thin-film device:</p> <ul style="list-style-type: none"> • Thin-film device technologies • Thin-film device layout • Photolithography, development, lift-off • Vacuum thermal evaporation
3	<p>Manufacturing a thin-film device:</p> <ul style="list-style-type: none"> • Patterning by photolithography and/or shadow masking (power, exposure time, coating speed, vacuum level) • Handling in gloveboxes (sample input/output, pumping-purging cycles, humidity and oxygen level control) • Thermal evaporation under vacuum (secondary vacuum, electrical power, Joule effect, power ramp, evaporation rate and thickness control, co-evaporation, multi-layer deposition), • Sealing of glass encapsulation by UV photocrosslinking of glue.
4	<p>Control of physical characteristics at each stage of manufacture:</p> <ul style="list-style-type: none"> • Optical and electrical microscopic measurements of deposits, • Control of organic multilayer deposition synoptic (thickness, evaporation/co-evaporation speed), • Mechanical control of encapsulant • Optical microscopy control of the lateral dimensions of the thin-film device, <ul style="list-style-type: none"> • Measurement of the OLED's Current-Voltage characteristic using an electronic tester, performance verification, • Optoelectronic tester measurement of the OLED's Current-Luminance characteristic, performance verification, • Calculation of the external efficiency of the OLED device using the experimental data obtained, performance verification.

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Apply EHS guidelines when working in a cleanroom environment	3. Apply	Teamwork	Self-assessment Report Presentation	Commitment Rigour Professional conduct	Cleanroom
Designing thin-film (opto-)electronic components	6. Create	Practical work Teamwork	Technical report Oral presentation Oral defence	Critical analysis Clarity of presentation Thinking-based approach Justification of choices Quality of drawings Active participation Rigour Presentation structure	Cleanroom
Carry out a sequence of technological processes for thin-film devices, respecting EHS guidelines in a cleanroom environment	2. Understand	Practical work Teamwork	Technical report Oral presentation Oral defence	Critical analysis Clarity of presentation Thinking-based approach Justification of choices Quality of diagrams Active participation Rigour Presentation structure	Cleanroom
Characterise and control the operation of a thin-film device	5. Assess	Practical work Teamwork	Technical report Oral presentation Oral defence	Clarity of presentation Thinking-based approach Justification of choices Quality of diagrams Active participation Rigour Presentation structure	Cleanroom

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Understand industrial manufacturing technologies to better design electronic components and reduce the inherent energy costs	10.5
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M. H. Chowdhury, Q. D. Hossain, P. Saha and M. M. Rahaman, "Design, fabrication and performance evaluation of a three electrode ECG recorder," *2016 International Conference on Innovations in Science, Engineering and Technology (ICSET)*, Dhaka, Bangladesh, 2016, pp. 1-4, doi: [10.1109/ICSET.2016.7856500](https://doi.org/10.1109/ICSET.2016.7856500)

E. Sazonov, Éd., *Wearable Sensors: Fundamentals, Implementation and Applications*, 2nd edition. London : Academic Press, 2020.

Educational Component: Electronics ECG + Multiplexer & Demonstrator Assembly

Educational Unit: ECG - Human-Machine Interface (Electronics Elective course - ELEC 2)

Educational Component Director

François BERNIER

francois.bernier@emse.fr

D102

In-person class time (in hours)	30
Individual work time (in hours)	6
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	3, 9

General description

The main objective of this Educational Component, which students complete in semi-autonomy, is to put into practice the knowledge acquired in i) analogue electronics ii) signal acquisition chains (first year).

This Educational Component is exclusively a practical exercise for students, who develop an understanding of the purpose of creating an embedded system-type technology demonstrator:

- input signal (ECG in this case, see the Educational Component on Technology Components in a Microelectronics Cleanroom)
- signal conditioning
- CAN -> microcontroller
- multiplexer
- output signal display (here passive matrix OLED, see the Educational Component: Design and Manufacture of Semiconductor Components in a Microelectronics Cleanroom)

Keywords

Bio-signals; ECG; Simulation; Multiplexer; Electronic manufacturing; Programming; 3D design; Prototyping; Measurement and testing

Type or organisation of classes

1	Practical 1-1 ECG theory
2	Practical 1-2 Power conditioner theory Simulation-Measurement
3	Practical 2 Power conditioners: Design & Circuit - Welding
4	Practical 3 Power conditioners: Welding tests with commercial electrodes
5	Practical 4 Multiplexer LEDs: principle & programming
6	Practical 5 Multiplexer LEDs: energy consumption
7	Practical 6 Packaging
8	Practical 7 Demonstrator assembly
9	Practical 8 Demonstrator test

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Describe the main characteristics of an ECG-type bio-signal	2. Understand	Lectures	Practical work	Achievement of goals	
Simulate the operation of a circuit responsible for conditioning an analog signal	2. Understand	Practical work: Simulation	Practical work: Simulation	Achievement of goals	
Build a signal conditioning circuit	6. Create	Practical work	Practical work	Achievement of goals	IDFab prototyping
Characterise a conditioner circuit and check that it operates correctly	1. Remember	Practical work	Practical work	Achievement of goals	
Record analog signals using a microcontroller	1. Remember	Practical work	Practical work	Achievement of goals	
Differentiate between the signals acquired and identify specific areas of an ECG signal	3. Apply	Practical work	Practical work	Achievement of goals	

Interpret the signals acquired	3. Apply	Practical work	Practical work	Achievement of goals	
Apply signal processing algorithms	3. Apply	Practical work	Practical work	Achievement of goals	
Determine heart rate from the signals acquired	3. Apply	Practical work	Practical work	Achievement of goals	
Break down an analog signal	3. Apply	Practical work	Practical work	Achievement of goals	
Detect significant signal peaks	4. Analyse	Practical work	Practical work	Achievement of goals	
Differentiate and filter noise from analog signals	4. Analyse	Practical work	Practical work	Achievement of goals	
Use a Multiplexer to control an OLED matrix manufactured in a cleanroom	4. Analyse	Practical work	Practical work	Achievement of goals	
Test the various components together to create a functional object	4. Analyse	Practical work	Practical work	Achievement of goals	

Assemble the various components to produce a prototype	4. Analyse	Practical work	Practical work	Achievement of goals	IDFab prototyping
Design 3D or 2D parts in order to assemble these elements	6. Create	Practical work	Practical work	Achievement of goals	IDFab prototyping
Manufacture all parts required for the final prototype	6. Create	Practical work	Practical work	Achievement of goals	IDFab prototyping
Check the accuracy of acquired, filtered and displayed signals	6. Create	Practical work	Practical work	Achievement of goals	
Identify areas for improvement	6. Create	Practical work	Practical work	Achievement of goals	
Evaluate the corrections to be made and apply them	6. Create	Practical work	Practical work	Achievement of goals	
Justify the solutions implemented	6. Create	Practical work	Practical work	Achievement of goals	

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	Design a low-cost medical monitoring system to facilitate deployment in low-income countries	/
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Raising awareness of the ecological impact of the microelectronics industry (water and energy consumption, consumption and recycling of chemicals - acids and solvents, extraction of rare minerals, etc.)	/

S. Behera, M. Samal, et R. Layak, "The Use of FIR Filter for Filtering of ECG Signal and Comparison of Some Parameters", *International Journal of Engineering Science Invention*, 2017.

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Educational Component: Microcontroller Programming for a Demonstrator

Educational Unit: ECG - Human-Machine Interface (Electronics Elective course - ELEC 2)

Educational Component Director

Raphael VIERA

raphael.viera@emse.fr

C203

In-person class time (in hours)	9
Individual work time (in hours)	3
Language(s) of instruction	French, English
Format	Hybrid
Sustainable Development Goals (SDGs)	9

General description

The main aim of this Educational Component is to put microcontroller programming into practice in a real-life application of an embedded electronic system demonstrator.

Student will program a microcontroller to receive data from a signal, process this data, then calculate and return the information to be displayed.

Keywords

Microcontroller programming; Microcontroller memory management; Microcontroller calculations

Type or organisation of classes

1	Practical 1 - Data acquisition and processing by microcontroller
2	Practical 2 - Data processing and transmission by microcontroller
3	Practical 3 - Demonstrator assembly & test

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Program a microcontroller for demonstration in a real-life application	6. Create	Case study	Self-assessment Technical report, Assessment by academic tutor	Program a microcontroller for demonstration in a real-life application
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Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Raising awareness of the environmental impact of the microelectronics industry (energy consumption, minimising storage space, data management flows, etc.)	/
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Essential

J. Yiu, *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors*, 3rd edition. Amsterdam : Newnes, 2013.

Useful

C. Noviello, *Mastering STM32*. Leanpub, 2015.

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Learn more

J. G. Proakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 5th edition. Pearson, 2021.

Educational Unit: Advanced Computer Science (Computer Science Elective course - INFO 1)

Educational Unit Director

Elodie SUZANNE

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B205

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	54
Individual work time (in hours)	42
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

The Educational Unit “Advanced Computer Science” is one of the Computer Science elective courses. It is a continuation of the Educational Units “Computer Science 1” (Semester S6) and “Computer Science 2” (Semester S7), building on the scientific culture and skills acquired in algorithms, programming and computer science in general. Upon completion of the Educational Unit, students will be able to:

- Address and solve concrete engineering problems: (i) analyse requirements, (ii) formalise the problem, (iii) structure and represent data, (iv) propose, design and implement algorithms/programs to solve the problem;
- Have a strong scientific background in computer science and a good understanding of combinatorial optimisation.

Keywords

Advanced algorithms; C++ programming; Combinatorial optimisation; Network security

Links between course sub-modules

The Educational Unit “Advanced Computer Science” is one of the Computer Science elective courses, which develops students’ knowledge of computer systems: Security of computer networks for the web and IoT (continuation of the Educational Unit “Intelligent and Secure Systems” in S7), advanced algorithms (based on knowledge acquired in the Educational Units “Computer Science 1” in S6 and “Computer Science 2” in S7) and introduction to combinatorial optimisation (linked to the Educational Unit “Computer Science 1” in S6).

Sub-modules

Network Security for the Web and IoT

Raphael VIERA

Advanced Algorithms

Dominique FEILLET

Introduction to Combinatorial Optimisation
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Nabil ABSI

Educational Component: IT Network Security for the Web

Educational Unit: Advanced Computer Science (Computer Science Elective course - INFO 1)

Educational Component Director

Raphael VIERA

raphael.viera@emse.fr

C203

In-person class time (in hours)	12
Individual work time (in hours)	12
Language(s) of instruction	French, English

General description

This Educational Component focuses on penetration testing in web security, exploring vulnerabilities in web and IoT infrastructure. The aim is to identify potential actions that could be taken by malicious users and assess the risks associated with privileged access to web and IoT resources.

Practical sessions reinforce students' technical skills through the installation and development of security tools, the identification and mitigation of vulnerabilities, and by carrying out web penetration tests. These exercises simulate various threat scenarios. The results obtained improve access controls and secure vulnerable web and IoT applications, providing recommendations to strengthen the overall security of these systems.

Keywords

Cybersecurity; Networks; Pentesting; Penetration testing; Ethical hacking

Type or organisation of classes

1	Understanding the fundamental concepts of web vulnerabilities, from both the client and server perspectives. Server vulnerabilities: SQL injection and authentication vulnerabilities
2	Server vulnerabilities: Directory traversal attacks, Access control
3	Server vulnerabilities: File uploading and server-side request forgery (SSRF)
4	Client vulnerabilities: Cross-site request forgery (CSRF), cross-site scripting (XSS) and Clickjacking

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the fundamental concepts of web vulnerabilities, from both the client and server perspectives.	2. Understand	Lectures Tutorials	Written test	Accuracy of answers Justification of choices Thinking-based approach
Server vulnerabilities: SQL injection and authentication vulnerabilities	2. Understand	Practical work	Written test	Accuracy of answers Justification of choices Thinking-based approach
Server vulnerabilities: Directory traversal attacks	2. Understand	Practical work	Written test	Accuracy of answers Justification of choices Thinking-based approach
Server vulnerabilities: Access control, File upload and Server-side request forgery (SSRF)	2. Understand	Practical work	Written test	Accuracy of answers Justification of choices Thinking-based approach
Client vulnerabilities: Cross-site request forgery (CSRF), cross-site scripting (XSS) and Clickjacking	2. Understand	Practical work	Written test	Accuracy of answers Justification of choices Thinking-based approach
Apply automation concepts to streamline a specific task using a programming script	3. Apply	Practical work Project-based learning	Written test	Accuracy of answers Justification of choices Thinking-based approach

Bibliography

Essential

G. Khawaja, *Practical Web Penetration Testing: Secure web applications using Burp Suite, Nmap, Metasploit, and more*, 1st edition. Packt Publishing, 2018.

J. Kurose et K. Ross, *Computer Networking: A Top-Down Approach*, 7th edition. Boston: Pearson, 2016.

D. Stuttard et M. Pinto, *The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws*, 2nd edition. Indianapolis, IN: Wiley, 2011.

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E. Cole, *Network Security Bible*, 2nd edition. Wiley, 2011.

M. McDonald, *Web Security for Developers: Real Threats, Practical Defense*, Illustrated edition. Erscheinungsort nicht ermittelbar: No Starch Press, 2020.

Learn more

J. Forshaw, *Attacking Network Protocols: A Hacker's Guide to Capture, Analysis, and Exploitation*. Erscheinungsort nicht ermittelbar: No Starch Press, 2017.

M. Zalewski, *The Tangled Web: A Guide to Securing Modern Web Applications*. Heidelberg: No Starch Press, 2011.

Educational Component: Advanced Algorithms

Educational Unit: Advanced Computer Science (Computer Science Elective course - INFO 1)

Educational Component Director

Dominique FEILLET

feillet@emse.fr

A312

In-person class time (in hours)	18
Individual work time (in hours)	9
Language(s) of instruction	French

General description

The primary objective of this ECUE is to help students develop their skills in creating complex algorithms. This involves discovering new C++ features since the C++11 standard, manipulating complex pseudocode, and coding algorithms derived from pseudocode. A secondary objective is to familiarise students with the concepts of exploration and deduction, which are fundamental to combinatorial optimisation.

Keywords

Object-oriented programming; Algorithms; Pseudocode; Constraint programming; Constraint satisfaction problems

Type or organisation of classes

1	Features of C++11 and subsequent standards
2	Introduction to constraint satisfaction problems and backtracking mechanisms. Application to a scheduling problem
3	Notion of arc consistency and introduction of deductive mechanisms. Application to a scheduling problem (cont.)
4	Application: Solving a Sudoku puzzle
5	Hyper arc-consistency and advanced deductive mechanisms (All different constraints). Application: solving a Sudoku puzzle (cont.)
6	Application: solving a Sudoku puzzle (cont.)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Interpret pseudocode	2. Understand	Project-based learning	Written test	Command of the subject
Create complex algorithms	3. Apply	Project-based learning	Written test	Command of the subject
Compare the efficiency of different algorithms	5. Assess	Project-based learning	Written test	Command of the subject

Bibliography

Learn more

W. J. van Hoeve, « The alldifferent Constraint: A Survey », 8 mai 2001, *arXiv*: arXiv:cs/0105015. doi: [10.48550/arXiv.cs/0105015](https://doi.org/10.48550/arXiv.cs/0105015).

F. Rossi, P. van Beek, et T. Walsh, Éd., *Handbook of Constraint Programming*, Amsterdam Heidelberg : Elsevier Science, 2006.

Educational Component: Introduction to Combinatorial Optimisation

Educational Unit: Advanced Computer Science (Computer Science Elective course - INFO 1)

Educational Component Director

Nabil ABSI

absi@emse.fr

B207

In-person class time (in hours)	24
Individual work time (in hours)	12
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	9

General description

The aim of this Educational Component is to introduce students to combinatorial optimisation, with an emphasis on modelling and using the most suitable approaches to finding solutions. The various techniques will be implemented using Python packages (Pyomo, etc.).

Keywords

Linear Programming; Dynamic Programming; Integer Linear Programming; Heuristics and Metaheuristics; Decomposition approaches

Type or organisation of classes

1	Introduction to Operations Research
2	Linear Programming
3	Duality and sensitivity analysis
4	Integer Linear Programming
5	Advanced ILP modelling and resolution techniques
6	Dynamic programming
7	Advanced approaches to operations research
8	Heuristics and metaheuristics

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Acquire the basic concepts and decision-making issues involved in supply chain planning	1. Remember	Lectures Tutorials Practical work	Individual oral presentation, IT development	Achievement of goals Clarity of presentation
Understand how to create models and solve decision-making problems related to supply chain planning	2. Understand	Lectures Tutorials Practical work	Individual oral presentation, IT development	Achievement of goals Clarity of presentation
Apply the most appropriate methods to the decision-making problems encountered	3. Apply	Lectures Tutorials Practical work	Individual oral presentation, IT development	Achievement of goals Clarity of presentation
Analyse the decision-making level and complexity of the problem encountered	4. Analyse	Lectures Tutorials Practical work	Individual oral presentation, IT development	Achievement of goals Clarity of presentation
Assess available resolution approaches	5. Assess	Lectures Tutorials Practical work	Individual oral presentation, IT development	Achievement of goals Clarity of presentation
Create algorithms specific to the decision-making problems encountered	6. Create	Lectures Tutorials Practical work	Individual oral presentation, IT development	Achievement of goals Clarity of presentation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Development of optimisation and decision support tools for sustainable development studies	3
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Bibliography

Useful

Y. Pochet et L. A. Wolsey, *Production Planning by Mixed Integer Programming*, Softcover reprint of hardcover 1st ed. 2006 edition. New York, NY Heidelberg: Springer, 2010.

Learn more

L. A. Wolsey, *Integer Programming*, 1st edition. New York, NY: Wiley-Interscience, 1998.

Educational Unit: AI and Data Analytics

Educational Unit Director

Claude YUGMA

yugma@emse.fr

A203

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	51
Individual work time (in hours)	25
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Mastering the basics of AI in semiconductor manufacturing. Using and developing simulation tools or digital twins to make decisions. Understanding the basics of advanced process control (maintenance, sampling, etc.). Embedding AI in tools. Making decisions in combinatorial and non-combinatorial contexts.

Keywords

Semiconductors; Prediction; Digital twins; Reinforcement learning; Simulation; Data

Links between course sub-modules

Objectives common to all sub-modules.

Sub-modules

AI and Manufacturing

Claude YUGMA

Decision Support

Dominique FEILLET

Embedded AI

Olivier POTIN

Educational Unit: AI Manufacturing

Educational Unit: AI and Data Analytics

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	24
Individual work time (in hours)	10
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

The aim is to gain a basic understanding of AI and its role in the semiconductor industry. We explore how AI optimises the production chain, from predictive maintenance to detecting defects and intelligent automation. Practical examples are used to illustrate its impact on efficiency and innovation in this key sector of modern technology.

Keywords

Semiconductor manufacturing process; Digital twins; Reinforcement learning; Advanced process control

Type or organisation of classes

1	Semiconductor manufacturing processes
2	Digital twins
3	Reinforcement learning
4	Advanced process control

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Describe the complexities of semiconductor manufacturing	2. Understand	Project-based learning	Project report	Achievement of goals
Create models using a simulation approach	5. Assess	Case study	Project report	Achievement of goals
Identify a semiconductor production problem	4. Analyse	Case study	Project report	Achievement of goals
Understand key concepts in AI	2. Understand	Case study	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Build solutions that are both industrialisable and resilient	/
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Educational Component: Decision Support

Educational Unit: AI and Data Analytics

Educational Component Director

Dominique FEILLET

feillet@emse.fr

A312

In-person class time (in hours)	15
Individual work time (in hours)	8
Language(s) of instruction	French

General description

This Educational Component has two main objectives. The first objective is to introduce theoretical tools to aid decision-making, highlighting the complexity of a purely objective and rational approach. The second objective is to introduce decision-making support methods in highly combinatorial environments, such as those encountered in planning (production, transport, etc.).

Keywords

Decision support; Multicriteria decisions; Social choice theory; Combinatorial optimisation; Linear programming and integer linear programming

Type or organisation of classes

1	Introduction to combinatorial optimisation: modelling
2	Introduction to combinatorial optimisation: resolution
3	Social choice theory
4	Multi-criteria decision support
5	Cognitive bias in decision-making

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Critically assess a collective or multi-criteria decision-making strategy	5. Assess	Lectures	Written test	Command of the subject
Understand a collective or multi-criteria decision-making strategy	2. Understand	Lectures	Written test	Command of the subject
Identify a combinatorial optimisation problem	1. Remember	Lectures	Written test	Command of the subject
Understand simple combinatorial optimisation concepts	2. Understand	Lectures	Written test	Command of the subject

Educational Component: Embedded AI

Educational Unit: AI and Data Analytics

Educational Component Director

Olivier POTIN

olivier.potin@emse.fr

A225

In-person class time (in hours)	12
Individual work time (in hours)	12
Language(s) of instruction	French

General description

The aim of the Educational Component is to set up a methodology for deploying a recurrent neural network (RNN) on an STM32 microcontroller using the STM32CubeAI package in STM32CubeIDE.

Keywords

Neural network architecture; Analysis of labelled data; RNN learning; RNN implementation constraints; RNN inference on a microcontroller

Type or organisation of classes

1	Introduction to embedded AI / Inference on microcontrollers
2	Tutorial 1: MNIST implementation on STM32
3	Practical 1: Project implementing a neural network (CNN or MLP) for predictive maintenance on STM32

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse RNN architecture according to implementation constraints	4. Analyse	Practical work	Technical project report	Critical analysis Achievement of goals Thinking-based approach Justification of choices
Implement an RNN on a microcontroller	3. Apply	Lectures		Methodology Quality of deliverables Relevance of argumentation

Educational Unit: Management and Strategy 2

Educational Unit Director

Thibaut METAILLER

thibaut.metailler@emse.fr

A316

Number of ECTS credits (European Credit Transfer Scale)	2
In-person class time (in hours)	19
Individual work time (in hours)	30
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	1 to 17 potentially

General description

The aim of this Educational Unit is to build on the learning started in S7, with a focus on experiential learning through a business creation project.

