UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Escola Superior d'Enginyeries Industrial, Aeroespacial i Audiovisual de Terrassa

General description

Name of the course: **Computational Methods in Science and Engineering**

Department: **Fluid Mechanics**

ECTS: **6 ETS**

Degree: **MASTER'S DEGREE IN RESEARCH IN MECHANICAL ENGINEERING**

Level:

Language: **English**

Code: **295801**

Type: **Elective**

Lecturers

Main teacher: Lluis Jofre Cruanyes

Others: -

General learning objectives of the course

Learn to identify problems whose solutions require computational approaches, understand the mathematical concepts and ideas behind the methods utilized, implement the corresponding methods using well-established programming languages, conduct thorough error analysis of the algorithms, including accuracy and stability, and acquire expertise on the discrete solution and optimization of differential equations describing multiphysics problems in science and engineering.

Competences

Specific competencies	Acquisition of analysis and problem solving skills: computational modeling, algorithm design and development, distributed computing, contemporary programming tools, data-based approaches
Generic competencies	Collaboration, team building and management of computational-based projects: technology evaluation and selection, technical writing, cost/benefit analysis, project estimation techniques

Credits: total hours of student work

		Dedication	
		Hours	%
Directed learning	Large Group (G)	75	50%
	Medium Group (M)	0	0%
	Small Group (S)	30	20%
Autonomous learning		45	30%

Modules

Module 1: Fundamentals		Dedication: 35 hours	Large group: 17.5 hours Small group: 7 hours Autonomous learning: 10 hours
Description	Numerical interpolation, differentiation, integration, PDE classification		
Related activities (*)	Activity 1		

Module 2: Spatial Discretization		Dedication: 35 hours	Large group: 17.5 hours Small group: 7 hours Autonomous learning: 10 hours
Description	Discretization methods, the Riemann Problem, hyperbolic systems		
Related activities (*)	Activity 2		

Module 3: Time-Stepping		Dedication: 35 hours	Large group: 17.5 hours Small group: 7 hours Autonomous learning: 10 hours
Description	Explicit and implicit time schemes and solvers		
Related activities (*)	Activity 2		

Module 4: Initial & Boundary Conditions		Dedication: 10 hours	Large group: 5 hours Small group: 2 hours Autonomous learning: 5 hours
Description	Description of initial and (main) boundary conditions		
Related activities (*)	Activity 2		

Module 5: Parallel Computing		Dedication: 35 hours	Large group: 17.5 hours Small group: 7 hours Autonomous learning: 10 hours
Description	Computer memory architectures, parallel programming models and algorithms		
Related activities (*)	Activity 3		

Activities

Activity 1: Fundamentals		Dedication: 15 hours	
Description	Linear advection, Burgers equation, linear diffusion		

Activity 2: Computational Solver		Dedication: 15 hours	
Description	Development of a 1-D Navier-Stokes solver		

Activity 3: Parallelization		Dedication: 15 hours	
Description	Parallelization of the 1-D Navier-Stokes solver		

Grading system (assessment)

Activities	30%
Project	40%
Final Exam	30%

Teaching methodology

The teaching methodology is based on a combination of theoretical classes, hands-on exercises, deliverable activities, a course project, and a final exam.

References

Basic	[-] Fundamentals of Engineering Numerical Analysis (P. Moin, CUP) [-] Computational Fluid Dynamics – An Open Source Approach (Vermeire et al., Concordia University) [-] Introduction to High Performance Computing for Scientists and Engineers (Chapman & Hall, CRC Press)
Complementary	[-] Numerical Recipes in C++ (Press et al., CUP) [-] Fluid Mechanics (F. M. White, McGraw Hill) [-] Turbulent Flows (S. B. Pope, CUP) [-] Boundary-Layer Theory (H. Schlichting & K. Gersten, Springer) [-] Riemann Solvers and Numerical Methods for Fluid Dynamics (E. F. Toro, Springer)