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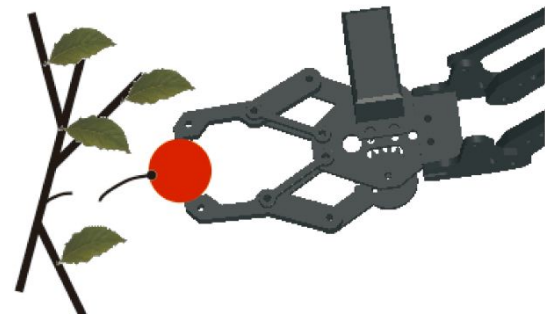
# Pick and Place Simulation of Parallel End Effector Grasping Fruits

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Jessica Anz & Trevor Oshiro

MAE 263F

December 11, 2024

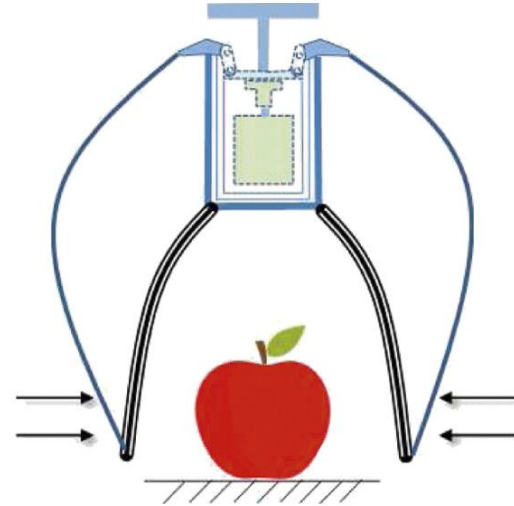


# Objectives

**Goal:** Develop simulated model of robotic harvesting of a piece of fruit for rapid testing and verification of soft robotic end-effectors

