
ENGINEERING PROGRAMME

2025-2026

Year 2 / Year 3

Specialisation option

**Mechanical Engineering for
Materials and Manufacturing
Processes**

OD MATEPRO

PROGRAMME SUPERVISOR

Erwan VERRON



Autumn Semester

Course unit	ECTS Credits	Track	Course code	Title
UE 73	12	Core course	CDMAT EXPER MEF_MATEPRO MPHY	Materials Selection in Mechanical Design Experimental methods in materials science Finite Element Method Multiphysics modelling
UE 74	13	Core course	CONFVE MELAST METAL P1MATEPRO POCOM	Conferences and company visits Mechanics of elastomers Metallurgy Project 1 Polymers and composites

Spring Semester

Course unit	ECTS Credits	Track	Course code	Title
UE 83	14	Core course	FARUP MATSOC MICOM MIMET P2MATEPRO	Fatigue and fracture of materials Materials and Society Composites processing Metal forming and processing Project 2

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 73 / 93

Materials Selection in Mechanical Design [CDMAT]

LEAD PROFESSOR(S): Guillaume RACINEUX

Objectives

Today, there are more than 100,000 materials available for product design, which constitutes a tremendous opportunity for innovation.

In order to choose the proper material, one needs:

- sound knowledge of the different classes of materials
- good understanding of their properties,
- a methodology that best meets the design specifications

At the end of this course, the students will:

- know the different classes of materials
- be able to proceed to a rational choice of materials

Course contents

- Presentation of the different classes of materials (metals, polymers, ceramics, composites and their properties)
- Presentation of the Ashby method for material selection
- Case studies

Course material

- Engineering Materials, I & II, M.F. Ashby and D.R.H. Jones, Elsevier (4th edition), 2012.
- Materials Selection in Mechanical Design, Butterworth-Heinemann (4th edition), 2010.

Skills developed through this course

- C1 : Design and prototype innovative systems that create value
 - C1C1 : Develop
 - Proficient
 - C1C2 : Dare
 - Proficient
 - C1C3 : Deliver and create value
 - Proficient

Skills assessed through this course

- C1 : Design and prototype innovative systems that create value
 - Proficient

Sustainable Development Goals (SDGs) covered by this course

Climate action / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

The CDMAT course is embedded in a framework of sustainable development and social responsibility by training students in

the informed selection of materials for product design. Mastery of material families and properties, combined with a rigorous selection methodology, enables the optimization of material use and energy efficiency in designed systems, while minimizing waste and the environmental impact of industrial processes. By raising future engineers' awareness of the importance of material choice from the early stages of design, the course contributes to more responsible production and the reduction of the carbon footprint of products, thereby supporting the fight against climate change.

Assessment

Collective assessment: EVC 1 (coefficient 0.4)

Individual assessment: EVI 1 (coefficient 0.6)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	10 hrs	4 hrs	16 hrs	0 hrs	2 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 73 / 93

Experimental methods in materials science [EXPER]

LEAD PROFESSOR(S): Michel CORET

Requirements

This course will build upon:

- The foundational knowledge of engineering students from all academic backgrounds, which is both necessary and sufficient (particularly first-year physics courses covering light, electromagnetic waves, and the constituents of matter).
- The linear algebra mathematics course.
- The MATER and MMCe courses.

Objectives

EXPER course aims to present experimental imaging methods widely used in materials mechanics, which are employed to observe materials or to identify certain physical properties. The imaging methods considered range from microscopic to macroscopic scales and include both surface and volumetric techniques.

