ANSYS CFD – SESSION1

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Agenda

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- Why meshing?
- Building blocks and terminology
- Mesh types
- Cell types
- Mesh quality
- Hands on: building CFD mesh for simulation of laminar flow in 2D U-bend channel

Why meshing?

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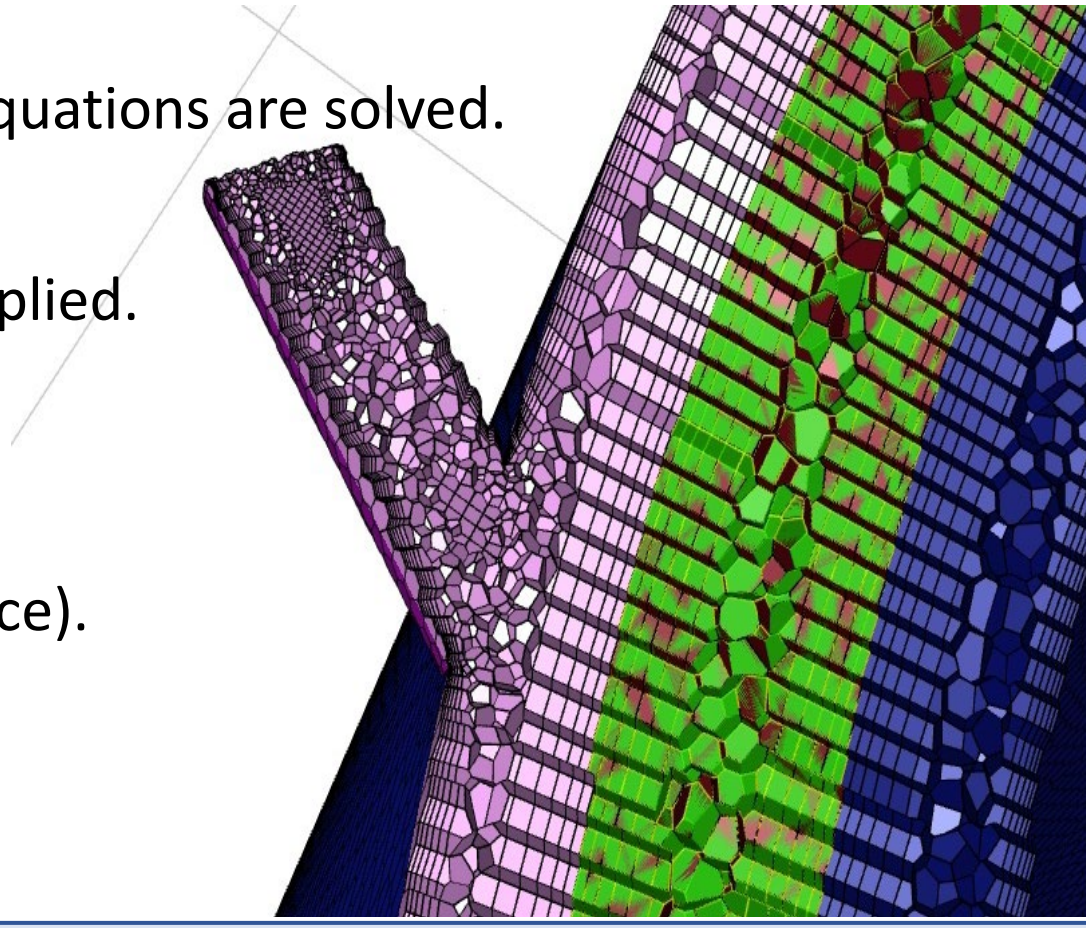
Why do we need mesh/grid?

- Designates the “elements” on which the flow equations are solved.
- Gives discrete representation of the geometry.
- Has entities (groups of cells) where b.c.’s are applied.



The mesh has impact on:

- Rate of convergence (or even lack of convergence).
- Solution accuracy.
- CPU time required.

