Institut National Polytechnique de Lorraine, École Européenne d'Ingénieurs en Génie des Matériaux, Nancy, France

1. Year (1st and 2nd Semester)

École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM - INPL), Nancy Courses	ECTS-CP	Winter	Summer
Flow and Transfer (Stéphane ANDRE), lectures and exercises Contents: Flux definition. Transfer mechanisms (diffusive and convective). Regimes and transfer modes. Approach through dimensional analysis. Conservation of mass, momentum, kinetic energy, internal energy and enthalpy. Transfer in boundary layers. Using correlations for the determination of transfer coefficient. Prerequisites: Elementary thermodynamics and mechanics, Fourier's equation.	4	●	
Solid State Diffusion (Abdelkrim REDJAÏMIA), lectures and exercises Contents: Basic concepts of solid state diffusion. Solving the Fick's equation. Illustrations provided for several instances. Application: dislocations, grain boundaries. Experimental Methods. Prerequisites: Fourier and Laplace transforms. Basic solid state physics.	4	●	
Metallic Materials (Benoît APPOLAIRE), laboratory work Contents: Materials testing, structure and microstructure analyses optical microscopy, scanning and transmission electron microscopy, X-ray and electron scattering, microanalysis. Application to solid state phase transformation obtained through heat treatment, thermo-mechanical and thermo-chemical treatments. Prerequisites: Illustrations of topics studied during the courses : "Materials Characterisation" and "Metallic materials processing".	3		●
Theory of Composite Beams (Michel NIVOIT), lectures and exercises Contents: Principal physical properties of composite materials (fibrous materials, sandwich composite materials). General information : beam geometry - statics of the beams - isotropic linear elastic material. Bending of the right beams : theories of Navier-Bernoulli, Timoshenko and generalised Navier-Bernoulli. Torsion of the right beams. Combined loading : Bresse equations. Strain energy. Finite element method. Procedure of assembly. Resolution method. Instability of the right beams. Prerequisites: Fundamentals of materials resistance.	3		●
Inorganic Materials Phase Transformation I (Gérard METAUER), lectures and exercises Contents: Phase diagrams, thermodynamical stability. Global approach to phase transformation, driving forces and kinetics. Phase transformations involving diffusion, homogeneous and heterogeneous nucleation and growth. Diffusionless transformations, martensitic ; supersaturated solid solutions ; amorphous materials. Prerequisites: Fundamentals of kinetics and thermodynamics.	5	●	
Inorganic Materials Phase Transformation II (Gérard METAUER), lectures and exercises Contents: Heat treatments, thermo-mechanical and thermo-chemical treatments. Illustrations with dual-phases steels, stainless steels, building steels, tool steels. Nickel and cobalt base superalloys. Titanium, aluminium and copper alloys. Micro-crystalline, amorphous and intermetallic alloys. Surface hardening. Prerequisites: Illustration of topics studied during the courses: "Inorganic materials phase transformation II".	5		●

