CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

2025-2026

YEAR 2

MECHANICAL ENGINEERING

ADVANCED COMPOSITE ENGINEERING AND SCIENCE

PROGRAMME SUPERVISOR(S):
Sébastien COMAS-CARDONA

YEAR 2 - Autumn Semester

CORE COURSES

Course code	Title	ECTS Credits
COCAR	Composites Characterization	4
COMOD1	Composites Processing Modeling 1	4
COMOD2	Composites Processing Modeling 2	4
CONF	Conferences	-
COPRO	Composites Constituents and Processes	4
COSTR	Composites Structures	4
MULTI	Multi-Physics Modeling for Processes	4
PROJT	Project	4

LANGUAGE COURSES

Course code	Title	ECTS Credits
CCE3	Cultural and Communication English	2
ESP3	Spanish Language	2
FLE3	French Language	2

YEAR 2 - Spring Semester

CORE COURSES

Course code	Title	ECTS Credits
THESIS	Master Thesis or Internship	30

Composites Characterization [COCAR]

LEAD PROFESSOR(S): Christian BURTIN / Sébastien COMAS-CARDONA

Objectives

This course covers the principles and algorithms for processing a non-destructive testing with tomography and U.S with particular emphasis on problems in material research.

At the end of the course the students will be able to:
- Understand what tomography is and optimize an experiment with any kind of material.
- Understand the specificities of composite materials both theoretically and in practice in the context of an ultrasonic wave

Course contents

- Principles of tomography and X-ray imaging
- Methods for analytical and algebraic mathematical reconstruction of a 3D image
- Technology of tomography
- Effect of an ultrasonic wave on an unbounded isotropic and anisotropic medium
- Effect of reflexion and refraction on the study of stress wave propagation in solids
- Wave propagation in plates and surface waves.
- Technology of ultrasonic testing

Lab activities: tomography and ultrasonic testing with examples of treatment.

Course material

- Computed tomography, from photon statistics to modern cone-beam CT, Buzug
- Ultrasonic guided waves in solid media, Rosen

Sustainable Development Goals (SDGs) covered by this course

Climate action / Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

This course places the characterization of composite materials at the heart of contemporary technological and environmental challenges, exploring the complex interactions between materials and the physical principles associated with characterization methods. It enables students to master characterization tools in order to design innovative solutions. By combining theory, practice, and critical analysis, this course prepares students to make robust and responsible technical decisions in a context where industrial and societal challenges demand a systemic and interdisciplinary approach.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

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

Composites Processing Modeling 1 [COMOD1]

LEAD PROFESSOR(S): Christophe BINETRUY

Requirements

Continuum mechanics
Composite processes

Objectives

At the end of the course the students will be able to:

- Describe main physical mechanisms in involved in Liquid Composites Molding (LCM) processes
- Model main mechanisms observed during manufacturing of polymer composites : flow within rigid and deformable fibrous media, steady-state and transient flows, flow within dual-scale porosity fabrics
- Simulate impregnation phase with software

Course contents

This course addresses the analysis and modeling of the main physical mechanisms involved in the processing of polymer composites through the use of governing equations and constitutive equations.
Governing equations (mass, energy and momentum conservation equations) will be given for the modeling of structural composites processing.
Exercises and lab sessions will focus on 1D analytical and 2D numerical modelling.

- Process classification based on the dominant physics involved
- Governing and constitutive equations (flow in single scale and dual scale porous media, squeeze flow of viscous composites, heat transfer,) adapted to composites and porous (fibrous) materials.
- Experimental identification (permeability for Darcy's law)
- Lab sessions: Liquid Resin Infusion (LRI), filling patterns, simulation of Liquid Composite Molding

