



The Dangers of Convenience: Applying Commercial CFD Programs

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Presenter Background

- BSME: University of Florida
- MSME, MSAE, PhDME: University of Michigan
- Post-Doc: University of Michigan
- Associate Professor in Department of Mechanical Engineering
- Courtesy Assistant Professor in Department of Chemical and Petroleum Engineering
- Emphasis: Sustainable Approach to Internal Combustion Engines, Automobiles, and Associated Energy Infrastructure

Outline

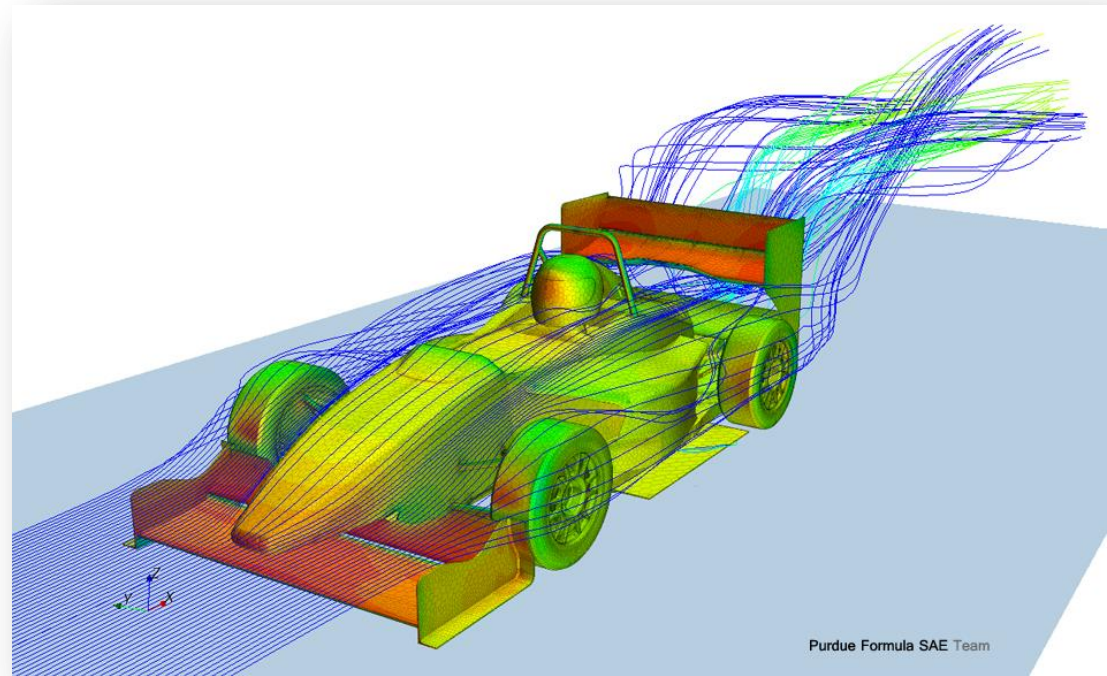
- Undergraduate Education
- Dangers of Convenience
- Graduate School Upgrade
- Fundamentals
- CFD Testing Outcomes
- Tactics
- Conclusion and Questions

Undergraduate Education

- Scientific and engineering knowledge doubles every ten years*
- Curriculum is the same length
- More material to cover in less time
- Simulations and computer programs ever more prevalent (students like to use)
- Reinforces lessons learned and (almost) required for new generation of students

Undergraduate CFD Exposure

- Black box
- Cool pictures
- Looks impressive
- Many hours spent tweaking
- Little validation



Student competitions like to use CFD programs to help with their design and product development

Graduation with Bachelor's Degree

- Passed the classes
- Understood the material
- Off to solve the world's problems
- I am enlightened
- I am “smart”



“I am Iron Man”

