

Engineering Simulation Software: Selection, Requirements, and Workflow



Why simulate: faster design cycles, lower prototyping cost, insight into hard-to-test physics



Three pillars: choosing the right tool, defensible requirements, repeatable workflow



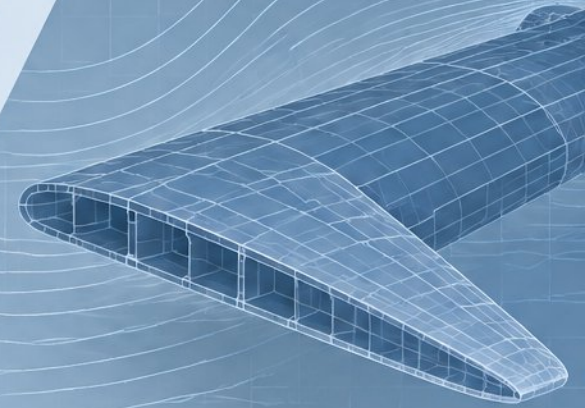
For students and junior engineers comparing tools and planning a first analysis



What 'good' looks like: traceable, verifiable, well-documented results—not just colorful contours



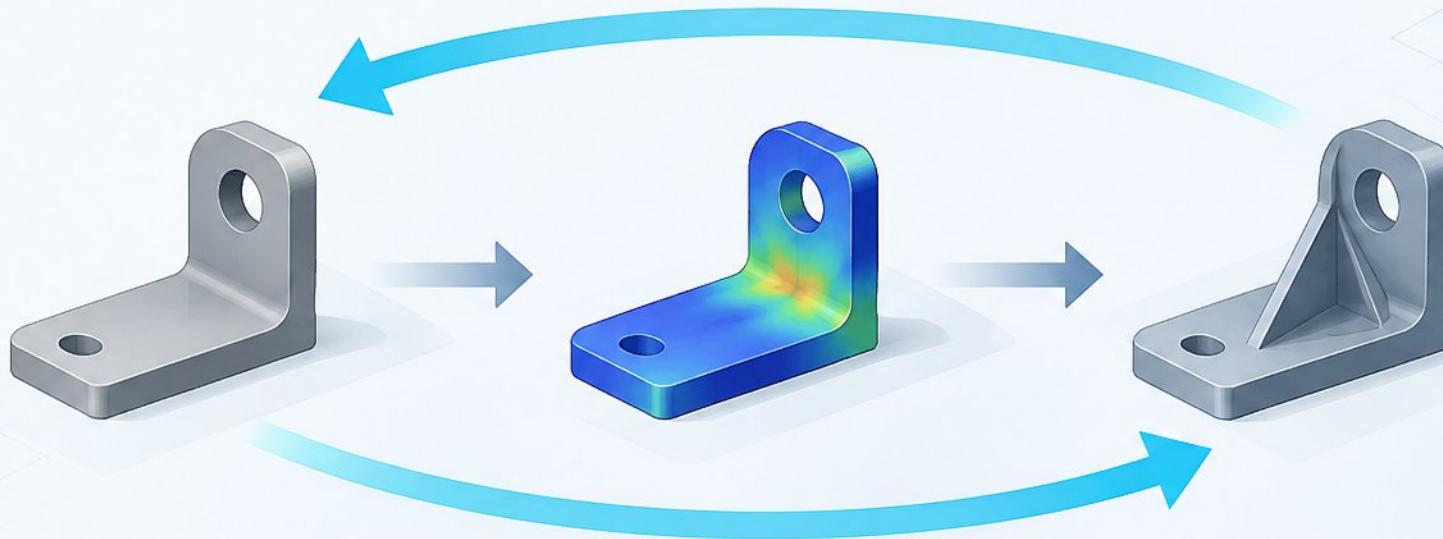
Market context: ~USD 15.46B in 2026; FEA and CFD lead spend; cloud/SaaS growing fast



Where Simulation Sits in the Design Process

- Simulation supports decisions at CAD, design review, and test planning—not a final stamp
- Early model changes are cheap; post-tooling fixes are expensive
- Replaces some prototypes and tests; adds design-space exploration and insight
- Skip simulation when hand checks, closed-form estimates, or physical tests are faster
- Anchors: bracket stress, heat sink thermal study, duct flow

