Homework 1

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MAE 263F Soft Robotics

October 16, 2025

Task: Implicit Euler Network Simulation from t = 0 to t = 100s

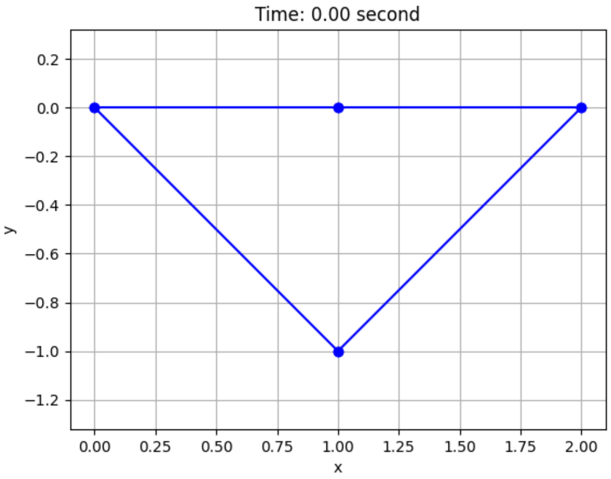

Figure 1: Simulation snapshot at $t = 0$ s.

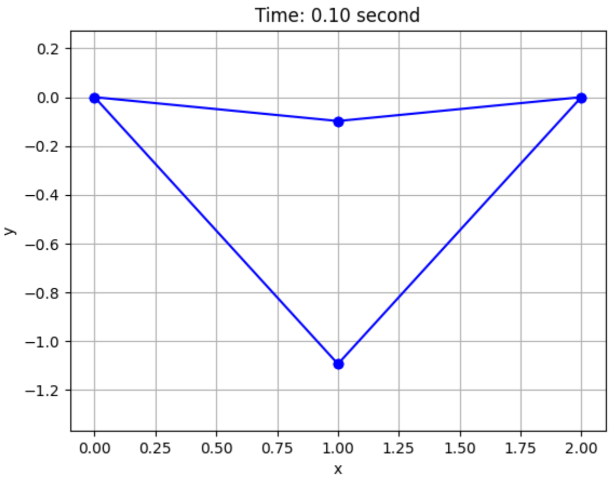

Figure 2: Simulation snapshot at $t = 0.1$ s.

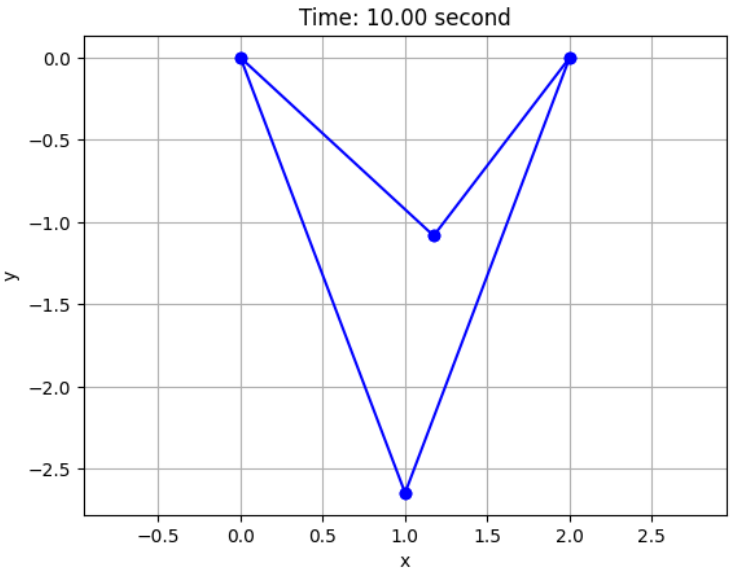

Figure 3: Simulation snapshot at $t = 10$ s.

