Mechanics of Flexible Structures & Soft Robots
MAE-263F
Fall 2025

Homework 5

Due Date: 11:59 PM, 12/05/2025

You should create a single GitHub repository for this class and share it with the instructor (`khalidjm@seas.ucla.edu`). All the homeworks, reports, presentations, and proposal should be uploaded to this repository. Do not create a separate repository for each assignment. Within your repository, create a separate folder for each assignment (e.g., `homework_1`, `homework_2`, `homework_3`, `homework_4`, `homework_5`, `proposal`, `midterm_report`, and `final_report`).

Submission Instructions: Your submission on BruinLearn should only contain the URL to your GitHub repository. Your GitHub repository should include the following items:

1. **Report in PDF format:** Submit a report in `.pdf` format (file name should be `Homework5_LASTNAME.pdf`, replacing `LASTNAME` with your last name) addressing the questions asked in the deliverables. Include all the plots and figures requested in the assignment and discuss them in the report. See the syllabus for formatting requirements. As stated in the syllabus, you must use one of the provided templates.
2. **Source code:** The submission should include one main file named exactly as `HomeworkX.[ext]` (where `X` is the homework number) along with any additional files (e.g., functions or text files) as necessary. The main file should require no more than a single command to run or one click for execution.
3. **README file:** Add a `README.md` file on GitHub to provide clear instructions on how to run your code and describe the purpose of each file included in your repository.

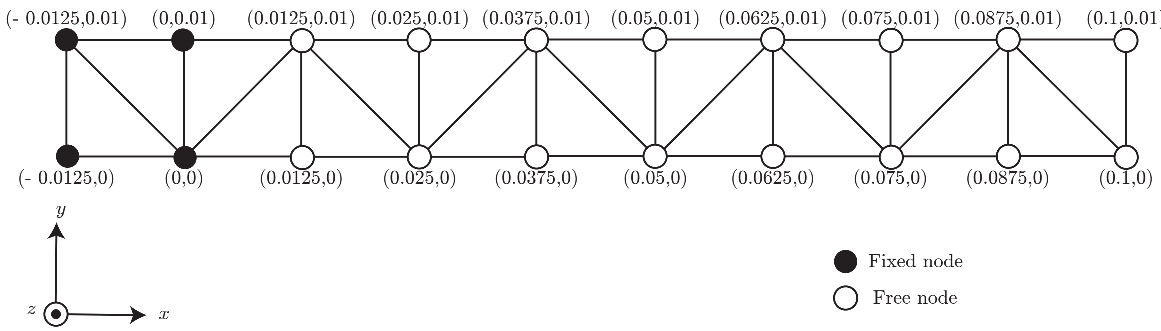
Deformation of a Clamped Thin Beam Using a Plate Model

In this homework, you will simulate the static deformation of a thin, rectangular beam under its own weight using the *discrete plate model* and compare your numerical results against the classical Euler-Bernoulli beam theory prediction.

Geometry & Material.
Beam dimensions:
length $l = 0.1$ m,
width $w = 0.01$ m,
thickness $h = 0.002$ m.

Material parameters:
Young's modulus $Y = 10^7$ Pa,
density $\rho = 1000$ kg/m^3.

Section properties (for Euler–Bernoulli comparison).
Cross-sectional area: $A = wh$.



Second moment of area: $I = \dfrac{wh^3}{12}$.
Distributed load from gravity: $q = \rho A g$.

Mesh.
Use the mesh shown in the figure above. The length of the free portion of the plate is $l = 0.1$ m. The four leftmost nodes are fixed to enforce the clamped boundary condition. Gravity acts in the negative z-direction.

Boundary Condition.
The left edge of the plate (at $x = 0$) is fully clamped: all displacement and rotation components are fixed.

Plate Model Simulation.
Model the domain $l \times w$ as a thin plate of thickness h. Compute the static deformation by solving the equilibrium equations until the configuration reaches steady state.

Let the tip displacement at the centerline of the free edge $x = l$ be

$$\delta_{\text{plate}}(t) = z_{\text{tip}}(t) - z_{\text{tip}}(t = 0).$$

Report the steady displacement in your report and include a plot of the tip displacement as a function of time.

Comparison with Euler–Bernoulli Beam Theory.
For a cantilever beam under uniform load q (Newton per meter), the Euler-Bernoulli tip displacement is

$$\delta_{\text{EB}} = \frac{q\, l^4}{8\, Y\, I}.$$

In your report, compare steady displacement from discrete plate simulation with the prediction from Euler-Bernoulli beam theory.

Deliverables. At minimum, your report must include:

- Steady displacement from discrete plate simulation (δ_{plate}) and theoretical prediction (δ_{EB}), and their normalized difference.
- A plot of δ_{plate} vs. time t.

Figure Requirements. All plots must include labeled axes with physical *units*, and each figure must have a caption with a figure number. Export high-resolution vector graphics (PDF). Do not use screenshots.