Keywords

Strategy and finance; Project management; Teamwork; Innovation; Intellectual property; Presentation and pitching

Sub-modules

Strategy and Finance 2

Thibaut METAILLER

Project Management 2

Maxime MALAFOSSE

Educational Component: Strategy and Finance 2

Educational Unit: Management and Strategy 2

Educational Component Director

Thibaut METAILLER

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A316

In-person class time (in hours)	6
Individual work time (in hours)	50
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	1 to 17 (potentially)

General description

Understand and apply key tools in corporate finance and project management through the creation of entrepreneurial/intrapreneurial activities.

Keywords

Fundamentals of general accounting; Balance sheet and income statement analysis; Financial analysis; Budget management; Introduction to cost accounting; Investment choices; BP

Type or organisation of classes

1	Drawing up financial documents for business start-ups and R&D projects
2	Putting together a business creation or R&D project development portfolio

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify key concepts in corporate and project finance	2. Understand	Project-based learning	Individual written report Oral presentation	Accuracy of answers Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Anticipation Methodology
Develop a responsible entrepreneurial or intrapreneurial project	5. Assess	Project-based learning	Group written report Oral presentation	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Anticipation Methodology
Mobilise the tools of finance	3. Apply	Project-based learning	Group written report Oral presentation	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Anticipation Methodology

Sustainable Development Goals

SDGs	Contribution
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	Topic to be addressed will depend on the project developed
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Topic to be addressed will depend on the project developed
Goal 3: Ensure healthy lives and promote well-being for all at all ages	Topic to be addressed will depend on the project developed
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Topic to be addressed will depend on the project developed

Goal 5: Achieve gender equality and empower all women and girls	Topic to be addressed will depend on the project developed
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Topic to be addressed will depend on the project developed
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Topic to be addressed will depend on the project developed
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Topic to be addressed will depend on the project developed
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Topic to be addressed will depend on the project developed

Goal 10: Reduce inequality within and among countries	Topic to be addressed will depend on the project developed
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Topic to be addressed will depend on the project developed
Goal 12: Ensure sustainable consumption and production patterns	Topic to be addressed will depend on the project developed
Goal 13: Take urgent action to combat climate change and its impacts	Topic to be addressed will depend on the project developed
Goal 14: Conserve and sustainably use the oceans, sea and marine resources for sustainable development	Topic to be addressed will depend on the project developed

<p>Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</p>	<p>Topic to be addressed will depend on the project developed</p>
<p>Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels</p>	<p>Topic to be addressed will depend on the project developed</p>
<p>Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development</p>	<p>Topic to be addressed will depend on the project developed</p>

Educational Component: Project Management 2

Educational Unit: Management and Strategy 2

Educational Component Director

Thibaut METAILLER

thibaut.metailler@emse.fr

A316

In-person class time (in hours)	13
Individual work time (in hours)	40
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	1 to 17 (to be chosen)

General description

Identify a need in society and create a project. Analyse and mobilise project management tools and methods. Learn to work in a team

Keywords

Project management; Project management methods and tools; UX design; Market (segments, competition, etc.)

Type or organisation of classes

1	Planning the project
2	Putting together a business creation or R&D project development portfolio: from idea to project
3	Final pitch

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Experiment with project management methods and tools	4. Analyse	Lectures Flipped classroom Project	Oral presentation Group report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Methodology
Develop a responsible and sustainable methodology for the company and society	3. Apply	Lectures Flipped classroom Project	Oral presentation Group report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Methodology
Present the project to a judging panel	3. Apply	Lectures Flipped classroom Project	Oral presentation Group report	Critical analysis Clarity of presentation Creativity Justification of choices Quality of deliverables Relevance of argumentation Methodology

Sustainable Development Goals

SDGs	Contribution
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	All projects must be in line with the SDG chosen by the group of students
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	All projects must be in line with the SDG chosen by the group of students
Goal 3: Ensure healthy lives and promote well-being for all at all ages	All projects must be in line with the SDG chosen by the group of students
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	All projects must be in line with the SDG chosen by the group of students

Goal 5: Achieve gender equality and empower all women and girls	All projects must be in line with the SDG chosen by the group of students
Goal 6: Ensure availability and sustainable management of water and sanitation for all	All projects must be in line with the SDG chosen by the group of students
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	All projects must be in line with the SDG chosen by the group of students
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	All projects must be in line with the SDG chosen by the group of students
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	All projects must be in line with the SDG chosen by the group of students

Goal 10: Reduce inequality within and among countries	All projects must be in line with the SDG chosen by the group of students
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	All projects must be in line with the SDG chosen by the group of students
Goal 12: Ensure sustainable consumption and production patterns	All projects must be in line with the SDG chosen by the group of students
Goal 13: Take urgent action to combat climate change and its impacts	All projects must be in line with the SDG chosen by the group of students
Goal 14: Conserve and sustainably use the oceans, sea and marine resources for sustainable development	All projects must be in line with the SDG chosen by the group of students

<p>Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss</p>	<p>All projects must be in line with the SDG chosen by the group of students</p>
<p>Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels</p>	<p>All projects must be in line with the SDG chosen by the group of students</p>
<p>Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development</p>	<p>All projects must be in line with the SDG chosen by the group of students</p>

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Educational Unit: Entrepreneurial Visa

Educational Unit Director

Marie BREZISKI

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A313

Number of ECTS credits (European Credit Transfer Scale)	1
In-person class time (in hours)	24
Individual work time (in hours)	18
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

This Educational Unit aims to develop the entrepreneurial/intrapreneurial and innovation skills of engineering students through practical and immersive activities. Raising awareness of entrepreneurship consists of several compulsory and optional educational activities spread over the three years of the ISMIN programme. In their first year, students participate in several activities designed to introduce them to business, entrepreneurship and the role of a business leader: a half-day “entrepreneurial visa” with a presentation of the main stakeholders in student entrepreneurship and stories from entrepreneurs; FEI and SME-Grandes Écoles meetings. On an optional basis, engineering students wishing to explore an entrepreneurial idea or project take the “Startup Engine” elective course, the [entrep’Aix-Marseille](#), activities offered by [PEPITE Provence](#) and receive support in obtaining the [National Student Entrepreneur status](#) and join the TEAM Mines Saint-Etienne incubator for support and advice in setting up their own business.

The activity is assessed during participation in an eight-hour challenge, a serious game that allows participants to experience the key moments in the launch of an entrepreneurial project: responding to a need, team management, project management with limited time and financial resources, sales arguments, pitch presentations, and the creation of deliverables, including a working prototype for an identified customer.

Keywords

Entrepreneurship; Innovation; Project management; Prototyping; Business model; Problem solving; Team management; Time management; Challenge; Pitch

Links between course sub-modules

This Educational Unit consists of a single sub-module

Sub-modules

Entrepreneurial Visa	
Marie BREZISKI	345

Educational Component: Entrepreneurial Visa

Educational Unit: Entrepreneurial Visa

Educational Component Director

Marie BREZISKI

marie.breziski@emse.fr

A313

In-person class time (in hours)	24
Individual work time (in hours)	10
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

This Educational Component aims to develop the entrepreneurial/intrapreneurial and innovation skills of engineering students through practical and immersive activities. The programme is divided into two parts: an introduction to entrepreneurship, with a morning presentation of the activities offered throughout the course and stories from engineering entrepreneurs. The second stage involves participation in an eight-hour challenge, a serious game that allows participants to experience the key moments in the launch of an entrepreneurial project: responding to a need, team management, project management with limited time and financial resources, sales arguments, pitch presentations, and the creation of deliverables, including a working prototype for an identified customer.

Keywords

Entrepreneurship; Innovation; Project management; Prototyping; Business model; Problem solving; Team management; Time management; Challenge; Pitch

Type or organisation of classes

1	Introduction and discovery of entrepreneurship
2	Eight-hour challenge

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify innovation opportunities in various sectors	4. Analyse	Simulation Project-based learning Problem-based approach	Continuous assessment throughout the day Oral presentation	Professional conduct Relevance of argumentation Time management Creativity Clarity of presentation Commitment
Rapidly design innovative solutions and create prototypes	6. Create	Simulation Project-based learning Problem-based approach	Continuous assessment throughout the day Oral presentation	
Assess the economic viability and social impact of an innovative project	5. Assess	Simulation Project-based learning Problem-based approach	Continuous assessment throughout the day Oral presentation	
Draw up a development strategy for a startup	6. Create	Simulation Project-based learning Problem-based approach	Continuous assessment throughout the day Oral presentation	
Communicate effectively about an entrepreneurial project	3. Apply	Simulation Project-based learning Problem-based approach	Continuous assessment throughout the day Oral presentation	
Organise teams to produce deliverables	3. Apply	Simulation Project-based learning Problem-based approach	Continuous assessment throughout the day Oral presentation	

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	This Educational Component contributes to encouraging an entrepreneurial spirit and the ability to innovate	8
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Educational Unit: Languages and Cultures 1

Educational Unit Director

Samantha CHIN

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A106

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	42.5
Individual work time (in hours)	29.5
Language(s) of instruction	English, Chinese, French as a Foreign Language, German, Japanese, Portuguese, Spanish
Sustainable Development Goals (SDGs)	4, 5, 8, 9, 10, 13, 16

General description

Modern languages at the heart of engineering students' training

As part of their training, engineering students are taught modern languages with a strong professional and international focus. The aim is to complement their technical and scientific knowledge with the development of high-level linguistic and intercultural skills, essential for their development in a multicultural environment.

Requirements and certifications

Fluency in English (1st foreign language) is a priority, with a minimum requirement of 800 TOEIC points or 90 TOEFL IBT points, as well as a B2 level according to the Common European Framework of Reference for Languages (CEFR), certified by the School. A second modern language (Spanish, German, Chinese, Japanese, French or Portuguese) is also taught, with the aim of ensuring operational proficiency adapted to the needs of engineers in an international context.

Professional and intercultural skills

The language teaching takes a pragmatic approach, with a strong focus on communication needs in real-life professional situations. This course helps to equip our future engineers with the tools they need to collaborate effectively in a global and multicultural environment, facilitating their professional integration and international mobility.

Keywords

English; Chinese; French as a Foreign Language; German; Japanese; Portuguese; Spanish

Links between course sub-modules

Objectives common to all sub-modules

Sub-modules

English

Samantha CHIN

Modern Languages 2 (2nd foreign language)

Samantha CHIN

Educational Component: English

Educational Unit: Languages and Cultures 1

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	19.5
Individual work time (in hours)	15
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	4, 8, 9, 10, 16

General description

(Level B1+/B2) The English programme in Semester 7 focuses on entrepreneurship, practicing pitching skills in English and acquiring vocabulary relevant to the TOEIC exam, while offering activities tailored to students' needs.

Assessments include written tests (TOEIC-style) and oral activities, as well as tutorials focusing on participation and preparation. Skills covered include professional communication, mastery of advanced grammar, and preparation for international contexts such as interviews and negotiations.

Keywords

Entrepreneurship; Start-ups; Oral presentation; TOEIC; Negotiation; Professional interview; Cover letter; Hypotheses; Passive voice; Reported speech

Type or organisation of classes

1	10 classes
2	5 tutorials

Intended learning and outcomes

Intended learning and outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to (target: B1+/B2 level):

Create and present a clear and convincing professional pitch in English	4. Analyse	Group work and oral presentation with feedback	Graded oral presentation	Clarity Structure Use of appropriate vocabulary
Use vocabulary specific to entrepreneurship and international business contexts.	3. Apply	Interactive games, case studies and vocabulary files	Online quizzes and in-class exercises	Accuracy Variety and relevance of terms used
Write a cover letter that is structured and tailored to a job application in English.	5. Assess	Writing workshop with proofreading in pairs	Written evaluation (homework)	Structure Relevance of arguments Grammar
Actively participate in a mock interview in English, highlighting experience and skills.	3. Apply	Role-playing with assessment by peers and teacher	Oral assessment on the quality of the performance	Relevance of answers Fluency Overall impact
Analyse and answer TOEIC-type questions correctly.	2. Understand	Practical exercises and timed tests	Multiple-choice questions and mini tests under real-life conditions	Fast, accurate responses

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	The S7 program focuses on language learning (B1+/B2 level), preparing students for international requirements such as the TOEIC exam, while reinforcing their professional skills (writing, negotiation, interviewing).	1
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	The focus on entrepreneurship and the development of professional skills (pitching, interviews, cover letters) helps prepare students for productive, decent work, while promoting sustainable economic growth.	2
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	The theme of entrepreneurship encourages students to think about innovation, particularly in relation to start-ups, which is in line with the promotion of sustainable industrialisation and resilient infrastructure.	2
Goal 10: Reduce inequality within and among countries	The programme helps students integrate more easily into international environments and reduces language barriers, thereby helping to reduce inequalities between countries.	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	By focusing on communication and intercultural skills, the programme encourages effective and inclusive dialogue, promoting responsible interactions on a global scale.	2

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Educational Component: Modern Languages 2 (2nd foreign language)

Educational Unit: Languages and Cultures 1

Educational Component Director

Samantha CHIN

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A106

In-person class time (in hours)	19.5
Individual work time (in hours)	14
Language(s) of instruction	Chinese, French as a Foreign Language, German, Japanese, Portuguese, Spanish
Sustainable Development Goals (SDGs)	4, 8, 9, 13, 16

General description

Level B1+/B2/B2+: The main objective of this Educational Component is to prepare students to navigate international academic and professional environments with ease, while strengthening their employability and intercultural skills. Students will develop advanced written and oral communication skills tailored to professional contexts, including presentations, negotiation and writing complex documents. The module also trains students in the ability to analyse and adapt in a variety of intercultural situations, by supporting them in planning study or work projects abroad in line with their personal and professional goals.

Level A1/A2/A2+: The main objective of this Educational Component is to provide the necessary linguistic and cultural foundations for interacting in simple everyday and professional contexts. Students will learn to introduce themselves, exchange basic information and understand the essential cultural practices of the target language. This module also focuses on the development of intercultural communication to help students integrate into multicultural environments.

Keywords

Intercultural communication; Professional skills; Adaptability; Oral presentations; International negotiation; Writing documents; Cultural practices; Cultural integration; Critical analysis; Project planning

Type or organisation of classes

1	10 classes
2	5 tutorials

Intended learning and outcomes

Intended learning and outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Level B1+/B2/B2+				
Communicate effectively in professional and intercultural contexts.	3. Apply	Role play Intercultural meeting simulations	Classroom observation Oral exercises	Fluency, Precision Contextual appropriateness
Write professional documents (reports, emails, letters).	4. Analyse	Writing reports or letters for professional purposes	Correction and feedback on written texts	Consistency Using formal conventions
Analyse intercultural situations to solve problems.	5. Assess	Case studies Interactive debates	Observation during discussions	Relevance of solutions Depth of analysis
Participate actively in multicultural presentations, presenting ideas clearly.	4. Analyse	Preparing and presenting professional presentations	Observation during presentations	Impact Clarity Interaction

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to (target: B1+/B2 level):

Level A1/A2/A2+				
Use simple sentences for everyday interactions	1. Recognise	Role-playing everyday scenarios	Simple oral assessment (introducing oneself, asking for information)	Correct pronunciation Understanding
Introduce oneself and exchange basic information	2. Understand	Guided dialogues and interactive activities	Individual oral or written presentation	Clarity Fluency Cultural adaptation
Reproduce simple grammatical structures	3. Apply	Practical grammar exercises	Multiple-choice questions or written exercises	Grammatical accuracy Correct use of basic rules
Discover and assimilate fundamental cultural elements	2. Understand	Discussion and analysis of local customs	Quiz or presentation on a cultural topic	Cultural understanding Relevance

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Develop the intercultural and linguistic skills needed to operate in an international academic or professional environment.	
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Raising awareness of social, ethical and legal standards for internships and jobs in different countries, to promote successful integration.	
Goal 10: Reduce inequality within and among countries	Analysis of cultural and economic inequalities between different countries to prepare students for diverse environments.	
Goal 13: Take urgent action to combat climate change and its impacts	Introduction to sustainable practices applied to international mobility (reducing the carbon footprint of travel, choosing eco-responsible destinations).	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Training on inclusive and ethical behaviour in international environments, promoting effective collaboration in multicultural teams.	

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Educational Unit: Languages and Cultures 2

Educational Unit Director

Samantha CHIN

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A106

Number of ECTS credits (European Credit Transfer Scale)	3
In-person class time (in hours)	38
Individual work time (in hours)	34
Language(s) of instruction	English, Chinese, French as a Foreign Language, German, Japanese, Portuguese, Spanish
Sustainable Development Goals (SDGs)	4, 5, 8, 10, 12, 13, 16

General description

Modern languages at the heart of engineering students' training

As part of their training, engineering students are taught modern languages with a strong professional and international focus. The aim is to complement their technical and scientific knowledge with the development of high-level linguistic and intercultural skills, essential for their development in a multicultural environment.

Requirements and certifications

Fluency in English (1st foreign language) is a priority, with a minimum requirement of 800 TOEIC points or 90 TOEFL IBT points, as well as a B2 level according to the Common European Framework of Reference for Languages (CEFR), certified by the School. A second modern language (Spanish, German, Chinese, Japanese, French or Portuguese) is also taught, with the aim of ensuring operational proficiency adapted to the needs of engineers in an international context.

Professional and intercultural skills

The language teaching takes a pragmatic approach, with a strong focus on communication needs in real-life professional situations. This course helps to equip our future engineers with the tools they need to collaborate effectively in a global and multicultural environment, facilitating their professional integration and international mobility.

Keywords

English; Chinese; French as a Foreign Language; German; Japanese; Portuguese; Spanish

Links between course sub-modules

Objectives common to all sub-modules.

Sub-modules

English Part 2

Samantha CHIN

Modern Languages 2 (2nd foreign language) Part 2
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Samantha CHIN

Educational Component: English Part 2

Educational Unit: Languages and Cultures 2

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	16
Individual work time (in hours)	17
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	4, 5, 12, 16

General description

Part 2 (B2 level) - This part of the semester is assessed on a pass/fail basis and focuses on practical and applicable skills, often related to collaborative projects or individual activities. Assessment criteria are based on commitment, participation and achievement of minimum objectives set by teachers. Consolidating practical skills in professional English through interactive exercises and role-plays. Collaborating effectively in projects by using linguistic and cultural skills. Developing autonomy in language learning, by integrating external resources such as online tools or English-language media.

Keywords

Youth culture; Philosophy; Ethics; Technology; Creativity; Narration; Debate; Cultural diversity; Oral skills; TOEIC preparation

Type or organisation of classes

1	7 classes
2	3 tutorials

Intended learning and outcomes

Intended learning and outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to (target: B2 level):

Write a structured report on a group project.	4. Analyse	Group work on a project with final written report	Graded written report	Clarity Structure and quality of analysis
Give an oral presentation on a cultural or technological topic.	3. Apply	Individual or group presentation on a choose topic	Graded presentation with feedback	Fluency Accuracy and use of appropriate vocabulary
Participate actively in debates on cultural topics.	5. Assess	Class debates on topics related to the course	Observation of debate interactions	Relevance of arguments Ability to interact
Create a multimedia resource (video, blog) on a subject.	6. Create	Individual or group projects to produce original content	Evaluating the multimedia content created	Originality Relevance and linguistic quality of the final product

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Use online tools to perfect skills.	2. Understand	Guided independent activities on platforms (Quizlet, TED Talks)	Check progress through quizzes or self-assessments	Consistent effort and application of acquired knowledge in work or discussions
Analyse texts and media related to youth culture.	4. Analyse	Critical analysis of texts, videos or images representing youth subcultures	Written summary or oral presentation	Relevance of analysis Clarity of written or oral expression
Work with others to prepare and organise a debate.	3. Apply	Teamwork to define topics, organise the event and lead a debate	Evaluation of role in preparing and participating in the debate	Organisational skills Collaboration and effective argumentation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Develop advanced language skills (B2) for better communication in a global context.	3
Goal 5: Achieve gender equality and empower all women and girls	Analyse and present examples of important figures who have contributed to gender equality.	
Goal 12: Ensure sustainable consumption and production patterns	Analyse texts and documentaries on the impact of consumption on the environment and society. Workshops to identify sustainable everyday practices.	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Improve intercultural skills by studying the social and political issues facing English-speaking countries. Participate in discussions on current conflicts and propose solutions within a collaborative framework.	

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Educational Component: Modern Languages 2 (2nd foreign language) – Part 2

Educational Unit: Languages and Cultures 2

Educational Component Director

Samantha CHIN

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A106

In-person class time (in hours)	16
Individual work time (in hours)	17
Language(s) of instruction	Chinese, French as a Foreign Language, German, Japanese, Portuguese, Spanish
Sustainable Development Goals (SDGs)	4, 8, 10, 13, 16

General description

Level B1+/B2/B2+: This Educational Component aims to prepare students to integrate successfully into international academic and professional environments. They will develop advanced written and oral communication skills tailored to the requirements of professional environments (presentations, negotiation, writing complex documents). The module also focuses on the ability to analyse and adapt in a variety of intercultural contexts, while guiding students in planning study or work projects abroad in line with their personal and professional goals.

Level A1/A2/A2+: This Educational Component aims to provide students with the basic language and cultural skills to interact in simple everyday and professional situations. Students will learn to introduce themselves, exchange basic information and understand the essential cultural aspects of the target language. The module also focuses on adaptability and intercultural communication to help students integrate into multicultural environments.

