UCLA Samueli
School of Engineering

Parametric Study of Granny and Reef Knot

Final Presentation
MAE 259B

Andrew Choi
Heebeom Park

Project Timeline

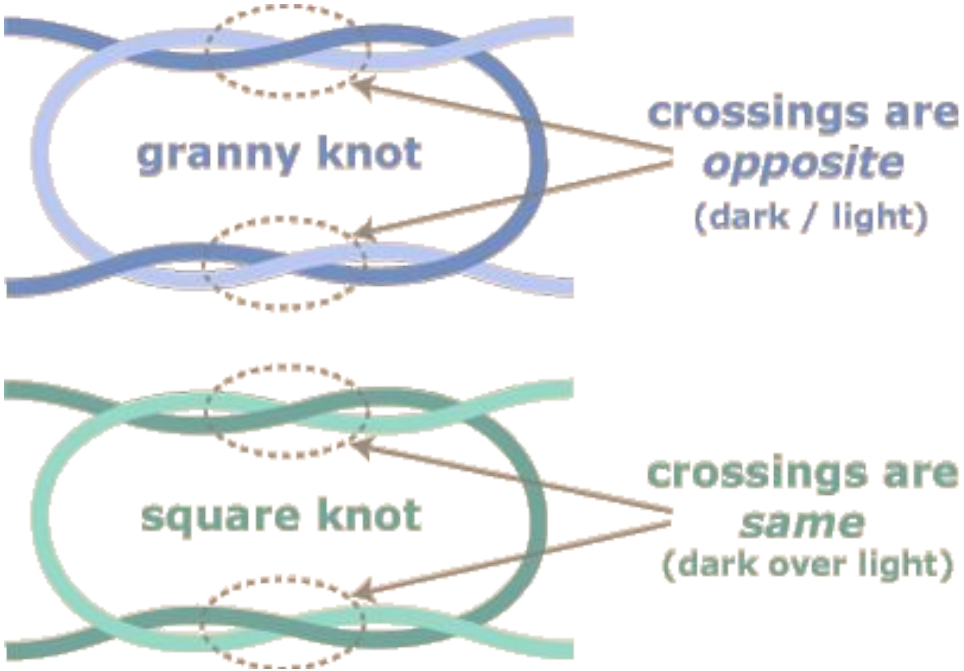
1. Implementation of Discrete Elastic Rod (DER)

2. Incorporate Implicit Contact Model (IMC)

3. Derive boundary condition for granny and reef knot

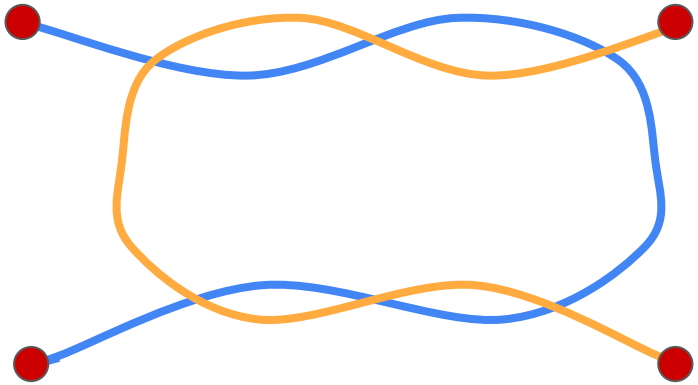
4. **Parametric study of both knots**
   a. A partial parametric study will be shown.
   b. Additional simulations still being run.

Granny vs. Reef Knot Overview

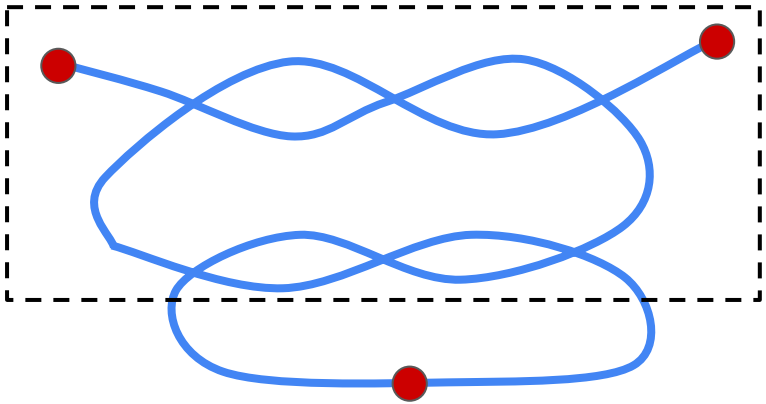


- Granny and reef knots differ in topology by one single crossing order difference.
- Despite this, reef knots are known to possess higher “knot strength”.
- **Can we replicate this in simulation using DER and IMC?**

