

MODULE HANDBOOK

SEMESTER 3	
Track 4: Design and Manufacturing	
Advanced Manufacturing Technologies	5 ECTS
Welding Science and Technology	5 ECTS
Mechanical Design in Biomedical Engineering	5 ECTS
Deformation and fracture of materials	5 ECTS
Machine Design	5 ECTS
Numerical Geometry	5 ECTS

Module #1 LMECA2453	ADVANCED MANUFACTURING TECHNOLOGIES		
Information	Credit points: 5 ECTS	Workload: 60 hours	Mode: Compulsory
Instructor(s)	A. Simar		
Content	Manufacturing process selection: selection strategy, project of process selection. Complements on machining and computer assisted processing: cutting forces, automatisisation, Mastercam programming project and realization on machine. Additive manufacturing: processes, process selection criteria, metallurgical quality of the workpieces, project on free workpiece in polymer produced by FDM (Fused deposition modelling) Non-conventional machining processes: electro-erosion, laser cutting, water cutting. Virtual manufacturing: Hypothesis of finite elements calculations, practical applications case study.		
Examination	Three projects during the semester (process selection, computer assisted manufacturing, additive manufacturing DM). Projects are part of the evaluation. Oral exam during the exam session.		
Requirement for examination	No specific requirement		
Learning outcomes	At the end of the course, the student will be able to: • choose a manufacturing process for a given workpiece using quantifiable criteria; • choose optimal cutting conditions (machines, forces, tools); • perceive the interest of computational tools for manufacturing; • evaluate the interest of additive manufacturing in comparison to classical processing methods; • pose hypothesis for the numerical modelling of manufacturing; • translate the geometry of a workpiece in manufacturing operations.		

Module #2 LMECA2860	WELDING SCIENCE AND TECHNOLOGY		
Information	Credit points: 5 ECTS	Workload: 60 hours	Mode: Compulsory
Instructor(s)	P. Jacques, A. Simar		
Content	- Definition of welding, welding joint and weldability - Influence of the heat input - The welding processes: gas welding, arc welding, resistance welding, ... - The evolution of the properties in the heat affected zone of the welded joint - Causes and solutions to avoid the main types of cracking		
Examination	Oral exam with written preparation		
Requirement for examination	No specific requirement		
Learning outcomes	After successful completion of the course, the student will be able to: • understand the main characteristics of each welding process • choose the best welding process for a given assembly • understand the physical principles underlying the joining operations by welding • anticipate the modifications of the microstructure that will be the result of a given welding operation (phase transformation, defects)		

Module #3 LMECA2355	MECHANICAL DESIGN IN BIOMEDICAL ENGINEERING		
Information	Credit points: 5 ECTS	Workload: 60 hours	Mode: Compulsory
Instructor(s)	A. Vankrunkelsven, G. Kerckhofs		
Content	The purpose of the course is to initiate students to the design methodologies involved in biomedical engineering, taking into account the specificities and constraints related to the area of medicine and surgery. Teaching includes several sessions and seminars on main topics in the area of medicine and surgery, and a project to design of a new medical/surgical device in collaboration with clinicians. The main contents of the course are: • design methods and specificities related to the area of medicine and surgery (identification of medical requirements, risk analysis, etc.) • the constraints intrinsic to the area of medicine and surgery (biocompatibility, sterilization, accuracy and precision, ergonomics and safety, etc.) • the industrial constraints (certification, cost, etc.)		
Examination	Evaluation will be based on the project, especially the written report (50%), the oral presentation (30%) and the quality of work done during the semester (20%). An evaluation grid will be given to students.		
Requirement for examination	No specific requirement		
Learning outcomes	At the end of the course, students will be able to: • address practical, relevant problems encountered in medicine and surgery, • understand specificities related to the medical/surgical area (e.g. orthopaedics or cardiac surgery), • clarify the medical needs and formulate the technical specifications, • develop a state-of-the-art of existing devices, • design a technical solution that complies with medical constraints, • test the solution with a 3D functional prototype (3D printed, etc.), • communicate findings in an oral presentation and a summary report.		

