Homework1 _Ren

Zhicheng Ren

***Abstract*—Homework1.**

I. PROBLEM 1

A. 1)

For Implicit

Figure 1. Structure Configuration at Time t = 0s

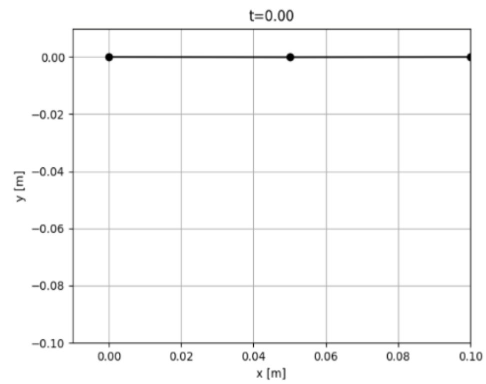


Figure 2. Structure Configuration at Time t = 0.01s

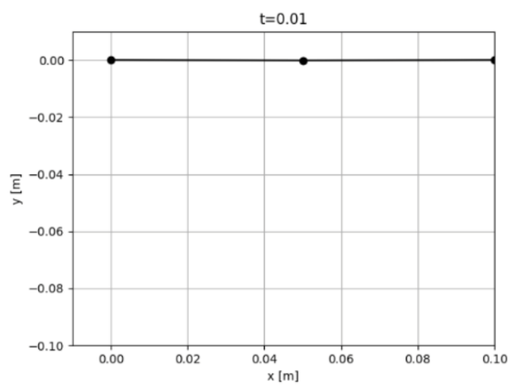


Figure 3. Structure Configuration at Time t = 0.05s

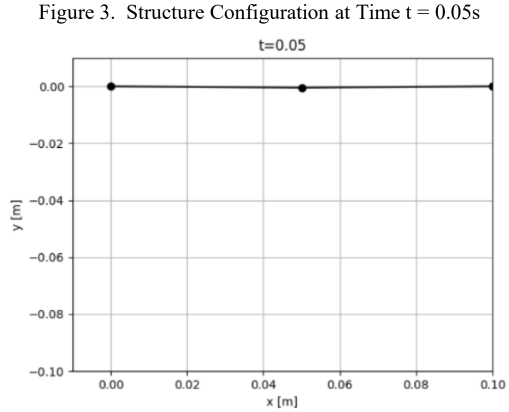


Figure 4. Structure Configuration at Time t = 0.1s

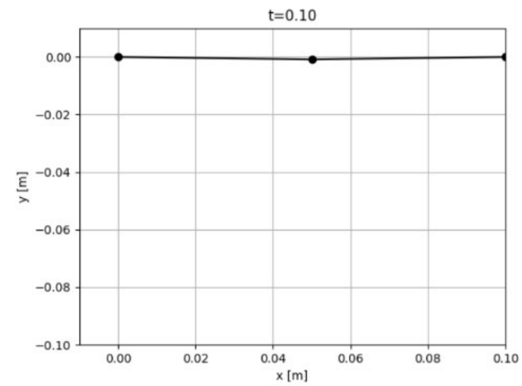


Figure 5. Structure Configuration at Time t = 1s

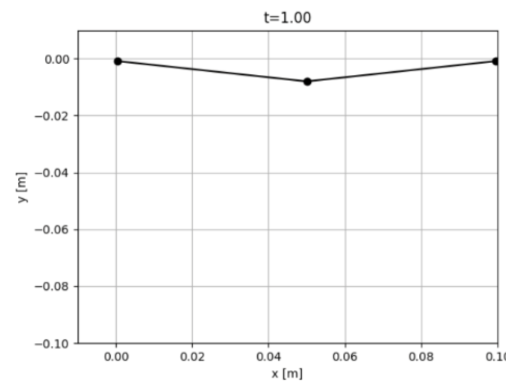


Figure 5. Structure Configuration at Time t = 10s

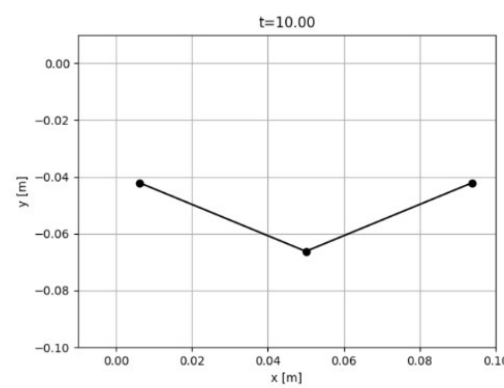


Figure 6. Position of R2

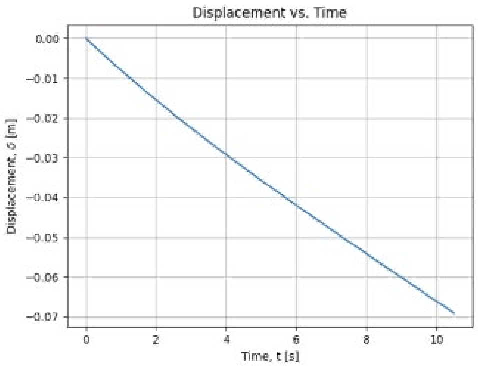
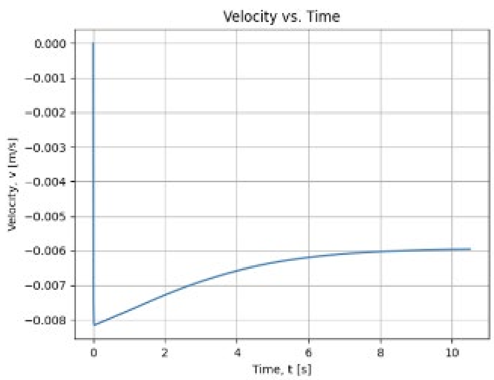


