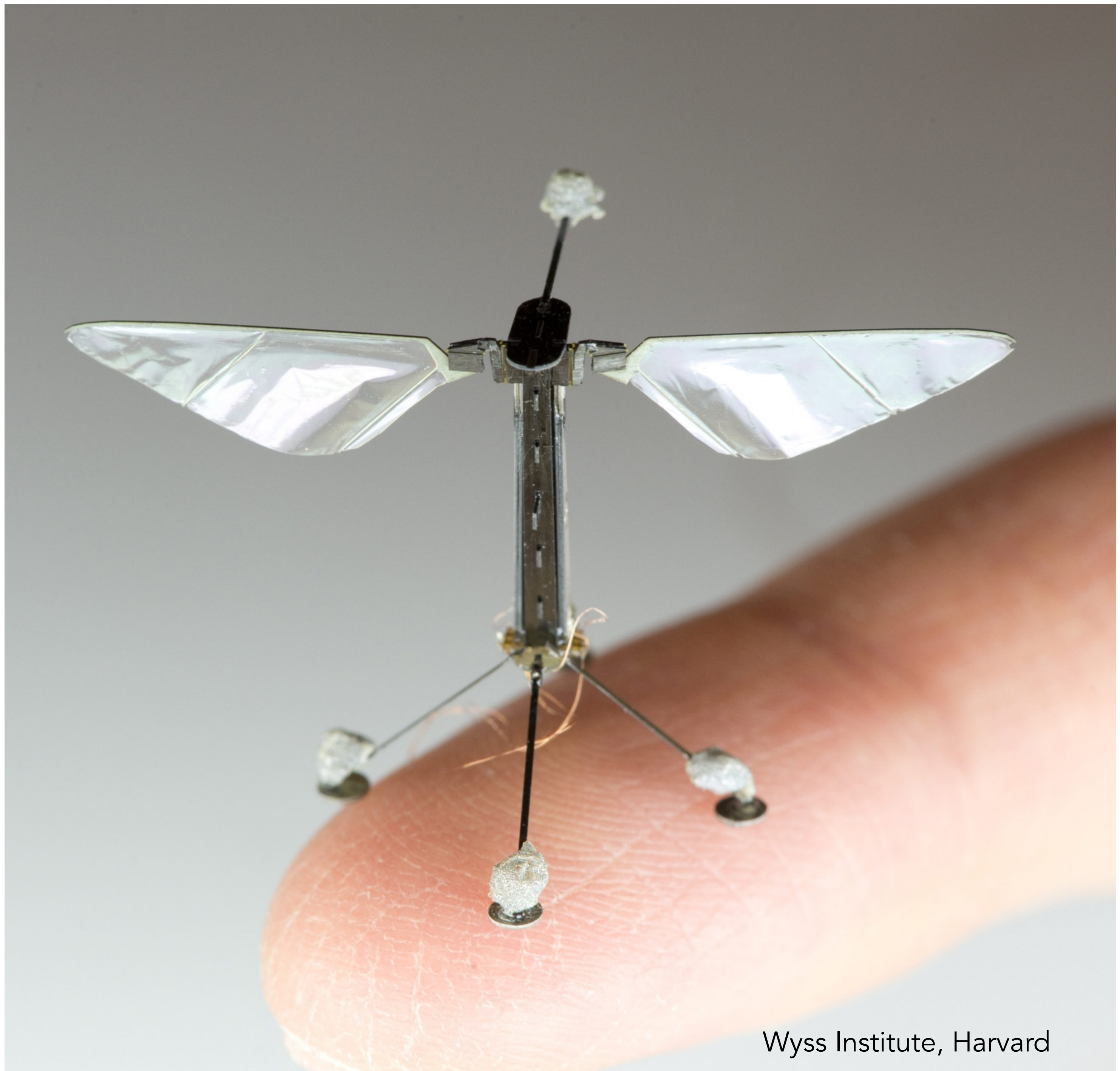
AE 370

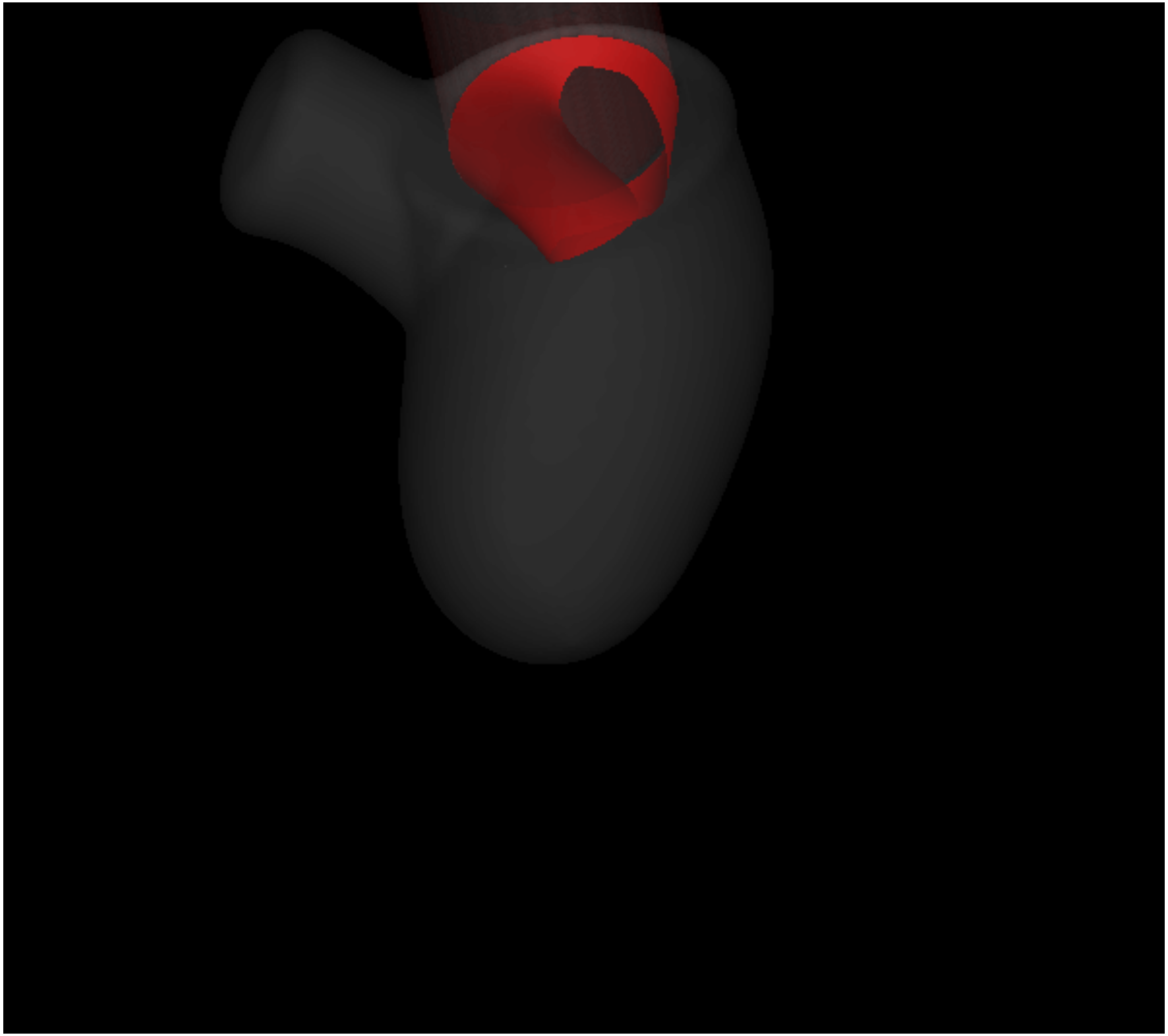
AKA how math is fun and powerful

Numerical methods: Drive understanding of the natural world

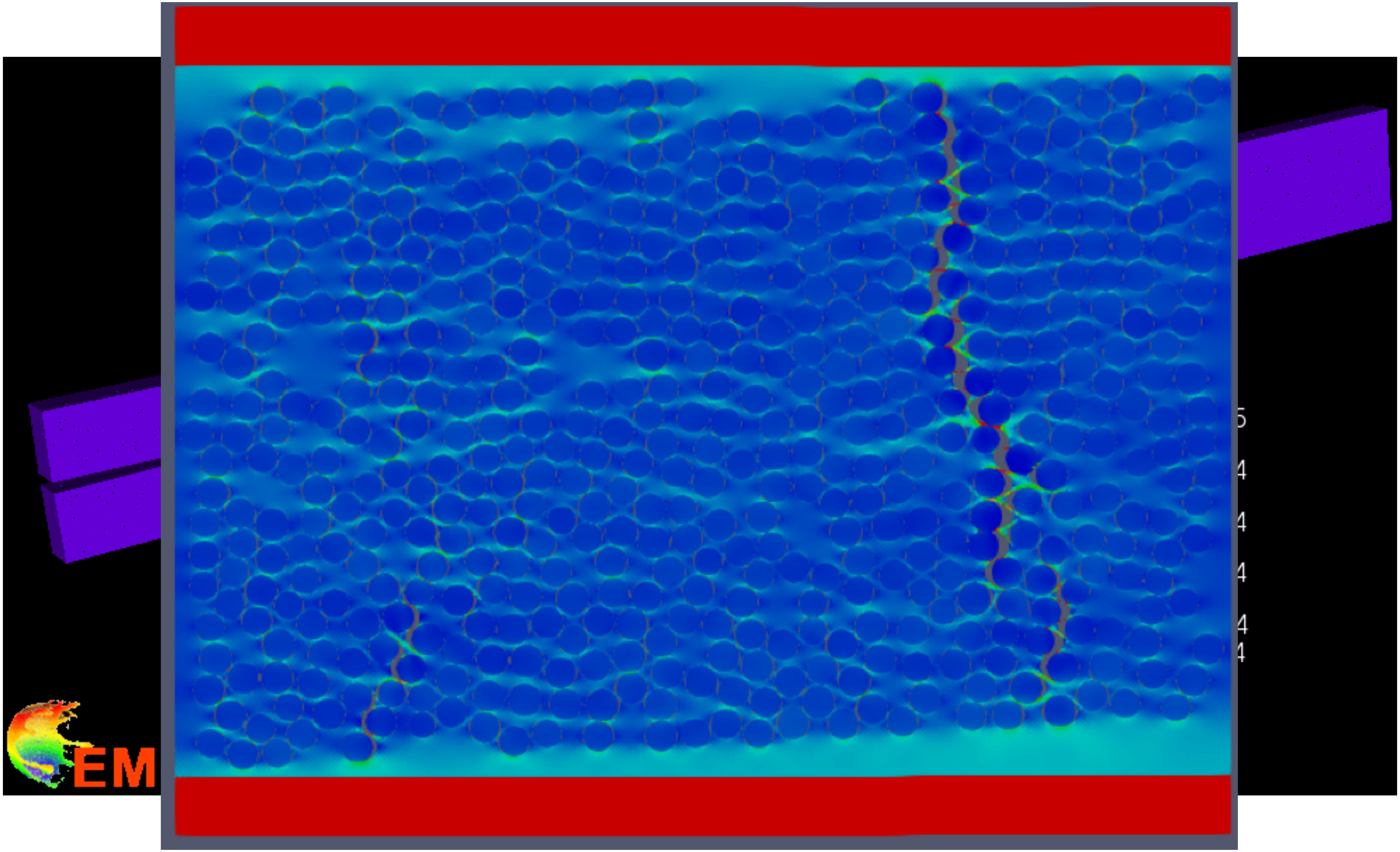
Inform new landscapes for the engineered world



Wyss Institute, Harvard



Rajat Mittal lab, UVA



Philippe Geubelle lab, UIUC

Goals for this class

Understand the mathematical fundamentals of prominent aerospace numerical methods

Be able to implement and apply these methods using code

Clearly communicate the application of these methods to challenging, open-ended problems through technical writing

Grow your comfort and appreciation for the beauty and power of mathematics and code

(have the ability to build off of 370 to develop methods for harder problems)

Weekly structure

Mondays: labs

Concept review + coding (topics from previous week)

We will work on a portion of that week's HW (yay for head starts!)

Goal: hands-on practice on understanding and implementing the material for homework-level problems

Wednesdays and Fridays: lectures

New concepts (theory)

