

SHAKE THE FUTURE.



ENGINEERING PROGRAMME

SPECIALISATION

**MECHANICAL ENGINEERING
FOR MATERIALS AND
MANUFACTURING PROCESSES**
AUTUMN SEMESTER

MATERIALS SELECTION IN MECHANICAL DESIGN

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Emmanuelle ABISSET-CHAVANNE

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.

Keywords

Materials selection, performance index and optimisation, Ashbys charts

Links with other programmes

First year course in Materials

Physical and Mechanical Metallurgy, Polymers and Composites

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	12 hrs	8 hrs	0 hrs	12 hrs

FINITE ELEMENT METHOD

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Grégory LEGRAIN

Objectives

To present the fundamentals of the Finite Element Method and aspects of its implementation. The framework is restricted to elliptic cases in 1D and 2D.

Course contents

- Classification of PDEs
- Weak formulation / variational formulation / weighted residuals
- Bubnov-Galerkin / Ritz-Galerkin methods
- Finite elements in 1D / 2D
- Isoparametric finite elements

Course material

- The Finite Element Method: Linear Static and Dynamic Finite Element Analysis. T.J.R. Hughes
- Analyse des solides déformables par la méthode des éléments finis. M. Bonnet, A. Frangi

Keywords

Galerkin; weak formulation; weighted residuals; isoparametric finite elements

Links with other programmes

Other courses of the following specialisations:

- Modelling and Simulation in Mechanics,
- Mechanical Engineering for Materials and Manufacturing Processes
- High Performance Computing in Engineering Science

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	12 hrs	8 hrs	10 hrs	0 hrs

STRUCTURAL MECHANICS

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Hervé OUDIN

Objectives

This course presents the link between practical engineering models and continuum mechanics equations for rods, beam and shells.

Students will be able to solve these equations for simple cases and use their numerical implementation for more complex examples.

Course contents

Concepts covered:

- Rod and Truss
- Beams

Each theme is presented through tutorials analytically and numerically. Projects are proposed for more complex examples, and the numerical results are compared with theoretical, numerical and experimental results.

This course concludes with a project on Cst3m.

Course material

See <https://meefi.pedagogie.ec-nantes.fr/MEF/MEF.htm>

Keywords

bars, beams, truss, finite element, numerical methods

Links with other programmes

Continuum mechanics

Other courses of the Modelling and Simulation in Mechanics and the Mechanical Engineering for Materials and Manufacturing Processes specialisations.

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	8 hrs	12 hrs	8 hrs	4 hrs

EXPERIMENTAL METHODS IN MATERIALS SCIENCE

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Michel CORET

Objectives

This course deals with experimental methods that are widely used in mechanics of materials. Most of them focus on the observation the materials or the identification of some physical properties.

Course contents

- Highly instrumented tests using electromechanical and hydraulic machines (with the use of digital image correlation)
- Observation and analysis using scanning electronic microscopes
- tridimensional measurements using tomography

Course material

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

Keywords

Mechanical tests; Scanning electronic microscope; Tomography

Links with other programmes

First year courses in:

- Materials,
- Modelling approaches in Mechanical Engineering,
- From measurement to control

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	14 hrs	6 hrs	12 hrs	0 hrs

PHYSICAL AND MECHANICAL METALLURGY

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Bertrand HUNEAU

Objectives

Industrial products are mostly made of metallic materials. In this context, it is absolutely necessary for engineers to know the structure and properties of the major metals and alloys. But it seems even more important to understand the influence of thermomechanical treatments during the production and the processing of these materials. Indeed, these processes generate the microstructure of metallic materials and thus determine their functional properties and durability.

