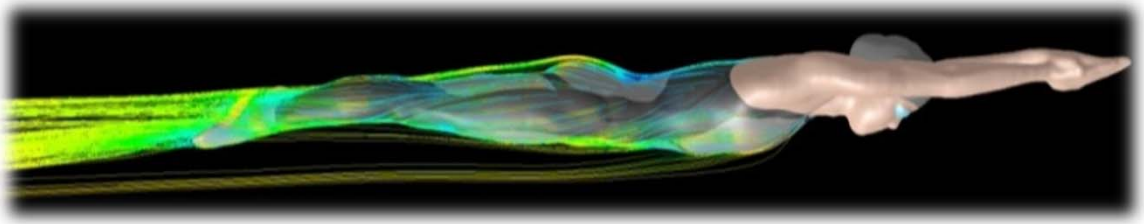
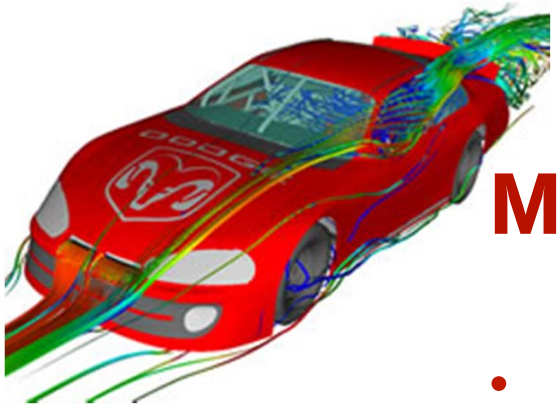
Modelling and approximation

What is CFD?

- Computational Fluid Dynamics
  - fluid flow
  - heat and mass transfer
  - chemical reactions, etc.
- Solving conservation equations for
  - mass
  - momentum
  - energy, etc.





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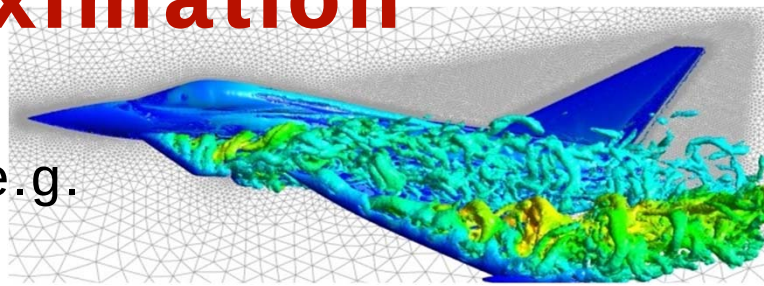
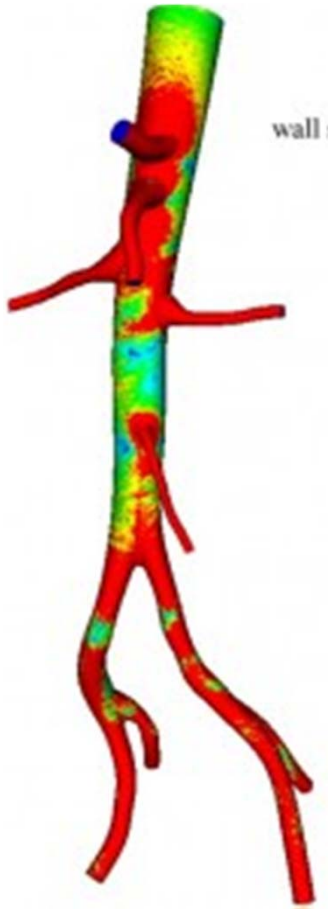
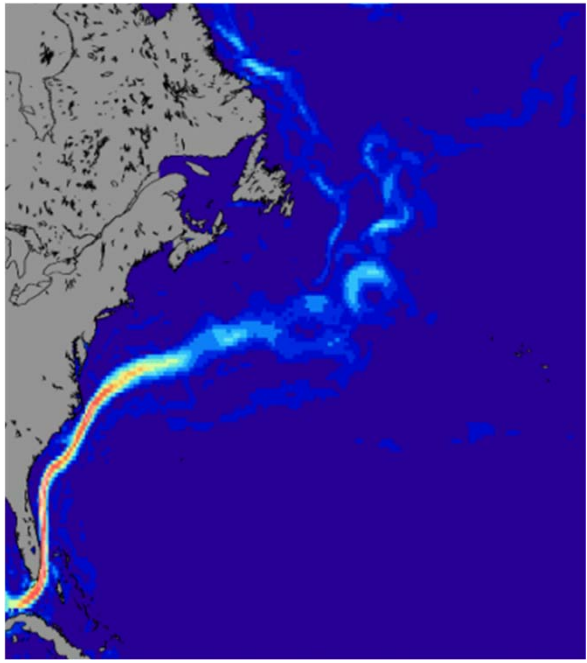
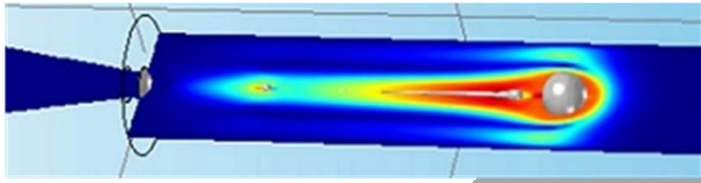


