MAE 259 Homework 1

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I. Problem 1

The code of this problem includes Problem1_explicit.m and Problem1_implicit.m. The plots of the position and the velocity of the sphere as a function of time implicitly and implicitly are shown below.

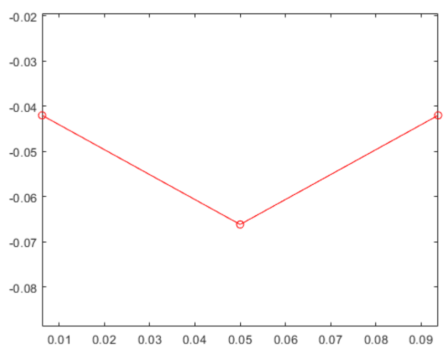

Figure 1. Final position of spheres with the implicit method

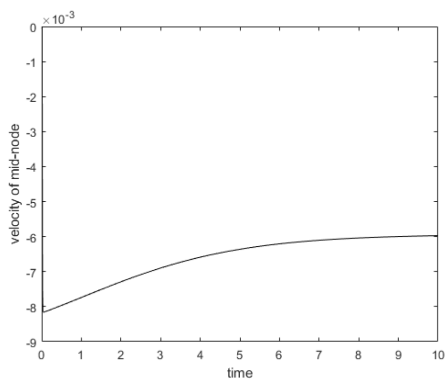

Figure 2. Velocity of the sphere as a function of time with the implicit method

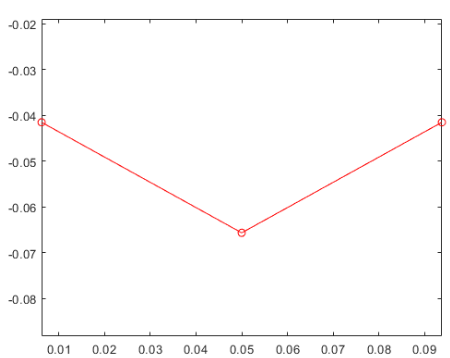

Figure 3. Final position of spheres with the explicit method

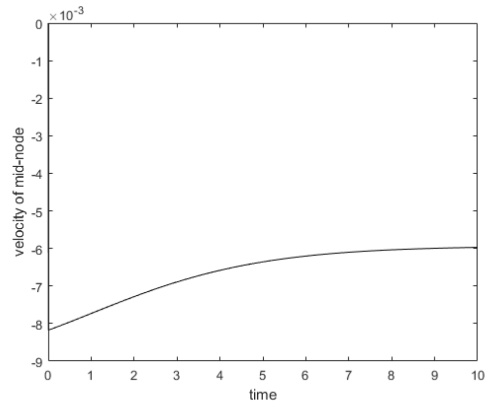

Figure 4. Velocity of the sphere as a function of time with the explicit method

A. *Question 1*

Assumption: when all the radii are the same, the turning angle should equal to zero. And the elastic beam would remain in its original shape. The simulation is shown in the Fig. 5 below, which verifies my assumption.

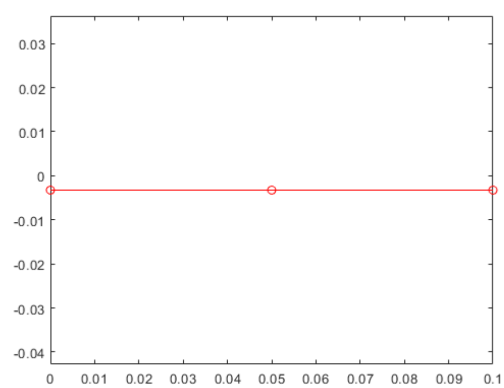

Figure 5. Final position of spheres when all the radii are the same

B. *Question 2*

For explicit simulation, it can be found that the simulation fails to execute when increasing the step size. When decreasing the step size, the solving time would be much slower but giving the accurate result. With that said, the explicit method has simpler algorithms but only works at small step size and much longer computation time, while implicit method has faster computation time and allows for larger step size.

