DOCTORAL PROGRAMME IN ELECTRICAL AND COMPUTER ENGINEERING

PROGRAMME GUIDELINES

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1 INTRODUCTION

This document defines the general guidelines of the Doctoral Programme in Electrical and Computer Engineering. Additional annual information is given in the Annual Annex to the Programme Guidelines, which contains information to a specific academic year.

The Department of Electrical and Computer Engineering (DEEC) of the Faculty of Engineering, University of Porto (FEUP) offers a Doctoral Programme in Electrical and Computer Engineering (PDEEC), covering the major areas of Electrical and Computer Engineering. A set of advanced mandatory and elective courses are offered during the first year, organized in two semesters. Typically the programme requires 8 courses of 7.5 ECTS\(^{(1)}\), and advanced research work to be submitted and defended as a PhD thesis.

The research environment is composed of DEEC and the following research institutes associated with FEUP: INESC-Porto (Institute for Systems and Computer Engineering of Porto), ISR - Porto (Institute for Systems and Robotics - Porto), and INEB (Biomedical Engineering Institute). Cister - Research Centre in Real-Time Computing Systems from ISEP (Instituto Superior de Engenharia do Porto) is a host research centre associated with PDEEC.

FEUP and DEEC have on-going cooperation programmes with MIT, Carnegie-Mellon University and University of Texas at Austin.

\(^{(1)}\) ECTS – European Credit Transfer System

1.1 Important Dates

The deadlines for application to PDEEC are the following:

- Fall semester: Not later than a date to be established in July.
- Spring semester: Not later than a date to be established in January.

The candidates will be informed of the admission to programme within one month after the deadlines. The accepted candidates should start the studies immediately after being notified.

1.2 Calendar

Fall semester:

- A date to be established in the period from September to February

Spring semester:

- A date to be established in the period from February to July
2 PROGRAMME ORGANISATION

PDEEC courses are organized in two semesters (see table below). The students typically select two main streams plus two other electives. Seminars and Individual Topics are additional courses designed to help the students starting the research work, and to prepare the thesis research plan under the supervision of a supervisor. The plan needs to be discussed and approved by a Supervisory Committee.

<table>
<thead>
<tr>
<th>1st Semester</th>
<th>2nd Semester</th>
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</thead>
<tbody>
<tr>
<td>Seminars</td>
<td>Individual Topics</td>
</tr>
<tr>
<td>Main Stream 1 (two courses)</td>
<td></td>
</tr>
<tr>
<td>Main Stream 2 (two courses)</td>
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<tr>
<td>Elective 1</td>
<td>Elective 2</td>
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</tbody>
</table>

The courses offered by PDEEC are organized into the following streams, each one having two semester courses:

- **ENMAR** - Energy Markets
- **PSDCO** - Power System Dynamics and Control
- **DICOM** - Digital Communications
- **COTEC** - Communication Technology
- **SYCON** - Systems and Control
- **DEHSY** - Discrete Event and Hybrid Systems
- **COMPS** - Computer Science
- **SIPRO** - Signal Processing
- **IMRML** - Image Recognition and Machine Learning
- **MICRO** - Microelectronics and Microsystems Operations
- **TTDTE** - Test Technology and Design for Testability
- **OPRES** - Operations Research
- **ROBOT** - Robotics
- **ERTS** - Embedded Real-Time Systems
3 Course Description

PDEEC courses are shown in the following table. The list of courses for each student needs a previous approval of the PDEEC Scientific Committee.

The streams and the corresponding courses are listed in the table below.

<table>
<thead>
<tr>
<th>Stream</th>
<th>1st Semester</th>
<th>2nd Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENMAR - Energy Markets</td>
<td>Markets and Regulation</td>
<td>Market Simulation</td>
</tr>
<tr>
<td>PSDCO - Power system dynamics and control</td>
<td>Signals, Dynamics and Control</td>
<td>Systems with Renewables</td>
</tr>
<tr>
<td>DICOM - Digital Communications</td>
<td>Special Topics in Digital Communications</td>
<td>Communication Networks and Multimedia</td>
</tr>
<tr>
<td>COTEC - Communication Technology</td>
<td>Mobile Communications Systems</td>
<td>Advanced Optical Communications Systems</td>
</tr>
<tr>
<td>SYCON - Systems and Control</td>
<td>Vector Space Methods</td>
<td>Measure Theory and Stochastic Processes</td>
</tr>
<tr>
<td>DEHSY - Discrete Event and Hybrid Systems</td>
<td>Discrete Event Systems</td>
<td>Hybrid Systems</td>
</tr>
<tr>
<td>COMPS - Computer Science</td>
<td>Model Driven/Aspect oriented Software</td>
<td>Grid computing</td>
</tr>
<tr>
<td>SIPRO - Signal Processing</td>
<td>Signal Analysis, Classification and Processing</td>
<td>Digital Signal Processing Systems Architectures</td>
</tr>
<tr>
<td>IMRML - Image Recognition and Machine Learning</td>
<td>Machine Learning</td>
<td>Image Analysis and Recognition</td>
</tr>
<tr>
<td>MICRO - Microelectronics and Microsystems</td>
<td>Microelectronic and Microelectromechanical Technologies</td>
<td>Advanced Microelectronic Systems Design</td>
</tr>
<tr>
<td>TTDTE - Test Technology and Design for Testability</td>
<td>Test and Design for Testability</td>
<td>Instrumentation and Systems Testing</td>
</tr>
<tr>
<td>OPRES - Operations Research</td>
<td>Decision Support</td>
<td>Optimization Techniques</td>
</tr>
<tr>
<td>ROBOT - Robotics</td>
<td>Robotic Manipulators</td>
<td>Mobile Robotics</td>
</tr>
<tr>
<td>ERTS - Embedded Real-Time Systems</td>
<td>Real-Time Embedded Systems</td>
<td>Distributed Embedded Systems</td>
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3.1 Streams

