CENTRALE NANTES

ENGINEERING PROGRAMME

2024-2025

Year 2 / Year 3

Specialisation option

Innovative and sustainable, products and processes

OD PRO2

PROGRAMME SUPERVISOR

Tugdual LE NÉEL

Autumn Semester

Course unit	ECTS Credits	Track	Course code	Title
UE 73	12	Core course	CMMO CONCEPT LOW MICRO	Choice of Materials and their Deployment Product ideation Low Tech - Sustainable innovation Electronics in products
UE 74	13	Core course	CMCAO CONFORM P1IPRO2 PLANEX RAPMA	Design and Modeling of Mechanisms in CAD Production compliance and stability Project 1 Design of Experiments - DOE Rapid Manufacturing

Spring Semester

Course unit	ECTS Credits	Track	Course code	Title
UE 83	14	Core course	DESIN FABAD P2PRO2 PROCD REVXR	Industrial Design Additive Manufacturing Project 2 Processes Reverse-engineering and Virtual Reality

Choice of Materials and their Deployment [CMMO]

LEAD PROFESSOR(S): Jérôme FRIANT / Tugdual LE NÉEL

Requirements

Objectives

Learn the properties of several materials and their applications

Course contents

Material properties and characteristics to define which will be the most adapted for a defined application
Material/Process selection approaches. Ashby Method
Design/Prototype manufacturing mini-project to understand the knowledge required and have a clear vision of the scope of the product engineering specialization

Course material

Assessment

Collective assessment: EVC 1 (coefficient 0.5)
EVC 2 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	8 hrs	10 hrs	14 hrs	0 hrs	0 hrs

Product ideation [CONCEPT]

LEAD PROFESSOR(S): Jean-François PETIOT

Requirements

Objectives

Present the different stages of the design process for industrial products.
Present the tools and methods used for:
- the definition of the user needs
- multicriteria decision making
- Machine elements - dimensionning
- innovation and creativity.

Course contents

Functional product analysis
- functional diagram
- functional specifications
- internal functional analysis

Decision making
- multicriteria decision making
- the AHP method
- the ELECTRE method
- vote aggregation

Design management
- user centered specifications
- creativity and usage situations - TRIZ method
- prototyping and user-tests

Machine Elements
Dimensioning calculations
- shafts
- bearings
- clutch and brakes
- gear and gearbox

Collaborative design
- the DELTA DESIGN serious game

Course material

Systèmes Mécaniques - Aublin et coll. DUNOD
Eppinger & Ullrich Product design and development. Third edition Mc Graw Hill.
La conception industrielle de produits. Hermès Science, Lavoisier, 2008

Assessment

Collective assessment: EVC 1 (coefficient 0.25)

Individual assessment: EVI 1 (coefficient 0.75)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	14 hrs	16 hrs	0 hrs	0 hrs	2 hrs

Low Tech - Sustainable innovation [LOW]

LEAD PROFESSOR(S): Jean-Marc BEN GUIGUI

Requirements

Basics of design and manufacturing processes

Objectives

General objective:
- Train players capable of designing, implementing and evaluating simple and sustainable technological solutions, responding to current environmental and social challenges.

Specific objectives per module:
- Understand the foundations of low-tech and its applications.
- Master the methods of designing and evaluating low-tech projects.
- Identify the economic, social and environmental issues linked to low-tech.
- Develop skills to innovate and undertake in the field of low-tech.

Course contents

Introduction to Low-Tech and its challenges:
- Definition, history and context of low-tech.
- The limits of high-tech and the reasons to adopt a low-tech approach.
- Environmental, social and economic issues.

Fundamental principles of Low-Tech:
- The systemic approach and complex thinking.
- The key principles: sobriety, resilience, adaptability.
- The thinkers and movements that inspired low-tech.

The low-tech approach in practice:
- Definition of needs and functional analysis.
- Design at the service of low-tech: principles and applications.
- Innovation methods adapted to low-tech.

Eco-design and environmental assessment:
- The stages of eco-design: from design to end of life.
- Life cycle analysis (LCA): an essential tool.
- Environmental, social and low-tech indicators

The circular economy and business models:
- The principles of the circular economy.
- Alternative economic models: rental, repair, functionality economy
- The challenges of recyclability and reuse.