**Components:**

- Linearly closing parallel end effector
- Simulated contact forces

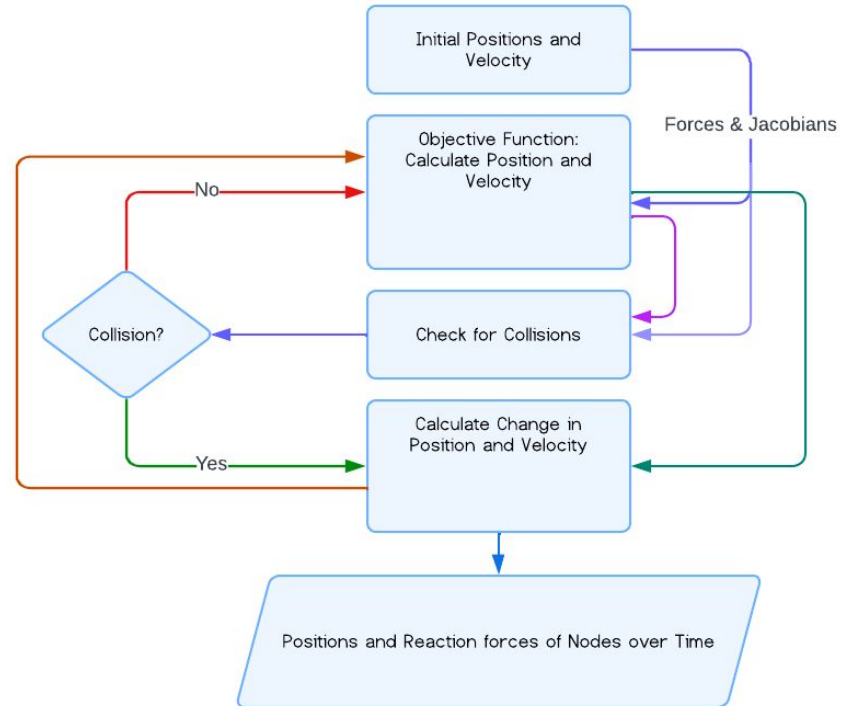


# Phase 0: Implementation of Contact

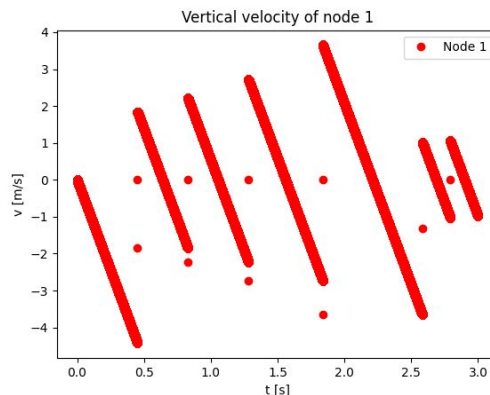
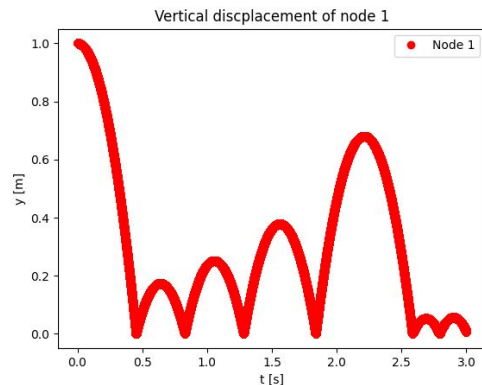
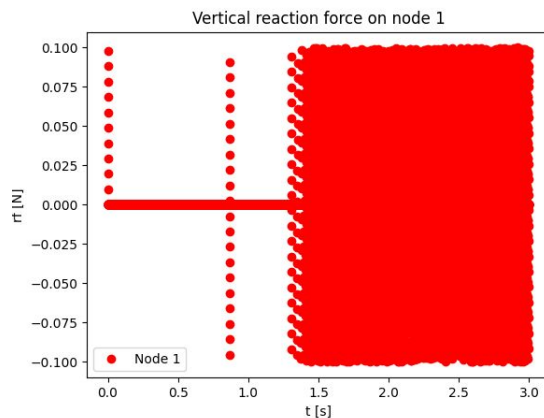
# Phase 0: Implementation of Contact

## Step 1:

- Modified Mass Method
- Rigid surface (fruit) contact  
flexible surface (gripper)
- Simulation of bouncing



# Phase 0: Implementation of Contact (Challenges)



## Inconsistent bouncing

- Artificial energy dissipation
- Spikes in velocity change

## Reaction force calculations

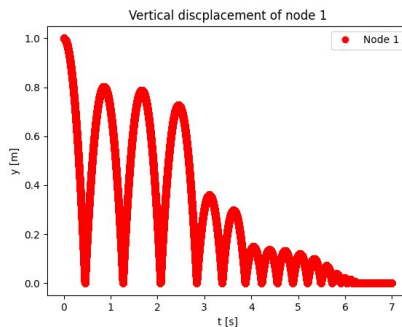
- Implementation of MMM



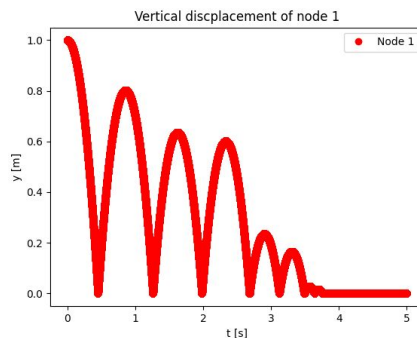
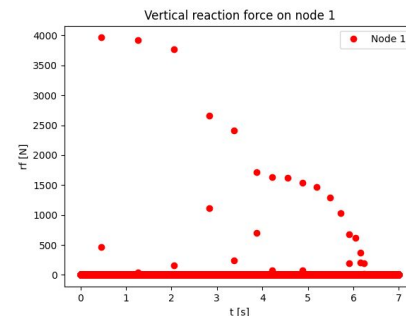
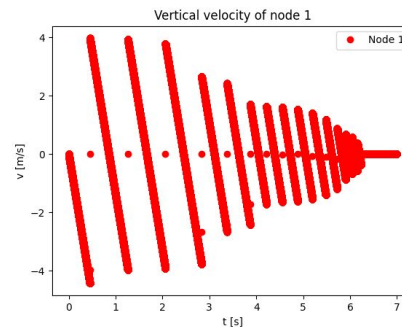
# Phase 0: MMM Plots for Different Timesteps

## MMM implementation adjustment:

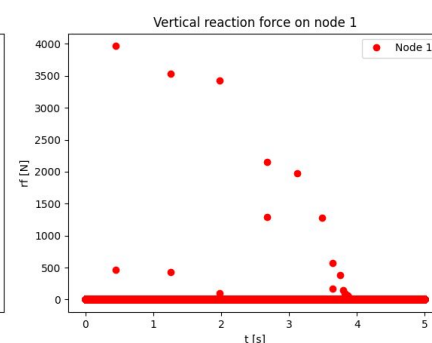
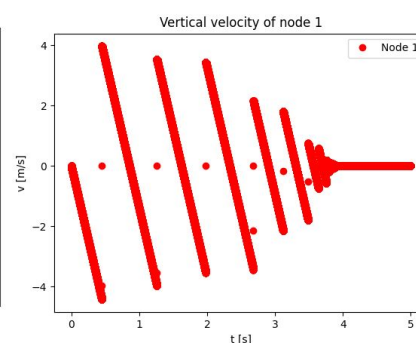
- Smaller time steps closer to contact
- Decrease computation time
- Improve consistency in contact visualization