Energy Markets

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<tr>
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<th>Semester</th>
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<th>Course name</th>
<th>Stream</th>
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<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td>Markets and Regulation</td>
<td>ENMAR</td>
</tr>
</tbody>
</table>

Introduction to electricity markets, new structures, agents and relations. The pool market (symmetric and asymmetric, voluntary and mandatory) and bilateral contracts (physical and financial). Simple bids and complexity conditions (concepts and mathematical optimization models). Network services and cost allocation methods (average, incremental and marginal approaches). Models to compute nodal short term active power marginal prices. Interpretation of nodal prices and computation of the congestion rent. Analysis and discussion of application examples. Regulatory approaches in use by regulatory agencies (Cost-of Service/Rate of Return, Price Caps, Revenue Caps and Comparison). Discussion on the advantages and disadvantages of these strategies and analysis of application examples. The Portuguese tariff code – structure, tariff variables, access tariffs and integral regulated tariffs.

Simulation of market processes and player interaction through mathematical programming is accomplished by traditional optimization using Linear Programming. Simulation through modern control theory as differential equation models and as discrete event system simulations (DESS) is accomplished with the inclusion of strategy for risk management. Simulation by intelligent agents is introduced as an extension of the previous models. Short term simulation and long term validation is made by comparing the use of repeated auctions into the future or the use of forecasting models to replace future markets. Industry segment models and decomposition provide the framework to isolate a single market simulation for a complete micro-economic model.

**Power system dynamics and control**

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<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td><strong>Signals, Dynamics and Control</strong></td>
<td>PSDCO</td>
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</tbody>
</table>

Detailed modelling of loads, excitation systems, prime movers (hydraulic turbines, thermal units) and frequency regulation systems. Description of emergency control actions. Study of advanced stability enhancement techniques. Modelling AGC system and performance analysis in systems with several control areas. Control via fuzzy controllers, neural networks and computational intelligence algorithms. Fuzzy controller design using Mamdani models. Training Takagi-Sugeno and neural network controllers to optimize parameters.

Analysis of power system oscillations due to the lack of damping torque at the generators rotors. Review of the concepts of eigenvalue analysis of linear systems, addressing the linearization of the state equations, the construction of the linear model in the canonical state space form and the physical meaning of eigenvalues, eigenvectors, participation factors, residues and controllability and observability factors. Design and tuning of power system damping controllers tackling with the configuration of power system stabilizers.

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<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td><strong>Systems with Renewables</strong></td>
<td>PSDCO</td>
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</tbody>
</table>

Detailed modelling of different types of renewable energy conversion systems Impacts of renewable energy conversion systems in power system operation. Impacts of wind power on grid voltage stability and on system dynamic behaviour - Ride through fault. Use of wind generators to damp electromechanical oscillations. Photovoltaic electric principles and determination of operation point of PV cells. Sizing PV systems, including solar resource evaluation, optimal sizing of PV system components.

Grid code requirements and new hierarchical managing control structures.

Economic Issues: Remuneration of renewable energy systems and participation in electricity markets. Combined wind generation / storage operation (optimizing wind – hydro pumping operation).


**Digital Communications**

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<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td><strong>Special Topics in Digital Communications</strong></td>
<td>DICOM</td>
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<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td>Communication Networks and Multimedia</td>
<td>DICOM</td>
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</table>

Preliminary program: Introduction: review of basic network concepts, architectural models and switching principles. Enabling network technologies for broadband and multimedia communications in LANs, MANs and WANs (Gigabit Ethernet, Wireless LANs, ATM, MPLS, etc); layer 2 and layer 3 network services (tunnels, VPNs, etc.). Quality of Service models - ATM and IP (IntServ and DiffServ) - and signaling control (RSVP, NSIS). Traffic Control and Resource Management - admission control, policing, shaping, congestion control, scheduling. Multimedia communications in IP networks - architecture and high-level protocols.