Keywords

Language skills; Intercultural interaction; Professional communication; Adaptation; Introducing oneself; Negotiation; Technical writing; Cultural diversity; International mobility; Career planning

Type or organisation of classes

1	7 classes
2	3 tutorials

Intended learning and outcomes

Intended learning and outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Level B1+/B2/B2+				
Communicate effectively in professional and intercultural contexts, adapting language to suit the context and the audience.	3. Apply	Role play Intercultural meeting simulations.	In-class observation and oral exercises	Fluency Precision Contextual appropriateness
Write clear, well-structured professional documents (reports, emails, letters) that meet the expectations of a professional context.	4. Analyse	Writing reports or letters for professional purposes	Correction and feedback on written texts	Consistency Using formal conventions
Analyse complex intercultural situations, identify cultural and social issues, and propose appropriate problem-solving solutions.	5. Assess	Case studies, Interactive debates	Observation during discussions (PASS/FAIL)	Relevance of solutions Depth of analysis
Actively participate in multicultural presentations, presenting ideas in a clear, structured way and encouraging interaction with other participants.	4. Analyse	Preparing and presenting professional presentations	Observation during presentations (PASS/FAIL)	Impact Clarity Interaction

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to (target: B1+/B2 level):

Level A1/A2/A2+				
Use simple phrases to introduce oneself and communicate basic information in everyday situations.	1. Recognise	Role-playing everyday scenarios	Simple oral assessment (introducing oneself, asking for information) (PASS/FAIL)	Correct pronunciation Understanding
Introduce yourself, exchange personal information and understand the cultural practices involved in basic interaction in a given context.	2. Understand	Guided dialogues and interactive activities	Individual oral or written presentation. (PASS/FAIL)	Clarity Fluency Cultural adaptation
Reproduce simple grammatical structures (sentences, conjugations) to express basic ideas accurately.	3. Apply	Practical grammar exercises.	Multiple-choice questions or written exercises. (PASS/FAIL)	Grammatical accuracy Correct use of basic rules
Discover and assimilate fundamental cultural elements to improve interaction in social and professional contexts.	2. Understand	Discussion and analysis of local customs	Quiz or presentation on a cultural topic. (PASS/FAIL)	Cultural understanding Relevance

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Develop the intercultural and linguistic skills needed to operate in an international academic or professional environment.	
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Raising awareness of social, ethical and legal standards for internships and jobs in different countries, to promote successful integration.	
Goal 10: Reduce inequality within and among countries	Analysis of cultural and economic inequalities between different countries to prepare students for diverse environments.	
Goal 13: Take urgent action to combat climate change and its impacts	Introduction to sustainable practices applied to international mobility (reducing the carbon footprint of travel, choosing eco-responsible destinations).	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Training on inclusive and ethical behaviour in international environments, promoting effective collaboration in multicultural teams.	

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Educational Unit: Technical Internship in France or Abroad

Educational Unit Directors

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Number of ECTS credits (European Credit Transfer Scale)	16
In-person class time (in hours)	0.5
Individual work time (in hours)	477
Language(s)	French, English (or any other language used during professional mobility)

General description

Main objective: Play an active role in carrying out an engineering mission as part of team.

Secondary objectives:

- Make connections between the lessons learned in the various disciplines during the first three ISMIN semesters and put them into practice
- Apply and/or acquire new concepts, tools, methods, etc.
- Work in a team, within a project
- Work to serve a client or partner
- Understand the context of the mission (economic, societal, organisational, industrial, scientific, etc.)
- Refine your professional and personal goals
- Strengthen written and oral communication skills, organise and present work

Keywords

Internship; Company; Technical; International experience; Interculturality; Engineering assistant; Mobility; Professional

Links between course sub-modules

The 2A internship is an essential part of the process of developing personal and professional goals: it allows students to test themselves in a work environment. Working alongside a team of engineers, students learn about the different aspects of their roles and consolidate their choices of specialisations and technological areas, which will lead them to a more comprehensive and demanding final-year internship, requiring a high degree of autonomy.

As part of their language classes, students receive specific training in preparing for finding an internship (CV, cover letter, interview basics). They also receive practical information about the engineering profession through several core teaching units in the ISMIN programme (Company Components, Corporate Investigation, Career Guidance Cycle, Collective Intelligence, Management and Strategy, Managerial Tools and Methods).

In addition, the ISA Project / Entrepreneurial Visa / Research Project / Workshop / Innov'Action activities can be an interesting source of inspiration and motivation for future entrepreneurs.

Sub-modules

Technical Internship in France or Abroad
--

Jade PESQUIES / Bérengère USAI

Educational Component: Technical Internship in France or Abroad

Educational Unit: Technical Internship in France or Abroad

Educational Unit Directors

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In-person class time (in hours)

0.5

Individual work time (in hours)

477

Format

In-company with tolerance for two days remote working per week

Language(s)

French, English (or any other language used during professional mobility)

General description

Main objective: Play an active role in carrying out an engineering mission as part of team.

Secondary objectives:

- Make connections between the lessons learned in the various disciplines during the first three ISMIN semesters and put them into practice
- Apply and/or acquire new concepts, tools, methods, etc.
- Work in a team, within a project
- Work to serve a client or partner
- Understand the context of the mission (economic, societal, organisational, industrial, scientific, etc.)
- Refine your professional and personal goals
- Strengthen written and oral communication skills, organise and present work

Keywords

Internship; Company; Technical; International experience; Interculturality; Engineering assistant; Mobility; Professional

Type or organisation of classes

1	Group presentation
2	In-company assignment for 3-5 months
3	Writing an internship report
4	Writing a summary report on interculturality (in the case of international professional mobility)
5	Individual presentation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the context of the mission (economic, societal, organisational, industrial, scientific,. etc.)	2. Understand	Internship	Individual oral (or written) presentation	Anticipation Critical analysis Command of the subject Analytical skills and ability to correlate parameters
Apply academic knowledge acquired in the first three semesters to practical situations	3. Apply	Internship	Drafting of technical specifications, individual written reports, interim presentation to school tutor, assessment by company tutor	Justification of choices Rigour Methodology Quality of diagrams Argumentation Accuracy of answers Media quality
Working in a team, within a project	3. Apply	Internship	Assessment by company tutor, group presentations, project report feedback	Commitment Professional conduct Active participation Critical analysis Thinking-based approach Ability to accept orders (from a customer, a partner, a colleague, a superior, etc.)

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Strengthen written and oral communication skills (formal/informal)	3. Apply	Internship	Self-evaluation, written report, oral presentation	Clarity of presentation Speech Grammar Spelling and level of language, quality of deliverables
Learn from professional situations and capitalise on them	4. Analyse	Internship	Self-evaluation	Learn from professional situations and capitalise on them
Refine personal and professional goals	4. Analyse	Internship	Self-evaluation	Refine personal and professional goals
Think critically about a given result/situation	5. Assess	Internship	Assessment by company tutor	Anticipation Critical analysis Accuracy of answers Justification of choices
Format and present work	4. Analyse	Internship	Internship report Individual presentation Individual written report Report on discoveries Assessment form by company tutor Assessment by academic tutor	Quality of deliverables Presentation structure Speech Language skills Relevance of argumentation Time management
Produce a written report in English (for international internships)	6. Create	Internship	Written report Summary	Quality of deliverables English language skills

Educational Unit: School Project

Educational Unit Director

Charles REZAEI

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A340

Number of ECTS credits (European Credit Transfer Scale)	13
In-person class time (in hours)	0.5
Individual work time (in hours)	305.5
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	3, 6, 7, 9, 11, 12, 13

General description

Main objective: Play an active role in carrying out an engineering mission as part of a research team.

Secondary objectives:

- Make connections between the lessons learned in the various disciplines during the first three ISMIN semesters and put them into practice
- Apply and/or acquire new concepts, tools, methods, etc.
- Work in a research team
- Understand the context of the mission (economic, societal, organisational, industrial, scientific, etc.)
- Refine your professional and personal goals
- Strengthen written and oral communication skills, organise and present work

Keywords

Research and development; Assistant R&D engineer; Interculturality; IT; Electronics; Microelectronics

Sub-modules

School project
Charles REZAEI

Educational Component: School Project

Educational Unit School Project

Educational Component Director

Charles REZAEI

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A340

In-person class time (in hours)	13
Individual work time (in hours)	0.5
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	3, 6, 7, 9, 11, 12, 13

General description

Main objective: Play an active role in carrying out an engineering mission as part of a research team.

Secondary objectives:

- Make connections between the lessons learned in the various disciplines during the first three ISMIN semesters and put them into practice
- Apply and/or acquire new concepts, tools, methods, etc.
- Work in a research team
- Understand the context of the mission (economic, societal, organisational, industrial, scientific, etc.)
- Refine your professional and personal goals
- Strengthen written and oral communication skills, organise and present work

Keywords

Research and development; Assistant R&D engineer; Interculturality; IT; Electronics; Microelectronics

Type or organisation of classes

1	Group presentation
2	Research and Development (R&D) laboratory assignment
3	Writing an internship report
4	Defence

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Understand the context of the mission (economic, societal, organisational, industrial, scientific,. etc.)	2. Understand	R&D laboratory project	Individual oral (or written) presentation	Anticipation, critical analysis, understanding of the subject, analytical skills and ability to correlate parameters	
Apply academic knowledge acquired in the first three semesters to practical situations	3. Apply	R&D laboratory project	Drafting of technical specifications, individual written reports, assessment by lab tutor.	Justification of choices, rigor, methodology, quality of diagrams, argumentation, accuracy of answers, quality of media	Depending on the subject Cleanroom IDFab prototyping Hardware security Platform
Work in a team, within an R&D project	3. Apply	R&D laboratory project	Assessment by lab tutor Group presentations, project reports	Commitment, professional conduct, active participation, critical analysis, thinking-based approach, ability to accept orders (from a customer, a partner, a colleague, a superior, etc.)	Depending on the subject Cleanroom IDFab prototyping Hardware security Platform
Strengthen written and oral communication skills (formal/informal)	3. Apply		Self-evaluation, written report, oral presentation	Clarity of presentation, elocution, grammar, spelling and language level, quality of deliverables	

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
Learn from professional situations and capitalise on them	4. Analyse	R&D laboratory project	Self-evaluation	Thinking-based approach, professional conduct	
Refine personal and professional goals	4. Analyse	R&D laboratory project	Self-evaluation	Creativity, achievement of objectives, career planning	
Think critically about a given result/situation	5. Assess	R&D laboratory project	Assessment by lab tutor	Anticipation, critical analysis, accuracy of answers, justification of choices	
Format and present work	4. Analyse	R&D laboratory project	Presentation of report, assessment by lab tutor	Quality of deliverables, structure of presentation, elocution, language skills, relevance of argumentation, time management	
Produce a written report in English (if applicable)	6. Create	R&D laboratory project		English language skills	

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	Certain projects can contribute to this objective	305
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Certain projects can contribute to this objective	305
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Certain projects can contribute to this objective	305
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Certain projects can contribute to this objective	305
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Certain projects can contribute to this objective	305
Goal 12: Ensure sustainable consumption and production patterns	Certain projects can contribute to this objective	305
Goal 13: Take urgent action to combat climate change and its impacts	Certain projects can contribute to this objective	305



ISMIN SYLLABUS

2025 – 2026

Semester 9

Direction de la Formation - ISMIN
Mines Saint-Etienne
June 2024

Semester 9

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Educational Unit: Concepts in Microelectronics

Microelectronics Design (Major)

Educational Unit Director

Jean-Baptiste RIGAUD

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A225

Number of ECTS credits (European Credit Transfer Scale)	6
In-person class time (in hours)	90
Individual work time (in hours)	63
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	7, 8, 9

General description

Acquiring the basic concepts of microelectronics, including semiconductor physics, component physics and integrated circuit manufacturing processes. Students then apply these principles to the design of analog and digital integrated circuits.

Keywords

Semiconductors; Silicon; Transistors; Electrical models; Doping; Current mirrors; CMOS

Links between course sub-modules

A step-by-step approach that takes the student from the physical phenomena occurring in the semiconductor to the electrical equations of MOS transistors. With this knowledge, any type of integrated electronic circuit can be designed, whether analog or digital.

Sub-modules

Semiconductor Physics

Agnès ROUSSY

Semiconductor Components

Agnès ROUSSY

Circuit Manufacturing Methods

Agnès ROUSSY

Introduction to Analog Design

Jean-Baptiste RIGAUD

Digital Circuit Design

Jean-Max DUTERTRE

PLEASE NOTE: Edith Kussener, a guest, will teach the Analog Design module

Educational Component: Physics of Semiconductors

Educational Unit: Microelectronics Concepts - Microelectronics Design

Educational Component Director

Agnès ROUSSY

roussy@emse.fr

B206

In-person class time (in hours)	15
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Understanding the behaviour and properties of semiconductor materials for use in microelectronic devices.

Keywords

Crystallography; Energy bands; Doping; Conduction/diffusion; Generation/recombination

Type or organisation of classes

1	Crystallography / energy bands
2	Intrinsic semiconductor / P-type doping / N-type doping
3	Influence of temperature on doping
4	Transport phenomena: conduction and diffusion
5	Generation/recombination of charge carriers

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Memorise the crystal structure of IV and III-V semiconductors	1. Remember	Lecture	Written assignment	Accuracy of answers
Link crystallography to the electronic and optical properties of a semiconductor material	3. Apply	Tutorials	Tutorials	Thinking-based approach Justification of choices
Distinguish between P-type and N-type doping mechanisms	4. Analyse	Tutorials	Tutorials	Relevance of argumentation Rigour
Discuss the phenomenon of conduction in a semiconductor	5. Assess	Tutorials	Tutorials	Relevance of argumentation Rigour
Justify the presence of generation/recombination phenomena in a semiconductor material	5. Assess	Tutorials	Tutorials	Relevance of argumentation Rigour
Discuss the continuity equation using all the knowledge acquired	6. Create	Tutorials	Tutorials	Relevance of argumentation Rigour

Bibliography

Essential

O. Bonnaud, *Composants à semiconducteurs : De la physique du solide aux transistors*. Paris: ELLIPSES, 2006.

H. Mathieu, *Physique des semiconducteurs et des composants électroniques*, 5e édition. Dunod, 2004.

S.-M. Sze, *Semiconductor devices: Physics and technology*, 2e édition. New York, NY Weinheim: John Wiley & Sons Inc, 2001.

Useful

C. Kittel et J. Wiley, *Physique de l'état solide - 8e éd. - Cours et problèmes : Cours et problèmes*, 8e édition. Dunod, 2019.

Educational Component: Semiconductor Devices

Educational Unit: Microelectronics Concepts - Microelectronics Design

Educational Component Director

Agnès ROUSSY

roussy@emse.fr

B206

In-person class time (in hours)	12
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Understanding the physical phenomena involved in basic microelectronic devices.

Understanding the main basic components in microelectronics to better understand the operation of more complex circuits.

Keywords

Ohmic contact; Schottky diode; Forward-biased PN junction; Reverse-biased PN junction; Fermi level alignment

Type or organisation of classes

1	Interfaces - Fermi level alignment
2	Metal/insulator interface: Schottky diode
3	Metal/insulator interface: ohmic contact
4	Semiconductor/semiconductor interface: PN junction

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Explain the concept of Fermi level alignment	2. Understand	Lecture Tutorials	Written assignment	Rigour Thinking-based approach Justification of choices
Interpret the behaviour of an Insulator/semiconductor interface: Schottky diode	4. Analyse	Lecture Tutorials	Written assignment	Relevance of argumentation
Interpret the behaviour of an ohmic contact interface	4. Analyse	Lecture Tutorials	Written assignment	Relevance of argumentation
Explain how a conducting PN junction works	5. Assess	Lecture Tutorials	Written assignment	Relevance of argumentation
Generalise the knowledge acquired in interface design to a component to be designed	6. Create	Lecture Tutorials	Written assignment	Relevance of argumentation

Bibliography

Essential

O. Bonnaud, *Composants à semiconducteurs : De la physique du solide aux transistors*. Paris: ELLIPSES, 2006.

H. Mathieu, *Physique des semiconducteurs et des composants électroniques*, 5e édition. Dunod, 2004.

S.-M. Sze, *Semiconductor devices: Physics and technology*, 2e édition. New York, NY Weinheim: John Wiley & Sons Inc, 2001.

Educational Component: Digital Circuit Design

Educational Unit: Microelectronics Concepts - Microelectronics Design

Educational Component Director

Jean-Max DUTERTRE

dutertre@emse.fr

A223

In-person class time (in hours)	12
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	8

General description

The aim of the Educational Component on Digital Circuit Design is to introduce the concepts and tools used to design logic gates in CMOS technology. More broadly, it provides an introduction to the design and understanding of digital integrated circuits, based on an understanding of how they work at analog level.

The Educational Component covers:

- Design of CMOS logic gates, starting with an understanding of their operation at the transistor level: study of statistical characteristics, dynamic properties (propagation time, power consumption), design at the transistor level (including sizing), and layout rules for standard cell design
- Design of memory elements (latches, D flip-flops) and understanding the timing constraints of synchronous circuits.
- Memory architecture, design principles and properties (ROM, SRAM, DRAM, Flash).

The Educational Component introduces practical work on simulating and building standard cells (ASIC design course).

Keywords

CMOS logic gates; Layout; Time constraints of synchronous circuits; D flip-flop; ROM; SRAM; Flash memory

Type or organisation of classes

1	Overview of MOS transistors and how they work
2	CMOS inverter, design, static characteristics
3	CMOS inverter, dynamic operation, sizing, layout
4	CMOS logic gates, design, sizing, layout, production of standard cells
5	Memory elements in CMOS logic, latches, D flip-flops, layout, timing constraints of synchronous circuits
6	Embedded memories ROM, SRAM, Flash, architecture, properties

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Design and develop layout of CMOS logic gates	5. Assess	Lecture Tutorials	Written assignment	Accuracy of answers Rigour Critical analysis
Design and develop layout of CMOS memory elements	5. Assess	Lecture Tutorials	Written assignment	Accuracy of answers Rigour Critical analysis
Make design choices for digital integrated circuits based on performance, power consumption and surface constraints	4. Analyse	Lecture Tutorials	Written assignment	Accuracy of answers Rigour Critical analysis
Choose CMOS technology based on performance, power consumption and surface constraints	4. Analyse	Lecture Tutorials	Written assignment	Accuracy of answers Rigour Critical analysis

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	For aspects of digital integrated circuit design taking into account low energy consumption constraints	N/A
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Bibliography

Essential

A. S. Sedra, *Microelectronic Circuits*, 8th edition. New York: Oxford University Press, 2020.

J. P. Uyemura, *Introduction to VLSI Circuits and Systems*. Wiley, 2001.

Useful

Ayers, *Digital Integrated Circuits*. C R C, Hardcover, 2009.

B. Razavi, *Fundamentals of Microelectronics*. Hoboken: Wiley, 2021.

J. P. Uyemura, *Chip Design for Submicron VLSI: CMOS Layout and Simulation (Hardback) - Common*.

Useful

B. Razavi, *Design of Analog CMOS Integrated Circuits*, 2nd edition. New York, NY: McGraw Hill, 2016.

Educational Component: Introduction to Analog Circuit Design

Educational Unit: Microelectronics Concepts - Microelectronics Design

Educational Component Director

Jean-Baptiste RIGAUD

rigaud@emse.fr

A225

In-person class time (in hours)	15
Individual work time (in hours)	15
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	8

General description

Understanding the techniques involved in designing analog integrated circuits.

Keywords

MOS transistor; Current source; Current mirror; Differential pairs; Amplification

Type or organisation of classes

1	Introduction to analog design, which circuit for which function
2	Bipolar and MOS transistors, polarisation and amplification
3	Current distribution in a circuit, constraints and current mirrors
4	Basic amplifiers and applications
5	Reference voltage and current

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Size the transistors of various elementary analog circuits	6. Create	Tutorials Lectures	Written examination	Accuracy of answers
Understand the operating modes of transistors	1. Remember	Tutorials Lectures	Written examination	Demonstration of concepts taught
Set up a small signal circuit	2. Understand	Tutorials Lectures	Written examination	Rigorous calculations

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	For aspects of analogue integrated circuit design taking into account low energy consumption constraints	N/A
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Bibliography

Essential

B. Razavi, *Design of Analog CMOS Integrated Circuits*, 2nd edition. New York, NY: McGraw Hill, 2016.

A. S. Sedra, *Microelectronic Circuits*, 8th edition. New York: Oxford University Press, 2020.

Useful

P. R. Gray, S. H. Lewis, P. J. Hurst, et R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 6th edition. Hoboken, New Jersey: Wiley, 2024.

Educational Component: Circuit Manufacturing Methods

Educational Unit: Microelectronics Concepts - Microelectronics Design

Educational Component Director

Agnès ROUSSY

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B206

In-person class time (in hours)	12
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Understanding the complexity of the microelectronics industry by examining the manufacture of chips.

Keywords

Cleanroom; Diffusion/implantation; Engraving; Photolithography

Type or organisation of classes

1	Microelectronics industry, technological advances, cleanroom
2	Photolithography, engraving
3	Diffusion, implantation
4	Deposition, oxidation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Explain cleanroom concepts	2. Understand	Lecture Tutorials	Written assignment	Rigour Thinking-based approach Justification of choices Command of the subject Quality of diagrams
Justify developments in photolithography techniques in the microelectronics industry	5. Assess	Lecture Tutorials	Written assignment	
Compare the different engraving methods according to the stages of manufacturing	4. Analyse	Lecture Tutorials	Written assignment	
Recommend diffusion and implantation doping techniques according to the stages of manufacturing	4. Analyse	Lecture Tutorials	Written assignment	
Compare different film deposition techniques in the microelectronics industry	4. Analyse	Lecture Tutorials	Written assignment	
Justify the different oxidation techniques according to the stages of manufacturing	5. Assess	Lecture Tutorials	Written assignment	
Generalise a manufacturing flow in the microelectronics industry	6. Create	Lecture Tutorials	Written assignment	

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Raising awareness of the ecological impact of the microelectronics industry (consumption of water, energy and chemicals (acids, solvents, gases), recycling of consumables, air quality, extraction of rare minerals, etc.).	2
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Bibliography

Essential

O. Bonnaud, *Composants à semiconducteurs : De la physique du solide aux transistors*. Paris: ELLIPSES, 2006.

H. Mathieu, *Physique des semiconducteurs et des composants électroniques*, 5e édition. Dunod, 2004.

S.-M. Sze, *Semiconductor devices: Physics and technology*, 2e édition. New York, NY Weinheim: John Wiley & Sons Inc, 2001.