Course contents

- Kinematic field measurements at the macroscopic scale (in particular, digital image correlation)
- Observation and analysis using scanning electronic microscopes
- Volumetric analysis using tomography

Course material

- ASM Handbook, Vol. 8, Mechanical Testing & Evaluation
- C. Esnouf, 'Caractérisation microstructurale des matériaux' P.P. Romandes, 2011

Skills developed through this course

- C1 : Design and prototype innovative systems that create value
 - C1C1 : Develop
 - Proficient
 - C1C2 : Dare
 - Proficient
 - C1C3 : Deliver and create value
 - Proficient

Skills assessed through this course

No skill observed

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Peace, justice and strong institutions

Sustainable Development and Social Responsibility Positioning

The EXPER course, dedicated to experimental imaging methods in materials mechanics (digital image correlation, optical and

electron microscopy, tomography), contributes to sustainable development and social responsibility challenges by training engineering students in advanced techniques for material observation and characterization, which are essential for the design of more reliable, more durable, and more responsible structures and industrial systems.

Assessment

Collective assessment: EVC 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	14 hrs	6 hrs	12 hrs	0 hrs	0 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 73 / 93

Finite Element Method [MEF_MATEPRO]

LEAD PROFESSOR(S): Erwan VERRON

Requirements

Continuum Mechanics (MMCe, 1st year), Materials (MATER, 1st year)

Objectives

This course focuses on two important aspects of structural mechanics, that will be used in other courses of the specialty MATEPRO: material strength (bending of beams) and Finite Element Analysis (FEA).

Course contents

This course is made of three distinct parts:

1. In-plane bending of beams
2. Formulation of Finite Element Analysis (one-dimensional)
3. Use of a commercial software for a project (Abaqus)

Course material

1. https://fr.wikipedia.org/wiki/R%C3%A9sistance_des_mat%C3%A9riaux
2. <https://www.coursera.org/learn/finite-element-method>
3. <https://www.3ds.com/fr/produits-et-services/simulia/produits/abaqus/>

Skills developed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - C2C1 : Represent and model
 - Proficient
 - C2C2 : Solve and arbitrate
 - Proficient
 - C2C3 : Think and act in an unpredictable and uncertain environments
 - Proficient

Skills assessed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - Proficient

Sustainable Development Goals (SDGs) covered by this course

Industry, innovation and infrastructure / Quality education

Sustainable Development and Social Responsibility Positioning

This course contributes to sustainable development by training students in the fundamental tools for the analysis and design of mechanical structures. Mastery of strength of materials and the finite element method enables the design of more reliable

and optimized structures, promoting the responsible use of resources and the development of sustainable infrastructure.

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	4 hrs	16 hrs	0 hrs	2 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 73 / 93

Multiphysics modelling [MPHY]

LEAD PROFESSOR(S): Sébastien COMAS-CARDONA

Objectives

At the end of the 32-hour course the students will be able to:

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

Course contents

1. Basics/Toolbox (6h)
 - Operators, Objectivity, Indicial calculus
2. Equations of conservation, behavior's law, constitutive or evolution equations (6h)
 - Elasticity, Heat transfer, Fluid dynamics, Electro-Magnetism, Plasticity
 - Existence/Unicity : Boundary and initial conditions
3. Coupling (4h)
 - Evolution equations, Material parameters, Case studies
4. Résolution (2h)
 - Scaling
 - Exact and approximated solutions
5. Scientific modeling article analysis(6h, Evaluation 1)
6. Engineering study case (8h, Evaluation 2)

Skills developed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - C2C1 : Represent and model
 - Proficient
 - C2C2 : Solve and arbitrate
 - Proficient
 - C2C3 : Think and act in an unpredictable and uncertain environments
 - Proficient

Skills assessed through this course

No skill observed

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 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

Collective assessment: EVC 1 (coefficient 0.7)

Individual assessment: EVI 1 (coefficient 0.3)

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

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 74 / 94

Conferences and company visits [CONFVE]

LEAD PROFESSOR(S): Bertrand HUNEAU

Requirements

None

Objectives

A series of 10 conferences illustrates the role of a Materials and Processes Engineer through testimony from engineers, mainly former students of the specialisation.

In addition, three visits of local companies are organized.

