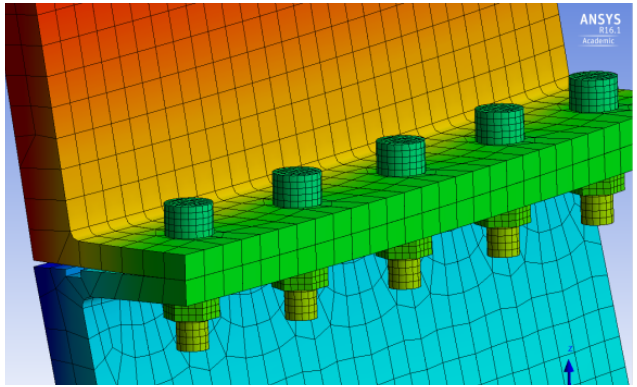
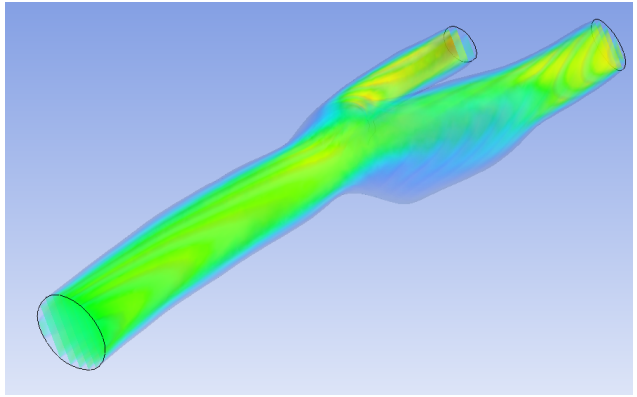
Cornell Engineering

A New Paradigm in Engineering Education Using Two Disruptive Technologies: Simulations & Online Learning





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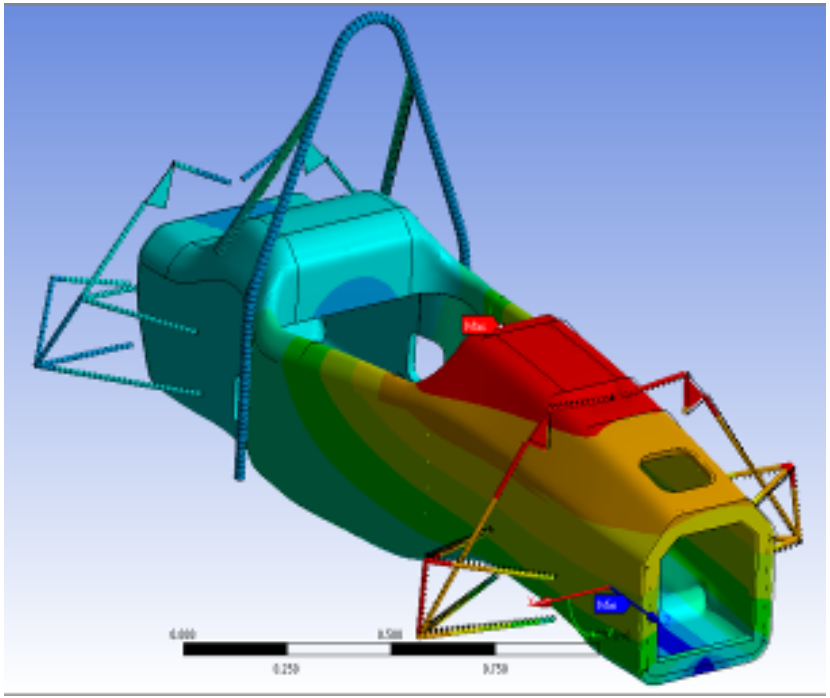
Cornell University

Outline

1. Backstory
2. Pedagogical framework
3. Hands-on simulation MOOC
4. A new paradigm



Swanson Simulation Program at Cornell University

Cornell Engineering

- Established in 2000 with an endowment from Dr. John Swanson, ANSYS Inc. founder
- Department: Mechanical & Aerospace Engr.
- Goals:
  - To facilitate routine use of computer simulation in M&AE curriculum
  - To provide support and leadership to the community on simulation in engineering education