MODEL
ANALYZE
LEARN
IMPROVE



Anchors:



bracket stress



heat sink
thermal study



duct flow

Core Concepts: Physics, Discretization, and Mesh

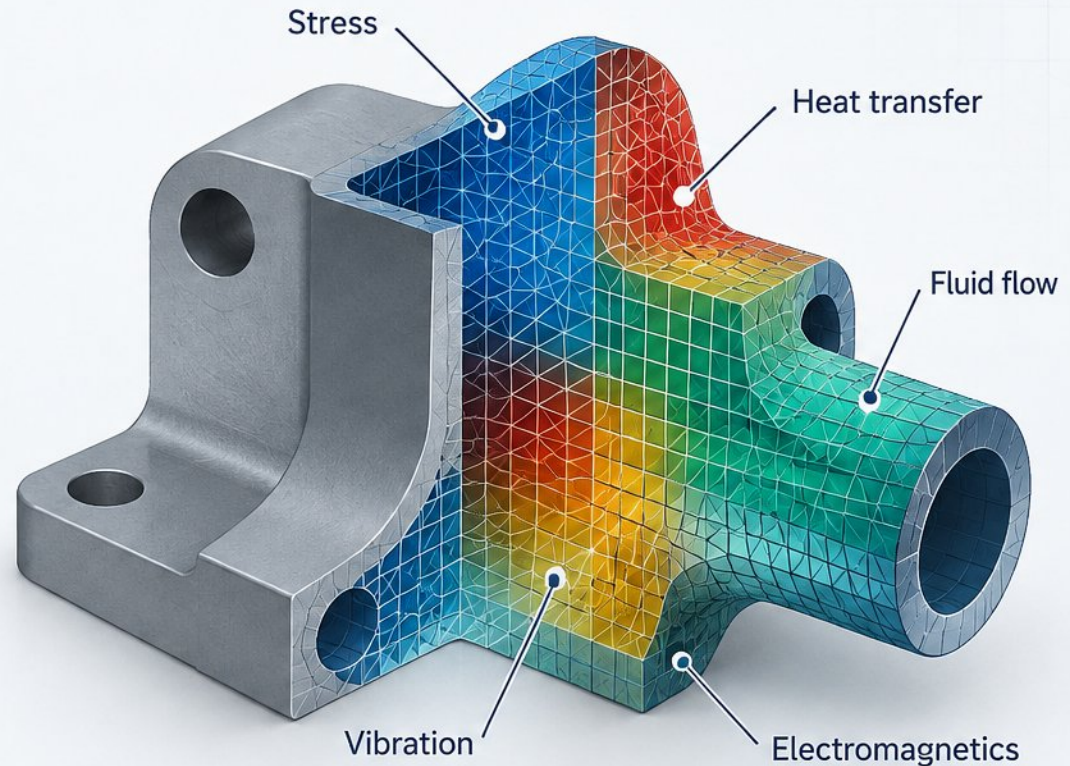
1 Governing physics by domain: stress, heat transfer, fluid flow, vibration, electromagnetics

2 FEM/FVM in plain terms: turn a continuum into a finite system of equations

3 Element types (tet, hex, shell, beam) must follow geometry and physics

4 Degrees of freedom, direct vs. iterative solvers, and practical convergence

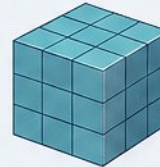
5 Analysis choices that change results: linear vs. nonlinear, static vs. transient



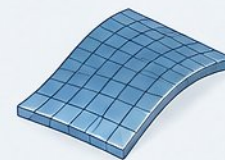
Element types



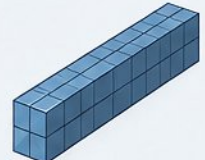
tet



hex



shell



beam

Mesh Quality: The Practical Metrics That Matter

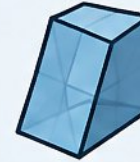


- Mesh quality drives accuracy and stability more than beginners expect
- Structural: aspect ratio under 5; avoid above 20 near high stress
- CFD: max skewness below 0.95; orthogonal quality above 0.1
- Refine at stress concentrations, near-wall regions, and steep gradients
- Mesh is good when the answer stops changing with refinement

