Assignment 1

Changrui Cai

I. Problem 1

A. Question (1)

For question 1, the figures derived by implicit approach are listed below:

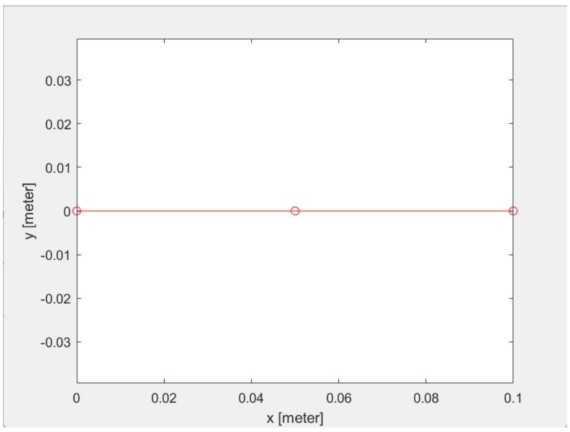

Figure 1.1: Shape at 0 second-implicit

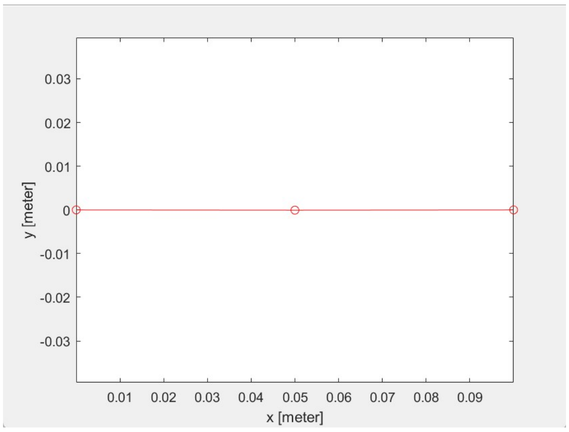

Figure 1.2: Shape at 0.01second-implicit

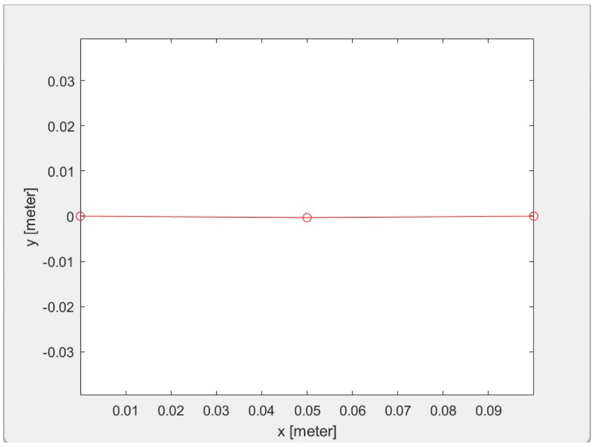

Figure 1.3: Shape at 0.05 second-implicit

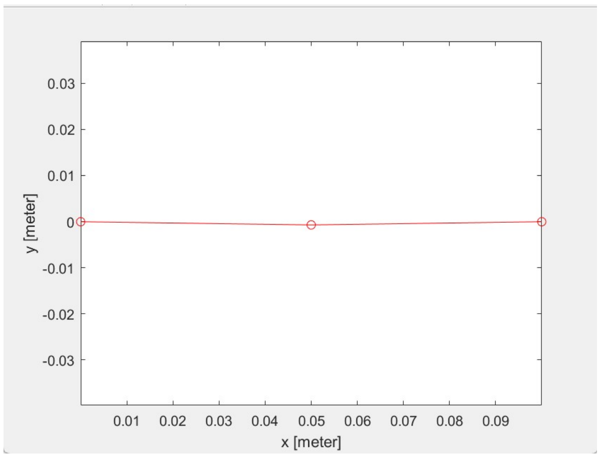

Figure 1.4: Shape at 0.1 second-implicit

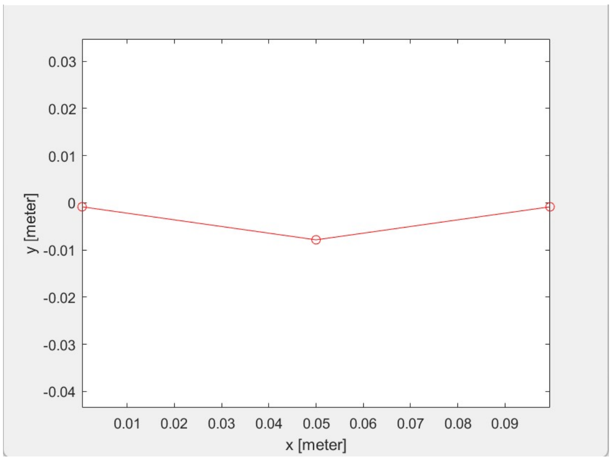

Figure 1.5: Shape at 1 second-implicit

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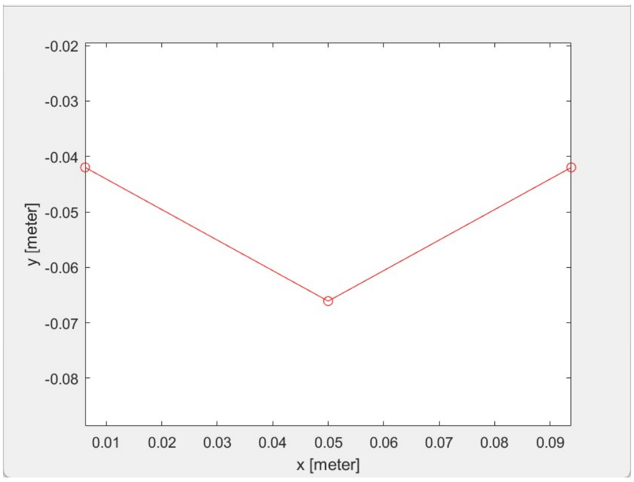

Figure 1.6: Shape at 10 seconds-implicit

The figures derived by explicit approach are listed below:

