COURSE SYLLABUS (2023-2024)

COMPUTATIONAL METHODS IN ENGINEERING

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OBJECTIVE:

This course aims to study the analysis and development of computational (or numerical) methods for solving problems in mechanical engineering, energy, and transportation.

SPECIFIC LEARNING OUTCOMES

Upon completion of this course, students will:

Gain a deep understanding of various mathematical models and computational techniques for problem-solving in engineering.

Be able to apply approximate methods to solve engineering problems using computer programs or designing their own codes.

RECOMMENDATIONS AND GUIDELINES

Prior knowledge of calculus, algebra, and differential equations is recommended for this course, as well as basic understanding of heat transfer, strength of materials, fluid mechanics, and electrical circuits, is recommended for this course.

Additionally, a suitable level of English proficiency and programming skills are required.

COURSE CONTENTS

1. Introduction to Matlab

Basic programming tips in Matlab

2. Initial-value problems in ordinary differential equations

Basic one-step numerical methods

Multistep numerical methods

Runge-Kutta methods

Implementation in Matlab

Matlab's ode suite

3. Nonlinear and linear equations

Root finding by iterative methods.

Fixed-point and Newton's methods

Direct methods for linear systems

Iterative methods for linear systems

Implementation in Matlab

Matlab's iterative methods

4. Boundary value problems in ordinary differential equations

Finite difference methods

Finite element methods

Shooting methods

Implementation in Matlab

5. Initial-boundary value problems for partial differential equations

Basic properties of partial differential equations

Methods of lines

Finite difference methods

Finite element methods

Finite volume methods

Implementation in Matalb

Matlab's PDE Toolbox

FORMATIVE ACTIVITIES

Face-to-Face Activities

Expository Activities: Lectures

Practical Activities in Specific Facilities: Computer Laboratory Practices

Non-Face-to-Face Activities

Practical Activities: Project Development and Evaluation

Self-Study: Personal Study

ASSESSMENT ACTIVITIES

Face-to-Face Assessment Activities

Student Assessment Activities

Final Examination

Completion of Assignments and/or Projects

ASSESSMENT METHODS

Students will have the option to choose between two types of assessment:

1. Continuous assessment, only available in the first examination period, based on laboratory practices, assignments, and projects, as well as the oral presentation of some of them, all conducted in English. To pass the course, it will be necessary to complete at least 80% of the proposed laboratory practices, assignments, and projects, which will account for 80% of the final grade. The remaining 20% will be based on the grade obtained in an examination held on the official examination day.

2. Final examination assessment in the official examination periods: The grade will be based on the performance in the final examination.

Part-time students and high-performance athletes will have the right to a flexible attendance regime that does not affect the evaluation process.

BASIC REFERENCES

David Kincaid and Ward Cheney, " Numerical Analysis: Mathematics of Scientific Computing," Brooks/Cole (1991)

Geoffrey D. Smith, "Numerical Solution of Partial Differential Equations: Finite-Difference Methods," Oxford University Press (1986)

John H. Mathews and Kurtis D. Fink, "Numerical Methods Using MATLAB", Prentice Hall (1998)

ADDITIONAL REFERENCES

Lloyd N. Trefethen and David Bau, III, "Numerical Linear Algebra", SIAM (1997)

William F. Ames, "Numerical Methods for Partial Differential Equations," Academic Press (1977)

William H. Press, Brian P. Flannery, Saul A. Teukolsky and William T. Vetterling, "Numerical Recipes: The Art of Scientific Computing," Cambridge University Press (1986)

Richard H. Pletcher, John C. Tannehill and Dale A. Anderson, "Computational Fluid Mechanics and Heat Transfer," CRC Press (2013).

STUDENT WORK DISTRIBUTION 150 hours

FACE-TO-FACE FORMATIVE ACTIVITY 45 hours

Lectures 30 hours

Laboratory Practices 15 hours

NON-FACE-TO-FACE FORMATIVE ACTIVITY 90 hours

Project Development and Evaluation 45 hours

Personal Study 45 hours

TOTAL HOURS OF ASSESSMENT ACTIVITY 15 hours

COMPETENCES / LEARNING OUTCOMES

General and Basic Competences

Basic Competences

1.1 Possess and understand knowledge that provides a foundation or opportunity to be original in the development and/or application of ideas, often in a research context.

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1.4 Enable students to communicate their conclusions and the underlying knowledge and reasoning to specialized and non-specialized audiences in a clear and unambiguous manner.

1.5 Equip students with learning skills that enable them to continue studying in a largely self-directed or autonomous manner.

General Competences

1.1 Ability to develop and integrate innovative and diverse technological solutions aimed at the design, development, or exploitation of intelligent systems in industrial environments, particularly in the field of energy and transportation.

1.2 Ability to conceive, write, organize, plan, develop, and implement innovative projects that integrate intelligent systems, leading their implementation and continuous improvement, and assessing their social and economic impact.

1.3 Ability to conceive, write, organize, plan, develop, and implement innovative projects that integrate intelligent systems, leading their implementation and continuous improvement, and assessing their social and economic impact.