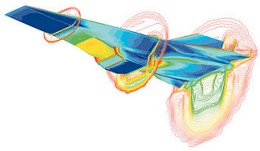
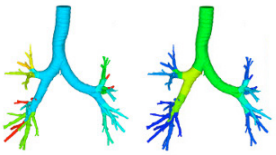
Hyper-X at Mach 7, NASA image in the public domain

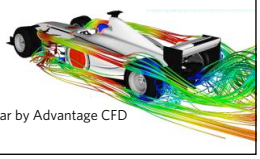


ME 702
Computational Fluid Dynamics, CFD

Prof. Lorena A. Barba



Human airways, by FuiDA nv



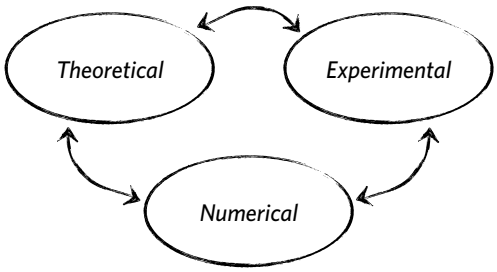
F1 car by Advantage CFD

BU

1

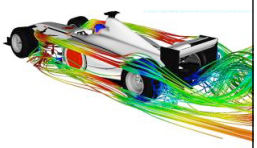
Understanding **Fluid Mechanics**

- Approaches:



2

Basic ingredients of CFD



3

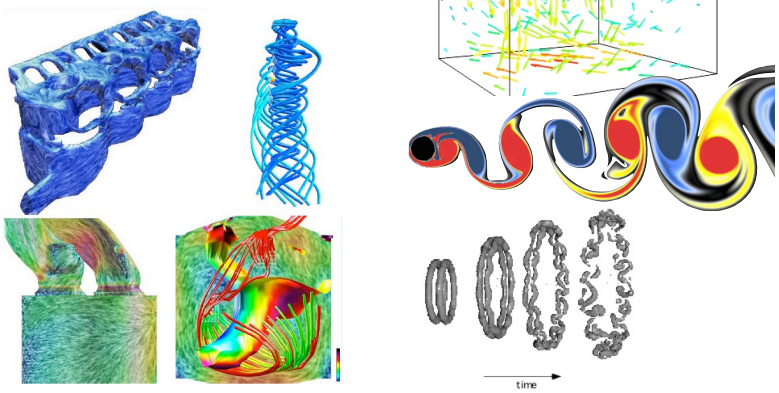
Model & discretize

- Choose Mathematical Model
- Choose discretization method
- Analyze the numerical scheme
- Solve & Visualize

4

Post-processing

- Fow visualization



5

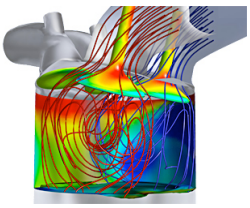
CFD research vs. engineering

- As a scientific discipline:

- CFD researchers work using *specially developed codes* to solve unique problems

- As an engineering tool:

- *commercial or open-source software*
  - ANSYS Fluent
  - ANSYS CFX
  - Star-CD
  - OpenFOAM



ANSYS Fluent

6

History of CFD

- Richardson, 1911
- Courant, Friedrichs, Lewy, 1928
- von Neumann, Richtmeyer, 1950
- Lax, 1954

IX. *The Approximate Arithmetical Solution by Finite Differences of Physical Problems involving Differential Equations, with an Application to the Stresses in a Masonry Dam.*

By L. F. Richardson, *King's College, Cambridge.*

Communicated by Dr. R. T. Glazebrook, *F.R.S.*

Received (in revised form) November 2, 1909,—Read January 13, 1910.

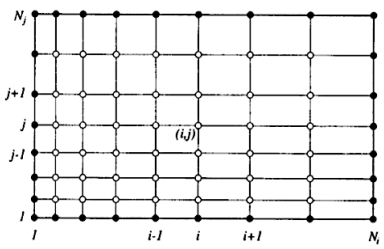
7

The finite difference method

8

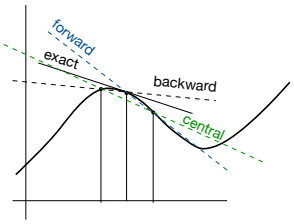
First step: **define numerical grid**

- Cartesian grid



9

- Recall the definition of a derivative: $\left(\frac{\partial u}{\partial x}\right)_{x_i} = \lim_{\Delta x \to 0} \frac{u(x_i + \Delta x) - u(x_i)}{\Delta x}$



10

Practical module:

"The 12 steps to computing Navier-Stokes"

11

① — 1D linear convection $\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$

12

① — 1D linear convection $\frac{\partial u}{\partial t} + c\frac{\partial u}{\partial x} = 0$

Pseudocode Step 1

```
nx = 20, nt = 50
dt = 0.01, c = 1
dx = 2/(nx-1)

for i = 1:nx
 if 0.5 <= x(i) <= 1
  u(i)= 2
 else
  u(i)= 1
 end
end

for it = 1:nt
 un=u
 for i = 2:nx-1
  u(i) = un(i)- c*dt/dx*...
       ( un(i)- un(i-1) )
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end
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Lecture 2 : 12

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