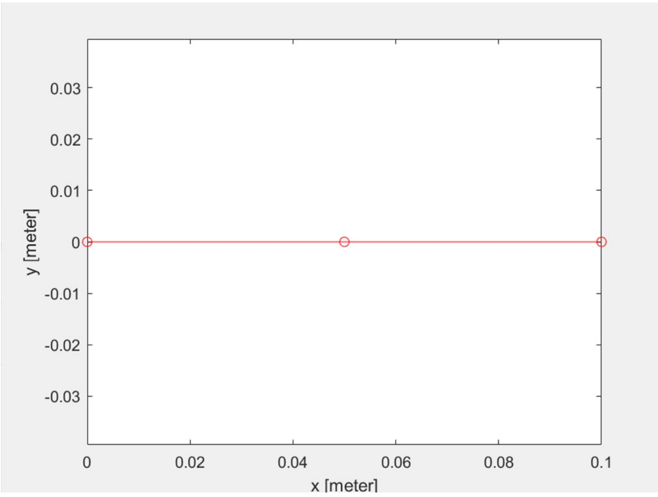

Figure 1.7: Shape at 0 second-explicit

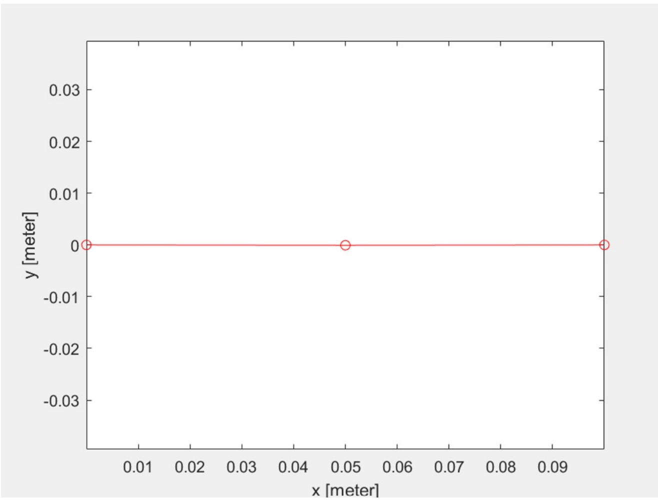

Figure 1.8: Shape at 0.01second-explicit

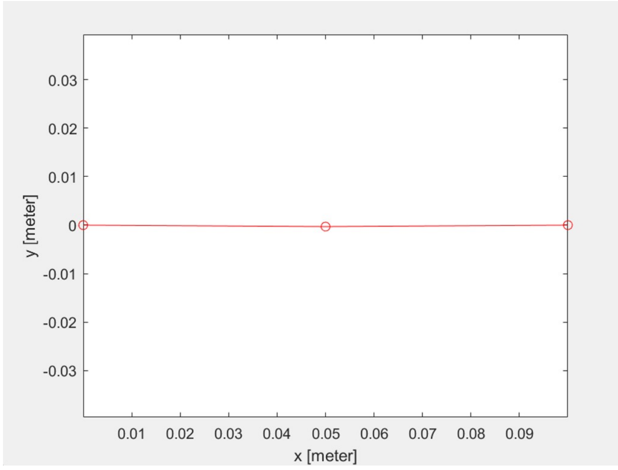

Figure 1.9: Shape at 0.05 second-explicit

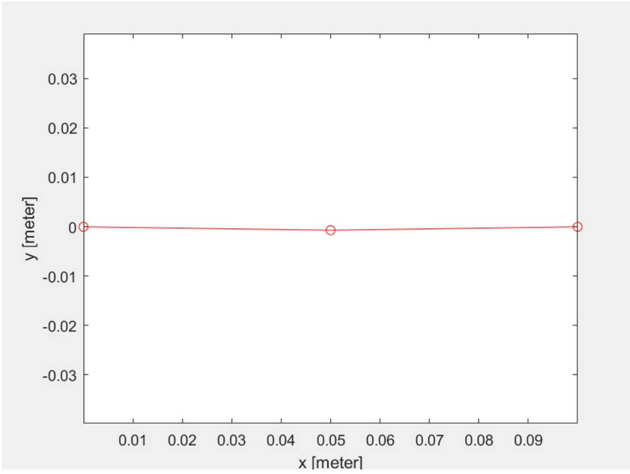

Figure 1.10: Shape at 0.1 second-explicit

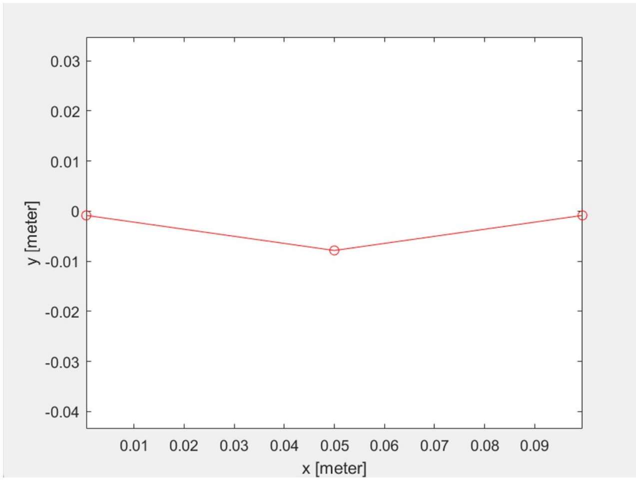

Figure 1.11: Shape at 1 second-explicit

