Homework1_He

Jiahua He

***Abstract*— This electronic document is a report of Homework1 for 263F.**

I. Problem 1

A. 1)

For Implicit

Figure 1. Structure Configuration at Time t = 0s

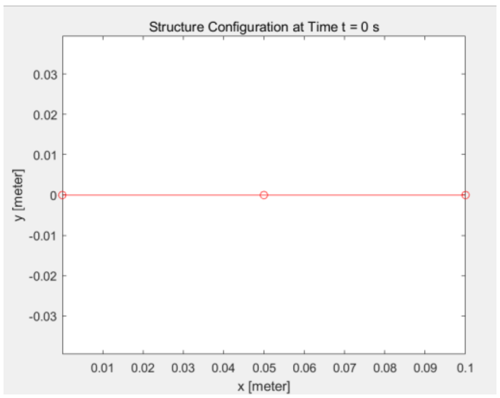


Figure 2. Structure Configuration at Time t = 0.01s

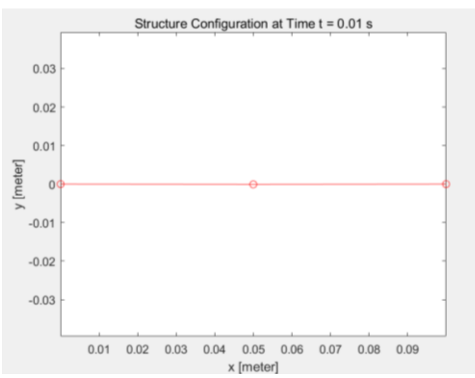


Figure 3. Structure Configuration at Time t = 0.05s

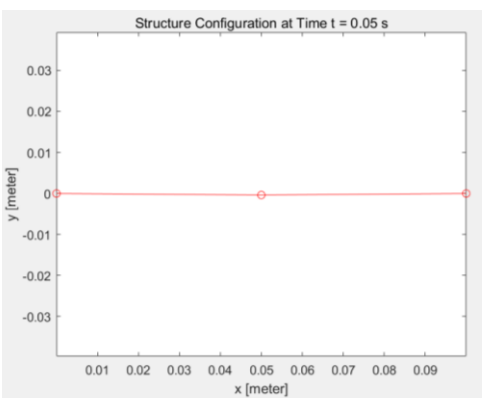