Advisory Committee	
ANSYS	ASME
Boeing	NAFEMS
GE	Penn State
MathWorks	CIMData
PTC	DatapointLabs

Swanson Simulation Program: Impact on Courses

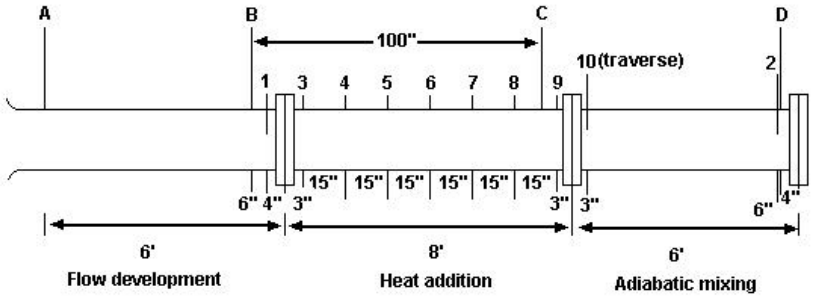
Cornell Engineering

	Course	Level	Enrollment	Software
1	MAE 3250 Mechanical Structures	Junior	150	ANSYS Mech.
2	MAE 3240 Heat Transfer	Junior	130	ANSYS Mech.
3	MAE 3272 Mechanical Lab	Junior	140	ANSYS Mech.
4	MAE 4272 Thermo-fluids Lab	Senior	160	ANSYS Fluent
5	MAE 4230/5230 Int. Fluid Dynamics	Ugrad/M.Eng	60	ANSYS Fluent
6	MAE 4700/5700 Finite-Element Analysis	Ugrad/M.Eng	50	ANSYS Mech.
7	MAE 4020/5020 Wind Energy	Ugrad/M.Eng	50	ANSYS Mech./ Flu.
8	MAE 4650 Biofluid Mechanics	Ugrad/M.Eng	20	ANSYS Fluent
9	BME 4490 Biomechanics Laboratory	Ugrad	4	ANSYS Mech.
10	MAE 6510 Advanced Heat Transfer	Ph.D./M.Eng	10	ANSYS Mech.
11	MAE 6690 Biofluids	Ph.D.	15	ANSYS Fluent
12	MAE 6640 Mechanics of Bones	Ph.D./M.Eng	15	ANSYS Mech.

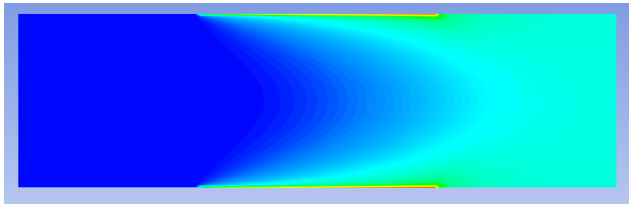
Simulation Examples from Cornell Courses

