Université de Bretagne Sud (UBS)
École Nationale Supérieure de Techniques Avancées Bretagne (ENSTA Bretagne)
École Nationale d'Ingénieurs de Brest (ENIB)
Université de Bretagne Occidentale (UBO)
Institut National des Sciences Appliquées Rennes (INSA Rennes)

Master of Science "Design Engineering"

Mechanical Engineering and Materials

Aims

This specialization offers opportunities for immediate professional integration after the Master's degree as well as doctoral pursuits.

For graduates who choose immediate employment, the jobs held are quite diverse. For the most part, these are jobs as research and development engineers specializing in the field of mechanics of materials and structures.

For those who choose to pursue a PhD, they can also apply for academic positions in universities or public research organizations such as CNRS at the end of their PhD.

Skills acquired

On the basis of general training in mechanical engineering, this high-level course aims to grant students a perfect mastery of the technical aspects of the implementation, material control and tracking, as well as modern tools for modelling and numerical calculation of structures. The skills targeted are in particular knowledge of the behaviour and durability of materials, criteria for choosing structural materials as well as numerical methods in the field of structural calculation.

Admission requirements

Access to this Master of Science (M2) is open to students with a Bachelor of Science in Mechanical Engineering.

Applications

The number of places is limited to 30 students for this specialization. ENIB does not deliver the M1 classes and only receives applications for M2. The admission process is application-based.

Application documents:

Application form, CV, cover letter, copy of diplomas and academic transcripts (post-secondary) - interview (possibly)

Internship

Mandatory long-term internship (4 to 6 months)

The internship can be completed in a university laboratory, a public research centre or a research and development department of a company. It is the subject of a written report and an oral defence before the master's jury.

> Start of internship: March-April
> Duration: 4 to 6 months (16 weeks minimum)

Further study

This Master's degree is a combined professional and research course and is built in such a way that graduates can directly enter the professional world or, for those wishing to work in research, to continue their studies in order to prepare a PhD.

Some of the projects studied are oriented towards the challenges faced by companies in the mechanical engineering field, while others are geared towards more fundamental subjects. During the course, students have the opportunity to be confronted with both types of problems. Each year, the different research teams at the Institut de Recherche Dupuy de Lôme (IRDL, UMR CNRS 6027) propose academic or industrial PhD thesis topics accessible to graduates of this Master's degree.

Career opportunities

Graduates of this Master's degree can work in the following fields of activity:

Transport, Energy, Mechanical Engineering, Shipbuilding, Construction and Public Works, ...

They can be employed in the following jobs:

Study Project Manager, Design and Development Engineer, Research and Development Officer, Researcher, Research Lecturer (after PhD and national examination).

Learning environment

Several very well equipped practical classrooms are available with testing and characterization machines as well as technical software. Emphasis is placed on projects and student autonomy. The programme is supported by a leading laboratory in the field of mechanics of materials and structures (IRDL, UMR CNRS 6027), granting the assurance that students will benefit from teaching provided by research lecturers familiar with the latest technologies, as well as opportunities for internships and PhD theses. Doctors of engineering from industry also contribute to the course to provide additional insight.

Promoting success

Class sizes are small to facilitate discussions with teaching staff and allow students to benefit from better supervision.

Practical information

> **Ecole Nationale d'Ingénieurs de Brest (ENIB)**
> Course available as co-op programme
> **Teaching location:** Brest
> **Contact :**

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Programme

The course is organized into two semesters: S9 and S10.

Semester S9 (36 ECTS) is composed of 6 mandatory scientific course units (6 ECTS each) (see table below)

Semester S10 (24 ECTS) is devoted to a research internship (4 to 6 months).

The Master's degree will be awarded to candidates who successfully obtain 60 ECTS credits by direct course unit validation.

Due to the difference in ECTS credits allocated to semesters S9 (36 credits) and S10 (24 credits), in the calculation of the overall average rating, the average of semester S9 is weighted with a coefficient of 0.6, and the average of semester S10 (research internship) is weighted with a coefficient of 0.4. At the end of S9, students must have a general average of more than 10 to access S10. Failing this, the student will not be able to start S10.

