European Master in Advanced Solid Mechanics

STRAINS

UCLouvain

The Catholic University of Leuven

Module handbook for Semester 2

6 MANDATORY MODULES		
1	Advanced Manufacturing Technologies	5 ECTS
2	Welding Science and Technology	5 ECTS
3	Mechanical Design in Biomedical Engineering	5 ECTS
4	Vehicule System Dynamics	5 ECTS
5	Machine Design	5 ECTS
6	Numerical Geometry	5 ECTS

Module #1	**ADVANCED MANUFACTURING TECHNOLOGIES**			
Information	Credit Points : 5 ECTS	Workload : 60h	Mode : Compulsory	Offered : 3rd semester
Institution in charge	Université Catholique de Louvain			
Instructors	Simar Aude			
Contents	Manufacturing process selection : selection strategy, project of process selection. Complements on machining and computer assisted processing: cutting forces, automatisation, 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	**WELDING SCIENCE AND TECHNOLOGY**			
Informations	<u>Credit Points :</u> 5 ECTS	<u>Workload :</u> 60h	<u>Mode :</u> Compulsory	<u>Offered :</u> 3rd semester
Institution in charge	Université Catholique de Louvain			
Instructors	Jacques Pascal ; Simar Aude ;			
Contents	- 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	**MECHANICAL DESIGN IN BIOMEDICAL ENGINEERING**			
Information	Credit Points : 5 ECTS	Workload : 50h	Mode : Compulsory	Offered : 3rd semester
Institution in charge	Université Catholique de Louvain			
Instructors	Vankrunkelsven Ann (subtitute for Raucent Benoit), Kerckhofs Greet			
Contents	The purpose of the course is to initiate students to the design metholodogies 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 medecine 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 orcardiac 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	**VEHICLE SYSTEM DYNAMICS**			
Information	Credit Points : 5 ECTS	Workload : 60h	Mode : Compulsory	Offered : 3rd semester
Institution in charge	Université Catholique de Louvain			
Instructors	Fisette Paul			
Contents	1. Introduction : Fundamental concepts of kinematics, multibody dynamics, vibration and numerical methods in view of analysis of vehicle stability, handling and comfort. 2. Railway vehicles - Technology : carbodies, bogies, primary and secondary suspensions, track, track irregularities, vehicle morphology (tramway, metro, high-speed trains, etc.), main concepts: load, Y/Q ratio, critical speeds 3. Railway vehicles - "Macro" models: carbodies/bogies/wheelset/wheel/rail contact simplified model, simplified wheelset model (stability) and vertical model (comfort) 4. Railway vehicles - specific models: wheelset-track 3D model, independent wheel-rail model, wheel-flange second contact, curved track model, primary and secondary suspensions models, etc. 5. Railway vehicles - specific models: (cont.) 6. Railway vehicles - use and interpretation of models : model versus experiment, parameter sensitivity analyses, model-based understanding of the fundamental dynamical phenomena 7. Road vehicles - Technology: suspensions (classification), role of the tire, anti-roll bar system, etc., main concepts: struts, car roll centre, torsion bars, suspension typical motions			

8. Road vehicles - "Macro" models : sprung and unsprung masses, geometrical roll centre computation, Ackermann steering geometry

9. Road vehicles - specific models : 3D kinematics of suspensions : McPherson strut, multi-link suspensions, etc., torsion and anti-roll systems, tire/ground modelling : description of the various models (lateral, longitudinal, vertical, combined) and model-based comparison ; flexible modelling of carbodies

10. Road vehicles - specific models: (cont.)

11. Road vehicles - use and interpretation of models : model versus experiment, parameter sensitivity analyses, model-based understanding of fundamental dynamical phenomena (understeering/oversteering, entry curving, steady state curving, comfort criteria with different road profile characteristics

12. Specific vehicles - Technology and Modelling : bicycles and motorcycles (stability, gyroscopic effects, wheel/ground contact models, '), and/or trucks and trailers (lateral stability, jacknifing), and/or tracked vehicles on loose and uneven terrains (geometrical models, constitutive models, ')

13. Seminar on hybrid modelling: 2 detailed applications (problem - model - results - analysis): these seminars will be closely linked to the research of the CEREM (Centre for Research in Mechatronics of UCL)

14. "Industrial" Seminar: "Railway dynamics, the point of view of the industry" (Bombardier-Transport, France) or "Car suspensions" (Tenneco-Automotive, Saint-Trond, Belgium).

Exercises - Projects - Pre-project : to become familiar with the modelling of wheel/ground and/or wheel/rail contact; duration = 3 weeks, software : ROBOTRAN. - Project : modelling of railway or road vehicle behaviours, among the following (non exhaustive) list of subjects (duration = 8 to 10 weeks):

- Cars with and without anti-roll bar system : comparison of curve performances
- Over/under steering behaviour of a simple car: analysis in entry curving
- Modelling of the "jacknifing" phenomenon of a truck+trailer.
- Lateral stability of a sidecar or of an ATV

	- Modelling of a car equipped with an ESP system - analysis of entry curving behaviour - Optimization of passive suspension parameters to improve passenger comfort criteria - Model-based computation of the critical speed of a railway bogie on a straight track (linear, non-linear cases) - Railway : study and modelling of the second-contact (flange contact) - application to entry curving - Modelling of railway bogies with independent wheels (ex. Tram2000): study of the behaviour on a straight track - Modelling and analysis of the " wobble " and " weave " phenomena of a motorbike. Students will work in groups of 2 or 3. They will either use the ROBOTRAN program or a commercial multibody program (SIMPACK or AMESIM), depending on the selected project. Training for using these programs will be organized at the beginning of the semester. Visit to a company - Bombardier-Transport Company : Crespin (France) or - Tenneco-Automotive Company, Saint-Trond, Belgique.
Examination	Project defence and oral examination related to the course and the project: - Project : a plenary session of group presentations will be organized - Oral examination (individual) related to the course and the project : students may have the course notes at their disposal.
Requirement for Examination	No specific requirement
Learning outcomes	By the end of this course, students should be able to understand the kinematic and dynamical phenomena responsible for road and railway vehicle behvaiour, in terms of stability, handling and comfort. They will also be able to model them mathematically and build a simulation program: using it, they will point out various vehicular behaviours and emphasize the role of mechanical devices which are at the root of vehicle dynamical performance.

Module #5	**MACHINE DESIGN**			
Information	Credit Points : 5 ECTS	Workload : 60h	Mode : Compulsory	Offered : 3rd semester
Institution in charge	Université Catholique de Louvain			
Instructors	Benoît RAUCENT, Thomas SERVAIS (substitute for Benoît RAUCENT)			
Contents	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	**NUMERICAL GEOMETRY**			
Information	Credit Points : 5 ECTS	Workload : 60h	Mode : Compulsory	Offered : 3rd semester
Institution in charge	Université Catholique de Louvain			
Instructors	Vincent LEGAT, Jean-François REMACLE			
Contents	The aim of this lecture is to introduce students to the principles and practice of computational geometry. Both theoretical issues and industrial applications will be presented in order to be able to solve some new problems arising a several fields : robotics, pattern recognition, geography, mechanical manufacturing. 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 inmedical 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.			

Examination	
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.