Advanced Computation in Fluid Mechanics
Project 2010

Project

The purpose of the course projects is for the students to use analysis, computation and available literature to study a fundamental (open) research problem in computational fluid dynamics. The course project consists of the following parts:

- 3 seminars: 1 presentation and 2 discussions,
- 1 set of computer problems
- 1 project report by each group (10 pages: as pdf-file)
- 1 peer review report by each group (1 page: as pdf-file)
- 1 final presentation
- 1 opponent at final presentation

The projects are done in groups (2-4 students), in one of the following themes:

1. Turbulence, computability and adaptive finite element methods
2. Turbulent flow separation and d'Alembert's paradox
3. Flight aerodynamics

Seminars

3 seminars are given focused on each of the three themes 1-3. At the seminar of the group theme; the group is expected to prepare a presentation of the literature for that seminar, where all students in the group are responsible for different parts of the presentation. The other groups are expected to ask questions and have a discussion on the topic.

Computer problems

Each group should use the computational software to address a set of basic problems connected to the group theme, and for the highest grades the group is also expected to study additional problems connected to the theme using computation. The basic problems for each theme are:

Theme 1: Turbulence, computability and adaptive FEM

1. Compute c_D for the cube at $Re = 10^4$ using adaptive mesh refinement: is the value for c_D converging as you refine the mesh? If so, after how many mesh refinements?

2. Is the value for the velocity in a point in the turbulent wake converging as you refine the mesh?

3. Is the time series for c_D converging in all points? Is the mean value of c_D over a time interval converging?

Theme 2: Turbulent flow separation and d'Alembert's paradox

1. Consider a circular cylinder with diameter $D = 1$ and length $4D$: compute c_D for $Re = 10^4, 10^6$ using adaptive mesh refinement with no slip boundary conditions.

2. Compute c_D with skin friction boundary conditions on the cylinder and $\nu = 0$, how does c_D and the flow change for different friction parameters $\beta = 0.1, 10^{-2}, 10^{-3}, 0$

3. For $\beta = 0$: initialize the flow with the potential solution; what happens?

Theme 3: Flight aerodynamics

1. Consider a section of a NACA 0012 airfoil with $\nu = 0$ and slip boundary conditions ($\beta = 0$): compute lift and drag coefficents for different angles of attack $\alpha = 2°, 8°, 14°, 18°$.

2. Compute the circulation of the flow for each α.

3. Change to no slip boundary conditions for $\alpha = 14°$: how does this change the flow?

Final report

The project report should be 10 pages, including a cover page and reference list, and should give a presentation of the group work on their theme; discussing the background of the problem, the computations (basic problems, together with other problems defined by the group), the literature and discussions from the seminars, and a summary and conclusion by the group.

Peer review report

The groups should prepare a short (1 page) peer review report of the report of another group.

Final presentations

For the final presentation, the group should prepare a 20 min presentation where all the members of the group are active. A computer projector will be available at the presentations. The groups should also prepare to act as opponents at the final presentation of another group for the discussion after the presentations (10 min).