Timestep: 1e-5, Proximity Step: 1e-6



Timestep: 5e-5, Proximity Step: 1e-6



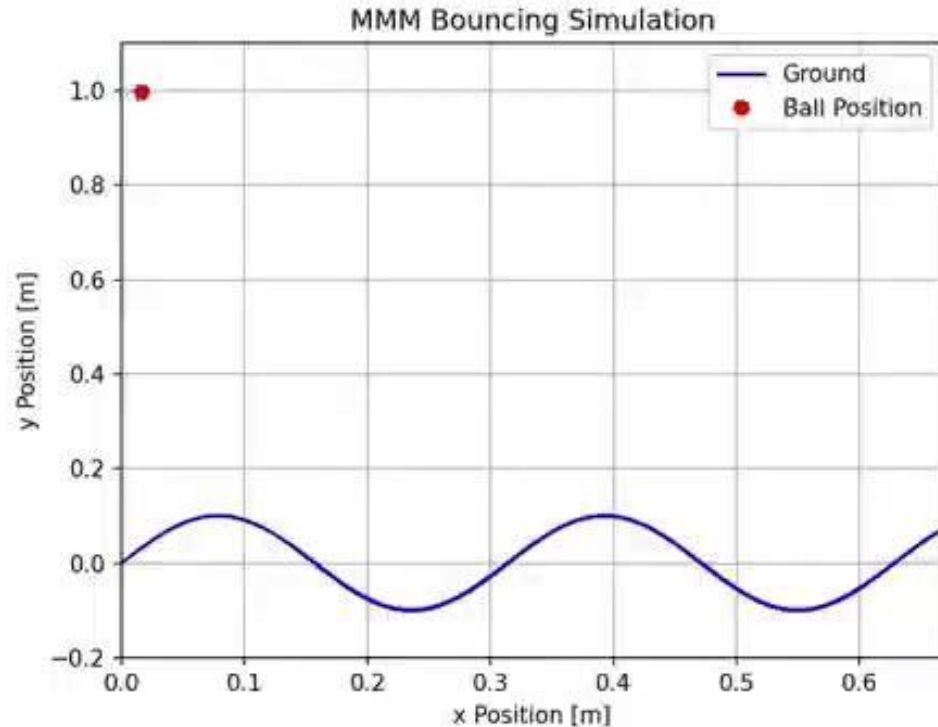
# Phase 1: Contact of Elastic Beams



# MMM Contact and Collision Verification

To check if MMM is working correctly:

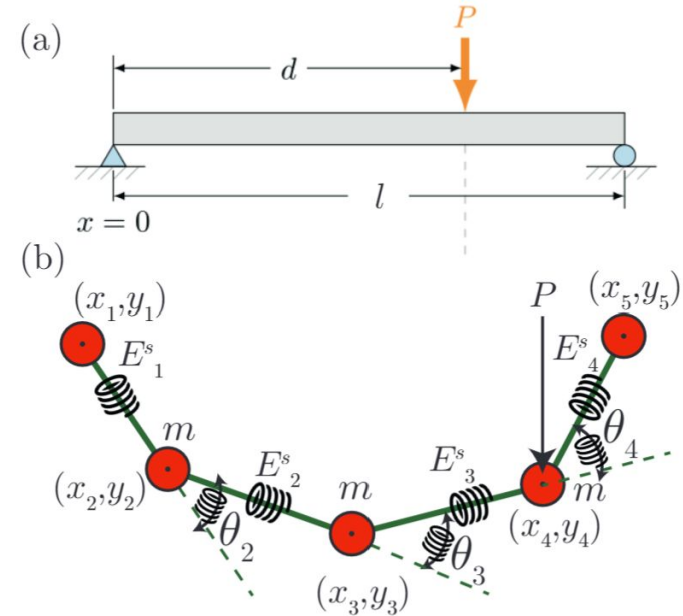
- Tested node bouncing on a sinusoidal surface
- Shows bounce along normal vector to surface



# Phase 1: MMM Implementation for Multiple Nodes

## MMM Implementation Assumptions:

- 2D: Effects of twist neglected
- Viscosity effects negligible (air)
- Constant acceleration in movement of grippers
- Initially grippers at rest
- 2cm x 1cm cross section
- Low elasticity:  $\sim 1e6$

