Course Package

Fluid Physics – Q2

Name module	Fluid Physics - Q2
Educational programme	MSc Applied Physics
Period	First semester (Quartile 2)
Study load	15 ECTS

Fluid Physics			
Quartile 1	**Quartile 2**	**Quartile 3**	**Quartile 4**
	Physics of Bubbles **193572010** (2,5 EC) **Ion Transport in Fluids** **201800327** (2,5 EC)		
	Granular Matter **201400194** (5 EC)		
	Turbulence **193580010** (5 EC)		

Suitable for: 3rd year student (or completed) the Bachelor of Applied Physics / Mechanical Engineering.

Required preliminary knowledge: Fluid Mechanics (or Physics of Fluids or Transport Phenomena); Calculus; Advanced Colloids and Interfaces (for Ion Transport in Fluids).

193572010 - **Physics of Bubbles**

The Physics of Bubbles course treats the physics of single bubble and describes the behavior of multiple bubbles and bubble clouds. The course treats the forces on bubbles, the acoustics of bubbles and bubble clouds, microstreaming and jets due to bubble oscillation, cavitation and bubble collapse. The course includes lectures on the use of bubbles in medical imaging and in molecular imaging with ultrasound. Also therapeutic applications of bubbles are discussed, along with bubbles in process technology and bubble formation and bubble dynamics in microfluidic devices and nanotechnology.

201800327 - Ion Transport in Fluids

Starting from the electrochemical potential, the Nernst-Planck equation will be derived and then used to understand the relative contribution of electromigration and diffusion. The validity of assuming electroneutrality in a fluid phase is discussed and investigated by introduction of the Poisson equation. In double layers and interfaces, the potential and ion distributions can be studied further. Next, the effect of fluid transport on ion transport and vice-versa will be introduced by combining the Poisson-Nernst-Planck equations with the Navier-Stokes equations. From this, electrokinetic mechanisms such as electro-osmosis can be derived. Finally, the use of these frameworks in relevant industrial processess where ion transport plays a crucial role is explored.

201400194 - Granular Matter

Granular Matter comprises all materials that consist of many particulate entities, each of which large enough not to be subject to thermal motion at room temperature. This somewhat technical definition comprises everyday materials such as sand, flour, gravel, snow, iron ore, and metal scrap. It is ubiquitous in nature, since mountains, soil and the bottom of the sea are predominantly granular. In industry, the most processed materials (with the exception of water) are in granular form, and problems with their handling are causing a staggering loss of 5% of the world energy budget (which corresponds to over 300 billion euros every year). In contrast to its obvious relevance the behaviour of granular materials remains poorly understood. Granular matter can be studied from a fundamental and an engineering perspective, commonly denoted as Granular physics and Particle Technology, respectively.
Because of the strong connection between the two subjects, this course aims at giving a basic introduction to both. Topics that will be covered are:

- particles, size analysis and characterization,
- contacts, inelasticity, restitution, and collision models,
- static granular materials, Rayleigh-Jansen law,
- Mohr-Coulomb and soil mechanics,
- dense flows and granular suspensions,
- granular gases and kinetic theory,
- micro/macro aspects and granular hydrodynamics,
- separation, mixing, and segregation,
- processing (granulation and fluidization),
- storage and transport,
- geophysical granular flows, chute flows.

193580010 - Turbulence

Below is an itemized list of the main topics that will be addressed during the course.

- Equations of fluid motion
  - Navier-Stokes equations
  - The role of pressure
  - Transformation properties of Navier-Stokes equations
- Statistical description of turbulent flows
  - Mean, standard deviation, skewness, kurtosis
  - Probability Density Function (PDF)
  - Energy spectrum
  - Structure functions
  - Statistical stationarity
- Mean flow equations
  - Reynolds Averaged Navier Stokes equations
  - Reynolds stresses
  - Closure problem in turbulence
- Free shear flows
  - Boundary layer equations
  - Self-similarity
- The scales of turbulent motion
  - The energy cascade and Kolmogorov hypothesis
  - Viscous subrange, Inertial subrange, Energy containing range

Please note: these packages are not fixed. They serve as an example of what you are able to select. It may be possible for you to make changes if you would like to do so.

The modules are tentative and subject to change. Please check [the website]() *regularly.*

    - Energy spectrum
    - Structure functions
    - Two-point correlations
    - Intermittency
- Wall flows
    - Channel flow, pipe flow, boundary layer flows
    - Mean velocity profile
    - Viscous sublayer, buffer layer, logarithmic layer
    - Inner and outer layer
    - Friction law
- Simulations of turbulent flows
    - We discuss the concepts, benefits, limitations of the most widely used simulation techniques of turbulent flows, i.e.
        - Reynolds Averaged Navier Stokes (RANS)
        - Large-eddy simulations (LES)
        - direct Numerical simulations (DNS)
- Discussion of special topics in turbulence
    - Theory of heat transfer in turbulent convection
    - Wind farm fluid dynamics

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