Cornell Engineering

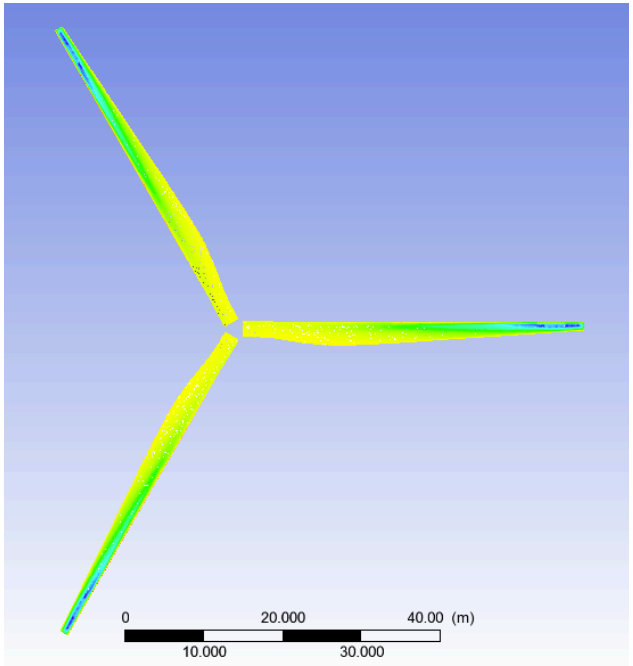
Thermo-Fluids Lab



Temperature Contours



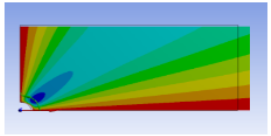
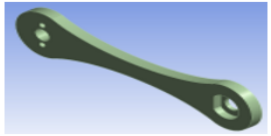
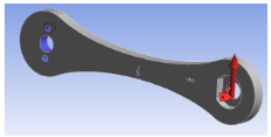
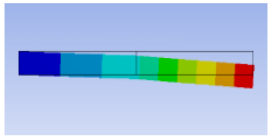
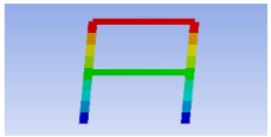
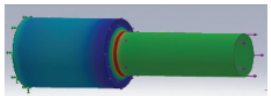
Wind Energy



SimCafe.org: Free Learning Portal for Simulations

Cornell Engineering

- Contains over 50 learning modules on FEA and CFD using ANSYS
- Has been critical for the integration of ANSYS-based simulations into courses
- Learning modules have a uniform structure

	Plate With a Hole	MAE 3250/ MAE 4700--5700
	Bike Crank	MAE 3250/MAE 3272
	Bike Crank: Part 2	MAE 3272
	Cantilever Beam	MAE 4700-5700
	Plane Frame	MAE 4700-5700
	A stepped shaft in axial tension	Prantil et al textbook

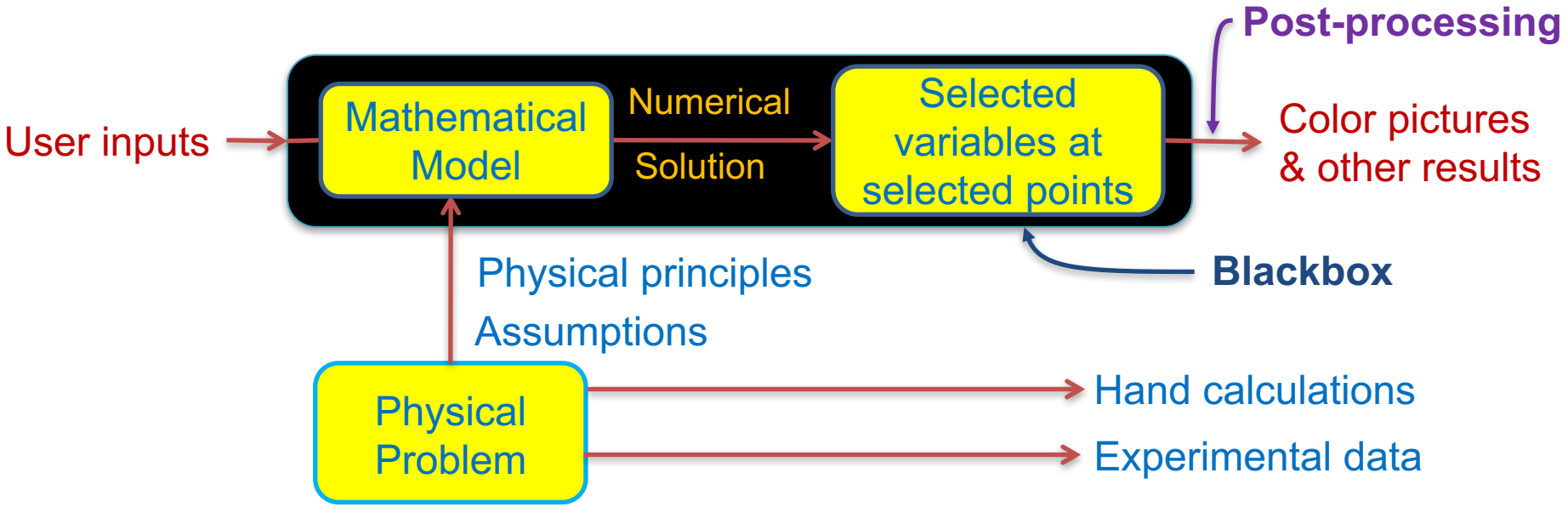
2016-17 Usage Statistics

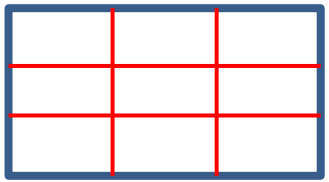
Pageviews	**2.1 million**
Unique visitors	158,000
Countries	172
Average session	9 minutes

