SHAKE THE FUTURE.

CENTRALE NANTES

MASTER OF SCIENCE, TECHNOLOGY AND HEALTH

MECHANICAL ENGINEERING

ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2

PROGRAMME SUPERVISOR:
SEBASTIEN COMAS-CARDONA

Établissement public sous tutelle du ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

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MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

Composite Processing Modeling

Composite Constituents and Processes

Composite Structures

Multi-Physics Modeling for Processes

Integrated Design Engineering of PSS

Project

Composite Characterization

Cultural and Communication English

French Language

COMPOSITES PROCESSING MODELING

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Christophe BINETRUY

Objectives

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

- Describe main physical mechanisms
- Model main mechanisms observed during manufacturing
- Simulate draping and impregnation phases with software

Course contents

This course deals with the analysis and modelling of the physics occurring during Composites processing through the use of governing equations and constitutive equations.
Governing equations will be given for the modelling of structural composites processing and suspension/short/long fiber processing.
Exercises and lab sessions will focus on 1D analytical and 2D numerical modelling.

- Process classification based on occurring physics, yield rate and performance
- Governing and constitutive equations (fluid dynamics, heat transfer, mechanics) adapted to composites and porous (fibrous) materials.
- Experimental identification (permeability for Darcy's law)
- Lab sessions: Simulation of composite processing

Course material

- Process Modelling in Composites Manufacturing, Second Edition, 2010 by CRC Press, 630 Pages, Suresh G. Advani, E. Murat Sozer
- Traité des matériaux, EPFL

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	3	14 hrs	8 hrs	8 hrs	0 hrs	2 hrs

COMPOSITES CONSTITUENTS AND PROCESSES

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Sébastien COMAS-CARDONA

Objectives

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

- Describe the constituents' synthesis & main properties (fibres, reinforcements, matrices)
- Simulate the chemo-rheological behavior of a thermosetting resin
- Describe the main composite processing technologies
- Produce a thermoplastic composite part by consolidation process and a thermoset composite
- part by infusion process.
- Select the best process to manufacture a given part.
- Calculate capacity planning and evaluate manufacturing cost
- Use Matlab to solve simplified engineering problems (optimization and ordinary differential equation solving)

Course contents

These introductory lectures aim to present the main markets and applications of fibre reinforced composites. The main physico-chemical and mechanical background on constituents (fibres, textiles, reinforcements and organic matrices) will be given. This course also presents Composite processing technologies, their various limits and advantages.

- Markets and applications
- Constituents: fibres and matrices (nature, synthesis, main properties)
- Fibrous reinforcements (manufacturing, properties)
- Semi-products, microstructures
- Short, long, chopped, discontinuous and continuous fibres technologies
- Thermosetting vs thermoplastic polymer challenges
- Process control (filling, heat, cure etc)
- Manufacturing planning – cost evaluation
- Lab sessions: Composite and Constituents Characterization, Consolidation Process, Infusion Process

Homework and lab sessions will provide an understanding of the major processes used in the composites industry.

Course material

- Traité des matériaux (Editions Ecole Polytechnique Fédérale de Lausane)
- 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

▪ Campbell Flake C. Manufacturing Processes for Advanced Composites. New York: Elsevier, 2004

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

COMPOSITES STRUCTURES

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: 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

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

MULTI-PHYSICS MODELING FOR PROCESSES

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: 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

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

INTEGRATED DESIGN ENGINEERING OF PSS

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Alain BERNARD

Objectives

At the end of the course, the students will be able to understand the main concepts and methods of integrated design engineering applied to new approaches related to product service systems

Course contents

This course proposes six modules related to integrated design engineering methods:

- Methods and tools of engineering design
- Definition of Product-Service system
- Innovation methods for product-service systems design
- Managing complexity in integrated design engineering
- Knowledge management and knowledge-based engineering applied to decision making
- Product-service systems lifecycle management based on an integrated platform

Course material

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	16 hrs	14 hrs	hrs	0 hrs	2 hrs

PROJECT

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Sébastien COMAS-CARDONA

Objectives

At the end of the project, the students will be able to:

- Solve an industrial engineering problem dealing with technical, economic and environmental constraints
- 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.

Course material

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

COMPOSITES CHARACTERIZATION

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Christian BURTIN

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.
- Select the proper parameters to do an the image treatment efficiently
- 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
- Image processing with linear operator
- Image processing with segmentation methods
- 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.

NB:
- Jupyter Notebook is used for the worked exercises. Please download ANACONDA
- A computer is mandatory for each student

Course material

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

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

FRENCH LANGUAGE

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Silvia ERTL

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. 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.

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).

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
French	**4**	**0 hrs**	**32 hrs**	**0 hrs**	**0 hrs**	**0 hrs**

CULTURAL AND COMMUNICATION ENGLISH

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - AUTUMN SEMESTER

LEAD PROFESSOR: Spencer HAWKRIDGE

Objectives

Team-building and Communicational English:

- Understand the general concepts of team-building
- Build a team-building project
- Understand and nurture the creative process
- Enhance self-belief and self-empowerment

Behavioral skills in an inter-cultural environment:

- Strengthen self-confidence and capacity for interaction
- Develop active listening and reformulation skills
- Develop networking skills

Course contents

Cultural and Communicational English: exercises to explore in practice the areas of culture and communication
Field-related or inter-cultural project (for example, construct content for inter-cultural teambuilding activities; example WIOBOX website etc).

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).

LANGUAGE OF INSTRUCTION	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT	EXAM
English	4	0 hrs	32 hrs	0 hrs	0 hrs	0 hrs

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - SPRING SEMESTER

Master Thesis / Internship

MASTER THESIS / INTERNSHIP

MECHANICAL ENGINEERING - ADVANCED COMPOSITE ENGINEERING AND SCIENCE

YEAR 2 - SPRING SEMESTER

LEAD PROFESSOR: 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.

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