Granny and Reef Knots using Single Elastic Rod

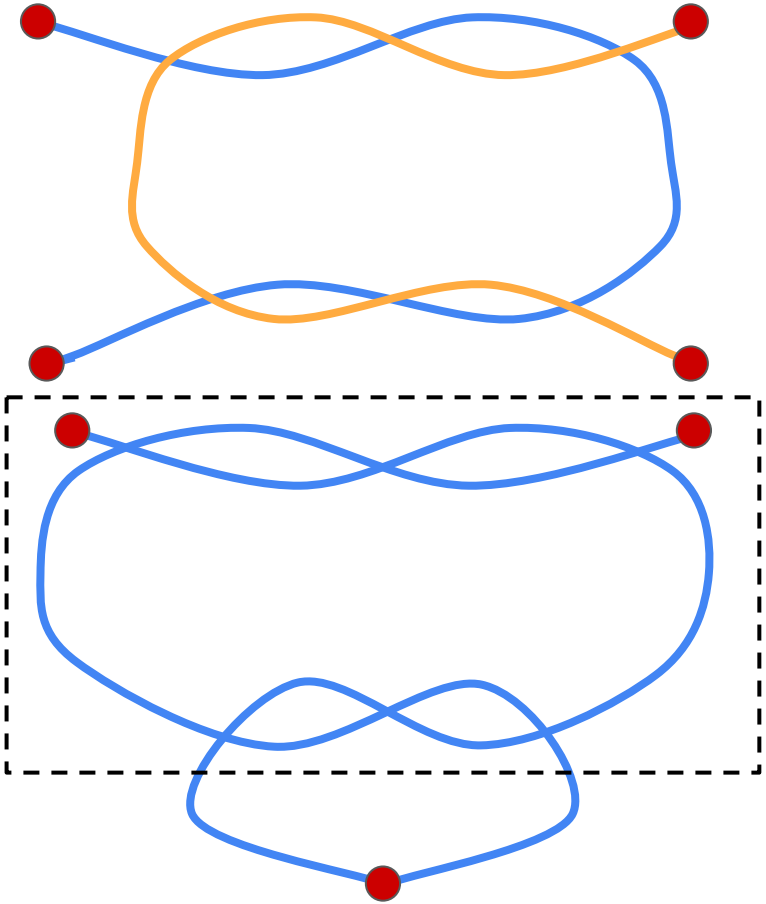


Instead of using two elastic rods, we can use a single elastic rod.



Simply, start off with an overhand knot and then tie another overhand to create a reef or granny.

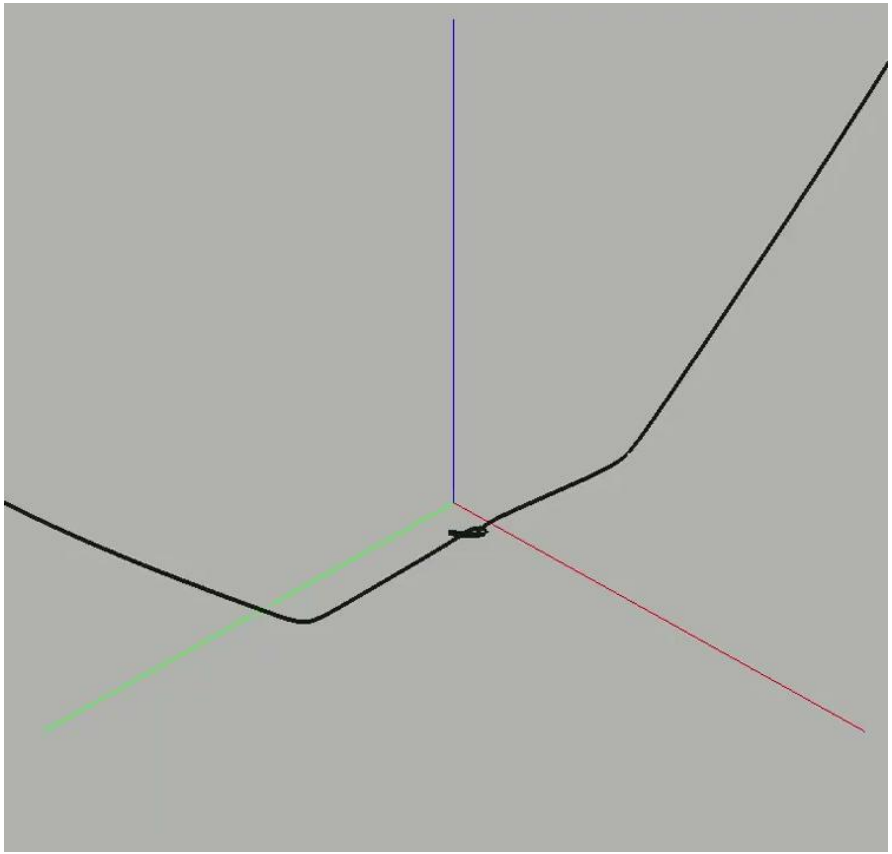
Granny and Reef Knots using Single Elastic Rod



Instead of using two elastic rods, we can use a single elastic rod.

