MAE 263F Homework 1

Vatsal Jain

I. Assignment 1: Rigid Spheres and Elastic Beam Falling in Viscous Flow

A. Figures and Plots

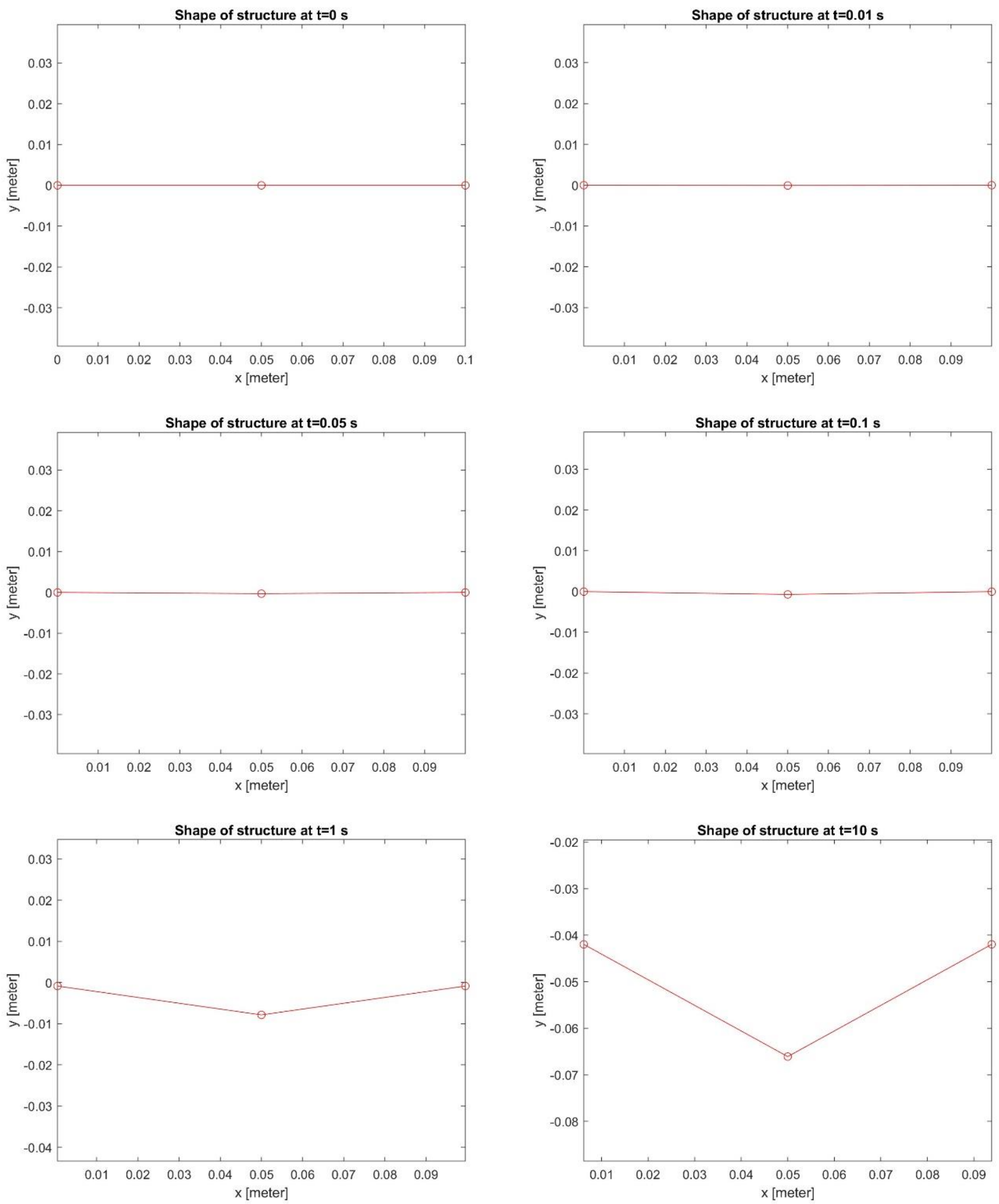

Figure 1. Shape of the structure at t = {0, 0.01, 0.05, 0.10, 1.0, 10} s.

