The University of Lille and the Centrale Lille Institute

Module handbook for Semester 1

9 MANDATORY MODULES		
1	Mathematical Tools for Engineering	5 ECTS
2	Numerical Methods in Engineering	5 ECTS
3	Continuum Mechanics	5 ECTS
4	Constitutive Laws	5 ECTS
5	Dynamics and Vibrations	5 ECTS
6	Experimental Mechanics	5 ECTS

Module #1	MATHEMATICAL TOOLS FOR ENGINEERING			
Information	Credit Points : 5 ECTS	Workload : 56h	Mode : compulsory	Offered : 1st semester
Institution in charge	Université de Lille – Centrale Lille Institut			
Instructors	A. Oueslati, P. Gosselet, T. Dao			
Contents	Tensorial Analysis. Tensor product. Contraction. Raising and lowering indices. Covariant derivative of tensor fields. Christoffels symbols. Complex analysis. Holomorphic functions and Cauchy's integral formula. Meromorphic functions and residues. Linear ordinary differential equations (ODEs). Special functions and their properties. Fourier and Laplace transforms. Spectral analysis. Convolution. Systems of ODEs, resolvant matrix and Wronskian. Softwares for ODE solving. Classification of first and second order partial differential equations (PDEs). Hyperbolic PDEs: method of characteristics, wave equation. Elliptic PDE's : Laplace's equation and harmonic functions. Parabolic PDEs: heat equation.			
Examination	Written final exam			
Requirement for examination	No specific requirement			
Learning outcomes	On successful completion of the course, students will be able to: ● Demonstrate a practical foundation in calculus and its applications; ● Demonstrate an understanding of matrices and eigenvectors; ● Demonstrate an awareness of common mathematical themes underlying different areas of mathematics (such as that of linearity).			

Module #2	**NUMERICAL METHODS IN ENGINEERING**			
Information	Credit Points : 5 ECTS	Workload : 50h	Mode : compulsory	Offered : 1st semester
Institution in charge	Université de Lille – Centrale Lille Institut			
Instructors	J.-B. Colliat, T. Dao			
Contents	This course aims at presenting the basis and fundamentals of the Finite Element Method (FEM). The standard discrete system and origins of the Finite Element Method. Generalization of the finite element concepts. Galerkin-weighted residual and variational approaches. ‘Standard’ and ‘hierarchical’ element shape functions: some general families of C0 continuity. Mapped elements and numerical integration – ‘infinite’ and ‘singularity elements’. Problems in linear elasticity.Field problems – heat conduction, electric and magnetic potential and fluid flow. The patch test, reduced integration, and non-conforming elements. The time dimension – discrete approximation in time. Solution of non-linear algebraic equations. Introduction to inelastic and non-linear materials. A large part of the examples shall be devoted to the use and the analysis of some basic FE procedures.			
Examination	Written final exam			
Requirement for examination	No specific requirement			
Learning outcomes	On successful completion of the course, students will be able to: ● demonstrate a practical foundation in calculus and its applications; ● demonstrate an understanding of matrices and eigenvectors; ● demonstrate an awareness of common mathematical themes underlying different areas of mathematics (such as that of linearity).			

Module #3	CONTINUUM MECHANICS			
Information	Credit Points : 5 ECTS	Workload : 50h	Mode : compulsory	Offered : 1st semester
Institution in charge	Université de Lille – Centrale Lille Institut			
Instructors	P. Lecomte-Grosbras, A. Oueslati, A. El Bartali			
Contents	The purpose of this introductory course of continuum mechanics is to develop the generalization of rational mechanics to continuum media, to present the basic concepts for modeling continuous classical media, and to deduce conservation laws and to provide simple constitutive laws for fluid and for solid. **Chapter 1**: The Cartesian tensor algebra and tensor analysis: calculation of tensor fields scalar, vector and higher-order tensor invariance relationship and basic operations: scalar, vector, dyadic products… differential operators: gradient, divergence, curl and Laplacian. Stokes, Gauss and Green theorems; Reynolds transport theorem. **Chapter 2**: Kinematics of continuum media: body configuration and motion, description of motion through 2 approaches : material or Lagrangian and spatial or Eulerian), material derivative, velocity, acceleration, trajectory, streamline. Deformation gradient tensor and strain deformation homogeneous equation of the movement kinematics of the rigid body, and the velocity gradient tensor associated. **Chapter 3**: The dynamics of continuous media: conservation of mass, volume forces, contact forces, and Cauchy postulate, conservation of momentum and angular momentum, equation of motion of a continuous medium, the properties of the stress tensor Cauchy, and simple stress state examples **Chapter 4**: Energy: energy conservation, entropy and the first and second principle laws of thermodynamics. **Chapter 5**: The laws of classical behavior for simple fluids and solid : viscous Newtonian (compressible and incompressible), and applications to Fluid Mechanics: Navier-Stokes equations; linear elastic solid with small deformation, Navier equations. Examples of simple applications like fluid solid possible to obtain analytical solutions that illustrate the power of modeling and proposed.			