Low-tech innovation tools and methods:
- Innovation methods: brainstorming, design thinking, etc.
- Innovation under constraint, disruption and frugality.
- The importance of experimentation and prototyping.

Low-tech, an economic and societal model:
- Triple accounting: a global assessment tool

- Low-tech industry: a new paradigm
- Low-tech economic models

Low-tech applications: various fields and case studies:
- This module would bring together low-tech applications in different areas (energy, food, housing, mobility) and would present concrete case studies.
- Meetings with stakeholders in the field: social enterprises, communities, associations.
- Analysis of successful projects and their impacts.

Course material

ADEME. (2022). Etat des lieux et perspectives des démarches "low-tech"
AFNOR. (2013). Management environnemental – Aide à la mise en place d'une démarche d'éco-conception. NF X30-264
Bellini, B., & Janin, M. (2019). Écoconception : état de l'art des outils disponibles. Techniques de l'ingénieur.
Bihouix, P. (2014). L'âge des low tech: vers une civilisation techniquement soutenable. Éditions du Seuil.
Brown, T., Katz, B. (2010). L'esprit design: le design thinking change l'entreprise et la stratégie. France: Pearson.
Brunet, E. (2019). La boîte à outils du Design Thinking. France: Dunod.
Crawford, M. B. (2016). Éloge du carburateur: Essai sur le sens et la valeur du travail. France: La Découverte.
Crawford, M. B. (2019). Contact: pourquoi nous avons perdu le monde, et comment le retrouver. France: La Découverte.
Ellul, J. (1988) Le bluff technologique.
Fustec, A. (2024). La stratégie du Y.
Illich, I., Giard, L., & Bardet, V. (1973). La convivialité. Editions du Seuil.
Le Moigne, R. (2018) L'économie circulaire: Stratégie pour un monde durable. Dunod. (2ème édition).
Mumford, L. (1966). Le Mythe de la machine, technique et développement humain.
Radjou, N., Prabhu, J., Ahuja, S. (2023). L'innovation Jugaad: redevenons ingénieux !. France: Diateino.
Raworth, K. (2021). La théorie du donut: l'économie de demain en 7 principes. France: J'ai lu.
Schumacher, E. (1973). Small is Beautiful: A Study of Economics As If People Mattered.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	8 hrs	22 hrs	0 hrs	0 hrs	2 hrs

Electronics in products [MICRO]

LEAD PROFESSOR(S): Tugdual LE NÉEL

Requirements

None

Objectives

Learn the bases of electronics so a mecatronics product can be built.

Course contents

Lecture => work => Lecture => work => Project

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	10 hrs	14 hrs	8 hrs	0 hrs	0 hrs

Design and Modeling of Mechanisms in CAD [CMCAO]

LEAD PROFESSOR(S): Olivier LEGOFF

Requirements

No prerequisites in relation to other courses.

Objectives

The definition, design, and 3D digital representation of products, along with CAD, are key areas of a general engineering education. The knowledge and skills developed form fundamental elements for various fields of engineering that can be further explored later on: design, production, computer graphics, virtual reality, ...

Knowledge and skills:
- Parametric modeling of 3D solid objects.
- Surface modeling.
- Mechanical system analysis and partial redesign (case study).
- Design for Manufacturing (DFM).
- Mechanical design of simple products.
- Communication, technical documentation editing (project communication).
- Elements of mechanical design: joints, power transmission.

Course contents

History of CAD:

- CSG and BREP modeling
- Curves and surfaces: Bézier, B-Spline
- Parametric modeler

Learning CAD with SolidWorks: part modeling, assembly, drafting
Partial LCA analysis (SolidWorks Sustainability)
Mechanical design mini-project.

Course material

Assessment

Collective assessment: EVC 1 (coefficient 0.5)

Individual assessment: EVI 1 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	8 hrs	12 hrs	12 hrs	0 hrs	0 hrs

Production compliance and stability [CONFORM]

LEAD PROFESSOR(S): Hervé THOMAS

Requirements

Objectives

To acquire the skills to master parts compliance and stabilization of the production process.

