Curricular Unit Form (FUC)

Course:	**FIRST CYCLE IN MECHANICAL ENGINEERING**						
Curricular Unit (UC)	**Vector Analysis and Differental Equations**					Mandatory	**X**
						Optional	
Scientific Area:	**Mathematics**						
Year: **1º**	Semester: **2º**	ECTS:**7,0**		Total Hours: **6,0**			
Contact Hours:	T: **45,0**	TP:**45,0**	PL:	S:	OT:	TT:	
Professor in charge		Academic Degree /Title		Position			
José Alberto de Sousa Rodrigues		**Doutor**		**Professor Adjunto**			

T- Theoretical ; TP – Theory and practice ; PL – Laboratory ; S – Seminar ; OT –Tutorial ; TT – Total of contact hours

Entry into Force	Semester: **Summer**	Academic Year: **2017/2018**

Objectives of the curricular unit and competences (max. 1000 characters)

Upon approval in this curricular unit, the student should be able to:

1. understand the basic concepts of limit, continuity and differentiability of scalar and vector fields;
2. solve problems in the context of Mathematics, Physics and Engineering involving the Chain Rule;
3. understand the calculus of multiple integrals, identifying the geometrical representation of the domain and the convenient coordinates to be used;
4. define parametric representations of lines and surfaces;
5. interpret and solve Engineering problems using properties and theorems relative to line and surface integrals;
6. use spacial reasoning and visualisation in the analysis and solution of real problems;
7. devise models for real situations using scalar and/or vector fields;
8. show a basic knowledge in the area of ordinary differential equations, including the solution of some differential equations of 1st order;
9. apply the properties of linear differential equations;
10. solve linear differential equations with constant coefficients;
11. choose autonomous and judicious learning strategies.

Syllabus (max. 1000 characters)

1. Introduction to scalar and vector fields.
   - 1.1. Notions of topology in IR^n.
   - 1.2. Definition of scalar and vector fields.
   - 1.3. Domains, level sets and graphics.
   - 1.4. Limit and continuity.
2. Differential Calculus in IR^n.
   - 2.1. Directional derivative. Partial derivatives of 1^{st}. order.
   - 2.2. Higher order partial derivatives. Schwarz's Theorem. C^k class functions.
   - 2.3. Differentiability of scalar fields. The concept of differential. Tangent plan.
   - 2.4. The derivative of a vector field as a linear mapping; differentiability, jacobian matrix.

- **2.5.** The Chain Rule.
- **3.** Integral Calculus in IR^n.
  - **3.1.** Double integrals.
    - **3.1.1.** Definition and properties.
    - **3.1.2.** Evaluation of double integrals. Fubini's Theorem.
    - **3.1.3.** Change of variables in double integrals; linear transforms and polar coordinates.
    - **3.1.4.** Aplications of double integrals.
  - **3.2.** Triple integrals.
    - **3.2.1.** Definition and properties.
    - **3.2.2.** Evaluation of triple integrals.
    - **3.2.3.** Change of variables in triple integrals; cylindrical and spherical coordinates.
    - **3.2.4.** Applications of triple integrals.
  - **3.3.** Line integrals.
    - **3.3.1.** The concept of trajectory. Parametric representation of a curve.
    - **3.3.2.** Arc length of a curve.Line integrals of scalar fields. Properties. Applications.
    - **3.3.3.** Line integrals of vector fields. Properties. The concept of work.
  - **3.4.** Surface integrals.
    - **3.4.1.** Surfaces. Parametric representation.
    - **3.4.2.** Surface integrals of scalar fields. Properties. Applications.
    - **3.4.3.** Surface integrals of vector fields. Properties. The concept of flux.
- **4.** Ordinary differential equations.
  - **4.1.** Generalities: the notion of differential equation, order, general solution, initial value problem. Existence and uniqueness of solution.
  - **4.2.** Solution of some 1st order equations: separable, homogeneous, exact and linear differential equations.
  - **4.3.** Applications.
  - **4.4.** Linear differential equations.
    - **4.4.1.** General properties. Solution by variation of parameters.
    - **4.4.2.** Linear equations with constant coefficients. Solution by undetermined coeficients.

Demonstration of the syllabus coherence with curricular unit's objectives (max. 1000 characters)

Objectives 1 and 2 are met by syllabus chapters 1 and 2.
The contents and practical examples of chapter 3 correspond to o objectives 3, 4 and 5.
The syllabus chapters 1 to 3, which may be included in the general area of Analysis in R^n, meet objectives 6 and 7 particularly well as a consequence of the emphasis placed on the examples in dimension up to n=3.
Syllabus chapter 4 acounts for objectives 8, 9 and 10.
Objective 11 is inherent to the mathematical context of the issues under study and the general orientation that has been set for the curricular unit.

Teaching methodologies (including evaluation) (max. 1000 characters)
The six hours of classes are equally divided between two theoretical and two practical sessions. The first are dedicated, through the teacher's initiative, to the presentation, discussion and exemplification of the issues scheduled for the respective week. The second are dedicated to the finishing of the resolution, by initiative of the student and with the assistance of the teacher, of a set of previously selected problems on the same issues. An additional set of exercises is proposed for consolidation of this work. Students may at this phase obtain further assistance during the complementary period of doubt clarification. All materials, contents and information above referred, as well as those concerning other issues relevant to the curricular unit, are electronically accessible to the students. There are two forms of evaluation: continuous (taking place during class period) and final (final exams). **Continuous evaluation:** The continuous evaluation comprises two partial tests. The student must obtain a minimum of ten values in the sum of the partial tests assessment to be approved. One of the partial test can be repeated on the day of the first final examination **Final evaluation:** The final exams – first, second and special dates - constitute this form of evaluation.

Demonstration of the teaching methodologies coherence with the curricular unit's objectives (max. 3000 characters)
The mathematical nature of this curricular unit requires a teaching approach including a time for formal correction, a time for intuitive interpretation and a time for getting acquainted with the issues under study and consolidating knowledge through practice and application. The separation of theoretical and practical classes aims to establish a weekly-based transition between these moments of the learning process. Emphasis is placed on the first two aspects during the theoretical classes taking place at the beginning of the week and on the third aspect during the following practical classes. This rhythmic process also implies the weekly transfer of the initiative from the teacher to the student in agreement with the curricular unit objective number 11. The scheduling of issues and corresponding sets of exercises is essential for this purpose, and allows the reinforcement of the student's habits of planning and finishing their work in an effective way.

Main Bibliography (max. 1000 characters)
1. R. Adams, *Calculus: a complete course*, Adison Wesley, 1999. 2. T. Apostol, *Cálculo*, Ed. Reverté, 1983. 3. Acilina Azenha e Maria Amélia Jerónimo, *Cálculo Diferencial e Integral em IR e* IR^n, McGraw-Hill, 1995. 4. W. E. Boyce e R. C. DiPrima, *Equações Diferenciais Elementares e Problemas de Valor de Contorno*, Livro Técnico e Científico, 1998. 5. M. Braun, *Differential Equations and their Applications*, Springer, 1979.