Examination	Written final exam
Requirement for examination	No specific requirement
Learning outcomes	On successful completion of the course, students will be able to: ● demonstrate a practical foundation in calculus and its applications; ● demonstrate an understanding of matrices and eigenvectors; ● demonstrate an awareness of common mathematical themes underlying different areas of mathematics (such as that of linearity).

Module #4	**CONSTITUTIVE LAWS**			
Informations	Credit Points : 5 ECTS	Workload : 50h	Mode : compulsory	Offered : 1st semester
Institution in charge	Université de Lille – Centrale Lille Institut			
Instructors	J.-F. Shao, W. Shen			
Contents	The aim of this course is, within the framework of continuous mechanics, to focus on the standard constitutive laws and to introduce general tools. Linear Elasticity: Hooke's law, class of materials, isotropic material, experimental testing, potentials of the Elasticity, decomposition into hydrostatic and deviatoric parts of the strain and stress tensors. Thermodynamic restrictions on elastic coefficients, thermoelasticity. Linear Viscoelasticity: Kelvin-Voigt and Maxwell models, more general rheological models, 3D viscoelasticity, functional formulation and correspondence method using Laplace transform. Experimental curves for proportional and cyclic loadings, plastic yielding and Saint-Venant model. Elastoplastic response of some simple hyperstatic structures, von Mises, Tresca and Mohr-Coulomb models, isotropic and kinematical hardening and internal variables models. Hill inequality and Drucker stability condition, Prager condition of consistency. Some extensions: Viscoplasticity, nonlinear creep of metals and Norton law, stress tensors and strain measures in finite deformation, hyperelasticity.			
Examination	Written final exam			
Requirement for examination	No specific requirement			
Learning outcomes	On successful completion of the course, students will be able to: ● demonstrate a practical foundation in calculus and its applications; ● demonstrate an understanding of matrices and eigenvectors; ● demonstrate an awareness of common mathematical themes underlying different areas of mathematics (such as that of linearity).			

Module #5	**DYNAMICS AND VIBRATIONS**			
Informations	Credit Points : 5 ECTS	Workload : 48h	Mode : compulsory	Offered : 1st semester
Institution in charge	Université de Lille – Centrale Lille Institut			
Instructors	J.F. Brunel, O. Thomas			
Contents	The course presents the key theoretical tools of dynamical analysis of structures and introduces the standard numerical methods of approximation and resolution. Fundamentals: waves, resonance, damping. 1D systems. Vibration of strings and cables: Wave equation, general solution, eigenmodes and eigenfrequencies. orthogonality properties and Rayleigh quotient. Traction-compression vibration of rods. Bending vibrations of beams. Torsional vibration of shafts and other rotating systems. 2D and 3D systems. Vibration of plates. Wave propagation in 3D solids. P-waves and S-waves in isotropic elastic solids. Reflexion and transmission of waves. Rayleigh surface waves. Forced vibration problems. General method of resolution by mode superposition. Mechanical impedance method. Spectral analysis. Numerical methods. Finite element method. Resolution algorithms for eigenvalue problems. Time-integration schemes.			
Examination	Written final exam			
Requirement for examination	No specific requirement			
Learning outcomes	On successful completion of the course students will be able to: ● demonstrate a practical foundation in calculus and its applications; ● demonstrate an understanding of matrices and eigenvectors; ● demonstrate an awareness of common mathematical themes underlying different areas of mathematics (such as that of linearity).			

Module #6	**EXPERIMENTAL MECHANICS**			
Informations	Credit Points : 5 ECTS	Workload : 56h	Mode : compulsory	Offered : 1st semester
Institution in charge	Université de Lille - Ecole Centrale de Lille			
Instructors	A. El Bartali, P. Lecomte-Grosbras, D. Najjar, O. Mayeur, E. Davin, L. Patrouix			
Contents	The aim of this course is to introduce the conventional experimental mechanical test leading to identification the mechanical properties of materials. **Part I : Introduction to sensors and testing machine** Strain sensors, force sensors, Video extensometer and Digital Imaging Correlation, Testing machine and mechanical test. **Part II : Experimental practice** Experimental practice for the characterization of the linear elastic behavior of polymer and metals, non linear elasto-plastic behavior of polymer and metals, anisotropic linear elastic behavior of composites materials, viscoelasticity and viscoplasticity of polymers and metals.			
Examination	Written final exam			
Requirement for examination	No specific requirement			
Learning outcomes	On successful completion of the course students will be able to: ● demonstrate a practical foundation in calculus and its applications; ● demonstrate an understanding of matrices and eigenvectors; ● demonstrate an awareness of common mathematical themes underlying different areas of mathematics (such as that of linearity).			