Study Plan

School: School of Sciences and Technology
Degree: Master
Course: Mechatronics Engineering (cód. 119)

1st Year - 1st Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS07203M	Components of Mechanical Systems	*** TRANSLATE ME: Projecto e Automação Industrial ***	6	Semester	156
FIS07204M	Computational Structural Mechanics	*** TRANSLATE ME: Projecto e Automação Industrial ***	6	Semester	156
FIS07205M	Computational Mechanics and Optimization	Mechanical Engineering	6	Semester	156
FIS07206M	Microprocessors	*** TRANSLATE ME: Electrónica e Instrumentação ***	6	Semester	156
EME07207M	Modelling and Simulation	Mechanical Engineering	6	Semester	156

1st Year - 2nd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS07199M	Advanced Control and Automation	*** TRANSLATE ME: Projecto e Automação Industrial ***	6	Semester	156
FIS07200M	Computer Aided Analysis of Mechatronic Systems	*** TRANSLATE ME: Projecto e Automação Industrial ***	6	Semester	156
FIS07201M	Power Electronics	*** TRANSLATE ME: Electrónica e Instrumentação ***	6	Semester	156
INF07202M	Programming and Intelligent Systems	Informatics	6	Semester	156
FIS07208M	Vibration and Noise	*** TRANSLATE ME: Projecto e Automação Industrial ***	6	Semester	156

2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
EME07196M	Variable Speed Electrical Drives	Electrotechnical Engineering	6	Semester	156
FIS07197M	Supervisory Control Systems	*** TRANSLATE ME: Projecto e Automação Industrial ***	6	Semester	156

2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
FIS07198M	Robotic Systems	*** TRANSLATE ME: Projecto e Automação Industrial ***	6	Semester	156

Mandatory alternatives

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					
Internship					
Project Work					

2nd Year - 4th Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours

Mandatory alternatives

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					
Internship					
Project Work					

Conditions for obtaining the Degree:

*** TRANSLATE ME: Para aprovação na componente curricular deste Mestrado, é necessário a aprovação (através de avaliação ou creditação), das seguintes unidades curriculares: {\}newline

1.º Semestre{\}newline

- 5 UC Obrigatórias num total de 30 ECTS{\}newline

2.º Semestre{\}newline

- 5 UC Obrigatórias num total de 30 ECTS{\}newline

3.º Semestre{\}newline

- 3 UC Obrigatórias num total de 18 ECTS{\}newline

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Para obtenção do grau é necessário também a aprovação em Dissertação, Trabalho de Projecto ou Relatório de Estágio, no total de 42 ECTS, no 3.º e 4.º Semestre. ***

Program Contents

Back

Components of Mechanical Systems (FIS07203M)

Introduction to design

The objectives of design, its phases and development. Practical aspects in mechanical design. General Considerations on cost, responsibility, standards and demanded construction codes.

The materials mechanical behaviour

General aspects on material behaviour. Material tests. The influence of cold work, temperature, heat and mechanical treatments, and manufacturing processes. Consequences arising from the presence of geometrical irregularities and materials defects in the component, notch sensitivity, stress intensity factor and crack propagation modes. Ductile and fragile behaviour. Fatigue and creep phenomena.

Static loading design methodologies

Mechanical strength, safety factor, failure criteria and allowable stress calculation. Design for strength, stiffness and avoid of crack propagation.

Dynamic loading design methodologies

Fatigue strength curves and data. Fatigue design. Cumulative fatigue damage.

Design of structural connections

Bolted, hinged and riveted joints. Design of welding connections. Concepts for the design of bonded joints.

Mechanical transmission systems

Friction wheels, gears. Forces developed during meshing. Gear design concepts. Gear trains. Design of belt, chain and cables transmissions. Design of clutches and breaks. Shaft connection mechanisms. Design of rolling contact and friction bearing supports.

Flexible elements

The different kinds of springs, stiffness constant, used materials and critical frequencies. Design for static and fatigue loads.

Introduction to Microelectromechanical Systems (MEMS)

The micro machines development and its applications. Main manufacturing processes: micromachining, etching, electro discharge machining, etc. The importance of the scale factor and the relevance of some associated physical phenomena. Development of miniaturized machines and sensor mechanisms.

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Computational Structural Mechanics (FIS07204M)

The stiffness method

Types of structural components. Rectilinear bars and beams analysis models. Systematization of the computing process. The concepts of discretization, approximation, node, element and mesh. Formulation of bar and beam elements by direct application of the structural analysis theories. non-structural problems obtained directly from the laws of Physics. The stiffness matrix and force vector. Global equilibrium equations. General coordinate transformations and its application to the derivation of truss and frame elements.

