



Environment fluid mechanics and hydraulics – Part I

Prof. Andrea Vacca

Credits: 3 CFU

Number of hours: 24 frontal hours

Data: 3 October-14 November 2025

Objectives:

The course will provide an introduction to the problem of the fluid dynamic transition and turbulence.

Course programme:

Different themes will be approached through a set of invited lectures that deal with:

- Transition: problem of the hydrodynamic stability.
- Transition: normal mode analysis.
- Transition: Squire theorem. Orr-Sommerfeld equation.
- Turbulence: Reynolds averaged equations (RANS).
- Turbulence: budgets of mean and turbulent kinetic energy.
- Turbulence: energy cascade process. Komogorov theory.
- Turbulence: RANS models with zero, one and two equations.

Assessment methods: Final interview

Contact for information:

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Lectures Program

N	Date	Schedule	Duration	Teacher	Topic
1	03/10/25	14:00 - 17:00	3 hours	A. Vacca	Course Introduction. Review of fluid mechanics: conservation equations of mass and momentum, both in differential and integral form
2	06/10/25	14:00 - 17:00	3 hours	Vacca	Flow between two parallel plates: laminar case. Velocity profile and resistance coefficient. Kinetic energy



					balance: differential and integral form. Physical interpretation of the various terms
3	10/10/25	14:00 - 17:00	3 hours	Vacca	Stability and transition to turbulence. Normal mode analysis: inviscid case. Three-dimensional and two-dimensional disturbances. Squire transformation and related theorem
4	13/10/25	14:00 - 17:00	3 hours	Vacca	Normal mode analysis: inviscid case. Rayleigh's criterion. Normal mode analysis: viscous case. Two- and three-dimensional disturbances. Squire transformation and related theorem. Two-dimensional stability curve: discussion
5	20/10/25	14:00 - 17:00	3 hours	Vacca	Orr–Sommerfeld equations. Turbulence: Reynolds decomposition and derivation of the RANS equations
6	27/10/25	14:00 - 17:00	3 hours	Vacca	Mean kinetic energy balance equation. Reynolds stress balance equation and turbulent kinetic energy
7	7/11/25	14:00 - 17:00	3 hours	Vacca	Elements of Kolmogorov's theory. Turbulent flow between two parallel plates. Discussion of turbulent shear stress. Velocity profile: viscous layer, inner layer, wake
8	14/11/25	14:00 - 17:00	3 hours	Vacca	RANS models: algebraic model and differential models with one equation (k) and two equations (k-epsilon). DNS and LES (overview)