Educational Unit: Design Methodologies

Microelectronics Design (Major)

Educational Unit Director

Jean-Baptiste RIGAUD

rigaud@emse.fr

A225

Number of ECTS credits (European Credit Transfer Scale)	5
In-person class time (in hours)	90
Individual work time (in hours)	60
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	8

General description

Learning and mastering the different stages of the integrated circuit design flow by applying the right methodology and using the corresponding industrial tools. To achieve this, students start with the circuit specification described in SystemVerilog, an HDL (hardware description language). They then synthesise it and follow all the steps through to transistor placement and mask design for the final integrated circuit. Particular attention is also paid to integrated circuit prototyping on FPGAs (programmable components).

Keywords

ASIC; Standard cells; Synthesis; Layout; FPGA; Simulation

Links between course sub-modules

A progressive approach that follows on from the previous semesters. Mastering SystemVerilog to carry out the synthesis steps and understanding advanced simulation and IC verification.

Sub-modules

Advanced Analog Circuit Design

Jean-Max DUTERTRE

ASIC Design

Jean-Baptiste RIGAUD

SystemVerilog Design and Synthesis

Jean-Baptiste RIGAUD

Codesign and FPGA Prototyping

Jean-Baptiste RIGAUD

Advanced Simulation

Jean-Baptiste RIGAUD

PLEASE NOTE: Thomas Sarno, a guest, will teach the Advanced Simulation course.

Educational Component: Advanced Analog Circuit Design

Educational Unit: Design Methodology - Microelectronics Design

Educational Component Director

Jean-Max DUTERTRE

dutertre@emse.fr

A223

In-person class time (in hours)	12
Individual work time (in hours)	8
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	8

General description

The Educational Component on Advanced Analog Circuit Design aims to teach analog circuit simulation techniques. It consists of four practical sessions using professional simulation tools (Cadence CAD tools). It complements the Introduction to Analog Design course, which takes a theoretical approach to analog circuit design.

Its objectives are to teach:

- The use of analog simulation tools,
- Critical understanding and practice of the main types of analog simulation: static operating point simulation, DC simulation (large-signal), AC simulation (small-signal), time simulation (transient).
- The sizing of transistors in conventional CMOS amplifier structures through theoretical study and careful adjustment using simulations to meet specifications (gain, bandwidth).
- The use of analog simulation tools used in industry.

Keywords

Analog simulation; Active load amplifier; Differential amplifier; DC simulation; Frequency simulation; Time simulation

Type or organisation of classes

1	Practical 1: Introduction to analog integrated circuit design, analog simulation tools (Cadence)
2	Practical 2: Sizing and simulation of a common-source NMOS amplifier with active load
3	Practical 3.1: Sizing and simulation of a two-stage CMOS operational amplifier
4	Practical 3.2: Sizing and simulation of a two-stage CMOS operational amplifier

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Design and run analog simulations, choosing the tools best suited to the case in question	6. Create	Practical work	Practical work report	Rigour Critical analysis
Size transistors in an amplifier circuit	5. Assess	Practical work	Practical work report	Rigour Critical analysis
Critically assess simulation results	5. Assess	Practical work	Practical work report	Rigour Critical analysis

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	For aspects of analogue integrated circuit design taking into account low energy consumption constraints	NA
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Bibliography

Essential

B. Razavi, *Design of Analog CMOS Integrated Circuits*, 2nd edition. New York, NY: McGraw Hill, 2016.

A. S. Sedra, *Microelectronic Circuits*, 8th edition. New York: Oxford University Press, 2020.

Useful

P. R. Gray, S. H. Lewis, P. J. Hurst, et R. G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 6th edition. Hoboken, New Jersey: Wiley, 2024.

Educational Component: ASIC Design

Educational Unit: Design Methodology - Microelectronics Design

Educational Component Director

Jean-Baptiste RIGAUD

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A225

In-person class time (in hours)	12
Individual work time (in hours)	12
Language(s) of instruction	French

General description

Discovering the steps involved in designing an ASIC integrated circuit by learning how to use the Cadence Virtuoso work environment and following the design steps, from sizing and electrical simulations to the micron-level layout of a standard cell mask, and finally all the verification mechanisms.

Keywords

ASIC; CMOS; Transistor schematic; Electrical simulation; Layout rules; Verification; DRC; LVS

Type or organisation of classes

1	Implementation of a multi-bit adder in the Virtuoso environment (hierarchical diagram entry and electrical simulation)
2	Balanced CMOS inverter design (transistor sizing and simulations of parameters)
3	Micron layout of CMOS inverter and design rule checking (DRC) and layout versus schematic checks (LVS)
4	Design of a significant standard cell with automatic transistor generation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Design a circuit by entering a schematic based on elementary cells	6. Create	Classes Practical work	Practical work reports	Accuracy of answers Ability to summarise Restitution of a method Justification of choices Highlighting results
Simulate an electrical circuit	3. Apply			
Create layout for an integrated circuit mask	3. Apply			
Check the accuracy of the circuit design	4. Analyse			

Educational Component: SystemVerilog Design and Synthesis

Educational Unit: Design Methodology - Microelectronics Design

Educational Component Director

Jean-Baptiste RIGAUD

rigaud@emse.fr

A225

In-person class time (in hours)	21
Individual work time (in hours)	18
Language(s) of instruction	French

General description

The objectives of the Educational Component are as follows:

- Understanding the rules for writing a hardware description language (SystemVerilog) to perform hardware implementation,
- Developing a digital system that can be modelled at the register-transfer level (RTL),
- A methodology for designing a digital system: logic simulation, the logic synthesis stage and post-synthesis simulation with back-annotation of delays.
- Implementing constraints for synthesis.

All concepts will be illustrated through the design of several significantly complex circuits.

Keywords

HDL description; RTL; Synthesis; Simulation; State machine; Clock period; Constraints

Type or organisation of classes

1	SystemVerilog overview and working environment
2	Logic synthesis of a circuit with Synopsys Design Compiler
3	Notion of constraints and simulation taking delays into account
4	Arithmetic operators
5	Modelling basic sequential circuits
6	Synthesis of a finite-state machine

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Simulate after RTL development	3. Apply	Practical work	Written assignment	Accuracy of answers
Simulate after synthesis	3. Apply	Lecture	Assessment by teacher	Justification of choices
Evaluate design constraints (clock period, etc.)	5. Assess			Methodology
Design a complex digital system using basic logic functions (ALU, multiplexers, FSM, etc.)	6. Create			

Bibliography

Useful

S. Sutherland, S. Davidmann, P. Flake, & P. Moorby, *SystemVerilog for Design: A Guide to Using SystemVerilog for Hardware Design and Modeling*, Second Edition 2006. New York, NY: Springer, 2010.

Learn more

S. F. Michael Keating, *The Simple Art of SoC Design: Closing the Gap between RTL and ESL*. [2]

S. Sutherland, *RTL Modeling with SystemVerilog for Simulation and Synthesis: Using SystemVerilog for ASIC and FPGA Design*, 1er édition. Sutherland HDL, Inc., 2017.

S. Sutherland et D. Mills, *Verilog and System Verilog Gotchas: 101 Common Coding Errors and How to Avoid Them*, 2007e édition. New York: Springer-Verlag New York Inc., 2007.

Educational Component: Codesign and FPGA Prototyping

Educational Unit: Design Methodology - Microelectronics Design

Educational Component Director

Jean-Baptiste RIGAUD

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A225

In-person class time (in hours)	12
Individual work time (in hours)	12
Language(s) of instruction	French

General description

Master FPGA design flow for software and hardware application development, including:

- software/hardware partitioning of the application,
- hardware implementation of a component on an FPGA target
- complete design of a system comprising a program in C running on an ARM processor supported by a hardware brick.

Keywords

Hardware design flow; HDL synthesis; FPGA placement and routing; Software drivers; Application software/hardware partitioning; Xilinx Vivado; Xilinx Vitis

Type or organisation of classes

1	1-2: Introduction to FPGA technology / Lab1 Xilinx
2	3-4: Xilinx IP core integration / Hardware encryption algorithm project
3	5-7: Lab 1 to 5 Xilinx Vivado Embedded design suite
4	8-9: Cryptographic IP core integration into software/hardware

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Unfold a design flow on an FPGA	3. Apply	Project-based learning Practical work	Written assignment	Critical analysis Creativity Thinking-based approach Justification of choices Methodology
Create a hardware implementation from an HDL description	6. Create			
Add IPs to an existing design	3. Apply			
Use an AXI communication bus to interface an IP with an ARM processor	2. Understand			
Partition an application into software and hardware	2. Understand			
Create a proprietary IP	6. Create			
Develop a software application accessing a hardware component using a driver	3. Apply			

Bibliography

“Workshops AMD”, AMD.

Accessed on: 14 April, 2025 [Online]. Available on: <https://www.amd.com/en/corporate/university-program/workshops.html>

Educational Component: Advanced Simulation

Educational Unit: Design Methodology - Microelectronics Design

Educational Component Director

Jean-Baptiste RIGAUD

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A225

In-person class time (in hours)	21
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Introduction to integrated circuit testing: this involves digital circuit simulation with random test vector generation, code coverage, co-simulation, assertions and protocol emulation in test programmes.

Keywords

Co-simulation; Random test vectors; AHB; Coroutines; SystemVerilog; DPI; Code coverage

Type or organisation of classes

1	SystemVerilog for integrated circuit testing: data types, interfaces, file and character string management, introspection.
2	128-bit AES testing using file manipulation
3	Using a C or Python model for co-simulation: application to AES 128 bits
4	Code coverage and test coverage
5	Concepts of assertions on communication protocols

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Compare the HDL description of a circuit with a reference model described in a higher-level language	5. Assess	Lectures	Practical work report	Accuracy of results
Understand a communications protocol specification	2. Understand	Practical work	Practical work report	Relevance of solutions proposed
Develop a test program that verifies code completeness	3. Apply	Practical work	Practical work report	Justification of choices
Manipulate files to test simulation results	4. Analyse	Practical work	Practical work report	Applying the methods taught
Run a simulation with a reference model	3. Apply	Practical work	Practical work report	Applying the methods taught

Educational Unit: Software/Hardware Interfaces

Embedded Systems (Major)

Educational Unit Director

Acacio MARQUES

marques@emse.fr

D103

Number of ECTS credits (European Credit Transfer Scale)	5
In-person class time (in hours)	81
Individual work time (in hours)	60
Language(s) of instruction	French

General description

Discover the operating systems used in embedded systems, and put them into practice in a project focused on the Internet of Things.

Keywords

Real-time kernels; Operating systems; Embedded Linux; Internet of Things

Links between course sub-modules

Two types of operating systems (OS) used in embedded systems are studied: one dedicated to real-time applications, the other to control in complex systems. These two OS are then combined in an Internet of Things application, providing a comprehensive overview of this category of system.

Sub-modules

Embedded Real-Time Systems
Acacio MARQUES
Embedded Linux
Acacio MARQUES
IOT Platforms
Acacio MARQUES

Educational Component: Embedded Real-Time Systems

Educational Unit: Software/Hardware Interfaces - Embedded Systems

Educational Component Director

Acacio MARQUES

marques@emse.fr

D103

In-person class time (in hours)	27
Individual work time (in hours)	30
Language(s) of instruction	French

General description

Discovering the basic concepts of real-time kernels, using the FreeRTOS kernel on STM32. Acquiring good practices in programming and debugging with a real-time kernel. Consolidating these best practices in a real-time system design methodology. Increasing skills in the field of embedded real-time systems through a project.

Keywords

Multi-tasking; RMS; Semaphores; Queues; Timers; Handler task; Priority inheritance protocol; WCET; Scheduler; FreeRTOS

Type or organisation of classes

1	Real-time kernel basics: FreeRTOS application
2	Task management
3	Task communication
4	Interruption task
5	Timer task
6	Scheduler
7	Methodology for real-time specification
8	Methodology for real-time design
9	Methodology for real-time creation
10	Real-time project start-up
11	Real-time project - individual work
12	Real-time project - individual work
13	Real-time project - individual work
14	Real-time project - individual work
15	Real-time project demonstration

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Program advanced microcontroller peripheral drivers	3. Apply	Project	Machine test Project demonstration	Compliance with specifications
Debug their application using the tools provided by the development platform	3. Apply	Project practical work	Machine test Project demonstration	Compliance with specifications
Optimise application performance, power consumption and security	6. Create	Project	Machine test Project demonstration	Optimised solution
Understand the vocabulary of embedded real-time systems	2. Understand	Classes	Questionnaire and report	Accuracy of answers
Take a methodical approach to embedded real-time problems	3. Apply	Classes	Design report	Compliance with method Feasibility of solution
Read an electronic/digital schematic or synoptic diagram	4. Analyse	Project	Design report	Presence of synoptics Diagrams of electronics

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Read and extract information from a data sheet	2. Understand	Project	Questionnaire	Accuracy of answers
Draw up a UML diagram of the proposed solution	6. Create	Report	Design report	Compliance with representation standards, functional solution
Configure and use a real-time kernel	3. Apply	Project practical work	Machine test Project demonstration	Quality of configuration
Apply best practices for real-time applications	3. Apply	Project practical work	Machine test Project demonstration	Robustness of software
Produce a real-time application based on specifications	6. Create	Project	Project demonstration	Compliance with specifications
Participate, communicate and sell the project	4. Analyse	Demonstration Report	Demonstration Report	Feedback from the customer

Bibliography

Essential

“FreeRTOS™”. Accessed on: 13 April, 2025 [Online]. Available on: <https://freertos.org>

Useful

C. Bonnet et I. Demeure, *Introduction aux systèmes temps réel*. Hermes Science Publications, 1999.

C. Noviello, *Mastering STM32*. Leanpub, 2015.

STMicroelectronics, “STM32 MOOCs (Massive Open Online Courses) - STMicroelectronics”, st.com.

Accessed on: 4 March, 2025 [Online]. Available on: https://www.st.com/content/st_com/en/support/learning/stm32-education/stm32-moocs.html

J. Yiu, *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors*, 3rd edition. Amsterdam: Newnes, 2013.

Educational Component: Embedded Linux

Educational Unit: Software/Hardware Interfaces - Embedded Systems

Educational Component Director

Acacio MARQUES

marques@emse.fr

D103

In-person class time (in hours)	24
Individual work time (in hours)	14
Language(s) of instruction	French

General description

Learning how to tailor a Linux kernel for embedded applications. Applying this to the Raspbian kernel on Raspberry boards.

Keywords

Buildroot; Rootfs; Bootstrap; Bootloader; Devicetree; BusyBox; WCET; Yocto; Gdbserver; cross compilation; Makefiles

Type or organisation of classes

1	Classes
2	Classes
3	Practical: Linux From Scratch
4	Practical: Linux From Scratch
5	Practical: Buildroot Raspberry
6	Practical: Buildroot Raspberry
7	Practical: Yocto Raspberry
8	Practical: Yocto Raspberry

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Create a minimalist embedded Linux system from scratch	3. Apply	Practical work	Report	Kernel working
Use the Yocto tool to create a Linux kernel	3. Apply	Practical work	Report	Kernel working
Create a minimalist embedded Linux system using the Buildroot distribution	3. Apply	Practical work	Report	Kernel working
Understand Linux kernel vocabulary and architecture	2. Understand	Classes	Written exam	Accuracy of answers
Use a Raspberry board	3. Apply	Practical work	Report	Description of operation in report
Build a cross-compilation chain	3. Apply	Practical work	Report	Functionalities
Implement sensors via I ² C bus, web HMI and WiFi	4. Analyse	Practical work	Report	Measurements in the report, learning in the report

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Bootlin.com, “Formation développement Linux embarqué avec Yocto Project et Open Embedded”. Accessed on: 13 April, 2025 [Online]. Available on: <https://bootlin.com/fr/formation/yocto/>

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P. Kadionik, “Welcome to the Patrice Kadionik’s HomePage”. Accessed on: 13 April, 2025 [Online]. Available on: <https://kadionik.enseirb-matmeca.fr/>

C. H. Ph.D, *Embedded Linux: Hardware, Software, and Interfacing*. Boston: AddisonWesley Professional, 2002.

K. Yaghmour, *Building Embedded Linux Systems*. Sebastopol: O’Reilly, 2003.

“LinuxGizmos.com”, LinuxGizmos.com. Accessed on: 13 April, 2025 [Online]. Available on: <https://linuxgizmos.com/>

Educational Component: IOT Platform Design

Educational Unit: Software/Hardware Interfaces - Embedded Systems

Educational Component Director

Acacio MARQUES

marques@emse.fr

D103

In-person class time (in hours)	27
Individual work time (in hours)	16
Language(s) of instruction	French

General description

Creating an IoT system from the object to its display on a web server via a gateway. IBM's Node-RED platform will serve as the basis for creating this system. Gaining autonomy and confidence in designing this type of system in a project.

Keywords

Bluetooth; services and characteristics; Gateway; Javascript; MQTT; Mosquitto; Raspberry; Nucleo; Node-RED; Linux

Type or organisation of classes

1	Gateway
2	Cloud
3	Object
4	Display server
5	Database
6	Presentation of project
7	Independent work
8	Independent work
9	Demonstration

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Design an IOT chain using the Node-RED platform	4. Analyse	Project	Demonstration	Compliance with specifications
Create an HTML and JavaScript website to display data	3. Apply	Project	Demonstration	Quality of display
Use a Raspberry board	3. Apply	Project	Demonstration	Board working
Understand the vocabulary of IOT systems	2. Understand	Classes	Demonstration	Accuracy of oral responses to questions
Install a software pack on a Nucleo board	4. Analyse	Project	Demonstration	Drivers working
Create a Bluetooth service on STM32	3. Apply	Classes Project	Demonstration	Bluetooth exchanges working
Use embedded Linux	3. Apply	Project	Demonstration	Familiarity with Linux commands
Use the MQTT protocol	3. Apply	Project	Demonstration	Local broker and MQTT exchange working

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Use a NoSQL database	3. Apply	Project	Demonstration	Quality of possible interactions with the database
Participation, Communication during the project	3. Apply	Project	Demonstration	Feedback from the customer and teacher

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J. Yiu, *The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 Processors*, 3rd edition. Amsterdam: Newnes, 2013.

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Educational Unit: Systems Design

Embedded Systems (Major)

Educational Unit Director

Olivier POTIN

olivier.potin@emse.fr

A225

Number of ECTS credits (European Credit Transfer Scale)	11
In-person class time (in hours)	165.30
Individual work time (in hours)	98.8
Language(s) of instruction	French, English (slides)

General description

The aim of this Educational Unit is to address all the abstraction layers of an embedded application, including hardware description/modelling using an HDL language and software applications on embedded processors.

The first Educational Component is dedicated to learning how to model a circuit using a hardware description language, logic simulation and synthesis to obtain a gate-level description.

The second Educational Component looks at the design and hardware/software implementation of an application using a design flow associated with programmable integrated circuits (FPGAs).

The third Educational Component focuses on embedded AI software applications and the security issues involved in inference.

Keywords

Hardware/software abstraction level: RTL -> software application; HDL description; Synthesis/Placement routing; Hardware IPs; Software/hardware communication via AXI protocol; Application software/hardware partitioning; Neural network inference; Microcontrollers; Implementation constraints; AI security

Links between course sub-modules

The three Educational Components address different abstraction layers (hardware/software) and different implementations of embedded AI on a processor (ARM core and programmable hardware/FPGA)

Sub-modules

SystemVerilog Design and Synthesis

Jean-Baptiste RIGAUD

Codesign and FPGA Prototyping

Olivier POTIN

Embedded AI on a Microcontroller

Olivier POTIN

Educational Component: SystemVerilog Design and Synthesis

Educational Unit: Systems Design - Embedded Systems

Educational Component Director

Jean-Baptiste RIGAUD

rigaud@emse.fr

A225

In-person class time (in hours)	18
Individual work time (in hours)	18
Language(s) of instruction	French

General description

The objectives of the Educational Component are as follows:

- Understanding the rules for writing a hardware description language (SystemVerilog) to perform hardware implementation,
- Developing a digital system that can be modelled at the register-transfer level (RTL),
- A methodology for designing a digital system: logic simulation, the logic synthesis stage and post-synthesis simulation with back-annotation of delays.
- Implementing constraints for synthesis.

All concepts will be illustrated through the design of several significantly complex circuits.

Keywords

HDL description; RTL; Synthesis; Simulation; State machine; Clock period; Constraints

Type or organisation of classes

1	SystemVerilog overview and working environment
2	Logic synthesis of a circuit with Synopsys Design Compiler
3	Notion of constraints and simulation taking delays into account
4	Arithmetic operators
5	Modelling basic sequential circuits
6	Synthesis of a finite-state machine

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Simulate after RTL development	3. Apply	Practical work	Written assignment	Accuracy of answers Justification of choices Methodology
Simulate after synthesis	3. Apply	Lecture	Assessment by teacher	
Evaluate design constraints (clock period, etc.)	5. Assess			
Design a complex digital system using basic logic functions (ALU, multiplexers, FSM, etc.)	6. Create			

Bibliography

Useful

S. Sutherland, S. Davidmann, P. Flake, & P. Moorby, *SystemVerilog for Design: A Guide to Using SystemVerilog for Hardware Design and Modeling*, Second Edition 2006. New York, NY: Springer, 2010.

Learn more

S. F. Michael Keating, *The Simple Art of SoC Design: Closing the Gap between RTL and ESL*.

S. Sutherland, *RTL Modeling with SystemVerilog for Simulation and Synthesis: Using SystemVerilog for ASIC and FPGA Design*, 1er édition. Sutherland HDL, Inc., 2017.

S. Sutherland et D. Mills, *Verilog and System Verilog Gotchas: 101 Common Coding Errors and How to Avoid Them*, 2007e édition. New York: Springer-Verlag New York Inc., 2007.