Computer implementation

Organization of the computer code. Storage of the necessary information. Automatic assembly and boundary conditions prescription process. Post-processing of results.

Introduction to the Mechanics of continuous mediums

The continuum hypothesis. Material and spatial descriptions, motion analysis and the strain tensor. The stress tensor. Governing equations and constitutive laws of isotropic and composite materials.

The Finite element method

Weak formulation using the weighted residuals method. Galerkin approximations. Interpolation and approximation concepts. Isoparametric formulation of bar, beam, 2D membrane and 3D solid elements. Numerical integration. Different types of elements and the problem of mesh generation. Locking problems. Evaluation of approximation errors. Mixed formulations.

The analysis of structures using computer codes

Different theories for the analysis of plates and shells and the corresponding finite element models. Analysis of some models used in commercial codes.

Dynamic analysis of structures, determination of natural frequencies and mode shapes. Some numerical time integration schemes, its computer implementation and stability conditions.

Introduction to the analysis of structures involving large deformations and nonlinear material models.

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Computational Mechanics and Optimization (FIS07205M)

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Microprocessors (FIS07206M)

Introduction Historical perspective. Presentation the different types of microprocessors available. Applications. Computer Architecture The datapath. The control unit. The central processing unit. The memory unit. Control word. Register transfer. Architecture of a simple computer. Instruction Set Architecture Addressing. Addressing modes. Instruction Set Architecture. Data transfer instructions. Data manipulation instructions. Control instructions. Program interrupt. Assembly programming. Central Processing Unit Architecture RISC e CISC architectures. Project of a CPU. Input-Output Units Series e parallel interfaces. Transfer modes: program control; interrupt initiated; DMA. I/O Processors. Memory Systems Memory hierarchy. Memory management. Cache memory. Virtual memory.

Back

Modelling and Simulation (EME07207M)

PART I: System Modeling

1. Mathematical models for automatic control (concentrated parameters) - generalized approach – variables of flux and potential.
2. Basic elements: Potential and Flux accumulators, dissipative elements. Constitutive relations.
3. Interconnectivity relations: continuity relations, compatibility relations for mechanical, electrical, thermal and fluidic systems.
4. Equivalent systems: electrical/ mechanical/ fluidic.
5. Modelling linear models using Variational methods.

PARTE II: System Simulation

1. Linearization of engineering models around steady-state operating points.
2. System representation using Transfer Functions: SISO and MIMO systems. Laplace transformation. System representation using State Space methodology.
3. Analytical solution of linear models (solution of ODE).
4. Analogue implementation of Engineering models using electrical. Analogue simulation of dynamic systems.
5. Numerical solution of Engineering systems using MATLAB.

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Advanced Control and Automation (FIS07199M)

I - Control Systems - analogue and digital:

1) Design of system Controllers using State-Space formulation: Controllability, Observability.
2) Optimal Control Systems: system performance indexes; cost functions; Optimization problem formulation; Optimal Control Systems based on quadratic performance indexes; optimal-time control systems.
3) Reference model Controllers. Introduction to adaptive control.
4) Predictive Control.
5) Digital systems analyse: digital implementation of analogue controllers, digital controllers.
6) Frequency domain analysis of discrete systems. Digital Controllers Design.

II - Industrial Automation :

1) Design and implementation of sequential systems using Siemens PLC S7-300.
2) Programming in Simatic S7: structured language ? FC, FB, DB.
3) Programming of Human-Machine Interfaces (HMI) and integration in automatic machines controlled by Siemens PLC S7-3**.

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Computer Aided Analysis of Mechatronic Systems (FIS07200M)

Fundamental concepts of dynamics{\}newline
Mathematical description of the kinematics of a rigid body, finite rotations, angular velocity, tensor derivatives, frames of reference in relative motion. Dynamics of rigid bodies and the equations of motion. Equations of constraint. Systems of differential algebraic equations (DAE).{\}newline
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Kinematic analysis of mechanical systems in 2D{\}newline
Methods for describing the position of each body. Types of kinematic joints (revolute, translational, composite, follower, etc.). Modelling of kinematic joints and driven connections as constraint equations. The equations of velocity and acceleration obtained by deriving the constraint equations. {\}newline
Formation of the global system of equations, computer implementation and numerical solution.
Dynamic analysis of mechanical systems in 2D{\}newline
Constructing the force vector, forces arising from the connections between bodies and the external loads. Computer implementation, time integration schemes.
Dynamic analysis of mechanical systems in 3D{\}newline
Description of each body position, rotation tensor and Euler parameters. Modelling kinematic joints in 3D. Equations of motion. Application to robotics.
Active structures{\}newline
Finite deformations of continua, deformation and stress measures, and the constitutive behaviour. Composite and active materials modelling (piezoelectrics, magnetostrictive, electrostrictive, etc.). Solution of coupled problems (electrical, magnetic, thermal, mechanical, etc.) using the finite element method. Application to mechatronic systems design and MEMS design. Introduction to structural optimization.

