Syllabus
Master de Mécanique
Parcours type Ingénierie 4.0 en Mécanique et Matériaux
Research dedicated Orientation: Mechanics of Materials, Structures and Process

2024/2028

Orientation : MMSP, Metz

UNIVERSITÉ DE LORRAINE | UFR MATHÉMATIQUES INFORMATIQUE MÉCANIQUE ET AUTOMATIQUE

Competences and skills that will be acquired and learning results (at the end of the master degree):

General Skills

Skill 1 To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results.	*Level 4*
Skill 2 To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering.	*Level 3*
Skill 3 To adopt free or commercial softwares, to solve physical problems.	*Level 4*
Skill 4 To develop capability to work in a team, with autonomy and also with colleagues for the benefit of the project.	*Level 4*
Skill 5 To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way).	*Level 3*

Specific skills for the different subdomains of the master degree:

Skill 6 To validate a model by comparing its predictions with experimental results and discuss its validity range.	*level 3*
Skill 7 To Solve problems to develop new knowledge and new procedures and integrate knowledge from different fields	*Level 2*

Skill 8 To identify, based on the well established skills in mechanical engineering, material sciences, salient simulation softwares and to propose to propose their uses in the industry.	*Level 4*

Program of the 2nd year of the master degree MMSP

SEMESTER 9

ORI Mécanique Matériaux Structures et Procédés
CHOI CHOI 1

BC 5: Strengthening the professional perspectives

UE 900 Internationalization and project
EC01 Internationalization
EC02 ORION excellence Practical Works
EC03 Seminar
UE 901 Integrative project or Apprenticeship

BC 12: Modeling material behaviors

UE 920 Experimental methods in solid mechanics
UE 921 Mechanical behaviour of materials
UE 922 Thermomechanical behavior of heterogeneous materials
UE 923 Continuum mechanics
UE 924 Structural mechanics and finite element analysis
UE 925 Deformation Mechanisms and microstructure

CHOI options

BC 13: Building advanced approaches for extreme loadings

UE 926 Numerical methods in computational mechanics
UE 927 Fracture and Damage mechanics
UE 928 Mechanics of composite materials and structures
UE 929 Control and damping of vibrations
UE 930 Material characterization and modeling in dynamic loading
UE 931 Machining Processes: Modeling and Experimentation
UE 932 Metal forming

SEMESTRE 10

SEMESTRE 10
STG UE101 5-month Internship in research laboratory academia or industry

Detailed Program

The course syllabus and the academic weekly planning may change due academic events or other reasons.

Name of the coordinating teacher may change.

Note that each course may not open each semester.

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM01

Nom complet de l'UE : UE 900 Internationalisation and research

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Éric Fleury eric.fleury@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 75h - 125h, Nombre de crédits ECTS : 5

Volume horaire travail personnel de l'étudiant : 60h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TP	TPL	DLOC	EqTD
EC 900.2 Foreign Language and Internationalization Research	6000	20				30
EC 900.4 Seminar Erasmus (par prof invité)	6000				30	
EC 900.5 TP ORION I2M	6000		15			15

Descriptif

The objective of this teaching unit is twofold: - Continue to develop language skills and obtain certification (level B2-C1). Depending on the orientations, this EC01 section will be organized in different ways, always in line with the objective of the orientation. For the 2 research degrees (MMSP and Biomechanics), in connection with the CMGS orientation of the Civil Engineering master's, it translates into an intervention on how to write and publish a research article in English. The associated volume is 20h CM. For pro MM orientation, this module is shared with other M2 SPI degrees GC and GSI). The associated volume is 30h (TPL). For the pro GM orientation, this module is shared with other M2 degrees with an ISFATES orientation. The associated volume is 30h (TPL) The internationalization aspect is increased by attending seminars by foreign researchers invited to LEM3. - The objective of the ORION labs of excellence is to provide complementary teaching with the research equipment available in the LEM3 laboratory. The orientations of the PT I2M will follow 1 cycle of TP of 15h while the students of the PT biomechanics will follow 2 cycles of TP (total 30h)

Pré-requis

None

Acquis d'apprentissage

The student will be able to understand, write and communicate in English in a fluent manner. The student will also conduct experiments on the latest equipments available at LEM3 laboratory. So the student will make the link between knowledge acquired during his degree and the today development in mechanical, material and biomechanical fields.