Educational Component: Codesign and FPGA Prototyping

Educational Unit: Systems Design - Embedded Systems

Educational Component Director

Olivier POTIN

olivier.potin@emse.fr

A225

In-person class time (in hours)	27
Individual work time (in hours)	12
Language(s) of instruction	French

General description

Master FPGA design flow for software and hardware application development, including:

- software/hardware partitioning of the application,
- hardware implementation of a component on an FPGA target
- complete design of a system comprising a program in C running on an ARM processor supported by a hardware brick.

Keywords

Hardware design flow; HDL synthesis; FPGA placement and routing; Software drivers; Application software/hardware partitioning; Xilinx Vivado; Xilinx Vitis

Type or organisation of classes

1	1-2: Introduction to FPGA technology / Lab1 Xilinx
2	3-4: Xilinx IP core integration / Hardware encryption algorithm project
3	5-7: Lab 1 to 5 Xilinx Vivado Embedded design suite
4	8-9: Cryptographic IP core integration into software/hardware

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Unfold a design flow on an FPGA	3. Apply	Project-based learning Practical work	Written assignment	Critical analysis Creativity Thinking-based approach Justification of choices Methodology
Create a hardware implementation from an HDL description	6. Create			
Add IPs to an existing design	3. Apply			
Use an AXI communication bus to interface an IP with an ARM processor	2. Understand			
Partition an application into software and hardware	2. Understand			
Create a proprietary IP	6. Create			
Develop a software application accessing a hardware component using a driver	3. Apply			

Bibliography

“Workshops AMD”, AMD.

Accessed on: 14 April, 2025 [Online]. Available on: <https://www.amd.com/en/corporate/university-program/workshops.html>

Educational Component: Embedded AI on MCU

Educational Unit: Systems Design - Embedded Systems

Educational Component Director

Olivier POTIN

olivier.potin@emse.fr

A225

In-person class time (in hours)	15
Individual work time (in hours)	21
Language(s) of instruction	French

General description

The objective of the Educational Component is twofold:

- 1) Establishing a methodology for deploying a neural network (RNN) on a microcontroller
- 2) Understanding RNN threats/vulnerabilities to software/hardware attacks

Keywords

Neural network architecture; RNN implementation constraints; RNN inference; Bit-flipping attack; Adversarial attack

Type or organisation of classes

1	Introduction to embedded AI / Inference on microcontrollers
2	Tutorial 1: Implementing MNIST on STM32
3	Practical 1: Project: implementing a neural network (CNN or MLP) on STM32
4	AI security
5	Practical 2: Attacks on the project developed

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse RNN architecture according to implementation constraints	4. Analyse	Lecture Practical work	Technical project report	Critical analysis Achievement of goals Thinking-based approach Justification of choices Methodology Quality of deliverables Relevance of argumentation
Implement an RNN on a microcontroller	3. Apply			
Assess the vulnerabilities of an RNN	5. Assess			
Carry out theoretical attacks on an RNN	4. Analyse			

Bibliography

“Workshops AMD”, AMD.

Accessed on: 14 April, 2025 [Online]. Available on: <https://www.amd.com/en/corporate/university-program/workshops.html>

Educational Unit: Methods Applied in Companies

Computer Science (Major)

Educational Unit Director

Claude YUGMA

yugma@emse.fr

A203

Number of ECTS credits (European Credit Transfer Scale)	5
In-person class time (in hours)	54
Individual work time (in hours)	24
Language(s) of instruction	French

General description

This Educational Unit offers an integrated, applied approach to the methods used in modern companies to analyse, model and support decision-making. It focuses on three complementary areas:

- Simulation - evaluating complex systems and testing risk-free decisions
- Mobile telecommunications - understanding the infrastructure and market mechanisms of mobile technologies
- Information systems - providing a global view of how data and software support business operations

This Educational Unit aims to:

- Provide students with applied tools and methods used in industry
- Foster interdisciplinary understanding between engineering, business processes and information systems
- Prepare students to interact with digital and analytical tools in companies

Keywords

Simulation; Optimisation; Information systems; Mobile telecommunications; Decision; Systems engineering

Links between course sub-modules

The three Educational Components - Simulation, Information Systems and Mobile Telecommunications - are complementary and form a coherent whole designed to equip students to model, analyse and manage the complex systems of the modern enterprise. Simulation provides modelling and evaluation methods, information systems deal with structuring and exploiting data, while telecommunications ensure connectivity and mobility. Together, they enable an integrated approach to performance and the digital transformation of organisations.

Sub-modules

Information Systems
Claude YUGMA (Guest: Christian FLORISOONE)
Mobile Telecommunications
Claude YUGMA (Guest: Jean-Marc ROCCHI)
Simulation
Claude YUGMA

Educational Component: Information Systems

Educational Unit: Computer Science

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	18
Individual work time (in hours)	8
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Understanding the key concepts of enterprise architecture and information systems.

Understanding project management and industrialisation methods.

Covering some key software design and development techniques for interoperability needs.

Understanding the fundamentals of Cloud Computing and Big Data.

Keywords

Information systems; IS management; IT technology; Big Data

Type or organisation of classes

1	Enterprise Architecture and Information Systems (IS)
2	Software Industrialisation
3	IT Technology
4	Cloud Computing and Big Data

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Characterise the project	4. Analyse	Project-based learning	Project report	Achievement of goals
Apply software development techniques	2. Understand	Case study	Project report	Achievement of goals
Break down a problem	3. Apply	Case study	Project report	Achievement of goals
Determine the right approach and solution	5. Assess	Case study	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing scalable and resilient solutions	NA
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Educational Component: Mobile Telecommunications

Educational Unit: Computer Science

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	18
Individual work time (in hours)	8
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	7

General description

Acquiring an engineering culture in mobile telecommunications: markets, standards, technologies and uses.

Keywords

Wireless technologies; Mobile market

Type or organisation of classes

1	Mobile and wireless market
2	Wireless technologies and standards
3	Choice of platform/use/market
4	Mobile software platform solutions
5	Presentations

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Understand a problem and a market	2. Understand	Project-based learning	Project report	Achievement of goals
Characterise the type of market	4. Analyse	Case study	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Proposing solutions for sustainable telecommunications	NA
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Educational Component: Simulation

Educational Unit: Computer Science

Educational Component Director

Claude YUGMA

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A203

In-person class time (in hours)	18
Individual work time (in hours)	8
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

This Educational Component is an introduction to simulation through an understanding of the fundamental concepts (queues, servers, agents, discrete events, etc.) for solving problems and making decisions.

Keywords

Discrete-event simulation; Excel and AnyLogic; Multi-agent modelling; AnyLogic

Type or organisation of classes

1	Discrete-event simulation,
2	Multi-agent modelling
3	Excel
4	AnyLogic
5	Practical work and exercises
6	Discrete-event simulation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Model using a simulation approach	4. Analyse	Project-based learning	Project report	Achievement of goals
Identify a problem and its characteristics	2. Understand	Case study	Project report	Achievement of goals
Use simulation to solve the problem with the right paradigm	5. Assess	Case study	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing scalable and resilient solutions	NA
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Educational Unit: Software Design

Computer Science (Major)

Educational Unit Director

Claude YUGMA

yugma@emse.fr

A203

Number of ECTS credits (European Credit Transfer Scale)	6
In-person class time (in hours)	90
Individual work time (in hours)	36
Language(s) of instruction	French

General description

The Educational Unit on Software Design aims to provide students with an understanding of the concepts and tools essential for the design, development and integration of modern software, using robust and recent technologies. The Educational Unit combines advanced skills in Java programming, database design (theoretical and practical), and mobile development, in order to train versatile profiles capable of creating high-performance, connected and user-centric applications.

Keywords

Java programming; Object-oriented design; Client-server; Android; Databases; Design patterns; Mobile development

Links between course sub-modules

The four modules of the Software Design unit form a coherent course of study focused on mastering the entire development cycle of a modern application, from design to implementation. The Advanced Java module provides the foundations of object-oriented programming, integrating notions of network communication and design patterns for robust architectures. This is complemented by the modules on databases: one focusing on conceptual design and performance optimisation, the other on the development of interactive applications in a client-server environment. Finally, the Mobile Design module extends these skills to the Android universe, applying them to contemporary uses such as social

networks and NFC communication. The unit prepares students to design comprehensive, interconnected software systems adapted to current market needs.

Sub-modules

Advanced Java
Claude YUGMA (Guest: Laurent FREUND)
Conceptual Databases
Claude YUGMA (Guest: Sophie NABITZ)
Applied Databases
Claude YUGMA (Guest: Sophie NABITZ)
Android Mobile Design
Claude YUGMA (Guest: Gaëtan MAISSE)

Educational Component: JAVA

Educational Unit: Computer Science

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	18
Individual work time (in hours)	8
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Learning advanced JAVA techniques

Keywords

Discrete-event simulation; Excel and AnyLogic; Multi-agent modelling; AnyLogic

Type or organisation of classes

1	Discrete-event simulation,
2	Multi-agent modelling
3	Excel
4	AnyLogic
5	Practical work and exercises
6	Discrete-event simulation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Model using a simulation approach	4. Analyse	Project-based learning	Project report	Achievement of goals
Identify a problem and its characteristics	2. Understand	Case study	Project report	Achievement of goals
Use simulation to solve the problem with the right paradigm	5. Assess	Case study	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing scalable and resilient solutions	NA
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Educational Component: Database Design

Educational Unit: Computer Science

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	18
Individual work time (in hours)	8
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Acquire the principles of relational schema design and RDBMS administration by studying the implementation techniques of these systems in order to understand how they work and thus enable optimal tuning in terms of response times.

Keywords

Databases; Indexing; Hash functions; SQL

Type or organisation of classes

1	Database design: relational schemas, UML
2	Physical media management
3	Techniques for creating user interfaces for IT systems
4	Indexing techniques
5	Query optimisation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Understand a problem	2. Understand	Project-based learning	Continuous assessment	Achievement of goals
Define the problem and propose appropriate solutions	4. Analyse	Project-based learning	Project report	Achievement of goals
Develop the best solution	6. Create	Project-based learning	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing a sustainable software solution	NA
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Educational Component: Database Applications

Educational Unit: Computer Science

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	18
Individual work time (in hours)	8
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Study of development standards for client/server relational databases.

Keywords

Databases; Indexing; Hash functions; SQL

Type or organisation of classes

1	Client-server database principles and applications
2	ODBC interface: architecture, environments, use
3	Techniques for creating user interfaces for IT systems
4	JDBC interfaces
5	Stored procedures: issues, architecture and operation, implementation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Understand a problem	2. Understand	Project-based learning	Project report	Achievement of goals
Define the problem and propose appropriate solutions	4. Analyse	Project-based learning	Project report	Achievement of goals
Develop the best solution	6. Create	Project-based learning	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
------	--------------	-----------------

This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing a sustainable software solution	NA
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Educational Component: Android Mobile Application Design

Educational Unit: Computer Science

Educational Component Director

Claude YUGMA

yugma@emse.fr

A203

In-person class time (in hours)	36
Individual work time (in hours)	12
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Acquiring skills for developing mobile applications on an Android platform (e.g. social network applications) using NFC technologies. Creating a responsive, user-friendly interface (XML + Java/Kotlin logic).

Implementing social network-type interactions (registration, publication, friends, likes, etc.).

Using NFC technology to exchange data between devices (e.g., share profile, add friend).

Managing local and remote databases (SQLite, Firebase, etc.).

Keywords

Android; Mobile applications; Mobile databases; NFC; API

Type or organisation of classes

1	Client-server database principles and applications
2	ODBC interface: architecture, environments, use
3	Techniques for creating user interfaces for IT systems
4	JDBC interfaces
5	Stored procedures: issues, architecture and operation, implementation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Understand a problem	2. Understand	Project-based learning	Project report	Achievement of goals
Define the problem and propose appropriate solutions	4. Analyse	Project-based learning	Project report	Achievement of goals
Design a solution	6. Create	Project-based learning	Project report	Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing a sustainable software solution	NA
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Educational Unit: Electronics and Energy

Technological Challenges

Educational Unit Director

Sylvain BLAYAC

blayac@emse.fr

D201

Number of ECTS credits (European Credit Transfer Scale)	9
In-person class time (in hours)	141
Individual work time (in hours)	100
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	2, 6, 7, 9, 12, 13, 15

General description

The aim of this Educational Unit is to give engineers with skills in microelectronics and/or embedded systems an in-depth understanding of issues related to energy in general and energy autonomy in particular. The courses cover energy issues in general, and the integration of renewable energies supported by information technologies (Smart Grids). In terms of electronic systems, the course covers the design of autonomous connected objects dedicated to environmental monitoring. Analysis of the environment and transducers makes it possible to quantify the average power available, and a low-power design approach allows for optimisation of the energy balance. At the end of the unit, students will be able to design an autonomous connected object.

Keywords

Renewable energies; Energy Harvesting; Autonomous connected objects; Low-energy embedded systems; Internet of Things; AI for energy; Smart grids; Low-energy antennas and communications

Sub-modules

Photovoltaic Technologies

Mohamed SAADAOUI

Energy Sources and Conversion for Autonomous Objects

Sylvain BLAYAC

Connected Autonomous Sensitive Secured Objects (OCASS)

Raphael VIERA

Low-Energy Antennas and Communication

Mohamed SAADAOUI

Economics of Energy Transition

Daniel OCHOA

Educational Component: Photovoltaic Technologies

Educational Unit: Electronics and Energy - Technological Challenges

Educational Component Director

Mohamed SAADAOUI

saadaoui@emse.fr

D206

In-person class time (in hours)	33
Individual work time (in hours)	0
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	7, 12, 13

General description

Photovoltaic technologies: from the cell to the panel

Keywords

Solar radiation, earth/sun energy balance, photovoltaic cell physics, solar cell manufacturing technology, sizing and materials, electrical characteristics of a solar cell, photovoltaic panels from individual cells, hot spots and electrical protection of panels

Type or organisation of classes

1	Lecture: Photovoltaic technology
2	Practical work: Simulation of a solar installation
3	Practical work: Characterising photovoltaic cells and panels

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Understand solar radiation and its distribution around the planet	1. Remember	Lecture	Written exam MCQs	Accuracy of answers Diagram and illustrations
Understand the photovoltaic effect from a physical point of view (light-electron conversion)	1. Remember			
Understand solar cell manufacturing technologies (from powder to the solar cell)	1. Remember			
Understand the electrical characteristics of a solar cell	1. Remember			
Understand how to assemble solar cells to create a photovoltaic panel. Understand how to protect a panel and its use in a domestic installation	1. Remember			

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Characterise and size a solar installation using digital methods and tools	3. Apply	Practical work Visit to a photovoltaic plant (CEA Cadarache and Urbasolar Gardanne)		
Experimentally characterise a photovoltaic cell and panel	3. Apply			
Apply theoretical and experimental knowledge to solve problems	4. Analyse		Written exam	Accuracy of answers Diagram and illustrations

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Discovering companies and facilities for renewable and low-carbon energies	33
Goal 12: Ensure sustainable consumption and production patterns	Discovering companies and facilities for renewable and low-carbon energies	33
Goal 13: Take urgent action to combat climate change and its impacts	Discovering companies and facilities for renewable and low-carbon energies	33

Educational Component: Energy Sources and Conversion for Autonomous Objects

Educational Unit: Electronics and Energy - Technological Challenges

Educational Component Director

Sylvain BLAYAC

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D201

In-person class time (in hours)	27
Individual work time (in hours)	20
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	2, 6, 9, 12, 15

General description

This module provides students with a thorough understanding of the design strategy for an autonomous connected object. The course begins by exploring available ambient energy sources and the associated transducers (photovoltaic, mechanical, thermal) and their equivalent models. This enables students to assess the average power density available in a given environment. For each device, the power must then be converted to generate a stable supply for the object. Conversion principles and circuits are covered in the second part of the module. This Educational Component culminates in a mini-project consisting of calculating the energy balance of an autonomous object based on the environmental conditions and consumption characteristics of the connected object.

Keywords

Energy Harvesting; Energy balance; Autonomous connected objects; Transducers; Solar cells; Triboelectricity; Thermoelectricity; Energy conversion

Type or organisation of classes

1	Introduction and principles of photovoltaic sources
2	Practical work: Solar cell simulation
3	Practical work: Characterisation of a solar cell
4	Mechanical sources: general information and modelling of a triboelectric wind turbine
5	Simulation of a triboelectric source and energy converter
6	Thermal sources: general information on thermics and thermoelectricity
7	Simulation of a heat source powered by human body heat
8	Batteries: general information and characterisation methods
9	Practical: multisource characterisation
10	Energy balance: mini-project presentation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Understand the fundamentals of coupling electronics with its environment	1. Remember	Lecture			
Understand the physical phenomena involved in energy transducers	2. Understand	Practical work Simulation			
Analyse a physical environment	4. Analyse	Project-based learning	Project report	Appropriation of methods	
Model transducers and propose an equivalent circuit diagram	4. Analyse	Practical work Simulation			
Calculate contributions within an energy conversion chain	3. Apply	Tutorials	Project report	Accuracy of answers	
Know the principles of converters and their different types	1. Remember	Lecture			

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
Design an energy harvesting system integrating the transducer and conditioner	6. Create	Project-based learning			
Calculate conversion efficiency and average available power	4. Analyse	Tutorials - simulation	Project report	Accuracy of answers	
Summarise work in a structured manner in an analysis report	2. Understand	Project-based learning	Project report	Careful and structured report	
Understand the main characteristics of batteries	1. Remember	Lecture			
Characterise and extract the main parameters of a solar cell from a battery	3. Apply	Practical work	Production of a technical data sheet	Accuracy of answers	Prototyping IDFab
Draw up an energy balance for an object	5. Assess	Project-based learning	Project report	Appropriation of methods	
Compare the performance of different sources	5. Assess	Project-based learning	Project report	Rigorous analysis	Prototyping IDFab

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	The module provides a foundation for designing environmental monitoring systems (e.g. efficient irrigation management)	NA
Goal 6: Ensure availability and sustainable management of water and sanitation for all	The module provides a foundation for designing environmental monitoring systems (e.g. efficient irrigation management)	NA
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	The project focuses on the creation of an innovative connected object for real-time monitoring of road engineering structures	6
Goal 12: Ensure sustainable consumption and production patterns	Efficiency and frugality lie at the heart of the module	6
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	The module provides a foundation for designing environmental monitoring systems (e.g. efficient irrigation management)	NA

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E. Sazonov, *Wearable Sensors: Fundamentals, Implementation and Applications*, 2e édition. Cambridge: Academic Press Inc, 2020.

Educational Component: Connected Autonomous Sensitive Secured Objects (OCASS)

Educational Unit: Electronics and Energy - Technological Challenges

Educational Component Director

Raphael VIERA

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C203

In-person class time (in hours)	2
Individual work time (in hours)	20
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	2, 6, 9, 12, 15

General description

The aim of this Educational Component is to design an energy-autonomous connected object, from the energy source to remote data processing, for a connected agriculture application. The first phase consists of learning the fundamentals of microcontroller programming for low-energy applications. The second phase focuses on the energy source and average power available. The third phase is carried out independently, with the aim of optimising the energy balance of the connected object.

Keywords

Autonomous connected objects; Low-energy programming; Energy balance

Type or organisation of classes

1	Introduction to the fundamentals of microcontrollers (HAL library, Cube IDE, basic functions such as UART)
2	Programming of a single-channel and multi-channel ADC, and acquisition of sensor values.
3	Introduction to the microcontroller clock tree, low-energy modes and measuring microcontroller and sensor power consumption.
4	Introduction to the LORA protocol, data transmission and consumption cycle evaluation
5	Study and description of the photovoltaic energy source and evaluation of the available power
6	Study and description of the conversion circuit and evaluation of efficiency
7	Assembly of self-contained device and energy balance
8	Independent work: customising the device and optimising energy use
9	Independent work: customising the device and optimising energy use
10	Independent work: customising the device and optimising energy use
11	Independent work: customising the device and optimising energy use
12	Independent work: customising the device and optimising energy use
13	Demonstration and presentation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Program a microcontroller in low-energy mode	3. Apply	Practical work	Report Presentation of project	Accuracy of answers Justification of choices Thinking-based approach	
Implement a low-energy communication solution	3. Apply	Practical work	Report Presentation of project	Quality of deliverables Accuracy of answers Justification of choices Thinking-based approach	
Measure the consumption curve of the connected object	5. Assess	Practical work	Report Presentation of project		IDFab prototyping
Size an energy source according to environmental conditions	2. Understand	Practical work	Report Presentation of project		
Use and characterise an energy converter circuit	4. Analyse	Practical work	Report Presentation of project		
Measure the consumption curve of the connected object	5. Assess	Practical work	Report Presentation of project		IDFab prototyping

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
Develop an energy management strategy	4. Analyse	Project-based learning	Report Presentation of project		IDFab prototyping
Measure the quantities associated with the energy balance	4. Analyse	Project-based learning	Project report and presentation		
Design an autonomous connected object	6. Create	Project-based learning	Report Presentation of project		IDFab prototyping
Optimise the energy balance	4. Analyse	Project-based learning	Report Presentation of project		
Present project results in summary form	2. Understand	Project-based learning	Report Presentation of project		

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	The module provides a foundation for designing environmental monitoring systems (e.g. efficient irrigation management)	
Goal 6: Ensure availability and sustainable management of water and sanitation for all	The module provides a foundation for designing environmental monitoring systems (e.g. efficient irrigation management)	
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	The project focuses on the creation of an innovative connected object for real-time monitoring of road engineering structures	6
Goal 12: Ensure sustainable consumption and production patterns	Efficiency and frugality lie at the heart of the module	6
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	The module provides a foundation for designing environmental monitoring systems (e.g. efficient irrigation management)	

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C. Noviello, *Mastering STM32*. Leanpub, 2015.

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G. Asch, P. Renard, P. Desgoutte, Z. Mammeri, É. Chambérod, et J. Gunther, *Acquisition de données - Du capteur à l'ordinateur*. Paris: Dunod, 2011.