Figure 7. Velocity of R2



For explicit

Figure 8. Structure Configuration at Time t = 0s

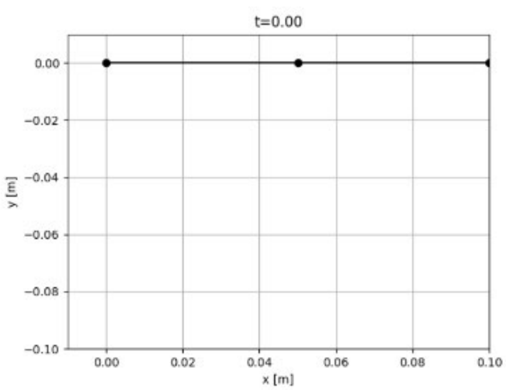


Figure 9. Structure Configuration at Time t = 0.01s

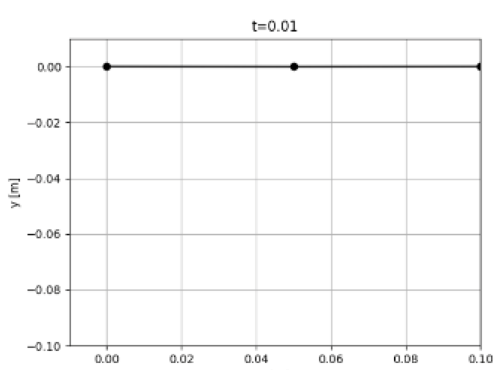


Figure 10. Structure Configuration at Time t = 0.05s

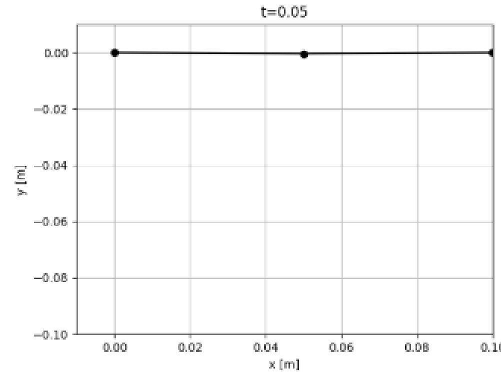


Figure 11. Structure Configuration at Time t = 0.1s

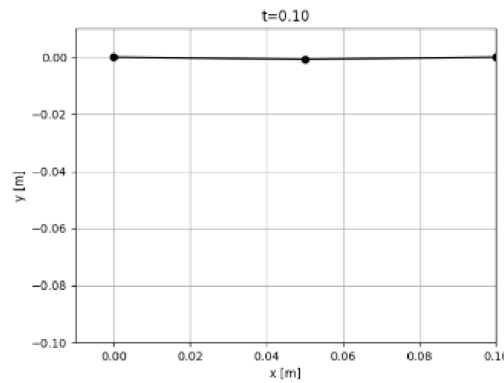


Figure 12. Structure Configuration at Time t = 1s

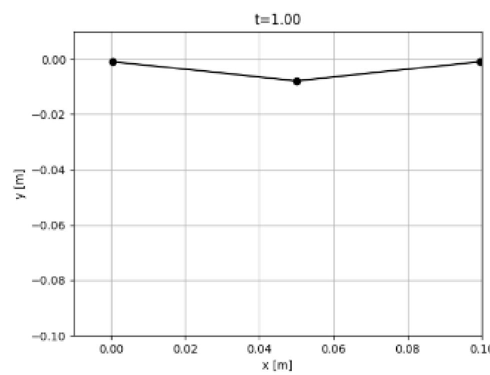


Figure 13. Structure Configuration at Time t = 10s

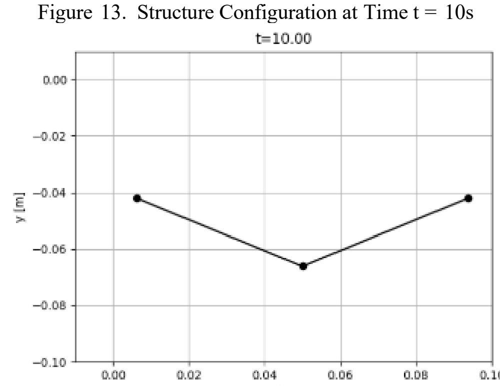


Figure 14. Position of R2

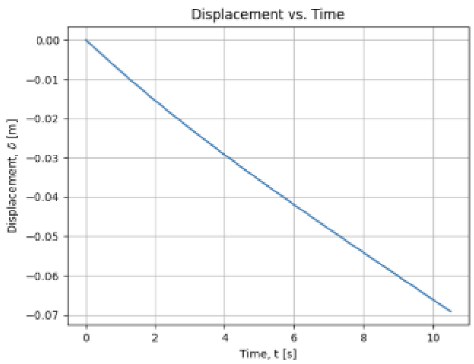
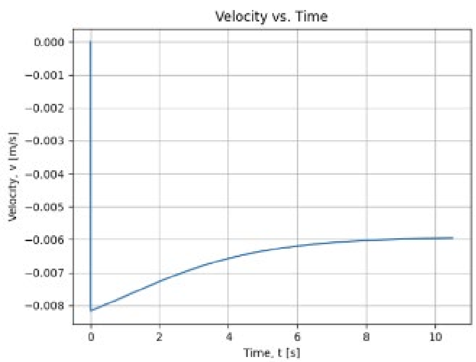


Figure 15. Velocity of R2



B. 2)

The system's terminal velocity along the y-axis is -0.00596627 m/s.

C. 3)