Building blocks

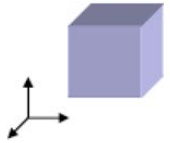
- Geometry is the starting point of any CFD study

  Geometry can be:

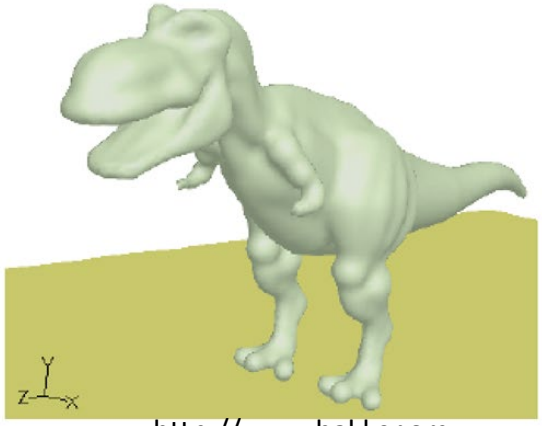
  - Basic or complex
  - Imported form CAD
  - Created using bottom-up/top-down/hybrid approach

  Is composed of:

  - Volumes
  - Surfaces
  - Curves
  - points



geometry for a "cube"



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Mesh types

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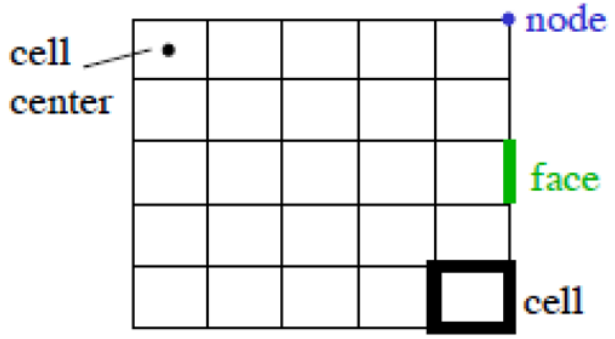
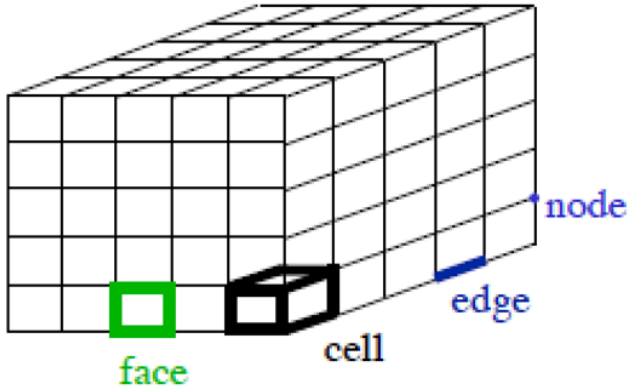


2D computational grid



3D computational grid

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Mesh terminology

- Cell – basic volume unit of the mesh
- Node – point when sides of different cells meet
- Cell center – center of the cell
- Edge – boundery of face
- Face – boundary of cell
- Zone – group of cells, faces, nodes
- Domain – group of zones