École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM - INPL), Nancy Courses	ECTS-CP	Winter	Summer
Polymer Physics (Serge ETIENNE), lectures and exercises Contents: Introduction to macro-molecules. Solid-state cohesion. Elasticity (role of entropy). Glassy state and liquid - glass transition. Linear visco-elasticity. Semi-crystalline polymers. Crystallisation, melting, properties *versus* structure. Mechanical behaviour at strong deformations. Prerequisites: Macromolecular chemistry. Fundamentals of physical chemistry.	5		●
Polymers (Serge ETIENNE), laboratory work Contents: Physical properties of polymers: Visco-elasticity, mechanical tests (tensile and resilience). Calorimetric analysis (DSC). Crystallisation study through optical microscopy. Synthesis of polymers: polymerisation processing (emulsion, suspension, copolymerisation). Molar-mass determination: Size Exclusion Chromatography (SEC), solution viscosimetry. Prerequisites: Illustrations of topics studied during the courses: "Polymer Physics" and "Macromolecular Chemistry".	3		●
Macromolecular Chemistry (Jean-Luc SIX), lectures and exercises Contents: Chain polymerisations (radical and ionic polymerisations will be discussed in details). Polycondensation. Copolymerisation. Introduction to physical-chemistry of polymer solutions. Determination of the molecular weights. Prerequisites: Knowledge of the reactivity of organic functions involved in polymer synthesis (reactivity of double bonds, condensation reactions…)	5	●	
Materials Characterisation (NN), lectures and exercises Contents: Scattering, microprobe analysis, X absorption and related spectroscopies, scanning and transmission electron microscopy, energy dispersive / energy-loss spectroscopies, resonance spectrometries (NMR, ESR, Mössbauer), infra-red and Raman spectroscopies. Prerequisites: Atomic structure, crystallography, Fourier's transform.	5	●	
Numerical Analysis (Gérard MAURICE), lectures and exercises Contents: Elementary presentation of the finite difference and finite elements methods. Interpolation and approximation (parametrical fitting). Numerical integration. Resolution of linear systems of equations. Resolution of non-linear systems. Calculation of eigen values and eigen vectors. Prerequisites: Linear and matrix algebras. Vector calculation.	5	●	
Numerical Mechanics (Zoubir AYADI), laboratory work Contents: Geometrical characteristics of the cross-sections. Beams. Plane-strain and plane-stress. Viscous-elasticity. Fracture Mechanics. Prerequisites: Numerical receipts.	2		●
Numerical Analysis (Gérard MAURICE), laboratory work Contents: Simple physical problems solving (algoritmics). Introduction to the solving of partial derivatives equations encountered in equilibrium problems. Prerequisites: Numerical receipts.	2		●
Molecular Modelling (Alexandre HOCQUET), lectures Contents: Classical molecular modelling : molecular mechanics, molecular dynamics. Quantum computational chemistry : Hartree Fock procedure, semi empirical calculations, analysis of the electronic density and electrostatic potential mapping. Applications to organic chemistry and materials case studies. Prerequisites: Basics of physical chemistry. Basics of organic chemistry.	3	●	

École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM - INPL), Nancy Courses	ECTS-CP	Winter	Summer
Physical Properties of Materials (Pierre PECHEUR), lectures and exercises Contents: Influence of the structures of materials on their physical properties: importance of microscopic structures (type of chemical bonds, atomic order in alloys, phase transitions…) and also of structures at an intermediate level (magnetic domains, grain structure of polycristals, dislocations…). Application: Magnets, Dielectrics, Ferroelectrics (BaTiO3). Response of dielectrics in alternative e.m. fields (Debye relaxation, resonance in the infrared and optical range). Prerequisites: Nearly free electron approach. Molecular orbital theory.	5	●	
Materials Mechanics (Zoubir AYADI), lectures and exercises Contents: Visco-elasto-plasticity and fracture of materials. Creep and relaxations. Visco-elastic behaviour in statics and dynamics. Stress intensity at a crack front (mechanical aspect) and tenacity (material aspect). Rheological behaviours and fracture mechanics. Prerequisites: Elastic theory (strain *versus* stress). Constitution laws	3		●
Corrosion (Jean STEINMETZ), lectures, exercises and laboratory work Contents: Thermodynamical and kinetic aspects of metal corrosion. Corrosion current determination using electrochemistry methods. Corrosion mechanisms. Protection against corrosion. Prerequisites: Electrochemistry. Pourbaix diagrams.	6	●	
Metallic Materials Processing (company invited talk), lectures Contents: Making processes of ferrous alloys. Study of steel solidification during continuous casting. Making processes of aluminium alloys. Comparison of the mechanical properties obtained in forged and moulded parts. Mechanical constructions, welding and bonding. Functional properties of surfaces : thermo-chemical treatment (nitriding, carburising, hardening), Physical and Chemical Vapour Deposition processes (PVD, CVD). Prerequisites: Inorganic chemistry. Extractive metallurgy. Diffusion processes.	2		●
Chemical Reaction Engineering (Marie-Odile SIMONNOT), lectures and exercises Contents: Energy and mass balance sheet for perfect reactors. Yield optimisation and selectivity (composite reactions). Thermal behaviour of reactors. Elapsed time distribution. Modelling. Prerequisites: Chemical reaction elements and basic thermodynamics.	4	●	
Separation Engineering (Danielle BARTH), lectures and exercises Contents: Column dimension calculation. Mass and heat balance relationships. Extraction, distillation and drying processes. Technological aspects. Prerequisites: Basic thermodynamical concepts and heat –matter transfer mechanisms.	2		●
Granular Solids and Porous Media (Danielle BARTH), lectures and exercices Contents: Populations of solid particles (size, shape and distribu-tion). Dry granular systems : stability, flow, mixing, segregation, pressing. Colloidal system : DLVO theory of suspension stabilisation, brief account of spherical stabilisation. Fixed porous media : capillary condensation, Darcy law for single phase gas or fluid flow. Prerequisites: Fundamentals of physical chemistry. Statistical analysis.	2		●