J. G. Proakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 5th edition. Pearson, 2021.

Educational Component: Antennas and Low-Energy Communication

Educational Unit: Electronics and Energy - Technological Challenges

Educational Component Director

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D206

In-person class time (in hours)	33
Individual work time (in hours)	0
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	7, 12, 13

General description

Designing a radio frequency device using design and measurement methods applied to embedded, IoT and low-energy systems.

Keywords

Miniature antennas; Radio frequency; Electromagnetic transmission; Electromagnetic simulation; Impedance matching; Energy; Low energy consumption

Type or organisation of classes

1	Lecture: designing miniature antennas
2	Practical work: Simulation and design (3 sessions)
3	Practical work: Antenna production (2 sessions)
4	Practical work: characterisation (prototyping platform)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Understand high-frequency signal transmission phenomena	1. Remember	Lecture			
Apply theoretical foundations using digital simulation tools	6. Create	Practical work	Final report	Justification of choices Methodology Achievement of goals	IDFab Prototyping
Make a connection between manufacturing constraints and simulation tools	5. Assess	Simulation Practical work			
Characterise the electromagnetic propagation of an antenna	4. Analyse	Practical work			
Evaluate the impact of electromagnetic design on the energy consumption of a circuit board	5. Assess	Practical work			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Discovering companies and facilities for renewable and low-carbon energies	33
Goal 12: Ensure sustainable consumption and production patterns	Discovering companies and facilities for renewable and low-carbon energies	33
Goal 13: Take urgent action to combat climate change and its impacts	Discovering companies and facilities for renewable and low-carbon energies	33

Educational Component: Economics of Energy Transition

Educational Unit: Electronics and Energy - Technological Challenges

Educational Component Director

Daniel OCHOA

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A321

In-person class time (in hours)	12
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	7, 12, 13

General description

The aim of this module is to explore different sectors linked to the energy transition. This contact between students and professionals is achieved through visits and seminars.

Keywords

Energy; Photovoltaic energy; Energy transition

Type or organisation of classes

1	Presentation and tour of the Sauvaire photovoltaic park (URBA SOLAR)
2	Visit the Cadarache research centre: Nuclear and New Energies
3	Rotating Seminar-Visit: CEREMA - Mobility information system (2024)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify business skills related to the energy transition	1. Remember	Seminar	N/A	N/A
Understand the challenges of information technology for the deployment and integration of renewable energy	2. Understand	Company visit	N/A	N/A

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Discovering companies and facilities for renewable and low-carbon energies	12
Goal 12: Ensure sustainable consumption and production patterns	Discovering companies and facilities for renewable and low-carbon energies	12
Goal 13: Take urgent action to combat climate change and its impacts	Discovering companies and facilities for renewable and low-carbon energies	12

Educational Unit: IT and Technologies for the Supply Chain

Technological Challenges

Educational Unit Director

Nabil ABSI

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B207

Number of ECTS credits (European Credit Transfer Scale)	10
In-person class time (in hours)	114
Individual work time (in hours)	53
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	9, 12

General description

The aim of the technological challenge on IT and Technologies for the Supply Chain is to train computer scientists with new skills covering three disciplinary fields:

- communicating technologies,
- optimisation and decision-making tools,
- production and logistics systems.

Upon completion of the Educational Unit, students will be able to:

- understand the complexity of logistics processes and be able to evaluate, integrate or develop IT tools for efficient logistics management,
- integrate new communication technologies into their IT systems.

Keywords

Decision support; Optimisation; Planning; Scheduling; Transportation; Production; Machine learning; Forecasting; Communicating technologies

Links between course sub-modules

5 Educational Components provide students with training in various concepts (communication technologies, optimisation and decision-making tools, production and logistics) enabling them to achieve the above objectives. The first Educational Component covers communicating technologies and their integration, the second Educational Component deals with optimisation issues encountered in supply chains, and Educational Components 3 and 4 cover optimisation and data analysis tools. Educational Component 5 includes presentations and visits by industrialist stakeholders.

Sub-modules

Optimisation for Decision Support
Nabil ABSI
Supply Chain Management
Nabil ABSI
Supply Chain Planning
Nabil ABSI
Short Range Communication
Nabil ABSI
E-business et bases de données
Elodie SUZANNE
Visits and Seminars
Nabil ABSI

Educational Component: Optimisation for Decision Support

Educational Unit: IT and Technologies for the Supply Chain - Technological Challenges

Educational Component Director

Nabil ABSI

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B207

In-person class time (in hours)	21
Individual work time (in hours)	9
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	9

General description

The aim of this Educational Component is to provide an overview of discrete optimisation techniques, with an emphasis on their application in real industrial contexts. On completion of the course, students will be able to participate effectively in advanced projects and collaborate with experts in decision support.

Keywords

Decision support; Optimisation; Modelling; Linear programming; Mixed integer programming; Branch and Bound; Decomposition methods; Heuristics; Metaheuristics; Multicriteria

Type or organisation of classes

1	Overview of optimisation techniques
2	Overview of optimisation techniques
3	Overview of optimisation techniques
4	Optimisation in practice
5	Optimisation in practice
6	Introduction to multi-criteria decision analysis
7	Presentation of an article (article from the <i>Interfaces</i> journal provided during the first session)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Remember mathematical modelling techniques and existing solution methods	1. Remember	Lecture Tutorials	Individual oral presentation	Clarity of presentation Critical analysis Command of the subject Media quality
Understand how to model and solve a decision problem using operational research techniques	2. Understand			
Apply modelling and resolution approaches to decision-making problems encountered in industry	3. Apply			
Analyse the models developed and the results obtained	4. Analyse			
Assess the solutions obtained	5. Assess			
Create efficient models and methods and develop robust algorithms	6. Create			

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Learn more

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Educational Component: Supply Chain Management

Educational Unit: IT and Technologies for the Supply Chain - Technological Challenges

Educational Component Director

Nabil ABSI

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B207

In-person class time (in hours)	12
Individual work time (in hours)	6
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	9

General description

This Educational Component provides an introduction to the fundamental concepts of supply chain management, covering all activities related to the management of the flow of goods, information and services, from suppliers to end customers.

It addresses the main activities of logistics (procurement, production, distribution), the challenges of coordination between stakeholders, and tools for analysis and optimisation.

Particular attention will be paid to understanding strategic, tactical and operational decisions in a globalised, uncertain and increasingly digitised environment.

Real-life case studies, practical exercises and interactive games (such as the Beer Game) will illustrate current issues and best practices in supply chain management.

Keywords

Supply chain management; Beer Game; Case studies; Decision making; Coordination; Globalisation

Type or organisation of classes

1	Introduction to supply chain management
2	Introduction to supply chain management - Beer Game
3	Presentation of case studies

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the basic concepts and decision-making issues related to supply chain planning	1. Remember	Lecture Tutorials	Individual oral presentation, Computer development	Achievement of goals Clarity of presentation
Understand how to model and solve decision-making problems related to supply chain planning	2. Understand			
Apply the methods best suited to the decision-making problems encountered	3. Apply			
Analyse the decision-making level and complexity of the problem encountered	4. Analyse			
Assess available resolution approaches	5. Assess			
Create algorithms suited to the decision-making problems encountered	6. Create			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing optimisation and decision-making tools to promote circularity in supply chains	2
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[Learn more](#)

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W. J. Stevenson, *Operations Management*, 14th edition. New York, NY: McGraw Hill, 2020.

Educational Component: Supply Chain Planning

Educational Unit: IT and Technologies for the Supply Chain - Technological Challenges

Educational Component Director

Nabil ABSI

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B207

In-person class time (in hours)	24
Individual work time (in hours)	12
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	9

General description

This Educational Component aims to provide the basics of production planning and scheduling, as well as the integration of production planning with other decisions such as inventory management, transport and scheduling. The goal is for students to learn how to model real-world production planning and scheduling problems and solve them using operational research approaches (Lagrangian relaxation, heuristics, etc.). They will also learn how an advanced planning system (APS) works. One session is specifically dedicated to the production of healthcare services.

The aim is also to provide a basic understanding of the design and optimisation of transport and distribution systems. The course will cover the theory behind some of the key issues in distribution planning: vehicle routing and warehouse management.

This Educational Component will be assessed through a mini-project, in which students will be confronted with a realistic problem and will have to develop a decision-making tool.

Keywords

Production planning; Production scheduling; Warehouse management; Vehicle routing; Transportation; Optimisation

Type or organisation of classes

1	Introduction to production planning
2	Advanced production planning models
3	Distribution and vehicle routing
4	Production planning and scheduling, joint inventory and transport planning and management
5	Production scheduling
6	Production of healthcare services
7	Warehouse management

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Understand the basic concepts and decision-making issues related to supply chain planning	1. Remember	Lecture Tutorials	Individual oral presentation, Computer development	Achievement of goals Clarity of presentation
Understand how to model and solve decision-making problems related to supply chain planning	2. Understand			
Apply the methods best suited to the decision-making problems encountered	3. Apply			
Analyse the decision-making level and complexity of the problem encountered	4. Analyse			
Assess available resolution approaches	5. Assess			
Create algorithms suited to the decision-making problems encountered	6. Create			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Developing optimisation and decision-making tools to promote circularity in supply chains	2
Goal 12: Ensure sustainable consumption and production patterns	Developing optimisation and decision-making tools to promote circularity in supply chains	2

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[Learn more](#)

Y. Pochet et L. A. Wolsey, *Production Planning by Mixed Integer Programming*, New York, NY Heidelberg: Springer, 2010.

L. A. Wolsey, *Integer Programming*, 2nd edition. Hoboken, NJ: Wiley, 2020.

Educational Component: Short Range Communication

Educational Unit: IT and Technologies for the Supply Chain - Technological Challenges

Educational Component Director

Nabil ABSI

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B207

In-person class time (in hours)	12
Individual work time (in hours)	6
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	9

General description

The aim of this Educational Component is to present traceability technologies (barcodes, RFID, NFC, etc.). Specialists in the field will explain how these technologies work, their uses and their main applications.

The first part of the Educational Component provides an introduction to RFID technologies. It provides an understanding of electronic solutions implementing RFID tags, with a focus on practical industrial applications. A brief history of these technologies will be presented, followed by an overview of the existing solutions. We will then discuss in more detail the issues related to powering passive tags, communication solutions with readers, and regulatory aspects.

Current technological trends will also be presented. This first part will conclude with practical work on HF and UHF technologies.

The second part of the Educational Component aims to present the essential points for the successful integration of new communication solutions, from project management to their use in supply chains.

Keywords

Traceability; RFID; Data science; Barcodes; NFC; Tag localisation; Integration

Type or organisation of classes

1	Introduction to communication technologies
2	Communication protocols: multiple tags in a single field
3	Regulatory and legal aspects. NFC and mobile RFID
4	Practical work (HF technology)
5	Practical work (UHF technology)
6	Development of a decision support tool
7	How to manage an RFID project
8	Assessing the impact of RFID technologies on supply chains
9	Feedback, discussions, markets, business models, technological choices

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the basic concepts and decision-making issues related to supply chain planning	1. Remember	Lecture Tutorials	Individual oral presentation, Computer development	Achievement of objectives Clarity of presentation
Understand how to model and solve decision-making problems related to supply chain planning	2. Understand			
Apply the methods best suited to the decision-making problems encountered	3. Apply			
Analyse the decision-making level and complexity of the problem encountered	4. Analyse			
Assess available resolution approaches	5. Assess			
Create algorithms suited to the decision-making problems encountered	6. Create			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Integration of new technologies	3
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Educational Component: E-business and databases

Educational Unit: IT and Technologies for the Supply Chain - Technological Challenges

Educational Component Director

Elodie SUZANNE

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B205

In-person class time (in hours)	33
Individual work time (in hours)	20
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

This Educational Component covers three concepts widely used in industry: e-business, ERP (enterprise resource planning) and Big Data. The course begins with an introduction to e-business concepts and shows how information systems interact within supply chains. The second part introduces the structure of ERP systems (SAP, Sage, etc.), highlighting the importance of middleware and its implementation. The last part of the course is devoted to an introduction to Big Data, with a focus on knowledge extraction via forecasting and data mining.

Keywords

Machine learning; Information systems; Deep learning; Forecasting; Time series; ERP; Databases; Data and text mining and analysis; Supply Chain Management; Reinforcement learning

Type or organisation of classes

1	Data pre-processing
2	Machine Learning
3	Supervised learning
4	Unsupervised learning
5	Introduction to Supply Chain Management and digital software and technologies
6	ERP: e-Prelude (configuration and use)
7	ERP: e-Prelude (practical application MRP2)
8	Implementing digital technologies, ERP market overview
9	Introduction to reinforcement learning and Markov decision process
10	Reinforcement learning methods (Monte Carlo, SARSA, Q-Learning)
11	Approximation methods in reinforcement learning
12	Time series analysis

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Inspect data quality	4. Analyse	Lecture Practical work	Written assignment	Thinking-based approach
Choose and implement a method for data pre-processing	4. Analyse		Written assignment	Thinking-based approach
Distinguish between different learning approaches (supervised, unsupervised)	5. Assess		Group oral presentation	Justification of choices Clarity of presentation Media quality
Choose and implement a machine learning model	5. Assess		Project report	Justification of choices Quality of deliverables
Experiment with ERP software	3. Apply		MCQs	Accuracy of answers
Explain the MRP2 method	2. Understand		MCQs	Accuracy of answers
Explain and experiment with reinforcement learning	5. Assess		Technical report Project report	Quality of deliverables Achievement of goals
Analyse and experiment with time series	4. Analyse		Technical report Project report	Quality of deliverables Achievement of goals

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 12: Ensure sustainable consumption and production patterns	Positive impact of data pre-processing on energy consumption in storage such as servers and warehouses. Supply chain management objectives (e.g. optimising the number of kilometres travelled in customer deliveries)	3
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Educational Component: Visits and Seminars

Educational Unit: IT and Technologies for the Supply Chain - Technological Challenges

Educational Component Director

Nabil ABSI

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B207

In-person class time (in hours)	21
Individual work time (in hours)	6
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	9

General description

Industry seminars and site visits complement the courses, giving students an additional practical understanding of supply chain management issues. These seminars and visits will be organised to cover the main modes of transport (road, rail, sea and air), while highlighting the contribution of information and communication technologies (ICT) to the production of goods and services. They will involve the main stakeholders in these fields.

Keywords

Logistics; Visits; Experience; Marine logistics; Rail logistics; Semiconductor manufacturing; Transportation

Type or organisation of classes

1	Marine logistics (CMA-CGM)
2	Multimodal transport seminar (CityWay)
3	Rail transport seminar (SNCF)
4	Air transport seminar (AMADEUS)
5	Visit to the port of Marseille and seminar on container shipping (GPMM)
6	Visit to a logistics platform (Airbus Helicopters, GEODIS or La Poste)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the basic concepts and decision-making issues related to supply chain planning	1. Remember	Lecture Seminars Visits	In progress	In progress
Understand how to model and solve decision-making problems related to supply chain planning	2. Understand			
Apply the methods best suited to the decision-making problems encountered	3. Apply			
Analyse the decision-making level and complexity of the problem encountered	4. Analyse			
Assess available resolution approaches	5. Assess			
Create algorithms suited to the decision-making problems encountered	6. Create			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Integration of new technologies	3
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Educational Unit: Mobility and Security (Technological Challenges)

Educational Unit Director

Nadia EL-MRABET

nadia.el-mrabet@mines-stetienne.fr

A216

Number of ECTS credits (European Credit Transfer Scale)	10
In-person class time (in hours)	165
Individual work time (in hours)	30
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understanding the challenges of security for communications and connected objects. The first part of the course is dedicated to securing trade, focusing on the techniques currently used and those under development. The second part of the Educational Unit is dedicated to hardware and cyber attacks. The last part helps students to understand the management of safety issues from both a technical and legal point of view.

Keywords

Encryption; Cryptanalysis; Cybersecurity; Biometrics; Certificates; Arithmetic; Regulations

Links between course sub-modules

The Educational Components dedicated to securing exchanges include the Educational Component on Advanced Encryption, which introduces current and future encryption methods, and the Educational Component on Algorithms for Encryption, which enables students to understand the issues involved in implementing encryption protocols, particularly arithmetic for large numbers.

Encrypting data secures exchanges, but it is still possible to compromise security either by applying cyber-attacks or hardware attacks, using implementation flaws to retrieve sensitive information. Two Educational Components are dedicated to these notions.

Finally, security management is studied theoretically with the management of public key certificates, the use of biometrics and RFID tags to authenticate people or products, but also legally with an analysis of various regulations including the GDPR.

Sub-modules

Advanced Encryption

Nadia EL MRABET

Algorithms for Encryption

Nadia EL MRABET

Software Security

Nadia EL MRABET

Attacks by Observation

Nadia EL MRABET

Fault Injection Attacks

Nadia EL MRABET

Biometrics

Nadia EL MRABET

RFID tags

Nadia EL MRABET

Web and Network Security

Nadia EL MRABET

Certificates

Nadia EL MRABET

Legal Aspects of Security

Nadia EL MRABET

Educational Component: Advanced Encryption

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	24
Individual work time (in hours)	16
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understanding the issues faced by engineers when deploying encryption solutions.

Keywords

Encryption; Protocols; Symmetrical; Asymmetrical; Post-quantum

Type or organisation of classes

1	Description of the issues and the various existing protocols.
2	Study of protocols or problems to be solved in groups of 3
3	Study of protocols or problems to be solved in groups of 3
4	Study of protocols or problems to be solved in groups of 3
5	Study of protocols or problems to be solved in groups of 3
6	Study of protocols or problems to be solved in groups of 3
7	Study of protocols or problems to be solved in groups of 3
8	Group presentation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse encryption tools to solve a given problem	4. Analyse	Flipped classroom	Presentation with supporting materials	Self-assessment and assessment by teacher
Understand the standards describing an encryption protocol	2. Understand	Flipped classroom	Presentation with supporting materials	Self-assessment and assessment by teacher
Implement encryption solutions	3. Apply	Flipped classroom	Presentation with supporting materials	Self-assessment and assessment by teacher

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	24
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	24

Bibliography

Essential

J.-M. Masereel, V. Nacheff, et E. Volte, *Evolution de la cryptographie à travers les âges : Cours, exercices corrigés, algorithmes en Scratch et Python*. Paris: Ellipses, 2024.

Educational Component: Algorithms for Encryption

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	18
Individual work time (in hours)	12
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understanding arithmetic problems useful for encryption.

Keywords

Encryption; Protocols; Finite bodies; Addition, subtraction, multiplication

Type or organisation of classes

1	Description of arithmetic issues and examples
2	Arithmetic development for ECC in software
3	Arithmetic development for ECC in software
4	Arithmetic development for ECC in software
5	Arithmetic development for ECC in software
6	Presentation of codes produced by students

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse the arithmetic required to develop encryption protocols	4. Analyse	Practical work Tutorials Monitoring	Written report	Quality of code and report
Develop an implementation architecture for an efficient arithmetic system	2. Understand	Practical work Tutorials Monitoring	Written report	Quality of code and report

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	24
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	24

Bibliography

Essential

H. Cohen, G. Frey, R. Avanzi, C. Doche, et T. Lange, *Handbook of Elliptic and Hyperelliptic Curve Cryptography: Theory and Practice*. Boca Raton: Chapman & Hall/CRC, 2005.

Educational Component: Software security

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	18
Individual work time (in hours)	18
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Learning and applying the principles of cyber attacks. Understanding how to protect computers and networks.

Keywords

Digital security; Cyber attacks; Networks

Type or organisation of classes

1	Definition
2	Presentation of current methods and tools
3	Tutorial - practical exercises
4	Tutorial - practical exercises

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand what a cyber attack is	2. Understand	Lecture	MCQs	Accuracy of answers
Analyse server resistance to known attacks	5. Assess	Practical work Tutorials	Report on practical work	NA
Use known attacks for pentesting	5. Assess	Practical work Tutorials	Report on practical work	NA

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	18
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	18

Educational Component: Theory and Practice of Attacks by Observation

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Olivier POTIN

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A225

In-person class time (in hours)	2
Individual work time (in hours)	15
Language(s) of instruction	French

General description

The objective of this Educational Component is based on three points:

- understanding the threats and vulnerabilities of electronic devices to information leakage,
- implementing a methodology for hardware attacks by measuring auxiliary channels (consumption, EM, etc.),
- studying countermeasures against these attacks.

Keywords

Information leakage assumptions and estimation; Unprofiled/profiled attacks; AES encryption algorithm; Countermeasure studies: masking/desynchronisation; Second-order attack; Resynchronisation; Jupyter notebook

Type or organisation of classes

1	Introduction and models of information leakage
2	Unprofiled / profiled attacks
3	Second-order attacks
4	Countermeasures
5	Post-processing of traces
6	Practical 1: Acquisition of EM traces from the execution of an AES encryption algorithm on unsecured CortexM3
7	Practical 2: Programming an AES correlation attack / Simulating and evaluating countermeasures

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Theorise information leakage mechanisms in electronic devices	4. Analyse	Lecture Tutorials Practical work	Technical report	Accuracy of answers Methodology Quality of deliverables Relevance of argumentation
Develop auxiliary channel attack methodologies	3. Apply			
Install a platform for measuring electromagnetic (EM) auxiliary channels	3. Apply			
Acquire EM traces on an electronic device	5. Assess			
Perform an attack on an AES encryption algorithm	6. Create			
Simulate a countermeasure	5. Assess			

Bibliography

Essential

S. Mangard, E. Oswald, et T. Popp, *Power Analysis Attacks: Revealing the Secrets of Smart Cards*, 1st ed. Softcover of orig. ed. 2007 édition. Springer, 2010.

Learn more

O. Savry, T. Hiscock, et M. E. Majihi, *Sécurité matérielle des systèmes - Vulnérabilité des processeurs et techniques d'exploitation : Vulnérabilité des processeurs et techniques d'exploitation*. Malakoff: Dunod, 2019.

