INSTITUTO SUPERIOR DE ENGENHARIA DE LISBOA

ADEM
Área Departamental de Engenharia Mecânica

Sheet course ()

Course	MSc IN MECHANICAL ENGINEERING		
Unit	COMPUTATIONAL FLUID DYNAMICS	Mandatory	☐
		Optional	☒
Unit scientific area	Thermofluids and Energy	Category	B

Unit category: B - Basic; C - Core Engineering; E - Specialization; P - Complementary.

Year: 2nd	Semester: 1st		ECTS: 5			
Contact time	Total:	T:	TP: 45,0	PL:	S:	OT:

T - Lectures; TP - Theory and practice; PL - Lab Work; S - Seminar; OT - Tutorial Guidance.

Unit Director	**Title**	**Position**
Jorge Filipe O. Mendonça e Costa	Ph.D.	Associate Professor

Learning Objectives (knowledge, skills and competences to be developed by students)

(max. 1000 characters)

This unit aims at giving the studenst the necessary skills to: i) develop a numerical solution to simple flows using code developed by themselves; ii) use commercial software to analyses flows in an engineering working environment. Mostly students should be able to understand the physical and mathematical/numeric foundations that will originate the results, in order to carry a critical analysis towards the validation of the results. In order to do that, it is imperative that the students acquire knowledge about flow differential analysis, as well as mathematical classification of the particular equations for different types of lows, so that they can understand the equations' discretization schemes. Knowledge about meshing, boundary conditions and turbulence, is also mandatory to accomplish the aforementioned objectives.

Syllabus

(max. 1000 characters)

1 Introduction: Importance of CFD in engineering, advantages and drawbacks, industrial fields of application;
2 Governing Equations of Fluid Dynamics: derivation of the equations representing the conservation of mass, momentum and energy using both finite and infinitesimal, fixed and moving control volumes. Equivalency between the equations, physical meaning of the several terms in the equations.
3 Types of partial differential equations: hyperbolic, parabolic and eliptical, and the implications in the numerical scheme and boundary conditions;
4 Discretization: finite differences, types of finite differences, difference equations, explicit and implicit schemes,;
5 Grids: physical and computational domain, transformation of coordinates, structured and unstructured grids;
6 CFD techniques: Crank-Nicolson and MacCormack methods;
7 Turbulence models: introduction to turbulence, the two equation k-e model;
8 Practical applications

Demonstration of consistency of the syllabus with the objectives of the course

(max. 1000 characters)

Studenst only have background on Control Volume analysis, making the derivation of the general fluid dynamics governing equations in the differential form necessary (2 in the syllabus) as well as the classification of the equations obtained by simplification according to the type of flow (3 in the syllabus). To understand how numerical results in fluids are obtained, students are also introduced to the discretization of the equations and some numerical schemes, that are implemented in their own code, written in Matlab (4, 5 and 6 of the syllabus). To allow the use of commercial codes in real engineering situations (8 in the syllabus), turbulence models are also covered (7 in the syllabus), as the students have no mandatory background on turbulence, as this topic is covered on an optional course.

Teaching methodology (evaluation included)

(max. 1000 characters)

The regualr classes are intermixed with the resolution of exercises and projects in Matlab, to solve for simple cases. While the use of commercial software for more complex cases is only possible at the end of point 7 in the syllabus, these codes are used throughout the course for laminar flow and simple cases so that the students can get used to the software and develop a good sense on the relationship of the several terms in the differential equations, by analysing the velocity/pressure fields obtained numarically and comparing with known analytical/experimental results. The evalution has a formal component in the form of a written test evaluating points 2 to 7 of the syllabus, as well as a practical component in the form of several projects evaluating points 4 to 8 of the syllabus. Each component has a weight of 50% in the final grade.

Demonstration of consistency of teaching methods with the learning objectives of the course

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To give the students the ability to develop their own code as well as to use commecial software, it is imperative that they develop/use these codes extensively, and therefore this is done throughout the course. On the other hand, the abovementioned objective is only useful for engineering practice if the students also develop the ability to criticise the numerical results, and for this reason they must be familiar with the physical and mathematical foundation in which these codes are based upon, and they need to deal with several practical examples that will allow them, by comparing the numerical results with known analytical/experimental results, to develop this ability.

Main Bibliography

(max. 1000 characters)

Anderson, John D.
COMPUTATIONAL FLUID DYNAMICS: The Basics with Applications, 1st Edition
McGrawHill, 1995
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ISBN-13: 978-0070016859

Zikanov, Oleg
Essential Computational Fluid Dynamics, 1st Edition
Wiley, 2010
ISBN-10: 0470423293
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Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu
Computational Fluid Dynamics: A Practical Approach, 1st Edition
Butterworth-Heinemann, 2007
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