**Communication technology**

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<th>Stream</th>
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<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td>Mobile Communications Systems</td>
<td>COTEC</td>
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<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td>Advanced Optical Communications Systems</td>
<td>COTEC</td>
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**Systems and control**

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<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td>Vector Space Methods</td>
<td>SYCON</td>
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</table>

Linear Spaces. Basic definitions, Normed linear spaces, Banach spaces, Complete subsets, Quotient spaces, Denseness and Separability.

Linear Dynamic Systems. Solution methods for (control and state) affine ODEs, Controllability and observability, Kalman decomposition, Systems compensation.


Linear Operators. Basic definitions, Inverse operators (Banach inverse theorem), Singular value decomposition, Adjoints, Pseudoinverse.

Dual Spaces. Basic concepts, Hahn-Banach theorem, Geometric interpretation, Minimum norm problems, Dual problems.

### Measure Theory and Stochastic Processes

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<td>7.5</td>
<td>Measure Theory and Stochastic Processes</td>
<td>SYCON</td>
</tr>
</tbody>
</table>

Introduction to Measure Theory: Theory of sets, Point set topology, Set functions, Construction and properties of measures, Measurability, Space of measurable functions, Definition and properties of the integral.


Stochastic models. General output sequence, ARMA models, Stochastic dynamic models, Innovations representations, Predictor models.


System Identification. Point estimation theory, Models, Parameter estimation for static and dynamic systems, Off-line and on-line parameter estimation, Three stage least squares and order determination for scalar ARMAX models.

### Discrete Event and Hybrid Systems

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<td>1st</td>
<td>7.5</td>
<td>Discrete Event Systems</td>
<td>DEHSY</td>
</tr>
</tbody>
</table>

Introduction - Discrete-Event Systems, System Classifications.


Time Models of Discrete-Event Systems - Timed State Automata, Timed Petri Nets, Algebra max-plus.


Queueing Theory - Queueing Models, Performance and Dynamics of a Queueing System, Analysis of Markovian Queueing Systems, Markovian Queueing Networks, Control of Queueing Systems, Non-Markovian Queueing Systems.

Discrete-Event Stimulation - The Event Scheduling Simulation Scheme, The Process-Oriented Simulation Scheme, Discrete-Event Simulation Languages, Output Analysis.


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<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td>Hybrid Systems</td>
<td>DEHSY</td>
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</table>

This course addresses four main topics as follows: structure and interpretation of hybrid systems, modelling and simulation, analysis and design and applications. The first one includes motivation (convergence of computation, control and communications), fundamental concepts in dynamic systems: models; reachability; invariance; optimality and models of computation. In the second topic they are addressed formal models for hybrid systems (Finite automata; Differential equations; Hybrid automata; Open hybrid automata; Dynamic networks of hybrid automata), executions of hybrid systems and simulation tools and methods (Numerical methods; Simulink, Stateflow, Ptolemy and Shift), The third topic addresses properties of hybrid systems (sequence, safety, stability, liveness and ensemble), formal verification and decidability, reach set computations, Lyapunov stability of hybrid
systems and controller design and optimal control of hybrid systems namely numerical methods (Fast Marching and Ordered Upwind Methods). Finally, the Applications include verified control architectures for multi-vehicle systems, coordination and control of dynamic systems, control over networks, embedded control and control and sensing languages.

### Computer Science

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<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td>Research Topics in Software Engineering</td>
<td>COMPS</td>
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Aspect Oriented Software Development: concepts associated to the aspect oriented programming paradigm. Aspect oriented programming languages. Aspect oriented requirements engineering and architecture design. Relationship and complementarily with other paradigms. Supporting tools and applications.

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<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td>Grid computing</td>
<td>COMPS</td>
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</table>

Parallel Computing: Introduction to parallel computing, computer architectures, processors, memory organization and interconnection networks. Parallel Programming Fundamentals: task/channel paradigm, communication patterns, synchronization, task granularity and scheduling. Cluster programming with MPI and OpenMP. Parallel computing characterization: execution models, programming models, performance and efficiency measures, scalability analysis.

Distributed Computing: a) peer-to-peer computing, pure and hybrid p2p networks, taxonomy of p2p systems and objectives of p2p networks. Applications: communications and collaborations, distributed computing, internet service support, data base applications and content distribution. P2P Algorithms for content distribution: centralized directory model, flooded request model and document routing model. b) Grid Computing Fundamentals and Standards Grid computing models: generic grid, utility grid and desktop grid; Evolution of grid middleware: metacomputing (Condor, LSF), resource-oriented (Globus 1, 2 and 3; LCG) and service-oriented (Globus 4, EGEE); Grid security: authentication, data integrity and encryption, authorization; Scheduling and Resource Management; Data Management; Grid Computing Portals; Hands-on Grid technology.