Cell types

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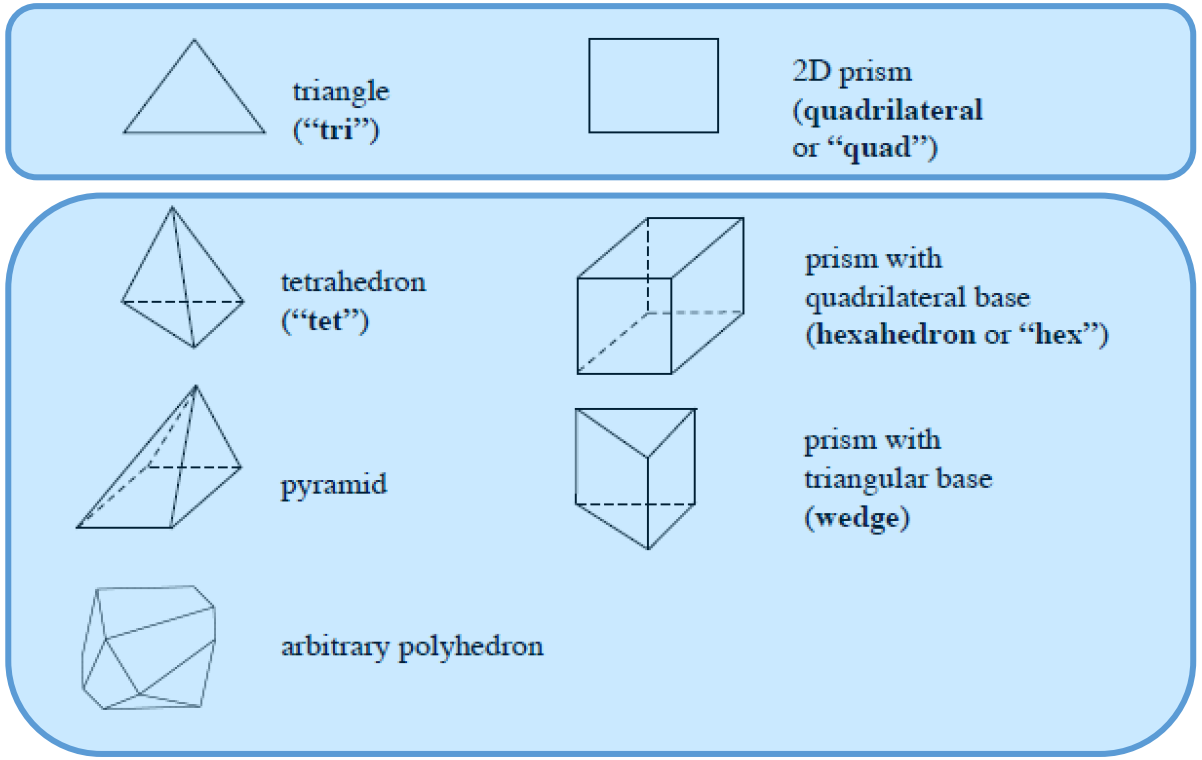
Cell types



Mesh types

- Structured
- Unstructured
- Hybrid

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Mesh types

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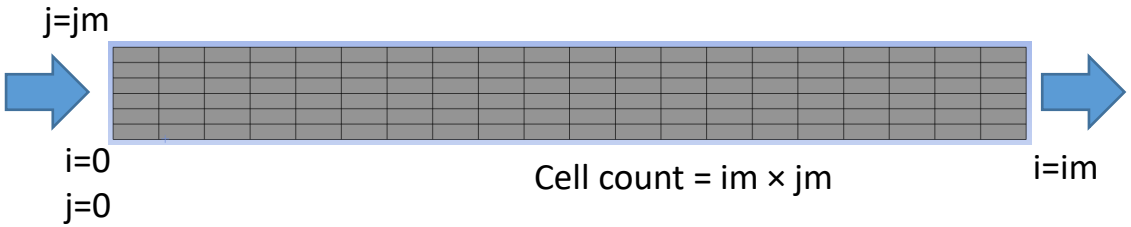
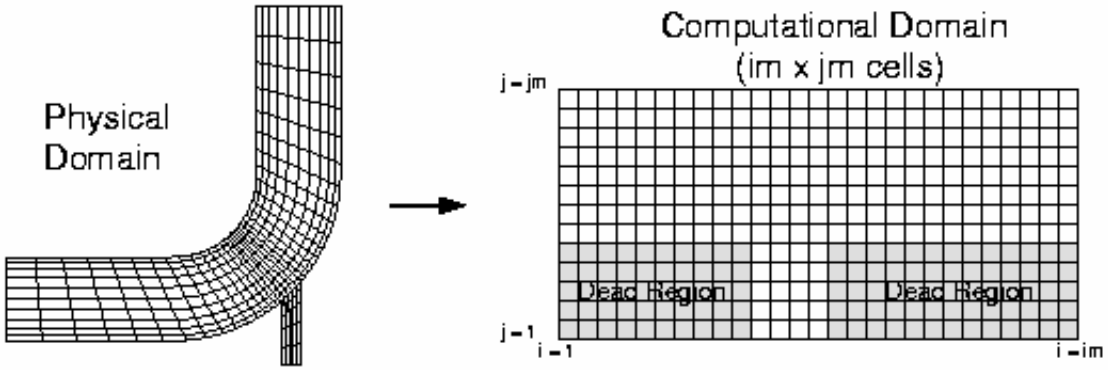
Structured mesh