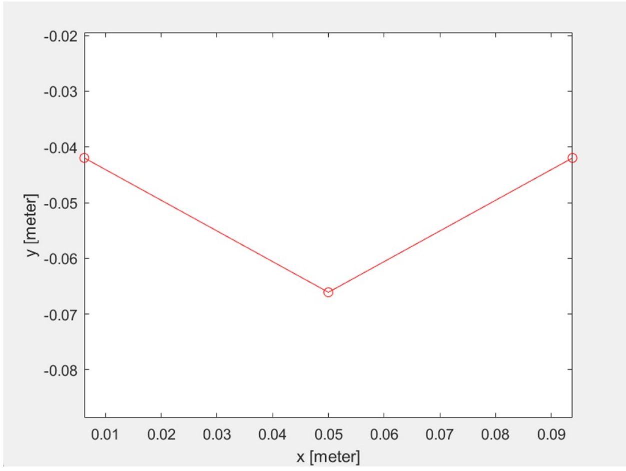

Figure 1.12: Shape at 10 seconds-explicit

Although the approach is different, the shapes of the system at same time are pretty similar.

The position and velocity of the R2 are listed below:

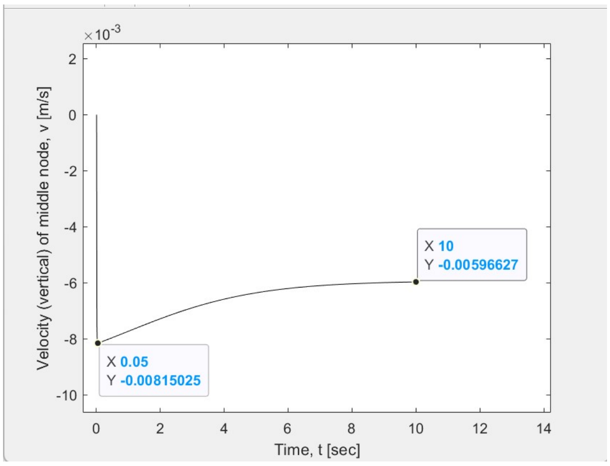

Figure 1.13: Velocity vs. time of R2 ball

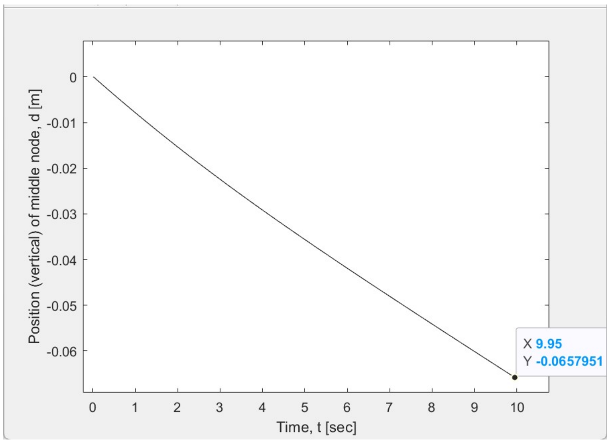

Figure 1.14: Position vs. time of R2 ball