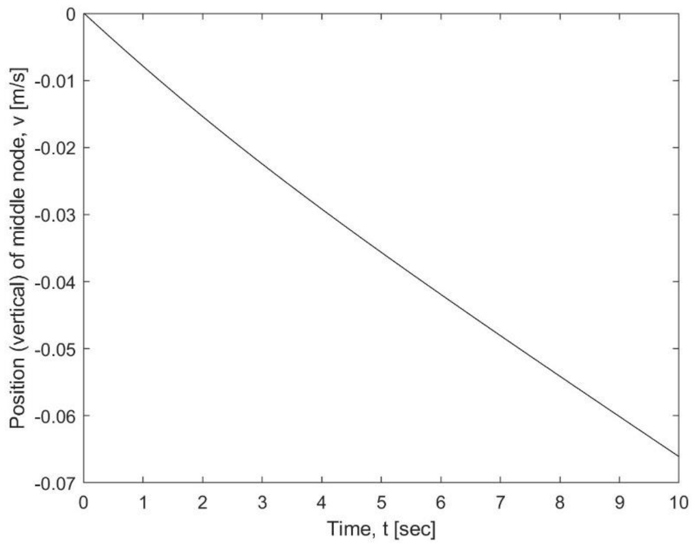

Figure 2. Position (along y-axis) of R_2 as a function of time.

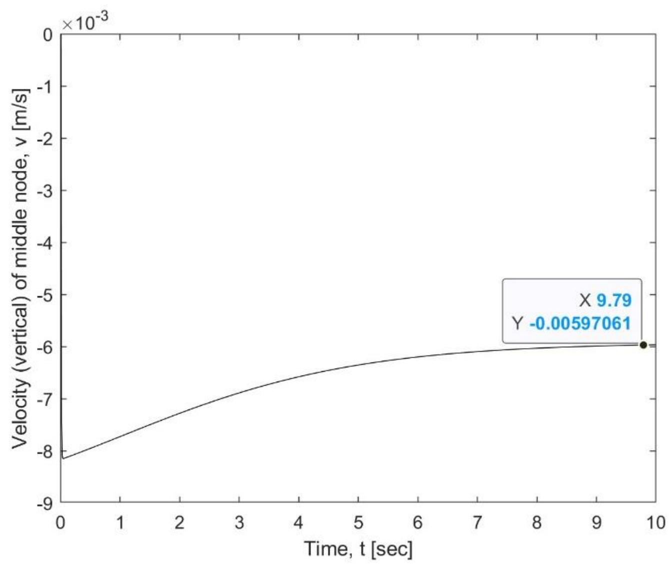

Figure 3. Velocity (along y-axis) of R_2 as a function of time.

B. *Discussion*

As seen in Figure 3, the terminal velocity of the middle node is 0.00597 m/s downward.

If all the radii are set to the same value, then my intuition says that the turning angle would remain 0 degrees meaning the structure would maintain its shape as all three nodes sink at the same rate. The results of the simulation, when the radii were set equal, confirmed my intuition.

When the time step size for the explicit method was increased by even a factor of ten (from the original 0.00001 s), the simulation would diverge, not providing an accurate solution. This highlights the drawback of using explicit simulation. Because of the extremely small time step required to provide accurate simulation results, the simulation will take many orders of magnitude longer to compute when compared to the implicit solution. The benefit of the explicit method is the simplicity in its execution, at the expense of time. When the implicit method time step was decreased (from the original 0.01 s), the simulation provided relatively same results. This highlights the benefits of the implicit solution. However, it can be much more complicated to execute.

II. ASSIGNMENT 2: GENERALIZED CASE OF ELASTIC BEAM FALLING IN VISCOUS FLOW

A. Figures and Plots

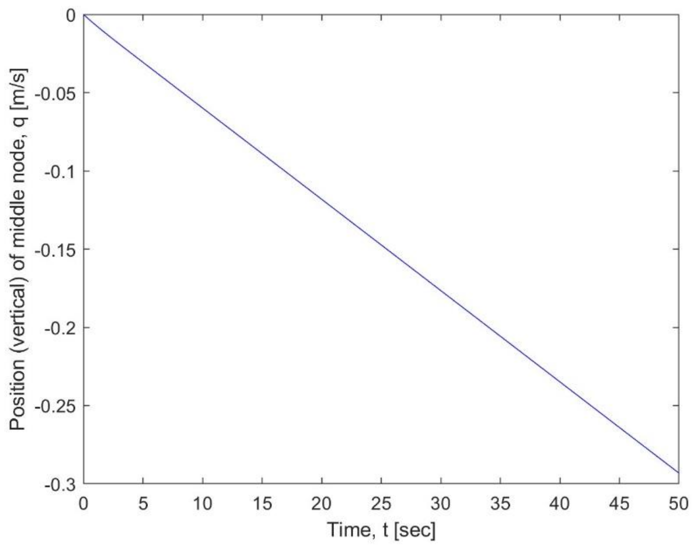

Figure 4. Position (along y-axis) of middle node as a function of time.