- The cells distribution follows the flow topology
- The cells are indexed
- Blocking analogy is used
- Structured meshes are of high quality and very good cell count/volume ratio
- Harder to do (compared to unstructured)
- Limited use for highly complex geometry





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Mesh types

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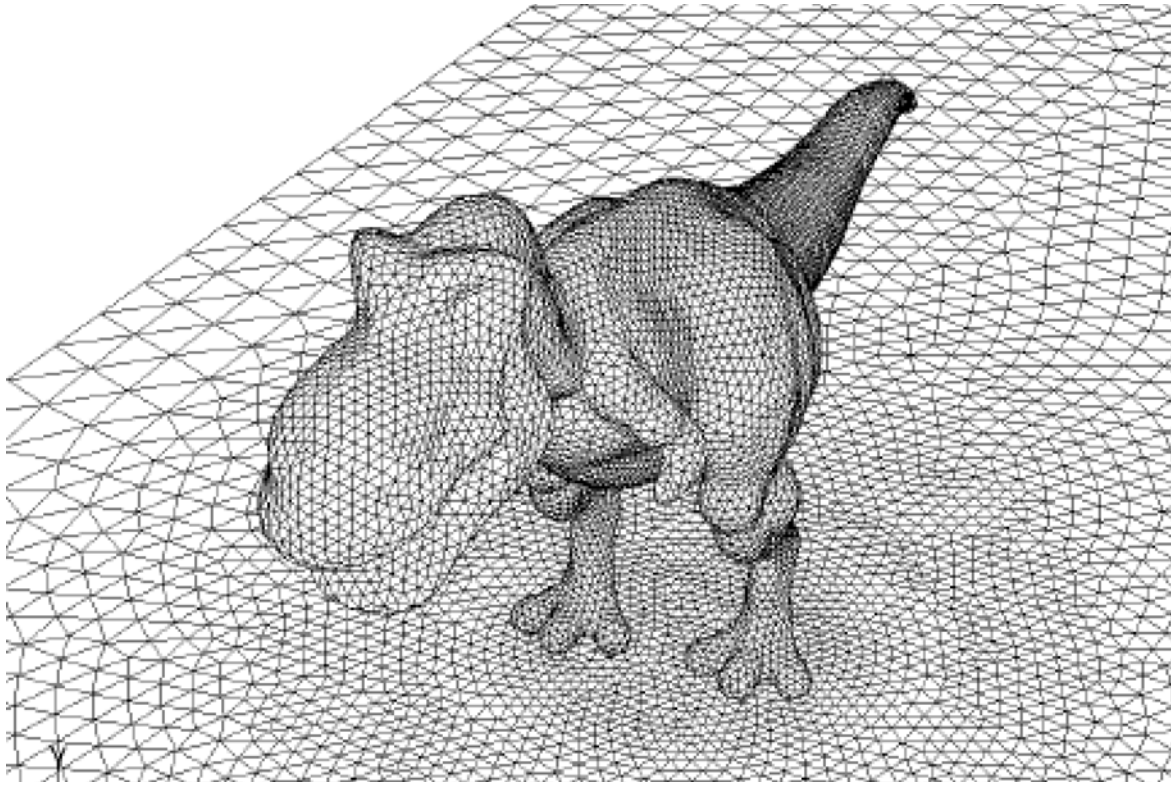

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Unstructured mesh

- The cells arbitrarily distributed
- No indexation of cells
- Meshing can be highly automized
- useful for highly complex geometry