The Simulation Blackbox

Novice thinking

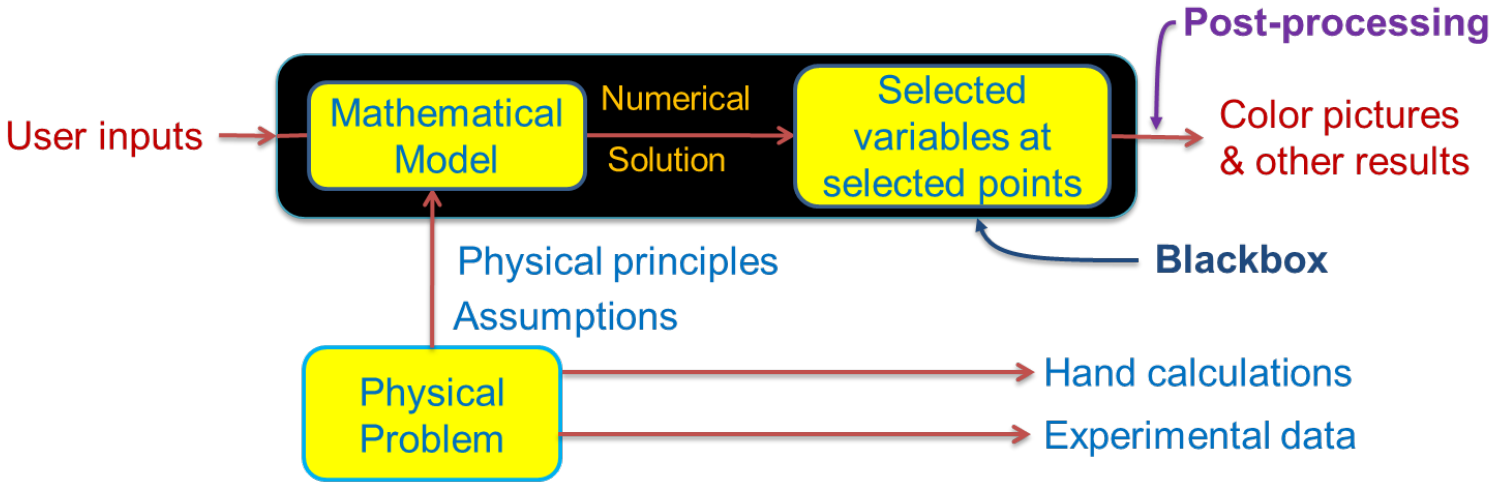
What's Inside the Blackbox?