Figure 4. Structure Configuration at Time t = 0.1s

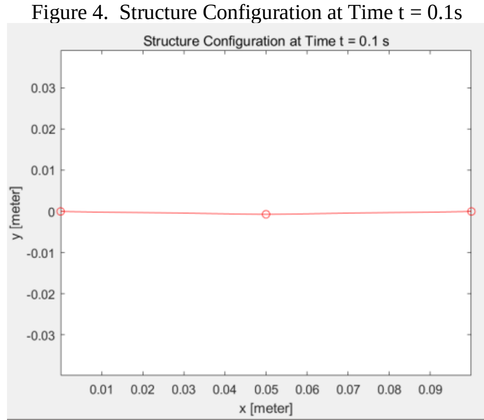


Figure 5. Structure Configuration at Time t = 1s

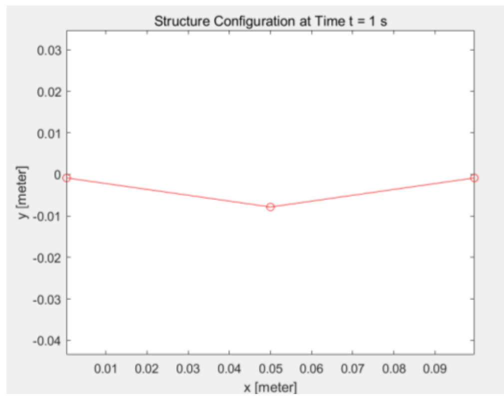


Figure 5. Structure Configuration at Time t = 10s

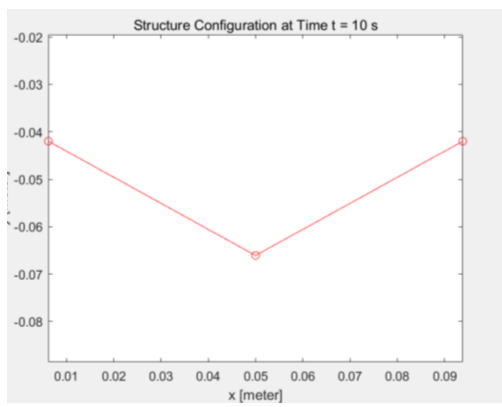


Figure 6. Position of R2

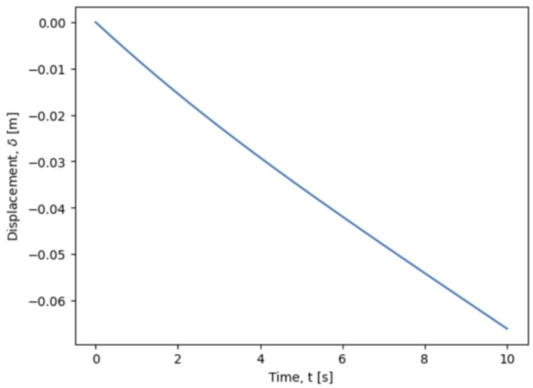
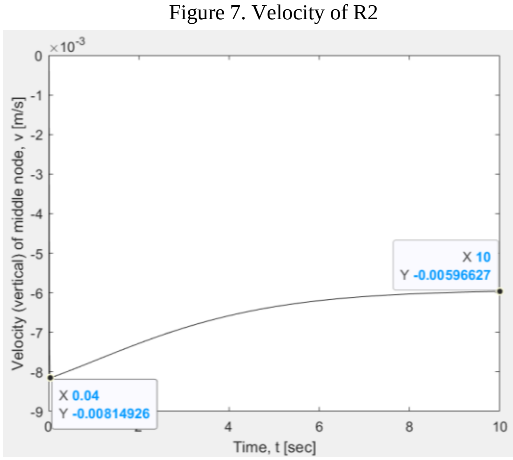