The Dangers of Convenience

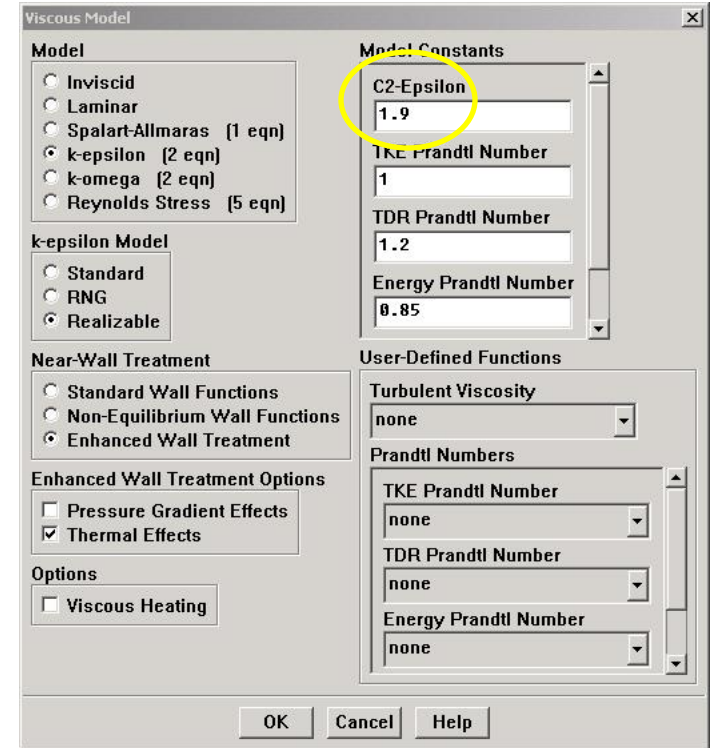
- Commercial CFD programs are robust and well done
- Easy to design and analyze
- Fantastic looking output
- Graduated BS students employ without thinking twice
- Could be completely physically wrong
- No way to know without fundamental understanding



Features like automatic mesh generation make it easy to set up computer programs for CFD analysis

Words of Wisdom

- “All models are wrong, but some models are useful” – George P. E. Box
- CFD in 2013*
 - Consider both geometry and physics when meshing
 - Industry specific CFD tools tuned for specific sets of problems
 - Quick turnaround is desired
 - CFD may not be the employees primary job



Fluent viscous model constants;
AERO 525 at Michigan discussed $k-\epsilon$
model and how c_2 is derived

Starting Masters of Science

- First day, first class was a rude awakening
- Learned only how to solve packaged problems
- Fundamentals severely lacking
- Had to start learning process all over