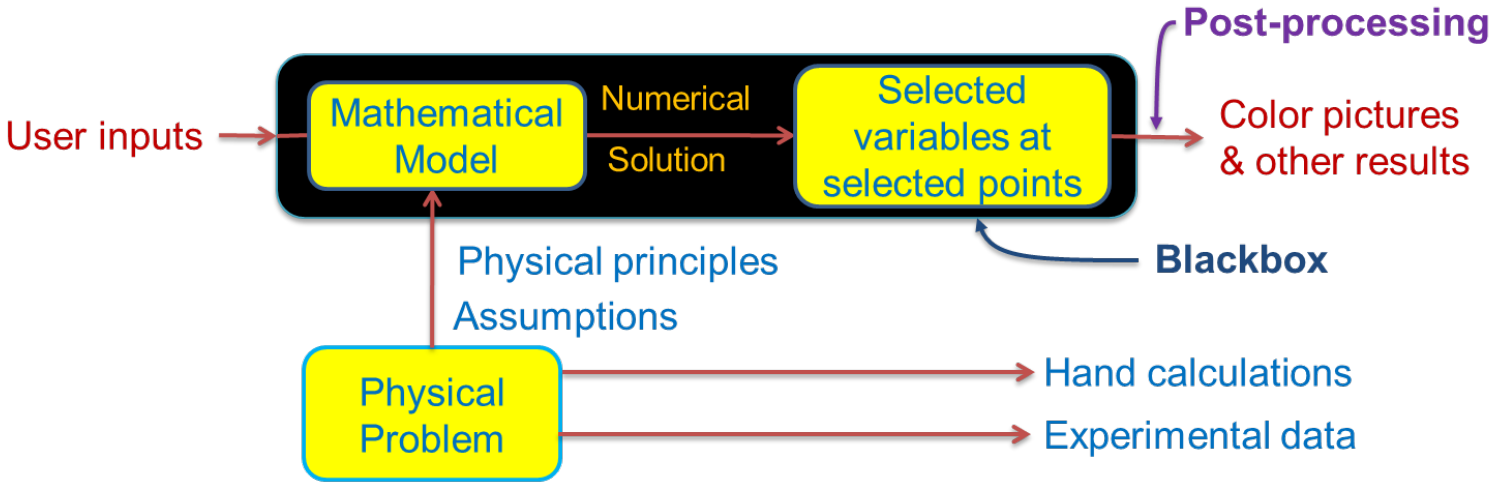
Expert thinking

Pre-Analysis



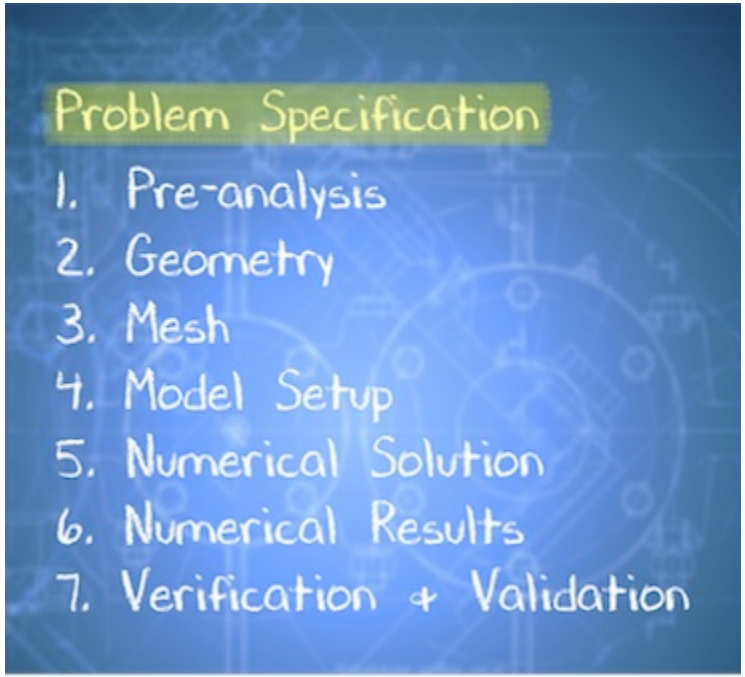
1. Mathematical model
2. Numerical solution procedure
3. Hand-calculations of expected results/trends

Verification & Validation



- Verification: Did I solve the model right?
- Validation: Did I solve the right model?

