

# MMAE 350 — Computational Mechanics

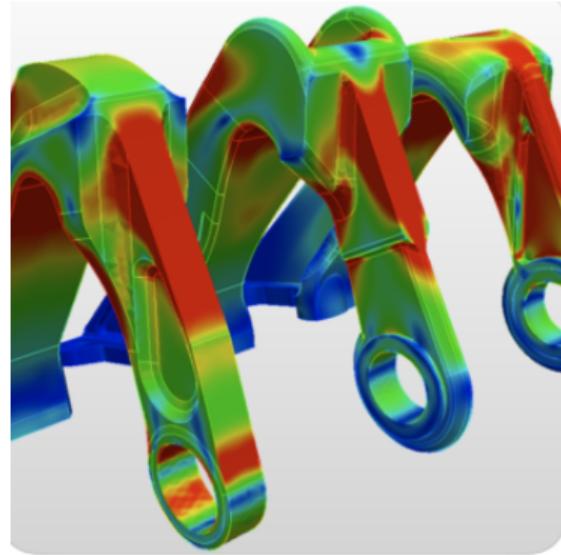
## Day 1: Course Introduction & Computational Workflow

Mike Gosz

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# Why Computational Mechanics?

- ▶ Many engineering problems have **no closed-form solution**
- ▶ Computation bridges **theory** and **real systems**
- ▶ Central in:
  - ▶ heat transfer
  - ▶ solid mechanics and dynamics
  - ▶ transport phenomena

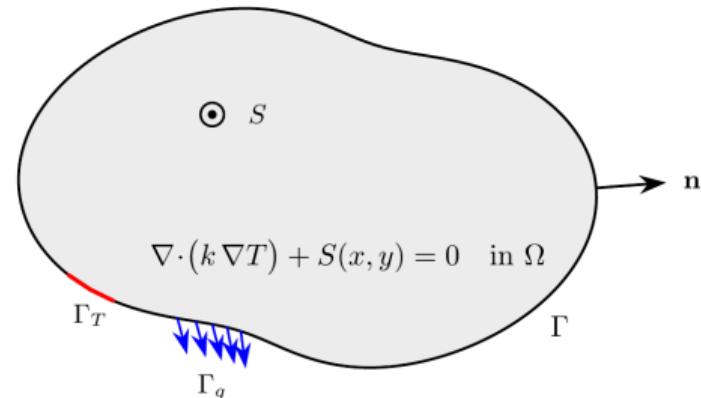


Stress distribution in mechanical part with complex geometry.

# What Is Computational Mechanics?

1. Physical system (assumptions + model)
2. Governing equations
3. Numerical approximation (discretization)
4. Computational solution
5. Interpretation and validation

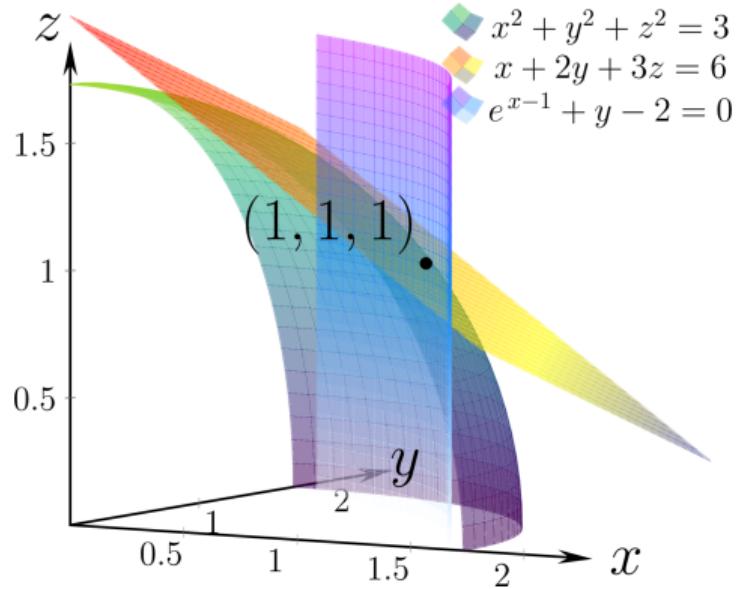
**Key message:** Computational mechanics is about **models**, not just numbers.