B. *Question (2)*

By analyzing the graph, the terminal velocity is near to -0.005966*10-3 m/s, and it reach the highest at the beginning of the motion.

C. *Question (3)*

When the radius are same the turning angle should be zero. The simulation result is listed below:

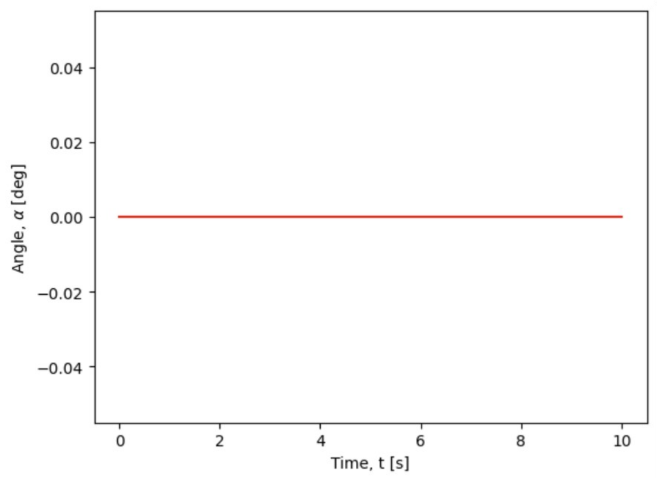

Figure 1.15: Turning angle

By analyzing the result from the simulation, the result match the assumption.