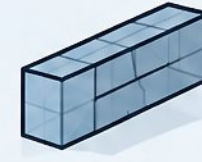
Key Mesh Quality Metrics



Element Quality



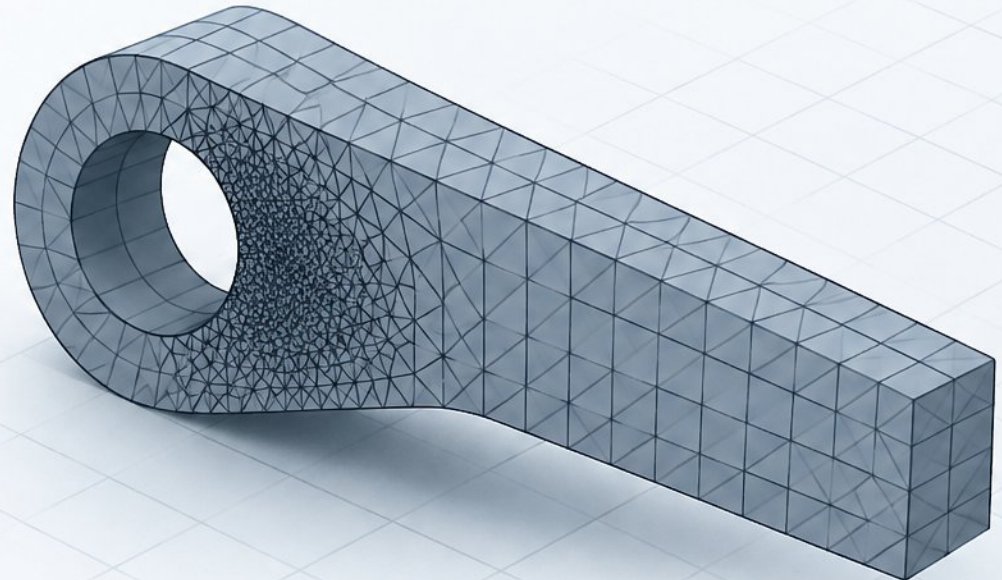
Jacobian Ratio



Aspect Ratio



Skewness



Requirements First: Define the Analysis Before Choosing the Tool

-  **Start from the engineering question** and acceptance criteria, not vendor demos
-  **Requirement categories:** physics coverage, geometry complexity, model size, accuracy, turnaround time
-  **Constraint check:** budget, license model, compute hardware, learning curve, IT/security, collaboration
-  **One-page brief:** question, physics, fidelity, deliverable, deadline, reviewer
-  **Traceability:** tie each requirement to the V&V activity that proves it is met
-  **Verification:** are the equations solved correctly? **Validation:** does the model represent reality for its intended use?

Analysis Requirements Brief

Question:

Physics:

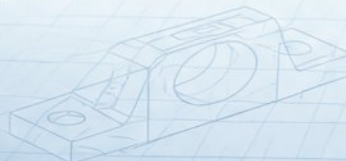
Fidelity:

Deliverable:

Deadline:

Reviewer:

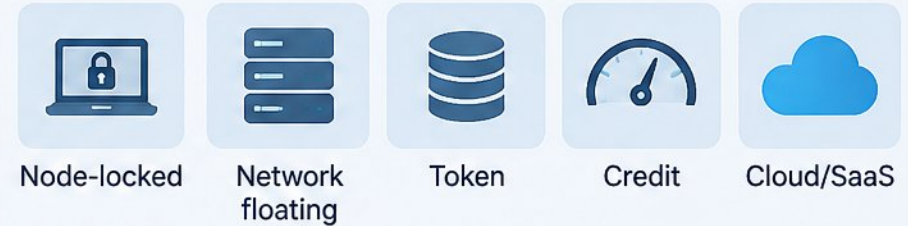
Analysis Tool Options



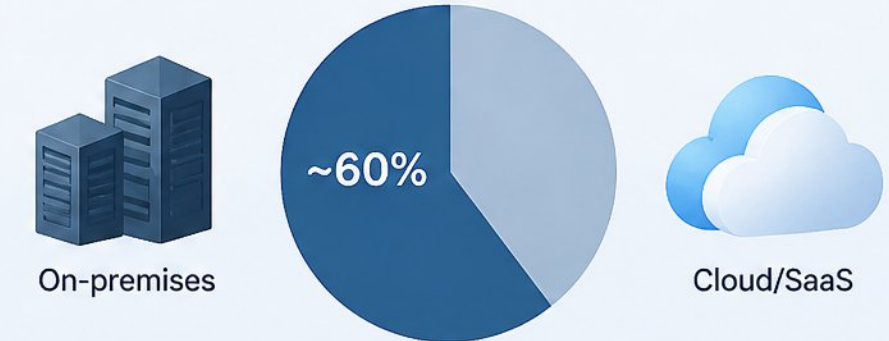
Licensing, Cost, and Deployment: What Students and Teams Actually Face