Compétences visées

Skill 4: To develop capability to work in a team, with autonomy and also with colleagues for the benefit of the project. Level 4

Skill 5: To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way). Level 3

Cette UE appartient au bloc de compétences "BC5 : conforter son choix d'orientation professionnelle"

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM02

Nom complet de l'UE : UE 901 Integrative project or Apprenticeship

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Éric Fleury eric.fleury@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 60h, Nombre de crédits ECTS : 4

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Français

Enseignements composant l'UE	CNU	PRJ	EqTD
EC 901.1 Integrative Project / Apprenticeship	6000	60	

Descriptif

the objective of this teaching unit is to continue the construction of the student's professional career. For those in initial training, this integrative project makes it possible to put into practice all the skills to solve a research or industrial problem. This project lasts the entire semester.

For those in apprenticeship, this makes it possible to apply these same skills in an already industrial context.

Pré-requis

None

Acquis d'apprentissage

The student will be able to apply all the knowledge of the semester to solve a research /industrial project in an academic or industrial environment.

Compétences visées

Skill 4: To develop capability to work in a team, with autonomy and also with colleagues for the benefit of the project. Level 4

Skill 5: To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way). Level 3

Cette UE appartient au bloc de compétences "BC5 : conforter son choix d'orientation professionnelle"

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM20

Nom complet de l'UE : UE 920 Experimental Methods in solid mechanics

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Fodil Meraghni fodil.meraghni@ensam.eu

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 3

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 920 Experimental Methods in solid mechanics (ENSAM)	6000	20	10	40

Descriptif

This course is an introduction to methods and tools specific to the implementation of experimental approaches in solid mechanics. It aims to provide students with basic scientific knowledge to define and implement a consistent experimental approach dedicated to the characterisation or identification of the mechanical behavior of materials and structures. In the first part, the course covers the main aspects inherent in the measurement and experimental data processing particularly in terms of measurement errors. The second part is devoted to presenting examples of experimental techniques and their recent advances in the characterisation particularly for mechanical tests. Besides the description of these techniques, we aim to show, through research studies, the interest of the experimental method to build, to identify or to enrich the modeling of solid state mechanics at different scales: micro-macro-meso levels. A part of the course is devoted to optical microscopy and scanning electron. Some experimental methods and techniques implemented for the study of fragile and ductile materials are included in the course.

Pré-requis

Mechanical bases of solids - Behaviour of Materials

Acquis d'apprentissage

The course represents an introduction for students to the methods and tools of research for the implementation of experimental approaches dedicated to the construction and identification of solid mechanics models.

Compétences visées

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Cette UE appartient au bloc BC12 : Modéliser le comportement des matériaux .

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM21

Nom complet de l'UE : UE 921 Mechanical behavior of materials

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Abdelhadi Moufki abdelhadi.moufki@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 3

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 921 Mechanical behavior of materials	6000	20	10	40

Descriptif

1. Elastic-viscoplastic behavior through classical mechanical models (Maxwell, Kelvin, Zener)
2. Elastoplasticity

Plasticity criteria (Tresca, Mises, Hill, Schmid) Prandtl-Reuss model (J2 theory)
Incremental relationship between stress and strain hardening in general

3. Viscoplasticity

viscoplastic
crystalline viscoplasticity

4. Elastoviscoplasticity
5. Behaviour of Nanocrystalline materials

Pré-requis

General notion of Materials Science and continuum mechanics

Acquis d'apprentissage

To develop theoretical knowledge and computational tools for the mechanical behavior of materials

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 5: To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way). Level 3

Cette UE appartient au bloc BC12 : Modéliser le comportement des matériaux .

