MAE 263F
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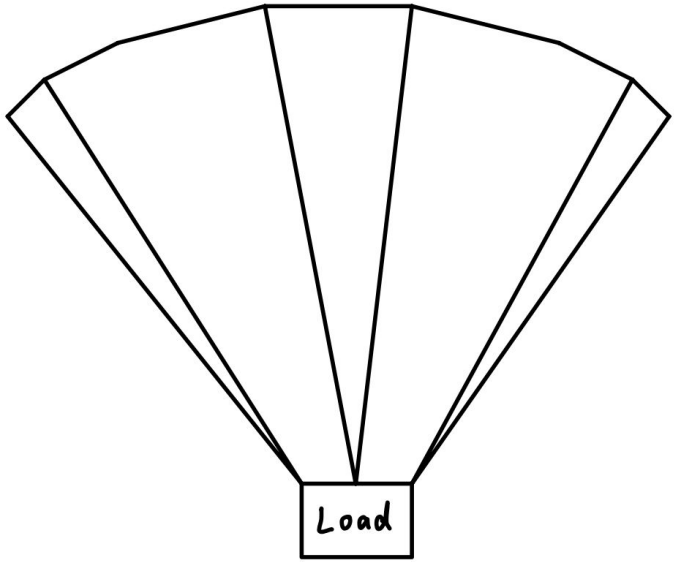
Flexible Structure of Parachutes in Flight

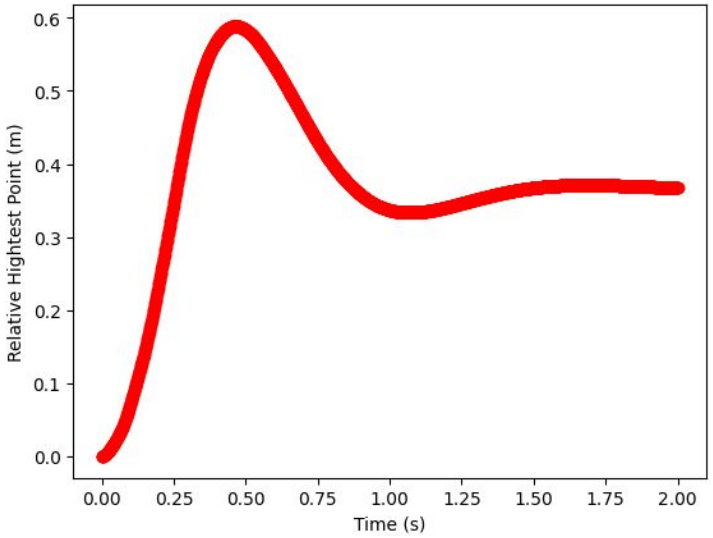
Implementation: DER Hydrodynamics

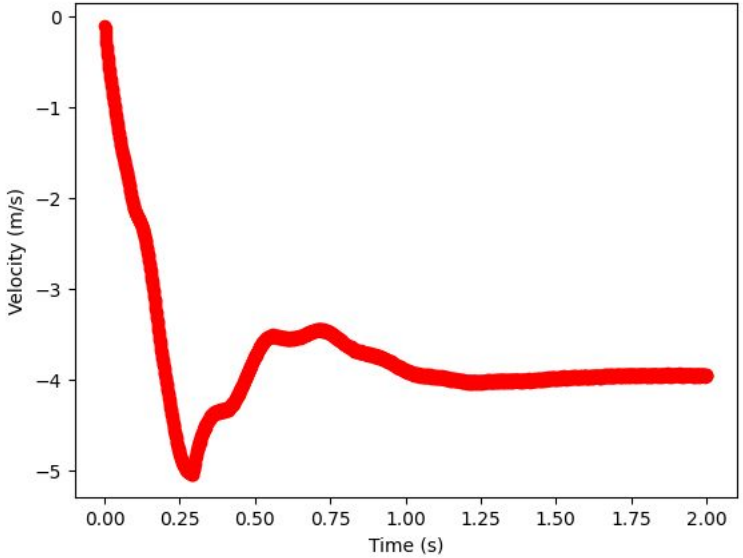
- High Reynolds Number Flow
- C_D = 1.75
- Length = 6 m
- Width = 3 m
- Thickness = 2 mm
- dt = 0.001
- Parachute Kevlar Material:
  - Young’s Modulus: 55 GPA