Course contents

Understand part dimensioning,
Know how to generate a manufacturing process,
Know how to generate and analyse computer-aided manufacturing trajectories,
Know how to generate and analyse computer-aided maintenance trajectories,
Analyze and stabilize the machining process,
Implement quality tools in the production process.

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	8 hrs	8 hrs	16 hrs	0 hrs	0 hrs

Project 1 [P1IPRO2]

LEAD PROFESSOR(S): Tugdual LE NÉEL

Requirements

Objectives

Real-life product development project with a customer from outside the school.
The aim of this project is to apply the concepts learned in class to an industrial case study, and to develop practical skills and the ability to work as part of a team.

Course contents

Students are divided into groups either to lead an independent project, or to work in competition on the same project.

Course material

Assessment

Collective assessment: EVC 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	1	0 hrs	0 hrs	0 hrs	32 hrs	0 hrs

Design of Experiments - DOE [PLANEX]

LEAD PROFESSOR(S): Jean-François PETIOT

Requirements

basics of statistics
basics on the linear model

Objectives

Provide the students with tools and methods for the experimental study of systems:
- Understand the effect of factors on a response
- model and predict a response according to experimental factors
- optimize a response and carry out a robust design

Course contents

General presentation
- DOE (the design of experiments approach)
- illustration: Hotelling's Experiment
- notion of design space

Full factorial designs: 2k
- two factor design example: fuel consumption of a vehicle
- three factor design
- Example with 5 factors
- Matrix of experiments

Fractional factorial designs: 2k-p
- fractional designs
- Alias theory
- computation of contrasts

Statistics and DOE
- Analysis of variance
- Multiple linear regression
- modelling of experimental data
- order of experiments

Response surface modelling
- optimal designs
- optimality criteria (D-Optimality)
- modelling - responses - optimisation

DACE - design analysis of computer experiments
- LHS and OSF designs

The Taguchi robust approach

3 Tutorials(4h) on Excel and MODDE

Project (8h) on the optimization of a system with the DOE approach

Course material

Gilles et Marie-Christine SADO. Les plans d'expérience. AFNOR Technique
Jacques GOUPY, Lee Creighton. Introduction aux plans d'expériences. DUNOD
Méthodologie Expérimentale. Baléo, Bourges, Courcoux, Faur-Brasquet, Le Cloirec. Editions TEC &DOC
Droesbeke J-J, Fine J., Saporta G. Plans d'expériences. Applications à l'entreprise. Editions TECHNIP.
Jacques GOUPY, Plans d'expériences pour surfaces de réponse. DUNOD
Maurice PILLET. Introduction aux plans d'expériences par la méthode TAGUCHI. EO.Sup.

Assessment

Collective assessment: EVC 1 (coefficient 0.3)

Individual assessment: EVI 1 (coefficient 0.7)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	10 hrs	20 hrs	0 hrs	0 hrs	2 hrs

Rapid Manufacturing [RAPMA]

LEAD PROFESSOR(S): Matthieu RAUCH

Requirements

Objectives

The objective of this course is to propose the methods and tools to be implemented within the framework of Computer Aided Manufacturing with Numerical Control Machine-Tools for Additive Manufacturing and Machining

Course contents

1. Evaluate the industrial situation of Rapid Manufacturing
2. Define the setup of Rapid Manufacturing in a CadCam Context: High Speed Machining, Incremental Sheet Forming
3. Tutorial.

From a designer specification we will set up High Speed Machining: Reception of the design specifications, Setup of the reverse engineering, Generation of the multi axe trajectories, High Speed Machining on Parallel Kinematic Machine, Comparison with an ISF process, Additive Manufacturing

Course material

Machine à Commande Numérique, B. Méry, Hermès
CadCam Theory and Practice, I. Zeid, Mc Graw-Hill
Surface Modeling for CadCam, BK. Choi, Elsevier
Fundamentals of Computer Integrated Manufacturing, A.L. Foston, C.L. Smith, T. Au, Prentice Hall
La CFAO- Concevoir et produire autrement, F. Piquet, JP Poitou, JC Tasse Nathan
NC Machine Programming and Software Design, C.H. Chang, M.A. Melkanoff, Prentice Hall
Lecture and tutorial notes.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	8 hrs	8 hrs	16 hrs	0 hrs	0 hrs

Industrial Design [DESIN]

LEAD PROFESSOR(S): Jean-François PETIOT

Requirements

no

Objectives

Present the three main values that drive industrial product development: technical values, usage values, communication values.
To learn tools and methods to control connotative aspects of products
To acquire the necessary skills to understand the actions of industrial designers, their added value in a design project, and organize their activities in a design project team.

