Study Plan

School: School of Sciences and Technology
Degree: Master
Course: Mechatronics Engineering (cód. 699)

1st Year - 1st Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
EME13149M	Computational Mechanics and Optimization	Mechanical Engineering	6	Semester	156
EME13043M	Signals and Systems	Electrotechnical Engineering	6	Semester	156
EME13150M	Components of mechanical systems	Mechanical Engineering	6	Semester	156
EME13191M	Advanced control and automation	Electrotechnical Engineering Mechanical Engineering	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
EME10373M	Power Electronics	Electrotechnical Engineering	6	Semester	156
EME13193M	Supervisory Control Systems	Electrotechnical Engineering Mechanical Engineering	6	Semester	156
EME13032M	Embedded Systems Programmin	Informatics	6	Semester	156

Options

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
EME13026M	Computer Aided Drafting and Manufacturing	Mechanical Engineering	6	Semester	156
INF10358M	Programming and Intelligent systems	Informatics	6	Semester	156
EME13151M	Noise and Vibration	Mechanical Engineering	6	Semester	156
EME13152M	Computer Aided Analysis of Mechatronic Systems	Electrotechnical Engineering Mechanical Engineering	6	Semester	156
EME07196M	Variable Speed Electrical Drives	Electrotechnical Engineering	6	Semester	156
EME13197M	Robotic Systems	Electrotechnical Engineering Mechanical Engineering	6	Semester	156

2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Dissertation					

2nd Year - 3rd Semester

Component code	Name	Scientific Area Field	ECTS	Duration	Hours
Report					
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:

1º ano

{\}newline

1.º Semestre{\}newline

- 5 UC Obrigatórias num total de 30 ECTS

{\}newline

2.º Semestre{\}newline

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

- 2 UC Opttaivas num total de 12ECTS do quadro de optativas{\}newline

{\}newline

Para obtenção do grau é necessário também a aprovação em Dissertação, Trabalho de Projecto ou Relatório de Estágio, no total de 30 ECTS, no 3.º Semestre. ***

Program Contents

Back

Computational Mechanics and Optimization (EME13149M)

1. Polynomial interpolation.
2. Numerical quadrature: basic methods and Gauss methods.
3. Brief introduction to dense linear algebra. BLAS operations.
4. Nonlinear equations making use of first derivatives.
5. Brent method and combination with Newton method. Functions that change sign and industrial-strength root finders.
6. ODE integration.
7. Sparse eigenvalue problems.
8. Introduction to partial differential equations (PDE). Finite difference methods for PDE. Galerkin method and finite element method.
9. Unconstrained optimization. Optimality conditions of first and second orders. Conjugate gradient method, Newton method and Quasi-Newton families.
10. Trust region method with dogleg.
11. Equality-constrained problems. Constraint classification. Transformation methods.
12. Inequality-constrained problems. Complementarity.
13. Numerical solution of PDE problems: Fourier heat equations and Cauchy equilibrium.
14. Applications to structural optimization

Back

Signals and Systems (EME13043M)

1. Introduction to signal processing
Signal characterization and classification. Typical operations in signal processing. Signal examples.
2. Discrete time systems and signals
Sampling. Discrete time systems. Characterization of linear and time invariant systems. Signal correlation.
3. Sampling of continuous signals
Sampling theorem. Aliasing problem. Signal reconstruction. Interpolation and decimation.
4. Z transform
Properties. Convolution. Transfer function of a discrete system. Stability and causality.
5. Discrete Fourier Transform (DFT)
DFT definition and its inverse. DFT computation of real sequences. Convolution using the DFT. Spectral leakage and temporal windows. FFT (Fast Fourier Transform).
6. Digital Filters
FIR (Finite Impulse Response) and IIR (Infinite Impulse Response) filters. Design of FIR type filters. Design of IIR type filters.