Classmate

Me

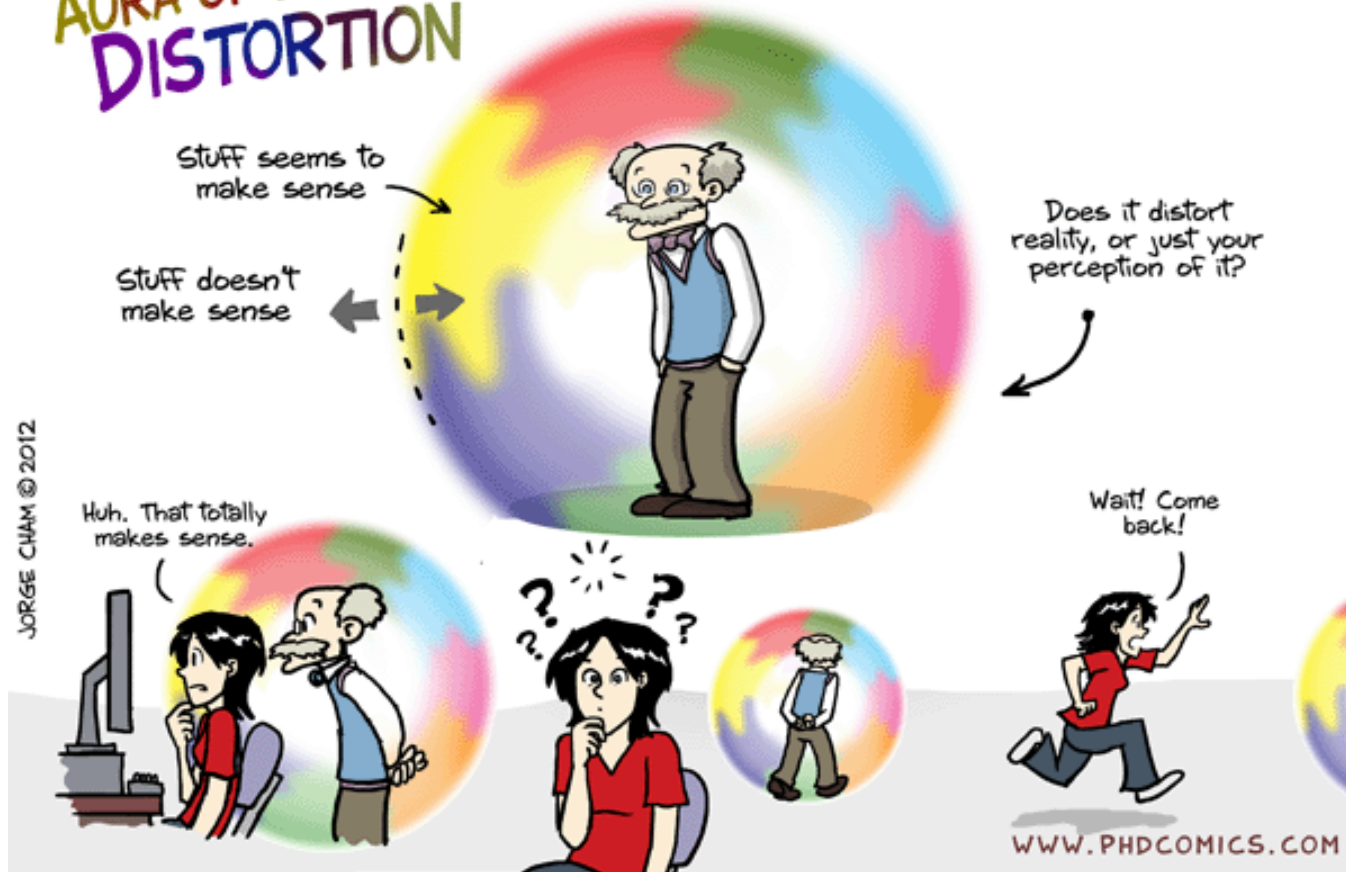
Lessons Learned

- Bram van Leer taught me the fundamentals
- Everything solved starts from the governing equations: mass, momentum, energy, species, and ideal gas law
- Dimensional simplification through source terms
- Research example: dynamic incompressibility
 - Automotive catalyst modeling employs this streamlining technique
 - Virtually no one realizes when the simulations are applicable and when they are not

Aura of Logical Distortion

Your Professor's
**AURA OF LOGICAL
DISTORTION**

THE FRUSTRATING PHENOMENON BY WHICH THINGS APPEAR TO MAKE SENSE WHEN YOUR ADVISOR IS THERE, BUT STOP MAKING SENSE AS SOON AS THEY WALK OUT THE DOOR.



Fundamentals Must Be Taught

- Sports analogy applies
- You simply do not get good without practice and training
- You cannot use CFD programs correctly without the proper practice and training



CFD Testing Outcomes

- Well-posed Problem
 - Physically-based output
 - Correct trends
 - Experimentally verified
- Testing ability of students to get right results
- Demonstrates how CFD helps engineers
- Looks Good, but Wrong
 - Non-physical results
 - Inverse trends
 - Experimentally erroneous
- Testing ability of students to diagnose simulation outcomes
- Demonstrates how CFD hurts engineers

Do Both & Do Not Tell
Students/Employees Which is Which

My Tactics

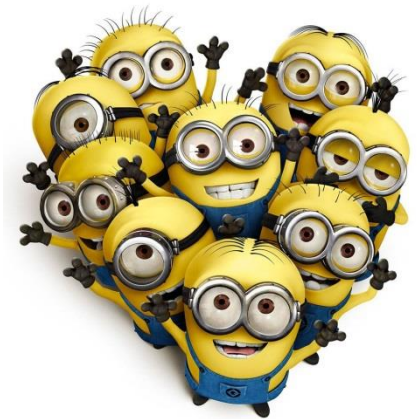
- Attempt to teach every class problem starting from the fundamental governing equation(s)
- Drill the basics into undergraduate and graduate students
- Do not believe any simulation result
- Require experimental validation
- Use common sense

Now

- I am not perfect
- Understand student limitations
- Work to build-up fundamentals
- Ask a lot of questions
- Use opportunity to continue to learn



Me



Graduate
Students

Thank you for your attention

Any Questions?