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Power Electronics (FIS07201M)

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Programming and Intelligent Systems (INF07202M)

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Vibration and Noise (FIS07208M)

+ The modeling and analysis of vibration in structures and equipments{\}newline
Classification of vibratory systems and time varying loads. Free vibration of linear one degree of freedom systems, with and without damping, for viscous and Coulomb damping. Forced vibration, response to harmonic excitations, resonance. Response to periodic, impulsive and general loads. Convolution integral. Transmissibility of motions, forces and vibration isolation. Stability and self-excitation.{\}newline
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+ Linear systems with N degrees of freedom{\}newline
Equations of motion and the reduction to a system of differential equations of first order. Eigenvalues and eigenvectors, matrix exponential and the resonse in free vibration with viscous damping. Forced vibration response. Modal analysis, proportional damping and diagonalization of the equations. Truncated modal superposition. Semi-definite systems. Numerical integration.{\}newline
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+ Linear continuum systems{\}newline
Equations of motion for cables, bars, shafts, beams and plates. Corresponding natural frequencies and mode shapes.{\}newline
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+ Introduction to modal analysis{\}newline
Experimental equipment. Vibration measurement. Response spectrum. Freqency response functions and system model parameters identification. Rotating mas balance.{\}newline
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+ Introduction to nonlinear vibration{\}newline
Response to nonlinear one degree of freedom oscilatory systems. Analysis in the phase space. Frequency response. Numerical solution.{\}newline
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+ Notions of acoustics and noise control{\}newline
The sound, noise and quantification parameters. The humam earing, the effects of noise, levels of exposure and legislation. Sound and noise measurement. Propagations of sound in air and structures. Industrial noise quantification and control.{\}newline
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+ Introduction to random vibration{\}newline
Random variables, processes and correlation functions. Stationary and Gaussian random processes. Response of an N degree of freedom system to stationary random excitation.

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Variable Speed Electrical Drives (EME07196M)

1. Introduction
Objectives. Functioning of a drive.
2. Parts of an electrical drive
2.1 – The Mechanical load
2.2 – The Electrical Machine
2.3 – The Power Electronics and the Electrical Power Supply
2.4 – The command and the control
3. Drives with DC Machines
3.1 – Speed Regulation – introduction
3.2 – Open loop Speed Regulation
3.3 – Feedback Speed Control (independent DC machine)
4. Drives with Three Phase Asynchronous machines
4.1 – Speed Regulation – introduction
4.2 – Command by Voltage magnitude with fixed frequency
4.3 - Command by Voltage frequency with fixed magnitude
4.4 – "Volts/Hertz" command
4.5 – Field Oriented Control
4.6 – Direct Torque Control
4.7 – Double-fed Asynchronous machine
5. Drives with Synchronous machines
5.1 – Speed Regulation – introduction
5.2 - Speed Regulation – PM Synchronous motor

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Supervisory Control Systems (FIS07197M)

1) Local Control and Remote Control. Communication in distributed systems. Local industrial networks.
2) Co-operation in GRAFCET multiple process. Master/slave control chains.
3) Industrial network Siemens-Profibus.
4) Industrial network Siemens-ethernet.
5) Introduction to the supervision and control systems (SCADA). A View of the SCADA systems: Axeda Supervisor and Siemens WinCC.
6) Implementation of SCADA system.
7) The NI systems of control and supervision. Labview project implementation.

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Robotic Systems (FIS07198M)

1) Manipulator robots. Robot classes. Components of a robotic system.
2) Mathematical models of typical joints. Kinematic chains. Kinematics and linear transformations: direct kinematics and inverse kinematics.
3) Robot Dynamics: Lagrange and Newton-Euler formulations.
4) Robot Control: independent joint-control, work space-control, gripper position and force control.
5) Trajectory Planning (optimization of cost-functions).
6) Robotic sensors: position/speed, proximity, force/torque, artificial vision sensors.
7) Introduction to automatic vision. Equipment for industrial vision. Filtering. Textures and form classification. Introduction to pattern recognition.
8) The integration of artificial vision in industrial automation controlled by PLC (Programmable Logic Controller). Practical implementations with vision sensors Siemens VS-710 (Siemens-ProVision).