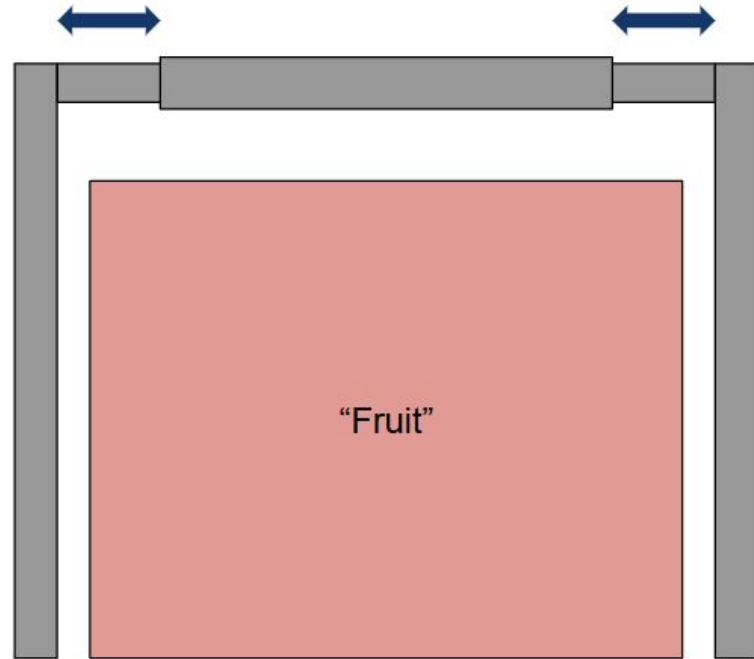


Khalid Jawed, M, and Sangmin Lim. "Discrete Simulation of Slender Structures". BruinLearn, 2022.

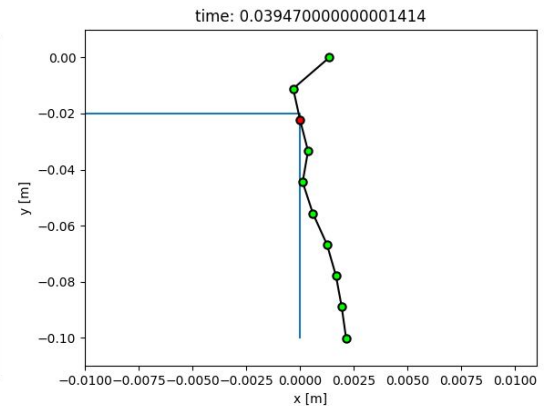
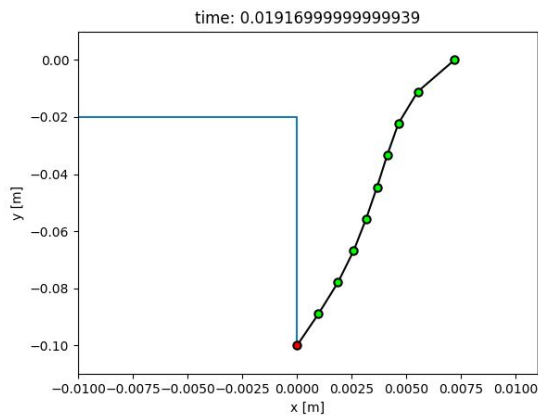
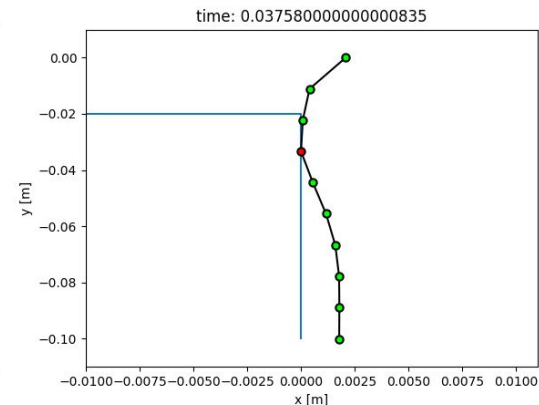
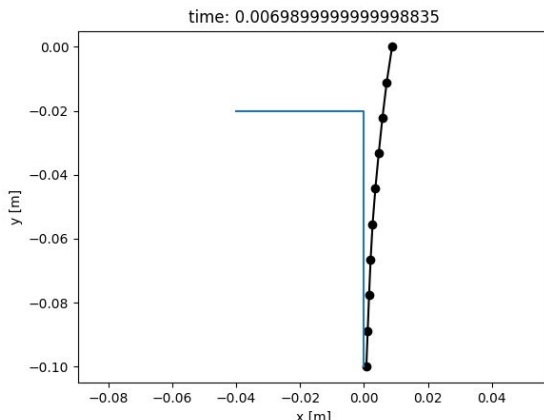
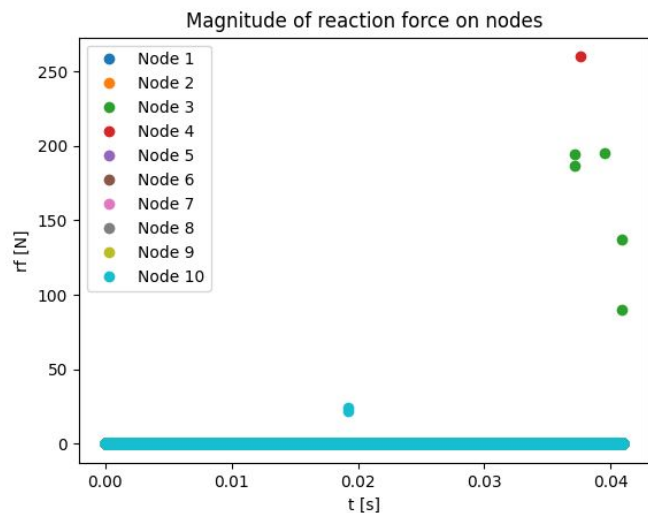
# Phase 1: MMM Implementation for Multiple Nodes

