Homework 2 MAE 263F

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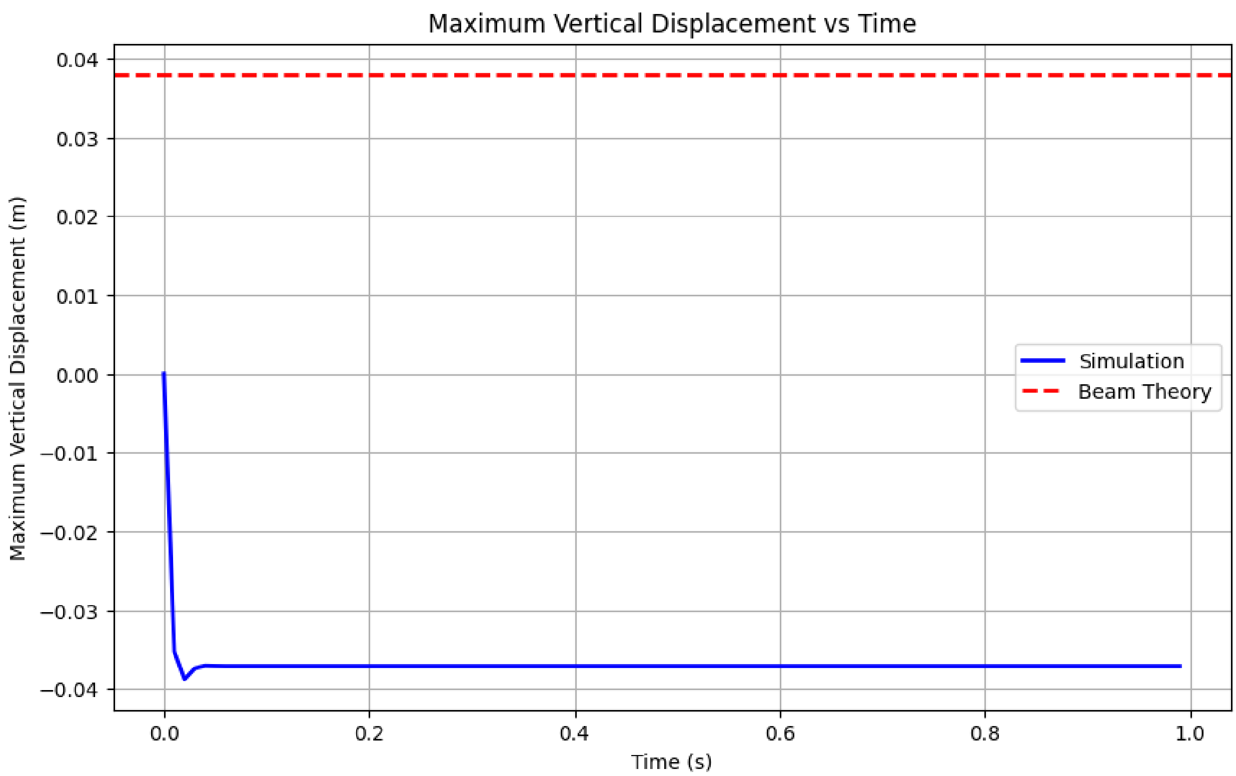
1. Plot the maximum vertical displacement, ymax, of the beam as a function of time. Depending on your coordinate system, ymax may be negative. Does ymax eventually reach a steady value? Examine the accuracy of your simulation against the theoretical prediction from Euler beam theory:

