ETH zürich

Distinguished Lecture Series

of the Department of Mechanical and Process Engineering

Surprises in Fluid Motions: From Microbiology to Engineering
Prof. Howard A. Stone, Princeton University
Donald R. Dixon ‘69 and Elizabeth W. Dixon Professor of Mechanical and Aerospace Engineering.
Chair, Department of Mechanical and Aerospace Engineering
2 November 2015 from 5:15 p.m. in HG F 30

Topology Optimization: State of the Art and Future Perspectives
Prof. Ole Sigmund, Danmarks Tekniske Universitet
Topology Optimization research group at DTU Mechanical Engineering & DTU Mathematics
30 November 2015 from 5:15 p.m. in ML E 12

Cut-Cell Method Based Analysis of Freely Moving Particles in Viscous Flows
Prof. Wolfgang Schröder, RWTH Aachen University
Institute of Aerodynamics
7 March 2016 from 5:15 p.m. in HG F 30

Sculpting water
Prof. David Quéré, ESPCI and École polytechnique Paris
21 March 2016 from 5:15 p.m. in HG F 30

An aperitif will be offered after the lectures.

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The subject of fluid mechanics is relevant to an enormous variety of phenomena. The designs of airplanes, sailing vessels, birds, and fish are determined by principles of fluid mechanics as is our physiology. Most industrial processing requires handling materials in the fluid state. To understand life on Earth we need to understand the fluid movements of the atmosphere, circulation in the oceans, and ice sheets in the Arctic.

The subject is also one with continual surprises. We will illustrate some of these themes by (i) highlighting the effect of fluid motion on biofilms, (ii) new observations on the impact of flow on the motility of bacteria on surfaces, and (iii) flow in an ordinary T-junction, which is a common element in piping systems. In this way we will gain exposure to a world of ideas relevant to industry, physiology, and environmental health.

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Topology optimization is a numerical tool for finding optimal material distributions for mechanical structures, fluids, nano-optics and many other engineering disciplines. The method consists in repeated FE simulations, adjoint sensitivity analyses and gradient-based design updates. Using element-based design variables, the approach has huge design freedom and is by now extensively being used in industry to save weight and/or improve dynamical response.

The talk presents the SOTA of density-based topology optimization methods and recent developments in large scale and multiphysics applications. Efficient codes have been developed for handheld devices (see TopOpt Apps at Appstore or Google Play) for education and demonstration, whereas research codes developed by the TopOpt-group now handle problems with +100M design variables and +250M degrees of freedom.

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Cut-Cell Method Based Analysis of Freely Moving Particles in Viscous Flows

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7 March 2016 from 5:15 p.m. in HG F 30 (aperitif after the lecture)

A Cartesian cut-cell method for viscous flows interacting with freely moving boundaries will be presented. The method provides a sharp resolution of the embedded boundaries and strictly conserves mass, momentum, and energy. A new explicit Runge-Kutta scheme is introduced which significantly reduces the computational time for tracking moving boundaries and subsequently reinitializing the solver without lowering stability or accuracy.

The structural motion is computed by an implicit scheme with high stability due to an iterative strong-coupling strategy. A new formulation for the treatment of small cut cells is presented with high accuracy and robustness for arbitrary geometries based on a weighted Taylor-series approach solved via singular-value decomposition. Unphysical oscillations occurring in Cartesian grid methods applied to moving-boundary problems are eliminated.

The efficiency and the accuracy of the new method are demonstrated for several three-dimensional cases of laminar and turbulent particulate flow such as a spherical particle settling in a quiescent fluid, rotation of an ellipsoidal particle in simple shear flow, and a cloud of particles in homogeneous turbulence.

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Sculpting water

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Water, and more generally liquids, are shapeless. However, the conjunction of surface tension with external actions (such as shocks, centrifugations, etc.) allows us to sculpt water, and thus to achieve specific functions. We discuss in particular how water-repellent materials can be used for such purposes, and which functions can be generated from these „sculptures“. We illustrate this discussion by showing various spectacular applications found in the natural world.

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