Titolo del corso: **Incompressible fluid dynamics: modeling and numerics – Modulo 1**

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(membro esterno proponente, Fabiana Zama)

Settori disciplinare del corso: IIND-01/F Fluid Dynamics --MATH-05

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Ore frontali di lezione: 20

Periodo di lezione: Novembre-Dicembre 2026

Tipologia di corso: Base

Modalità di verifica dell’apprendimento: discussione di un argomento di approfondimento assegnato dal docente.

Abstract del modulo:

Fluids behaviour is of paramount importance in a very wide variety of systems, both natural or man-made. For example, in climate change studies it is necessary to predict and understand the general motion of both the air and the ocean. In medicine, it is important to know how blood flows in the arteries and the heart.

The equation of motion, the Navier-Stokes equations, have been known for about a hundred and fifty years and yet many questions about they solution remain open. This is despite the fact that, using a suitably compact notation, the equations are so short that they can each be written down in two lines.

This course module will introduce students to the equations that govern the motion of fluids. We will extract a few simple solutions of these equations and discuss how they can be interpreted. Various fundamental notions are instrumental for this aim: particle paths; rates of change following the fluid flow (so-called material derivatives); mass and momentum conservation equations; and vorticity, which leads to an important distinction between two possible types of flow. The course can further develop the students’ mathematical modelling skills and real-life problem solving.

Programma del modulo:

Particle paths. Rate of change following the fluid. Mass conservation and incompressibility. Pressure forces. (3h)

No-slip conditions. Definition of the stress tensor. Symmetry of the stress tensor. Derivation of the Navier-Stokes equations. (3h)

Vorticity: rotational and irrotational flow. Bernoulli theorems. Vorticity evolution equations. (3h)

Non-dimensionalisation, Reynold's number and its interpretation, dynamic similarity. Simple potential flows. Simple viscous flows. (3h)

Exact solutions: Flow in channels. Approximate solutions: Boundary layer theory. (3h)