Semester S9	
UE-1 Finite element method for linear and non-linear problems	**Number of ECTS:** 6 **Prior knowledge required:** Mechanics of continuous media; Strength of materials; Basics of finite element method in the case of linear elasticity **Objective:** The objective of this course is to study the hypothesis, the approximations and the numerical methods used in finite element codes for the resolution of linear and non-linear problems. The goal is to study the choice of parameters of finite element modelling and to analyse and interpret numerical results. **Course content:** - Foundation of finite elements method: concepts of strong and weak formulations; Galerkin method; approximation by finite elements - Application of finite element method to non-linear problems: implementation; resolution of non-linear system of algebraic equations; notion of control and continuation methods - Element technology: problems of volumetric locking in the case of bending; complete, reduced and selective integration; beam and shell elements
UE-2 Thermodynamics of continuous media and behaviour laws	**Number of ECTS:** 6 **Prior knowledge required:** Mechanics of continuous media; Notions of mechanics of materials **Objective:** The main objectives of this course are to present a general framework for the development of behaviour laws and, on the other hand, a certain number of models making it possible to approach the usual mechanical behaviours of solid materials. **Course content:** - Introduction: roles of behaviour laws - Thermodynamics of Continuous Media (1 part) - Thermoelasticity - Viscoelasticity - Thermodynamics of Continuous Media (2 part) - Elastoplasticity

	- Elastoviscoplasticity
UE-3 Stability and non-linear mechanics	**Number of ECTS:** 6 **Prior knowledge required:** Mechanics and Thermodynamics of Continuous Media, Behaviour Laws (plasticity), Strength of Materials, Plate Theories **Objective:** The objective of this course is to present the main concepts of the formalism of large deformations and to apply them to the thermodynamics of deformable media; then, to address two instability phenomena: material instability by the limit analysis of elastoplastic structures (framework of the ultimate load with extremal principles) and geometric instability by the analysis of the elastic buckling of thin or slender structures. **Course content:** - Large transformations: Finite transformations and deformation measurements - Constraints in large deformation formalism - Observational frameworks and objective derivatives - Thermodynamics of continuous media in large transformations and Fourier's law - Limit analysis: Perfectly plastic rigid behaviour - Maximum plastic work principle - Static and kinematic variational approaches - Compound bending - Continuous gantries and beams in simple bending - Plates under bending - Stability of elastic structures: Introduction to buckling (geometric instability), notions of stability and bifurcation, application to discrete and continuous systems - Finite element and analytical resolution of a linearized buckling problem - Buckling of beams and plates
UE- 4 Elastomers and composites	**Number of ECTS:** 6 **Prior knowledge required:** Mechanics of Continuous Media, Mechanics of Solid Polymeric Materials, Finite Elements **Objective:** The objective of this course unit is to present the basic knowledge required to understand the process/material/structure triptych by adopting an approach based on experimental observations, modelling and numerical simulation. The student must be able to perform a relevant numerical simulation, apply one or more sizing criteria and take a critical approach to the results. Two major families of materials will be studied: composite materials (short and long fibres) and elastomers. **Course content:** - Rheology and implementation (practical and numerical) - Isotropic behaviour laws (hyperelasticity theory) and anisotropic behaviour (composites) - Thermomechanical aspects (coupling and dissipation) - Damage - Structural calculations - Dimensioning criteria

UE-5 Fatigue and experimental techniques	**Number of ECTS:** 6 **Number of ECTS:** Mechanics of continuous media; Notions of mechanics of materials **Objective:** The objective of this course is to present different approaches in the high cycle fatigue dimensioning of structures and also to present the modern experimental techniques to study the behaviour of materials and structures. **Course content:** High Cycle Fatigue - Introduction - Qualitative study of metallic materials behaviour under fatigue Qualitative identification from simple 1D tests (tensile, bending, torsion) Qualitative identification from multiaxial tests - Simplified modelling and approaches for dimensioning under high cycle fatigue Historical method Case of multiaxial loadings Illustration in the case of structures - Multi-scale approach for dimensioning under high cycle fatigue Presentation of the multiscale approaches framework Case of Dang Van criterion Proposition of probabilistic approaches Recent technique of fatigue properties identification: self-heating method Perspectives: considering the influence of production parameters on fatigue properties of materials and structures Experimental techniques - In-situ Stereo Digital Image Correlation (DIC) measurements - In-situ thermal field measurements - Stress analysis using X-ray diffraction method - Functioning principals of Scanning Electron Microscopy (SEM)
UE- 6 Scale transition techniques	**Number of ECTS:** 6 **Prior knowledge required:** Mechanics of continuous media, Notions of mechanics of materials **Objective:** The purpose of this course is to address the modelling of the behaviour of materials based on scale transition techniques. These techniques will be used in three areas of behaviour: linear elasticity, plasticity and phase transformation. **Course content:** - Modelling of elastic behaviour: generalities on homogenization models, models derived from the Eshelby elasticity problem - Modelling of elastoplasticity: generalities on plasticity, local scale modelling, homogenization (Taylor-Lin) - Modelling of phase transformation: generalities on phase transformation, local scale modelling, homogenization (Sachs, self-consistent)

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