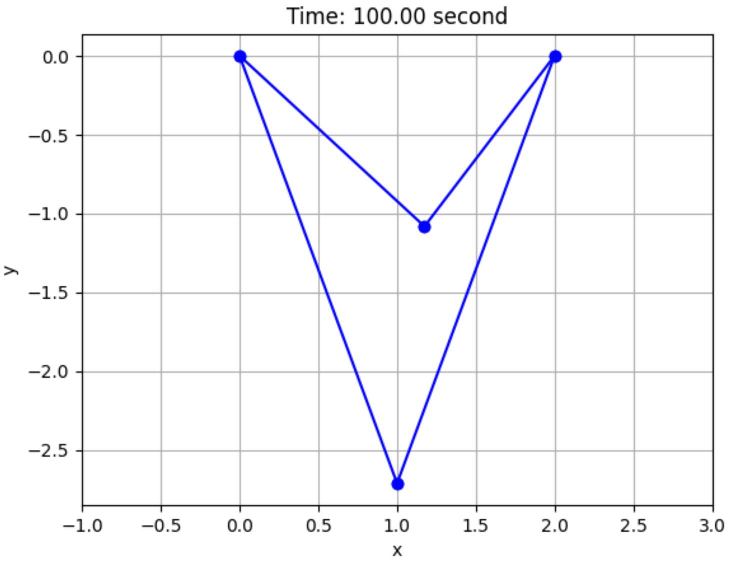

Figure 4: Simulation snapshot at $t = 100$ s.

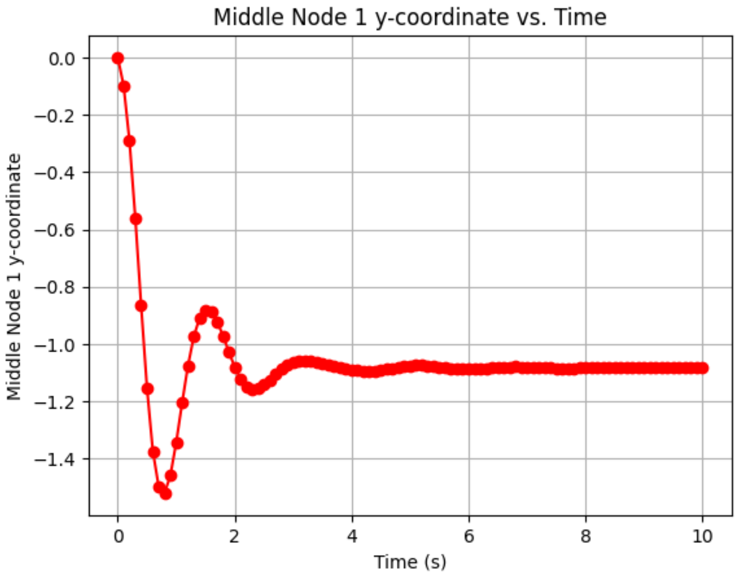

Figure 5: Free Node 1

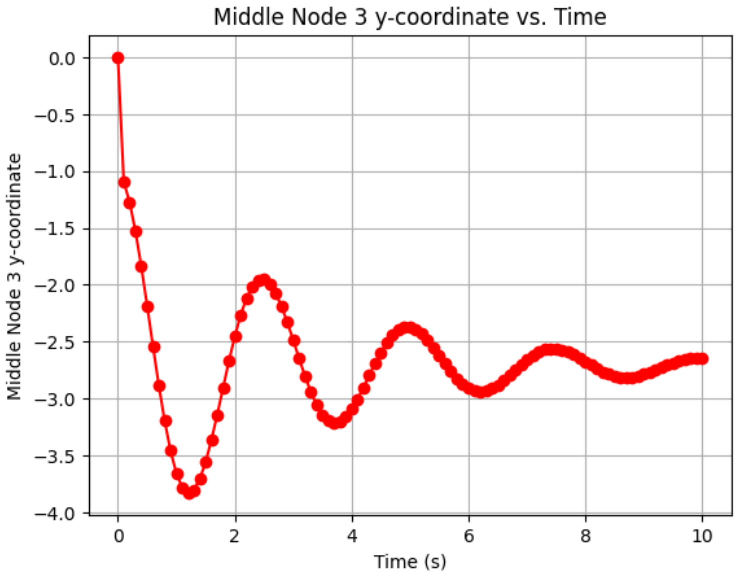

Figure 6: Free Node 3

Report Questions:

1. Pseudo Code:

    - `gradEs()` – Computes gradient (force) for one spring
    - `hessEs()` – Computes Hessian (Jacobian contribution) for one spring
    - `getFexternal()` – Returns gravity forces