Skills developed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - C2C1 : Represent and model
 - Proficient
 - C2C2 : Solve and arbitrate
 - Proficient
 - C2C3 : Think and act in an unpredictable and uncertain environments
 - Proficient

Skills assessed through this course

No skill observed

Sustainable Development Goals (SDGs) covered by this course

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

Sustainable Development and Social Responsibility Positioning

Testimonials from Centrale Nantes graduates specialising in Materials and Processes discuss the sustainable development aspects of their professional activities. Furthermore, approximately 50% of testimonials are provided by women.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	20 hrs	12 hrs	0 hrs	0 hrs	0 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 74 / 94

Mechanics of elastomers [MELAST]

LEAD PROFESSOR(S): Adrien LEYGUE

Requirements

Continuum Mechanics (MMCe, 1st year), Materials (MATER, 1st year)

Objectives

This course presents the nonlinear elastic constitutive equations classically used for elastomers. More precisely, it focuses on their theoretical derivation and on the fit of the parameters thanks to experimental data.

Course contents

This course adopts a project-based approach. It is divided in three parts:

- part 1 (2h). Conference on hyperelastic models and their applications
- part 2 (8h). Four exercises, covering the four chapters of the course, are solved by the students; video of the solutions can be used for self-study.
- part 3 (20h). Using a scientific article, students discover a given model. They must understand its formulation, then determine its parameters using experimental data from literature. This part is conducted by groups of 3 to 5 students.

Course material

Verron E., Modèles hyperélastiques pour le comportement mécanique des élastomères, Techniques de l'ingénieur, AM8210v1, 2018.

Holzapfel G. A., Nonlinear Solid Mechanics. A Continuum Approach for Engineering, John Wiley & Sons, Chichester, 2000.

Skills developed through this course

- C3 : Manage complex programmes or change responsibly
 - C3C1 : Design a project/programme
 - Proficient
 - C3C2 : Manage/lead a project/programme
 - Proficient
 - C3C3 : Finalise and leverage feedback
 - Proficient

Skills assessed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - Proficient

Sustainable Development Goals (SDGs) covered by this course

Affordable and clean energy / Industry, innovation and infrastructure / Quality education / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

This course is part of a sustainable development approach, focusing on the rational and innovative use of elastomers—key materials for eco-responsible applications (recycling, durability, waste reduction). The hyperelastic models studied enable the

optimization of component design, thereby reducing resource overconsumption and promoting eco-design.

Assessment

Collective assessment: EVC 1 (coefficient 0.7)

Individual assessment: EVI 1 (coefficient 0.3)

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

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 74 / 94

Metallurgy [METAL]

LEAD PROFESSOR(S): Bertrand HUNEAU

Requirements

- Physics and Chemistry, bachelor level, the CC-MATER (EI1) course is not a compulsory prerequisite, although it is recommended

Objectives

Industrial products very often contain metallic materials. In this context, it is necessary for an engineer to know the different metals and alloys. Their methods of production from ores will first be studied. Knowing that the whole of the operations of extraction and transformation of the ore into metal represents today approximately 10% of the world emissions of CO₂ (source UNEP 2020), one will wonder about the possible reductions of this Carbon footprint. Secondly, the structure of metals and the behaviour of mixtures (alloys) will be considered. Then, the influence of heat treatments during the transformation of these materials into products will be examined. Finally, the mechanical behaviour of metals and alloys and methods to improve their mechanical properties will be described.

Course contents

Part I: Extractive Metallurgy

1. Metal production
2. From ore to metal
3. Steel and aluminium production: towards less polluting processes?

Part II: Physical Metallurgy

1. Cohesion, structure and properties of metals
2. Point, linear, surface and volume defects in metals
3. Thermodynamic equilibria and phase diagrams (Pb-Sn and Fe-C diagrams)
4. Diffusion

Part III: Structural Transformations (= Physical Metallurgy 2)

1. Germination and growth of a new phase / solidification / precipitation
2. Martensitic and bainitic transformations; heat treatment of steels
3. Heat treatments of aluminium alloys

Part IV: Mechanical Metallurgy

1. Plastic deformation of metals
2. Physical mechanisms of plasticity
3. Hardening of metallic materials

Course material

- "Engineering Materials 2", M.F. Ashby and D.R.H. Jones, Elsevier, 2012 (4th edition)
- "Materials Science and Engineering: An Introduction", W.D. Callister, D.G. Rethwisch, Wiley, 2018 (10th edition).