École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM - INPL), Nancy Courses	ECTS-CP	Winter	Summer
Chemistry and Processing of Polymer Blends and Composites (Guo-Hua HU and Jean-Luc SIX), lectures Contents: Main scientific and technical challenges for making polymer blends. New properties seeking. Notions of the miscibility/ non-miscibility of polymer blends. Formulation and compounding processes of polymer blends. Nano-structured polymer blends and polymer composites. Survey of composites. Studies of polymer matrix and reinforcing agents. Concept of interfacial adhesion between matrix and reinforcing agent. Processing of polymer composites. Prerequisites: Macromolecular chemistry.	2		●
Process Engineering (Marie-Odile SIMONNOT), laboratory work Contents: Fluid mechanics. Basic operations related to material manufacturing processes (for instance: drying, filtration, fluid beds). Prerequisites: Illustrations of topics studied during the courses "Chemical reaction engineering" and "Separation engineering".	3		●
Seminars: Integrated into Courses			

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2nd Year (3rd and 4th Semester)

École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM - INPL), Nancy Courses	ECTS-CP	Winter	Summer
Plastic Deformation and Microstructures (Amand GEORGE), lectures Contents: Crystallised materials microstructures. Plastic deformation and hardening mechanisms. Microstructure building. Phase transformations. Prerequisites: Equilibria and phase diagrams, crystallography, elasticity (Hooke's law).	3	●	
Microstructure Origin (Sabine DENIS), lectures Contents: Phase transformation through nucleation and growth. Instabilities and morphology (spinodal decomposition). Diffusionless transformation. Metastable microstructure, relaxation processes. Prerequisites: Diffusion, thermodynamics.	3	●	
Materials Processing (Elisabeth GAUTIER and Elizabeth BAUER-GROSSE), lectures Contents: Structure, processes and related properties : methodology (system analysis and phenomenological approach), limiting mechanisms (diffusion, convection transports, interfacial transfer and interfacial chemical reaction). Prerequisites: Thermodynamics, diffusion and fundamentals of physical chemistry.	3	●	
Advanced Processing of Materials (Denis ABLITZER), lectures Contents: Analysis and mathematical modelling of elaboration processes and treatments. Economical analysis. Prerequisites: "Materials processing" course.	3	●	
Surface Treatment (Thierry BELMONTE), lectures Contents: Gaseous phase and / or plasma enhanced surface treatments (PVD, CVD processes). Prerequisites: Gas kinetic theory. Gas-solid equilibria.	3	●	
Crystalline Growth and Solidification (Gérard LESOULT), lectures Contents: Atomic mechanism of crystalline growth. Grain size control. Dendritic microstructures growth. Plane interface stability. Prerequisites: Fundamentals of thermodynamics and kinetics.	3	●	
Composite Materials and Semi-Crystalline Polymers (Christian G'SELL), lectures Contents: Polymer crystal structure. Nucleation and growth of crystalline structures. Spherolitic crystallisation. Crystallisation rate measurement. Mechanical behaviours. Fabrication processes. Gas permeability of polymers. Prerequisites: Macromolecular chemistry. Mechanics.	3	●	
Surface of Solids (Thierry BELMONTE and Jurgen von STEBUT), lectures Contents: Interfacial reactions (adsorption, desorption, segregation). Oxidation and corrosion protection of metals and alloys. Wear properties. Prerequisites: Fundamentals of physical and solid chemistry. Mechanics.	3	●	
Phase transformation and internal stresses (Jean-Pierre BELLOT), lectures Contents: Internal stresses. Phase transformation - stresses relationships. Consequences upon thermo-mechanical behaviour. Appearance of internal stresses during thermal treatment of bulk material. Prerequisites: Mechanics. Metallurgy.	3	●	

