CENTRALE NANTES

# MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2025-2026

YEAR 1

## CONTROL AND ROBOTICS

## ELECTRIC VEHICLE PROPULSION AND CONTROL (E-PICO)

PROGRAMME SUPERVISOR(S):
Malek GHANES,Mohamed Assaad HAMIDA

# YEAR 1 - Autumn Semester

## CORE COURSES

| Course code | Title | ECTS Credits |
|---|---|---|
| COSYS | Control system | 4 |
| EVSIM | Electrical Vehicle Modelling and Simulation | 4 |
| EVSYS | Fundamentals of Electrical Vehicle System | 4 |
| MICRO | Embedded Computing | 4 |
| PROJECT | Project E-Pico | 4 |
| REMET | Research Methodology | 4 |
| STATES | Statistical signal processing and estimation theory | 4 |

## LANGUAGE COURSES

| Course code | Title | ECTS Credits |
|---|---|---|
| CCE1 | Cultural and Communication English | 2 |
| ESP1 | Spanish Language | 2 |
| FLE1 | French Language | 2 |

# Control system [COSYS]

*LEAD PROFESSOR(S): Franck PLESTAN / Guy LEBRET*

## Requirements

A prerequisite to this course is a first course in control (classical control of linear systems). A course in Linear algebra is also highly recommanded.

## Objectives

The main objective of this course is to introduce the basics for the analysis and control of linear and nonlinear systems in the state approach.

## Course contents

Linear systems
Part 1: Time domain state response, modal decomposition of the response
Part 2: Systems analysis (controllability, observability)
Part 3: Controller Synthesis (state feedback, observers, estimated state feedback)
Part 4: Robust stability

Nonlinear systems
Part 5: Systems analysis (accessibility, observability)
Part 6: Synthesis regulators (input-output linearization, robust control– sliding mode, backstepping)

Practical lab sessions:
Lab1: inverted pendulum (linear version)
Lab2: inverted pendulum (nonlinear version)

## Course material

- “Control Systems Engineering”, N.S. Nise, 6th Edition John Wiley & Sons, 2011.
- “Modern control systems , R.C. Dorf et R.H. Bishop,”, 12th. edition, Pearson Prentice Hall, 2011
- “Control system design”, G.C. Goodwin, S.F. Graebe and M.E. Salgado, Prentice Hall, 2001.
- “Linear Multivariable Control, A Geometric Approach”, W.M.Wonham. Springer Verlag, New York, 1985.
- “Linear Systems”, T. Kailath, Prentice-Hall, New Jersey, 1980.
- “Nonlinear Control Systems-3rd edition”, A. Isidori, Springer, New York, 1996.
- “Nonlinear systems”, Hassan K. Khalil, Prentice Hall, New Jersey, 2002.
- “Sliding mode control and observation”, Y. Shtessel, C. Edwards, L. Fridman, A. Levant, Springer, New York, 2016.

## Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Quality education

## Sustainable Development and Social Responsibility Positioning

High-quality teaching based on international scientific literature in the field. The developed control laws are used in the industrial world.

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 4 | 18 hrs | 4 hrs | 8 hrs | 0 hrs | 2 hrs |

# Electrical Vehicle Modelling and Simulation [EVSIM]

*LEAD PROFESSOR(S): Malek GHANES*

## Objectives

At the end of the course (30 hours + personal work) the students will have acquired skills in:

- Modeling and simulation of electric vehicle components
- Models for electric vehicles
- Design of an electric vehicle model and simulator on Matlab-Simulink.
- Design of an electric vehicle model and simulator on the industrial tool AMESIM

## Course contents

Hybrid electric vehicles (HEVs) will be studied and simulated using advanced analysis and modelling of powertrain components. A thorough analysis and study of power flows, losses and energy consumption are considered for isolated powertrain components and HEV configurations. Simulation tools will be developed and applied to specify powertrain and vehicle components and to develop control and calibration for optimisation in line with the vehicle's technical specifications.