Skills developed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - C2C1 : Represent and model
 - Proficient
 - C2C2 : Solve and arbitrate
 - Proficient
 - C2C3 : Think and act in an unpredictable and uncertain environments
 - Proficient

Skills assessed through this course

No skill observed

Sustainable Development Goals (SDGs) covered by this course

Quality education / Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

The 'Extractive Metallurgy' section of the course covers the processes involved in transforming ores into metals and introduces ongoing research and development in laboratories and industry aimed at decarbonising and reducing the environmental impact of these processes.

Assessment

Individual assessment: EVI 1 (coefficient 1.0)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	18 hrs	8 hrs	4 hrs	0 hrs	2 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 74 / 94

Project 1 [P1MATEPRO]

LEAD PROFESSOR(S): Erwan VERRON

Requirements

All courses from the specialty MATEPRO

Objectives

This course aims to apply the academic lectures of the specialisation to practical cases. Moreover, students are initiated to the management of scientific projects, and also to written and oral presentation of scientific and technical subjects.

Each group of students is supervised by a professor. All subjects are directly related to the scientific activities of the research group.

Course contents

Depends on the subject

Course material

Depends on the subject

Skills developed through this course

- C3 : Manage complex programmes or change responsibly
 - C3C1 : Design a project/programme
 - Proficient
 - C3C2 : Manage/lead a project/programme
 - Proficient
 - C3C3 : Finalise and leverage feedback
 - Proficient

Skills assessed through this course

No skill observed

Sustainable Development Goals (SDGs) covered by this course

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

Sustainable Development and Social Responsibility Positioning

This project contributes to sustainable development by training students in the management of scientific projects closely linked to research and industrial needs. It develops technical, methodological and communication skills, while raising awareness of responsible innovation, resource efficiency and the sustainability of materials-based solutions. Supervision by academic researchers promotes an ethical and rigorous approach to scientific knowledge production.

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

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Autumn Semester - Course Unit 74 / 94

Polymers and composites [POCOM]

LEAD PROFESSOR(S): Sébastien COMAS-CARDONA

Objectives

At the end of the course (32h) the students will be able to:

- Describe the constituents' synthesis & main properties (fibers, reinforcements, matrices)
- Model and simulate behaviors of thermosetting and thermoplastic polymers
- Homogenize thermal and mechanical properties of composites
- Calculate the stiffness matrix of laminates and the stresses and strains in each ply
- List and use laminates' failure criteria
- Use programming software to solve simplified engineering problems involving polymer composites

Course contents

Composites, Fibers and Reinforcements (2h)
 Thermoplastic Polymers (3h)
 Thermosetting Resins (3h)
 Structural Mechanics (3D towards 2D in-plane stress) (2h)
 Isotropic multilayered structure (2h)
 Anisotropic multilayered structure (Ply behavior, Laminates Theory) (4h)
 Homogenization (6h)
 Failure criteria (2h)
 Final project+Examination (8h)

Course material

1. Traité des matériaux (Editions Ecole Polytechnique Fédérale de Lausanne)
2. P. Boisse, Composite Reinforcements for optimum performance , 2011
3. Friedrich Klaus, Fakirov Stoyko, & Zhang Zhong. (2005). Polymer Composites: From Nano- to Macro-Scale. Boston, MA: Springer Science+Business Media, Inc
4. Pascault J.-P. et al. Thermosetting Polymers. New York Basel: M. Dekker, 2002.
5. Bourban Pierre-Etienne, Carlsson Leif A, et Mercier Jean-Pierre, Matériaux Composites à Matrice Organique: Constituants, Procédés, Propriétés. Lausanne: Presses polytechniques et universitaires romandes, 2004
6. Gay Daniel, Matériaux Composites. 6e édition revue et augmentée. Paris: Lavoisier, 2015
7. Mechanics of fibrous composites, C.T. Herakovich, Wiley 1998
8. A first course in finite elements, Jacob fish, Ted Belyscho, Wiley 2007
9. Mechanics of solid materials, J. Lemaitre and Chaboche, Cambridge 2000