Simply, start off with an overhand knot and then tie another overhand to create a reef or granny.

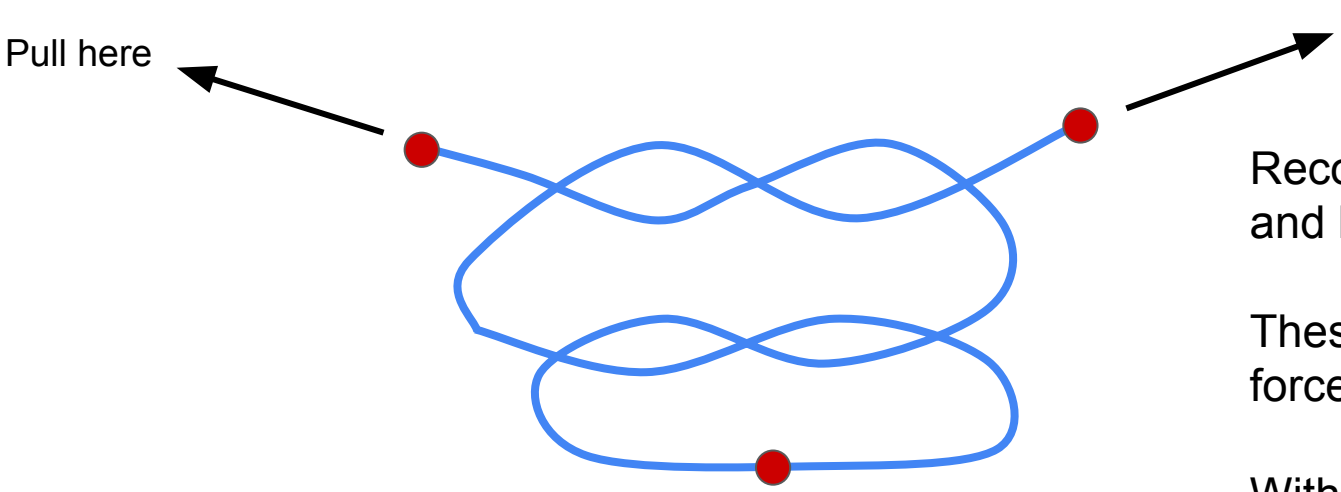
Boundary Condition Sequence



Much thanks to Guanjin Wang (Postdoc in SCI Lab) for helping us obtain the boundary conditions for forming the reef and granny knots.

For reef knot, similar procedure with opposite movements.

Boundary Condition Sequence for Tightening Knots



Record the forces on the first and last edges.

These will be our traction forces.

Without static boundary condition, bottom overhand will invert and we will lose the reef / granny knot topologies.

Experiment List

1. Granny knot visualization, μ=0.1
2. Reef knot visualization, μ=0.1
3. Granny knot visualization, μ=0.5
4. Reef knot visualization, μ=0.5
5. Parametric study for μ on traction force.