D. *Question (4)*

Explicit techniques take longer to compute than implicit methods since they require a small Δt for stability. However, the explicit method is simple since it need the data from the past. Although implicit approaches are more computationally demanding and expensive per step, they are appropriate for stiff issues since they allow bigger Δt for stability.

II. PROBLEM 2

A. *Question (1)*

The vertical position and velocity versus time are listed below:

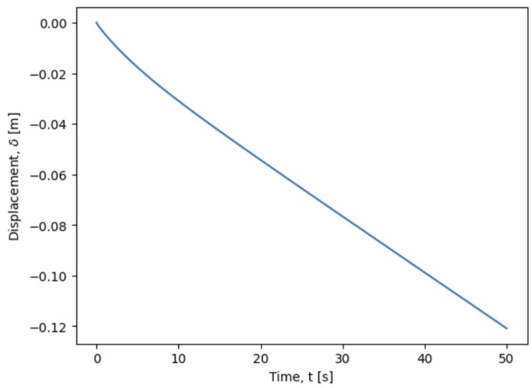

Figure 2.1: Position vs. time of middle ball

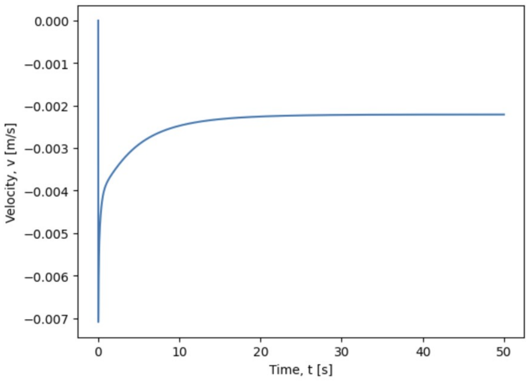

Figure 2.2: Velocity vs. time of middle ball

By analyzing the graph, the terminal velocity is near to -0.0023 m/s, and it reach the highest at the beginning of the motion.

B. Question (2)

The final deformed shape is provided below:

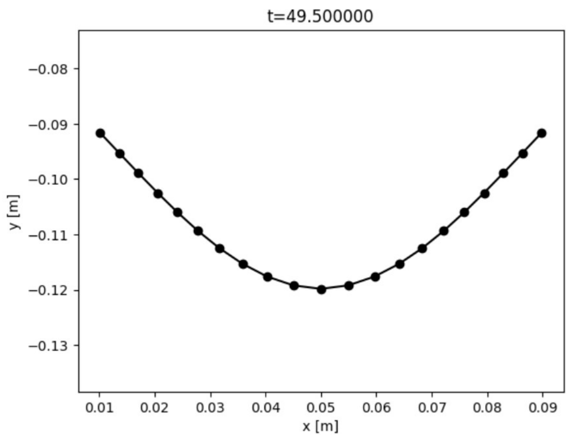

Figure 2.3: Final shape of the beam

C. Question (3)

To analyze the relationship between number of nodes and terminal velocity. The initial number of nodes are 21 and I increase the number of nodes by 2 each time. The relation between terminal velocity vs. number of nodes is provided in table and figure below:

TABLE I. TERMINAL VELOCITY OF DIFFERNET NODE NUMBER

Node number	Terminal Velocity(m/s)
15	-0.00298919
17	-0.00278383
19	-0.00261571
21	-0.00247545
23	-0.00235653
25	-0.00225428