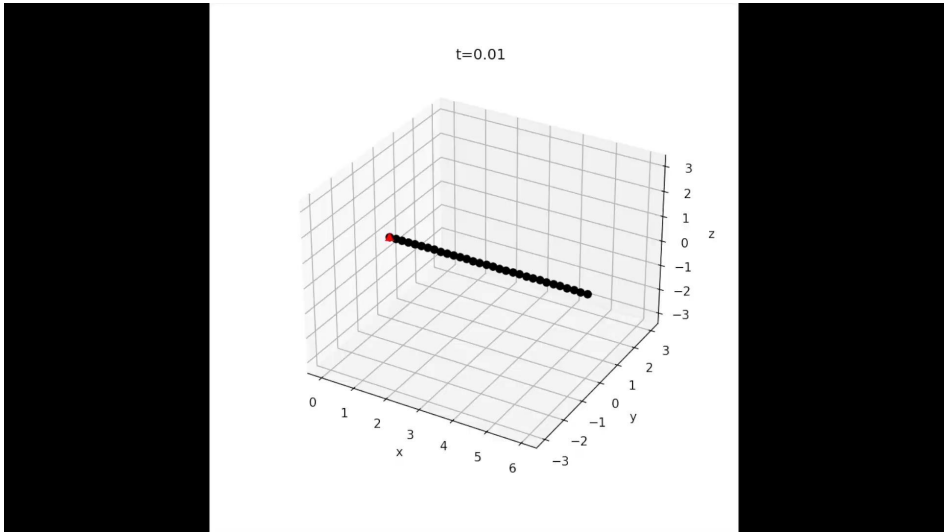


DER Hydrodynamics: Load = 20N

- Terminal Velocity: -3.9 m/s
- Time Reached: 1.25s

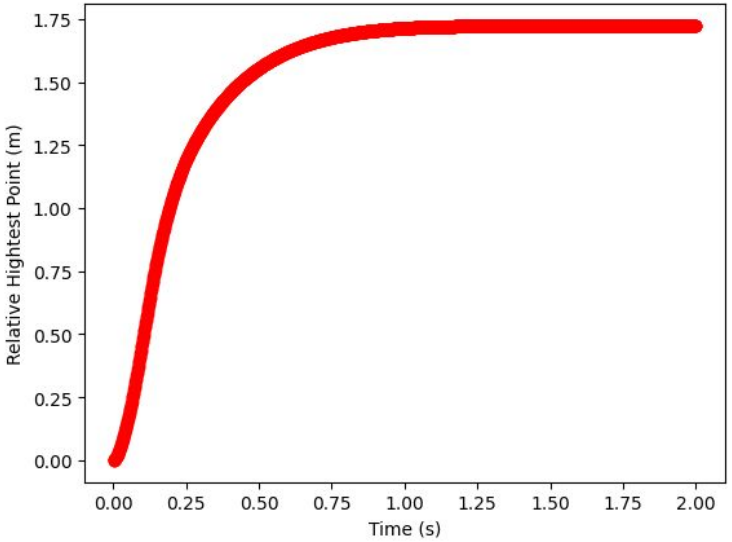


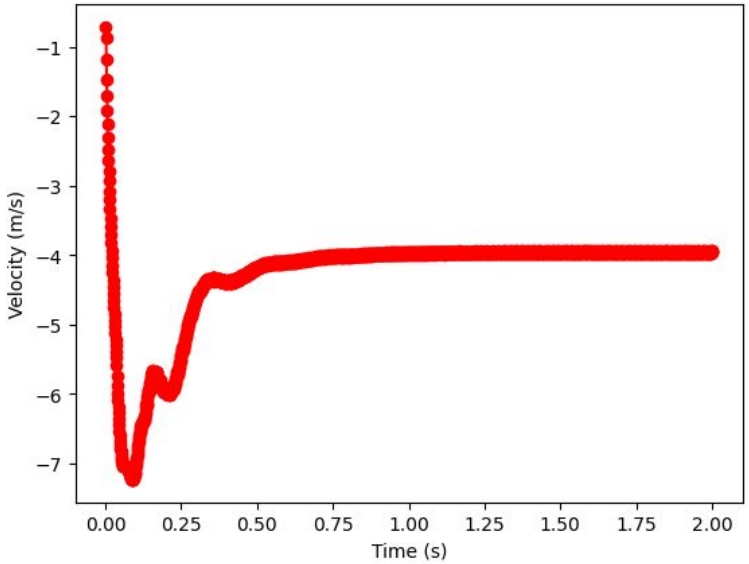


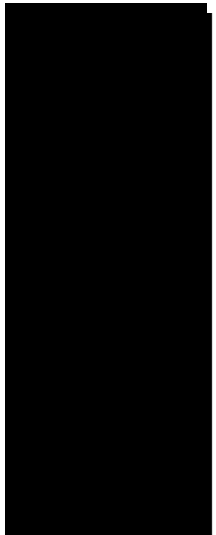


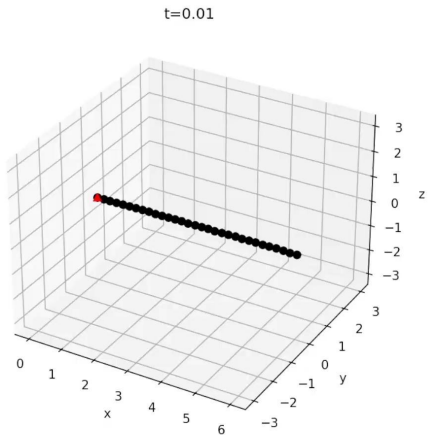