Course material

- Process Modelling in Composites Manufacturing, Second Edition, 2010 by CRC Press, 630 Pages, Suresh G. Advani, E. Murat Sozer
- Advani, Suresh, and Kuang-Ting Hsiao, eds. Manufacturing techniques for polymer matrix composites (PMCs). Elsevier, 2012
- Hoa, Suong V. Principles of the manufacturing of composite materials. DEStech Publications, Inc, 2009
- Boisse, P. (Ed.). (2015). Advances in Composites Manufacturing and Process Design. Woodhead Publishing.
- Long, A. C. (Ed.). (2014). Composites forming technologies. Elsevier.
- Lecture notes : Flow and heat transfer in stationary fibrous media
- User's guide for LIMS et GMSH

Sustainable Development Goals (SDGs) covered by this course

Decent work and economic growth / Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

Organic composites provide an effective solution for designing lightweight structures, helping to reduce energy consumption and materials while maintaining equivalent performance targets. A detailed understanding of the manufacturing processes of composite parts can address several issues relating to sustainable development and social responsibility. It enables more robust manufacturing strategies to be developed, thereby limiting the excessive use of materials and energy caused by empirical trial-and-error approaches. It also enables a quicker response to process deviations resulting in significant production waste.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	14 hrs	8 hrs	8 hrs	0 hrs	2 hrs

Composites Processing Modeling 2 [COMOD2]

LEAD PROFESSOR(S): Sébastien COMAS-CARDONA

Objectives

At the end of the course (32h) the students will be able to:
▪ Describe main physical mechanisms occurring during composite manufacturing
▪ Model main mechanisms observed during manufacturing of polymer composites : squeeze flow of viscous composites and draping of fabrics
▪ Simulate draping/forming stage with numerical tools
▪ Identify the parameters of kinetics of solidification (polymerization or crystallization)
▪ Identify the parameters of models of viscoelasticity and thermomechanical behavior of thermoplastic and thermoset polymers.

Course contents

This lecture aims at analyzing and modeling the physics occuring during composites processing through the use of governing equations and constitutive equations. Governing equations will be given for the modeling of structural composites processing. Practice and lab sessions will focus on 1D analytical and 2D numerical modeling.

- Process classification based on occuring physics, yield rate and performances
- Governing and constitutive equations (fluid dynamics, heat transfer, mechanics) adapted to composites and porous (fibrous) materials.
- Lab sessions: Simulation of draping/forming steps, Experimental identification (cure kinetics laws for thermosetting polymers, and viscoelastic and thermomechanical behavior)

Course material

▪ Process Modelling in Composites Manufacturing, Second Edition, 2010 by CRC Press, 630 Pages Suresh G. Advani, E. Murat Sozer
▪ Advani, Suresh, and Kuang-Ting Hsiao, eds. Manufacturing techniques for polymer matrix composites (PMCs). Elsevier, 2012
▪ Hoa, Suong V. Principles of the manufacturing of composite materials. DEStech Publications, Inc, 2009
▪ Boisse, P. (Ed.). (2015). Advances in Composites Manufacturing and Process Design. Woodhead Publishing.
▪ Long, A. C. (Ed.). (2014). Composites forming technologies. Elsevier.
▪ Course Notes: Flow and heat transfer in stationary fibrous media, Squeeze flow manufacturing processes,
▪ Simplified user-guide of LIMS and GMSH software

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

In an advanced composite modeling course, it is essential to study current materials (such as carbon fibers and petroleum-based epoxy resins) in order to transition toward more environmentally friendly alternatives. This involves examining both traditional and bio-based composites. The analysis helps raise students' awareness of the trade-offs between performance and sustainability.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	14 hrs	8 hrs	8 hrs	0 hrs	2 hrs

Conferences [CONF]

LEAD PROFESSOR(S): Sébastien COMAS-CARDONA

Objectives

Conferences will be organized over the semester so as to propose to the students an overview of:
- the industrial network
- examples of applications
- tools and feedback from alumni to help them build their career
- research studies through seminars

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

Conferences linked to composite matérials

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	-	14 hrs	0 hrs	0 hrs	0 hrs	0 hrs

Composites Structures [COSTR]

LEAD PROFESSOR(S): Laurent GORNET

Objectives

At the end of the course the students will be able to:

- Identify an orthotropic material and calculate a laminate utile failure
- Simulate beams and laminated structures using the FE code Abaqus

Course contents

This lecture deals with modelling the behaviour of composite structures. Starting from the constituent behaviour, the calculations are performed at various scales from the single ply to the complete laminate theory. Finite Element simulations are performed with Abaqus or Cast3M (CEA). Thermosetting vs thermoplastic polymer challenges.