Course contents

1. Physical Metallurgy (crystal structure and crystal defects, phase diagrams)
2. Structural Transformations, heat treatments of metallic alloys
3. Mechanical Metallurgy: Physical mechanisms of plasticity and strengthening mechanisms

Course material

- Métallurgie. Du minerai au matériau, J. Philibert, A. Vignes, Y. Bréchet et P. Combrade, Dunod, 2002.
- Des Matériaux, J.-P. Bâillon and J.-M. Dorlot, Presses Internationales Polytechnique, 2000.
- Introduction à la science des matériaux, Traité des matériaux tome 1, W. Kurz, J.-P. Mercier and G. Zambelli, Presses Polytechniques Romandes, 2002.
- Précis de métallurgie, G. Maeder, J. Barralis. Nathan/AFNOR, 1997.
- Engineering Materials 2, M.F. Ashby and D.R.H. Jones, Elsevier, 2012.

Keywords

Microstructure, Phase diagrams, Structural transformations, Heat treatments, Dislocations, Mechanical properties.

Links with other programmes

- Materials (first year course)
- Materials Selection
- Experimental tools
- Metal forming

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	18 hrs	8 hrs	4 hrs	0 hrs

NON-LINEAR CONTINUUM MECHANICS

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Erwan VERRON

Objectives

This course aims to extend Continuum Mechanics concepts to the case of large strain, in order to model the mechanical response of engineering materials. The focus is placed on theoretical foundations and on the extension of the finite element method to non-linear problems.

Course contents

1. Kinematics of large strain problems
2. The different stress tensors. Mechanical equilibrium
3. Hyperelastic constitutive equations
4. Introduction to numerical methods for non-linear problems

Course material

- Holzapfel G. A., Nonlinear Solid Mechanics: a continuum approach for engineering, Wiley-Blackwell, 2000.
- Bonet J. and Wood R. D., Nonlinear Continuum Mechanics for Finite Element Analysis, second edition, Cambridge University Press, 2008
- Abaqus, Matlab

Keywords

Continuum Mechanics, Large strain, Non-linear elasticity, Constitutive equations, Finite element method for non-linear problems

Links with other programmes

- Continuum Mechanics, first year course
- Finite element method
- Engineering methods for structures
- Experimental methods

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	10 hrs	8 hrs	12 hrs	0 hrs

PROJECT 1

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Erwan VERRON

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

Course material

Keywords

Links with other programmes

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	1	0 hrs	0 hrs	0 hrs	32 hrs

POLYMERS AND COMPOSITES

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Emmanuelle ABISSET-CHAVANNE

Objectives

- Final objective: pre-design of composite structures
- General knowledge of composite materials, from the constituents to the structure via their mode of degradation and failure
- Study of laminate elastic behavior
- Introduction of non-linear behavior models
- Study of degradation mechanisms until failure

Course contents

- Design problem resolution, 1D, 2D and 3D continuous mechanics reminder
- Overview of composites: matrices (thermoplastic, thermosetting), fiber, textile reinforcements (woven, non-woven), sandwiches etc
- Reinforced polymer matrix composite long fibers, solid polymers and fibers, interaction
- Study of an elementary ply: constitutive relation, homogenization
- Study of a stack: laminate theory
- Nonlinear Behavior: anelastic deformation, damage and fracture

Course material

- Matériaux Composites - Comportement Mécanique et Analyse des Structures (éditions Tec & Doc Lavoisier)
- Traité des matériaux EPFL

Keywords

Polymer, composite materials, homogenization, laminate theory, damage / failure

Links with other programmes

- Modelling approaches in mechanical engineering, first year course
- Materials, first year course
- Structural Mechanics
- Materials Selection in Mechanical Design
- Composite processing

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	16 hrs	8 hrs	4 hrs	2 hrs

CONFERENCES AND COMPANY VISITS

MECHANICAL ENGINEERING FOR MATERIALS AND MANUFACTURING PROCESSES,
ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Bertrand HUNEAU

Objectives

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

In addition, three visits to local companies will be organized (e.g. for 2016-2017: Safran Aircraft Engines, Airbus, Vibracoustic)

Course contents

Course material

Keywords

Links with other programmes

All the courses of the specialisation

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	32 hrs	0 hrs	0 hrs	0 hrs