Deusto
Deusto International Research School

Title of the course

• Numerical methods applied to mechanical and industrial engineering (BASIC)

Organizing center/area leading the course

Deusto International Research School (DIRS) – PhD program in Engineering for the Information Society and Sustainable Development

Training category

AF7. Methodology and research techniques

Professor/Coordinator of the training course

Coordinator: Borja Sanz

Professors: Giulio Bonifazi, Damian Knopoff, Sebastian Zamorano, Alejandro López, Imanol Sarría

Priority group

2nd year PhD students, but it can be taken by 1st and 3rd year students too

Competences

SPECIFIC COMPETENCE SC1: To understand and apply basic numerical methods for solving differential equations in engineering contexts.

SPECIFIC COMPETENCE SC2: To discretize and implement numerical methods such as finite differences, finite volumes, and finite elements for engineering problems.

SPECIFIC COMPETENCE SC3: To employ industrial simulation tools (OpenFOAM, ANSYS) for solving practical mechanical and industrial engineering cases.

SPECIFIC COMPETENCE SC4: To analyze, validate, and compare numerical and analytical results.

Pre-requisites / prior knowledge

Basic mathematics and introductory programming skills are recommended but not mandatory.

Contents

Unit 1. Fundamentals of Numerical Differentiation and Differential Equations

Numerical Differentiation & Integration. Stability and Accuracy. Introduction to ordinary and partial differential equations

Unit 2. Finite Difference Method

Grid discretization. Discretization of the 1D Poisson and heat equation. Numerical implementation

Unit 3. Numerical methods for 2D Partial Differential Equations

Weak formulation of PDEs. Finite element method. Numerical methods for linear systems. Overview of finite volume method.

Unit 4. Computational Fluid Dynamics with OpenFOAM

BlockMesh and SnappyHexMesh. Boundary condition types and implementation. Example case: Lid-driven cavity or backward-facing step. Running icoFoam/simpleFoam, post-processing with ParaView, turbulence models, residuals, convergence, mesh refinement, customizing solvers.

Unit 5. Basic Introduction to Finite Element Method with ANSYS Workbench

Weak formulation and Galerkin method. Overview of ANSYS Workbench GUI. Example problem: Cantilever beam, geometry, meshing, boundary conditions, steady-state heat transfer or modal vibration analysis. Familiarization with multiphysics setup in ANSYS. Comparison of numerical and analytical results.

Level of the course

Introductory

Methodology

Next, the methods and techniques used during the course are summarized and the research strategy is defined:

- Lecture. The lecturer presents the contents of the course in a detailed and organized manner, within the lecture room. The contents, available during the lectures, will be made available in advance to the students (as slides) and classified by units.
- Practical cases: exposition, analysis and sharing of practical cases
- Individual work. The students will carry out a set of guided practical activities associated to the course units and to the evaluation with users of their thesis.

Language of instruction

English

Mode of instruction

Presencial

Number of places

PhD students: 20
Personnel: 2

Assessment

Be able to apply the techniques demonstrated in the module to a given exercise proposed by each lecturer at the end of their module

Number of hours

20

Bilbao Campus

- Month when the course begins: April 2025

- Dates:

  Monday, December 1, 2025 (3:00 PM – 6:00 PM)

  Tuesday, December 2, 2025 (3:00 PM – 6:00 PM)

  Wednesday, December 3, 2025 (3:00 PM – 6:00 PM)

  Thursday, December 4, 2025 (3:00 PM – 6:30 PM)

  Wednesday, December 10, 2025 (3:00 PM – 6:00 PM)

  Thursday, December 11, 2025 (3:00 PM – 6:30 PM)

  Monday, December 15, 2025 (3:00 PM – 6:00 PM)

  Tuesday, December 16, 2025 (3:00 PM – 6:00 PM)