Educational Component: Fault Injection Attacks on Secure Circuits

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Jean-Max DUTERTRE

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A223

In-person class time (in hours)	9
Individual work time (in hours)	3
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	9

General description

Understanding the concept of fault attacks on secure integrated circuits. Understanding the physical mechanisms of fault injection in a synchronous circuit linked to disturbances of the clock signal, power supply, and exposure to an EM interference or laser pulse. Understanding and implementing fault models associated with injection methods, in particular modelling faults at the level of instructions executed by a microcontroller. Understanding techniques for extracting information based on fault injection, in particular differential fault attacks (DFA) used to extract the secret key used by a symmetric encryption algorithm. Learning the main principles of hardware and software countermeasures against fault injection. Carrying out a fault attack. Experimental implementation of a fault attack (bypassing an identification function implemented on a microcontroller). The practical work is carried out either on a laser illumination bench or on an electromagnetic interference bench.

Keywords

Hardware attacks; Differential fault attacks (DFA); Laser fault injection (LFI); Electromagnetic injection (EMFI); Power glitch injection; Instruction skipping

Type or organisation of classes

1	Class (3 hours): Introduction to the concept of fault injection, description of physical mechanisms and associated fault models.
2	Class (3 hours): Microcontroller injection mechanisms, differential fault attacks, countermeasure principles.
3	Practical work (3): Experimental implementation of an LFI or EMFI fault attack (bypassing an identification function implemented on a microcontroller).

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Explain the physical mechanisms of fault injection	5. Assess	Lecture Practical work	Technical report	Achievement of goals Relevance of argumentation	Hardware security
Explain the concept of a differential fault attack	4. Analyse	Lecture	Self-assessment		
Propose countermeasures to fault injection attacks	3. Apply	Lecture Practical work	Technical report	Achievement of goals Relevance of argumentation	Hardware security
Perform a fault injection attack	5. Assess	Practical work	Technical report	Achievement of goals Relevance of argumentation	Hardware security

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	This Educational Component contributes to the development of resilient infrastructure. This infrastructure will make use of connected objects and systems using microcontrollers (sensitive to hardware attacks such as fault injection). In order to be adopted, these systems must be secure against attacks. The development of countermeasures against attacks will make them resilient.	N/A
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Bibliography

Essential

E. Prouff, G. Renault, M. Rivain, et C. O'Flynn, *Embedded Cryptography 1*. Newark: ISTE Ltd, 2025.

O. Savry, T. Hiscock, et M. E. Majihi, *Sécurité matérielle des systèmes - Vulnérabilité des processeurs et techniques d'exploitation : Vulnérabilité des processeurs et techniques d'exploitation*. Malakoff: Dunod, 2019.

Useful

K. Sakiyama, Y. Sasaki, et Y. Li, *Security of Block Ciphers: From Algorithm Design to Hardware Implementation*. Singapore: Wiley-IEEE Press, 2016.

Educational Component: Biometrics

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	12
Individual work time (in hours)	0
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understanding what biometrics is and the different tools used.

Keywords

Biometrics; Cases of use

Type or organisation of classes

1	Definition of biometrics
2	Presentation of current methods and tools
3	Tutorial - practical exercises
4	Tutorial - practical exercises

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand what biometrics is	2. Understand	Lecture	MCQs	Accuracy of answers
Analyse biometric tools	5. Assess	Practical work Tutorials	MCQs	Accuracy of answers

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	18
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	18

Educational Component: RFID Tags

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	6
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understand what RFID tags are, the security issues they are subject to, and what information they can leak.

Keywords

Digital security; IoT; RFID tags

Type or organisation of classes

1	Introduction to RFID tags
2	Presentation of current methods and tools

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand what a RFID tag is	2. Understand	Lecture	MCQs	Accuracy of answers
Understand what attacks they may be subject to	2. Understand	Practical work Tutorials	MCQs	Accuracy of answers

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	6
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	6

Educational Component: Web and Network Security

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	12
Individual work time (in hours)	12
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understanding the concept of certificates and the management of public key infrastructure.

Keywords

Certificates; Public key; Networks

Type or organisation of classes

1	Definition
2	Presentation of current methods and tools
3	Tutorial - practical exercises
4	Tutorial - practical exercises

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand what a certificate is	2. Understand	Lecture	MCQs	Accuracy of answers
Analyse high-layer network communications	5. Assess	Practical work Tutorials	Report on practical work	NA

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	18
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	18

Educational Component: Certification

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	6
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understanding the use of digital certificates.

Keywords

Digital security; Encryption; Certificates

Type or organisation of classes

1	Describing a certificate
2	Using a certificate

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand what a digital certificate is	2. Understand	Lecture	MCQs	Accuracy of answers
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Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	6
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	6

Educational Component: Legal Aspects of Encryption

Educational Unit: Mobility and Security - Technological Challenges

Educational Component Director

Nadia EL-MRABET

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A216

In-person class time (in hours)	6
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 9

General description

Understanding the standards, rights and rules governing data security.

Keywords

Digital security

Type or organisation of classes

1	Regulations on rights and security
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Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the regulations on rights and security	2. Understand	Lecture	MCQs	Accuracy of answers
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Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	This Educational Component is part of a lifelong learning programme designed to train future engineers	6
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Digital sovereignty is an issue for the future	6

Educational Unit: Biomedical Devices - Technological Challenges

Educational Unit Director

David MOREAU

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A331

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	54
Individual work time (in hours)	42
Language(s) of instruction	French / English
Sustainable Development Goals (SDGs)	3

General description

After a review of the fundamentals of biology, this Educational Unit provides an introduction to the theoretical bases of bioelectronics and applications in biodiagnostics and neuroscience. These lessons are supplemented by modules in medical imaging, biomechanics, biodiagnostics and specific development methodology, in order to open up career prospects in the medical device sector, in both research and industrial activities. On completion of the Educational Unit, students will be able to design a medical device as part of a technically and multiculturally multidisciplinary team, including doctors, and incorporating the concept of the patient. The overall aim is to open the doors of the biomedical engineering field to students.

Keywords

Medical devices; Bioelectronics; Biomechanics; Medical imaging; Neurosciences; Biodiagnostics; Multidisciplinarity; Multiculturalism

Links between course sub-modules

The various ECUEs provide an insight into the multidisciplinary nature of the biomedical field, including, for example, imaging, bioelectronics, biomechanics, etc., to enable students to appreciate the multitude of fields in the biomedical industry that can benefit from the skills they have acquired throughout their course. Without this being delimited by each ECUE, the multicultural nature of the field, involving doctors, patients, engineers, researchers, economic players, etc., is integrated into the UE by the diversity of the contributors. All of this is enhanced by specific discoveries in the biomedical field, with a presentation of the classification of medical devices, the standards to be met, a presentation of the diagnostics market, visits to hospital departments and participation in live surgery.

Sub-modules

Introduction to biology

O'CONNOR Rodney

Neuroscience

MOREAU David

Contemporary research in bioelectronics

REZAEI-MAZINANI Charles

Medical Imaging

MOREAU David

Biodiagnostics

MOREAU David

Biomechanics

MOREAU David

Medical Device Design

MOREAU David

Educational Component: Introduction to Biology

Educational Unit: Biomedical Devices - Technological Challenges

Educational Component Director

Rodney O’CONNOR

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A339

In-person class time (in hours)	21
Individual work time (in hours)	13.5
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	3

General description

The aim of this Educational Component is to provide an introduction to the elements of biology necessary to understand the techniques and materials used in the field of biomedical instrumentation and engineering at different levels of observation.

Keywords

Cellular biology; Molecular biology; Physiology

Type or organisation of classes

1	Introduction to the world of biology
2	Components of eukaryotic cells and how they function
3	Components of eukaryotic cells and how they function
4	Types of cells and organisation of tissues
5	Types of cells and organisation of tissues
6	Physiology of the immune system, cardiovascular system and cancer
7	Physiology of the immune system, cardiovascular system and cancer

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Identify the main components of biological tissue	1. Remember	Lecture	MCQs	Accuracy of answers
Understand how a biological cell functions	2. Understand	Lecture	MCQs	Accuracy of answers
Understand how the immune and cardiac systems function	2. Understand	Lecture	MCQs	Accuracy of answers
Understand the different developmental phases of cancer	2. Understand	Lecture	MCQs	Accuracy of answers

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	This Educational Component takes place in a context with biomedical applications	34.5
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Bibliography

- B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, et P. Walter, *Molecular Biology of the Cell*, 5e édition. New York : Garland Publishing Inc, 2007.
- J. Berg, G. J. Gregory, H. Justin, T. John, et S. Lubert, *Biochemistry*, Tenth édition. Austin Boston New York Plymouth : W.H.Freeman & Co Ltd, 2023.
- R. Skloot, *The Immortal Life of Henrietta Lacks*. Picador, 2023.
- G. J. Tortora et B. H. Derrickson, *Principles of Anatomy & Physiology*, 16e édition. Wiley, 2020.

Educational Component: Neuroscience

Educational Unit: Biomedical Devices - Technological Challenges

Educational Component Director

David MOREAU

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A331

In-person class time (in hours)	30
Individual work time (in hours)	19
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

The aim of this Educational Component is to provide an introduction to the elements of biology necessary to understand the techniques and materials used in the field of biomedical instrumentation and engineering at different scales of observation.

Keywords

Cellular biology; Molecular biology; Physiology

Type or organisation of classes

1	Introduction to the world of biology
2	Components of eukaryotic cells and how they function
3	Components of eukaryotic cells and how they function
4	Types of cells and organisation of tissues
5	Types of cells and organisation of tissues
6	Physiology of the immune system, cardiovascular system and cancer
7	Physiology of the immune system, cardiovascular system and cancer

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Identify the main components of biological tissue	1. Remember	Lecture	MCQs	Accuracy of answers
Understand how a biological cell functions	2. Understand	Lecture	MCQs	Accuracy of answers
Understand how the immune and cardiac systems function	2. Understand	Lecture	MCQs	Accuracy of answers
Understand the different developmental phases of cancer	2. Understand	Lecture	MCQs	Accuracy of answers

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	This Educational Component takes place in a context with biomedical applications	49
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Bibliography

M. Bear, B. Connors, et M. A. Paradiso, *Neuroscience: Exploring the Brain, Enhanced Edition: Exploring the Brain, Enhanced Edition*, 4th edition. Burlington: Jones & Bartlett Learning, 2020.

E. R. Kandel, J. H. Schwartz, T. M. Jessell, S. A. Siegelbaum, et A. J. Hudspeth, Éd., *Principles of Neural Science*, 5th edition. New York: McGraw-Hill Education / Medical, 2012.

Educational Component: Contemporary Research in Bioelectronics

Educational Unit: Biomedical Devices - Technological Challenges

Educational Component Director

Charles REZAEI-MAZINANI

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A340

In-person class time (in hours)	15
Individual work time (in hours)	9.5
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	3

General description

The aim of this ECUE is to familiarise students with current research in bioelectronics. This involves a review of the original literature published in recent years. The introduction provides broad overview of organic electronics. This approach will begin by describing the electronic properties of conjugated materials and progress to the operation of devices.

Keywords

Bioelectronics; Microfabrication; Neurotechnologies; Organic electronics

Type or organisation of classes

1	Introduction to organic electronics and the materials used
2	Research in optoelectronics
3	Neurotechnologies: from manufacture to use
4	Practical: Electrochemical characterisation and biological testing
5	Practical: Electrochemical characterisation and biological testing

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Differentiate between the concepts of organic and inorganic electronics	2. Understand	Lecture	Group oral presentation	Critical analysis Clarity of presentation Media quality
Understand how neurotechnological devices are manufactured	2. Understand	Lecture Lecture	Group oral presentation	Critical analysis Clarity of presentation Media quality
Identify applications for organic bioelectronics	2. Understand	Lecture	Group oral presentation	Critical analysis Clarity of presentation Media quality
Differentiate between the concepts of organic and inorganic electronics	2. Understand	Lecture	Group oral presentation	Critical analysis Clarity of presentation Media quality

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	This Educational Component takes place in a context with biomedical applications	24.5
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R. R. Pethig et S. Smith, *Introductory Bioelectronics: For Engineers and Physical Scientists*. Chichester, West Sussex: John Wiley & Sons Inc, 2012.

Educational Component: Medical Imaging

Educational Unit: Biomedical Devices - Technological Challenges

Educational Component Director

David MOREAU

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A331

In-person class time (in hours)	9
Individual work time (in hours)	5.5
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	3

General description

The aim of this Educational Component is to develop knowledge of the interaction between electromagnetic waves and living tissue, and to present medical imaging technologies, their development and applications.

Keywords

Medical imaging; Interaction between waves and living tissue

Type or organisation of classes

1	Interaction between waves and biological tissue
2	Medical imaging technologies: principles, developments, applications
3	Medical imaging technologies: principles, developments, applications - assessment

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand the mechanisms of interaction between waves and tissue	2. Understand	Lecture Case study	Individual written report	Thinking-based approach Critical analysis
Associate imaging techniques with their applications, possibilities and limitations	1. Remember			
Critique a scientific article based on the concepts covered in this course	4. Analyse			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	This Educational Component takes place in a context with biomedical applications	14.5
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Educational Component: Biodiagnostics

Educational Unit: Biomedical Devices - Technological Challenges

Educational Component Director

David MOREAU

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A331

In-person class time (in hours)	18
Individual work time (in hours)	11.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

This Educational Component offers students the opportunity to discover the state of the art in biomedical diagnostics in relation to DNA and emerging technologies in this field, to discover the international medical diagnostics market (with a focus on Europe and France) and to consider future developments, with the emergence of personalised medicine.

Keywords

DNA; PCR; Diagnostics market; Personalised medicine

Type or organisation of classes

1	DNA, amplification and quantification (1)
2	DNA, amplification and quantification (2)
3	In silico molecular biology
4	In silico molecular biology
5	The medical diagnostics market and healthcare costs
6	Personalised medicine

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand DNA and related technologies	2. Understand	Lecture Practical work	Proactive approach	Active participation Professional skills
Use genomic databases	3. Apply	Lecture - Practical work	Proactive approach	Active participation Professional skills
Correlate and analyse genotyping results with databases	4. Analyse	Lecture - Practical work	Proactive approach	Active participation Professional skills
Describe the medical diagnostics market	2. Understand	Lecture	Proactive approach	Active participation Professional skills
Anticipate the future of medical diagnostics	6. Create	Lecture	Proactive approach	Active participation Professional skills

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	This Educational Component takes place in a context with biomedical applications	29.5
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Educational Component: Biomechanics

Educational Unit: Biomedical Devices - Technological Challenges

Educational Component Director

David MOREAU

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A331

In-person class time (in hours)	18
Individual work time (in hours)	11.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

This Educational Component aims to provide students with an understanding of how the musculoskeletal system works, the development processes of biological tissues and the mechanobiological phenomena involved in the osteoarticular system. Students will analyse the results of a model of the biomechanical behaviour of a bone/implant system and learn how to interact with medical staff on a number of clinical issues.

Keywords

Biomechanics; Musculoskeletal system; Biomechanical modelling; Interaction with medical staff

Type or organisation of classes

1	General introduction to biomechanics / Bone tissue
2	Bone tissue (continued)
3	Bone development, remodelling and dysfunction
4	Biomaterials, biocompatibility
5	Live hip/knee replacement surgery - discussion with medical staff
6	Mechanical behaviour of bones and bone tissue Presentation of doctoral students' work

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Understand how the musculoskeletal system works	2. Understand	Lecture Lecture Passive participation in live surgery	MCQs	Accuracy of answers
Understand the development processes of biological tissues	2. Understand	Lecture Lecture Passive participation in live surgery	MCQs	Accuracy of answers
Understand the mechanobiological phenomena occurring in the osteoarticular system	2. Understand	Lecture Lecture Passive participation in live surgery	MCQs	Accuracy of answers
Analyse the results of biomechanical behaviour modelling of a bone/implant system	4. Analyse	Lecture Lecture Passive participation in live surgery	MCQs	Accuracy of answers
Interact with medical staff on a number of clinical issues	4. Analyse	Lecture Lecture Passive participation in live surgery	Active discussion between surgeon and medical staff and students	Active participation Professional skills

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	This Educational Component takes place in a context with biomedical applications	23.5
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Educational Component: Medical Device Design

Educational Unit: Biomedical Devices - Technological Challenges

Educational Component Director

David MOREAU

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A331

In-person class time (in hours)	18
Individual work time (in hours)	11.5
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3

General description

The aim of this Educational Component is to develop the concept of innovation in medical devices, through two aspects: a general methodology, developed by Stanford University's BioDesign, with which the Eurobiomed competitiveness cluster (involved in this Educational Component) has signed a partnership agreement, and the development of this methodology in France. This methodology will focus on the development of new medical devices to meet the challenges of ageing and independent living for the elderly. This Educational Component also allows students to work in groups on an innovation theme, applying theoretical concepts.

Keywords

Biomedical devices; Innovation

Type or organisation of classes

1	Medical devices: history, definition, classification, regulation, market, financing, evaluation
2	Innovation: definition, impact, methodology, issues
3	A medical and technological case study
4	A medical and technological case study
5	Feedback report (assessment)
6	Feedback report (assessment)

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Develop the concept of innovation in medical devices	3. Apply	Lecture Problem-based approach Teamwork	Group oral presentation	Thinking-based approach Clarity of presentation Media quality
Understand the classification, regulation, market, financing and evaluation of medical devices	2. Understand	Lecture Problem-based approach Teamwork	Group oral presentation	Thinking-based approach Clarity of presentation Media quality

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	This Educational Component takes place in a context with biomedical applications	29.5
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Educational Unit: Innovation Management

Educational Unit Director

Thibaut METAILLER

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A316

Number of ECTS credits (European Credit Transfer Scale)	2
In-person class time (in hours)	18
Individual work time (in hours)	30
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	4, 7, 9, 16

General description

The aim is to approach and experiment with the principles of innovation management, focusing on aspects of responsibility and sustainability within organisations and society. This Educational Unit is designed to clearly identify the roles and activities of engineers in innovation and society.

Keywords

Innovation management; Responsible innovation; Organisational learning; Innovation and technology; Change management

Sub-modules

Innovation Management
Thibaut METAILLER
Case study
Thibaut METAILLER

Educational Component: Innovation Management

Educational Unit: Innovation Management

Educational Component Director

Thibaut METAILLER

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A316

In-person class time (in hours)	12
Individual work time (in hours)	12
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 7, 9, 16

General description

The aim is to approach and experiment with the principles of innovation management, focusing on aspects of responsibility and sustainability within organisations and society.

Keywords

Innovation management; Responsible innovation; Organisational learning; Innovation and technology; Change management

Type or organisation of classes

1	What is innovation?
2	Innovation, business and society
3	Organisational learning and innovation from SMEs to large corporations
4	Innovation management and change management

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse innovation needs and issues (from technology to implementation)	4. Analyse	Lecture Flipped classroom	Written report	Critical analysis Thinking-based approach Commitment Justification of choices Methodology Active participation Relevance of argumentation
Assess the challenges and criteria of technological and organisational innovation	5. Assess	Case study	Group oral presentation Self-evaluation	
Create a responsible innovation approach	6. Create	Project-based learning	Group oral presentation	
Define key concepts related to innovation management	2. Understand	Lecture Flipped classroom	Peer assessment and report	

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Discussions on learning organisations	3
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Reflecting on resource issues in innovation, critiquing technology-intensive approaches to innovation	2
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Approaching innovative organisations and organisational cultures conducive to innovation	6
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Debate on innovation and the role of business in society	2

Educational Component: Case Study

Educational Unit: Innovation Management

Educational Component Director

Thibaut METAILLER

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A316

In-person class time (in hours)	6
Individual work time (in hours)	12
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	7, 9, 16

General description

The aim is to approach and experiment with the principles of innovation management, focusing on aspects of responsibility and sustainability within organisations and society.

Keywords

Innovation management; Responsible innovation; Organisational learning; Innovation and technology; Change management

Type or organisation of classes

1	Case study: Tesla, an innovative company?
2	Case study: organisational transformation and innovation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Analyse innovation needs and issues (from technology to implementation)	4. Analyse	Case study	Written report Oral presentation	Critical analysis Thinking-based approach Justification of choices Relevance of argumentation
Assess the challenges and criteria of technological and organisational innovation	5. Assess	Case study	Written report Oral presentation	
Create a responsible innovation approach	6. Create	N/A	N/A	N/A
Define key concepts related to innovation management	2. Understand	N/A	N/A	N/A

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Reflecting on resource issues in innovation, critiquing technology-intensive approaches to innovation	3
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Approaching innovative organisations and organisational cultures conducive to innovation	6
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Debate on innovation and the role of business in society	3

Educational Unit: Professional Life: The Essentials

Educational Component Director

Maxime MALAFOSSE

maxime.malafosse@emse.fr

A319

Number of ECTS credits (European Credit Transfer Scale)	3
In-person class time (in hours)	39
Individual work time (in hours)	33
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3, 4, 5, 16

General description

Enabling students to make informed career choices, in line with their personality, to succeed in recruitment interviews and thrive in jobs that motivate them. This Educational Unit helps students develop the collaborative, strategic and professional skills essential for a successful career. Students will learn to understand organisational dynamics to optimise collective potential, acquire the basics of principled negotiation, and explore engineering professions through examples, in order to fine-tune their choice of career.

Keywords

Motivation; Organisation theory; Cooperation; Negotiation; Career choice; Personal branding; Interview techniques; Digital technology and recruitment; Employment contracts

Links between course sub-modules

Development of interpersonal skills combined with an understanding of engineering professions and preparation for recruitment. Leveraging collective potential and principled negotiation strengthens collaboration, while recruitment workshops and simulations, as well as the digital recruitment conference, provide students with practical preparation for successful interviews and help them find the right career path.

Sub-modules

The Fundamentals: Processes, Power, Negotiation, Orientation
--

Maxime MALAFOSSE

Preparation for Recruitment

Maxime MALAFOSSE

Educational Component: Motivations, Issues, Negotiation, Career Choices

Educational Unit: Professional Life: The Essentials

Educational Component Director

Maxime MALAFOSSE

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A319

In-person class time (in hours)	21
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	3, 5, 16

General description

This Educational Component aims to help students develop the collaborative, strategic and professional skills essential for successful career choices and development. It will enable students to:

- Understand and appreciate organisational dynamics in order to optimise collective potential and contribute effectively to collaborative projects.
- Acquire the basics of reasoned negotiation by developing communication and conflict management skills to reach balanced and sustainable agreements.
- Explore engineering professions, their challenges and opportunities, drawing on feedback from former students and professionals, in order to better guide their career choices.