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM22

Nom complet de l'UE : UE 922 Thermomech. behavior of heterogeneous materials ENSAM

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Sébastien Mercier sebastien.mercier@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 3

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	DLOC	EqTD
EC 922 Thermomechanical behavior of heterogeneous materials	6000	30	

Descriptif

Resp. ENSAM : georges.chatzigeorgiou@ensam.eu - 20HCM - 10HTD
The goal is to provide a deep understanding in the behavior of homogeneous and heterogeneous materials under thermomechanical loading conditions.
The following topics will be presented:

Recall of continuum mechanics principles kinematics, kinetics, conservation laws, thermoelasticity
Thermodynamics of irreversible processes Thermodynamics,
Dissipation, energy balance,
Example with plasticity (isotropic/kinematic hardening)

Heterogeneous materials : Micromechanics nature of heterogeneities
classical micromechanics concepts (average theorems, Hill-Mandel)
Eshelby inclusion problems, Eshelby-based approaches (Mori-Tanaka, self consistent)
other homogenization schemes effective thermoelastic properties

Pré-requis

Background in continuum mechanics, in mechanics of materials. Basic knowledge in thermodynamics

Acquis d'apprentissage

With the present course, the student will be able to :

- derive the constitutive laws and evolution equations for dissipative materials using the thermodynamic principles
- identify effective elastic and thermal properties of composites with random structure using micromechanics (Eshelby-based methods), or with a periodic microstructure (laminates)

- understand the effect of martensitic transformation and the behavior of shape memory alloys
- compute the stress-strain response in simple problems of homogeneous and heterogeneous materials.

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 5: To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way). Level 3

Cette UE appartient au bloc BC12 : Modéliser le comportement des matériaux

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM23

Nom complet de l'UE : UE 923 Continuum mechanics

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Sébastien Mercier sebastien.mercier@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 3

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 923 Continuum mechanics	6000	20	10	40

Descriptif

The goal is to provide a deep understanding of fundamental concepts in the description of motion of deformable bodies.
The following topics will be presented :

Kinematics of continuum medium Lagrangian/ Eulerian motions
Deformation gradient, polar decomposition, finite strain Infinitesimal deformation, small strain, compatibility conditions Transport relations

Description of internal forces
Cauchy stress tensor, PK stress tensor Conservation laws
Constitutive models
Thermodynamics principle, frame indifference

Mechanics of elastic solids Linear elasticity, Non linear elasticity

Pré-requis

Background in continuum mechanics, in mechanics of materials.

Acquis d'apprentissage

With the present course, the student will be able to :

- describe motion, finite deformation, stresses and forces in a continuum medium
- derive equations of motion and conservation laws for a medium
- understand various constitutive models
- solve simple boundary value problems for solids.

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 5: To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way). Level 3

Cette UE appartient au bloc BC12 : Modéliser le comportement des matériaux

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM24

Nom complet de l'UE : UE 924 - Structural mechanics and finite element analysis

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Hamid Zahrouni hamid.zahrouni@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 3

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 924 Structural mechanics and finite element analysis	6000	20	10	40

Descriptif

This course aims to present the fundamental concepts of structural mechanics and numerical simulation of deformable solids. Variational principles of mechanical problems are presented. Principle of virtual power, potential energy, complementary energy theorem. Applications to beam models and to three dimensional elasticity. Finite element method considering various types of structural elements. Numerical methods for nonlinear problems, resolution techniques: Newton Raphson, Asymptotic Numerical Methods. Application to nonlinear models as contact mechanics in the finite element framework, nonlinear elasticity including large displacements and rotations, nonlinear constitutive relations, instability and buckling phenomena, steady and transient problems.

Pré-requis

Background in continuum mechanics, in mechanics of materials and in finite element method.