### Signal Processing

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<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td>Signal analysis, classification and processing</td>
<td>SIPRO</td>
</tr>
</tbody>
</table>

Preliminary program: Advanced mathematical foundations for signal processing and stochastic systems: Signals models and distributions; Signal transforms, multiresolution processing and filterbanks; Feature extraction; Entropy-based signal analysis; Optimization and estimation techniques; Wiener and Kalman filtering; Dynamics of non-linear systems; Signal classifiers: Trainable systems: Neural networks and Hidden-Markov chains; Statistical classifiers: vector quantization and clustering techniques

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<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td>Digital signal processing systems architectures</td>
<td>SIPRO</td>
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Module2: Design of DSP-based systems. Technologies and methods for audio and speech processing systems and for artificial vision systems.
Image Recognition and Machine Learning

<table>
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<th>Year</th>
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<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td><strong>Machine Learning</strong></td>
<td>IMRML</td>
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<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td><strong>Image Analysis and Recognition</strong></td>
<td>IMRML</td>
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Microelectronics and Microsystems

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<thead>
<tr>
<th>Year</th>
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<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td><strong>Microelectronic and Microelectromechanical Technologies</strong></td>
<td>MICRO</td>
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</table>

The main goal of the Microelectronics and Microsystems course is to develop the background knowledge necessary to understand the state-of-the-art of semiconductor technology, as well as of Micro-Electro Mechanical Systems (MEMS), and the integration of mechanical elements and electronics. The course is divided in three modules: Module-I will cover the microelectronics fundamentals, such as: technology and modelling foundations of semiconductor devices (focus on MOS-FET) and low-voltage, low-power, high-speed and non-linear electronics. Module-II, MEMS sensors and actuators, focuses on Micro-Electro Mechanical Systems (MEMS) and the integration of mechanical elements and electronics. Module-III, deals with the interface between MEM-analogue and digital worlds, both at the circuit level and design methodologies, to bring understanding of the fundamental aspects associated with full integrated systems.

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<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td><strong>Advanced Microelectronic Systems Design</strong></td>
<td>MICRO</td>
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</tbody>
</table>

The course provides students with the background needed for the design and implementation of complex integrated electronic systems, starting from high-level abstract requirements and proceeding through successive refinement stages to a complete physical implementation in a modern, highly
Integrated, IC technology. The course promotes an understanding of the fundamental aspects of the timing, power and testability involved in this task, and a solid knowledge of how these factors influence design methodologies and design decisions for different target implementations (e.g., sub-micron CMOS or platform FPGA). The main topics are high-level digital system specification and modelling, system integration and physical synthesis, system timing and clock management, power-aware system design, and testable system design.

Test Technology and Design for Testability

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<tbody>
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<td>1st</td>
<td>7.5</td>
<td><strong>Test and Design for Testability</strong></td>
<td>TTDTE</td>
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</table>

This module addresses the area of test and design for test, with an emphasis on four main topics: i) basic concepts, involving the rationale and economics of testing, as well as various introductory technological subjects; ii) digital design for test, discussing scan design and the IEEE 1149.X digital scan test standards; iii) memory testing, as an example of an application area where non-scan design for test methods and a variety of fault models coexist; iv) analogue and mixed-signal design for test, where IEEE scan-test methods and built-in self-test approaches are discussed. Various practical assignments are envisaged for the three last topics, involving IEEE 1149.x applications and circuitry, and a visit to the test department of an electronics assembly plant in the vicinity of Porto.

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<td>2nd</td>
<td>7.5</td>
<td><strong>Instrumentation and Systems Testing</strong></td>
<td>TTDTE</td>
</tr>
</tbody>
</table>

Instrumentation and Systems Testing aims at complementing the studies on testing methods started with the Test and Design for Testability course, addressing now an upper level in the electronic systems hardware hierarchy, i.e., that concerning with the interaction among different parts in a system. The course contents address both hardware and instrumentation issues. Regarding hardware this course point towards studying the embedded testing of embedded cores, multi-chip modules, boards, and micro-electromechanical systems. For instrumentation, the goal is to discuss the architecture and functional requirements of automatic test equipment and the implementation of test instruments based on virtual instrumentation.

Operations Research

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>ECTS</th>
<th>Course name</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td><strong>Decision Support</strong></td>
<td>OPRES</td>
</tr>
</tbody>
</table>

The program of this course includes six main topics as follows: Operations research basics, Decision theory, Multicriteria decision-making, Simulation, Non-populational metaheuristics and Populational metaheuristics. Regarding Operations research basics, it addresses linear programming (the art and science of modelling – case studies and practice, linear programming and integer programming algorithm basic concepts and solving linear programming problems using open source tools) and heuristics and local search (heuristic approaches versus optimization algorithms, general combinatorial optimization models and constructive and improvement heuristics). Decision theory addresses topics as alternatives and states of nature, utility theory and decision trees. Multicriteria decision-making includes methods for multi attribute and multi objective problems and analytical hierarchy process. Simulation includes topics as simulation basics, statistical simulation and event based discrete simulation models. In non-populational metaheuristics they are studied techniques as Simulated Annealing, Tabu Search, Greedy Randomized Adaptive Search Procedure and Variable neighborhood search approaches while in Populational metaheuristics they are addressed Genetic Algorithms, Ant Colonies and Particle Swarm Optimization.

