

Computational Fluid Dynamics Cheat Sheet

Workflow, governing equations, software and error sources

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Conservation of mass	$\partial \rho / \partial t + \nabla \cdot (\rho \mathbf{v}) = 0$	Textbook form; post names the law
Conservation of momentum	Newton's second law	Navier-Stokes for single-phase flow
Conservation of energy	First law of thermodynamics	Gives temperature field
Drop viscosity terms	Navier-Stokes → Euler	Post's simplification ladder
Drop vorticity terms	Euler → full potential	Then linearize for small disturbances
Linearized potential	Subsonic or supersonic only	Not transonic or hypersonic
Unknowns solved for	Velocity, pressure, temperature	At grid points and time instants

Key takeaways

- Three stages: pre-processing (geometry, boundary conditions, mesh), solving (iterate until converged), post-processing (contours, vectors, forces).
- Methods named in the post: finite difference, finite element, finite volume, spectral.
- Software named: ANSYS Fluent, ANSYS CFX, Siemens STAR-CCM+, OpenFOAM (open source), Autodesk CFD.
- CFD vs CAD: CAD builds the geometry; CFD analyzes the flow around it. CFD vs FEA: fluids vs solid stress and deflection.
- Error sources: discretization (grid), input data, initial and boundary conditions, and modeling (turbulence, multiphase).
- Validate with wind tunnels or full-scale tests (flight tests, automotive coast-down). Results are never exactly precise.
- Advantage: shared wind tunnel queues take days or weeks; CFD is faster, cheaper, and shows the full flow field.
- McLaren MP4-20 (2005): CFD showed the raised front wing's endplate vortex hitting the lower suspension wishbone (Newey, 2017).