- Starting point: real-life problem, e.g.
  - flow around a car or airplane
  - flow in the Golf stream
  - blood flow in the cardiovascular system
  - propelling of droplets in inkjet printers
- CFD Setup
  - What is the aim
  - Modelling options
  - Accuracy needed and turn-around time
- CFD always a compromise between
  - Computational resources
  - Modelling level







Flow physics

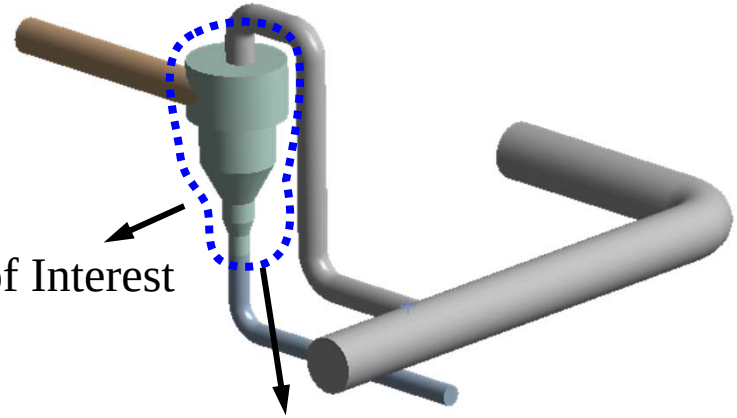
complex and unintuitive flow fields

- level of approximation
- turbulence (and transition to) modelling
- structure interaction
- real gas effects
- combustion
- non-newtonian fluid
- two-phase flows
- magneto hydro dynamical flows