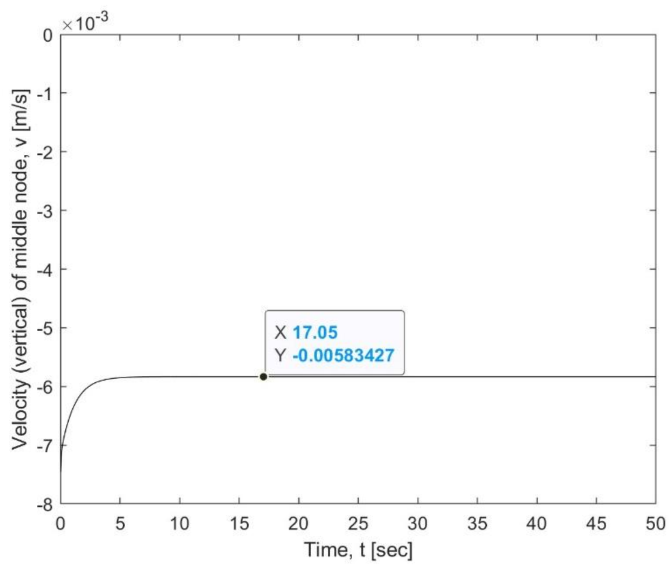

Figure 5. Velocity (along y-axis) of middle node as a function of time.

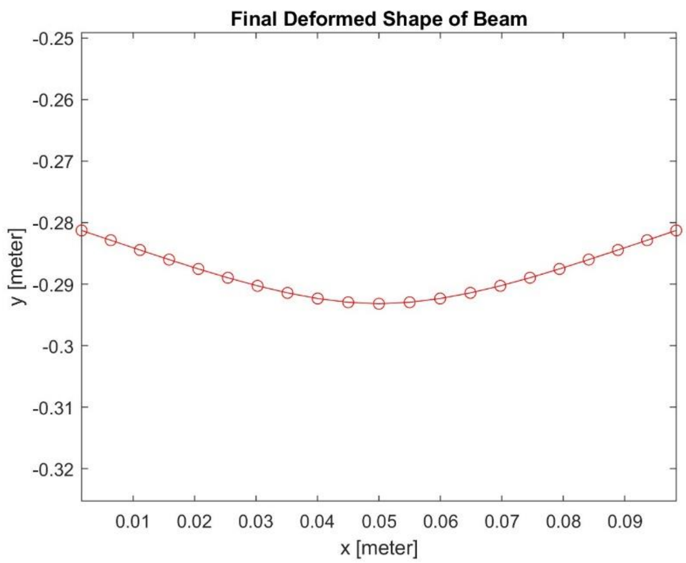

Figure 6. Final deformed shape of beam at t = 50 s.