- `getForceJacobian()` – Builds full system force and Jacobian
- `myInt()` – Performs one implicit Euler time integration step
- `plot()` – Plots spring network geometry

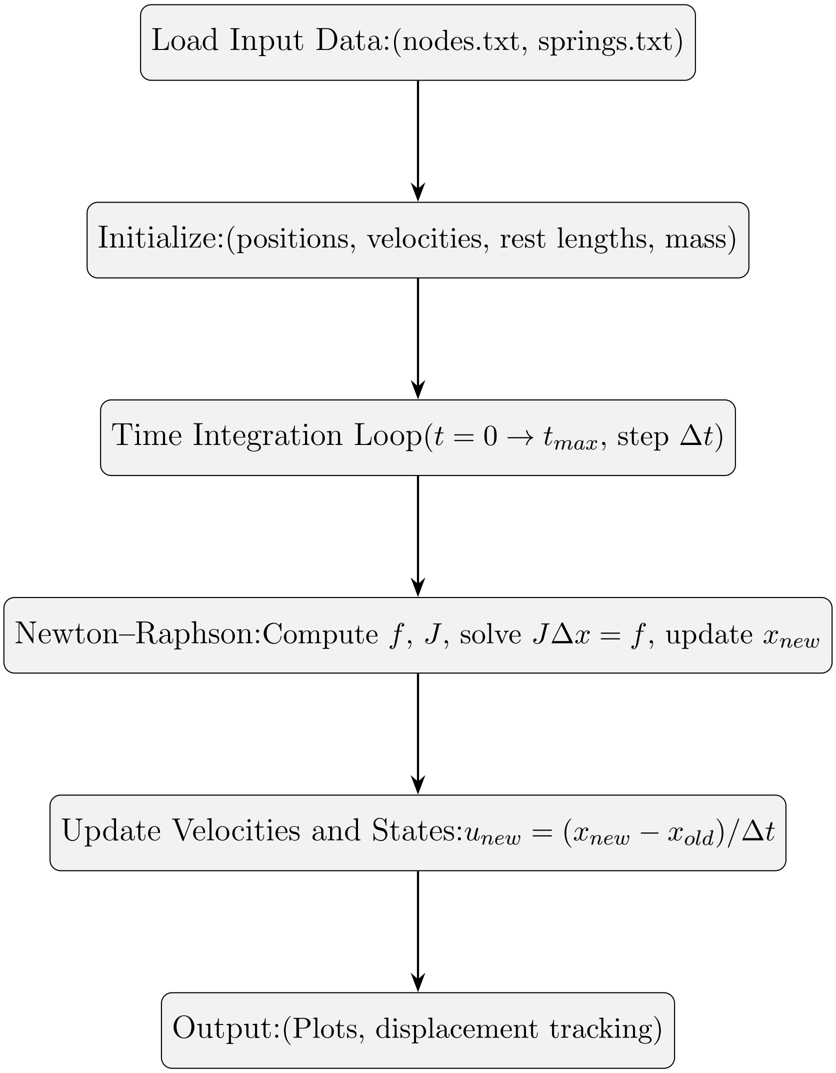
Load Input Data:(nodes.txt, springs.txt)
Initialize:(positions, velocities, rest lengths, mass)
Time Integration Loop($t = 0 \to t_{max}$, step Δt)
Newton–Raphson:Compute f, J, solve $J\Delta x = f$, update x_{new}
Update Velocities and States:$u_{new} = (x_{new} - x_{old})/\Delta t$
Output:(Plots, displacement tracking)

Figure 7: Block diagram of the implicit spring network simulation workflow.

2. Choosing an appropriate time step involves ensuring that a balance between accurate results and computational power. Too small of a time step results in slow computational efficiency and will only make slight improvements in accuracy. Making time steps too large, however, may skip important changes in a system's behavior or even diverging results and oscillate, both making a por approximation to the solution.

3. The implicit method is preferable because even though it may have a slightly higher computational cost, it is able to handle larger step sizes and more accurately simulates the system

4. In the implicit Euler problem, there is numerical damping. Newmark Beta family of time integrators is helpful because it allows you to adjust the integration parameters such as beta and gamma. In addition, the solver is more accurate because it uses the current and previous states to evaluate the forces based on displacements.