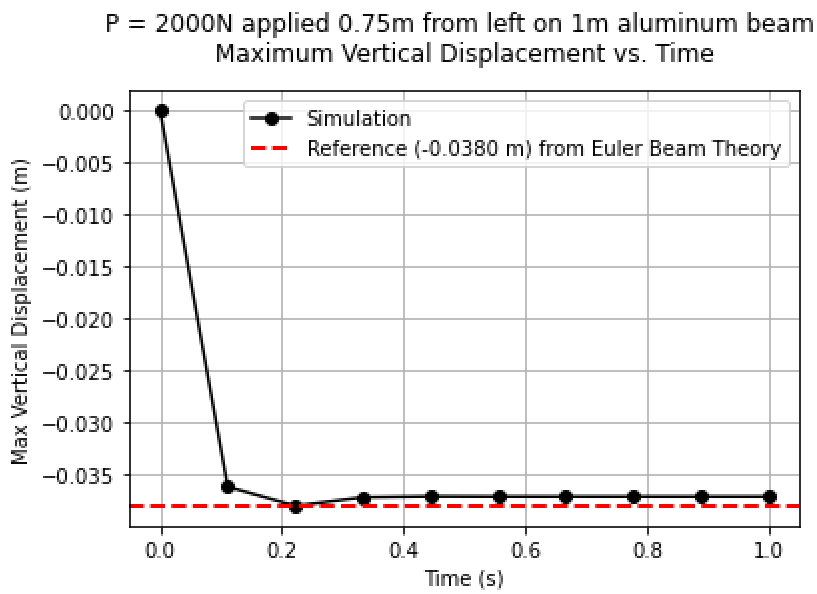
Nathan Ge
905597306

MAE 263F HW2

Task: Write a solver that simulates the beam as a function of time (between 0 ≤ t ≤ 1 seconds) implicitly. Use Δt = 10−2 s for the implicit simulation and N = 50.

1. Plot the maximum vertical displacement, ymax, of the beam as a function of time. Depending on your coordinate system, ymax may be negative. Does ymax eventually reach a steady value? Examine the accuracy of your simulation against the theoretical prediction from Euler beam theory:



y_{max} does eventually reach steady state.

Theoretical prediction from Euler beam theory: $y_{max} \simeq - 0.038045\ m$

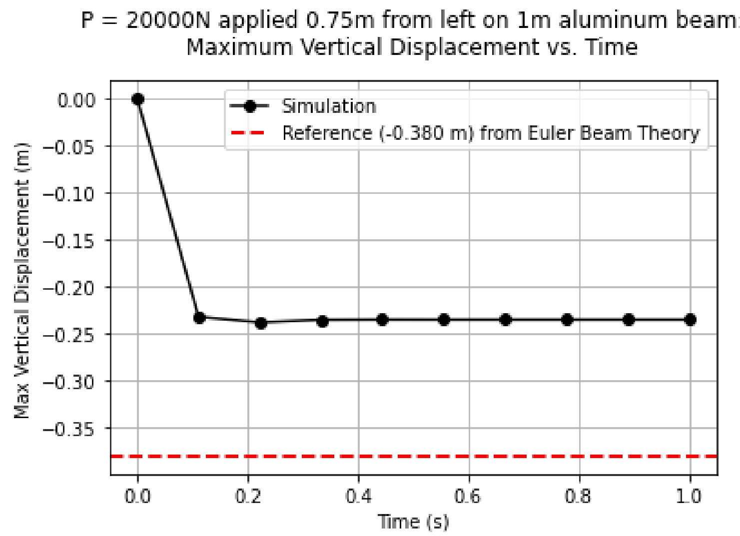
The simulation resolves to, or reaches a steady state y_{max} value of $- 0.03711\ m$

Relative steady error (%): E_rel = 100 * (y_sim_ss - y_theory)/y_theory = 2.458%

The simulation results show that the beam's max deflection eventually reaches a steady-state value of –0.03711 m, while the theoretical deflection predicted by Euler–Bernoulli beam theory is –0.038045 m. The relative steady-state error between the two is approximately 2.46%. This level of agreement indicates that the simulation accurately captures the static response of the beam.

Nathan Ge
905597306

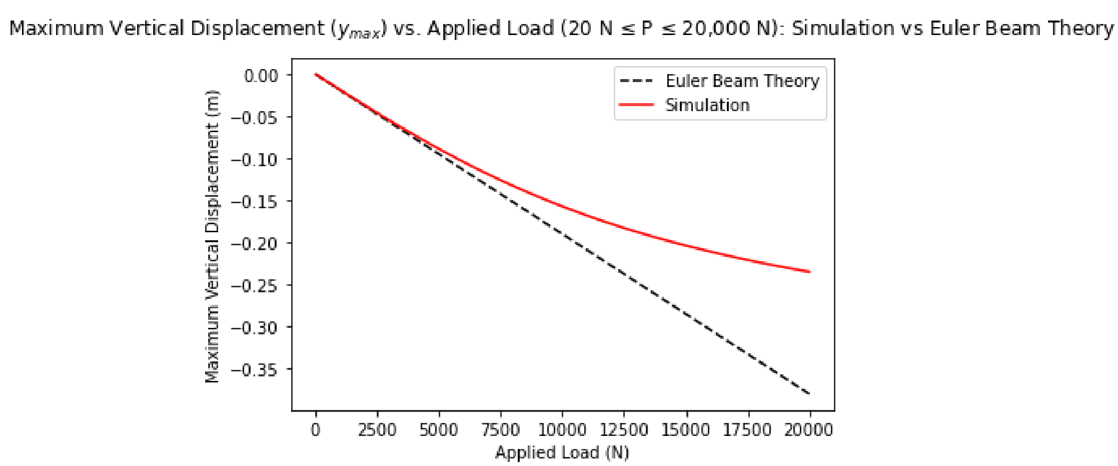
2. What is the benefit of your simulation over the predictions from beam theory? To address this, consider a higher load P = 20,000N such that the beam undergoes large deformation. Compare the simulated result against the prediction from beam theory in Eq. 5. Euler beam theory is only valid for small deformation whereas your simulation, if done correctly, should be able to handle large deformation. You should create a plot of P (20 N ≤ P ≤ 20, 000 N) vs. ymax using data from both simulation and beam theory and quantify the value of P where the two solutions begin to diverge.



Theoretical prediction from Euler beam theory: $y_{max} \simeq -\ 0.3805\ m$

The simulation resolves to, or reaches a steady state y_{max} value of $-\ 0.2352\ m$

Relative steady error (%): E_rel = 100 * (y_sim_ss - y_theory)/y_theory = 38.186%
The relative steady-state error between the two is approximately 38.186%, which represents a significant deviation from the theoretical value. Such a large difference suggests that the assumptions underlying the Euler–Bernoulli beam model are not entirely valid for this case.



Nathan Ge
905597306

At P = 6220.69 N, the simulation predicted a displacement of -0.107887 m, deviating from the theoretical value by more than 1cm, marking a point of significant departure from Euler–Bernoulli beam theory.

Maximum Vertical Displacement (y_{max}) vs. Applied Load (20 N ≤ P ≤ 20,000 N): Simulation vs Euler Beam Theory