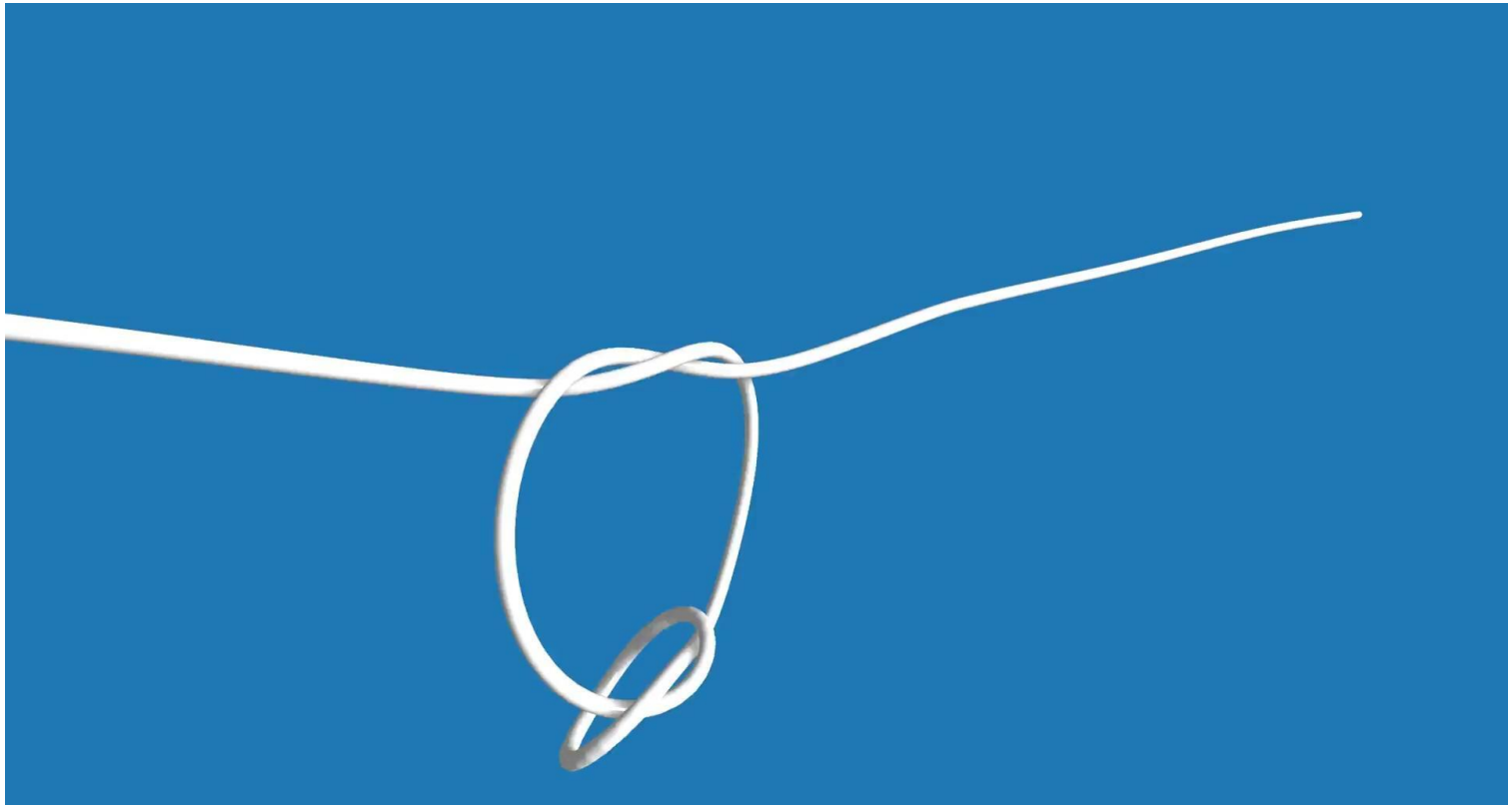
Physical Parameters used

- h = 2 mm
- E = 0.18 MPa
- L = 1 m