- License models: node-locked, network floating, token, credit, and cloud/SaaS
- Token and credit systems price compute and concurrency—plan for peaks and HPC
- On-premises held ~60% of 2025 revenue; cloud/SaaS grows faster and lowers entry cost
- Commercial vs. open-source: weigh cost, support, transparency, community, and certification
- Budget check: solver time, hardware, and people time often exceed the license price

License Models



2025 Revenue by Deployment



Precision
drives better
decisions.

The Tool Landscape by **Physics Domain**

SIMULATE | UNDERSTAND | SOLVE

Structural FEA

- Ansys Mechanical, Abaqus, MSC Nastran; open source CalculiX, FreeFEM



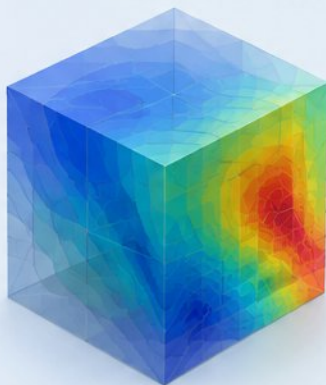
CFD

- Ansys Fluent, STAR-CCM+, OpenFOAM; cloud-native SimScale



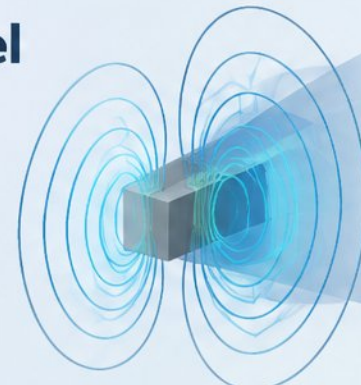
Multiphysics

- COMSOL for fully coupled models; Ansys and Simcenter enterprises



EM and system-level

- HFSS, CST, Maxwell; Simulink/Simscape, Simcenter



Naming is not endorsement—match tools to your requirements brief, not logos

Selection Criteria and a Trial Evaluation Plan



Build a weighted rubric: solver capability, CAD interoperability, meshing, robustness, post-processing, scripting



Check ecosystem fit: native CAD integration, PLM data management, HPC/cloud, collaboration



Weigh open source: reproducibility and no license cost vs. setup effort and convergence know-how



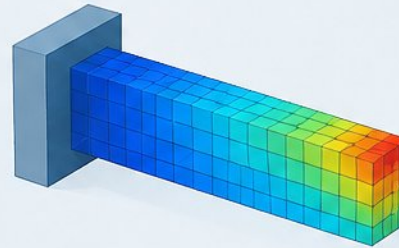
Trial every candidate on a benchmark you can verify against theory or test data



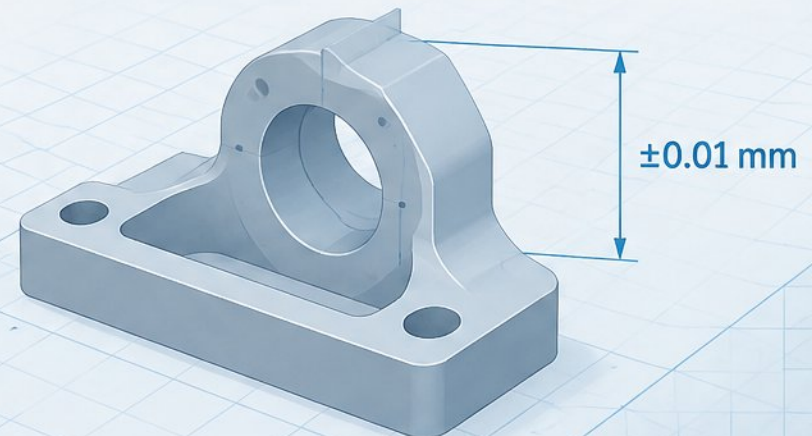
Score candidates, run a pilot, and document why the winner won