- Brief review of various EV components
- Introduction to electric vehicle component modelling
- View of energy flows
- Computer simulation of the electric vehicle propulsion system using Matlab/Simulink
- Introduction to the industrial simulation tool AMESIM
- Electric vehicle power chain simulation using AMESIM

## Course material

1. Nicolò Daina, Aruna Sivakumar, John W. Polak, “Modelling electric vehicles use: a survey on the methods”, Renewable and Sustainable Energy Reviews, Volume 68, Part 1, 2017.
2. Ferdinando Luigi Mapelli and Davide Tarsitano, "Modeling of Full Electric and Hybrid Electric Vehicles", www.intechopen.com, 2015.

## Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Responsible consumption and production

## Sustainable Development and Social Responsibility Positioning

This module addresses the challenges of sustainable development and social responsibility by examining electrified vehicle systems as a key solution for reducing the environmental impact of the transportation sector. Reviewing the components of electric vehicles and analyzing their environmental and economic impacts provides an understanding of the drivers for reducing greenhouse gas emissions, local pollution, and fossil fuel consumption, while taking into account cost constraints and industrial transition. Component modeling, energy flow studies, and powertrain simulation using digital tools

(Matlab/Simulink and AMESIM) promote optimized and efficient system design by evaluating their energy performance before physical implementation. This approach limits the use of prototypes, reduces resource consumption, and minimizes the environmental impact of industrial development. Finally, the use of industrial simulation tools raises students' awareness of responsible engineering, focused on energy efficiency, sustainable solutions, and cleaner, more socially responsible mobility.

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 4 | 18 hrs | 4 hrs | 8 hrs | 0 hrs | 2 hrs |

# Fundamentals of Electrical Vehicle System [EVSYS]

*LEAD PROFESSOR(S): Malek GHANES*

## Objectives

At the end of the course (30 hours + personal work) the students will be able to understand:

- policy ambitions and policy instruments for electric mobility
- the role of electric vehicles (EV) and hybrid electric vehicles (HEV) in energy transition
- EV/HEV architecture and topologies
- the different components of the EV system

## Course contents

1- Electrified vehicle systems: history, environmental and economical impacts

2- Architectures, Topologies of EV (and HEV)

3- Power Electronics: Components and Converters

4- Electrical Machines for EV and HEV

5- Energy Storage system for EV and HEV

6- Demonstration of the electric vehicle propulsion chain

## Course material

1. James Larmine and John Lowry, “Electric Vehicle Technology Explained”, Wiley, 2008.

## Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Responsible consumption and production

## Sustainable Development and Social Responsibility Positioning

This module is fully in line with the challenges of sustainable development and social responsibility by addressing electrified vehicle systems as a major technological response to current environmental and energy challenges. Studying the history of electrified vehicles, as well as their environmental and economic impacts, provides an understanding of their role in reducing greenhouse gas emissions, local pollution, and dependence on fossil fuels, while also taking into account issues of cost, social acceptability, and industrial transition. The analysis of the architectures and topologies of electric vehicles (EVs) and hybrid

electric vehicles (HEVs), power electronics, electric machines, and energy storage systems emphasizes the optimization of energy efficiency, the sober use of resources, and the improvement of environmental performance throughout the entire life cycle of vehicles. Finally, the demonstration of the electric vehicle powertrain raises students' awareness of responsible and systemic design of mobility solutions, integrating criteria of reliability, durability, and safety, thereby contributing to cleaner, more sustainable, and socially responsible mobility.

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 4 | 18 hrs | 4 hrs | 8 hrs | 0 hrs | 2 hrs |

# Embedded Computing [MICRO]

*LEAD PROFESSOR(S): Mickael HILAIRET*

## Objectives

At the end of the course the students will be able to:
- understand the architecture of a microcontroller
- design a low-level driver to access a peripheral of a microcontroller and deal with microcontroller interrupts
- design a bare metal application, i.e. without any real time operating system.

## Course contents

The first part of the course deals with the software environment for deeply embedded systems:
- data representation
- cross compiler: bit operations, memory model, common C design rules, low level C and assembly specific attributes
- debugging : breakpoints, memory watch, etc

The second part introduces some basic hardware peripherals of a microcontroller to interact with the environment:
- standard GPIO
- timers and PWM
- interrupts, external interrupts
- serial communication peripherals

The third part of the module focuses on the design of both bare metal applications and driver, including concurrent execution of both software and hardware parts.