- Three-dimensional anisotropic elasticity, concepts of homogenization and micro mechanics,
- Constitutive equation, lamination theory and sandwich structures, failure criteria
- Finite Element predictions of laminates
- Notions of damage mechanics

Course material

- Mechanics of fibrous composites, C.T. Herakovich, Wiley1998
- A first course in finite elements, Jacob fish, Ted Belyscho, Wiley 2007
- Mechanics of solid materials, J. Lemaitre and Chaboche, Cambridge 2000

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Quality education / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

The composite materials and structures course is fully aligned with the challenges of sustainable development and social responsibility. It trains students in advanced predictive modeling tools, enabling them to anticipate the degradation and end-of-life of structures while ensuring their safety and durability.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	14 hrs	8 hrs	8 hrs	0 hrs	2 hrs

Multi-Physics Modeling for Processes [MULTI]

LEAD PROFESSOR(S): Guillaume RACINEUX

Objectives

At the end of the course the students will be able to:

- Read and explain scientific articles or bibliography related to multi-physics modeling of processes
- Identify the formulation of proper modelling including domain, physics, boundary conditions, constitutive equations and assumptions
- Generate appropriate modelling for a given process and question to answer

Course contents

This course covers:

- Mathematical background (vectors, tensors and partial differential equations)
- Governing equations (conservations and principles, elasticity, fluid mechanics, electro-magnetism, plasticity, heat transfer etc)
- Constitutive equations (identification)
- Existence and unicity of solutions
- Resolution of problems (exact solutions, analytical approximates, numerical approaches)
- Multi-physics coupling

A combination of lectures, homework and lab sessions will develop the tools and student skills.

Course material

- Process Modeling in Composites Manufacturing, Second Edition, 2010 by CRC Press, 630 Pages, Suresh G. Advani, E. Murat Sozer
- P. Boisse, Composite Reinforcements for optimum performance, 2011
- Friedrich Klaus, Fakirov Stoyko, & Zhang Zhong. (2005). Polymer Composites: From Nano- to Macro-Scale. Boston, MA: Springer Science+Business Media, Inc

Sustainable Development Goals (SDGs) covered by this course

Climate action / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

This course places multiphysics modeling at the heart of contemporary technological and environmental challenges, exploring the complex interactions between physical, mechanical, thermal, electrical, and chemical phenomena within materials, processes, and systems. It enables students to master the analytical modeling tools needed to predict, optimize, and design innovative solutions. By combining theory, practice, and critical analysis, this course prepares students to make robust and responsible technical decisions in a context where industrial and societal challenges demand a systemic and interdisciplinary approach.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	16 hrs	16 hrs	0 hrs	0 hrs	0 hrs

Project [PROJT]

LEAD PROFESSOR(S): Sébastien COMAS-CARDONA

Objectives

At the end of the project, the students will be able to:
- Solve an industrial engineering or research problem
- Put in practice the scientific, numerical and technical skills acquired in the past semesters
- Strengthen interpersonal skills
- Be part of or manage a project
- Organize tasks, analyze results and build deliverables

Course contents

The topics are provided by the instructors. The project is evaluated after the submission of a written report and an oral defense. Topics may also be submitted by companies or elaborated with the students.