Module #4 LMAPR2482	DEFORMATION AND FRACTURE OF MATERIALS		
Information	Credit points: 5 ECTS	Workload: 60h	Mode: Compulsory
Instructor(s)	T. Pardoen and H. Idrissi		
Content	The main topics involve 1. The physical and mathematical description at the atomic, microscopic and macroscopic scales of (thermo-visco-) elastic deformation mechanisms within all material classes; 2. The physical and mathematical description at the atomic, microscopic and macroscopic scales of the (visco-) plastic deformation mechanisms within all material classes, involving creep; 3. The physical and mathematical description at the atomic, microscopic and macroscopic scales of the damage and fracture mechanisms within all material classes, involving fracture mechanics theory.		
Examination	Evaluation will be based on the project, the laboratories and the final written exam.		
Requirement for examination	No specific requirement		
Learning outcomes	At the end of this course, the student will be able to • Distinguish and classify the different classes of mechanical behaviour: reversible deformation, permanent deformation (rate dependent or not), damage and fracture; • Define the macroscopic properties characterizing the mechanical performances of materials : stiffness, strength, ductility, creep resistance, fracture toughness and explain how these quantities are measured experimentally and indexed (units); • Identify and schematically represent the various mechanisms in terms of length and time scales, interactions and couplings, for the various classes of materials, responsible for the macroscopic properties; • Solve simple mechanical problems using the physical/mechanical models derived during the lectures as well as the new concepts discovered in this course (e.g. internal stress, stress intensity factor, energy release rate, ...); • Establish, justify and present a strategy of resolution of a complex engineering problem involving plasticity and fracture, implying in particular the simplification of the geometry, of the loading conditions and of the material response in order to reveal to key parameters playing a role;		

Module #5 LMECA2801	MACHINE DESIGN		
Information	Credit points: 5 ECTS	Workload: 60 hours	Mode: Compulsory
Instructor(s)	R. Ronsse, A. Simar		
Content	Main themes: • Functional analysis of machines and their components • Properties of component • Elements of calculus of machine components		
Examination	Part of the course is taught as lectures and by problem and project-based learning (PBL) within groups of 6 students. Two projects are proposed: - Project 1: Design of a machine - Project 2: Design for digital manufacturing		
Requirement for examination	No specific requirement		
Learning outcomes	At the end of the course, the students will be able to: • write functional specifications for a machine; • identify the functionalities of a machine (actuation, bearing systems, transmission, sealing, ...); • estimate the installed and maximum power, the energetic consumption and the efficiency of a machine; • design a simple machine following an adapted methodology; • take into account environmental, social, and economic impacts from the initial phase of design through to the end of life (sustainable design); • identify the basic hypothesis of elements dimensioning; • choose materials and their shape as a function of the service conditions and the conditions of failure; • dimensioning following various criteria (static strength, elastic deformation, fatigue, ...) of usual elements (e.g. shafts); • choose machine components (bearing, gasket, transmission, brake, clutch, hydraulic, spring); • read and interpret the drawing of an existing machine; • hand drawing machine elements and overall drawings; • place tolerances for a mechanical system; • conduct a risk analysis; • take into account in the design process of digital manufacturing technologies.		

Module #6 LMECA2170	NUMERICAL GEOMETRY		
Information	Credit points: 5 ECTS	Workload: 60 hours	Mode: Compulsory
Instructor(s)	V. Legat, J.-F. Remacle		
Content	Computational Geometry is a relatively new field concerned with designing algorithms and computer programs to perform geometric computations. A need for such computations arises in many fields: computer graphics, robotics, pattern recognition, geography, manufacturing, and so on. An example is the following problem that arises in medical imaging. From a CAT or MRI scan, slices through a three-dimensional object are obtained, perhaps a brain tumor. From these slices the object must be "reconstructed." The basic step of this reconstruction is connecting two polygons lying in parallel planes. The connection is effected by finding a collection of triangles that span the two planes, have their corners at vertices of the polygons, and fit together seamlessly to form a closed polyhedron. This basic problem of reconstructing a polyhedron from two parallel polygonal slices has been heavily studied due to its importance, but no completely satisfactory algorithm has been found" (J O'Rourke) As the objective of this course is to give the student a quick overview in the problems of computational geometry, modelling and design, the content of the course is as follows: - Polygons triangulations and partitions, - Convex hulls in 2D and 3D - Voronoi diagrams and Delaunay triangulations - Infography and interactive computer graphics with OpenGL. - Solid modelling through Bezier and NURBS curves or surfaces. In addition, a specific variable topic is selected and analyzed.		
Examination	Assignments + open-book written exam		
Requirement for examination	No specific requirement		
Learning outcomes	Upon completion of the course, the students should: • have a basic understanding of computational modelling issues and what can be achieved through its use; • be aware of the complexity of some problems, including selection of algorithms; • have a basic knowledge of computer graphics; • be able to code small code with OpenGL; • be aware of the range of applications of computational geometry.		