Homework 3

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I. Part 1

In this section with $D = 0.04m$, we achieve a steady state displacement of the end of approximately $8.49E-4$ m. We can look at the coil at 5 different time points. 0, 750, 1500, 2250, and 3000 seconds. In this section because of the high damping from $\mu = 1.0$ it took approximately 5000-7000s to converge so a step size of 30s was used when computing the displacements. To determine convergence when $\delta_z^* < 0.01 \cdot \delta_z^{max}$ over the last 10% of the time. If we were to eliminate the damping term μ it would fix the extremely long convergence times.

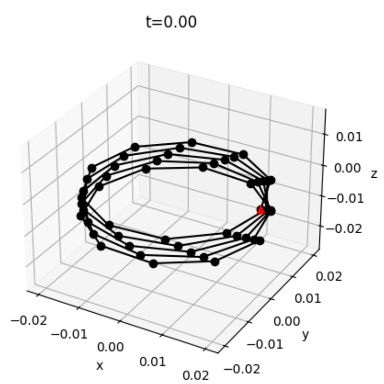

Fig. 1. Coil at $t = 0s$.

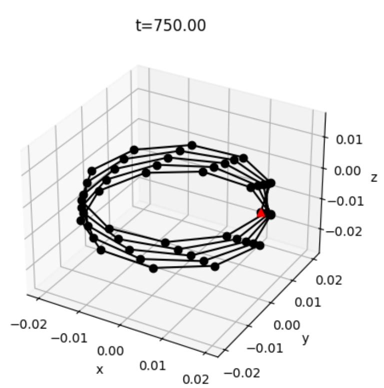

Fig. 2. Coil at $t = 750s$.

II. Part 2

In this section we calculate the value of k for the coil by using varying force values of $0.1 \cdot F_{char}$ to $10 \cdot F_{char}$. With

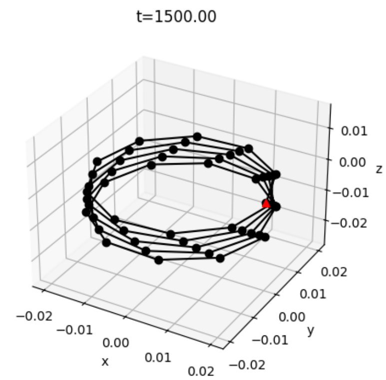

Fig. 3. Coil at $t = 1500s$.

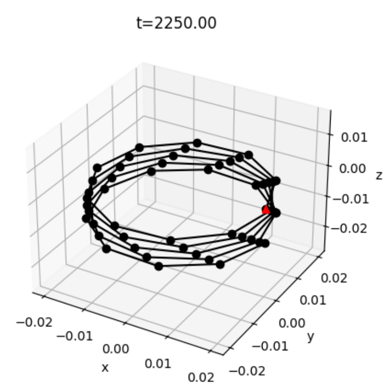

Fig. 4. Coil at $t = 2250$.

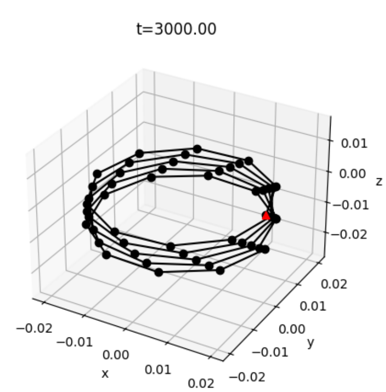

Fig. 5. Coil at $t = 1500s$.

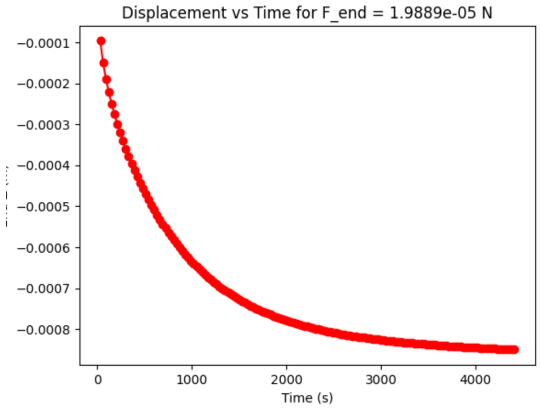

Fig. 6. Coil at $t = 1500s$.

$D = 0.04$ and fitting according to the format $F = k \cdot \delta_z^*$ we get a value for $k = 0.0234N/m$ which can be seen from the plot where we overlay our best fit over the displacements. As we can see from this, with the large variance in our choice of $F_{applied}$ we still see very little error between our best fit line and our actual felt displacement points.

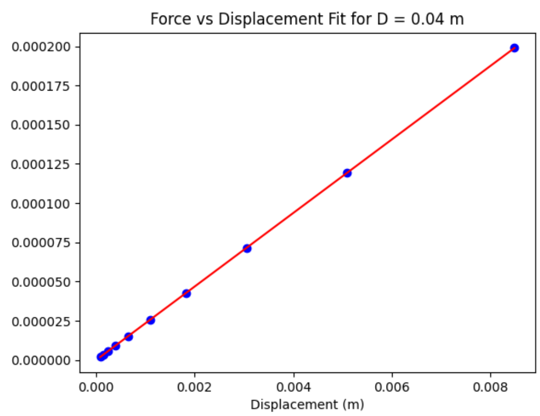

Fig. 7. Force vs δ_z^* for $D = 0.04$

III. Part 3

In this section we look at how the k_{sim} compares with the k_{text} which comes from the equation $k_{text} = \frac{Gd^4}{8ND^3}$. What we see is the same overall pattern with the stiffness decreasing exponentially with diameter, seeing the the largest changes over the smallest diameters. Due to our simulation approaching signficantly lower stiffnesses as the diameters increase it rapidly approaches 0compared to the theory which is unexpected given our simulation, but could be most likely due to not plotting it log scale. It is interesting that they share such common shape while the simulated stiffness drops much closer to 0 in the range of diameters we chose even though the simulated stiffnesses were lower regardless.

References

[1] M. K. Jawed, Lecture_13_Helix_Simulation.ipynb, UCLA, 2025

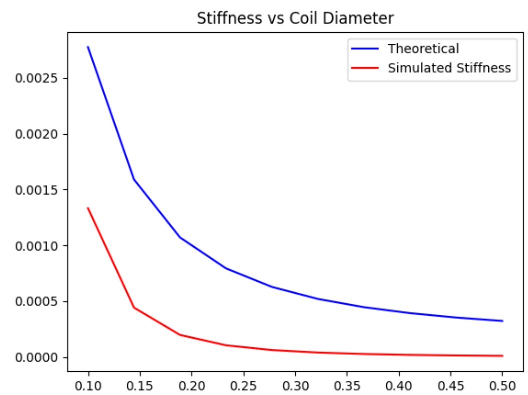

Fig. 8. Stiffness vs coil Diameter