Uniform Process Across Courses



Just-in-time, problem-based learning

cf. Just-in-case, content-based learning

Novice > Expert thinking

Outline

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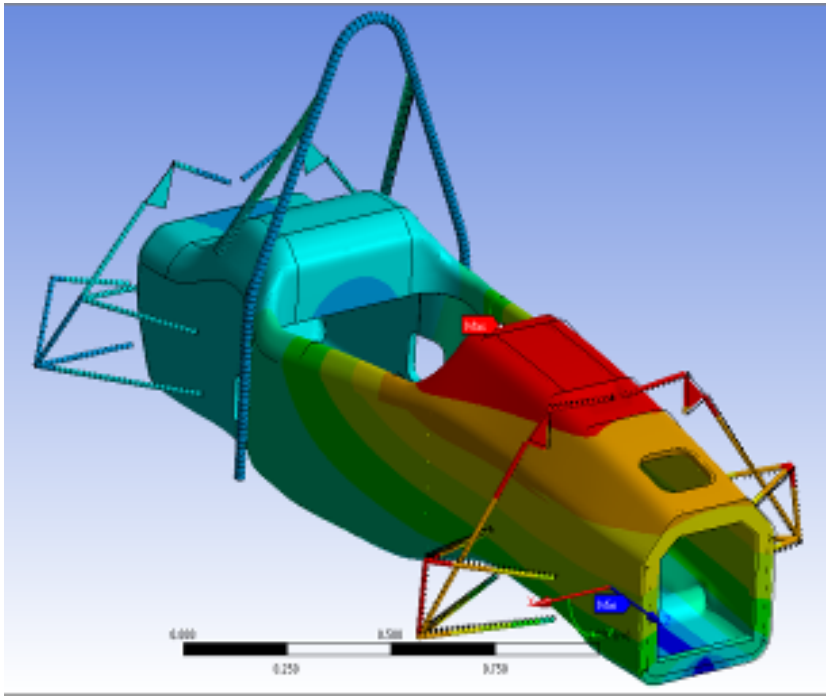
2. Pedagogical framework
3. Hands-on simulation MOOC
4. A new paradigm

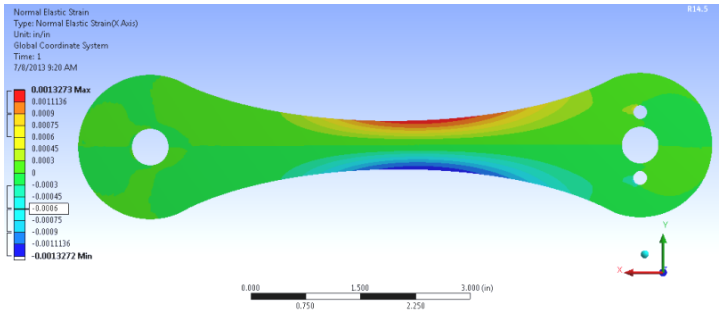


MOOC: A Hands-on Intro to Engineering Simulations

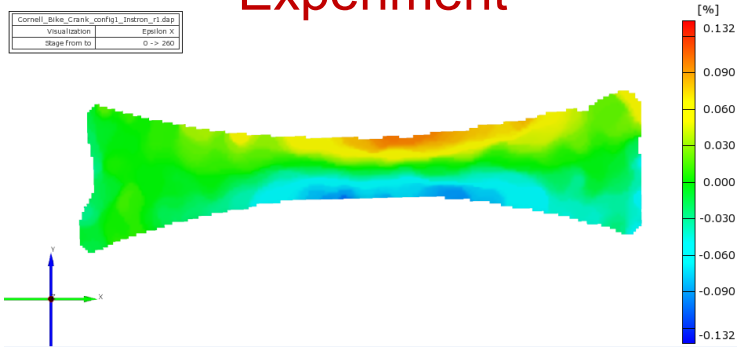
Cornell Engineering

- Holistic approach to teaching math/physics and hands-on simulations
- Simulation app: ANSYS Student
- 6 simulation case studies drawn from 5 engineering courses
- “Big ideas” sections
- Cuts across traditional boundaries
  - Common approach to problems involving different physics
  - Common approach to FEA and CFD
- A new kind of engineering course