École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM - INPL), Nancy Courses	ECTS-CP	Winter	Summer
Heat Transfer in Semi-Transparent Materials (AlainDEGIOVANNI), lectures Contents: Macroscopic modelling of radiative transfer in semi-transparent materials. Radiative balance and boundary conditions. Application to a slab. Condition radiation coupling. Prerequisites: Fundamental of heat transfer (conduction and radiation).	2	●	
Thermal Characterisation of Materials (Sophie DIDIERJEAN), lectures Contents: Inverse problems in heat transfer. Application to thermal conductivity and thermal diffusivity measurements. Review of the existing measurements techniques Prerequisites: Fundamental of heat transfer (conduction)	2	●	
Transfer in Porous Media (Didier STEMMELEN), lectures Contents: This course introduces the basic principles and methods necessary to quanfity flow of fluids, heat transfer and transport of solutes through porous media. The emphasis is placed on upscaling (method of volume averaging and homogeneisation). Prerequisites: Fluid mechanics. Thermodynamics. Heat transfer (conduction, convection, phase exchange).	2	●	
Material Selection for Mechanical Applications (Christian CUNAT), lectures Contents: Structure of crystalline and non crystalline solids. Alloys and phase diagrams. Fe-C phase diagram. Corrosion. Plastics: structure, processing and properties. Prerequisites: Fundamentals of crystallography and thermodynamics.	2	●	
Mechanical Behaviour and Structural Calculation of Composites (Christian CUNAT), lectures Contents: Fabrication process. Mechanical behaviour of plies. Multilayer composites. Homogenisation of composite beams. Sandwich materials. Conception of composite structures. Prerequisites: Fundamentals of mechanics.	2	●	
Shape Forming Analysis of Materials (R. RAHOUADJ), lectures Contents: Classification of processes. Mechanics and physics of plasticity. Plastic flow of anisotropic materials. Limit analysis. Analytical methods. Finite elements methods. Study of rolling, extrusion, forging under plane strain conditions. Prerequisites: Fundamentals of physics and mechanics.	2	●	
Electronic Properties of Solids (Denis BILLAUD), lectures Contents: Introduction to chemical bond. Relationship between bond and electronic structure: molecular orbitals, crystal field theory (stabilisation energy, Jahn-Teller effect). Energy diagram and electronic properties. Prerequisites: Fundamentals of physics and physical chemistry.	5	●	
Structures and Electrical Properties of Materials (Bernard MALAMAN), lectures Contents: Main structural types for binary and ternary compounds. Order-disorder transformations. Normal valence and mixed valence compounds. Non-stoechiometry. Effect of impurities. Defects and superstructures. Electrical properties and solid electrolytes (ionic conductivity, applications). Thermoelectrical, piezoelectrical, dielectrical and ferroelectrical compounds. Superconductivity. Prerequisites: Basics of physics and crystallography.	4	●	
Project Work (Compulsory) Bibliography project.	15	●	

École Européenne d'Ingénieurs en Génie des Matériaux (EEIGM - INPL), Nancy Courses	ECTS-CP	Winter	Summer
Master Thesis (Compulsory) The master thesis is to be carried out in one of the following laboratories: LSGS, LSG2M, LPM, LEMTA, LSGC, LCPM, LTMP, DCPR (INPL), LPM, LCSM, LCM3B, LPMIA (UHP)	30		●