Mesh types

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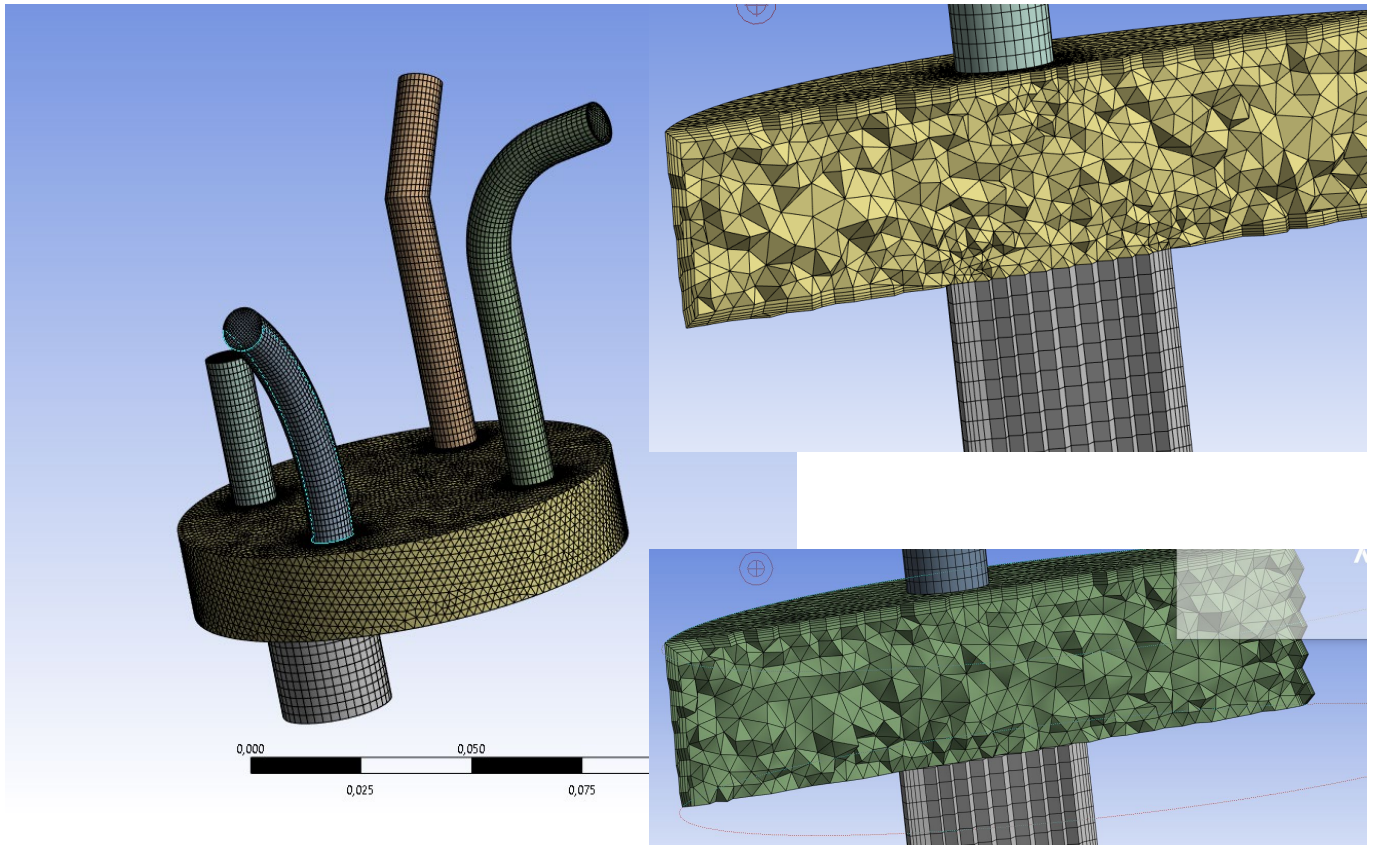
"Hybrid" mesh