## MMM Implementation Objectives:

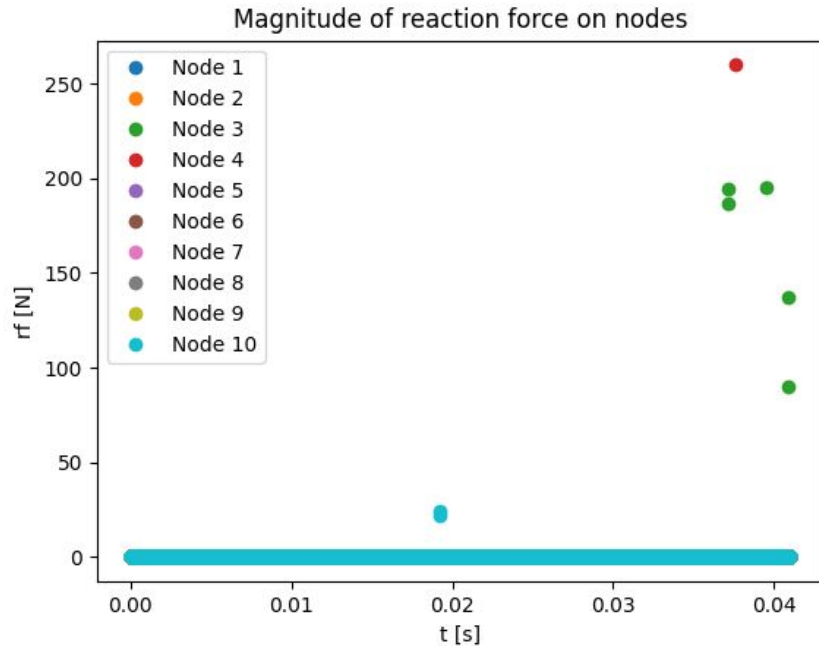
- Modeling 2D elastic beams
- Implement appropriate boundary conditions
  - Parallel end-effector
- Test “square fruits”
- Obtain reaction force plot shapes



# Phase 1: Beam Collision with Flat Surface

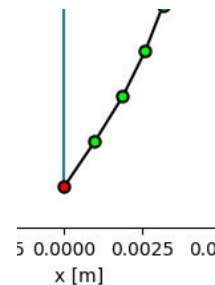


# Phase 1: Beam Collision with Flat Surface

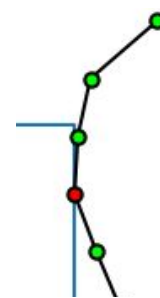


## MMM Implementation Results:

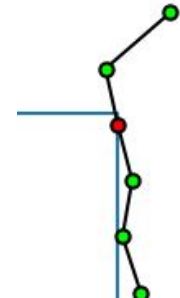
- Reaction force from induced acceleration
- Nodes 3 and 4 critical points



