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

General description

Name of the course: **Multiscale Engineering Fluid Mechanics**

Department: **Fluid Mechanics**

ECTS: **6 ETS**

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

Level:

Language: **English/Spanish**

Code: **295802**

Type: **Elective**

Lecturers

Main teacher: Attila Husar

Others: - Fernando García, Bernhard Semlistch, Lluis Jofre Cruanyes

General learning objectives of the course

The objectives of this course are through a combination of theoretical lectures, case studies and hands-on exercises, students will learn the principles of multiscale fluid dynamics which bridge multiple length and time scales and identify the influential phenomena that can be transposed into other scales. The students will construct multiscale simulation frameworks for analyzing hierarchical systems, and how to utilize them to design and optimize multiscale fluid phenomena in engineering applications such as microfluidics, nanotechnology, micro-electro-mechanical systems (MEMS), biological systems, hydrogen technologies among others

Competences

Specific competencies	Students are required to have a well-founded knowledge on multivariate calculus, linear algebra and differential equations, have taken the Computational Methods in Science and Engineering and Flow and Transport Phenomena courses, and ability to program in Python, Matlab, Fortran, C++, or other language.
Generic competencies	Collaboration, team building and management of computational and experimental-based projects: technology evaluation and selection, technical writing, cost/benefit analysis and project estimation techniques.

Credits: total hours of student work

		Dedication	
		Hours	%
Directed learning	Large Group (G)	82	54%
	Medium Group (M)	0	0%
	Small Group (S)	28	19%
Autonomous learning		40	27%

Modules

Module 1: Introduction Multiscale theory and modeling	Dedication: 10 hours	Large group: 5 hours Small group: 2 hours Autonomous learning: 5 hours
Description	Introduction: separation of time, spatial, and modeling scales, molecular to macroscopic driving forces, molecular dynamics to balance of plant integration;	
Related activities (*)		

Module 2: Transport Phenomena	Dedication: 40 hours	Large group: 23 hours Small group: 7 hours Autonomous learning: 10 hours
Description	Mass, heat and species transport: convection and diffusion, transfer analogies, radiative transfer.	
Related activities (*)	Activity 1	

Module 3: Multiscale simulation	Dedication: 40 hours	Large group: 22 hours Small group: 7 hours Autonomous learning: 10 hours
Description	Introduction to coarse-graining, dissipative particle dynamics, lifting and restriction. Turbulent flows: statistical description and scales of turbulence, mean-flow equations, free shear and wall flows.	
Related activities (*)	Activity 2	

Module 4: Transport in micro and nano-confined systems	Dedication: 40 hours	Large group: 22 hours Small group: 7 hours Autonomous learning: 10 hours
Description	General properties of micro and nanoscale flows. Hydrophobicity and wetting, slip conditions. Flow motion and its coupling with larger scales. Hydraulic circuits in microchannels. Electrokinetics phenomena. Dispersion and mixing	
Related activities (*)	Activity 3	

Module 5: Multiscale Fluid Mechanics case studies	Dedication: 20 hours	Large group: 10 hours Small group: 5 hours Autonomous learning: 5 hours
Description	Open discussions on selected peer-reviewed journal papers.	
Related activities (*)	Activity 4	

Activities

Activity 1: Fundamentals	Dedication: 15 hours	
Description	Hands-on exercises on discrete solutions of advection-diffusion equations and programming	

Activity 2: Turbulent flows	Dedication: 15 hours	
Description	Exercises on discrete solutions of Navier-Stokes equations and simulation.	

Activity 3: Simulation of fluid flows in microfluidic devices	Dedication: 15 hours	
Description	Exercises and simulation of microfluidic devices	

Activity 4: Multiscale Fluid Mechanics case studies	Dedication: 15 hours	
Description	Analysis of multiscale fluid mechanics applications related to advanced energy, biomedical or manufacturing technology.	

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	[-] Principles of Multiscale Modeling (E. Weinan, CUP) [-] Transport Phenomena (Bird et al., Wiley) [-] Micro-and Nanoscale Fluid Mechanics (B. J. Kirby, CUP) [-] Turbulent Flows (S. Pope, CUP)
Complementary	[-] Fuel Cell. Fundamentals (R. O'Hayre, Wiley) [-] Transport Phenomena in Biological Systems (G.A. Truskey, Pearson) [-] Microfluidics for Biotechnology (J. Berthier,ARTECH) [-] Peer-reviewed journal papers.