## Course material

- Philip Koopman, Better Embedded Software Systems, Drumnadrochit Education LLC, 2010
- D. Patterson & J. Hennessy, Computer Organization and Design – ARM Edition, Morgan Kaufmann, 2017

## Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure

## Sustainable Development and Social Responsibility Positioning

The entire module deals with the implementation of a software architecture to control electrical systems such as renewable energy sources.

## Assessment

Individual assessment: EVI 1 (coefficient 1.0)
EVI 1 (coefficient 1.0)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 4 | 12 hrs | 2 hrs | 16 hrs | 0 hrs | 2 hrs |

# Project E-Pico [PROJECT]

*LEAD PROFESSOR(S): Malek GHANES / Mohamed Assaad HAMIDA*

## Objectives

Several topics related to electric propulsion/traction and its control are proposed as part of these projects. The objective is to enable students to carry out these projects using a scientific research methodology:

Bibliographic research
Development of critical thinking
Report writing
Presentation of work in the form of an oral presentation

## Course contents

Students spend a half-day per week working on these projects.

## Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Responsible consumption and production

## Sustainable Development and Social Responsibility Positioning

As part of projects on electric propulsion and traction and their control, students develop methodological skills (bibliographic research, critical thinking, report writing, oral presentation). These projects are part of a sustainable development and social responsibility approach, as they encourage the design and analysis of more efficient and environmentally friendly electric mobility solutions, while raising students' awareness of the societal challenges related to energy and transportation.

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 4 | 0 hrs | 0 hrs | 0 hrs | 32 hrs | 0 hrs |

# Research Methodology [REMET]

*LEAD PROFESSOR(S): Mohamed Assaad HAMIDA*

## Objectives

Understand research terminology.
Be familiar with the attributes of researchers.
Describe quantitative, qualitative and mixed methods approaches to research.
Prepare bibliographic research.

## Course contents

Digital ID of researchers
Qualitative research methods
Literature review:
- Systematic literature review
- Content analysis
- Bibliography citation management

Scientific writing
- Basics of scientific writing
- Structured scientific writing
- Writing a research proposal
- Writing an article

## Course material

C R. Kothari, "Research methodology, methods and techniques", Springer, 2008.

## Sustainable Development Goals (SDGs) covered by this course

Quality education

## Sustainable Development and Social Responsibility Positioning

This course contributes to sustainable development by training students in rigorous and responsible research methods. It raises awareness of the ethical use of scientific information, critical data analysis, and the production of well-documented work, promoting a reliable and socially responsible scientific approach.

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 4 | 8 hrs | 10 hrs | 12 hrs | 0 hrs | 2 hrs |

# Statistical signal processing and estimation theory [STATES]

*LEAD PROFESSOR(S): Eric LE CARPENTIER*

## Objectives

This course addresses the characterization and the processing of random signals by means of statistical tools. It thus provides the theoretical foundations used in the development of signal modelling methods for the resolution of numerous problems: biomedical signal and image processing (diagnosis, tools to assist the disabled), music signal processing (restoration of old recordings, reconstruction of the score, coding and compression), positioning systems (fusion of GPS and odometry), etc.

At the end of the course the students will be able to:
- Provide a statistical description of a random process
- Solve a statistical estimation problem in a practical situation
- Develop a numerical algorithm to calculate and to characterize the solution

## Course contents

- Probability theory: random vectors, PDF, PMF, mean, variance, covariance, conditional probability.
- Classical estimation vs Bayesian estimation: maximum likelihood (ML), minimum mean square error (MMSE) , maximum a posteriori (MAP), linear minimum mean square error (LMMSE).
- Markov chains, Markov processes
- Statistical filtering: Bayes, Kalman, EKF, UKF

## Course material

- Probability, Random Variables and Stochastic Processes. A. Papoulis, S.U. Pillai. McGraw Hill.
- Fundamentals of Statistical Signal Processing, Vol.1: Estimation theory, S. Kay, Prentice Hall.

## Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Goo health and well-being / Industry, innovation and infrastructure / Quality education

## Sustainable Development and Social Responsibility Positioning

The course is based on a document designed to provide students with long-term support in their studies and professional lives (SDG4). It provides a solid theoretical foundation for understanding the research work carried out at the school (SDG9), particularly in the medical field (SDG3), which most students will have to deal with during their end-of-study internship.

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 4 | 12 hrs | 10 hrs | 8 hrs | 0 hrs | 2 hrs |

# Cultural and Communication English [CCE1]

*LEAD PROFESSOR(S): David TROYA*

## Objectives

This course aims at improving your critical thinking and persuasion skills in English. Using documentaries, we will explore, discuss and debate a range of cultural, political, social, and environmental issues relevant to current world events.

Speaking and understanding English as a second or third language is a great achievement, but does it mean you are an effective communicator? The next step involves, among other things, critical thinking and persuasive skills, both of crucial importance in the modern professional environment. We will address these issues by analyzing documentaries that will lead to formal debates.

Several competencies will be developed through class exercises. Oral presentations will be an opportunity put your verbal as well as your non-verbal communication skills into practice. During debate, you will be able to sharpen your analytical skills, provide constructive feedback, defend an argument, and prove a point.

Course objectives

- Improving your communication skills

- Becoming an active listener

- Enhancing your non-verbal communication skills

- Developing critical thinking toward media

- Boosting leadership skills through moderating

- Organizing evidence and arguments

## Course contents

Each session will be dedicated to a particular cultural, political, social or environmental topic of relevance in the wider anglophone world. Each topic will include multimedia material in the form of a short documentary or documentary excerpt. During class, students will lead a primer presentation, a moderated discussion and a formal debate.

Primer Presentation:

In pairs, you will hold a short talk to prime us on the topic of that week's documentary: you will introduce us to the topic by setting it in a wider context and establishing what's at stake.

Moderated Discussion :

In pairs, you will moderate a discussion related to the themes explored by the documentary. Moderators will come prepared with open-ended questions pertaining to the strengths and weakness of the documentary. They will distinguish between content and form and encourage critical, constructive opinions.

Formal Debate:

What's the difference between an opinion and an argument? You will soon find out. After the moderated discussion, we will brainstorm potential topics for debate, and follow the British Parliamentary model to sharpen your research, critical thinking, and persuasive skills.

During the debate, each speaker will be assigned an audience member who evaluates their individual performance and provides a short debrief. A panel of two judges will determine which side wins.

## Course material

Written and televised press, information and digital tools, general documents, business environment and company strategies. Internet conferences (Ted Talks, etc.), our own educational materials on Hippocampus (Moodle).

## Sustainable Development Goals (SDGs) covered by this course

Climate action / Industry, innovation and infrastructure / Partnership s for the goals / Quality education / Reduced inequalities

## Assessment

Individual assessment: EVI 1 (coefficient 1.0)
EVI 1 (coefficient 1.0)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 2 | 0 hrs | 32 hrs | 0 hrs | 0 hrs | 0 hrs |

# Spanish Language [ESP1]

*LEAD PROFESSOR(S): Marta HERRERA*

## Objectives

For beginners:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of vocabulary and linguistic structures
Be able to talk about yourself and those around you
Be able to express oneself during daily activities
Know how to give your opinion

For advanced students:
Practice and reinforcement of the five skills (oral and written expression and comprehension as well as interaction)
Acquisition of specialised vocabulary
Be able to understand the essential content of concrete or abstract subjects including a technical discussion
Be able to communicate spontaneously and fluently
Be able to express oneself in a clear and detailed manner, to express an opinion on a topical subject

## Course contents

For beginners:
Personal environment (introduce yourself, express yourself, your tastes, your character, your hobbies, etc.), your surroundings (friends, family, location, climate), your interests (sports, leisure)
Present tense (regular and irregular)
Language patterns to express habit, obligation, "gustar" and its equivalents,
Possessive adjectives
Differences between "es", "está", "hay"
Use of "por" and "para"
Adverbs and frequency patterns
Numeral adjectives

