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205070 - High Performance Computing Projects for Aerospace Engineering

Coordinating unit: 205 - ESEIAAT - Terrassa School of Industrial, Aerospace and Audiovisual Engineering
Teaching unit: 758 - EPC - Department of Project and Construction Engineering
Academic year: 2018
Degree: MASTER'S DEGREE IN SPACE AND AERONAUTICAL ENGINEERING (Syllabus 2016). (Teaching unit Optional)
MASTER'S DEGREE IN AERONAUTICAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)
ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Manel Soria

Others: Ivette Rodríguez
Josep Maria Bergadà
Daniel Garcia-Almiñana
Silvia Rodríguez-Donaire

Prior skills

The student must have a basic undestanding of programming (in C or Fortran), fluid dynamics, Computational Fluid Dynamics (CFD), and project management.

Teaching methodology

After a short theoretical introduction, amost all the lessons are developed in a workshop like format, with students distributed in groups to work in a group project.

Learning objectives of the subject

-Understand what is a high performance computing project for aerospace applications
-Understand the basic aspects of high performance computing aerodynamics, sucha as turbulence models, mesh generation, post-processing
-Be able to planify a high performance computing project, from its initial proposal to its conclusion, managing correctly the computer time available, as well as the project schedule

Study load

Total learning time: 75h	Hours large group:	27h	36.00%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	0h	0.00%
	Self study:	48h	64.00%

Content

Introduction to turbulence modelling for aerodynamic applications	Learning time: 18h 45m Theory classes: 6h 45m Self study : 12h

Description:
The equations governing turbulent flows (the Navier-Stokes equations) are well known since 1820. However, the computational effort needed to solve them is huge and grows with Re^3 (Reynolds number to the power of three). Thus, to understand and predict turbulent flows typically found in aerospace applications, with very large Re numbers, turbulence modelling is needed. In this part of the course, the basic turbulence concepts will be reviewed and the main ideas behind LES and RANS models will be outlined.

Related activities:
Theory lessons

Specific objectives:
-Understand the main turbulence conceprts and the main ideas behind LES and RANS turbulent models

Fundamentals of Parallel Computing for CFD	Learning time: 18h 45m Theory classes: 6h 45m Self study : 12h

Description:
The key concepts of parallel computing for CFD will be outlined.

Related activities:
- Theory lessons.
- Workshops.

Specific objectives:
-Understand the different types of parallel computers
-Understand the main parallel programming models
-Understand the distributed memory programming model
-Understand the standard MPI
-Be able to program, compile and debug a small MPI program (in C or Fortran)

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Use of CFD software	Learning time: 18h 45m Theory classes: 6h 45m Self study : 12h

Description:
Using an open-source CFD code, the fundamentals of CFD will be described. The topics to be covered are: mesh generation, selection of a turbulence model, selection of an algorithm, parallel running of the code, post-processing of the results, obtention of mesh-independent results.

Related activities:
-Workshops

Specific objectives:
-Understand how to generate a mesh
-Be able to select a turbulence model, understanding the implications of the decision in terms of simulation cost and accuracy
-Be able to select the main parameters for a CFD solver: accuracy, algorithm, number of iterations etc
-Understand the concept of mesh independency

Supercomputing project management	Learning time: 18h 45m Theory classes: 6h 45m Self study : 12h

Description:
The steps involved in the management of a supercomputing project will be outlined. The main aspects to be discussed will be: estimation of resources needed, proposal submission, project milestones, dealing with uncertainty in computing cost.

Related activities:
-Workshops

Specific objectives:
-Understand the main aspects associated with the management of a supercomputing project

Qualification system

- Individual exercises: 30%
- Final group project: 70%

Bibliography

Basic:

Anderson, John David. Computational fluid dynamics. New York [etc.]: McGraw-Hill, cop. 1995. ISBN 9780070016859.

Grama, Ananth. Introduction to parallel computing. 2nd ed. Harlow, England: Pearson Education, 2003. ISBN 9780201648652.

Pope, S. B. Turbulent flows. Repr. with corr. Cambridge [etc.]: Cambridge University Press, 2000. ISBN 9780521591256.