Keywords

Motivation; Organisation theory; Cooperation; Negotiation; Career choices

Type or organisation of classes

1	Appreciating the collective potential of the organisation
2	Reasoned negotiation
3	Engineering professions

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Appreciate the collective potential of the organisation	3. Apply	Case study	Pass/fail	Active participation
Reasoned negotiation	3. Apply	Tutorials	Pass/fail	Active participation
Engineering professions	2. Understand	Tutorials	Pass/fail	Active participation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 3: Ensure healthy lives and promote well-being for all at all ages	Discussing disability in the corporate world and the construction of prejudices in order to better combat them	N/A
Goal 5: Achieve gender equality and empower all women and girls	Expressing personal beliefs about equality in an interview	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Carefully preparing for recruitment and thinking through personal goals can help promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	3

Educational Component: Preparation for Recruitment

Educational Unit: Professional Life: The Essentials

Educational Component Director

Maxime MALAFOSSE

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A319

In-person class time (in hours)	18
Individual work time (in hours)	4
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 5, 16

General description

Enabling students to make more informed career choices in line with their personality, maximising their chances of success in interviews for jobs that truly motivate them.

Keywords

Personal branding; Interview techniques; Digital technology and recruitment; Employment contracts

Type or organisation of classes

1	Recruitment workshop
2	Skills identification workshop
3	Digital recruitment conference
4	Recruitment simulation
5	Employment contracts

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Create a recruitment strategy	5. Assess	Tutorials	Pass/fail	Active participation
Identify own skills	4. Analyse	Tutorials	Pass/fail	Active participation
Perform in recruitment interviews	3. Apply	Tutorials	Pass/fail	Active participation
Identify the elements of an employment contract	2. Understand	Tutorials	Pass/fail	Active participation

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	The culmination of quality education and scientific endeavour	3
Goal 5: Achieve gender equality and empower all women and girls	Expressing personal beliefs about equality in an interview	3
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Carefully preparing for recruitment and thinking through personal goals can help promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	8

Educational Unit: Languages and Cultures

Educational Unit Director

Samantha CHIN

samantha.chin@emse.fr

A106

Number of ECTS credits (European Credit Transfer Scale)	4
In-person class time (in hours)	42.5
Individual work time (in hours)	29.5
Language(s) of instruction	English, Chinese, French as a Foreign Language, German, Japanese, Portuguese, Spanish
Sustainable Development Goals (SDGs)	1, 4, 5, 8, 10, 13, 16

General description

Modern languages at the heart of engineering students' training

As part of their training, engineering students are taught modern languages with a strong professional and international focus. The aim is to complement their technical and scientific knowledge with the development of high-level linguistic and intercultural skills, essential for their development in a multicultural environment.

Requirements and certifications

Fluency in English (1st foreign language) is a priority, with a minimum requirement of 800 TOEIC points or 90 TOEFL IBT points, as well as a B2 level according to the Common European Framework of Reference for Languages (CEFR), certified by the School. A second modern language (Spanish, German, Chinese, Japanese, French or Portuguese) is also taught, with the aim of ensuring operational proficiency adapted to the needs of engineers in an international context.

Professional and intercultural skills

The language teaching takes a pragmatic approach, with a strong focus on communication needs in concrete professional situations. This course helps to equip our future engineers with the tools they need to collaborate effectively in a global and multicultural environment, facilitating their professional integration and international mobility.

Keywords

English; Chinese; French as a Foreign Language; German; Japanese; Portuguese; Spanish

Links between course sub-modules

Objectives common to all Educational Components

Sub-modules

English
Samantha CHIN

Modern Languages 2 (2nd foreign language)
Samantha CHIN

Educational Component: English

Educational Unit: Languages and Cultures

Educational Component Director

Samantha CHIN

samantha.chin@emse.fr

A106

In-person class time (in hours)	7
Individual work time (in hours)	21
Language(s) of instruction	English
Sustainable Development Goals (SDGs)	1, 4, 5, 8, 13, 16

General description

(Level B2/C1) - Developing advanced oral and written communication skills in English, suited to professional and technical contexts, through presentations, debates and writing complex reports. Improving the ability to analyse and assimilate technical information in English, in order to reproduce the most relevant elements in international professional situations. Fostering intercultural openness and the ability to work in English in multicultural environments, with an emphasis on interaction and mediation.

Keywords

Communication; Presentation; Technical report; Debate; Interaction; Analysis; Mediation; Intercultural skills; Certification (TOEIC); Professional context

Type or organisation of classes

1	7 tutorials in pairs or threes
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Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to (target: B1+/B2 level):

Take part in a debate on a technical or intercultural topic.	5. Assess	Group debate simulation with role-playing.	Teacher observation and feedback.	Relevance of arguments, interaction and compliance with the debate framework.
Use technical terms to analyse a text in English.	4. Analyse	Analytical reading and class discussion.	Multiple-choice questions or written exercises.	Understanding of vocabulary, precision of analysis and summary.
Collaborate effectively on team projects.	6. Create	Group project, such as a report or presentation.	Assessment of the final product and collaboration.	Originality, individual contribution, relevance and respect for deadlines.

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	Analysing texts in English to understand the causes of poverty in the world and solutions.	N/A
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Debating in English about educational inequalities in different countries.	N/A
Goal 5: Achieve gender equality and empower all women and girls	Expressing ideas and proposing solutions on gender equality issues.	N/A
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Proposing innovative solutions in English for sustainable economic development.	N/A
Goal 13: Take urgent action to combat climate change and its impacts	Developing arguments in English to support action to fight climate change.	N/A
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Giving arguments on ways to create inclusive societies in an international context.	N/A

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Educational Component: Modern Languages 2 (2nd foreign language)

Educational Unit: Languages and Cultures

Educational Component Director

Samantha CHIN

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A106

In-person class time (in hours)	24.5
Individual work time (in hours)	41.5
Language(s) of instruction	Chinese, French as a Foreign Language, German, Japanese, Portuguese, Spanish
Sustainable Development Goals (SDGs)	4, 8, 10, 13, 16

General description

Level B2/B2+/C1: This Educational Unit aims to enable students to develop advanced and specialised skills to succeed in international academic and professional environments. Students will learn to master written and oral communication in complex contexts, in particular for writing professional documents, making presentations, and handling intercultural negotiations. The module focuses on the ability to analyse intercultural situations and adapt to diverse professional and academic contexts, preparing students to undertake study or work projects abroad in line with their professional and personal goals.

Level A2+/B1/B1+: This Educational Unit aims to provide students with the linguistic and cultural foundations essential to communicating in simple everyday and professional situations. Students will learn to introduce themselves, exchange basic information with fluency and understand the essential cultural aspects of the target language. The module also focuses on developing the adaptability and intercultural skills required to interact effectively in multicultural environments, in order to support students' integration into diverse international and cultural professional contexts.

Keywords

Career management; International travel; Cultural diversity; Specialised writing; Business discussion techniques; Introducing oneself; Flexibility; Professional expression; Multicultural exchange; Language skills

Type or organisation of classes

1	14 classes
2	7 tutorials

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Level B2/B2+/C1				
Listen to and analyse complex arguments in intercultural contexts to make decisions or resolve professional situations.	5. Assess	Discussions on complex case studies.	Observation during debates and discussions.	Ability to identify key points and react appropriately.
Use digital tools to create presentations and professional reports tailored to multicultural contexts.	3. Apply	Preparing presentations using digital tools.	Observation of classroom presentations.	Relevant content, appropriate use of digital tools.
Communicate effectively in professional and intercultural contexts, adapting language to suit the context and participants.	3. Apply	Role-playing, simulations of intercultural meetings.	Classroom observation and oral exercises.	Fluency, precision, contextual relevance.
Write clear, structured professional documents (reports, emails, letters) that meet the expectations of a professional context.	4. Analyse	Writing reports or letters for professional purposes.	Correction and feedback on written texts.	Consistency, use of formal conventions.
Analyse complex intercultural situations, identify cultural and social issues, and propose appropriate problem-solving solutions.	5. Assess	Case studies, interactive debates.	Observation during discussions.	Relevance of solutions, depth of analysis.
Actively participate in multicultural presentations, presenting ideas in a clear, structured way and encouraging interaction with other participants.	4. Analyse	Preparing and presenting professional presentations.	Observation during presentations.	Impact, clarity, interaction.

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to (target: B1+/B2 level):

Level A2+/B1/B1+				
Interact simply but effectively in group situations, using appropriate basic vocabulary.	3. Apply	Group discussions on simple topics.	Classroom observation and oral assessment.	Interaction, fluency, appropriate use of vocabulary.
Adapt speech to suit the audience and communication objectives in simple contexts.	2. Understand	Presentation exercises in front of the class.	Individual oral or written presentation.	Clarity, relevance of message, adaptation to audience.
Use simple phrases to introduce themselves and communicate basic information in everyday situations.	1. Recognise	Role-playing everyday scenarios.	Simple oral assessment (introducing oneself, asking for information).	Correct pronunciation, comprehension.
Introduce themselves, exchange personal information and understand the cultural practices involved in basic interaction in a given context.	2. Understand	Guided dialogues and interactive activities.	Individual oral or written presentation.	Clarity, fluency, cultural adaptation.
Reproduce simple grammatical structures (sentences, conjugations) to express basic ideas accurately.	3. Apply	Practical grammar exercises.	Multiple-choice questions or written exercises.	Grammatical accuracy, observance of basic rules.
Discover and integrate fundamental cultural elements to improve interaction in social and professional contexts.	2. Understand	Discussion and analysis of local customs.	Quiz or presentation on a cultural topic.	Cultural understanding, relevance.

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	(Depending on level) Developing the intercultural and linguistic skills needed to operate in an international academic or professional environment.	N/A
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	(Depending on level) Raising awareness of social, ethical and legal standards for internships and jobs in different countries, to promote successful integration.	N/A
Goal 10: Reduce inequality within and among countries	(Depending on level) Analysis of cultural and economic inequalities between different countries to prepare students for diverse environments.	N/A
Goal 13: Take urgent action to combat climate change and its impacts	(Depending on level) Introduction to sustainable practices applied to international mobility (reducing the carbon footprint of travel, choosing eco-responsible destinations).	N/A
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	(Depending on level) Training on inclusive and ethical behaviour in international environments, promoting effective collaboration in multicultural teams.	N/A

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SYLLABUS ISMIN

2025 – 2026

Semester 10

Direction de la Formation - ISMIN
Mines Saint-Etienne
June 2025

Semester 10

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Educational Unit: Innov’Action

Educational Unit Director

Thibaut METAILLER

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A316

Number of ECTS (European Credits Transfer Scale)	2
In-person class time (in hours)	24
Individual work time (in hours)	6
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	1 to 17 (potentially)

General description

The aim of this course is to raise participants’ awareness of technological innovation through prototyping activities, including technological and economic aspects (identifying new markets in marketing classes), collaborative aspects (collective creativity with partner students from Pépite and AMU) and methodological aspects (project management, design thinking). This course takes the form of a three-day seminar.

Keywords

Prototyping; Entrepreneurship; Interdisciplinary collaboration; Responsible innovation; Change management

Links between course sub-modules

This Educational Unit a comprehensive seminar led by a specialised consulting firm

Sub-modules

Innov’Action (3 days)
Thibaut METAILLER

Educational Component: Innov'Action

Educational Unit: Innov'Action

Educational Component Director

Thibaut METAILLER

thibaut.metailler@emse.fr

A316

In-person class time (in hours)	24
Individual work time (in hours)	6
Language(s) of instruction	French
Sustainable Development Goals (SDGs)	4, 7, 9, 16

General description

The aim of this course is to raise participants' awareness of technological innovation through prototyping activities, including technological and economic aspects (identifying new markets in marketing classes), collaborative aspects (collective creativity with partner students from Pépite and AMU) and methodological aspects (project management, design thinking). This course takes the form of a three-day seminar.

Keywords

Prototyping; Entrepreneurship; Interdisciplinary collaboration; Responsible innovation; Change management

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Mobilise design thinking approaches	5. Assess	Seminar Experiential learning	Group oral presentation	Critical analysis Anticipation Creativity Thinking-based approach Commitment Professional conduct
Apply prototyping methodologies	4. Analyse			
Appreciate teamwork	5. Assess			
Communicate and present a project	4. Analyse			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals:

Goal 1: End poverty in all its forms everywhere	Topic to be addressed will depend on the project developed	24
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Topic to be addressed will depend on the project developed	24
Goal 3: Ensure healthy lives and promote well-being for all at all ages	Topic to be addressed will depend on the project developed	24
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Topic to be addressed will depend on the project developed	24
Goal 5: Achieve gender equality and empower all women and girls	Topic to be addressed will depend on the project developed	24

Goal 6: Ensure availability and sustainable management of water and sanitation for all	Topic to be addressed will depend on the project developed	24
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Topic to be addressed will depend on the project developed	24
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	Topic to be addressed will depend on the project developed	24
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Topic to be addressed will depend on the project developed	24
Goal 10: Reduce inequality within and among countries	Topic to be addressed will depend on the project developed	24
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Topic to be addressed will depend on the project developed	24
Goal 12: Ensure sustainable consumption and production patterns	Topic to be addressed will depend on the project developed	24

Goal 13: Take urgent action to combat climate change and its impacts	Topic to be addressed will depend on the project developed	24
Goal 14: Conserve and sustainably use the oceans, sea and marine resources for sustainable development	Topic to be addressed will depend on the project developed	24
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	Topic to be addressed will depend on the project developed	24
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels	Topic to be addressed will depend on the project developed	24
Goal 17: Strengthen the means of implementation and revitalise the global partnership for sustainable development.	Topic to be addressed will depend on the project developed	24

Educational Unit: Workshop

Educational Unit Director

Bernard DHALLUIN

dhalluin@emse.fr

A229

Number of ECTS (European Credits Transfer Scale)	1
In-person class time (in hours)	30
Individual work time (in hours)	10
Language(s) of instruction	French

General description

Exploration of themes complementary to the fields studied in the ISMIN programme.

Keywords

Scientific exploration; Multidisciplinarity

Links between course sub-modules

This Educational Unit consists of a single Educational Component. However, students choose one of 6 or 7 topics. The different topics available change every year.

For example, the topics proposed in 2024 were:

Sub-modules

Design for Digital Services

François JAUJARD

Cleanroom Production of OLED Pixels

Sébastien SANAUR

Cleanroom Production of MOS Components and Circuits

Bernard DHALLUIN

Artificial Intelligence and Digital Twin

Christophe LOUSSERT

Deep Learning

Olivier PHILIP

Secure, Analog Platform for Smartphone eSIMs

Clément CHAMPEIX, Nicolas BORREL

Cryptocurrencies, Tokenisation and Decentralised Finance

Justine DESTOBBELEIRE

Creation of IOS Applications

Jessy NAUSS

Educational Component: Workshop: Design for Digital Services

(Workshop example)

Educational Unit Director

Maxime MALAFOSSE

dhalluin@emse.fr

A319

Number of ECTS (European Credits Transfer Scale)	1
In-person class time (in hours)	30
Individual work time (in hours)	0
Language(s) of instruction	French

General description

The aim of the “Design for Digital Services” workshop week is to enable students to develop an integrated approach to design in the context of creating digital services. The programme combines several complementary dimensions: image analysis to develop critical thinking, an introduction to graphic design to master the basics of visual communication, prototyping sessions to bring concepts to life, and a theoretical overview of creation to fuel reflection. This framework aims to combine practice and theory to equip students with the tools they need for their digital design projects.

Keywords

Design; Image; Digital uses; Graphic design; Photography; Programming

Type or organisation of classes

1	Start of the workshop
2	Choice of topics
3	Introduction to Design and choice of graphic codes
4	Development of features and interfaces
5	Prototyping
6	Exploration of artistic aspects

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
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Upon completion of the Educational Component, students will be able to:

Create a digital service that meets user expectations	3. Apply	Interdisciplinary project	Group oral presentation	Quality of deliverables
Identify suitable images for projects	4. Analyse			
Engage in reflection on creative aspects	6. Create			

Educational Unit: Research Project

Educational Unit Director

Agnès ROUSSY

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B206

Number of ECTS (European Credits Transfer Scale)	4
In-person class time (in hours)	3
Individual work time (in hours)	157
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	7, 9, 11

General description

Carry out an assignment in a research and development environment: analysis, design, implementation of a scientific or technical project.

Secondary objectives:

- The role of an engineer in a research laboratory
- Gaining perspective on the knowledge acquired throughout the programme
- Demonstrating a range of skills: technical, methodological, behavioural and managerial

Keywords

Project; Research and development; Group work

Links between course sub-modules

This Educational Unit consists of a single Educational Component

Sub-modules

Research project
Agnès ROUSSY

Educational Component: Research Project

Educational Unit Director

Agnès ROUSSY

roussy@emse.fr

B206

Number of ECTS (European Credits Transfer Scale)	4
In-person class time (in hours)	3
Individual work time (in hours)	157
Language(s) of instruction	French, English
Sustainable Development Goals (SDGs)	7, 9, 11

General description

Carry out an assignment in a research and development environment: analysis, design, implementation of a scientific or technical project.

Secondary objectives:

- The role of an engineer in a research laboratory
- Gaining perspective on the knowledge acquired throughout the programme
- Demonstrating a range of skills: technical, methodological, behavioural and managerial

Keywords

Project; Research and development; Group work

Type or organisation of classes

1	Understanding of project
2	Review of the state of the art
3	Specifications for completing the project in one month
4	Distribution of tasks within the group
5	Carrying out the work
6	Preparing the report and presentation

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria	Platform
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Upon completion of the Educational Component, students will be able to:

Summarise a topic	2. Understand	Teamwork	Group written report Technical report Oral presentation	Critical analysis Achievement of goals Clarity of presentation Thinking-based approach Justification of choices Time management Quality of deliverables Soundness of reasoning Professional conduct Presentation structure	IDFab prototyping Cleanroom
Solve problems	4. Analyse	Research work			
Test theories	5. Assess	Project-based learning			
Mobilise learning to form a coherent and new entity	6. Create	Case study			

Sustainable Development Goals

SDGs	Contribution	Volume in hours
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This Educational Component contributes to achieving the following goals (depending on level):

Goal 7: Ensuring access to affordable, reliable, sustainable and modern energy for all	Some projects focus on energy	Variable
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	Innovation in many projects	Variable
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	Logistics-related projects	Variable

Educational Unit: Final Year Internship

Educational Unit Director

Emmanuelle RICORDEAU

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A111

Number of ECTS (European Credits Transfer Scale)	24
In-person class time (in hours)	6
Individual work time (in hours)	834
Language(s) of instruction	French, English (or any other language used during professional mobility)

General description

Main objective

Carry out a project involving research, analysis, design and implementation of a scientific or technical project or development.

Secondary objectives

- Confirm career plans through practical experience
- Master standard job search communication tools (CV, cover letter, interview)
- Practical application of the knowledge acquired throughout the programme
- Demonstrate a range of skills: technical, methodological, behavioural and managerial
- Develop an approach to engineering that leads to the gradual assumption of responsibilities

Keywords

Internship; Company; International experience; Interculturality; Engineer; Mobility; Professional; Autonomy

Educational Component

At the start of Semester 9 (S9), students are given the same opportunity as in their second year (2A) to find out more about the engineering professions, and to test themselves against real-life recruiters (mock interviews).

The electronics and computer science electives, workshop or research project can be followed by an internship on the same topics, particularly in the specific framework of a research Master's degree.

The "professions", "sectors of activity" and "round table" modules explain how the Final Year Internship can be a natural way of gaining experience that will facilitate access to a first job.

The third-year internship (3A) confirms the student's career plan and is often in line with their choice of major and technological focus.

The 3A internship is an important part of the overall review of the ISMIN curriculum.

Educational Component

Final Year Internship

Emmanuelle RICORDEAU

Intended learning outcomes

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
----------------------------	----------------------	---------------------------	--------------------	---------------------

Upon completion of the Educational Component, students will be able to:

Carry out documentary research / identify resources	2. Understand	Internship	Project report Summary	Methodology Quality of deliverables Clarity of presentation
Plan / organise / manage the project / take a critical approach	5. Assess	Internship	Self-evaluation Written or oral presentation Gantt chart	Anticipation Achievement of goals Understanding of the subject Quality of deliverables Rigour Thinking-based approach
Acknowledge the human factor, evaluate it and use it to benefit the project	5. Assess	Internship	Assessment by company supervisor MCQs Group oral presentation Group written report	Critical analysis Achievement of goals Professional conduct
Identify and understand the host company's decision-making processes	2. Understand	Internship	Self-evaluation Assessment by company supervisor MCQs Individual oral presentation Individual written report	Accuracy of answers Understanding of the subject Active participation Rigour
Adopt responsible behaviour / assess the consequences of actions	5. Assess	Internship	Peer assessment	Professional conduct Thinking-based approach Achievement of goals Active participation

Intended learning outcomes	Classification level	Type of teaching activity	Type of assessment	Assessment criteria
Use job search tools (CV, cover letter, interviews)	3. Apply	Internship	Written report, summary	Methodology Quality of deliverables Spelling and grammar Presentation structure
Think critically about a given result/situation	5. Assess	Internship	Assessment by company supervisor	Anticipation Critical analysis Accuracy of answers Justification of choices
Format and present work	4. Analyse	Internship	Internship report Individual presentation Individual written report Report on discoveries Company supervisor assessment sheet Assessment by academic supervisor	Quality of deliverables Presentation structure Speech Language skills Soundness of reasoning Time management
Produce a written report in English (for international internships)	6. Create	Internship	Written report Summary	Quality of deliverables English language skills



Direction de la Formation - ISMIN
Mines Saint-Etienne
June 2024