Simulation

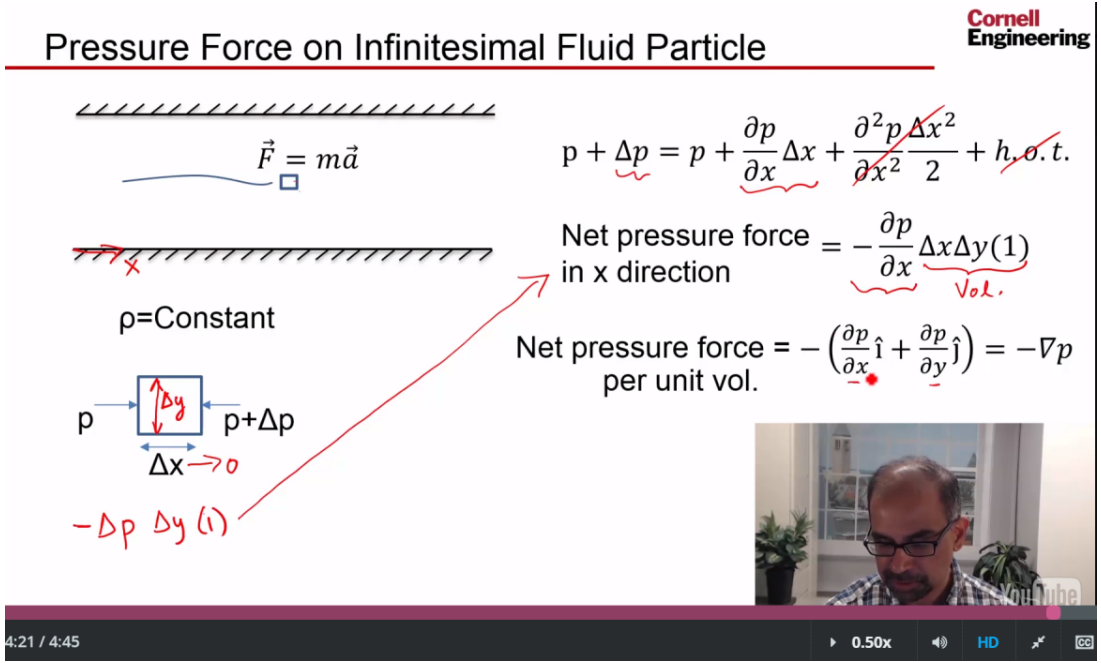


Experiment



MOOC Lectures and Assessments

- Lectures
  - Overlay chalkboard, PowerPoint, ANSYS
  - Self-recorded
    - Now edited by undergrad TA's
  - Four minutes long on average
  - Sage on the stage > Guide by the side
  - Bring in industry expert as needed
- Assessments facilitate active learning & guided exploration



MOOC Statistics

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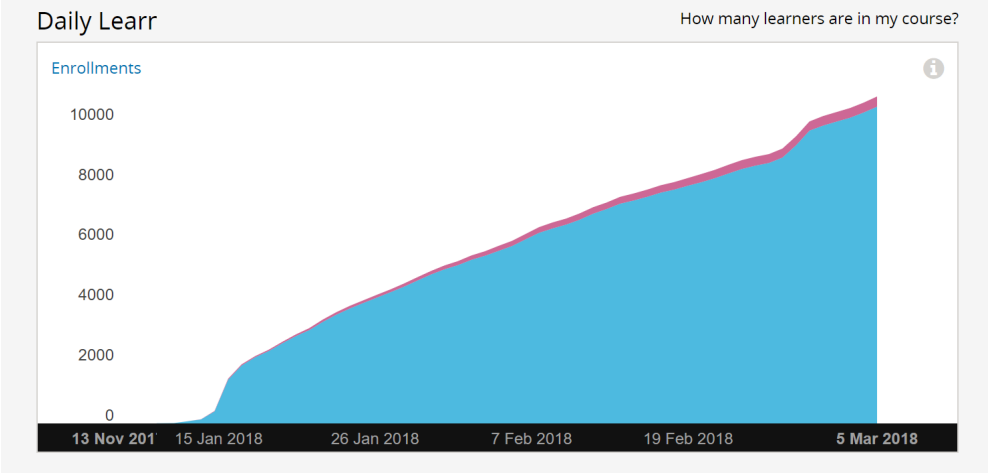
	Total
Enrollment	80k
Countries	173
Verified certificates ($49 each)	2700
YouTube views	1.9 million (5.7 million minutes)



Open Comments Analysis (by Dr. Kim Nicholson)

Cornell Engineering

Top 3 Themes:

- *Great course/Amazing*
- *Positive experience/I enjoyed learning*
- *Thanks*

Secondary Themes in Comments:
I gained a better understanding of the underlying math & physics
The connection between math/physics to industry was effective
Please provide more materials/courses of this kind

Student Comments

Cornell Engineering

1. After this course, I'm going to do more "Verification and Validation."

2. In other courses I attended, the instructor was teaching how to do by just pushing buttons but now I know that there is no demon inside the computer to do the magic; it is just science. Now I know how the software is working, what is the theory behind the calculations and how to check if my model is correct.