Evaluation Rubric

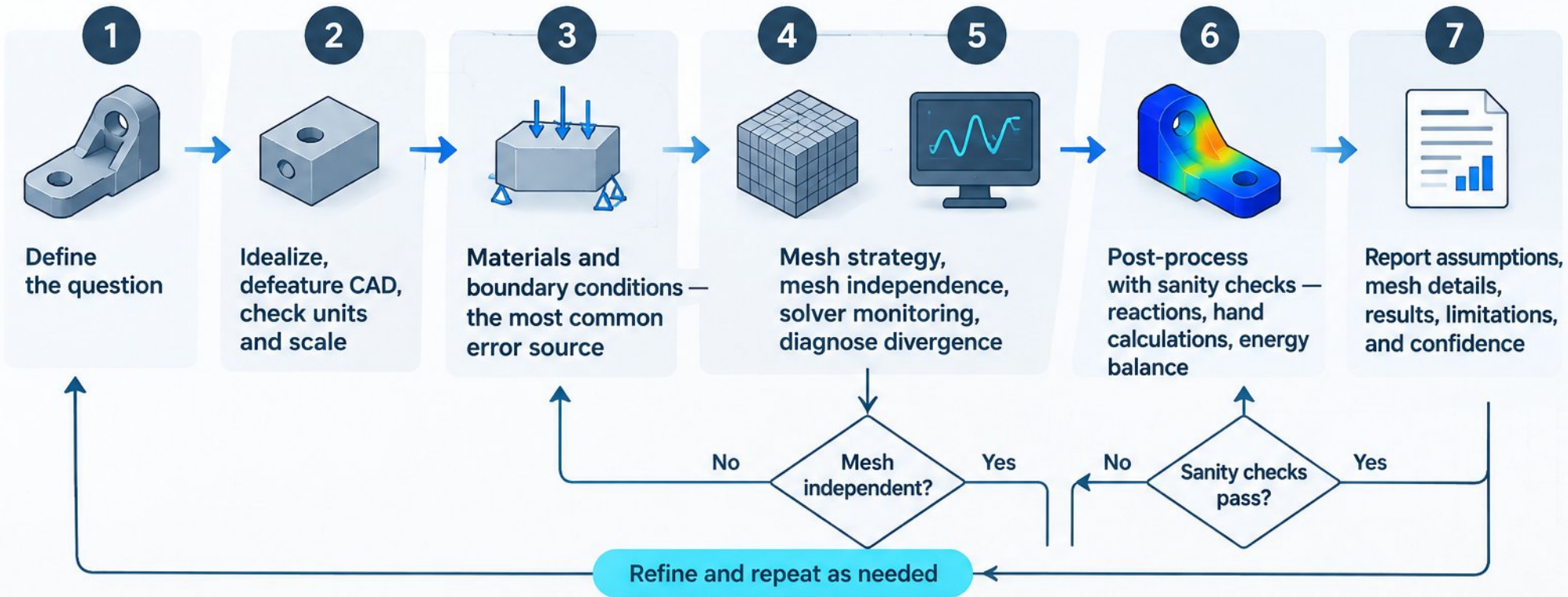
Benchmark Problem



Pilot and Decision Log



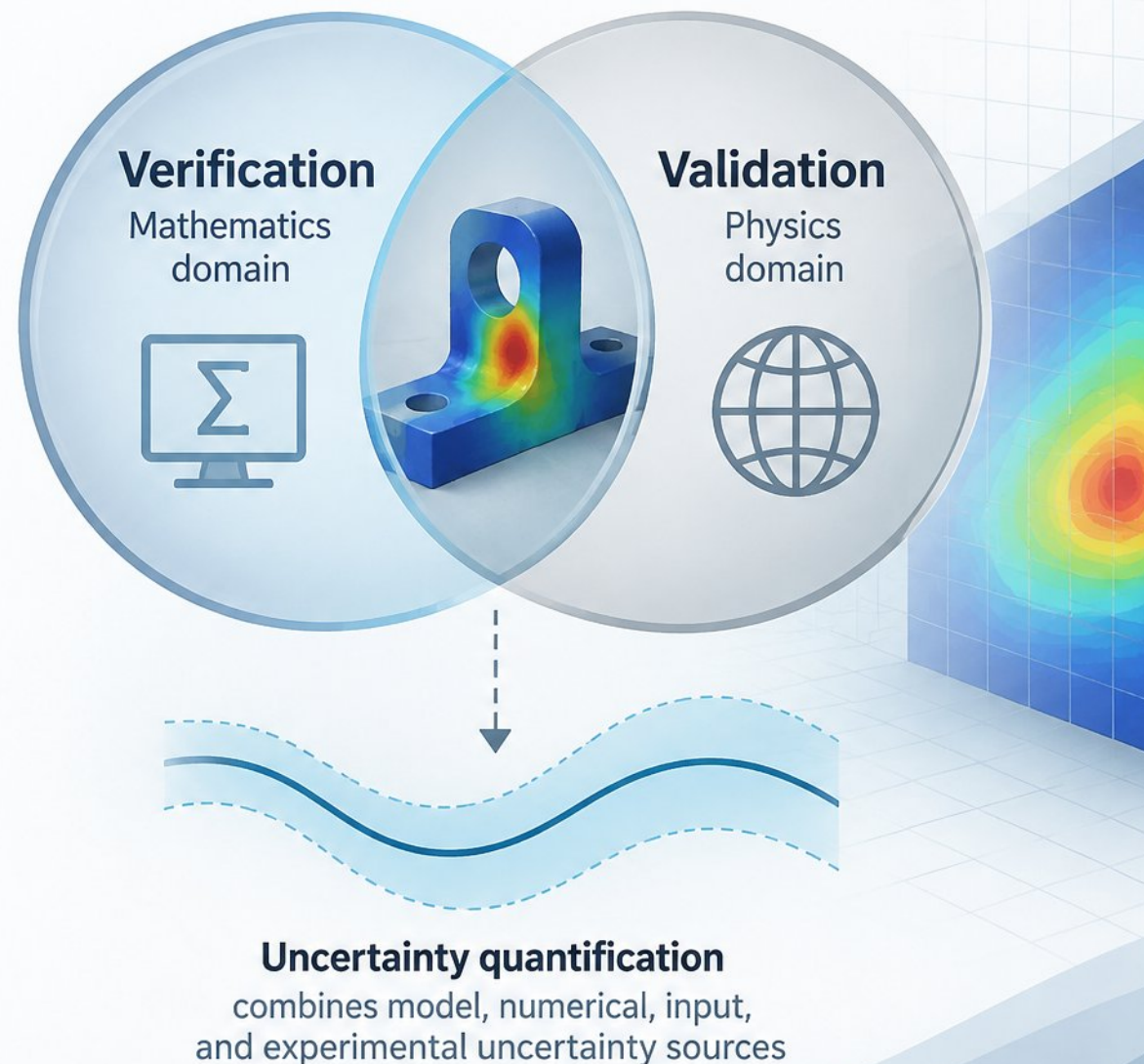
A Repeatable Analysis Workflow: From CAD to Report



- 1** Steps 1–2: define the question, idealize, defeature CAD, check units and scale
- 2** Step 3: materials and boundary conditions — the most common error source
- 3** Steps 4–5: mesh strategy, mesh independence, solver monitoring, diagnose divergence
- 4** Step 6: post-process with sanity checks — reactions, hand calculations, energy balance
- 5** Step 7: report assumptions, mesh details, results, limitations, and confidence

Verification, Validation, and Uncertainty in Plain Terms

- **Verification:** are the equations solved correctly? Mathematics domain
- **Validation:** does the model represent the real world for its intended use? Physics domain
- Uncertainty quantification combines model, numerical, input, and experimental uncertainty sources
- ASME V&V 10 (solid mechanics) and V&V 20 (CFD, heat transfer) give common language
- Validation experiments need documented uncertainty and conditions relevant to intended use
- No universal 'validated' stamp—V&V is specific to a model and its intended use

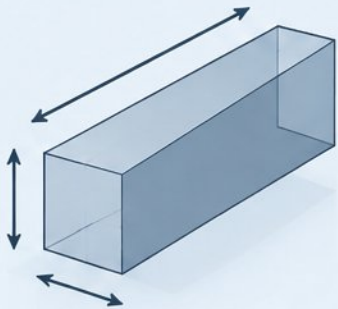


Common Pitfalls and How to Avoid Them

BUILD BETTER MODELS. GET MORE RELIABLE RESULTS.



