

# Free and controlled particles in viscous incompressible flows

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*Lecture 1:*

## **Rigid bodies immersed in a viscous incompressible fluid: basic modelling and analysis issues**

We begin by introducing the PDE systems modelling the motion of rigid bodies in a viscous fluid. We next describe the main difficulties encountered in the mathematical analysis of these problems and we recall the main existence and uniqueness of solutions results. Detailed proofs are given for a toy model.

*Lecture 2:*

## **A scratch course in control theory**

In this second lecture we introduce the basic notions on control theory which will be necessary in the remaining part of these lectures. We consider both finite and infinite dimensional control systems and we recall some basic tools such as Chow's theorem for affine finite dimensional systems or duality of controllability and observability concepts.

*Lecture 3:*

## **Controlling the motion of solids immersed in a viscous incompressible fluid**

In this second lecture we formulate two control problems for solids moving in a viscous incompressible fluid. In the first one, the aim consists in steering the bodies to prescribed positions by means of exterior forces acting on them. We show, in particular, that in the presence of control forces we can obtain existence and uniqueness results which are "better" than in the uncontrolled case. The second control mechanism consists in appropriate deformation of the solids: this is the swimming problem.

*Lecture 4:*

## **Swimming at low Reynolds numbers**

The last lecture is devoted to the second control problem stated above, in the particular case in which the viscosity forces are dominant. This type of question occurs when modelling the motion of aquatic microorganisms. Swimming in this regime is a challenging control problem, for which we describe important progress has been obtained during the last decade.