Node 10



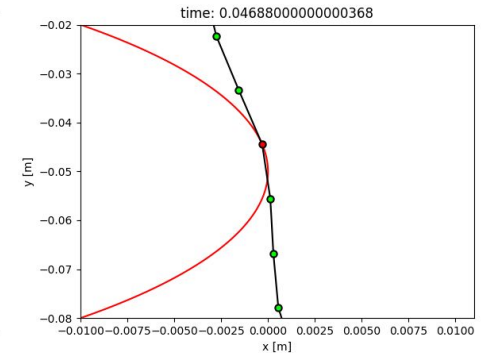
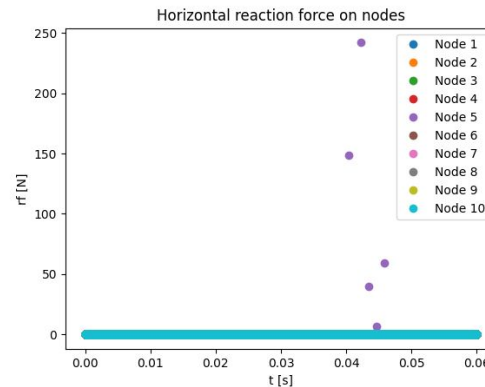
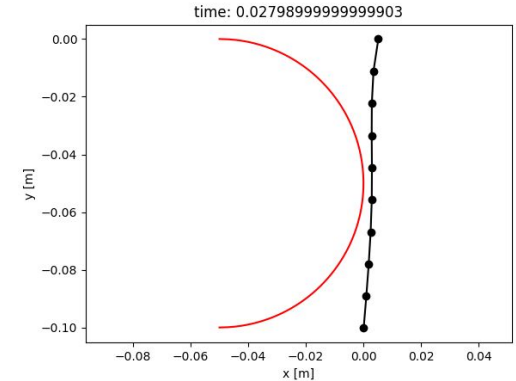
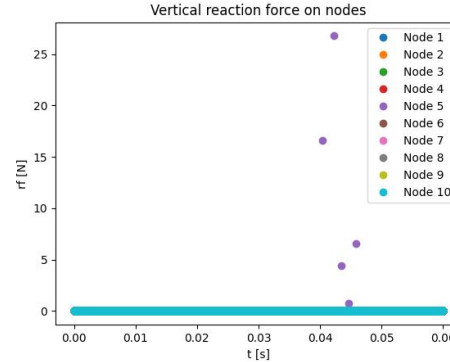
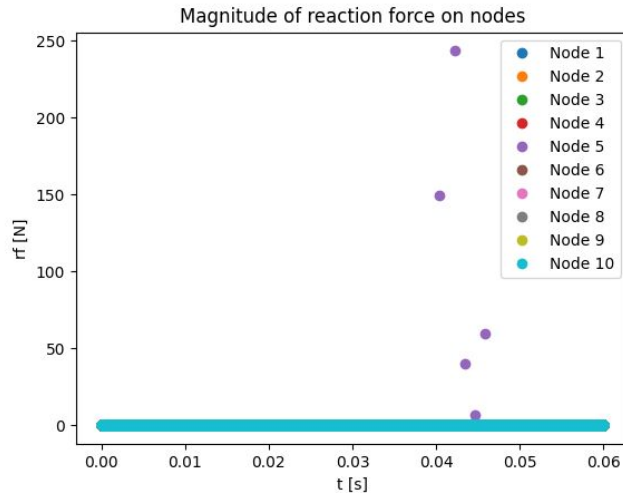
Node 4



Node 3

## Phase 2: Contact of Elastic Beams and Curved Surfaces

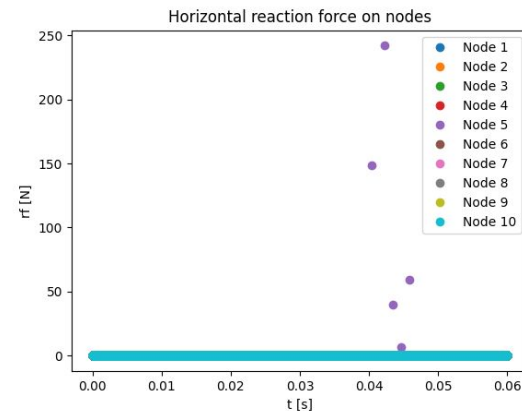
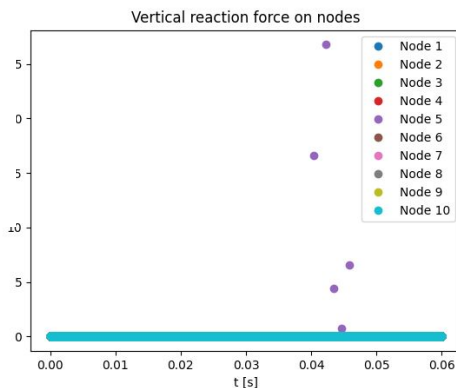
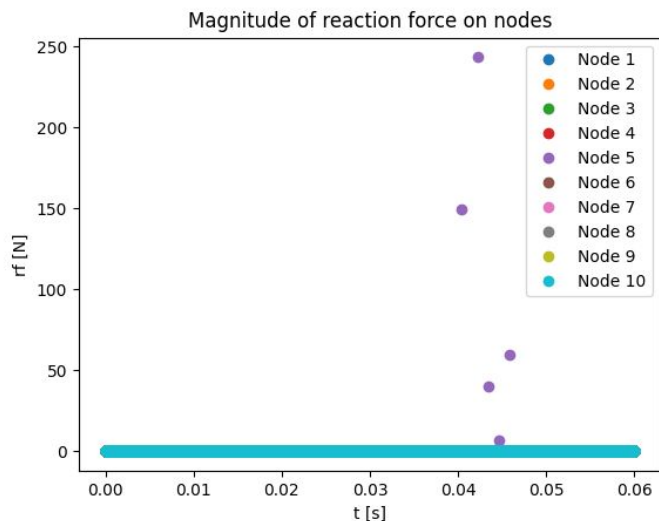
# Phase 2: Beam Collision with Circle