DER Hydrodynamics: Load = 200N

- Terminal Velocity: -3.9 m/s
- Time Reached: 0.75s



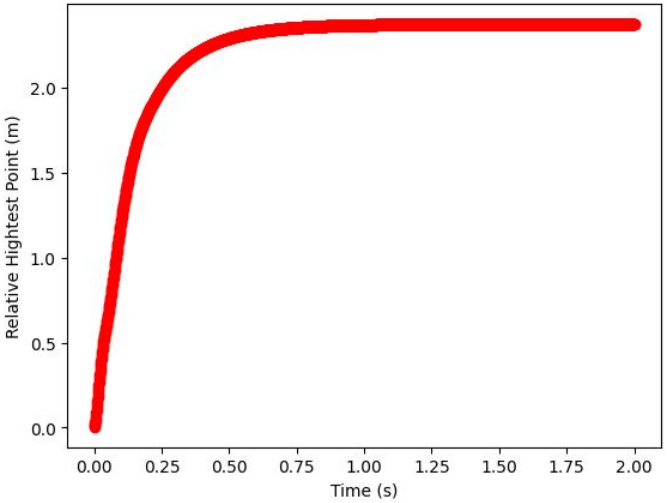


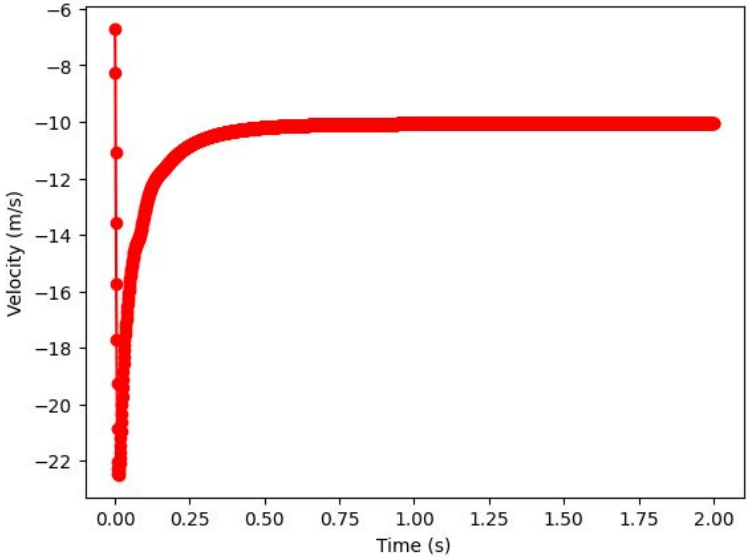


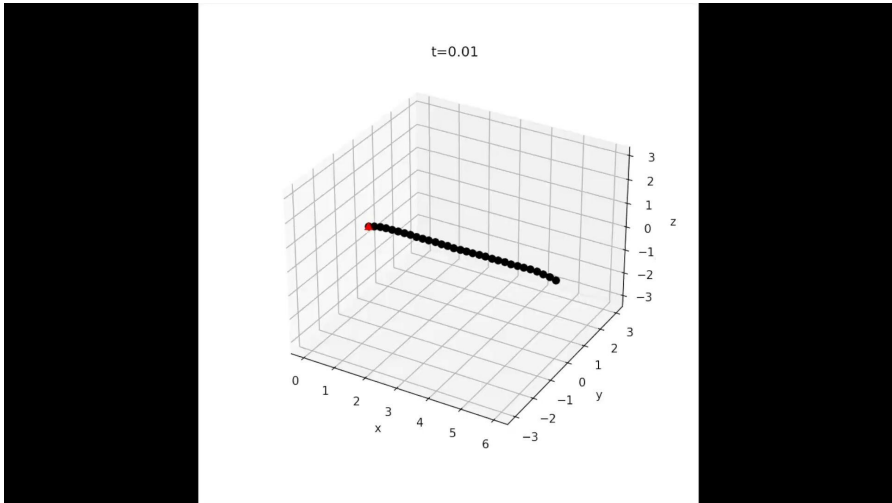


DER Hydrodynamics: Load = 2000N

- Terminal Velocity: -10 m/s