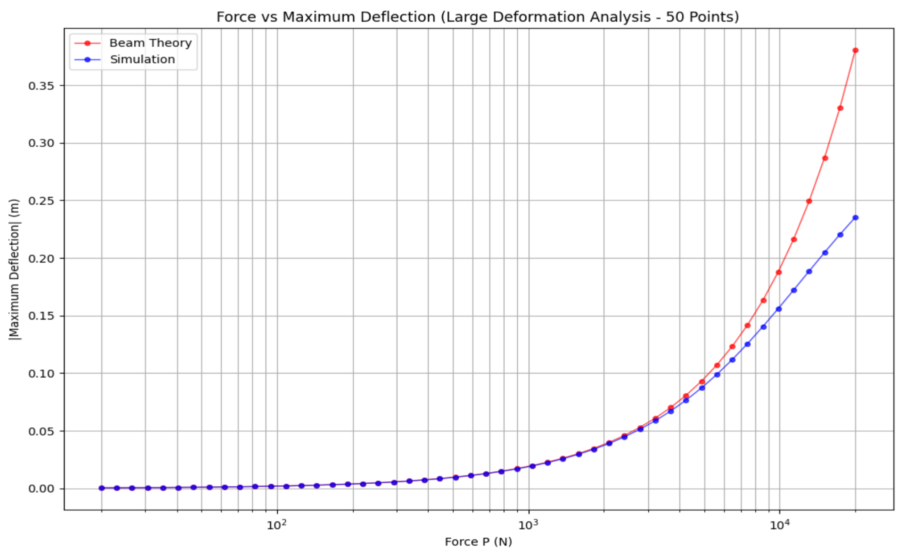
Theoretical maximum deflection: 0.038045 m

Simulated maximum deflection: -0.037109 m



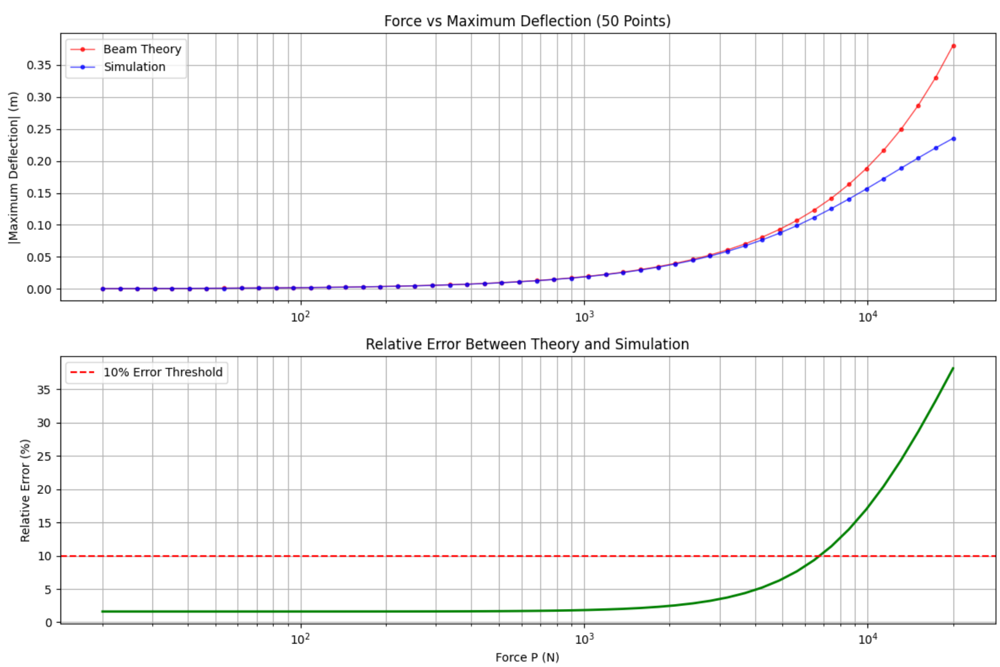
The plot above shows Y_{max} as negative due to the chosen coordinate system. The beam reaches steady state in under 0.05 s, with a final displacement magnitude of 0.0371 m. The analytical prediction is 0.0380 m, giving a 2.5% error. This close match confirms that the analytical model and simulation are both accurate for small-deformation behavior.

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.



First significant divergence point found at P ≈ 7455 N

Relative error: 11.4%



The simulation captures large-deformation effects that Euler–Bernoulli theory misses. Both methods agree well at small loads, but they start to diverge around $P \approx 7455$N, where the error reaches about 11%. Beyond this point, beam theory underestimates deflection due to the small-angle and linear strain assumptions. At higher loads (e.g. $P = 20{,}000$N), the simulation remains accurate by including geometric nonlinearities, making it more reliable for large deflections where classical theory fails.