boundary conditions

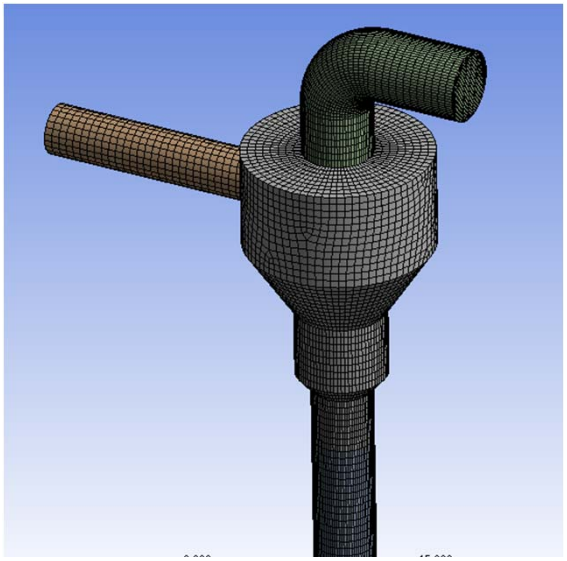
Defines the problem

- inflow, outflow
- far field
- wall
- Symmetries

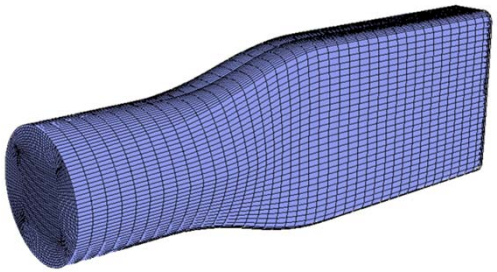


Defines the computational domain

- part of a larger system
- estimate/approximate boundary information
- simplifications, symmetry



Computational grid



Solution never better than the grid

- resolving gradients

  shocks, boundary layers, free shear layers, vortices, adaptation, ...

- scale separation

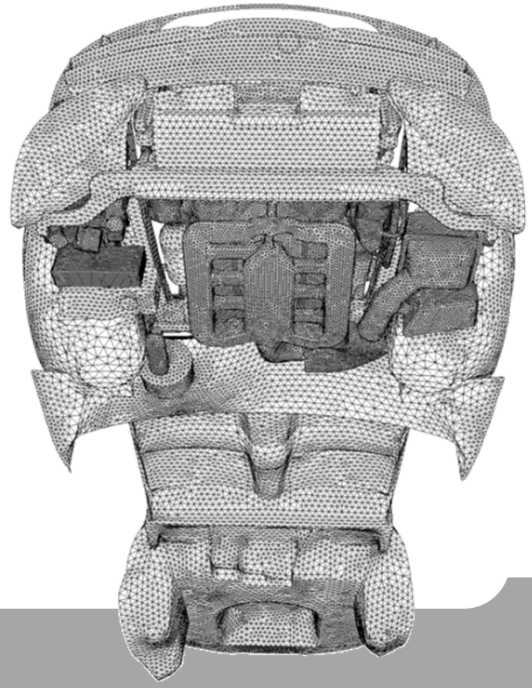
  global scales, viscous scales (turbulence), molecular scales (shocks), ...

- grid topology

  stretching, cell orientation and shape, structured/unstructured/hybrid grids

- geometry

  approximations of details



Numerical method

no universal method

- basic concept

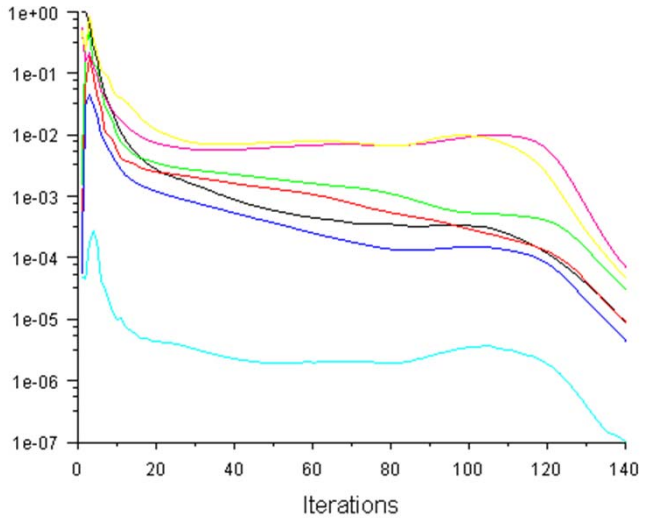
  FEM, FVM, FDM, ...

- solution methods

  pressure or density based, multi-grid, implicit, explicit, steady state, ...

- spatial schemes

  central, upwind, higher order, ...



Computational resources

Never enough

- Computational time
  - parallelization
  - number of grid points (~100.000 points - 1 CPUh)
- Memory use
  - number of grid points (100-1.000 byte / grid point)

Quality

Examine the results

- Compare with observations / experiments
- Consistency checks (grid convergence, dependencies, ...)

Consider to revise the setup

- Modelling
- Computational domain
- Meshing
- ...