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>ECTS</th>
<th>Course name</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td><strong>Optimization Techniques</strong></td>
<td>OPRES</td>
</tr>
</tbody>
</table>

The program of this course includes five main topics as follows: Operations research basics, Tree search algorithms, Constraint programming, Complexity analysis and design and Dynamic programming. Regarding Operations research basics, it addresses linear programming (the art and
science of modelling – case studies and practice, linear programming and integer programming algorithm basic concepts and solving linear programming problems using open source tools) and heuristics and local search (heuristic approaches versus optimization algorithms, general combinatorial optimization models and constructive and improvement heuristics). Tree search algorithms include the following topics: Branch and Bound algorithms, Column generation, branch and price algorithms and valid inequalities and branch and cut algorithms. Within Constraint programming they are studied constraint-based modelling, constraint propagation and consistency, constraint models for combinatorial problems and constraint programming languages – ILOG CP. In Complexity analysis and design they addressed algorithm complexity analysis and algorithm design. Finally, Dynamic programming includes the Bellman’s optimality principle, recursion functions and states and stages – discrete dynamic programming.

### Robotics

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>ECTS</th>
<th>Course name</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td>Robotic Manipulators</td>
<td>ROBOT</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>ECTS</th>
<th>Course name</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td>Mobile Robotics</td>
<td>ROBOT</td>
</tr>
</tbody>
</table>


### Embedded Real-Time Systems

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>ECTS</th>
<th>Course name</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>7.5</td>
<td>Real-Time Embedded Systems</td>
<td>ERTS</td>
</tr>
</tbody>
</table>

Specification and modelling: Definition of real-time and embedded system; Origin and type of real-time constraints; Specification languages; Modeling techniques and technologies. Real-time scheduling: The recurrent task model and constraints (revisit multi-tasking OSs and concurrency concepts, the WCET…); Periodic task scheduling; Aperiodic task scheduling; Accessing shared resources. Real-time operating systems: Existing RTOS and their architecture (RTOS vs GPOS); Programming models associated to RTOS; Building an RT kernel.

<table>
<thead>
<tr>
<th>Year</th>
<th>Semester</th>
<th>ECTS</th>
<th>Course name</th>
<th>Stream</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2nd</td>
<td>7.5</td>
<td>Parallel and Distributed Embedded Systems</td>
<td>ERTS</td>
</tr>
</tbody>
</table>

Multiprocessors: architecture and scheduling: Multiprocessors and multicores; Interprocessor communication paradigms; Global and partitioned scheduling; Access to globally shared resources. Distributed architectures and communication protocols: Distributed systems versus multiprocessors, global architecture (include highly dispersed distributed architectures); Modeling paradigms for distributed embedded systems; Protocols for real-time communication, the protocol stack; Holistic and end-to-end scheduling. Programming distributed systems: Time and state in distributed systems, clock synchronization; Concurrency issues in distributed systems; Program partitioning and allocation; Middleware paradigms.
3.2 Pre-requisites for the courses in the streams

The two courses included in one stream are offered in a sequence. Depending on the stream, the courses in the spring semester may have pre-requisites on the material studied in the corresponding course in the fall semester. Although there are no formal pre-requisites, the students before registering for the first time in the Spring semester should contact the PDEEC Scientific Committee to validate her/his registration.

3.3 Seminars and Individual Topics

Seminars and Individual Topics are two courses that prepare students to initiate their research work. During Seminars, students attend a set of technical and non-technical seminars (see section 5.2 to see the seminars offered in 2007-2008) together with a special topic under the supervision of a faculty member. Early in the semester, students must engage in conversations with the faculty and choose the thesis supervisor, who must be appointed by the Scientific Committee.

During Individual Topic with the help of the selected supervisor, students must define the scope and topic of the research. This typically consists in identifying the state-of-the-art material, and developing a research plan that must be submitted as a Thesis Research Plan (TRP).

3.4 Special Topics

The offer of the course Special Topics (7,5 ECTS) as an elective course started in the second semester of the 2009/2010 academic year. The PDEEC Scientific Committee will credit 7,5 ECTS to this course to students involved in teaching activities, as a Teaching Assistant (TA) in DEEC/FEUP. The goals of the course are the following:

- To give PDEEC students the opportunity to be involved in teaching activities in Master Degree Courses offered in the Department;
- To create opportunities for TAs to use their expertise and skill to co-operate in the development of course curriculum;
- To give TAs the opportunity to co-operate in course planning;
- To expose TAs to teaching activities at lab level to a limited number of students and at a lecture hall to the entire class.