II. PROBLEM 2

The code of this problem includes Problem2.m and Problem2_function.m.

A. Question 1

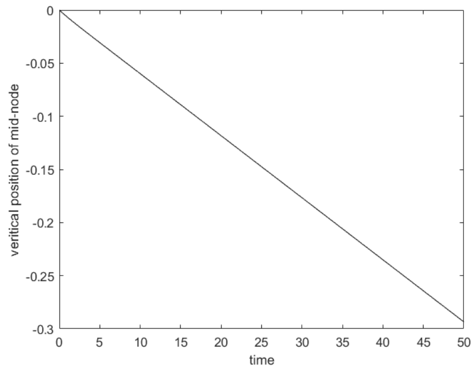

Figure 6. Vertical position of the middle node vs. time

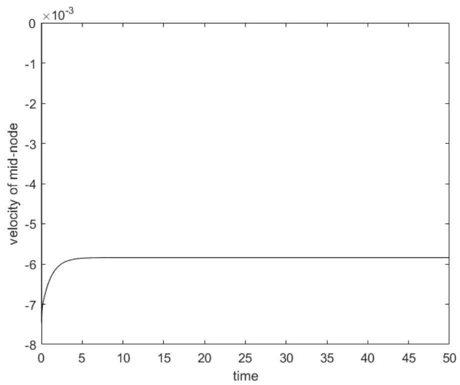

Figure 7. Vertical velocity of the middle node vs. time

From Fig. 7, it can be found that the terminal velocity is -0.0058 m/s.

B. Question 2

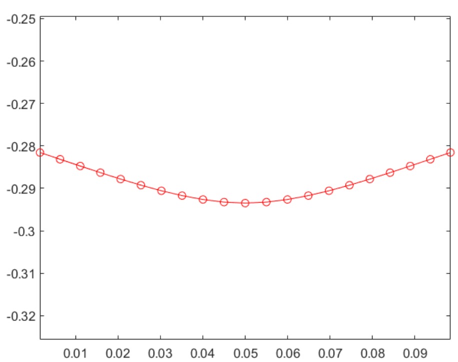

Figure 8. Final deformed shape of the beam

C. Question 3

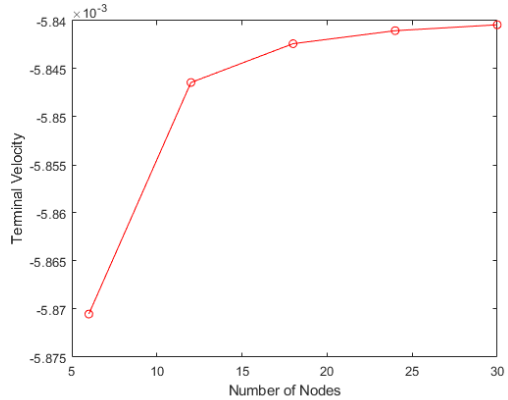

Figure 9. Terminal velocity vs. number of nodes

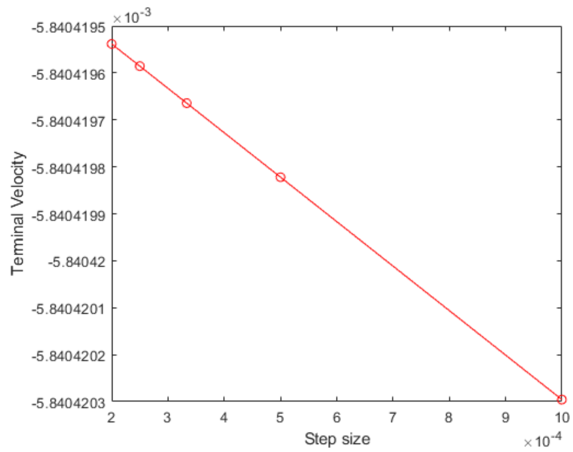

Figure 10. Terminal velocity vs. time step size

From Fig. 9 and Fig 10, it can be found that the terminal velocity slightly varies with the increasing number of nodes or the decreasing time step size, indicating that the spatial discretization has little effect on the quantifiable metrics (terminal velocity) in this case.