- Time Reached: 0.5s

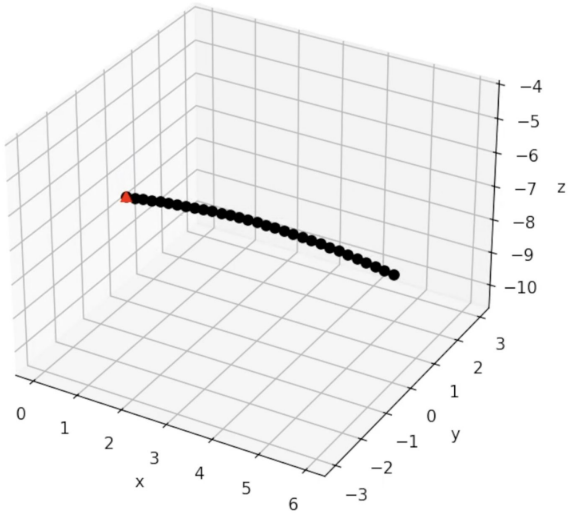


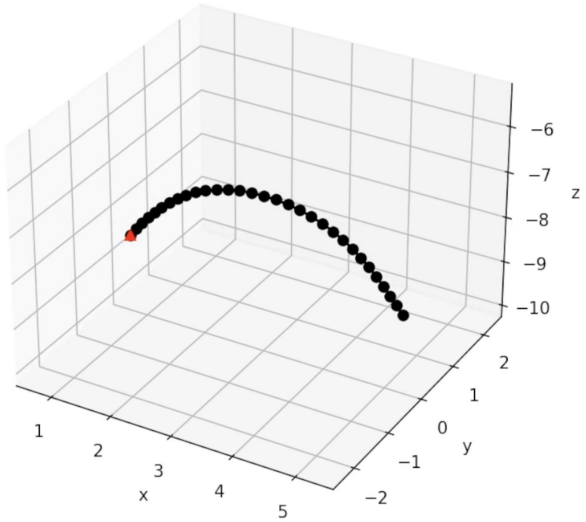


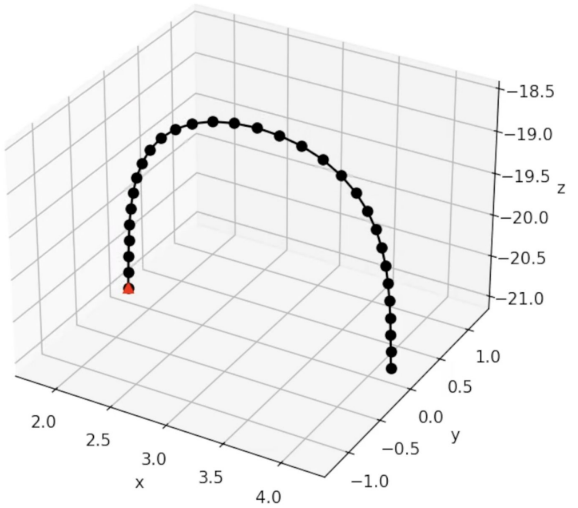


DER Hydrodynamics Conclusion

- Loads: 20, 200, 2000 N
- Terminal Velocities: -3.9, -3.9, -10 m/s
- Time to Terminal Velocity: 1.25, 0.75, 0.4s