Skills developed through this course

- C1 : Design and prototype innovative systems that create value
 - C1C1 : Develop
 - Proficient
 - C1C2 : Dare
 - Proficient
 - C1C3 : Deliver and create value
 - Proficient

Skills assessed through this course

No skill observed

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 composite materials at the heart of current industrial and environmental challenges, exploring their physical and mechanical properties, homogenization, and behavior under complex loading. It enables students to master mechanical pre-design methods, failure criteria, and modeling tools specific to these materials, in order to design lightweight (SDG 13), high-performance, optimized (SDG 9), and sustainable (SDG 12) structures. By combining theory, practice, and critical analysis, this course prepares future engineers to meet the challenges of mechanical design, not only through technological solutions, but also by integrating the challenges of structural weight reduction, resource conservation, and ethical considerations to limit their impacts.

Assessment

Collective assessment: EVC 1 (coefficient 0.7)

Individual assessment: EVI 1 (coefficient 0.3)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	16 hrs	8 hrs	6 hrs	0 hrs	2 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Spring Semester - Course Unit 103 / 83

Fatigue and fracture of materials [FARUP]

LEAD PROFESSOR(S): Erwan VERRON

Requirements

Continuum Mechanics (MMCe, 1st year), Materials (MATER, 1st year)

Objectives

This course aims to introduce the fundamental concepts to handle fracture and fatigue problems. It is divided into two parts:

- Fracture Mechanics to define the physical quantities and the theoretical developments necessary to investigate fracture at the macroscopic scale,
- Fatigue of Materials, which presents this kind of damage and the relationships between microstructure and fatigue resistance.

Course contents

Part 1: Linear Fracture Mechanics

1. Flaws. Stress concentration
2. Local approach: stress intensity factor and toughness
3. Energetic approach: energy release rate and fracture energy

Part 2: Fatigue of Materials

1. Introduction to the fatigue phenomenon. Definitions.
2. Study of fatigue: fatigue life and fatigue crack propagation
3. Physical mechanisms of fatigue
4. Factors that affect the fatigue of materials
5. Case studies

Course material

- E.E. Gdoutos, Fracture Mechanics. An introduction, Kluwer Academic Publishers, 1993.
- A.T. Zehnder, Fracture Mechanics, in Lecture Notes in Applied and Computational Mechanics vol. 62, Springer, 2012.
- J.-L. Engerand, Mécanique de la Rupture, Techniques de l'Ingénieur, pp. B 5 060-1 - B 5 060-12, 1990.
- C. Bathias, J.-P. Bailon, Fatigue des matériaux et des structures, Hermes, 1997.
- G. Hénaff, F. Morel, Fatigue des structures, Technosup, 2005.
- S. Suresh: Fatigue of Materials, Second Edition, Cambridge University Press, 1998.
- J. Schijve: Fatigue of Structures and Materials, Second Edition, Springer, 2009.

Skills developed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - C2C1 : Represent and model
 - Proficient
 - C2C2 : Solve and arbitrate
 - Proficient
 - C2C3 : Think and act in an unpredictable and uncertain environments
 - Proficient

Skills assessed through this course

No skill observed

Sustainable Development Goals (SDGs) covered by this course

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

Sustainable Development and Social Responsibility Positioning

This course contributes to sustainable development by encouraging the design of reliable and durable mechanical structures. Understanding fracture and fatigue mechanisms helps to extend the service life of materials and limit waste of resources, while improving infrastructure safety.