Figure 7. Velocity of R2



For explicit

Figure 8. Structure Configuration at Time t = 0s

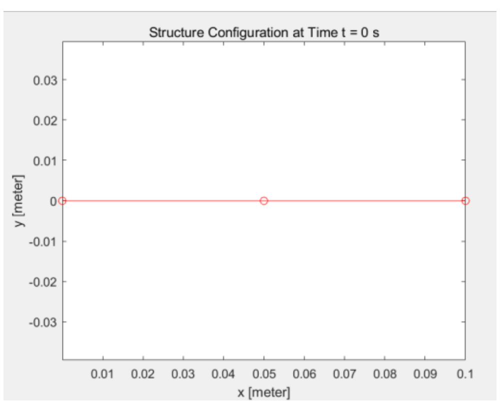


Figure 9. Structure Configuration at Time t = 0.01s

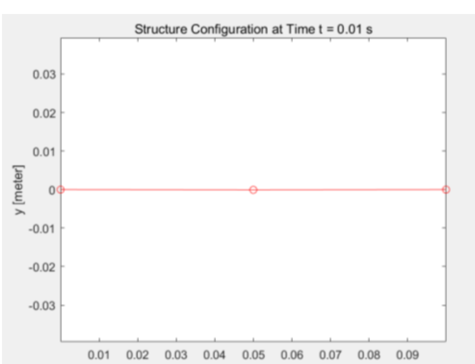


Figure 10. Structure Configuration at Time t = 0.05s

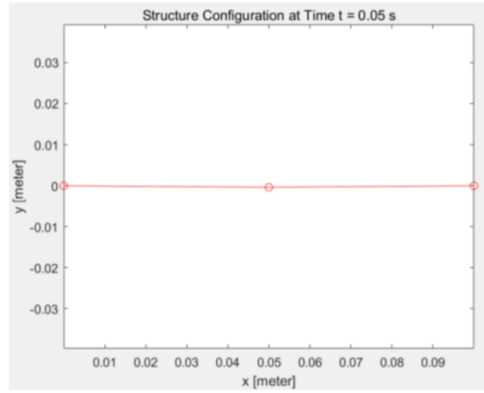


Figure 11. Structure Configuration at Time t = 0.1s

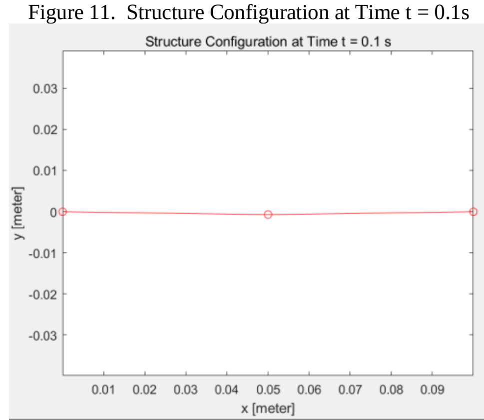


Figure 12. Structure Configuration at Time t = 1s

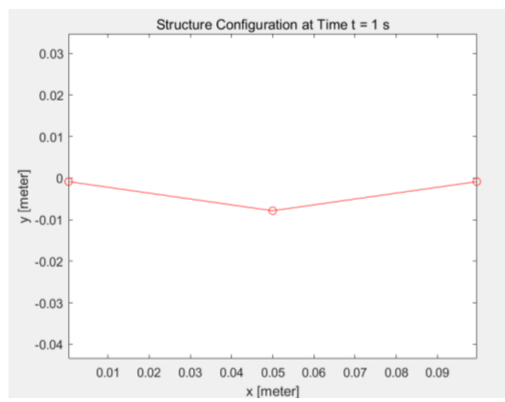


Figure 13. Structure Configuration at Time t = 10s

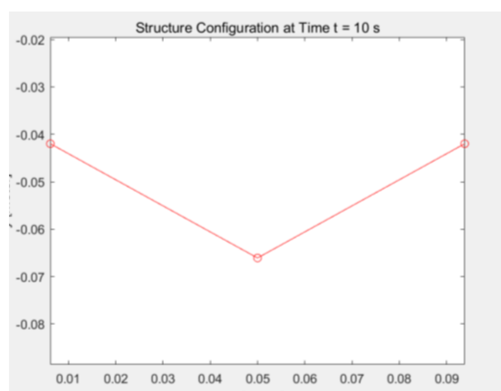


Figure 14. Position of R2

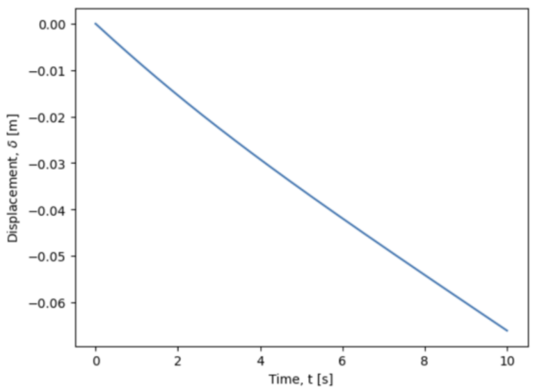
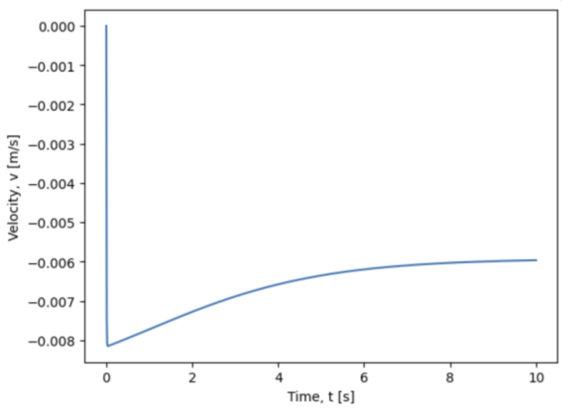