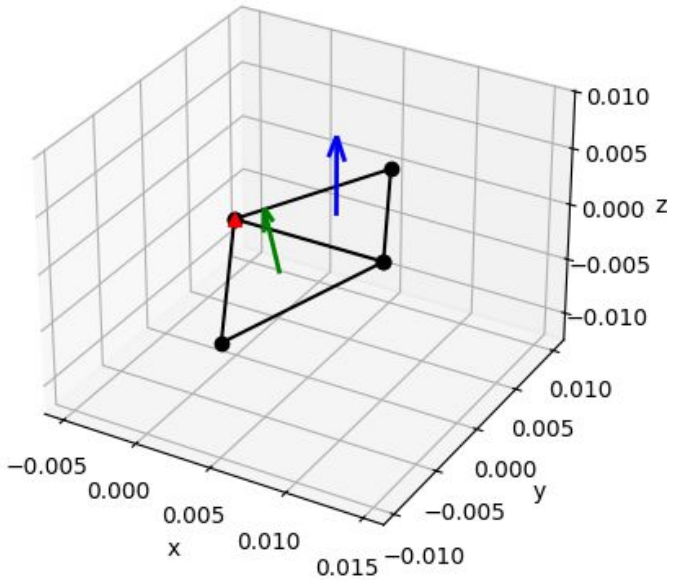






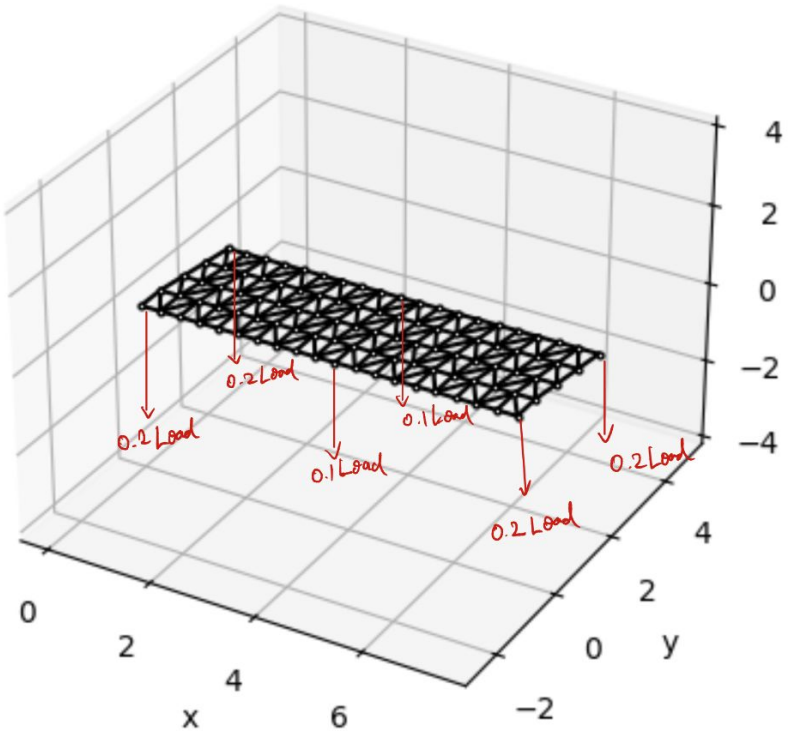
Implementation: Shell Hydrodynamics

- High Reynolds Number Flow
  - C_D_normal = 1.75
  - C_D_tangent = 0.5 (Skin Friction)
  - Drag force acts on planform area
- Dimension:
  - Length = 6 m
  - Width = 3 m
  - Thickness = 2 mm
- Parachute Kevlar Material:
  - Young's Modulus: 55 GPA

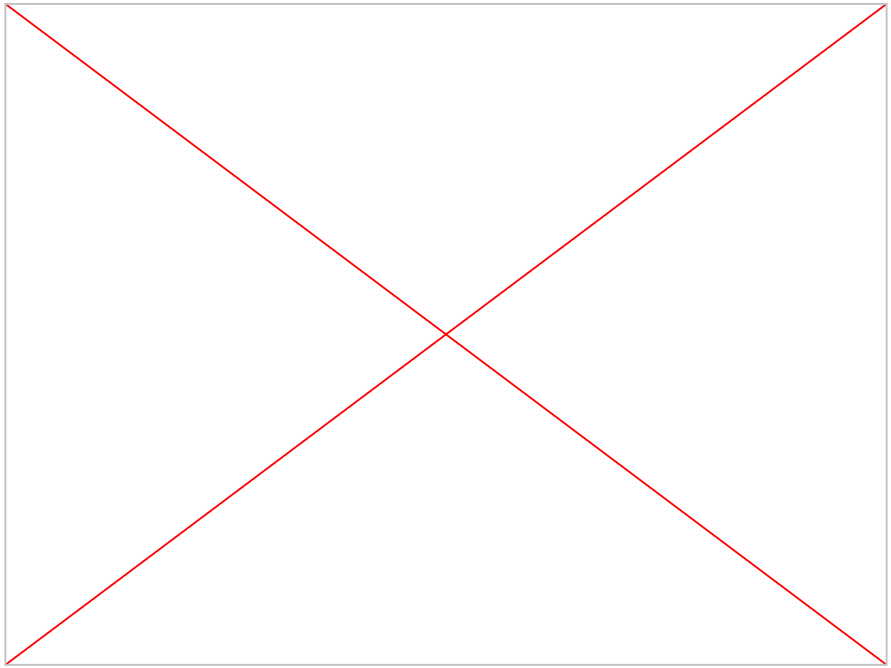


Implementation: Shell Hydrodynamics

- Mesh:
  - 20 x 5 Nodes
  - Alternating hinges
- External Load:
  - Gravitational force on every node
  - Tensile Load:
    - Load = 200 kg
    - Distributed across the parachute