When the radii R1,R2,R_1, R_2,R1,R2, and R3R_3R3 are all equal, the turning angle should consistently be zero. Simulations confirm that setting all three sphere radii to 0.025 m results in a turning angle of zero, aligning with intuitive expectations.

D. 4)

Increasing the step size causes the explicit method to become unstable at large time steps, leading to sudden spikes in position and velocity, as well as oscillations in position. Therefore, a small time step is necessary to ensure accurate and stable calculations. While the explicit method is computationally straightforward, it loses stability with larger step sizes. In contrast, the implicit method, although more complex to compute, remains stable even when using larger step sizes.

II. PROBLEM 2

A. 1)

Figure 17. Velocity of the middle node

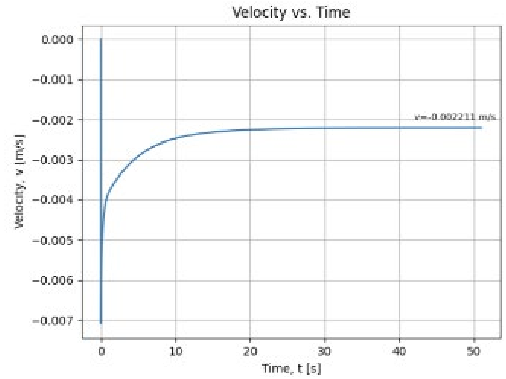
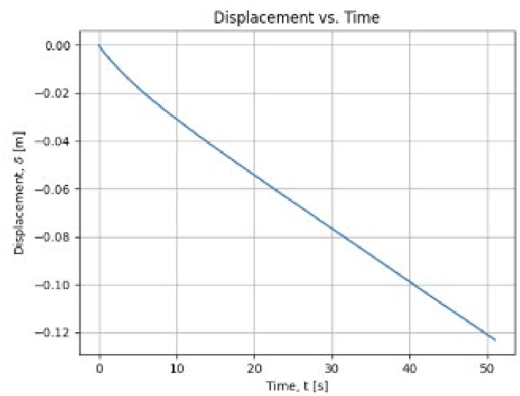


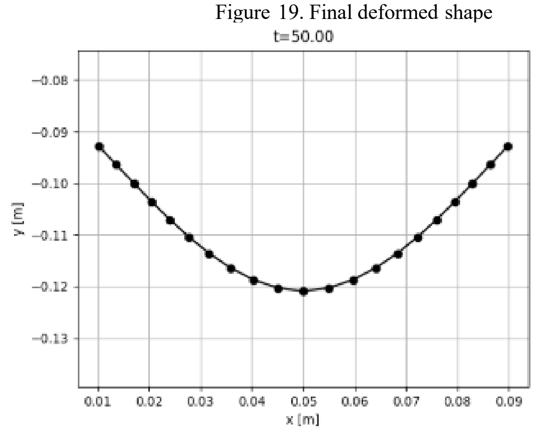
Figure 18. Vertical position of the middle node