Assessment

Individual assessment: EVI 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	20 hrs	6 hrs	4 hrs	0 hrs	2 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Spring Semester - Course Unit 103 / 83

Materials and Society [MATSOC]

LEAD PROFESSOR(S): Thomas CORRE

Requirements

- Energy, Environment and Climate Challenges
- Matter: Engineering and societal challenges

Objectives

The objective of the course is to raise students' awareness of the social and environmental issues related to their training, namely the impacts of material extraction and use. The approach is based on developing critical thinking through engagement with the complexity of real-world situations involved in the deployment of technologies, and through reflection on the interactions between science and society.

Course contents

This 32-hour module consists of 8 hours of lectures delivered by external speakers on current environmental issues, and 24 hours of practical sessions. The students' work consists of producing, in groups, a controversy map on an assigned topic related to the use of materials. The group work is presented in the form of a poster during a 2-hour session attended by the entire teaching staff of the Matepro track.

The controversy analysis follows the methodology developed within the FORCCAST project, which is dedicated to training through controversy mapping applied to the analysis of science and technology.

Skills developed through this course

- C3 : Manage complex programmes or change responsibly
 - C3C1 : Design a project/programme
 - Proficient
 - C3C2 : Manage/lead a project/programme
 - Proficient
 - C3C3 : Finalise and leverage feedback
 - Proficient

Skills assessed through this course

No skill observed

Sustainable Development Goals (SDGs) covered by this course

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

Sustainable Development and Social Responsibility Positioning

This module addresses the Ecological Transition for Sustainable Development (TEDS), drawing on concrete examples of interactions between science and society.

Assessment

Collective assessment: EVC 1 (coefficient 1)

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LAB	PROJECT	EXAM
French	3	10 hrs	0 hrs	22 hrs	0 hrs	0 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Spring Semester - Course Unit 103 / 83

Composites processing [MICOM]

LEAD PROFESSOR(S): Christophe BINETRUY

Requirements

Continuum mechanics
 Polymer composites

Objectives

The course introduces the fundamentals of manufacturing polymer composite materials and structures. It is divided into two main sections.

First, the technological aspects and dominant physical mechanisms of organic composite manufacturing processes are presented.

The second part presents process modelling approaches. These focus on the study of resin flows in rigid and deformable fibre networks, the forming of fibre reinforcements and composite prepregs, and the flow of fibre suspensions. The course then illustrates these approaches using numerical modelling to address case studies inspired by real-world applications. Finally, students have the opportunity to apply their knowledge in practical exercises.

Course contents

1/ Review of Composites Processes

2/ Modeling of LCM processes

Description of fibrous reinforcements

Governing equations for flows in porous media

Macroscopic scale : upscaling

Flow of simple fluids in non-deformable fibrous microstructures

Permeability

Flow in deformable fibrous microstructures

Numerical simulation

3/ Forming

Fishnet algorithm

Methods based on differential geometry

Continuum mechanics based approach

4/ Squeeze flow

Squeeze flow mechanics

Squeeze flow in unidirectional prepregs

Squeeze flow in cross-ply stacks of UD prepregs and woven prepregs

SMC compression

Course material

Advani, Suresh G., and E. Murat Sozer, eds. Process modeling in composites manufacturing. Vol. 59. CRC Press, 2010

Advani, Suresh, and Kuang-Ting Hsiao, eds. Manufacturing techniques for polymer matrix composites (PMCs). Elsevier, 2012

Advani, Suresh G. Flow and Rheology in Polymer Composites Manufacturing, COMPOSITE MATERIALS SERIES, Volume 10, Elsevier, 1994

Hoa, Suong V. Principles of the manufacturing of composite materials. DEStech Publications, Inc, 2009

Coussy, O. Poromechanics. John Wiley & Sons, 2004

Boisse, P. (Ed.). (2015). Advances in Composites Manufacturing and Process Design. Woodhead Publishing.

Long, A. C. (Ed.). (2014). Composites forming technologies. Elsevier.

