# Computation Methods in Fluid Mechanics (M16)

***Non-Examinable (Graduate Level)***

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*The aim of this Graduate course is to provide an overview of some of the computational methods used to solve the partial differential equations that arise in fluid dynamics and related fields. The idea is to provide a feel for the computational methods rather than study them in depth.*

The course will start with a four-lecture introduction to the numerical solution of the Navier-Stokes equations at moderate Reynolds number; the issues and difficulties will be highlighted.

Next some general issues will be covered in greater detail.

- Discretisations: finite difference, finite element and spectral.
- Time-stepping: explicit, implicit, multi-step, splitting, symplectic.
- Solution of Linear Systems: packages, LU and QR decompositions, sparse matrices, conjugate gradients, eigenproblems.

The remaining lectures will focus on specific issues selected from the following.

- Demonstration of the software package FreeFem++.
- Methods for hyperbolic equations.
- Representation of surfaces.
- Boundary Integral/Element Method.
- Fast Poisson Solvers: Multigrid, Fast Fourier, Domain Decomposition.
- Fast Multipole Method.
- Nonlinear considerations.
- Particle Methods.
- Wavelets.

### Pre-requisites

Attendance at an introductory course in Numerical Analysis that has covered (at an elementary level) the solution of ordinary differential equations and linear systems will be assumed. Some familiarity with the Navier-Stokes equations and basic fluid phenomena will be helpful (as covered by a first course in Fluid Dynamics).

### Literature

1. E.J.Hinch *Think Before You Compute: a Prelude to Computational Fluid Dynamics* CUP 2020

### Additional support

MatLab code will be provided for the first four lectures.