# Phase 2: Beam Collision with Circle

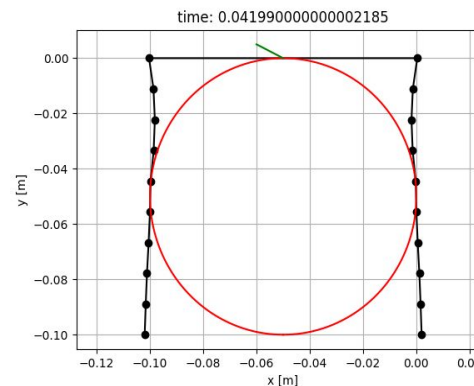
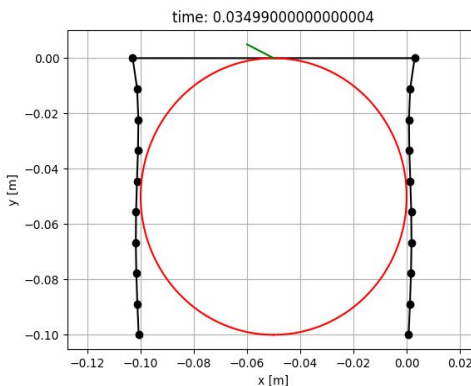
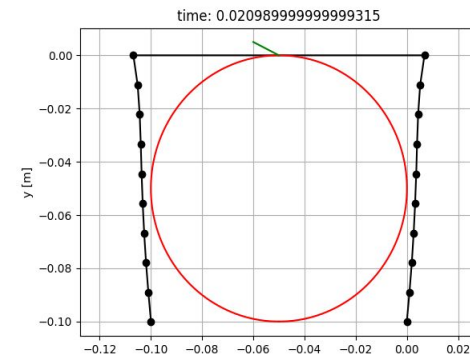
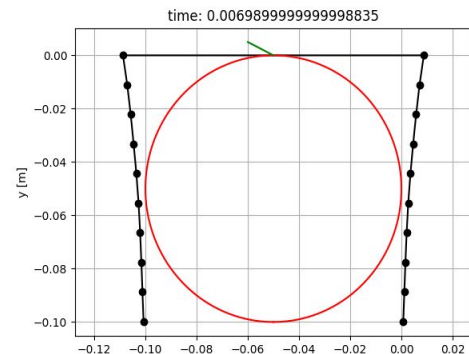
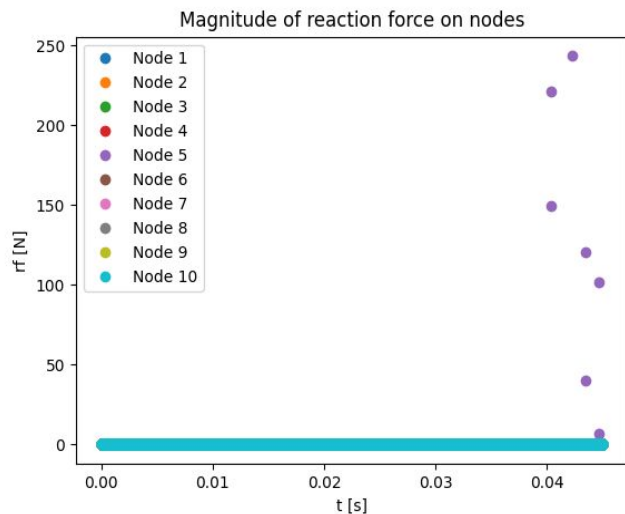
## MMM Implementation Results:

