Computational Grid
Geometry definition

• Sources of geometry definitions
  – CAD definition of the structure (complex “engineering” geometries)
  – Mathematical definition of surfaces (simple geometries)
  – Surface grid (previous CFD or other computations)
• Need to be converted for input to grid generation tools
  – Preferable in “clean surface definitions” (e.g. splines)
  – Cleaning of CAD definitions no at all a trivial task
Element types

- 2D:
  - triangle ("tri")
  - 2D prism (quadrilateral or "quad")

- 3D:
  - tetrahedron ("tet")
  - prism with quadrilateral base (hexahedron or "hex")
  - pyramid
  - prism with triangular base (wedge)
Body-fitted grids

- Grid lines follow the surfaces
- Geometry details can be captured
- Grid points easily clustered in viscous boundary layer
- Could be structured or unstructured or hybrid
- Most frequently used
Structured body-fitted grids

- Efficient solver algorithms
- Solution of high accuracy on well designed grids
- Multi-block approach for complex geometries
- No general automatic grid generation algorithm
- Grid generation a tedious “art” (complex grids can take months!)
- Grid points not easily located where they are needed
Unstructured body-fitted grids

- Most common in commercial CFD solvers today
- Grid cells of different types (tetrahedra, hexahedra, prisms and pyramids)
- Cell connectivity information -> less efficient solver algorithms
- Grid generation can be highly automized
- Grid points easily clustered without influencing the whole computational domain
Grid quality

- Sufficiently fine grids
  - Gradients
  - Adaptation
- Shape of the cells
  - Skewness
  - Aspect ratio
- Orientation of cell faces
  - Normal to gradients
- Spatial distribution of cell sizes
  - Smooth change – max 20%

smooth change in cell size
sudden change in cell size — AVOID!

optimal (equilateral) cell
circumcircle
actual cell

aspect ratio = 1
high-aspect-ratio quad

aspect ratio = 1
high-aspect-ratio triangle
Grid quality ...

- Grid quality is particularly important around large gradients
- Grid quality may influence both
  - accuracy and
  - numerical stability
- Grid topology
- “Prismatic layers” in boundary layers (unstructured grids)
  - “structured” near-wall grid
  - Improves grid quality
  - High $Re$ boundary layers