The requirements are:

- Preparation of lab work: set-up the experiments, prepare the theoretical background and elaborate the experimental guide (at least 4 lab works);
- Teaching activity in lab classes: to assist lab classes, accompanying students and evaluation activities of lab work;
- Teaching activity in theoretical classes: to teach two different topics in theoretical classes.

How to apply:

- Enroll in the course Special Topics;
- Interact with PDEEC Scientific Committee to define the course/professor of the Master Degree course offered by DEEC/FEUP.

The course will be evaluated by the professor of the master degree course, taking into consideration the requirements mentioned above.

3.5 Electives

Electives are optional courses. The students may select as an elective any course included in other streams or other courses offered by doctoral programmes in FEUP. Electives need to be approved by PDEEC Scientific Committee. If the student has already a supervisor, the electives should be approved by the supervisor and communicated to the Scientific Committee.
4 RESEARCH OVERVIEW

The PDEEC is organized in the Department of Electrical and Computer Engineering (DEEC) encompassing the major areas in Electrical, Electronics and Computer Engineering. Presently, the department has 77 faculty members.

The DEEC research activity is mostly organized in R&D units recognized by the Portuguese Research Council (FCT). You may find relevant information regarding the research activities in the websites of these Institutes:

- INESC-Porto - Instituto de Engenharia de Sistemas e Computadores do Porto (www.inescporto.pt);
- INEB – Instituto de Engenharia Biomédica (http://www.ineb.up.pt – follow the Signal & Image division link);
- ISR–Porto – Instituto de Sistemas e Robótica (http://paginas.fe.up.pt/isrp/);
- IT – Instituto de Telecomunicações (http://www.it.pt/).

As a host research centre associated with PDEEC Cister - Research Centre in Real-Time Computing Systems from ISEP (Instituto Superior de Engenharia do Porto) also cooperates in this doctoral program.
5 PROGRAMME ACTIVITIES

5.1 Seminars

As part of the course Seminars, the PDEEC invites a number of researchers to present overviews on advanced research topics in electrical and computer engineering as well as broader topics of general interest for science and engineering. Participating in these Lectures is mandatory for the PDEEC students as part of the development of their scientific background and general knowledge.

PDEEC also organizes a number of seminars in which Ph.D. students are invited to present their research. These seminars are intended to let the community know the research activities that are being conducted in the department. On the other hand, they are also an excellent way to help students develop their presentation skills. Every PDEEC Ph.D. student must present at least one seminar during their Ph.D. programme.

5.2 Past activities

As examples of the Lectures and Seminars just referred, during 2007/2008 the PDEEC organized the following Lectures:

- "Brain Machine Interface - modeling strategies for signal processing", Prof José Carlos Principe, University of Florida, USA, and Invited Professor of FEUP, Porto, Portugal;
- "The Energy Challenges of the 21st Century - the role of renewable sources and rational end-use of energy", by Prof. Hans Puttgen, École Polytechnique Federale de Lausanne, Switzerland;
- "The Resilient Analogue, by Prof. Dinis Magalhães Santos, University of Aveiro, Portugal;
- "The Invisible Omnipresence of the Technologic Mediations", by Prof Teresa Levy, from the Centre for the Philosophy of Sciences, University of Lisbon, Portugal;
- "Cognitive Robotics: a multidisciplinary effort for the synthesis of socially intelligent robots", by Prof Estela Guerreiro Silva Bicho Erlhagen, University of Minho, Portugal.

Regarding the student seminars, the sessions already organized included the following presentations:

- "Management of Dynamically Reconfigurable Resources in Combined CPU/FPGA Systems”, by Miguel Lino Magalhães Silva;
- "Overlay Networks over Wireless Sensor Networks", by Bruno Filipe Lopes Garcia Marques;
- "Synthetic Aperture Sonar Assisted by Satellite", by Sérgio Rui Santos Barbosa Oliveira da Silva;
- "Hybrid System Modelling and Control: An Impulsive Approach”, by Rui Manuel Ferreira Gomes;
- "Infrastructure for the Coordination and the Distributed Control of Autonomous Heterogeneous Vehicles with Man-System Interactions”, by Paulo Alexandre de Sousa Dias;
- "Distribution of Informational Contents via Internet”, by Helder Fernandes de Castro.

In the first semester of 2009/2010 a number of sessions devoted to different topics on ECE were organized. More detailed information on these activities can be obtained in http://sites.google.com/site/eceback2basics/.
6 Path in the programme

6.1 Enrolling in the Programme
Students graduated in Electrical and Computer Engineering (including Electronics and Telecommunications) can apply to the PDEEC. Other profiles are likely to be accepted, especially in Computer Science, Physics or Energy and Environment. The admission of any candidate is subject to analysis and approval by the Scientific Committee of the Doctoral Programme PDEEC.