Unit and scale errors



- Unit and scale errors: lock one system, then verify reactions and deflection magnitude



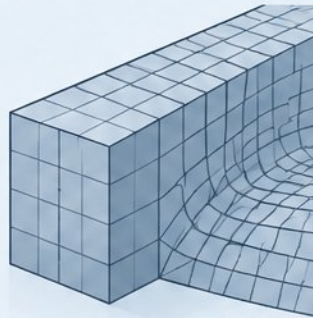
Bad constraints



- Bad constraints: redundant supports or missing rigid-body constraints distort the load path



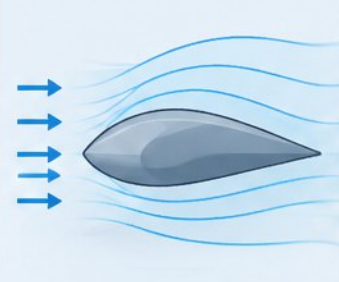
Mesh traps



- Mesh traps: a single element through thickness, coarse gradients, and highly skewed cells



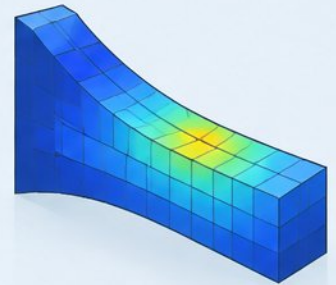
Boundary-condition errors



- Boundary-condition errors: wrong inlet velocity or turbulence values, outlet too close to the wake



Convergence traps



- Convergence traps: never stop on residuals alone—monitor forces and check the solver log

Hands-On Comparison: Same Problem, Different Tools



Benchmark: cantilever beam with known analytical tip deflection and stress



Compare commercial GUI tools (Ansys, Abaqus) against open-source paths (CalculiX, Code Aster)



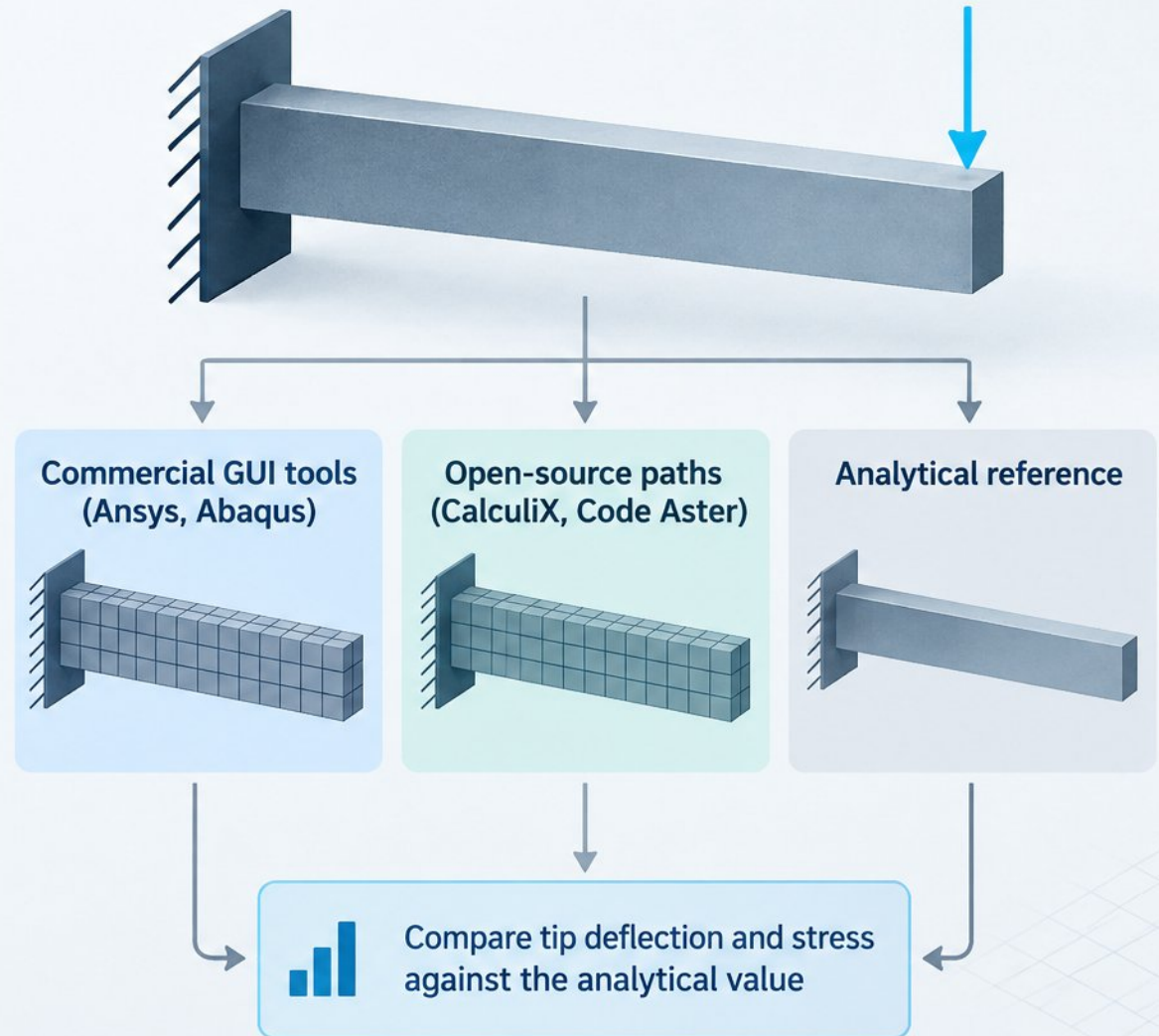
What differs: setup steps, meshing defaults, solver controls, post-processing, scripting



