UNIVERSITY OF CALIFORNIA, LOS ANGELES

MAE 263F: Mechanics of Flexible Structures and Soft Robot

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Homework 2 Report

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Oct 27, 2025

1. Implicit Simulation For A Falling Beam

This Homework covers the deflection of a beam with discrete representation through spherical masses with springs. The following are inputs:

Parameter	**Value**
L	1
R	0.013 m
r	0.011 m
P	2000 m
d	0.75 m
E	70 GPa

Table 1: Input Parameters

I is the moment of inertia of the cross section,

$$I = \frac{\pi}{4}(R^4 - r^4). \tag{1}$$

The beam can be represented as a mass-spring system with a mass m located at each node, where

$$m = \pi(R^2 - r^2)l\rho/(N-1). \tag{2}$$

With the following boundary conditions:

$$\begin{aligned} x_1(t_{k+1}) &= 0, \\ y_1(t_{k+1}) &= 0, \\ y_N(t_{k+1}) &= 0. \end{aligned} \tag{3}$$

Goal: Simulate the beam as a function of time (between $0 \leq t \leq 1$ seconds) implicitly with $\Delta t = 10^{-2}$ s. The code for the simulation is the same implicit solver that was used in HW 1 with increased number of nodes, different boundary conditions, and the masses are now determined according to the beam total mass, not simply a unit mass like before.

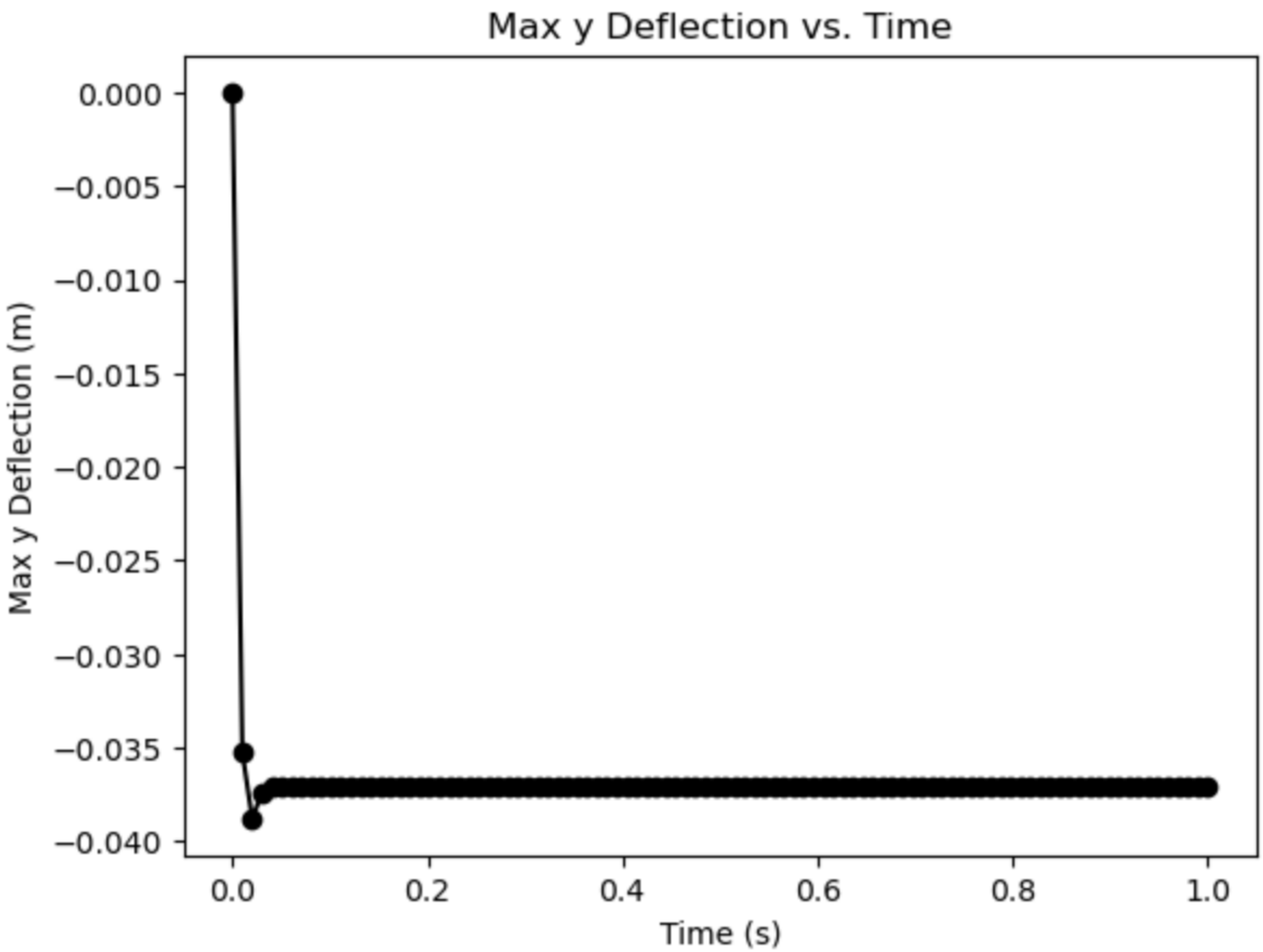

Figure 1: Maximum y deflection over time

The maximum deflection for this case is $y_{max} = -0.0371$m with the simulation while the Euler beam theory result is $y_{max} = -0.0380$m using the following relation:

$$y_{\max} = \frac{Pc(l^2 - c^2)^{1.5}}{9\sqrt{3}EIl} \quad \text{where} \quad c = \min(d,\, l - d) \tag{4}$$

The results match very closely in this case. The Euler beam theory is valid at this applied point load.