Complex geometry  $\Rightarrow$  discretization  $\Rightarrow$  computation

# Where This Course Fits

- ▶ Builds on:
  - ▶ calculus
  - ▶ differential equations
  - ▶ linear algebra
- ▶ Develops:
  - ▶ numerical thinking
  - ▶ computational implementation
  - ▶ interpretation of results
- ▶ Prepares you for:
  - ▶ upper-level MMAE courses
  - ▶ research and modeling
  - ▶ engineering simulation tools
  - ▶ machine learning
  - ▶ data analytics



Intersection of nonlinear surfaces representing a system of equations.

## What This Course Emphasizes

- ▶ Modeling, not memorization
- ▶ Algorithms, not button-pushing
- ▶ Understanding:
  - ▶ accuracy
  - ▶ stability
  - ▶ limitations and failure modes

**We will care why methods work—and when they fail.**

# Tools We Will Use

- ▶ **Python** as the computational language
- ▶ **Jupyter notebooks** for code + math + narrative
- ▶ Core libraries:
  - ▶ NumPy (arrays, linear algebra)
  - ▶ SymPy (symbolic math)
  - ▶ Matplotlib (plots)

**No prior Python experience is required.**

- Example 1.1--Python Warm UP

```
[1]: # Import Packages
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sympy import symbols, Matrix, solve
```

Create a simple NumPy array

```
[2]: x = np.linspace(0, 2*np.pi, 100)
y = np.sin(x)
plt.plot(x, y)
plt.xlabel('x')
plt.ylabel('sin(x)')
plt.title('Plot of the sine function')
plt.show()
```

Create and manipulate a matrix

```
[3]: A = Matrix([[2, 1], [5, 3]])
b = Matrix([5, 7])
x = A.LUsolve(b)
x
```

The command symbolically solves the system  $Ax = b$  and returns the solution vector.

```
[4]: for i in range(1, 6):
    print(f"Square of {i} is {i**2}")
for i in range(1, 6):
    print(f"Square of {i} is {i**2}")
```

The for loop

```
[5]: def area_rectangle(a, b):
    print(area_rectangle(3, 4))
```

Define and call a function

```
[6]: Note: functions are typically placed at the top of the Jupyter notebook after importing packages.
```

```
[7]: def area_rectangle(a, b):
    print(area_rectangle(3, 4))
12
```

Read and write data files

```
[8]: data = {'Name': 'John', 'Liam', 'Noah', 'Score': [92, 85, 88]}
df = pd.DataFrame(data)
df.to_csv('scores.csv', index=False)
df2 = pd.read_csv('scores.csv')
print(df2)
df2.to_csv('names_scores.csv')
```

Name	Score
John	92
Liam	85
Noah	88

# Why Jupyter Notebooks?

- ▶ Combine: formatted text, equations, executable code, and plots
- ▶ Ideal for:
  - ▶ exploration
  - ▶ verification of derivations
  - ▶ clear communication of results

# How the Course Is Structured

- ▶ Weekly modules on Canvas
- ▶ Mix of:
  - ▶ lectures
  - ▶ guided notebooks
  - ▶ homework assignments
- ▶ Two midterms + final exam or final project

The screenshot shows the Illinois Tech Canvas course page for Spring 2026 Computational Mechanics (MMAE-350-01). The course navigation bar includes links for Home, Syllabus, Modules, Discussions, Zoom, Precept Videos, People, Grades, Grade Library, and Course Evaluation. The main content area displays course details and several module cards with preview images.

A consistent weekly rhythm: learn → practice → assess

## What You Should Do This Week

- ▶ Review the syllabus (PDF)
- ▶ Complete Module 0 setup (Python + environment)
- ▶ Run Notebook 01 and make small edits
- ▶ Start Homework 1 (reflection + small computations)