The terminal velocity is -0.00247545m/s

B. 2)

Figure 19. Final deformed shape



C. 3

When the spatial discretization—represented by an increased number of nodes NNN—is refined and the temporal discretization—indicated by a decreased time step size Δt\Delta tΔt—is made finer, the terminal velocity reaches a stable value. Using too few nodes or larger time steps can lead to errors or instability, whereas overly fine refinement can escalate computational costs with minimal gain. By plotting the terminal velocity against the number of nodes and time step sizes, one can verify the convergence of the solution and ensure the results are reliable.

Figure 20. Terminal velocity vs. Number of nodes

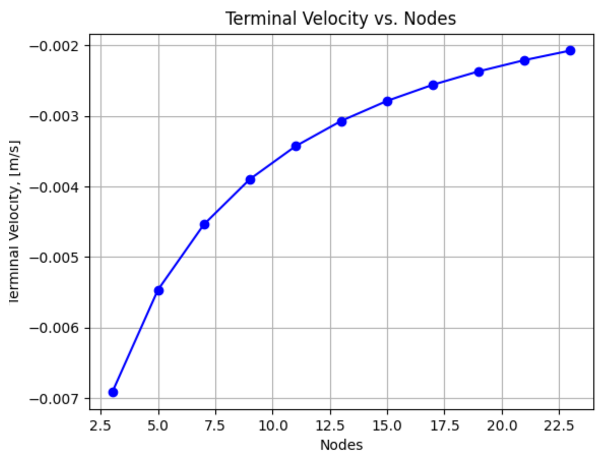
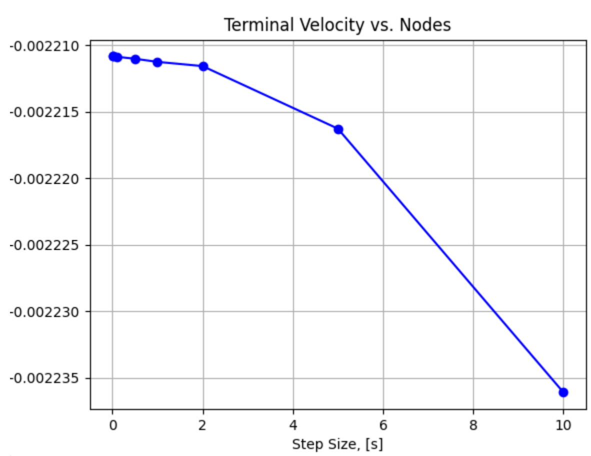


Figure 21. Terminal velocity vs. Time step size



III. PROBLEM3

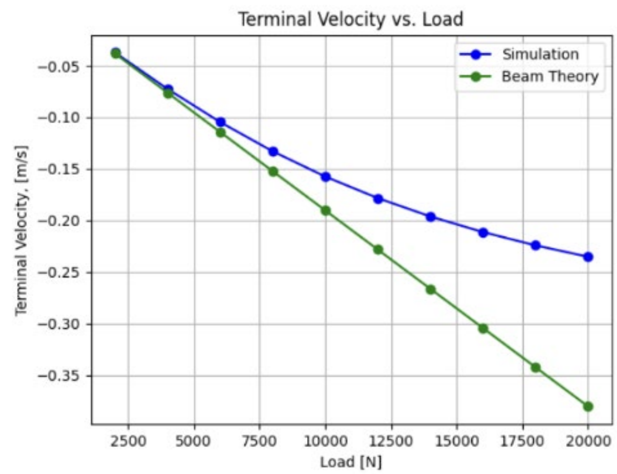
A. 1)

By using the equation below:

$$y_{\max} = \frac{P_c (L^2 - c^2)^{1.5}}{9\sqrt{3} E I l}$$

We can get y_{max} is 0.03804m. Which have an error compared to the simulation results.

Figure 22. Vertical position of the max node



B. 2)

By gradually increasing the load, a significant discrepancy between Euler beam theory and simulation emerges at a load of 20,000 N. At this point, the maximum deflection ymaxy,ymax predicted by Euler beam theory is smaller than that obtained from the simulation. Compared to Euler beam theory, simulations have the advantage of handling large deformations. Euler beam theory is applicable only to small deformations, and when the load is large, the beam experiences nonlinear large deformations, making the simplified assumptions of beam theory invalid. Simulations can capture these nonlinear effects and provide more accurate results.