Acquis d'apprentissage

With the present course, the student will be able to :

- Formulate a mechanical problem using variational principles,
- Solve nonlinear problems with adapted techniques,
- Formulate and solve buckling problems

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 3: To adopt free or commercial softwares, to solve physical problems. Level 4

Cette UE appartient au bloc BC12 : Modéliser le comportement des matériaux

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM25

Nom complet de l'UE : UE 925 Deformation Mechanisms and microstructure

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Éric Fleury eric.fleury@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 3

Volume horaire travail personnel de l'étudiant : 0h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 925 Deformation mechanism and microstructures	3300	20	10	40

Descriptif

- Complements on Geometric crystallography (symmetry point group) and introduction to the concept of crystallographic texture (stereographic projection, crystallographic orientation, representation of the ODF and elementary calculations)
- Mechanisms of plastic deformation, strengthening mechanism, microstructural evolution during the deformation
- Recovery, recrystallization and grain growth

Pré-requis

Elementary geometric crystallography (Bravais lattice, crystal symmetry) General notion of Materials Science

Acquis d'apprentissage

Understanding and mastering the basic mechanisms of plastic deformation and recrystallization in polycrystalline materials / Effects on microstructure evolution during thermomechanical treatment and its effect on the mechanical properties

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 3: To adopt free or commercial softwares, to solve physical problems. Level 4

Cette UE appartient au bloc BC12 : Modéliser le comportement des matériaux

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM13

Nom complet de l'UE : UE 926 Numerical methods in computational mechanics

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Michael Brun michael.brun@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 2

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 926 Numerical methods in computational mechanics	6000	20	10	40

Descriptif

The course presents detailed and advanced numerical strategies for solving dynamic problems. It includes the variational formulation for the space discretization as well as the time discretization using different time integration schemes. Stability, order of accuracy and convergence associated with the numerical methods are of interest. Programmation in Matlab environment in order to solve simple static and dynamic probelms allows the students to improve their mechanical modeling skills when using industrial Finite Element codes.

II. Strong form of Partial Differential Equations in Mechanics
Strong form for the static equations and equations of motion
Partial Differential Equations for structural elements with kinematic assumptions (bar, beam, shell elements)

III. Weak form for the spatial and time discretization
Virtual Work Principle
Stationary-Action Principle

IV. Spatial Discretization

1. Finite Element Method
Displacement approximation
Isoparametric elements
Order of the polynomial approximation (P1, P2)
Gauss integration
Building of the Mass matrix, Stiffness matrix, Damping matrix and nodal Force vector
Discrete equations for the statics and dynamics
Accuracy and order of convergence in terms of the finite element size
Treatment of Dirichlet boundary condition with Lagrange multipliers

2. More modern discretization methods
Spectral elements: High order Lagrange polynomials and Gauss-Lobatto-Legendre

integration in the case of quadrilateral and hexaedral elements
Isogeometric Analysis: B-spline approximation of the displacement in the case of quadrilateral and hexaedral elements

V. Time Discretization
Generalities on time integration schemes: Stability, consistency, accuracy and order of convergence in terms of the time step size
Time integration schemes for structural dynamics and wave propagation in solids: Euler, Newmark, Explicit (Central Difference scheme), Implicit (Constant Average Acceleration), schemes with numerical damping.

VI. Transient problems for structural dynamics
Modal analysis for linear dynamics and Modal Transient Response analysis
Direct Explicit and Implicit time integration of the discrete equation motion
Non-linear dynamics: Case of nonlinear material law, iterative methods (Newton-Raphson) with Implicit time integration and Explicit analysis for nonlinear dynamics with frictional contacts

Pré-requis
Background in continuum mechanics and basics in the Finite Element Method.