Course contents

Lectures:
Semiology - design theory
Gestalt theory, semiotics, mood boards, constraints and creativity
Conjoint analysis for product design.
Communication via graphic design

Tutorials:
Design exercices - communication on trends by product
Conjoint analysis tutorial
Group design project

Course material

Danielle QUARANTE. Eléments de design industriel. 3ième Edition. Polytechnica. 2001.
EGER A., BONNEMA M., LUTTERS E., VAN DER VOORT M. Product Design. Eleven International Publishing, 2013.

Assessment

Collective assessment: EVC 1 (coefficient 0.5)
EVC 2 (coefficient 0.5)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	8 hrs	20 hrs	4 hrs	0 hrs	0 hrs

Additive Manufacturing [FABAD]

LEAD PROFESSOR(S): Tugdual LE NÉEL

Requirements

Non

Objectives

Learn metal additive manufacturing.

Course contents

Lecture + work + project.

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	6 hrs	18 hrs	8 hrs	0 hrs	0 hrs

Project 2 [P2PRO2]

LEAD PROFESSOR(S): Tugdual LE NÉEL

Requirements

Objectives

Real-life product development project with a customer from outside the school.
The aim of this project is to apply the concepts learned in class to an industrial case study, and to develop practical skills and the ability to work as part of a team.

Course contents

Students are divided into groups either to lead an independent project, or to work in competition on the same project.

Course material

Assessment

Collective assessment: EVC 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	2	0 hrs	0 hrs	0 hrs	48 hrs	0 hrs

Processes [PROCD]

LEAD PROFESSOR(S): Jérôme FRIANT

Requirements

Objectives

Know the different methods of manufacturing associated to materials
Increase knowledge of conventional methods and new ways of manufacturing.
Impact of their choice on the design, manufacture and consideration of the product life cycle

Course contents

Approach for material / process selection. Ashby Plots.
Development of a specific program based on the method of learning by problem and by project.
Foundry processes, forging, stamping, automated welding, cutting, and automated boiler making.
Extension to other methods

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	4 hrs	8 hrs	20 hrs	0 hrs	0 hrs

Reverse-engineering and Virtual Reality [REVXR]

LEAD PROFESSOR(S): Florent LAROCHE

Requirements

Objectives

In an increasingly digital world, mastering immersive technologies and digital tools is essential for tomorrow's engineers. This innovative course immerses students in the world of Virtual Reality (VR) and Mixed Reality (XR), with a particular focus on industrial applications such as reverse engineering and photogrammetry.

Students will be introduced to the use of modeling, simulation, and human-machine interface (HMI) creation software to design complex virtual environments. They will also learn how to integrate CAD (Computer-Aided Design) files into these environments, allowing them to visualize and interact with their creations through virtual reality headsets.

Course contents

1. Introduction to Virtual Reality and XR
   - Basic concepts and overview of immersive technologies.
   - Exploration of software tools commonly used in industry.

2. Digitalization and Reverse Engineering: Methods and Tools
   - Presentation of reverse engineering processes, from data capture to digital modeling.
   - Practical cases with leading software to reconstruct 3D models from real objects.

3. Introduction to Photogrammetry
   - Method of capturing physical objects in 3D using photos.
   - Transformation of photogrammetric models into usable files for VR and CAD.

4. Virtual Environments and HMIs
   - Creation of immersive environments with lighting management, cinematics, and animations.
   - Design and customization of HMIs to optimize interaction in VR.

5. Integration of CAD Files into a Virtual Environment
   - Method for importing CAD files and integrating them into a virtual environment.
   - Manipulation and visualization of technical objects in VR.

6. Hands-on Mini-Project
   - Students will apply all the skills acquired to create an immersive virtual environment incorporating 3D modeling elements, physical simulation, and interactions.
   - This project will be tested using virtual reality headsets to simulate complex industrial scenarios.

Course material

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	11 hrs	18 hrs	2 hrs	0 hrs	1 hrs