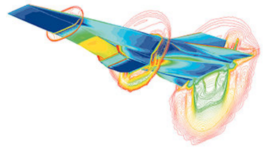
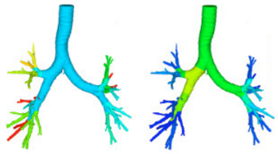
Hyper-X at Mach 7, NASA
image in the public domain

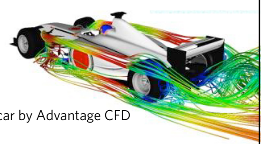


ME 702
Computational Fluid Dynamics, CFD

Prof. Lorena A. Barba



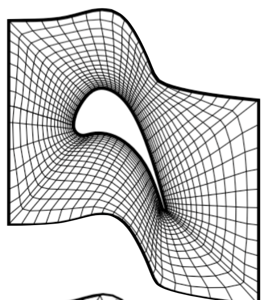
Human airways, by
FuiDA nv

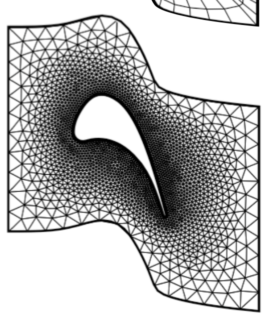


F1 car by Advantage CFD

BU

The Finite Volume Method





- The ***most widely used*** method in CFD. Why?
  - Very general, flexible
  - can handle ***any type of grid***
  - Essential advantage: *Conservative discretization*
- Uses the *Integral Formulation* of the conservation laws

The FVM **Conservative discretization**

- What is a conservation law?

1.1 GENERAL FORM OF A CONSERVATION LAW

As mentioned in the introduction, the conservation law is the fundamental concept behind the laws of fluid mechanics.

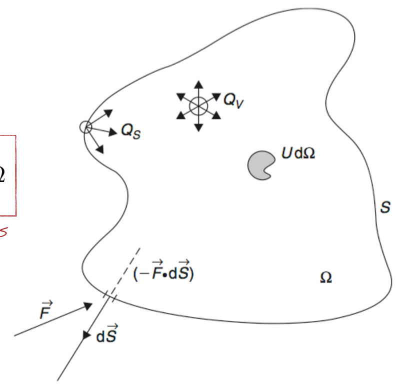
But what is a conservation law?
It is altogether very simple in its basic logic, but can become complicated by its internal content. Conservation means that the variation of a conserved (intensive) flow quantity within a given volume is due to the net effect of some internal sources and of the amount of that quantity which is crossing the boundary surface.

The FVM **Conservative discretization**

- What is a conservation law?

$$\frac{\partial}{\partial t}\int_\Omega U\,\mathrm{d}\Omega + \int_S \vec{F}\cdot \mathrm{d}\vec{S} = \int_\Omega Q\,\mathrm{d}\Omega$$

variation of U — surface fluxes — sources



The FVM **Discretization**

- Divide the domain into many (small) sub-domains Ω_j
- satisfy the conservation law ***in each sub-domain*** (finite volume)

$$\frac{\partial}{\partial t}\int_{\Omega_j} U\,\mathrm{d}\Omega + \int_{S_j} \vec{F}\cdot \mathrm{d}\vec{S} = \int_{\Omega_j} Q\,\mathrm{d}\Omega$$

↓

$$\frac{\partial}{\partial t}(\bar{U}_j\,\Omega_j) + \sum_{\text{faces}} \vec{F}\cdot\Delta\vec{S} = \bar{Q}_j\Omega_j$$

average — average

The FVM **Discretization**

- fluxes need to be consistent

$$\frac{\partial}{\partial t}(\bar{U}_j\,\Omega_j) + \sum_{\text{faces}} \vec{F}\cdot\Delta\vec{S} = \bar{Q}_j\Omega_j$$

Write the conservation law for each volume