Figure 15. Velocity of R2



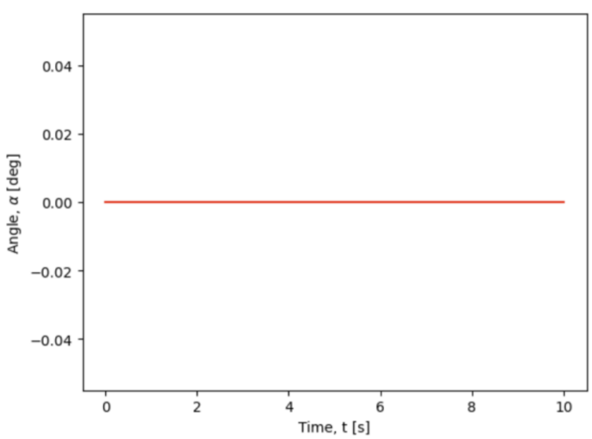
B. 2)

The terminal velocity (along y-axis) of this system is -0.00596627m/s

C. 3)

When all the radii (R1, R2, R3) are the same. The turning angle should always be 0.

Figure 16. Turning angle



Through simulation, when the radii of all three spheres are set to 0.025 m, the turning angle remains 0, matching the intuition result.

D. 4)

With an increased step size, the explicit method tends to become unstable at large time steps, leading to sudden increases in position and velocity, as well as oscillations in the position. Therefore, a small time step is required to ensure the accuracy and stability of the calculations. Although the explicit method is computationally simple, it becomes unstable with large step sizes. In contrast, the implicit method, though more complex to compute, remains stable even with larger step sizes.

II. PROBLEM 2

A. 1)

Figure 17. Velocity of the middle node

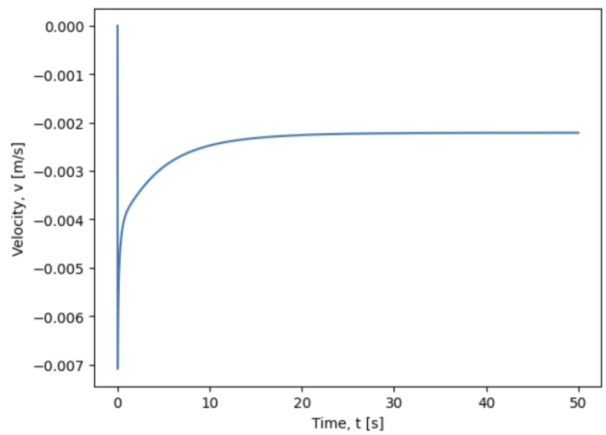
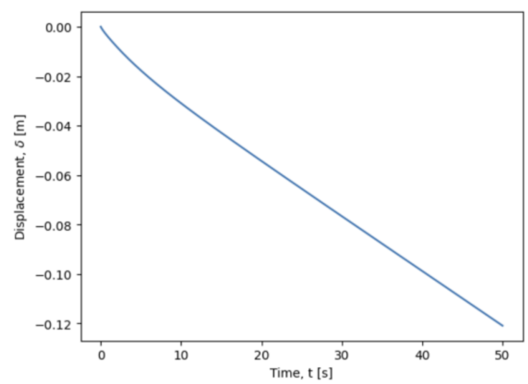