- Both components of reaction force present
- Node 5 critical point





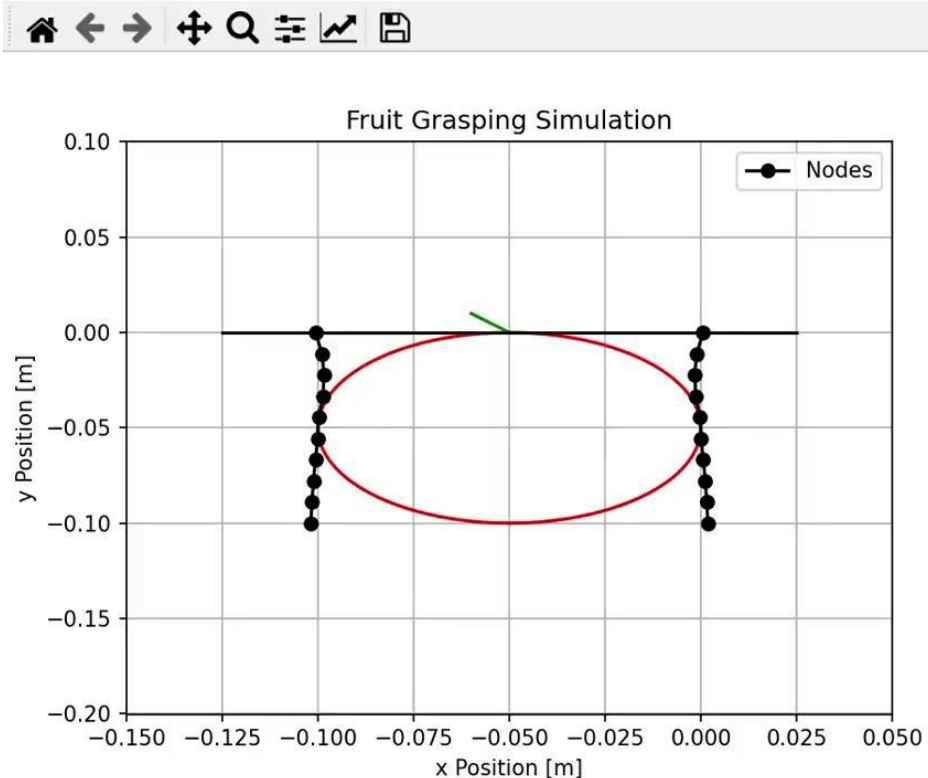
# Phase 2: Beam Collision with Curved Surface



# Phase 2: Beam Collision with Curved Surface

## Simulated Gripper:

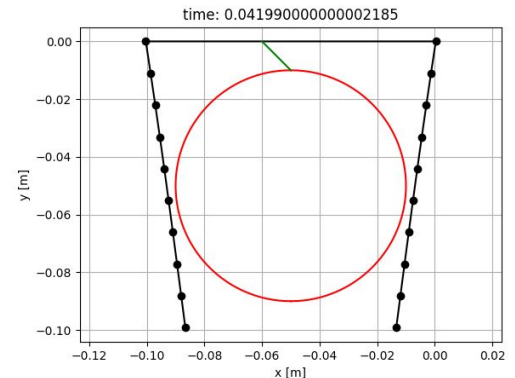
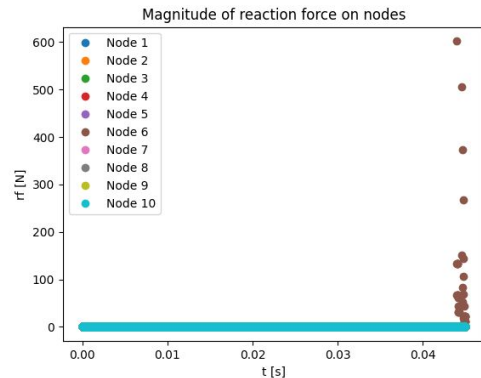
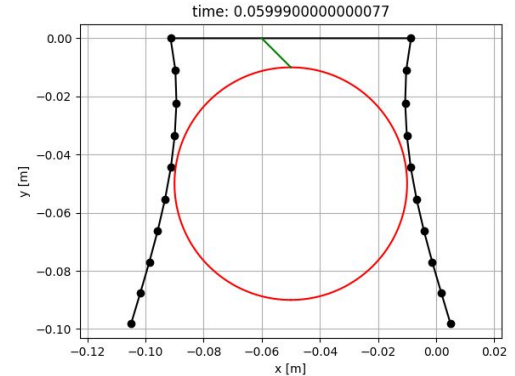
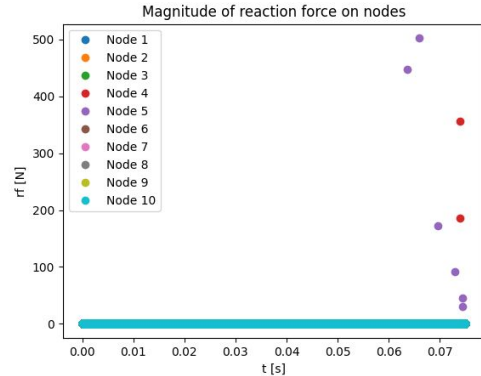
- Gripper prongs start to grasp the fruit
- Tested with Young's Modulus of  $1 \times 10^6$  Pa (Soft Rubber)



# Phase 2: Beam Collision with Curved Surface

## Varying Parameters:

- Decreased fruit radius
- Increased stiffness to Young's Modulus of 1 GPa (Polyethylene)



# Future Work:

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## Project Results:

- Implementation of simulation for 2D geometries of soft end-effectors
- Adjustable parameters: material properties, acceleration, geometry

## Potential areas of investigation:

- Representation of internal stress in nodes
- Representation of elasticity within impact
- Optimized time-stepping for MMM

# References

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