What stays the same: physics, boundary conditions, mesh convergence, theory comparison



Read critically: stress singularities at constraints, mesh dependence, shear-locking in coarse elements



Building Your Starter Workflow and Learning Path



Pick one tool and one physics domain; go deep before going broad



Free options: Ansys Student, Abaqus Learning Edition (1000 nodes), COMSOL academic, FreeCAD FEM, OpenFOAM



Starter kit: tutorials, benchmark problems, forums, vendor Innovation Courses



Habit checklist: requirements brief, unit check, mesh check, validation case, written report

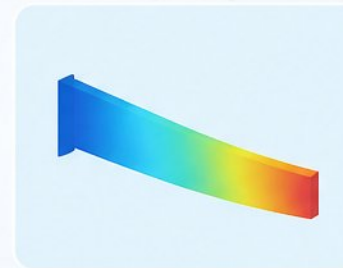
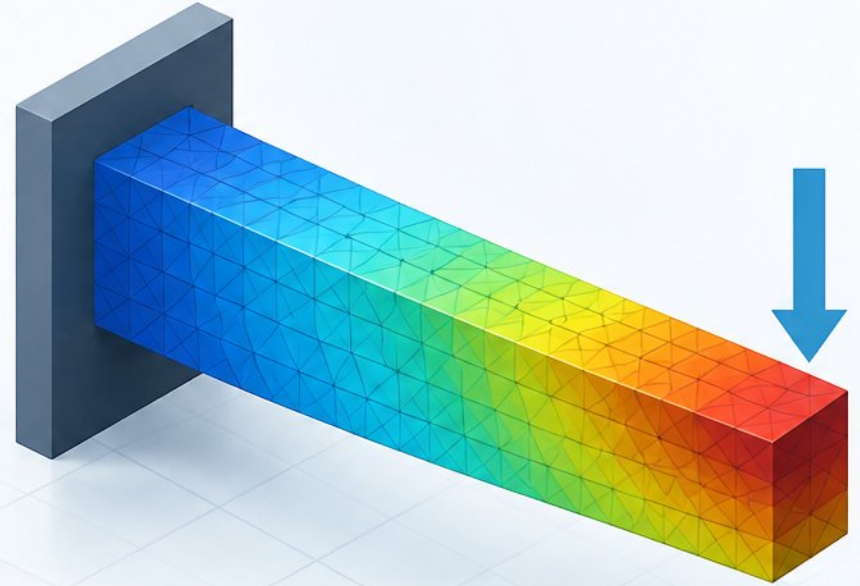


Skills roadmap: courses, certifications, portfolio projects, and periodic tool re-evaluation



Key Takeaways and Your Next Step

- Requirements come before tools: define the question and acceptance criteria first
- Selection is a trade-off across physics, cost, ecosystem, and learning curve
- The workflow repeats: idealize, prepare, set materials and BCs, mesh, solve, check, report
- Verification and validation make results defensible—document assumptions and limitations



Next step: run a benchmark problem and compare against an analytical or test value

PersonWise.

PersonWise • AI digital-human course platform



Scan the code or click anywhere to watch this course live, with voice Q&A

personwise.ai/t/7b0696fc/public