	M	Tu	W	Th	F	Sa	Su
Lecture							
Take quiz							
Lab							
Do HW							

Imperatives

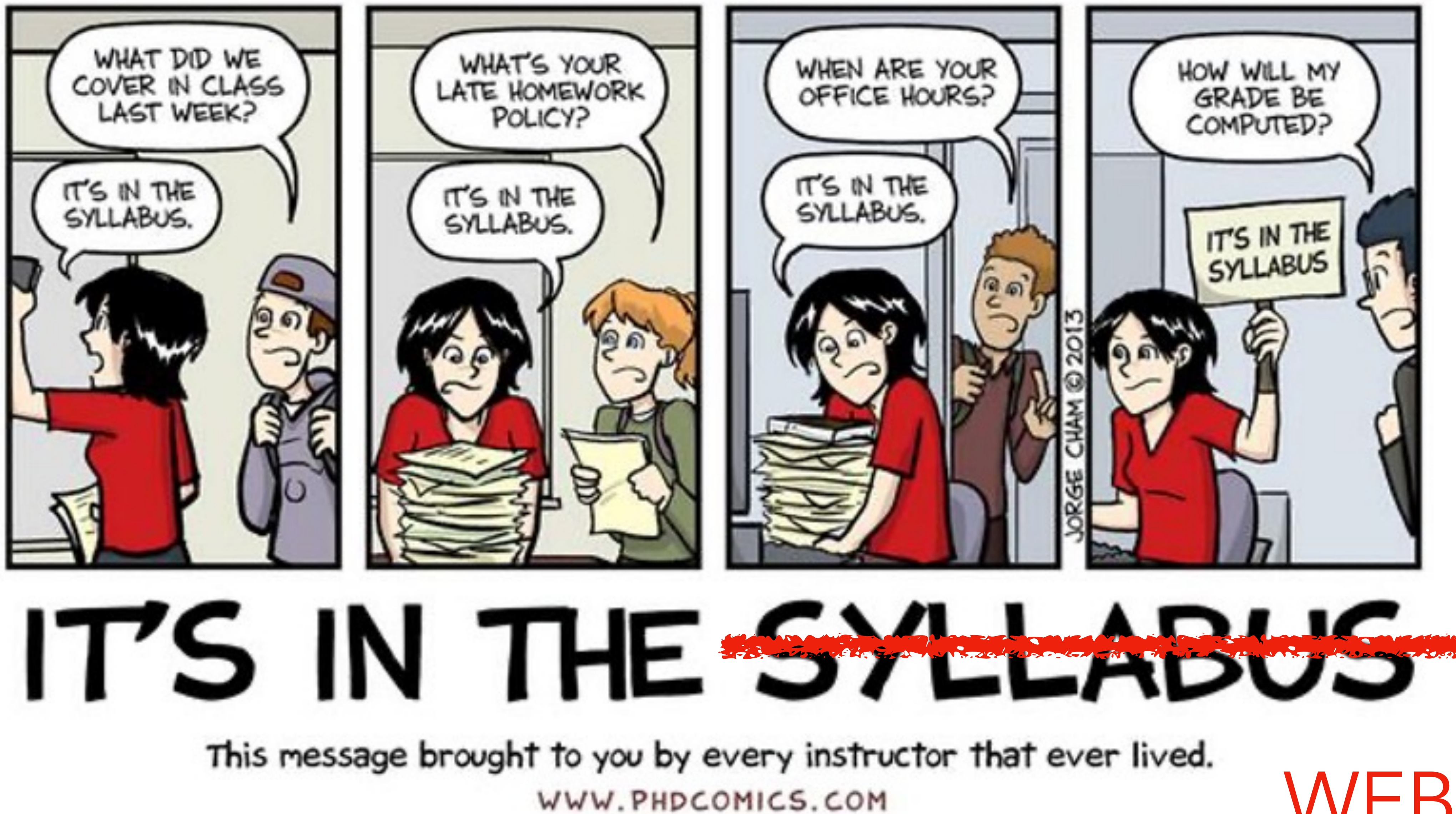
Embrace math and coding

Embrace failure

Engage with the course material and your peers!

Time management

Check the website!



WEBSITE

https://uiuc-ae370.github.io/

What are numerical methods?

We want to robustly & efficiently predict complex engineering phenomena

How do we turn that into a mathematical question?

To motivate this aim, remember the butterfly flapping video from lecture 1.

The flow dynamics are governed by Naiver-Stokes

$$\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} = -\nabla p + \frac{1}{Re} \nabla^2 \mathbf{u}$$

$$\nabla \cdot \mathbf{u} = 0$$

To predict phenomena, we have to be able to solve PDEs!

That is a hard problem. We will harness computers to help!
Let's build up in stages.

How will we approach numerical methods?

$$\frac{\partial \mathbf{u}}{\partial t} + \mathbf{u} \cdot \nabla \mathbf{u} = -\nabla p + \frac{1}{Re}\nabla^2 \mathbf{u} \qquad (1)$$

Let's make some observations:

Start w/ this next!

$\mathbf{u}$ is a function of $\mathbf{x}, t$ (space and time) → **Step 1**: we will learn how to approximate *prescribed* functions

Equation (1) is a PDE that depends on both space and time → **Step 2**: we will learn how to numerically solve *ODEs* in *time*

→ **Step 3**: we will learn how to numerically solve *ODEs* in *space*

→ **Step 4**: we will learn how to numerically solve *PDEs* in *space and time*

This is our roadmap for the semester!