Turbulence (Prof. V. Armenio, University of Trieste - frontal lessons, 15 h; laboratory classes, 10 h)

Theory

- Introduction to turbulence
- Statistical description of turbulence
- Turbulent scales and Energy cascade
- Neutral and stratified flows: mean momentum and Reynolds Stresses transport equations
- Free-shear flows
- Wall bounded flows
- Numerical modeling of turbulent flows (DNS, LES, RANS)
- Analysis of complex turbulent flows

Laboratory activity

Post processing and analysis of a turbulent field developing in a turbulent plane channel flow. The data were generated through direct numerical simulation of the flow developing between two plane, infinite, walls.

Minimum skills and equipment

Students are required to be familiar with MATLAB or Fortran. Students are required to bring their own laptop for the laboratory activity equipped with MATLAB or Fortran.

Final exam

The exam is based on the analysis of a report prepared by the student by the end of the course with a discussion and a critical analysis on the turbulent field post-processed during the laboratory activity.

Suggested books

Tennekes H., Lumley J.L. An introduction to Turbulence, The MIT Press, XVII Edition, 1999.

Pope S. B., Turbulent flows, Cambridge University Press, 2000

Perturbation methods (Proff. P. Blondeaux, G. Besio, University of Genoa - frontal lessons, 10 h)

Perturbation methods underlie numerous applications of physical applied mathematics: including boundary layers in viscous flow, celestial mechanics, optics, shock waves, reaction-diffusion equations, and nonlinear oscillations. These methods are commonly used to solve problems characterized by the presence of very small or very large parameters. The aim of the course is to give a clear and systematic account of perturbation methods and to show their applications to differential equations. The practical methods handled in the course are those of Multiple Scales and of Matched Asympotic Expansion. Some simple practical problem are showed in order to have an insight into the details of the application of the methods. The final exam consists in the solution of two problems, one on the Multiple Scale and one on the Matched Asymptotic Expansion.

Hydrodynamic stability (Prof. Jan Pralits, University of Genoa - frontal lessons, 10 h)

The course is a short introduction to hydrodynamic stability theory, mainly focusing on modal analysis, and covers the basic concepts regarding temporal stability of parallel shear flows in the context of incompressible flows. Moreover, numerical exercises will be given in order for the students to apply and test the presented theory. The theoretical part can be outlined as follows :

- Introduction of linear stability theory in the in the context of receptivity and transition from laminar to turbulent flow
- A brief outline regarding the history of hydrodynamic stability analysis
- Basic definitions of stability
- Temporal inviscid stability theory
- Temporal viscous stability theory
- A brief introduction to nonmodal stability analysis
- Examples from different fields of fluid mechanics

References

- P.J. Schmid & D.S. Henningson, 2001, "Stability and Transition in Shear Flows", Springer - Applied Mathematical Sciences