INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Computer Integrated Design	Field of study	Solid Mechanics and Structures
Master in	Industrial Engineering - Mechanical Engineering	School	School of Technology and Management
Academic Year	2022/2023	Year of study	2
Level	2-2	ECTS credits	6.0
Type	Semestral	Semester	1
Code	9572-356-2102-00-22		

Workload (hours)	Contact hours	T	TP	PL	TC	S	E	OT	O
162		-	-	60	-	-	-	-	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s)	Luís Manuel Ribeiro Mesquita

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Understand the importance of the integration of geometric modelling tools with finite element codes in fluid flow, thermal, dynamic and structural behaviour in mechanical engineering design problems.
2. Conduct dynamic analysis and synthesis of multibody systems. Implement computational solutions in multibody dynamics.
3. Understand and use basic concepts of structural optimization to improve a mechanical engineering design.
4. Conduct geometric modelling in parametric CAD/CAE programs. Use several formats of geometric models and their transfer to multibody dynamics and finite element codes.
5. Understand and analyse coupled field problems, in thermal, fluid flow and structural applications.

Prerequisites

Before the course unit the learner is expected to be able to:
1. Apply the acquired competences of Differential and Integral Calculus and Matrix Algebra.
2. Apply the acquired competences of Applied Mechanics, Mechanics of Materials.
3. Apply the acquired competences Geometric Modelling.

Course contents

Application of advanced computational codes in structural, thermal and fluid flow problems. Coupled field problems. Geometric modelling of solids and surfaces with applications to mechanical design using integrated CAD/CAE environments. The computational approach to multibody dynamics. Application of optimization algorithms to structural design, using integrated CAD/CAE environments.

Course contents (extended version)

1. Chapter 1
   - Computer integrated design and its importance in mechanical engineering design and development.
   - The use of advanced programs for the study of structural and thermal systems and fluid flow.
2. Chapter 2
   - Numerical analysis of mechanisms. Kinematics and dynamics study of the multibody systems.
   - 2D kinematic analysis. Constraints and kinematic joints, Position, velocity & aceleration analysis.
   - Singular configurations. Constraint equations calculation and the Jacobian matrix.
   - Assembly analysis. Numerical methods for the solution of the of linear & non-linear equations.
   - Detection and elimination of redundant constraints. Computational applications.
   - Dynamic analysis of two dimensional multibody systems. Equations of motion of constrained systems.
   - Inverse dynamic analysis, Equilibrium conditions, Joint reaction forces.
   - Numerical solution of algebra-differential equations of motion. Computational applications.
   - Kinematics and Dynamics of three dimensional systems.
   - Computational applications to mechanical design (CAD/CAE programs).
3. Chapter 3
   - Optimisation algorithms in structural and mechanical engineering component design.
   - Numerical methods for unconstrained and constrained non-linear optimisation.
   - One-dimensional search methods. Feasible directions of search.
   - Methods for unconstrained minimisation: Steepest Descent, Conjugate Gradient, Newton & Quasi-Newton.
   - Applications to mechanical engineering design problems using integrated CAD/CAE programs.
4. Chapter 4
   - Geometric modelling of solids and surfaces. Migration of geometric models to numerical simulation.
   - Finite element methods and multibody dynamics programs.
   - Coupled field problems (thermo-mechanical and thermo-fluid problems, fluid-structure interaction).
   - Computational applications to mechanical engineering design problems.

Recommended reading

1. O. C. Zienkiewicz , R. L. Taylor. The finite element method. Vols. 1, 2, 3, Oxford: Butterworth, 2000.
2. E. Haug, Computer Aided Kinematics and Dynamics of Mechanical Systems, Vol. I: Basic Methods, Allyn and Bacon, 1989.
3. R. Haftka, Z. Gurdal. Elements of Structural Optimization, Kluwer, 1992.
4. J. Arora. Introduction to Optimum Design, McGraw-Hill, 1989.
5. H. Hahn. Rigid Body Dynamics of Mechanisms, Vols. I, II, Springer-Verlag, 2001, 2003.

Teaching and learning methods

Exposure to the theoretical foundations, problem solving strategies and techniques, and typical application problems (60 hours). Study of subjects, problem and assignment solving (98 non contact hours).

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final)
   - Practical Work - 100%
2. Alternative 2 - (Regular, Student Worker) (Supplementary, Special)
   - Final Written Exam - 100%

Language of instruction

1. English
2. Portuguese, with additional English support for foreign students.

Electronic validation

Luís Manuel Ribeiro Mesquita	Debora Rodrigues de Sousa Macanjo Ferreira	José Alexandre de Carvalho Gonçalves	Paulo Alexandre Vara Alves
06-10-2022	07-10-2022	07-10-2022	03-11-2022