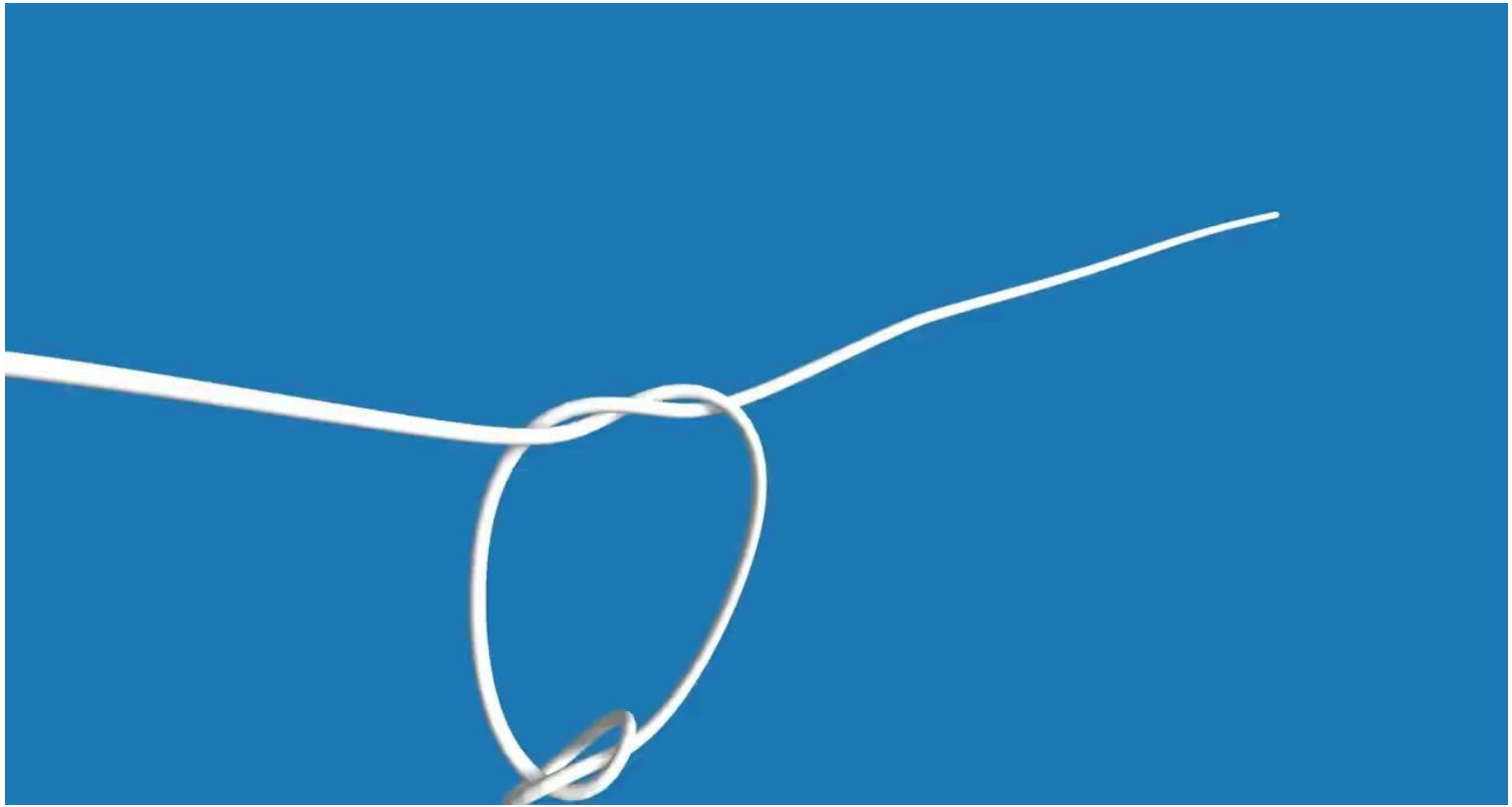
Numerical Parameters used

- N = 301
- dt = 2.5 ms
- δ = 5e-4 (IMC)
- N = 1e-4 (IMC)