III. PROBLEM 3

The code of this problem is Problem3.m

A. Question 1

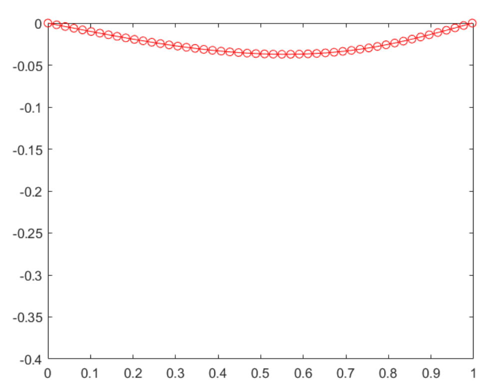

Figure 11. The shape of final beam when P = 2000

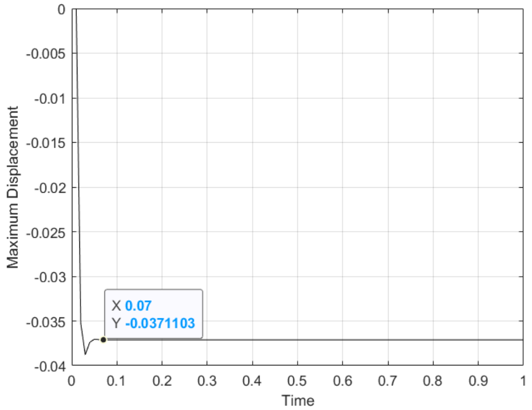

Figure 12. Maximum beam displacement when P = 2000

From Fig. 12, it can be found that maximum vertical displacement, y_{max} reaches a steady value of -0.0371m at t = 0.07s, where y_{max} equals to -0.038m calculating from Euler beam theory. Therefore, the result verifies the accuracy of this simulation.

B. Question 2

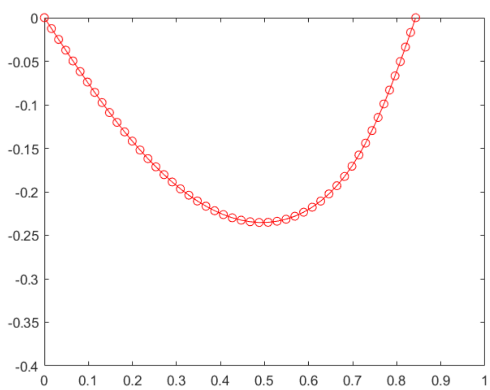
Figure 13. The shape of final beam when P = 20000

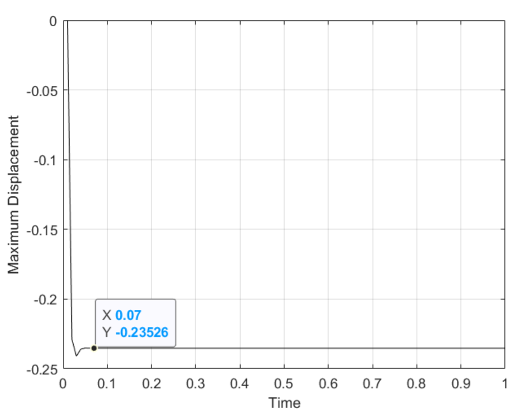

Figure 14. Maximum beam displacement when P = 20000

From Fig. 14, it can be found that maximum vertical displacement, y_{max} reaches a steady value of -0.2353m at t = 0.07s with a load P = 20000, where y_{max} equals to -0.3804m calculating from Euler beam theory. This result indicates that the prediction from beam theory only applies to small deformation.