



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 |
|----------------|--|--|------|----------|-------|
| FIS7203 | Components of Mechanical Systems | *** TRANSLATE ME: Projecto e Automação Industrial *** | 6 | Semester | 156 |
| FIS7204 | Computational Structural Mechanics | *** TRANSLATE ME: Projecto e Automação Industrial *** | 6 | Semester | 156 |
| FIS7205 | Computational Mechanics and Optimization | Mechanical Engineering | 6 | Semester | 156 |
| FIS7206 | Microprocessors | *** TRANSLATE ME: Electrónica e Instrumentação *** | 6 | Semester | 156 |
| FIS7207 | Modelling and Simulation | Mechanical Engineering | 6 | Semester | 156 |

1st Year - 2nd Semester

| Component code | Name | Scientific Area Field | ECTS | Duration | Hours |
|----------------|--|--|------|----------|-------|
| FIS7199 | Advanced Control and Automation | *** TRANSLATE ME: Projecto e Automação Industrial *** | 6 | Semester | 156 |
| FIS7200 | Computer Aided Analysis of Mechatronic Systems | *** TRANSLATE ME: Projecto e Automação Industrial *** | 6 | Semester | 156 |
| FIS7201 | Power Electronics | *** TRANSLATE ME: Electrónica e Instrumentação *** | 6 | Semester | 156 |
| INF7202 | Programming and Intelligent Systems | Informatics | 6 | Semester | 156 |
| FIS7208 | 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 |
|----------------|----------------------------------|--|------|----------|-------|
| FIS7196 | Variable Speed Electrical Drives | Electrotechnical Engineering | 6 | Semester | 156 |
| FIS7197 | 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 |
|----------------|-----------------|--|------|----------|-------|
| FIS7198 | Robotic Systems | *** TRANSLATE ME: Projecto e Automação Indus- trial *** | 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

{ \ } newline

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



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Components of Mechanical Systems (FIS7203)

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 (FIS7204)

1) Basic structural modelling: Physical and Mathematical modelling.

2) Different techniques for numerical analysis of structures.

3) An introduction to the finite element method.

4) Continuum media. Basic theory.

5) Governing equations (balance equations) and constitutive equations, including composite materials and active materials.

6) Integral formulation.

7) Finite element technology: continuum elements, beam and rod elements and shell elements.

8) Eigenvalue problems: Critical load and natural frequencies.

9) Dynamic analysis.

10) Elasto-plastic analysis and large deformation analysis.

11) Verification and validation.



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Computational Mechanics and Optimization (FIS7205)

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. Dense linear algebra (LU and LDLT decompositions).
7. ODE integration.
8. Sparse eigenvalue problems.
9. Introduction to partial differential equations (PDE). Finite difference methods for PDE. Galerkin method and finite element method.
10. Unconstrained optimization. Optimality conditions of first and second orders. Conjugate gradient method, Newton method and Quasi-Newton families.
11. Trust region method with dogleg.
12. Equality-constrained problems. Constraint classification. Transformation methods.
13. Inequality-constrained problems. Complementarity.
14. Numerical solution of PDE problems: Fourier heat equations and Cauchy equilibrium.

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Microprocessors (FIS7206)

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.



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Advanced Control and Automation (FIS7199)

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 (FIS7200)

Fundamental concepts of dynamics{\}

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).{\}

{\}

Kinematic analysis of mechanical systems in 2D{\}

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. {\}

Formation of the global system of equations, computer implementation and numerical solution.

Dynamic analysis of mechanical systems in 2D{\}

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{\}

Description of each body position, rotation tensor and Euler parameters. Modelling kinematic joints in 3D. Equations of motion. Application to robotics.

Active structures{\}

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 (FIS7201)

1. Power Quality

Electricity as a product. Standards. Continuity of service and commercial quality. Indicators of quality of service. Harmonics in the power grid. Quality of current waveform and voltage waveform. Harmonic mitigation techniques.

2. Switching Converters natural

3. Forced switching converters

3.1 bilevel converter

3.2 Multilevel Converter

3.3 Matrix Converter

4. Uninterruptible Power Supplies (UPS)

4.1 UPS such as "offline"

4.2 UPS of type "line interactive"

4.3 double conversion UPS type

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Programming and Intelligent Systems (INF7202)

1. Object oriented programming 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, and alarm settings. Data processing.

3. Control and automation. - Application to control and automation processes of production processes.

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Vibration and Noise (FIS7208)

Linear systems with 1 degree-of-freedom. Virtual power principle. Euler-Lagrange equations. Rayleigh ratio as an estimation tool. Mass matrix, damping matrix and stiffness matrix for n-dof systems. Modal superposition and truncated modal superposition. Static shift and correction. Cayley-Hamilton theorem and proportional damping. Reduction to first order systems. Matrix exponential and applications in Mathematica. Continuum systems: hyperbolic problems. Separation of variables. Non-linear vibrations: Rough-Hurwitz criterion, Liapunov criterion and method. Perturbation methods, Lindsedt method. Noise and acoustics: acoustic pressure and power, noise level, noise exposure, noise perception, reflection, flutter. Reverberation, absorption and transmission, propagation and structures. Examples of application.



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Variable Speed Electrical Drives (FIS7196)

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 (FIS7197)

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 (FIS7198)

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).