- Tetrahedral mesh in complex regions
- Hexahedral mesh in simpler regions
- Conformal vs non-conformal



General guidelines

- Hexahedral mesh will give you superior results to tetrahedral mesh and lower cell count with the same cell size
- Mesh should be dense enough to capture flow phenomena
- Local refinements may be used in areas of high gradients

- No mesh is universal it has to be built with application in mind

Mesh quality

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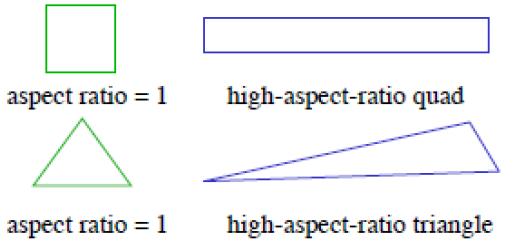
Quality metrics for shape of cells

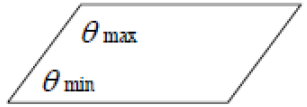
- Aspect ratio



- Skewness $\max\left[\frac{\theta_{max}-\theta_e}{180-\theta_e}, \frac{\theta_e-\theta_{min}}{\theta_e}\right]$

where:

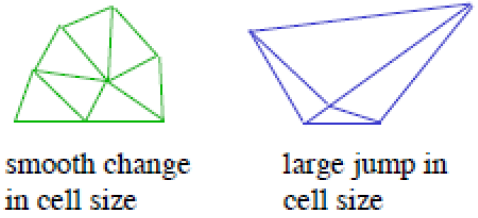
- θ_{max} = largest angle in face or cell.
- θ_{min} = smallest angle in face or cell.
- θ_e = angle for equiangular face or cell.
  - e.g., 60 for triangle, 90 for square.



Skewness should not be smaller than 0.85

Quality metrics distribution of cells

- Smoothness



Sudden jump in cell size should be avoided
Growth ratio should not exceed 1.2

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Hands on: 2D u-bend

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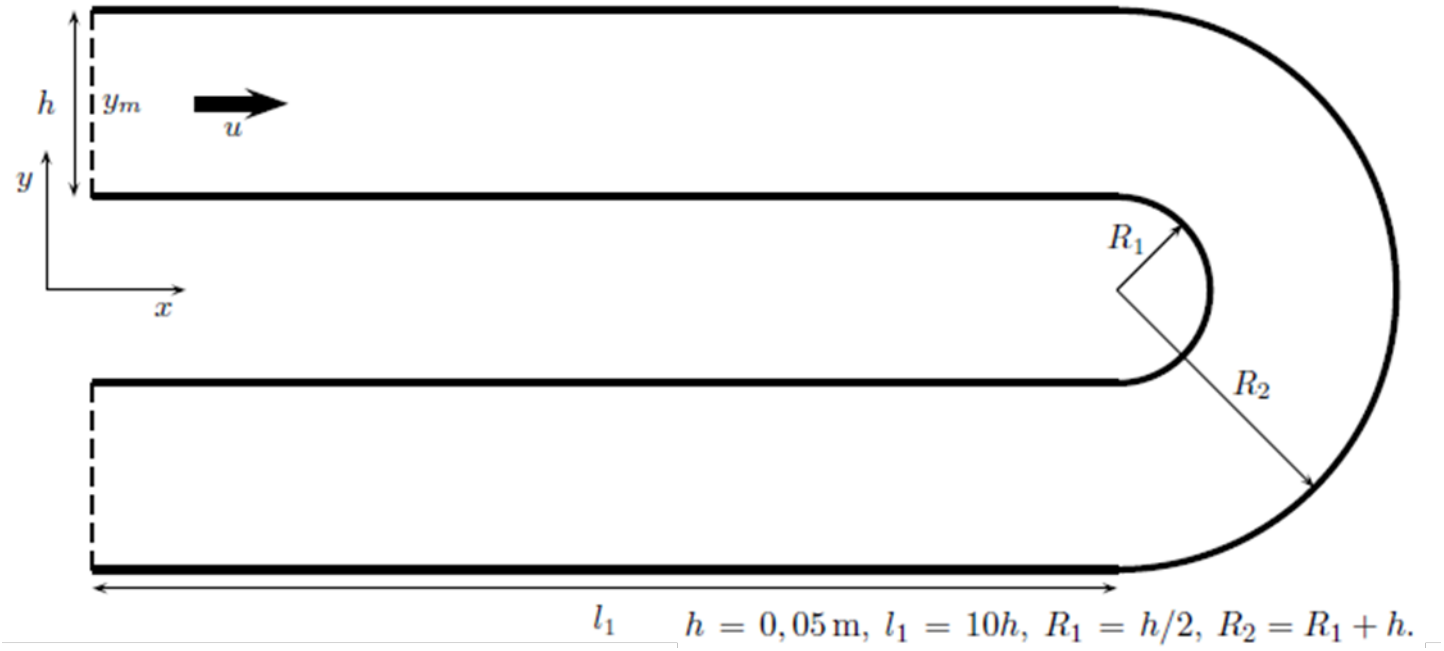