C. Binetruy. Lectures notes:

- Flow and heat transfer in stationary fibrous media : Porous Media Manufacturing Process

- Squeeze flow manufacturing processes

Skills developed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - C2C1 : Represent and model
 - Proficient
 - C2C2 : Solve and arbitrate
 - Proficient
 - C2C3 : Think and act in an unpredictable and uncertain environments
 - Proficient

Skills assessed through this course

No skill observed

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

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	8 hrs	12 hrs	0 hrs	2 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Spring Semester - Course Unit 103 / 83

Metal forming and processing [MIMET]

LEAD PROFESSOR(S): Guillaume RACINEUX

Objectives

This course aims to describe the more common processes we can find in industry and the models associated for process modeling. The focus is placed on the mathematical modeling of the processes by order of complexity and the simplified models are given before the generalized standard mechanical behavior. An introduction to non linear finite element modeling for processes is given at the end of the course.

Course contents

- Introduction of metal forming processes
- Bending of sheet metals. Plasticity models
- Forging. Visco-plasticity models
- Stamping. Damage models
- Multi-physics coupling and induced properties
- Numerical simulations

Course material

- Mécanique des matériaux solides, J.Lemaitre & J.L. Chaboche
- Mécanique non linéaire des matériaux, S.Forest, J.L Chaboche, J Besson G. Cailletaud
- Techniques de l'ingénieur

Skills developed through this course

- C2 : Analyse a complex system from all angles (scientific, economic, human, social) and propose a solution
 - C2C1 : Represent and model
 - Proficient
 - C2C2 : Solve and arbitrate
 - Proficient
 - C2C3 : Think and act in an unpredictable and uncertain environments
 - Proficient

Skills assessed through this course

No skill observed

Sustainable Development Goals (SDGs) covered by this course

Responsible consumption and production

Sustainable Development and Social Responsibility Positioning

The Metal Forming course is embedded in a sustainable development and social responsibility framework by providing students with an in-depth understanding of forming processes and the associated modelling tools. These approaches enable them to develop realistic process models in order to optimise technological choices in terms of material and energy consumption, while contributing to waste reduction within a responsible production and consumption perspective. The introduction of advanced models and numerical simulation tools further promotes eco-design of industrial processes by limiting the need for experimental trials and their environmental impact. The course thus raises awareness among future engineers of the key role played by mastery of metal forming processes in reducing the carbon footprint of industrial systems

and contributing to the fight against climate change.

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	16 hrs	6 hrs	8 hrs	0 hrs	2 hrs

ENGINEERING - OD MATEPRO

Year 2 / Year 3 - Spring Semester - Course Unit 103 / 83

Project 2 [P2MATEPRO]

LEAD PROFESSOR(S): Erwan VERRON

Requirements

All courses from the specialty MATEPRO

Objectives

This course aims to apply the academic lectures of the specialisation to practical cases. Moreover, students are initiated to the management of scientific projects, and also to written and oral presentation of scientific and technical subjects.

Each group of students is supervised by a professor. All subjects are directly related to the scientific activities of the research group.

Course contents

Depends on the subject

Course material

Depends on the subject

Skills developed through this course

- C3 : Manage complex programmes or change responsibly
 - C3C1 : Design a project/programme
 - Proficient
 - C3C2 : Manage/lead a project/programme
 - Proficient
 - C3C3 : Finalise and leverage feedback
 - Proficient

Skills assessed through this course

- C3 : Manage complex programmes or change responsibly
 - Proficient

Sustainable Development Goals (SDGs) covered by this course

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

Sustainable Development and Social Responsibility Positioning

This project contributes to sustainable development by training students in the management of scientific projects closely linked to research and industrial needs. It develops technical, methodological and communication skills, while raising awareness of responsible innovation, resource efficiency and the sustainability of materials-based solutions. Supervision by academic researchers promotes an ethical and rigorous approach to scientific knowledge production.

Assessment

Collective assessment: EVC 1 (coefficient 0.7)

Individual assessment: EVI 1 (coefficient 0.3)

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