Acquis d'apprentissage
Thanks to the present course, the student will be able to :
- Understand the salient points of numerical strategies for solving quasi-static and dynamic problems
- Program the Finite Element Method in statics and dynamics in the Matlab environment

Compétences visées
Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 3: To adopt free or commercial softwares, to solve physical problems. Level 4

Cette UE appartient au bloc de compétences « BC13 : Construire des approches avancées pour des chargements intenses »

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM14

Nom complet de l'UE : UE 927 Fracture and Damage Mechanics (CMGS)

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Cristian Dascalu cristian.dascalu@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 2

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC905.1Fracture & damage mechanics	6000	20	10	40

Descriptif

The course presents fundamental concepts of fracture and damage mechanics in solid materials. Main topics covered by the lectures:

Fracture mechanics
- Singularities, asymptotic analysis
- Stress Intensity Factors
- Energy Release Rate and J integral
- Crack propagation criteria
- Mixed mode crack propagation
- Fatigue crack growth
- Crack-tip plasticity, strip yield models
- Cohesive-zone laws

Damage mechanics
- Micromechanics of damage
- Thermodynamic formulation
- Brittle damage laws
- Microcracks closure effects
- Ductile and creep damage
- Damage models for fatigue

Pré-requis

Background in continuum mechanics and mechanics of materials.

Acquis d'apprentissage

The student will have a global view of the failure theories for materials starting from

distributed damage, initiation of cracks and their growth up to ultimate failure of mechanical structures. He/she will know how to choose the appropriate modeling depending on the type of loading or the material behavior and will be able to solve fracture and damage problems by analytical methods or have the necessary background for their implementation in numerical codes.

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 5: To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way). Level 3

Cette UE appartient au bloc de compétences « BC13 : Construire des approches avancées pour des chargements intenses »

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM15

Nom complet de l'UE : UE 928 Mechanics of composite materials and structures

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Fodil Meraghni fodil.meraghni@ensam.eu

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 2

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 928 Mechanics of composite materials and structures	6000	20	10	40

Descriptif

The course aims at providing students with manufacturing knowledge and theoretical background to choose a fabrication process and to design laminated polymer matrix composites. In the first part, the course covers an introduction to composite materials in terms of reinforcement architectures and matrix types, presents the main manufacturing process and the relationship between a process and the subsequent performances of the composite. The second part of the course provides analytical methods for the computation of the effective properties of composites and laminated materials. This part aims at developing an understanding of the linear elastic analysis of composite materials including anisotropic material behavior and the analysis of thin laminated plates.

The following topics will be presented:

Motivations - examples of composites. Nature and types of reinforcement.
Fabrication process for fibrous reinforced composites. Mechanical properties of the plies. Sandwich materials.
Specific design rules for composites Classical Laminate theory
Mechanical behavior of laminated composites. Elastic constants of a ply in arbitrary directions.
Response of laminated composite (in-plane and out of plane coupling) Anisotropic failure criteria (Tsai-Wu, Hill, generalized Von-Mises …) Composite beams under combined loading (bending and torsion).
Hands-on and case studies using elamx and Abaqus
Introduction to homogenization theory: computation of effective moduli for periodic and random media.
Introduction to the mechanics of generalized continua

Pré-requis

Background in continuum mechanics, in mechanics of materials.

Acquis d'apprentissage

With the present course, the student will be able to:

- Compute the effective thermomechanical properties of stratified materials.
- Design stratified materials based on Hill's criterion.
- Solve problems of composite beams.
- Determine the effective properties of periodic elastic composites.

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 5: To know how to communicate in both written and spoken French and English and become a team manager (to plan, organize, create and conduct meetings in an efficient way). Level 3

Cette UE appartient au bloc de compétences « BC13 : Construire des approches avancées pour des chargements intenses »

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM16

Nom complet de l'UE : UE 929 Control and damping of vibrations

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : El Mostafa Daya el-mostafa.daya@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 2

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 929 Control and damping of vibrations	6000	20	10	40

Descriptif

The goal of this course is to study the vibration of mechanical systems and structures. Indeed, the control and the damping of vibrations are still important tasks to design structures in many industrial domains such as aerospace, automobile, civil engineering,..This will give comprehensive skills to analyze the linear and nonlinear vibrations, especially on basic techniques of resolution and modeling.