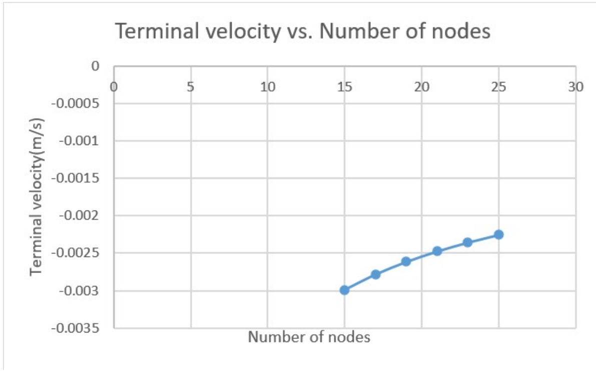

Figure 2.3: The terminal velocity vs. number of nodes

As the number of the nodes increase, the terminal velocity increase slightly as well. This slightly increase are caused by the accuracy of the system, which means the simlations are sufficiently discretized.

To analyze the relationship between delta_t and terminal velocity. The initial delta_t is 0.001 and I increase the delta_t each time while the number of the nodes doesn't change. The relation between terminal velocity vs. delta_t is provided in table and figure below:

TABLE II. TERMINAL VELOCITY OF DIFFERNET DELTA_T

Delta_t	Terminal velocity(m/s)
0.001	-0.00247461
0.005	-0.00247498
0.01	-0.00247545
0.05	-0.00247918
0.1	-0.00248388
0.5	-0.00252325
1	-0.00257697

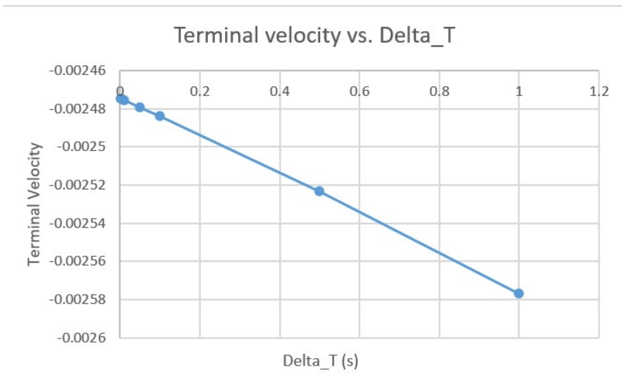

Figure 2.4: The terminal velocity vs. delta_t

As the number of the nodes, the terminal velocity decrease slightly as well. This slightly decrease are caused by the accuracy of the system, which means the simlations are sufficiently discretized as well. Therefore, the significane of spatial discretization and temporal discretization are

III. PROBLEM 3

A. *Question 1*

The displacement of y is finally become steady. The graph is listed below:

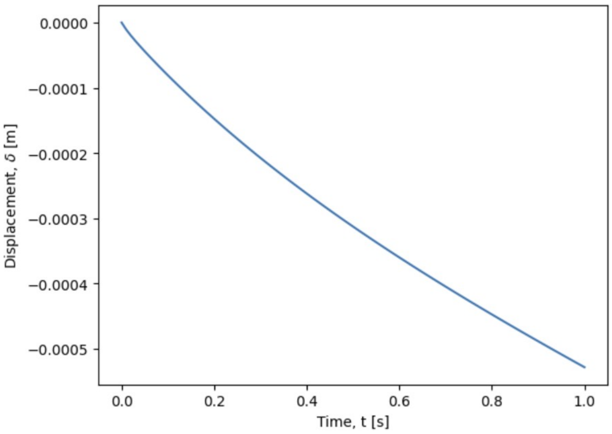

Figure 3.1: The y-displacement

However, the value get from the simulation is different from the calculation by using the Euler beam theory, which is -0.038 m.

B. *Question 2*

When the applied force is increased, the deformation derived by the simulation is quite differ from the calculation by using Euler beam theory.