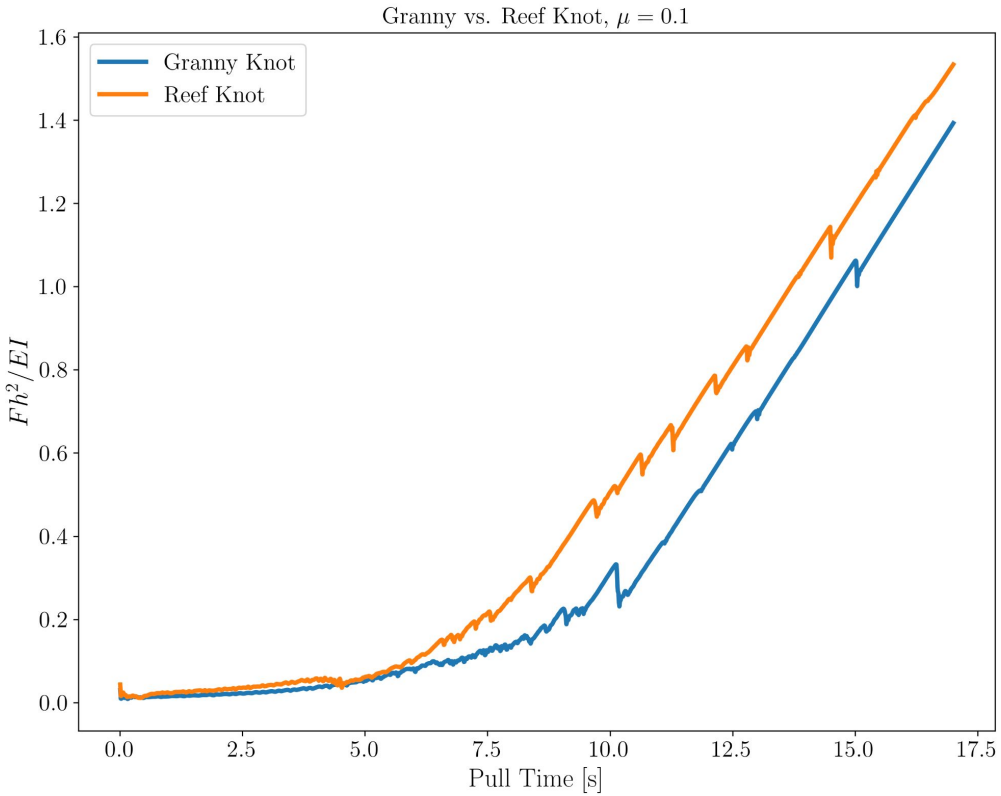
Granny Knot Tightening Video, μ=0.1



Reef Knot Tightening Video, μ=0.1



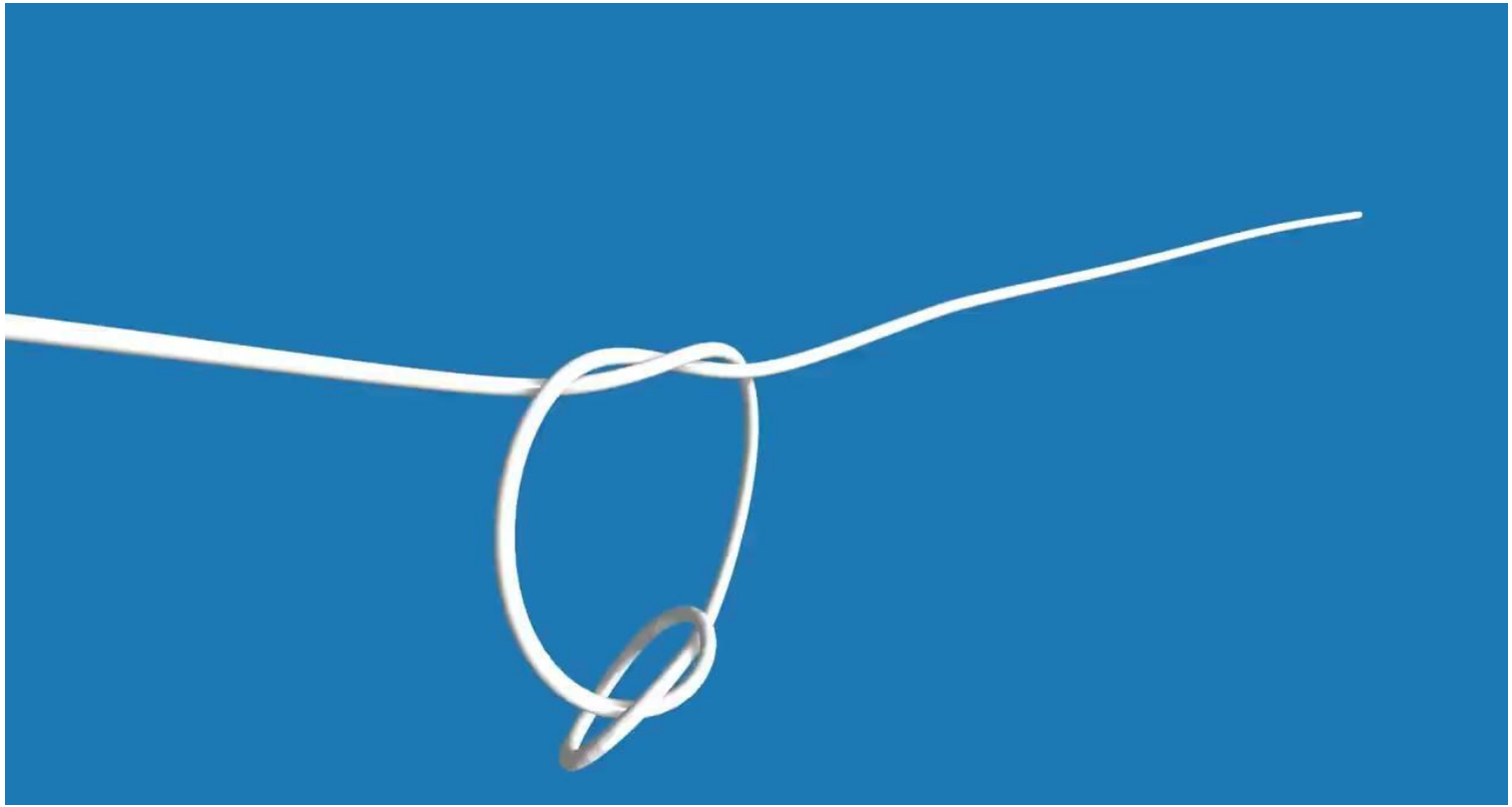
Granny vs. Reef Knot Traction Force, μ=0.1