The following topics will be presented:

- Linear vibrations analysis,
- Effects of the nonlinearities in structural dynamics,
- Study of Duffing oscillator, Amplitude equation and backbone curves.
- Nonlinear vibrations of beams,
- Methods and modal analysis in nonlinear structural dynamics,
- Active control and passive damping of vibrations

Pré-requis

Background in continuum mechanics, in structural mechanics and a preliminary course in structural dynamics

Acquis d'apprentissage

With the present course, the student will be able to:

- describe different parameters influencing the vibration problems (frequency, modes, damping coefficient)
- formulate and solve the vibration problems

- understand the influence of nonlinearities in vibration problems

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 3: To adopt free or commercial softwares, to solve physical problems. Level 4

Cette UE appartient au bloc de compétences « BC13 : Construire des approches avancées pour des chargements intenses »

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM17

Nom complet de l'UE : UE 930 Material charact. and modeling in dynamic loading

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Sébastien Mercier sebastien.mercier@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 2

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
EC 930 Material charac and modeling in dynamic loading	6000	20	10	40

Descriptif

In collaboration with CEA GRAMAT
The goal is to provide a deep understanding of fundamental concepts in the description of material behavior under dynamic loading and all processes related to strain rate effect and wave propagation.
The following topics will be presented:

- Introduction: Illustration of configurations where material is under dynamic loading.

Moderate loading: constitutive relations, phenomenological approach, thermoviscoplastic behavior.

Extreme loading: behavior of material subject to shock loading. Equation of state. Hugoniot Equation

Dedicated experimental techniques in dynamic conditions: SHP technique, Taylor test, plate impact test …..

Pré-requis

Background in continuum mechanics, in mechanics of materials.

Acquis d'apprentissage

With the present course, the student will be able to:
- Model material behavior for a large range of temperatures and strain rates
- Use the correct technique to analyze material behavior under dynamic loading
- Have a correct understanding on mechanical measurements.

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 3: To adopt free or commercial softwares, to solve physical problems. Level 4

Cette UE appartient au bloc de compétences « BC13 : Construire des approches avancées pour des chargements intenses »

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM18

Nom complet de l'UE : UE 931 Machining Processes: Modeling and Experimentation

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Abdelhadi Moufki abdelhadi.moufki@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 2

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	CM	TD	EqTD
UE 931 Machining Processes: Modeling and Experimentation	6000	20	10	40

Descriptif

The aim is to analyze and to model the thermomechanical mechanisms of the chip formation process during cutting. This allows to characterize the interaction between the cutting tool, work material and the cutting process. Different industrial applications will be studied in the case of advanced cutting processes such as deep drilling, broaching and gear hobbing.

To achieve this purpose, several approaches will be provided:

- Mechanistic and experimental methods
- Analytical models
- Numerical simulations

Pré-requis

Background in continuum mechanics, and material sciences.

Acquis d'apprentissage

With the present course, the student will be able to :

- use his background in continuum mechanics, in mechanics of materials for modeling in machining processes.
- analyze how the cutting conditions affect the chip formation mechanisms, tribological conditions, workpiece surface integrity, tool wear and tool life.
- estimate the cutting forces and the tool temperature.

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 3: To adopt free or commercial softwares, to solve physical problems. Level 4

Skill 8: To identify, based on the well established skills in mechanical engineering, material sciences, salient simulation softwares and to propose to propose their uses in the industry. Level 4

Cette UE appartient au bloc de compétences « BC13 : Construire des approches avancées pour des chargements intenses »

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 9JUJBM19

Nom complet de l'UE : UE 932 Metal forming (ENSAM)

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Sébastien Mercier sebastien.mercier@univ-lorraine.fr

Semestre : 9

Volume horaire enseigné : 30h, Nombre de crédits ECTS : 2

Volume horaire travail personnel de l'étudiant : 30h

Langue d'enseignement de l'UE : Anglais

Enseignements composant l'UE	CNU	DLOC	EqTD
EC 932 Metal forming	6000	30	

Descriptif

Resp ENSAM : Farid.ABEDMERAIM@ensam.eu - 20HCM et 10HTD
Classification of forming processes – Physics and modeling of plasticity in metal forming (from single crystals to polycrystals) – Crystallographic texture analysis –Plastic flow of anisotropic materials – Finite deformations and material objectivity –Limit analysis and analytical methods – Presentation of major processes: rolling, forging, polymer processing, sintering, glass forming, deep drawing, high-speed machining – Finite element method and forming processes – Damage, plastic instabilities and prediction of sheet metal formability.