6.2 Student supervision
The student must find in the first semester a scientific supervisor. The dialogue between the Ph.D. candidate and the supervisor should be planned, frequent, encompass a fruitful discussion of scientific topics, and it is deemed crucial for the successful completion of the degree. The supervisor helps the student select the elective courses, formulate the research proposal, assist the students during the research period, check for timeliness of the research plan, and is also the liaison between the Ph.D. student and the PDEEC. Once the student chooses the Ph.D. supervisor, the Scientific Committee officially appoints the Supervisor and a Supervising Committee to each student and defines each student’s Study Plan.

6.3 Supervisory Committee
The Supervisory Committee must include the Supervisor, a second member from FEUP and a third external member, and it is appointed by the Scientific Committee in the 1st semester of the 2nd year. The supervisory committee must submit a yearly progress report to the PDEEC Scientific Committee evaluating the progress of the research.

6.4 Getting a degree
The Doctor Degree in Electrical and Computer Engineering is granted to the student that successfully:
- Completes 8 courses in PDEEC, obtaining 60 ECTS credit units;
- Gets approval from his Supervisory Committee for a Thesis Research Plan, submitted in the first semester of the second year in the Programme;
- Submits and successfully defends an original Thesis, as a result of the Research Plan previously accepted.

6.5 Defending the Thesis Research Plan
The research work to be done by the student must be defined by his Supervisor as early as possible, up to the end of the 1st year. The work done in the course Individual Topic 2 must contribute to the preparation of the Thesis Research Plan to be submitted to the Supervising Committee. This plan is a written document that the student shall defend in an oral exam, to take place within 30 days of the submission of the TRP. If the student fails the oral portion of the exam, s/he may retake it only once within two semesters of the original defense date. A doctoral student becomes definitively a doctoral candidate when the following requirements are satisfied:
- The student academic record in all the courses is satisfactory;
- The student has a dissertation topic approved by the programme Scientific Committee;
- The student has Thesis Research Plan approved in the oral exam.

6.6 Thesis Submission
The Thesis must be submitted in English (or Portuguese, in cases accepted by the Scientific Committee) before the end of 4 years in the Programme. A provisional version of the Thesis will be evaluated by a Committee upon a public defense where the candidate passes or fails, and amendments may be stipulated. The Diploma is only granted upon successful defense of the thesis and the delivery of a corrected and final version of the Thesis.
7 Admission Procedures

For application the candidates should submit to the address below an application form and enclosing the following documents:

- Education certificates
- Curriculum Vitae
- Copy of the passport or other identity document
- 2 letters of recommendation
- Photograph

The selection criterion is based on the CV of the candidate and on the overall marks in the undergraduate courses. A minimum of 16 out of 20 is required. All other cases will be evaluated by the PDEEC Scientific Committee in a case by case analysis. An overall mark in the range 14/20 to 16/20 will require a strong recommendation letter. The other cases can be exceptionally considered if strongly recommended by a Professor of the DEEC-FEUP.

Address:
Faculdade de Engenharia da Universidade do Porto
Serviços Académicos – Divisão de Pós-graduação e Educação Contínua
Rua Dr. Roberto Frias
4200-465 Porto, Portugal
Tel.: +351225082130 | 225081406
Fax: +351225081409
Email: sposgrad@fe.up.pt
8 Important Documents and Forms

- Application form and other instructions: http://www.fe.up.pt/pdeec (follow the link Documents. This form is need for the application to the programme).
- Programme bylaws: http://www.fe.up.pt/pdeec (follow the link Documents). This document is in Portuguese. It defines the framework of the programme.
- For important information for candidates to FEUP go to the website: http://paginas.fe.up.pt/~candidat/en/
# 9 PhD Checklist

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<tbody>
<tr>
<td>√</td>
<td>In the 1&lt;sup&gt;st&lt;/sup&gt; semester, complete 4 courses in 2 streams (2 courses per stream), plus Individual Topics 1 and an optional course (typically a course in a different stream. This list of courses needs approval from the Programme Scientific Committee.</td>
</tr>
<tr>
<td></td>
<td>Appoint the supervisor and co-supervisor if exists. The supervisor (and co-supervisor) must be appointed during the first year, being the 2&lt;sup&gt;nd&lt;/sup&gt; semester the recommended period for this appointment.</td>
</tr>
<tr>
<td></td>
<td>In the 2&lt;sup&gt;nd&lt;/sup&gt; semester, complete 4 courses in 2 streams (2 courses per stream), plus Individual Topics 2 and an optional course (typically a course in a different stream. This list of courses needs approval from the Programme Scientific Committee.</td>
</tr>
<tr>
<td></td>
<td>Arrange with the supervisor(s) the details of your written Thesis Research Plan that is to be defended in the oral exam.</td>
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<tr>
<td></td>
<td>The Scientific Committee nominates the Supervising Committee</td>
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<tr>
<td></td>
<td>Take the oral exam during the 2&lt;sup&gt;nd&lt;/sup&gt; year.</td>
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<tr>
<td></td>
<td>At least two weeks in advance of the oral exam, notify, in writing, the Student Services Office of plans to complete the qualifying exam.</td>
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<tr>
<td></td>
<td>Pass oral exam</td>
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<tr>
<td></td>
<td>Based on a positive evaluation of your academic record in the courses and in the oral exam, the Scientific Committee can issue the definitive registration as a Doctoral Candidate</td>
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<tr>
<td></td>
<td>Check with the Graduate Office to see if all graduation requirements, including appropriate course credits, will be satisfied.</td>
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<tr>
<td></td>
<td>Give the supervisor(s) and Graduate Office 10 copies of the dissertation in a provisional version. The Dissertation will be evaluated by an Examination Committee who will decide if it can be defended as is or if it needs any change. In this last case it needs a second re-submission.</td>
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<tr>
<td></td>
<td>After the Final Examination correct the Dissertation following the recommendations of the Examination Committee and organize the document according to the defined rules for thesis organization.</td>
</tr>
<tr>
<td></td>
<td>Submit the signed, original copy of the dissertation to the Editorial Office of the Graduate School. Submit a copy to the Student Services Office.</td>
</tr>
</tbody>
</table>
10 Living in Porto