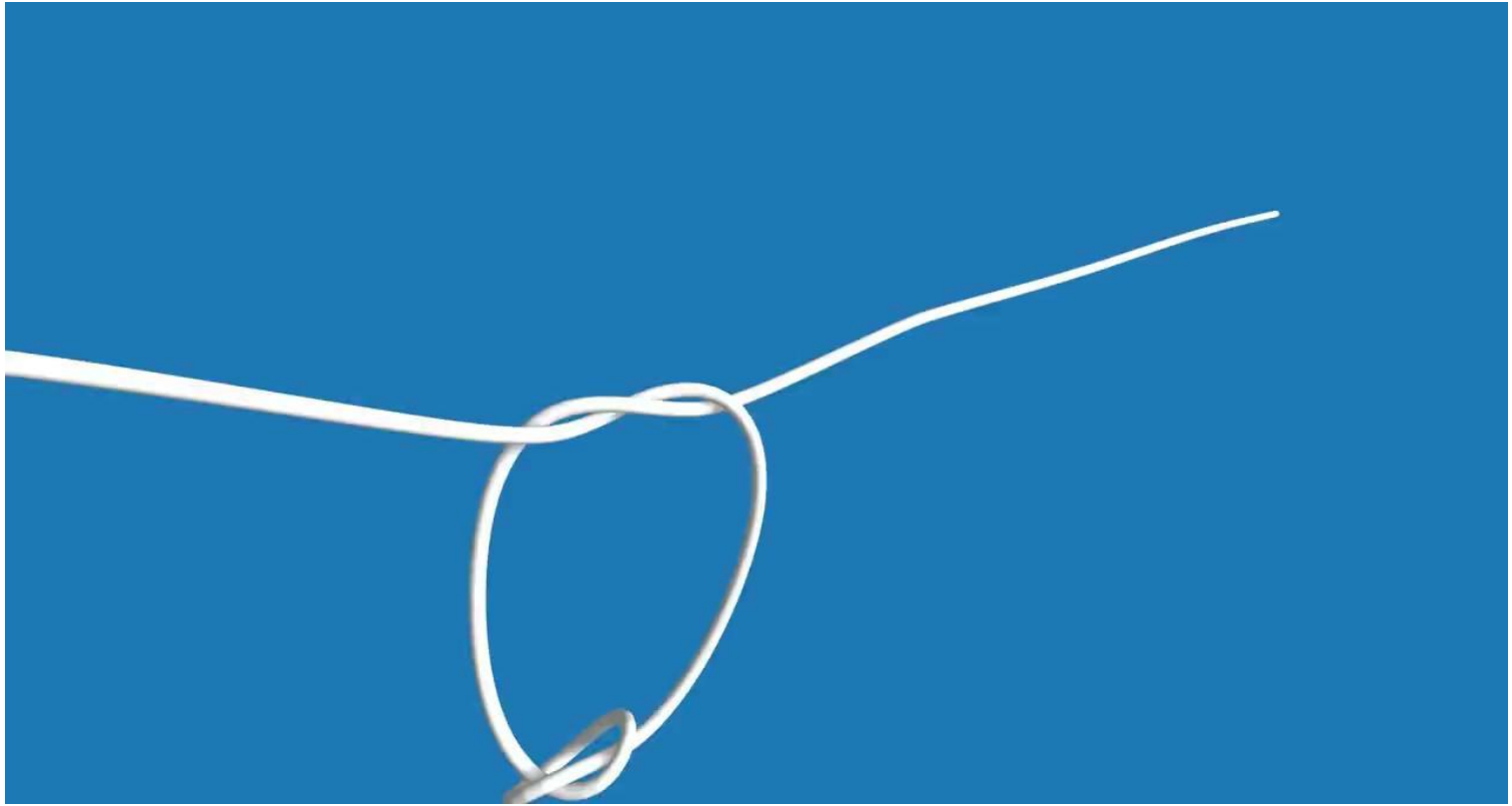
Note that the reef knot experiences higher traction forces than the granny knot.

Our simulation framework is able to replicate expected results.