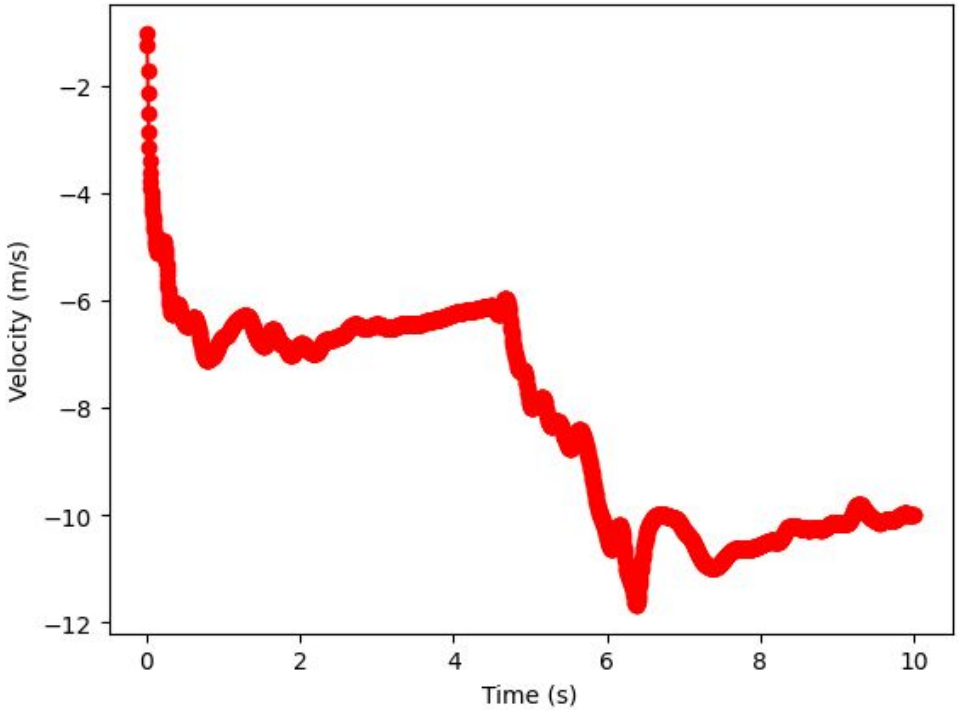


Parachute with Shells & Hydrodynamics



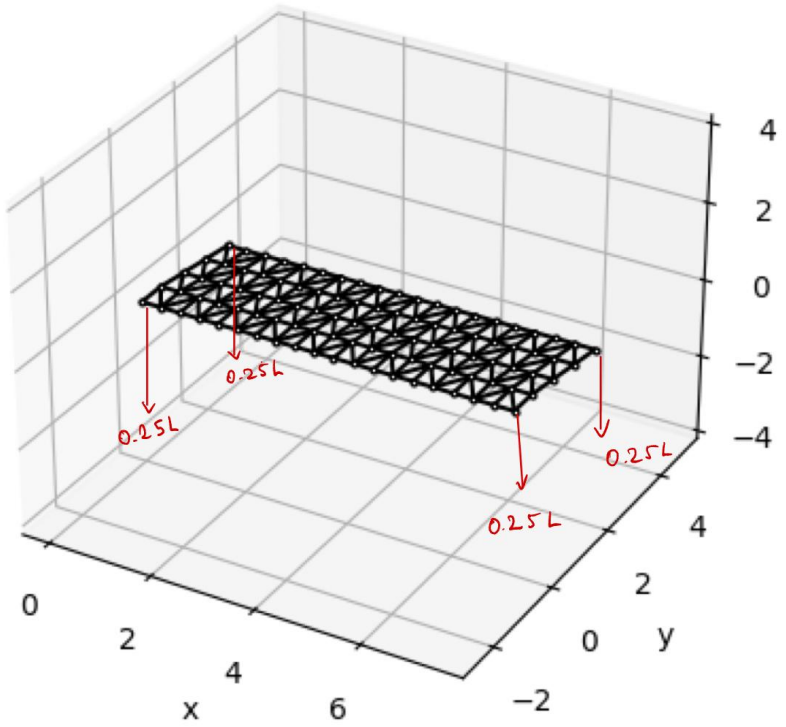
Parachute with Shells & Hydrodynamics

- Terminal Velocity:
  - Extended Canopy
    - ~ 6 m/s
  - After collapse
    - ~ 10 m/s

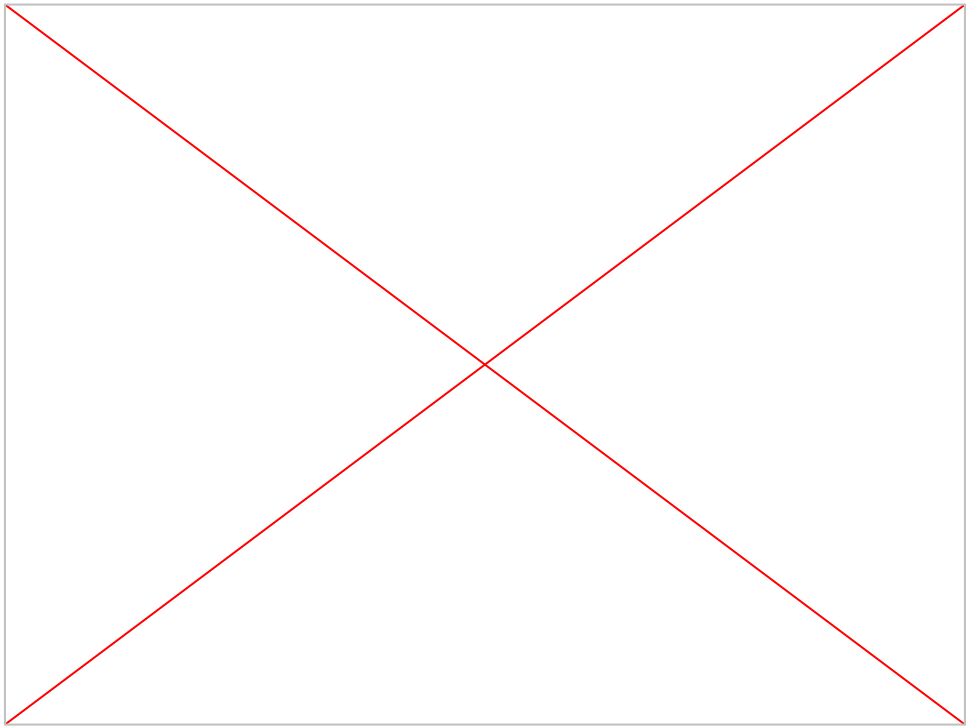


Implementation: Shell Hydrodynamics

- External Load:
  - Gravitational force on every node
  - Tensile Load:
    - Load = 200 kg
    - Only on the Left and Right Side

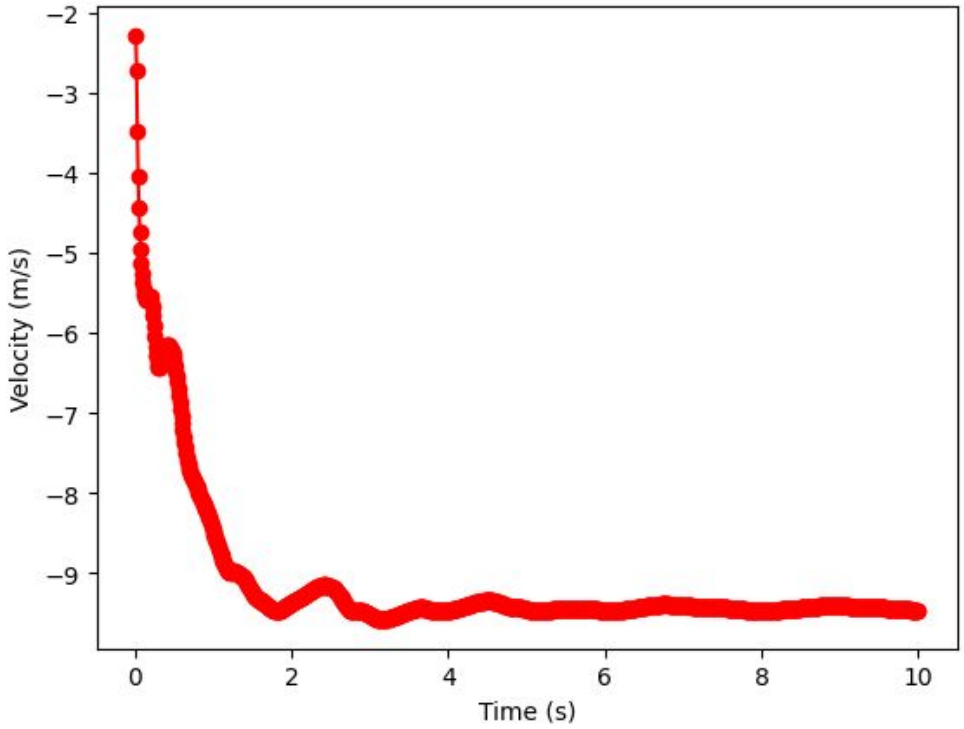


Parachute with Shells & Hydrodynamics

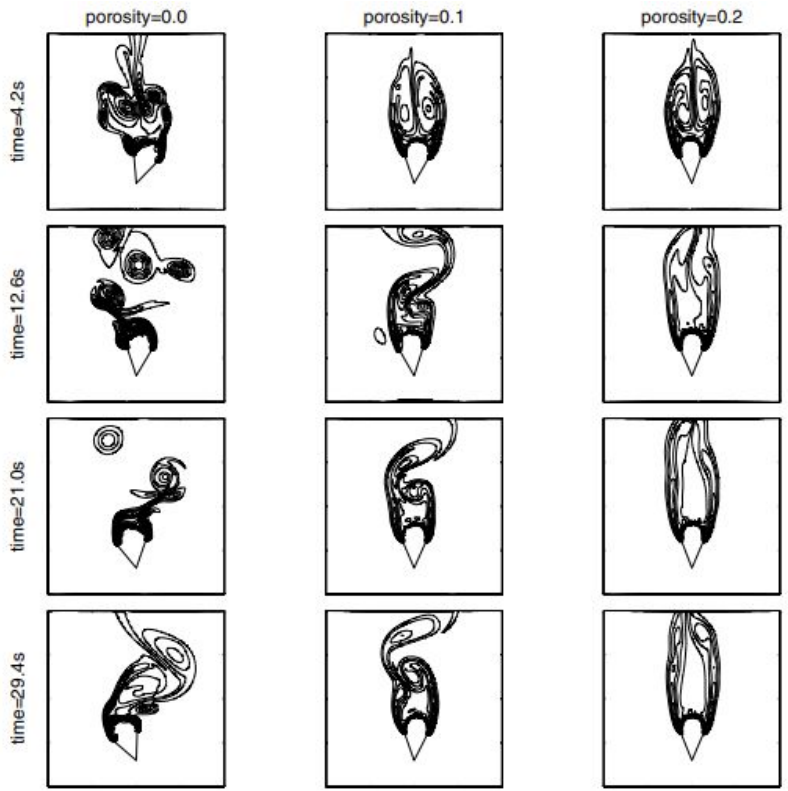


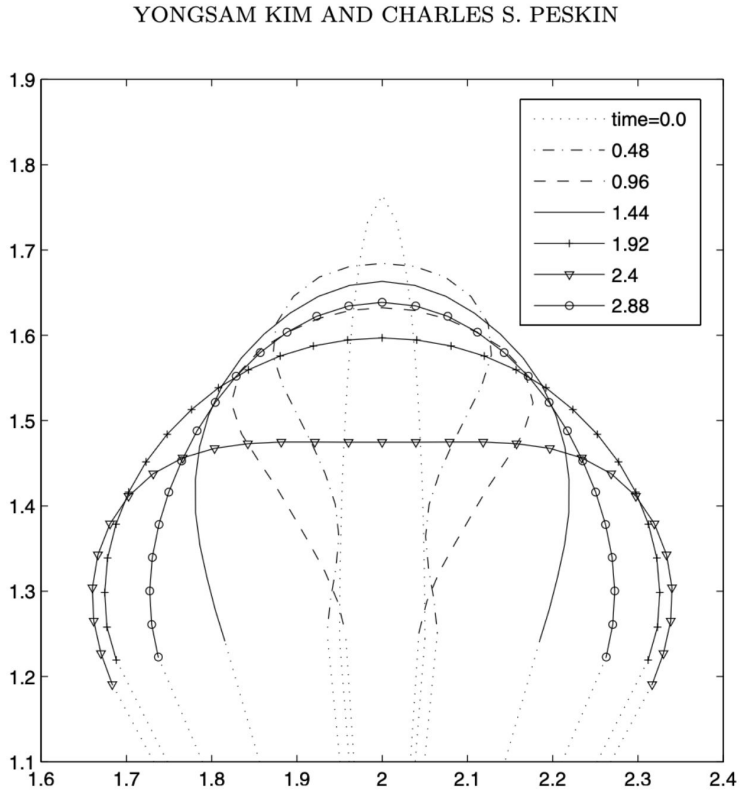
Parachute with Shells & Hydrodynamics

- Terminal Velocity:
  - Extended Canopy
    - ~9.6 m/s



Immersed Boundary Method Parachute





Kim, Y., & Peskin, C. S. (2009). 3-D parachute simulation by the immersed boundary method. *Computers & Fluids*, *38*(6), 1080–1090. https://doi.org/10.1016/j.compfluid.2008.11.002