10.1 About Portugal

Portugal is located is the westernmost country of mainland Europe and is bordered by the Atlantic Ocean to the west and south and by Spain to the north and east. The Atlantic archipelagos of the Azores and Madeira are also part of Portugal. Lisboa is the capital and the largest city. The second largest city is Porto.

The climate in Portugal is warm, and the annual temperature averages in mainland Portugal are 13 °C in the north and 18 °C. Recent studies indicate Portugal to be the 7th most peaceful and the 13th most globalized country in the world, ranking 19th with respect to the highest quality of life.

Portugal has a relatively low cost of living, as compared to other EU Member States, although some products might be more expensive here than in other countries. For example, you may have a full meal between €5 to €11 per person in a snack bar, or between €13 and €20 in a restaurant. We can take a taxi from the airport to the city centre for about €20 or a Metro ticket from FEUP to the city centre can cost you around €1. As for culture an entrance ticket to a Museum, National Monument or exhibition may cost between €2 and €5. A cinema ticket costs around €5.00.

10.2 About Porto

For relevant information about "Studying at FEUP" or "Living in Porto" or similar issues go to the web page [http://paginas.fe.up.pt/~candidat/en/](http://paginas.fe.up.pt/~candidat/en/). Here we just summarize some of them.

The City of Porto has one of the richest artistic, cultural and historical heritages in Portugal, with several monuments and museums all over the city. This was officially recognised by UNESCO, which considered Porto (its historical part) as "World Heritage". It is to be stressed as well that Porto was chosen "European Capital of Culture 2001" in cooperation with Rotterdam. But Porto is also a city where its history can be found in a small street or in a dialogue with its inhabitants, so we invite you to explore it and start a new adventure here. Porto Wine is also world-famous and has left its mark on Porto.

There are several student residences. Please look at the following links to get more information:

- Accommodations: University of Porto
  [http://sigarra.up.pt/sasup_uk/WEB_BASE.GERA_PAGINA?P_pagina=2287](http://sigarra.up.pt/sasup_uk/WEB_BASE.GERA_PAGINA?P_pagina=2287)
- Residential Structures: [www.bonjoia.org](http://www.bonjoia.org)

10.3 How to arrive to Porto

BY PLANE

Porto is just 15/20 minutes away from Francisco Sá Carneiro - Porto International Airport, that has frequent flights to the main cities in Europe and America. For transportation to the city you can take the Metro (see the instructions below).

BY TRAIN

Porto is served by the "Porto - Campanhã" and "Porto - São Bento" train stations. To get to the hotel and the conference venue you must take a taxi or a bus. For updated information on timetables, lines and services: [http://www.cp.pt](http://www.cp.pt). If you aim to visit the capital city, the price of Porto/Lisbon one-way ticket in an Alfa Pendular Train costs about € 30.00.

BY METRO

After getting the ticket at the Aeroporto Station, take line E (Violet) and change to line B (Red) at Verdes station (see the lines of metro here) and take the Metro till Porto (direction South). For more information: [http://www.metrodoporto.pt/](http://www.metrodoporto.pt/).
10.4 Arriving at FEUP

FEUP is served by the line D of METRO. The closest Metro Stations is IPO in line D (yellow line). For more details follow the link http://www.metrodoporto.pt/.

10.5 Useful information

You may find additional useful information in the following documents:

- **EURAXESS – Researchers in Motion:**
  http://sigarra.up.pt/up_uk/web_base.gera_pagina?p_pagina=122322
  Within the scope of the Research Mobility Strategy of the European Research Area, the European Commission launched **EURAXESS**. EURAXESS aims to encourage and support international mobility of researchers, within and outside Europe. EURAXESS – Researchers in Motion is, therefore, a gateway to attractive research careers in Europe and to a pool of world-class research talents;


- Carnegie-Mellon Portugal Student Guide: