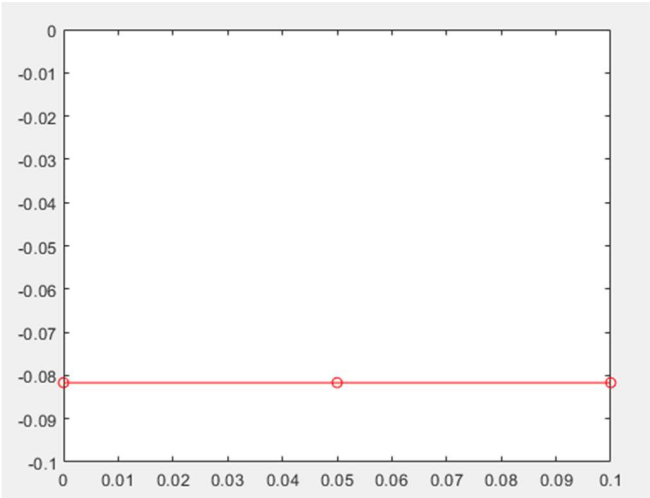
MAE 259B HW1

Huangshuai Shi

I. ASSIGNMENT 1

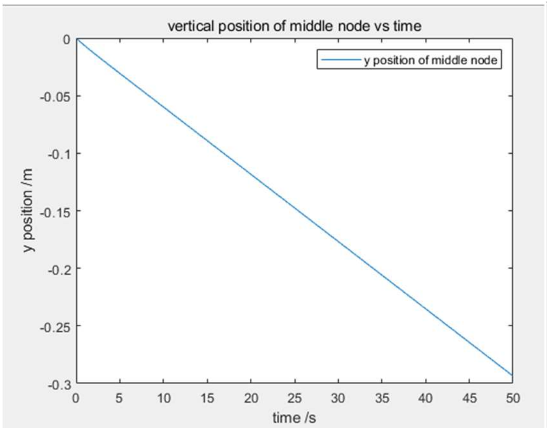
1. What happens to the turning angle if all the radii (R1, R2, R3) are the same? Does your simulation agree with your intuition?
   If all the radius are the same, the turning angle will always be zero. And the simulation agrees with my intuition.

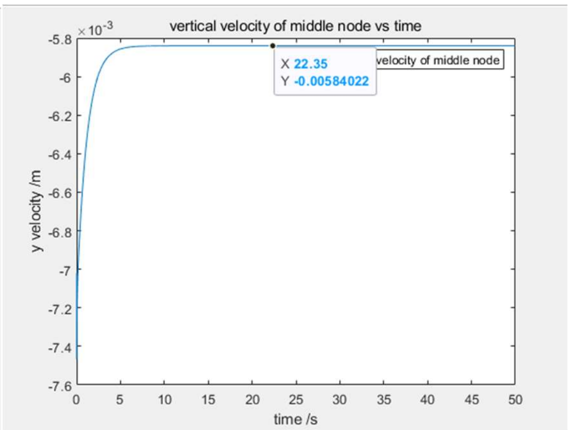


2. Try changing the time step size (Δt), particularly for your explicit simulation, and use the observation to elaborate the benefits and drawbacks of the explicit and implicit approach.
   When using the explicit method, Δt must be set to a very tiny value. I tried set it to 0.0001 s and 0.001 s, the explicit method just doesn't work.
   From my observation, though implicit method requires info from next time step, which cause much computational cost at every step, its accuracy is not quite sensitive to the length of the time step, compared to the explicit method.
   For explicit method, even it spends less time at every step, it needs extremely shorter time step length to achieve the same accuracy as implicit method.

II. ASSIGNMENT 2

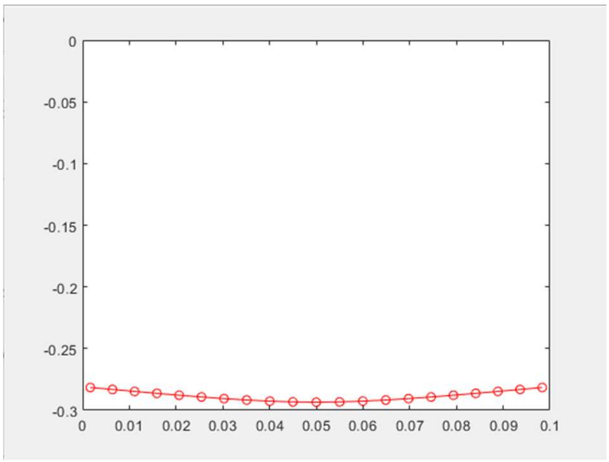
1. Include two plots showing the vertical position and velocity of the middle node with time. What is the terminal velocity?





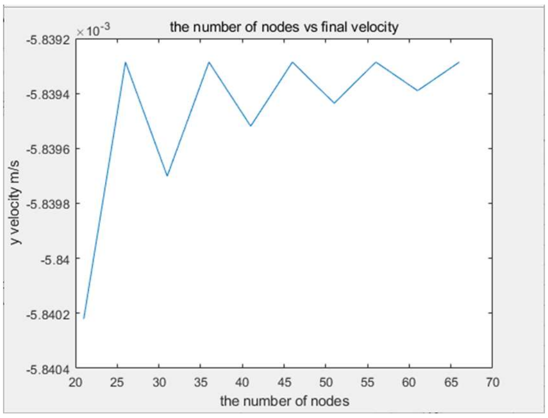
   The terminal velocity is -0.00584m/s

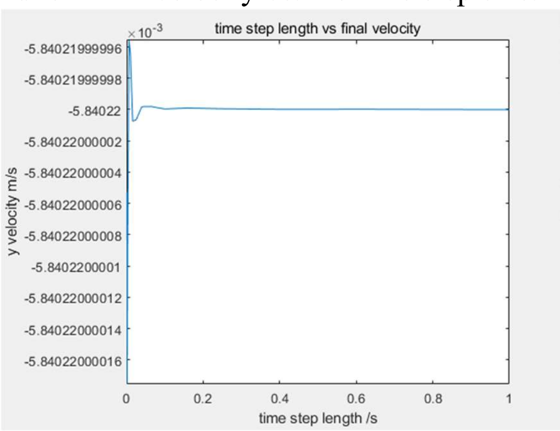
2. Include the final deformed shape of the beam.



Final deformation

3. Discuss the significance of spatial discretization (i.e. the number of nodes, N) and temporal discretization (i.e. time step size, Δt). Any simulation should be sufficiently discretized such that the quantifiable metrics, e.g. terminal velocity, do not vary much if N is increased and Δt is decreased. Include plots of terminal velocity vs. the number of nodes and terminal velocity vs. the time step size.





As shown in the figures, the terminal velocity doesn't change much when the number of nodes or time step length change.

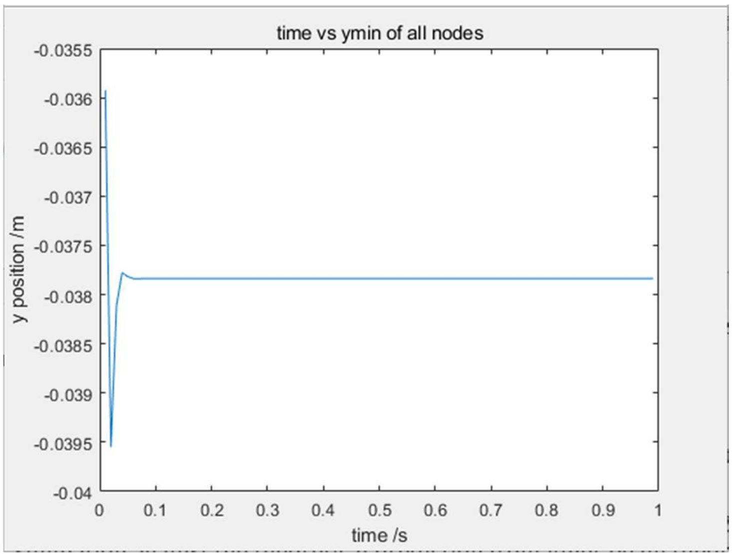
III. ASSIGNMENT 3

1. Plot the maximum vertical displacement, y_{max}, of the beam as a function of time. Depending on your coordinate system, y_{max} may be negative. Does y_{max} eventually reach a steady value? Examine the accuracy of your simulation against the theoretical prediction from Euler beam theory:

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

By theoretical, $\boldsymbol{y_{max} = -0.0380\, m}$

But by simulation, $\boldsymbol{y_{max} = -0.0371\, m}$

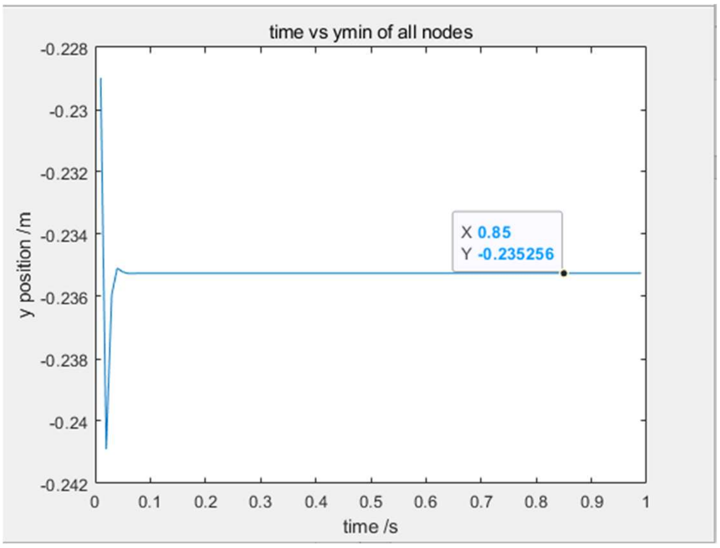


And $\boldsymbol{y_{max}}$ become steady in the end.

2. What is the benefit of your simulation over the predictions from beam theory? To address this, consider a higher load P = 20000 such that the beam undergoes large deformation. Compare the simulated result against the prediction from beam theory in Eq. 4.21. Euler beam theory is only valid for small deformation whereas your simulation, if done correctly, should be able to handle large deformation.

After setting P = 20000N

The plot becomes:



Where $\boldsymbol{y_{max} = -0.2352\ m}$
However, from theoretical prediction, $\boldsymbol{y_{max} = -0.3804\ m}$
Obviously, the prediction gets bad accuracy.
From my observation, the benefit of discrete simulation method is that when the deformation is getting much bigger, the accuracy of this method is much higher than just theoretical analysis.