Pré-requis

Background in continuum mechanics and rheology of materials.

Acquis d'apprentissage

With the present course, the student will be able to :

- classify a forming process,
- formulate the nonlinear problem,
- take into account contact, friction, nonlinear constitutive laws, anisotropy, instability…
- solve the resulting problems using industrial codes

Compétences visées

Skill 1: To solve a mechanical problem with its boundary conditions, to propose a model as simple as possible and to conduct a critical analysis of the results. Level 4

Skill 2: To apply the usual concepts of various scientific fields of a technical subdomain to solve a complex problem, including a problem of design or engineering. Level 3

Skill 3: To adopt free or commercial softwares, to solve physical problems. Level 4

Cette UE appartient au bloc de compétences « BC13 : Construire des approches avancées pour des chargements intenses

Mention et/ou parcours dont relève cette UE : ST_M_Mécanique

Code Apogee de l'UE : 0JUJBM01

Nom complet de l'UE : 1000 Stage / Internship

Composante de rattachement : FB0 - UFR MATHEMATIQUES INFORMATIQUE MECANIQUE

Nom du responsable de l'UE et adresse électronique : Sébastien Mercier sebastien.mercier@univ-lorraine.fr

Semestre : 10

Volume horaire enseigné : 0h, Nombre de crédits ECTS : 30

Volume horaire travail personnel de l'étudiant : 200h

Langue d'enseignement de l'UE : Français

Enseignements composant l'UE	CNU	EqTD	EC1000.1 Stage

Descriptif

L'objectif de cette UE est de mettre en situation l'étudiant au sein d'une entreprise ou d'un laboratoire de recherche lors d'un stage ou d'une alternance.
Le stage se déroule sur une période de 20 semaines minimum en entreprise ou en laboratoire de recherche (universitaire ou industriel).
Cette période d'immersion en fin de cursus de Master de Mécanique a pour objectif de mettre en situation pratique l'étudiant au sein de son futur univers (académique ou industriel) et de mettre en pratique les connaissances universitaires acquises au cours de la formation.

Pré-requis

Avoir suivi le Master Mécanique

Acquis d'apprentissage

- Réaliser un travail long en immersion dans le futur environnement professionnel ou de recherche
- S'approprier un sujet, respecter le cahier des charges.
- Travailler en équipe, tout en faisant preuve d'autonomie et d'adaptation
- Mobiliser les connaissances et savoir-faire acquis en formation pour apporter de la valeur ajoutée à l'organisme d'accueil
- Rédiger un mémoire et réaliser une présentation orale avec support visuel.

Compétences visées

Compétence 1: Formuler un problème de mécanique avec ses conditions limites, l'aborder de façon simple, le résoudre et conduire une analyse critique du résultat. Niveau 4

Compétence 2 : Mobiliser les concepts usuels de plusieurs champs disciplinaires au sein d'un sous-domaine scientifique et technique cohérent pour résoudre un problème complexe, notamment un problème de conception ou d'ingénierie. NIveau 4

Compétence 3 : Utiliser les outils numériques, libres ou non, pour la résolution de problèmes physiques. Niveau 4

Compétence 4 : Travailler en équipe autant qu'en autonomie et responsabilité au service d'un projet. Niveau 4

Compétence 5 : Savoir communiquer à l'écrit et à l'oral en français et en anglais et savoir manager une équipe de travail (animation, conduite de réunion et de projet, organisation et planification). Niveau 4