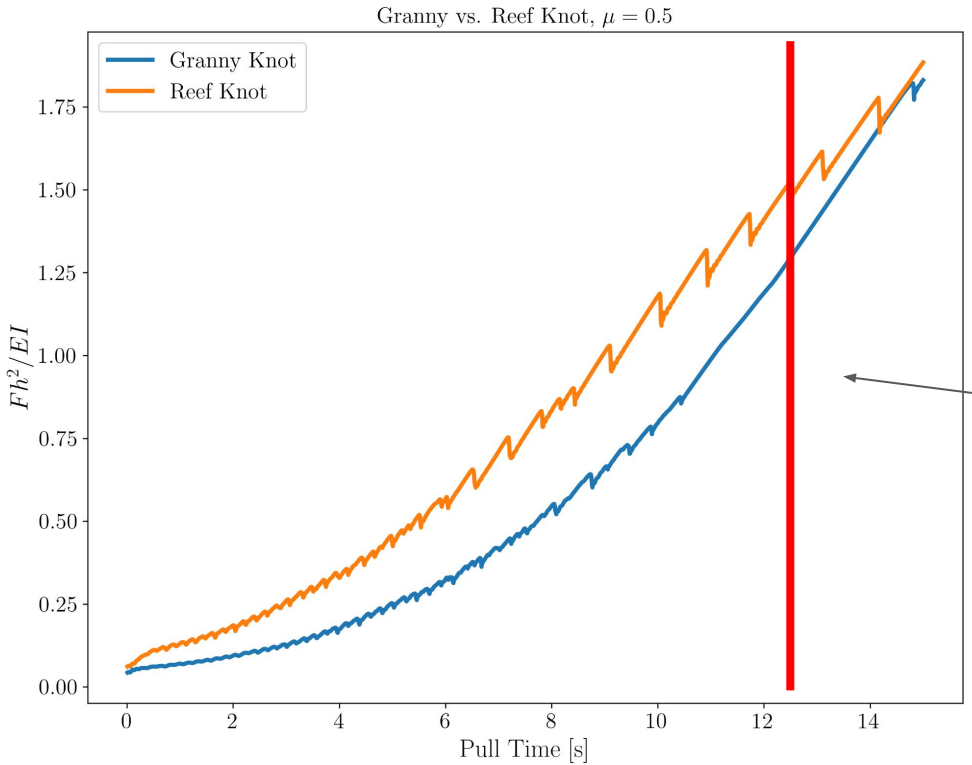
Granny Knot Tightening Video, μ=0.5



Reef Knot Tightening Video, μ=0.5



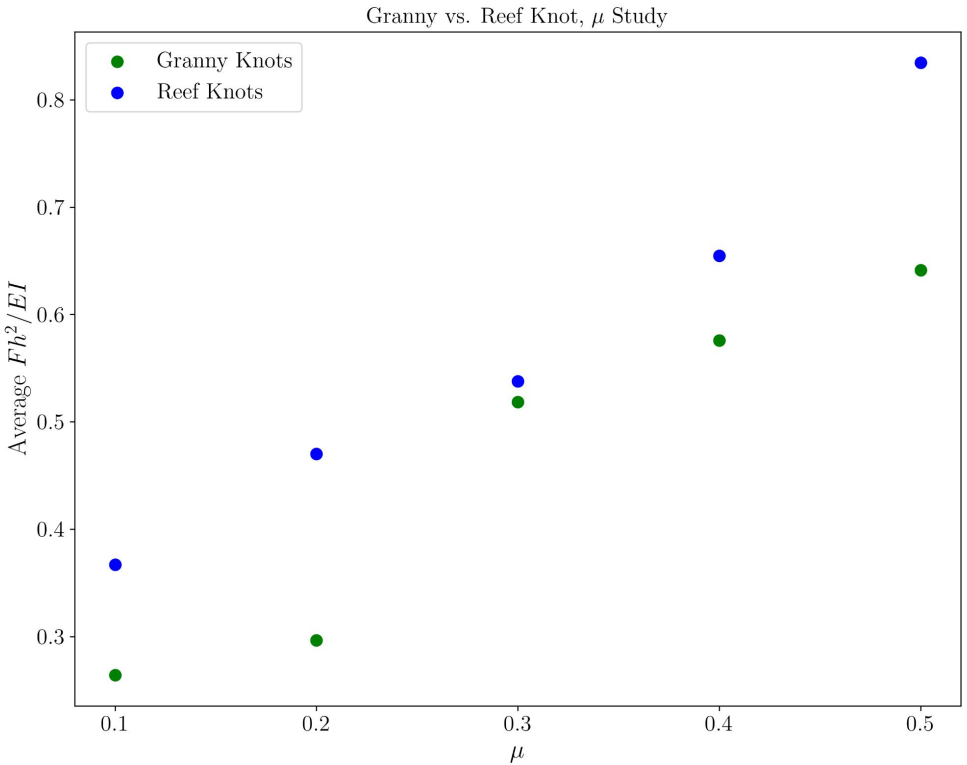
Granny vs. Reef Knot Traction Force, μ=0.5



Note that the reef knot experiences higher traction forces than the granny knot.

The granny knot becomes taut at this point whereas the reef knot still has slack.

Effects of μ on Traction Force



For all friction coefficient values, reef knots possess a higher average traction force compared to the granny knot.

Result for μ=0.3 do not have good separation, but still follow a monotonically increasing trend.

What’s Left?

- Additional simulations will be run for a full parametric study.
  - Effects of rod radius?
  - Effects of Young’s Modulus?

- Focus on final report!
  - Create nice figures and perhaps additional videos.