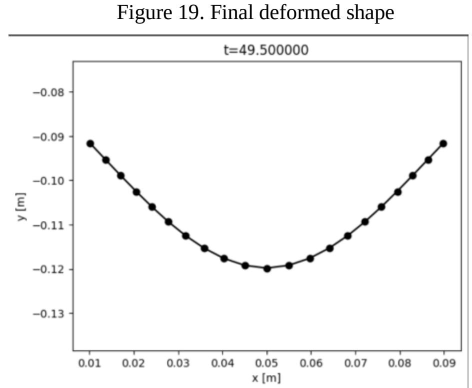
Figure 18. Vertical position of the middle node



The terminal velocity is -0.00247545m/s

B. 2)

Figure 19. Final deformed shape



C. 3

The terminal velocity stabilizes as the spatial discretization (i.e. the number of nodes, N) increases and the temporal discretization (i.e. time step size, Δt) decreases. Too few nodes or large time steps can introduce errors or instability, while excessive refinement increases computational cost with minimal benefit. Plotting the terminal velocity against the number of nodes and temporal discretization helps verify solution convergence and ensure reliable results.

Figure 20. Terminal velocity vs. Number of nodes

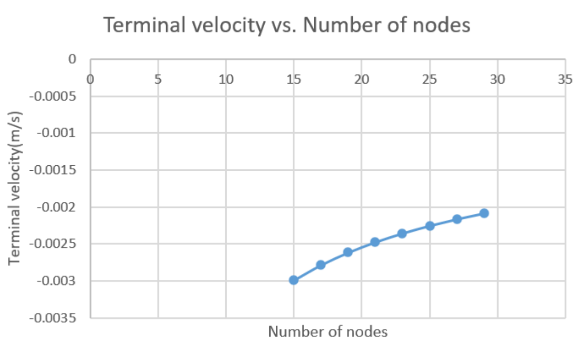
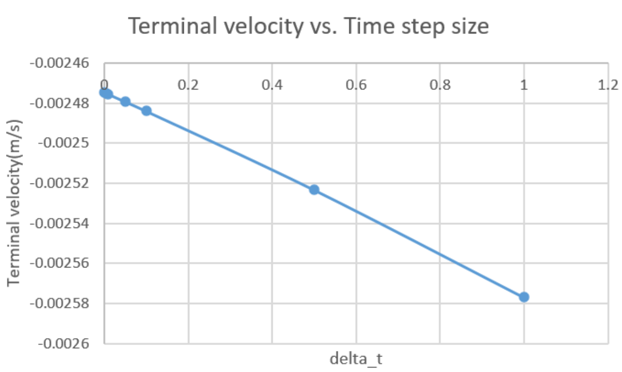


Figure 21. Terminal velocity vs. Time step size



III. PROBLEM3

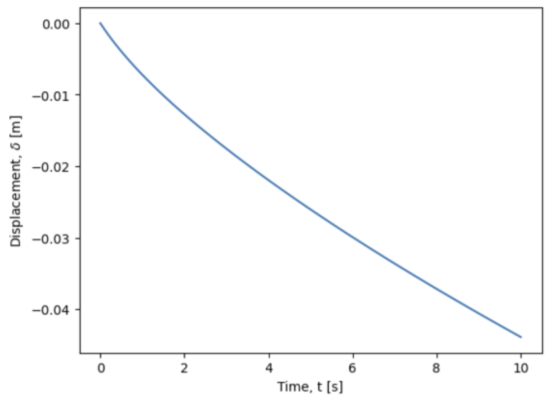
A. 1)

By using the equation below:

$$y_{\max} = \frac{Pc\,(L^2 - c^2)^{1.5}}{9\sqrt{3}EI\,l} \qquad \text{where} \qquad c = \min(d, l - d)$$

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, at a load of 20000N, a significant deviation appears between Euler beam theory and the simulation, with the y_{max} predicted by Euler beam theory being smaller than the simulation. Compared to Euler beam theory, the advantage of simulations is their ability to handle large deformations. Euler beam theory is only applicable to small deformations, and when the load is large, the beam undergoes nonlinear large deformations, making the simplified assumptions of beam theory invalid. Simulations can capture these nonlinear effects and provide more accurate results.