3. The high quality of the introduction to problems (LOVE the big ideas pieces) and careful stepping through complex mathematics to get the learner to a point where the ANSYS task makes sense is very engaging.

   I have a good understanding of the mathematics but the way it is explained here would have made my acquisition of that understanding so so much quicker. I [greatly] appreciate this course for the big picture and practical frame it puts over a very complex and what for me at times past was a bewildering area.

Instructor Comment

Cornell Engineering

- I will be using ANSYS as a tool for a freshman project-based course. I was looking for a tutorial online that the students could use considering that they would have never used ANSYS before.

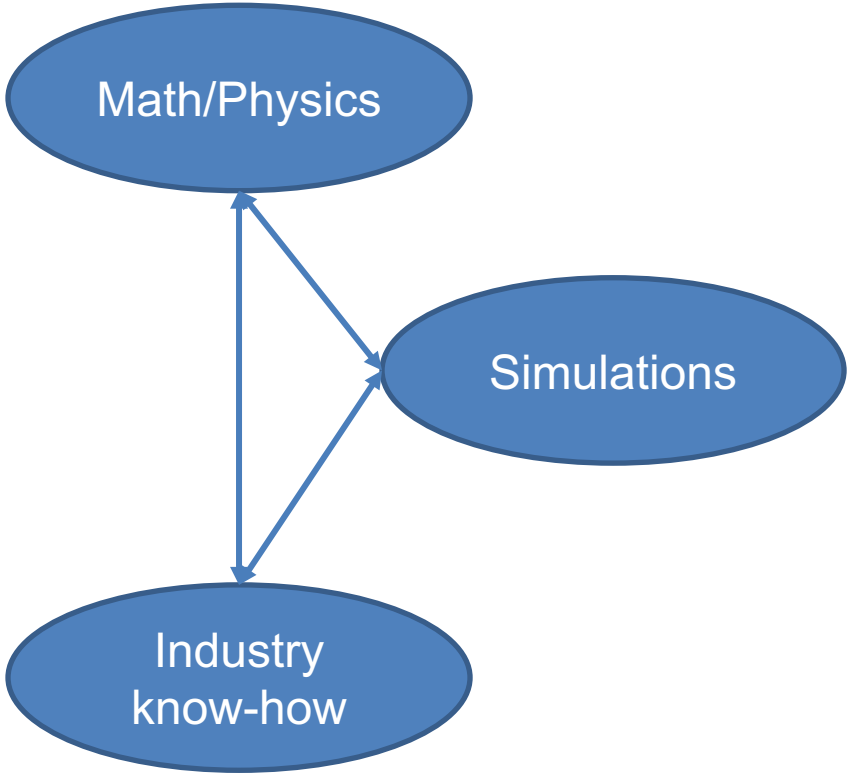
  Yesterday I was lucky enough to stumbled upon your [course]. I signed up to take it and, having gone over the first section, I'm sold! =) You've done an amazing job! Also, it is exactly the sort of thing I was looking for! I wanted the students to know what is under the hood without having to go into so much detail that you never get to use the software!

  The question I have is, would it be possible to use part of your course for my course?

A New Paradigm

Cornell Engineering

- Holistic approach
- Multi-disciplinary
- Just-in-time problem-based learning
- Novice > Expert
- Embraces automation
  - Simulation
  - Online learning
- Sage on the stage > Guide by the side
- Scales well
  - One person teaches thousands, one person at a time



Disrupting Engineering Ed to Democratize Simulations

Cornell Engineering

- Win-win
  - Learners
  - Employers
- Challenges
  - Cultural
    - Students are agents of change
  - Simulation app evolution