2. Implicit Simulation vs Euler Beam Theory

This section covers the comparison of the beam theory with the simulation.

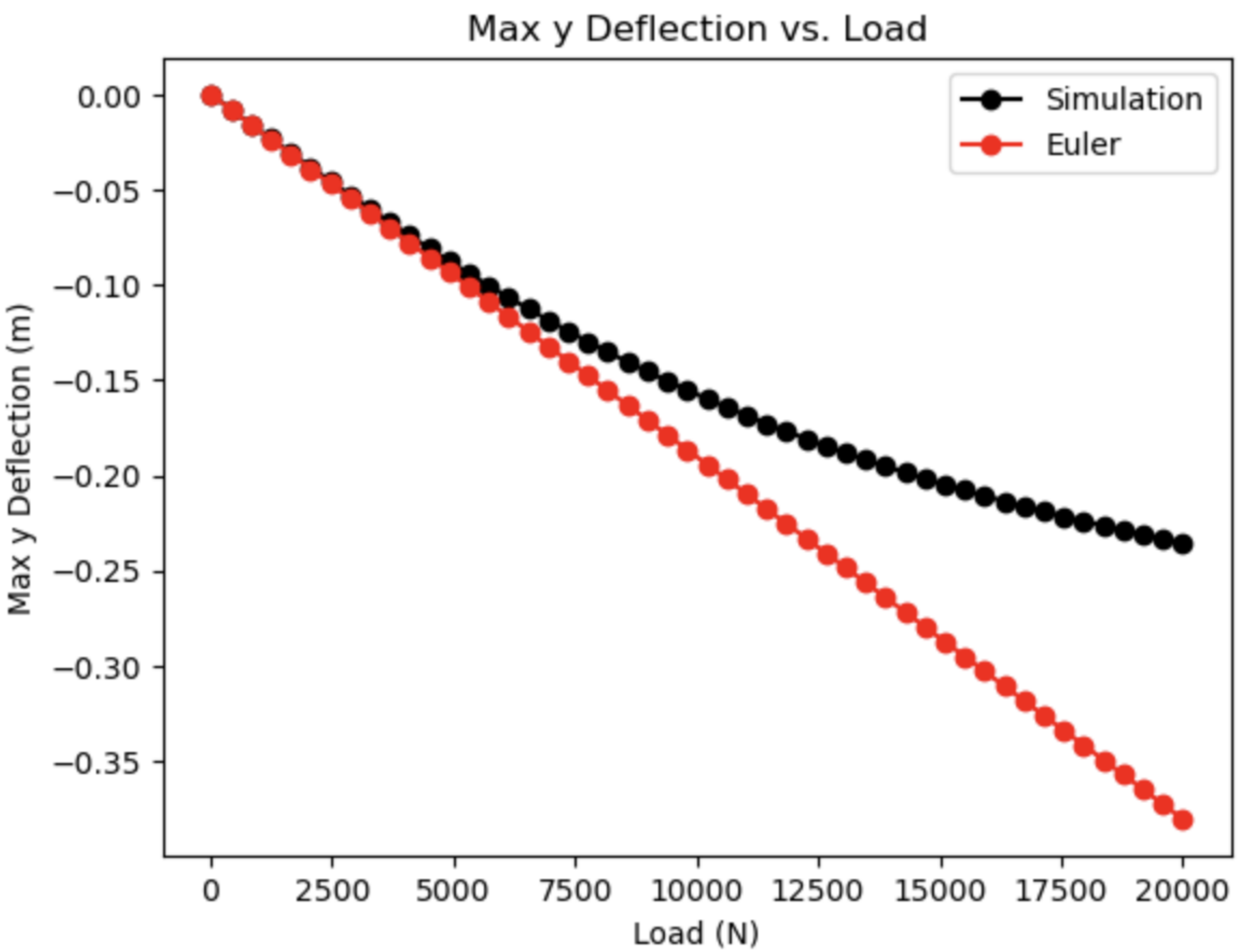

Figure 2: Simulation and Euler Beam Theory Results with Increasing Load

The results indicate that the beam theory diverges from simulation results near a load of 4000N in this system. The exact number depends on the range of error set between the two, number of nodes in the simulation, and the number of steps plotted in the 0 to 20000N range of load. Roughly around this load, for this given system configuration, the small deformation assumption in the beam theory starts to fall apart. The simulation is valid for larger deflections. Simulation results for deflection with increased load are non linear as apposed to the beam theory, which assumes linear as the results are linear near the lower range of loads.