Curricular Unit Sheet

1. Curricular Unit Syllabus.

1.1. Curricular Unit

Electrical Machines Design

1.2. Scientific area acronym

EE

1.3. Duration

2nd semester

1.4. Total of Working Hours

4.5

1.5. Contact hours

4.5

1.6. ECTS

6

1.7. Observations

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2. Responsible Academic staff and lecturing load in the curricular unit (enter full name)

Ricardo Jorge Ferreira Luís	4.5h-7.5h

3. Other academic staff and lecturing load in the curricular unit

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4. Learning outcomes of the curricular unit

Objectives and Specific Abilities: - Calculation and design of electrical machines through the finite elements method using computational tools; - Make possible the magnetic field analysis in detail, allowing in this way a new approach to the electrical machines theory; - Supply to the students a set of problems to achieve the visual magnetic field behaviour. Knowledge delivered on the learning process in Electrical Machines Design: - Basics of Maxwell's equations; basic elements on the finite element method (FEM); - FEM modelling of some examples: transformer, DC machine, synchronous machine, induction machine and other electromagnetic devices; - Theory and application of finite element analysis, static and dynamic to electrical machines as electromagnetic and electromechanical systems;

- Use of computational tools such as FEMM and ANSYS.

5. Syllabus

- Techniques of computer-aided design (CAD / CAE) in Engineering. Production Systems; CIM Technology - Computer Integrated Manufacturing, CAD / CAM - Design and Computer Aided Manufacturing.

- Fundamental Equations. Maxwell's equations. Equations of Laplace, Poisson and Helmholtz. Thermal Fields.

- Fundamentals of Finite Element Methods (FEM). Problems with boundary conditions.

- Classical method of residues (Galerkin method). Classical variational method (Rayleigh-Ritz method).

- Brief introduction to the mathematical theory of finite elements. Discretization by finite elements conform. Examples of conforming finite elements. Approximation error. Reference to non-conforming finite elements. Evolution problems: discretization in time and space.

- Application of the FEM analysis to design of electrical machines: Transformers. Synchronous generators. Machines with permanent magnets and synchronous reluctance. Reluctance motors and three-phase induction.

6. Demonstration of the syllabus coherence with the curricular unit's objectives

In Electrical Machines Design the computer-aided design techniques applied to engineering are presented. It covers the aspects necessary for the project electromagnetic computer-assisted and is given an introduction to programs using the finite element method (FEM).

It is given an overview of the FEM, as well their formulation supported in Maxwell's equations. The main design steps through computational tools based on FEM are introduced: pre-processing, processing and post-processing.

These computational tools enable the detailed analysis of the magnetic field, allowing study and improve the electromechanical conversion and / or electromagnetic energy processes.

Through the FEM are studied some modelling of electromagnetic devices and several electrical machines. The finite element analysis allows a better view on critical design parameters on a virtual prototype developing.

7. Teaching methodologies (including evaluation)

The Design of Electrical Machines lectures comprises the branches: theory, theory-practical and laboratory training. Each component has a duration of 1.5 hours contact weekly.

In the theoretical classes (T) the contents of the UC are taught. In TP classes are presented and solved problems of practical cases in line with the contents taught in the theoretical component. In laboratory classes (PL) the skills acquired with the performance of practical laboratory work in groups are applied.
Students are organized in groups of 2 or 3 elements and develop a project of your choice / research within electric machines or other electromagnetic devices.

Evaluation elements:

- Project developed;
- Presentation and discussion of the project;
- Article about the project.

Final quantitative grade:

The final grade is obtained from the student performance evaluation during the execution of the project (70%), from the presentation and discussion about the project (15%) and from the evaluation of the scientific paper produced (15%).

The evaluation elements "Project developed" and "Presentation and discussion" are considered pedagogically necessary to obtain the final quantitative grade.

8. Demonstration of the coherence between the teaching methodologies and the learning outcomes

The teaching / learning methods in Electrical Machine Design are based mainly on the development of a project in electrical machines field, encouraging the students to a cooperative working.

The class is organized into working groups with 2 or 3 students. The specific project theme to develop is selected by working groups during the first two weeks of classes. In this choice the working groups perform a literature research based on scientific papers, books and works done previously.

Thus is developed a project idea and are defined the main goals and objectives.

The design work takes place mainly during the laboratory classes, where there is a continuous evaluation of all steps of project development.

Weekly, there are also theory lectures and theory-practical classes, where techniques and development tools design, based on the finite element method, are given.

The presentation of the project developed allows a sharing of knowledge between all groups of students to present the results of their work. The presentation of the work also allows an improvement in students' global competencies in communicating information, ideas, problems and solutions, to the audiences constituted by experts and non-experts.

The scientific paper about the project work allows a connection of the results obtained in the project developed with the syllabus discussed in the lectures.

9. Bibliography

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