IPG Polytechnic of Guarda School of Technology and Management	**SUBJECT DESCRIPTION**	MODELO PED.013.01

Course	**Master in Civil Constructions**			*Academic year*		2021/2021	
Subject	**Applied Mathematics in Civil Engineering**			ECTS		5,0	
Type of course	**Compulsory**						
Year	**1st**	*Semester*	**2nd**	*Student Workload:*			
Professor(s)	**PhD Fernando Pires Valente**			*Total*	140	*Contact*	52,5
Area disciplinary Coordinator	**PhD Fernando Pires Valente**						

Planned

1. LEARNING OBJECTIVES

Provide students with knowledge and skills in the field of numerical methods and statistics that enable them to understanding matters of other subjects of the course and the application of that knowledge in professional life, in particular, understanding of basic concepts of theory of errors, resolution of non-linear equations, interpolation, solving systems of linear and nonlinear equations, solving problems of approximation and integration. Understand the approximate solution of ordinary differential equations and the application of finite difference method in its resolution and in solving differential equations with partial derivatives. Introduction to the finite element method. Provide students with knowledge of probability, random variables and their distributions and sampling theory, estimation and hypothesis testing.

2. PROGRAMME

Theory of errors

Absolute and relative errors. Approximation of functions. Condition number.

Non-linear Equations

Separation of roots. Estimation of approximation. Polynomial equations. Rules of Descartes, Lagrange and Budan. Methods of the bipartition, false position, secant, Newton and fixed point.

Polynomial interpolation

Lagrange and Newton formulas. Divided differences. Errors in Lagrange and Newton formulas. Inverse interpolation. Progressive and regressive differences. Interpolation with equidistant nodes. Newton formulas.

Systems of linear equations

Introduction. Direct methods. Triangular factorizations, LU, LDU, of Doolittle and Crout. Choice of pivot and condition number. Norms of vectors and matrices. Iterative method, Jacobi and Gauss-Seidel. Generic formulation. Convergence estimates. Semi-iterative methods, steepest descent and conjugate gradient. Convergence.

Systems of non-linear equations

Methods of successive approximations and Newton.

Approximation

Least squares approach of a set of points. Adjustment functions. Approximation of continuous functions. Legendre polynomial. Least squares approach by Legendre polynomial.

Numerical integration

Trapezoidal and Simpson rules. Errors. Composite rules. Gauss formulas.

Differential equations

Integration by Taylor series. Euler method, convergence. Runge-Kutta methods. Multiple step formulas. Adams-Bashfort and Adams-Moulton methods.

The finite difference method

Finite difference operators. Finite difference method for linear problems. Finite difference method for nonlinear problems. Numerical solution of differential equations with partial derivatives. Parabolic equations. Elliptic equations. Hyperbolic equations. Implementing algorithms. Introduction to the finite element method.

Probability theory

Introduction. Concept of probability. Random variables. Distributions. Discrete and continuous distributions. Normal distribution.

Statistical inference

Sampling theory. Estimation and hypothesis testing.

3. COHERENCE BETWEEN PROGRAMME AND OBJECTIVES

The syllabus of UC are the classic content from any biannual discipline of numerical analysis or numerical methods and statistics in an engineering course of higher education in Portugal or any developed country and allow you to achieve the goals set out in point 1.

4. MAIN BIBLIOGRAPHY

Fundamental:

1. Valente, F. P., **Análise Numérica**, Edição do IPG, 2015.

2. Valente, F. P., **Análise Numérica**, Tópicos e Problemas, Edição do IPG, 2018.

3. Pina, H. L. G., **Métodos Numéricos,** Escolar Editora, 2010.

4. Valente, F. P., **Probabilidades e Estatística**, resumo da teoria e exemplos de aplicação, Apontamentos para a UC, 2016.

5. Ames, W. F., **Numerical Methods for Partial Differential Equations**, Academic Press, 1992.

6. Valente, F. P., **O método das diferenças finitas para equações diferenciais às derivadas parciais**, Apontamentos para a UC, 2013.

7. Valente, F. P., **Sistemas de equações lineares**, Apontamentos para a UC, 2014.

8. Guimarães, R. C. e Cabral, J. A. S., **Estatística**, McGraw-Hill, 1997.

9. Murteira, J. F. B.; Ribeiro, C. S.; Silva, J. A. e Pimenta, C., **Introdução à Estatística**, McGraw-Hill, 2001.

Recommended:

10. Asaithambi, N. S., **Numerical Analysis,** Saunders College Publishing, 1995.

11. Atkinson, K. E., **An Introduction to Numerical Analysis,** John Wiley & Sons, 1989.

12. Hildedrand, F. B., **Introduction to Numerical Analysis,** Dover, 1974.

13. Ralston, A. e Rabinowitz, P. A., **A First Course in Numerical Analysis,** McGraw-Hill, 1978.

14. Fonseca, J., **Estatística Matemática**, vol.1 e 2, Ed. Sílabo, 2001

5. TEACHING METHODOLOGIES (INCLUDING EVALUATION)

Theoretical-practical training with practical resolution of application examples. Two tests during the semester with an average of 10 values and note at least 5 values in each one. Frequency or final exam. Programming work in FORTRAN of finite differences (optional).

6. COHERENCE BETWEEN TEACHING METHODOLOGIES AND OBJECTIVES

The teaching methodology used is mainly theoretical and practical with a short exposure of the essential theoretical concepts of subjects taught, followed by the resolution of practical problems where possible linked to an engineering course, using scientific calculator. It is intended so that the knowledge gained to consolidate so they turn to the professional life.

7. ATTENDANCE

There is no system of attendance, it is recommended that students attend all lessons.

8. CONTACTS AND OFFICE HOURS

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Signatures of Professor and area disciplinary Coordinator