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

Project linked to the program

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	4	0 hrs	0 hrs	0 hrs	40 hrs	0 hrs

Cultural and Communication English [CCE3]

LEAD PROFESSOR(S): David TROYA

Objectives

- Understand the fundamental principles of scientific writing and the importance of clarity and precision in communication.
- Structure scientific documents effectively, adhering to genre-specific conventions.
- Employ appropriate language and tone for diverse scientific audiences.
- Integrate and cite sources correctly to support research arguments and findings.
- Edit and revise their writing for coherence, style, and grammatical accuracy.
- Prepare and deliver scientific presentations, both written and oral.

Course contents

Introduction to Scientific Writing

Overview:

This course provides an essential foundation in scientific writing, equipping students with the skills necessary to effectively communicate research findings and scientific concepts. Through a combination of lectures, workshops, and practical assignments, students will learn the conventions of scientific writing, including structure, style, and clarity. The course will cover various types of scientific documents, such as research papers, literature reviews, grant proposals, and poster presentations.

Course Structure:

The course will be organized into weekly sessions that include lectures on theoretical concepts, hands-on writing exercises, peer review workshops, and discussions of exemplary scientific literature. Students will engage in collaborative projects and receive constructive feedback to enhance their writing skills.

Assessment:

Students will be assessed through a combination of assignments, including written documents, peer review participation, and presentations. Active participation in workshops and discussions is also required to foster a collaborative learning environment.

Course material

Hoogenboom BJ, Manske RC. How to write a scientific article. Int J Sports Phys Ther. 2012 Oct;7(5):512-7. PMID: 23091783; PMCID: PMC3474301.

Paré G, Kitsiou S. Chapter 9Methods for Literature Reviews. In: Lau F, Kuziemsky C, editors. Handbook of eHealth Evaluation: An Evidence-based Approach [Internet]. Victoria (BC): University of Victoria; 2017 Feb 27. Available from: https://www.ncbi.nlm.nih.gov/books/NBK481583/

How to Create a Research Poster. A guide fo creating a research poster. https://guides.nyu.edu/posters

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Quality education

Assessment

Individual assessment: 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 [ESP3]

LEAD PROFESSOR(S): Marta HERRERA

Requirements

N/A

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)

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

French Language [FLE3]

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, 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. Those who already completed the first year of the French course will be prepared for working in a French business environment.

Course contents

Two different tracks are proposed: track 1 for students newly arrived at Centrale Nantes and track 2 for students who have completed the first year of the French course. Track 1:
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. Giving 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

Track 2:
This track follows on directly from the first-year French course, developing and completing the concepts studied thus far. The main themes are: housing, health and work. These topics will help prepare students for their future work environment. For example, housing is explored in the form of a search for accommodation upon arrival in a new city. Special workshops for CVs and cover letters, elevator pitches and job interviews.

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)

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

Master Thesis or Internship [THESIS]

LEAD PROFESSOR(S): Sébastien COMAS-CARDONA

Objectives

- Be exposed to and adapt to an industrial or research environment
- Put in practice the scientific and technical skills acquired in the previous semesters
- Strengthen interpersonal and communication skills
- Be part of or manage a project
- Organize tasks, analyze results and build deliverables

Course contents

Students should be pro-active and career-oriented in the search for their thesis/internship. The topics are validated by the program supervisor to ensure an adequate Master level. The thesis/internship is evaluated through the submission of a written report and an oral defense.

Course material

- Turabian Kate Larimore, Booth Wayne Clayton, Colomb Gregory G., Williams Joseph M., & University of Chicago press. (2013). A manual for writers of research papers, theses, and dissertations: Chicago style for students and researchers (8th edition.). Chicago (Ill.) London: University of Chicago Press.
- Bui Yvonne N. How to Write a Master's Thesis. 2nd ed. Thousand Oaks, Calif: Sage, 2014.
- Evans David G., Gruba Paul, et Zobel Justin. How to Write a Better Thesis. 3rd edition. Carlton South, Vic: Melbourne University Press, 2011.

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

Internship linked to the program

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
English	30	0 hrs	0 hrs	0 hrs	0 hrs	0 hrs