Back

Components of mechanical systems (EME13150M)

Recap of Mechanics.
Introduction to the Mechanics of continuous media. Analysis of motion, deformation measures. The principles of mass conservation, linear momentum and angular momentum. The concept of stress. Constitutive laws for linear elastic solids.
Introduction to design and its phases. Cost, responsibility, standards and demanded construction codes.
Safety factor and reliability.
The materials mechanical behavior. Material tests. Stress intensity factor. Ductile and fragile behaviour.
Design for static loads.
Fatigue design.
Design of structural bolted, welded and bonded connections.
Mechanical transmission systems. Design concepts for gear, trains, chain and cable transmissions. Clutches and brakes. Shaft connection mechanisms. Design of rolling contact and friction bearing supports.
Spring design for static and fatigue loads.
Introduction to Microelectromechanical Systems (MEMS). Development of miniaturized machines and sensor mechanisms.

Back

Advanced control and automation (EME13191M)

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**.

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.

Back

Power Electronics (EME10373M)

1. Introduction to power electronic converters

The importance of inverters in the context of electrical systems; Structure of converters.

2. Naturally commutated converters

The rectifier using diodes and thyristors with ideal adjacent circuits; connection of the converter to the generator using adjacent non-ideal circuits; Converters AC-AC; Modeling and control.

3. Forced commutated converters

Study of forced commutated circuits; DC-DC with ideal adjacent circuits and non-ideal circuits; Modeling and control.

Back

Supervisory Control Systems (EME13193M)

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

Back

Embedded Systems Programmin (EME13032M)

1. Introduction to Embedded Systems

2. Embedded Systems Programming

3. Introduction to System Design

4. Peripheral Interface Methods

5. Waveform Interfaces

6. Serial Interfaces

7. Analog Interfaces

8. Avionics Systems

Back

Computer Aided Drafting and Manufacturing (EME13026M)

1. Geometrical product specification GPS. Associated metrology and corresponding processes.
2. Technical drawing and introduction to the design of welding, bolted and riveted connections.
3. Technical drawing electronic schematics. Introduction to circuit simulation. Layout and introduction to the manufacturing of printed circuit boards.
4. Technical drawing of electrical and telecommunications schematics. Circuit protection and switching components.
5. Technical drawing of compressed air and oleo-hydraulics actuated systems. Schematics of fluid networks.
6. Introduction to computer aided manufacturing. Generation of code for numerically controlled machines. Machining. Additive manufacturing.

Back

Programming and Intelligent systems (INF10358M)

1. Object oriented programmig paradigm. Data structures. Flow Control instructions. Control and monitoring systems application.
2. Graphical user interfaces - Instrument Data logging, data transmission to instruments, PLCs and computers. Data presentation; time series, andn alarm settings. . Recebimento de ordens provenientes de um utilizador humano através da interface gráfica. Data processing.
3. Control and automation. - Application to control an d automation processes of production processes.

Back

Noise and Vibration (EME13151M)

1) Relevant laboratory equipment: accelerometers, hand vibrometers, microphones, data loggers.
2) Linear systems with 1 degree of freedom.
3) Principle of virtual power. Euler-Lagrange equations.
4) Deduction of mass matrices, damping and stiffness for n degrees of freedom.
5) Laboratory experiments in model structures. Experimental modal analysis.
6) Modal superposition and truncated modal superposition - static shift and static correction
7) Generalized proportional damping. Reduction to first order.
8) Analysis of continuous medium - second and fourth order hyperbolic systems.
9) Non-linear vibrations: Routh-Hurwitz criterion, Liapunov criterion. Methods of perturbation, method of Lindsedt. Noise and acoustics: pressure and acoustic power, noise level, noise exposure, noise perception, reflection, flutter.
10) Reverberation, absorption and transmission, propagation and structures. Application examples.

Back

Computer Aided Analysis of Mechatronic Systems (EME13152M)

1. Kinematic and dynamic computer analysis of rigid body mechanical systems in 2D and 3D. Application to robotics.
2. Electric and electronic circuit simulation.
3. Finite element analysis of coupled electrical, magnetic, thermal, fluid flow, structural and control problems. Modelling of active materials. The piezoelectric and magnetostrictive cases.
4. Application to MEMS.

Back

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

Back

Robotic Systems (EME13197M)

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) Mobile Robots.
6) Robotic sensors: position/speed, proximity, force/torque, artificial vision sensors.
7) Introduction to automatic vision. Equipment for industrial vision. Digital signal processing. 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).