- Steady state, 2D, laminar, isothermal flow of water at standard conditions
  Re=500; ρ=998.2 kg/m^3; ν=1.003×10^{-6} m^{2}s^{-1}
- INLET: Parabolic velocity profile
- OUTLET: Constant ambient pressure

Hands on: 2D u-bend

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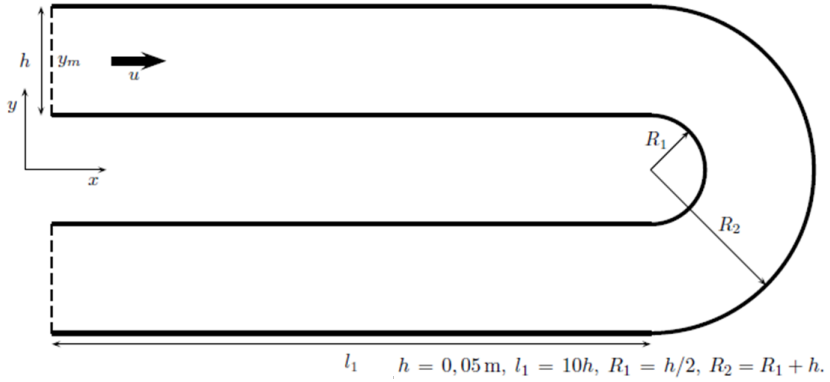
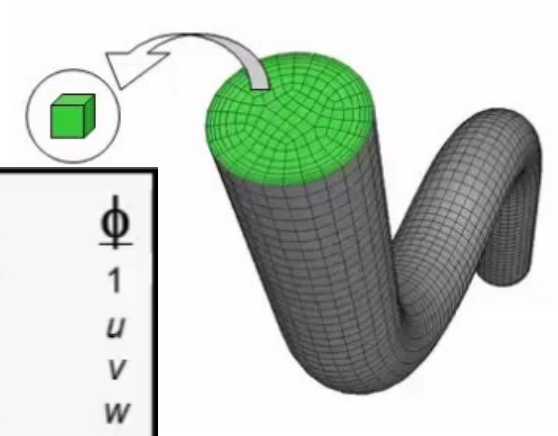
$$\underbrace{\frac{\partial}{\partial t}\int_V \rho\phi\, dV}_{\text{Transient}} + \underbrace{\oint_A \rho\phi\mathbf{V}\cdot d\mathbf{A}}_{\text{Convection}} = \underbrace{\oint_A \Gamma_\phi \nabla\phi \cdot d\mathbf{A}}_{\text{Diffusion}} + \underbrace{\int_V S_\phi\, dV}_{\text{Source}}$$





Equation	ϕ
Continuity	1
X momentum	u
Y momentum	v
Z momentum	w
Energy	h

- How many equation do we have to solve (which variables)
- Which terms can be neglected
- Any special consideration for meshing?

End of Session 1

Thank you for your attention!

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