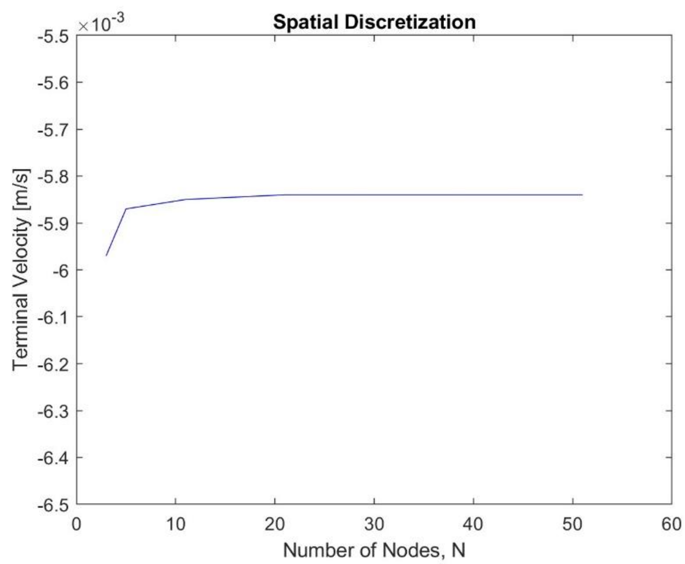

Figure 7. Terminal Velocity vs. Number of Nodes

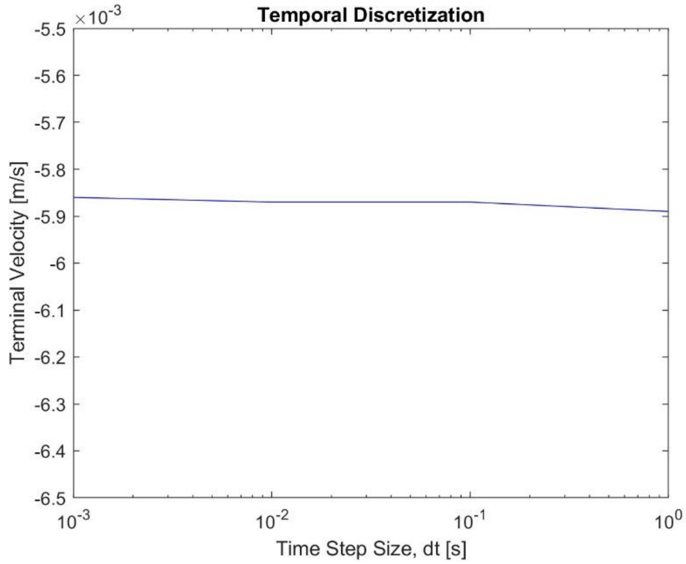

Figure 8. Terminal Velocity vs. Time Step Size

B. Discussion

As seen in Figure 5, the terminal velocity of the middle node is 0.00583 m/s downward.

As seen in Figure 7, the almost imperceivable changes in terminal velocity highlight the low importance of spatial discretization, particularly after N=10.

Similarly in Figure 8, the almost imperceivable changes in terminal velocity highlight the low importance of temporal discretization.

III. Assignment 3: Elastic Beam Bending

A. Figures and Plots

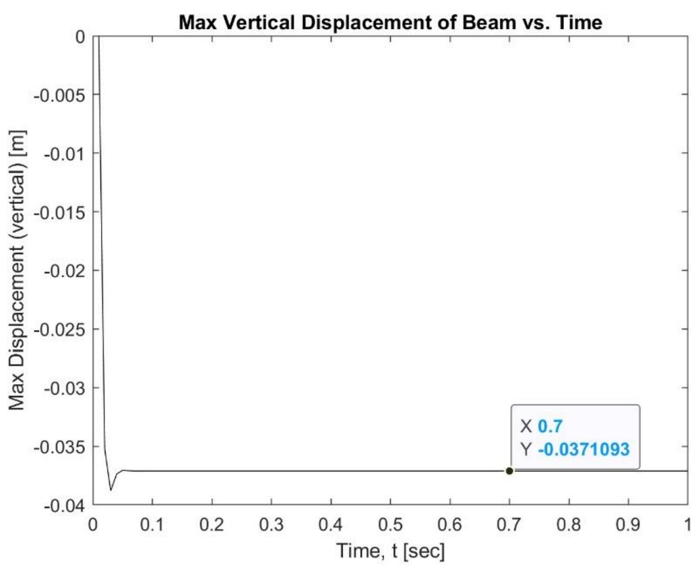

Figure 9. Maximum vertical displacement of the beam as a function of time.

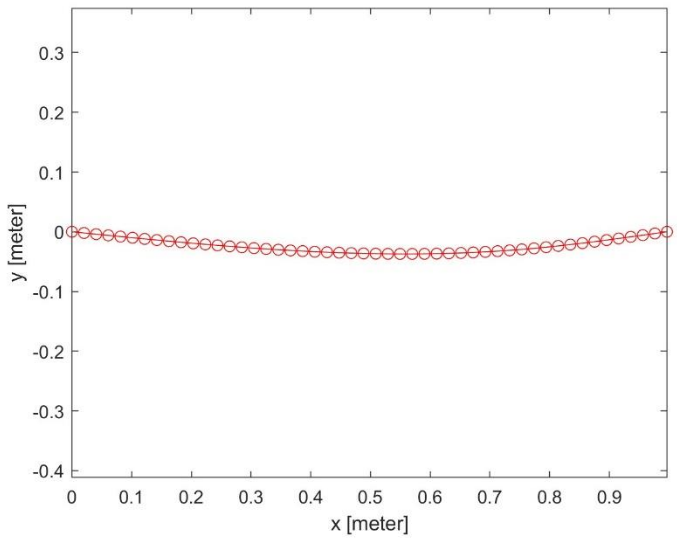

Figure 10. Final Deformed Shape of Beam with 2000 N Point Load Applied.

B. Discussion

As seen in figure 9, the maximum vertical displacement peaks and then reaches a steady value of -0.037 m. The Euler beam theory provides a theoretical prediction of -0.038 m, which is extremely close to the simulation value.

$$y_{max} = \frac{Pc(l^2 - c^2)^{1.5}}{9\sqrt{3}EI\,l}$$

Where P = point load, c=0.25, l = length of beam, E = modulus of elasticity, I = inertia of cross section.

However, for higher loads, the theoretical prediction begins to fail and diverge from the simulation value. For example, for a point load of 20000 N, the simulation results in a steady displacement of -0.235 m whereas the beam theory results in -0.38 m. These values are significantly different, highlighting the functionality of simulations.