For advanced students:
Knowledge of the Hispanic world (economic, technical, cultural and social environment)
Present tense (regular and irregular)
Imperative
Past tenses
Direct / indirect style
Future tense
Conditional tense
Present and past subjunctive moods

## Course material

Preparation manuals, our own tailor-made documents, written and internet press, general civilization documents, digital tools

## Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Climate action / Decent work and economic growth / Gender equality / Goo health and well-being / Industry, innovation and infrastructure / No poverty / Partnership s for the goals / Peace, justice and strong institutions / Quality education / Reduced inequalities / Responsible consumption and production / Sustainable cities and communities / Zero hunger

## Sustainable Development and Social Responsibility Positioning

Key competencies for sustainability Collaboration: the abilities to learn, to understand and respect others; to deal with conflicts in a group; and to facilitate collaborative and participatory problem solving. Critical thinking: the ability to reflect on one's own values, perceptions and actions. Self-awareness: the ability to reflect on one's own role in a group; to continually evaluate and further motivate one's actions; and to deal with one's feelings and desires.

## Assessment

Individual assessment: EVI 1 (coefficient 1)
EVI 1 (coefficient 1)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| Spanish | 2 | 0 hrs | 32 hrs | 0 hrs | 0 hrs | 0 hrs |

# French Language [FLE1]

*LEAD PROFESSOR(S): Silvia ERTL*

## Requirements

N/A

## Objectives

The objective is to familiarize the learner with the French language and French culture through an entertaining task-based communicative language teaching, focused on speaking combined with:

- Phonetics
- Self-correcting exercises on our learning platform
- Learning Lab activities
- Project work
- Tutoring

Course objectives include the acquisition and reinforcement of vocabulary, syntax, and pronunciation by both traditional means and through the use of digital resources.
Students will learn general French, develop language skills of oral and written comprehension and expression.

After completing this course (32 hours + personal work), the students will be able to communicate in spoken and written French, in a simple, but clear manner, on familiar topics in the context of study, hobbies etc. Another important goal of this course is to introduce the student to French culture. At the end of the course (2 semesters), complete beginners can achieve an A1 level and some aspects of the A2 of The Common European Framework of Reference for Languages. More advanced students may aim for B1/B2 levels.

## Course contents

Full range of practical communication language exercises: reading comprehension, listening comprehension, written expression, oral expression.

Learners will be able to use the foreign language in a simple way for the following purposes:

1. Gving and obtaining factual information:
- personal information (e.g. name, address, place of origin, date of birth, education, occupation)
- non-personal information (e.g. about places and how to get there, time of day, various facilities and services, rules and regulations, opening hours, where and what to eat, etc.)

2. Establishing and maintaining social and professional contacts, particularly:
- meeting people and making acquaintances
- extending invitations and reacting to being invited
- proposing/arranging a course of action
- exchanging information, views, feelings, wishes, concerning matters of common interest, particularly those relating to personal life and circumstances, living conditions and environment, educational/occupational activities and interests, leisure activities and social life

3. Carrying out certain transactions:
- making arrangements (planning, tickets, reservations, etc.) for travel, accommodation, appointments, leisure activities
- making purchases

- ordering food and drink

## Course material

Preparation manuals, our own tailor-made documents, written and televised press, internet, general civilization documents, digital tools, our own educational materials on Hippocampus (Moodle).

## Sustainable Development Goals (SDGs) covered by this course

Quality education

## Sustainable Development and Social Responsibility Positioning

Targeted competencies extracted from: Education for sustainable development goals, learning objectives (UNESCO) https: //unesdoc.unesco.org/ark:/48223/pf0000247507 https://www.coe.int/fr/web/common-european-framework-reference-languages/official-translations-of-the-cefr-global-scale

## Assessment

Individual assessment: EVI 1 (coefficient 1.0)
EVI 1 (coefficient 1.0)

| LANGUAGE OF INSTRUCTION | ECTS CREDITS | LECTURES | TUTORIALS | LAB | PROJECT | EXAM |
|---|---|---|---|---|---|---|
| English | 2 | 0 hrs | 48 hrs | 0 hrs | 0 hrs | 0 hrs |