Investigating the Helicoseir: Mathematical Modeling

Andy Rundquist, Nadine Burkhead, Ray Culp, Keenan Obayuwana, Zac Pearson, Autumn Schmidt

Abstract

Using *Mathematica,* we modeled the motion of a traditional helicoseir after adding springs between the beads. We concentrated on the different shapes the modes would make, and we analyzed the motion of the helicoseir while it was switching modes.

Lab Calibration

Three tests had to be performed to calibrate the lab model to the *Mathematica* (MMA) model:

- Time Calibration

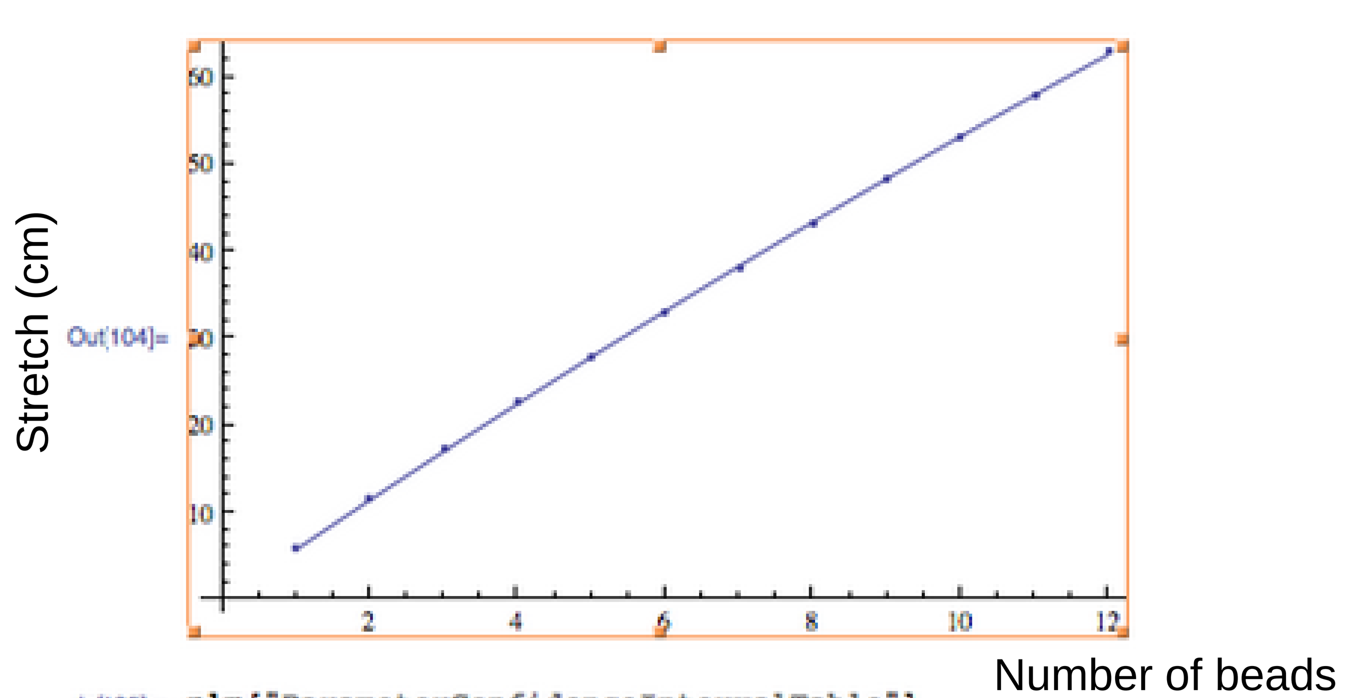
  Compared high speed videos of the beads' motion and modeled the same motion in MMA. We found that one second lapsed in the video was the same as one second lapsed in MMA.

- Friction Calculation

  Compared high speed video to MMA video, and varied friction until the motion matched exactly.

- Spring Constant and Length of Springs

  It became clear that the MMA model was shorter than our physical lab model, meaning that our "happy length was too short or our spring constant was too high. To match it we used the NonLinearFit function in MMA (seen below).




```
In[105]:= nlm["ParameterConfidenceIntervalTable"]
```

Out[105]=

	Estimate	Standard Error	Confidence Interval
h	0.0454691	0.000534092	{0.044279, 0.0466591}
kc	281.765	18.3973	{240.773, 322.756}

Acknowledgements

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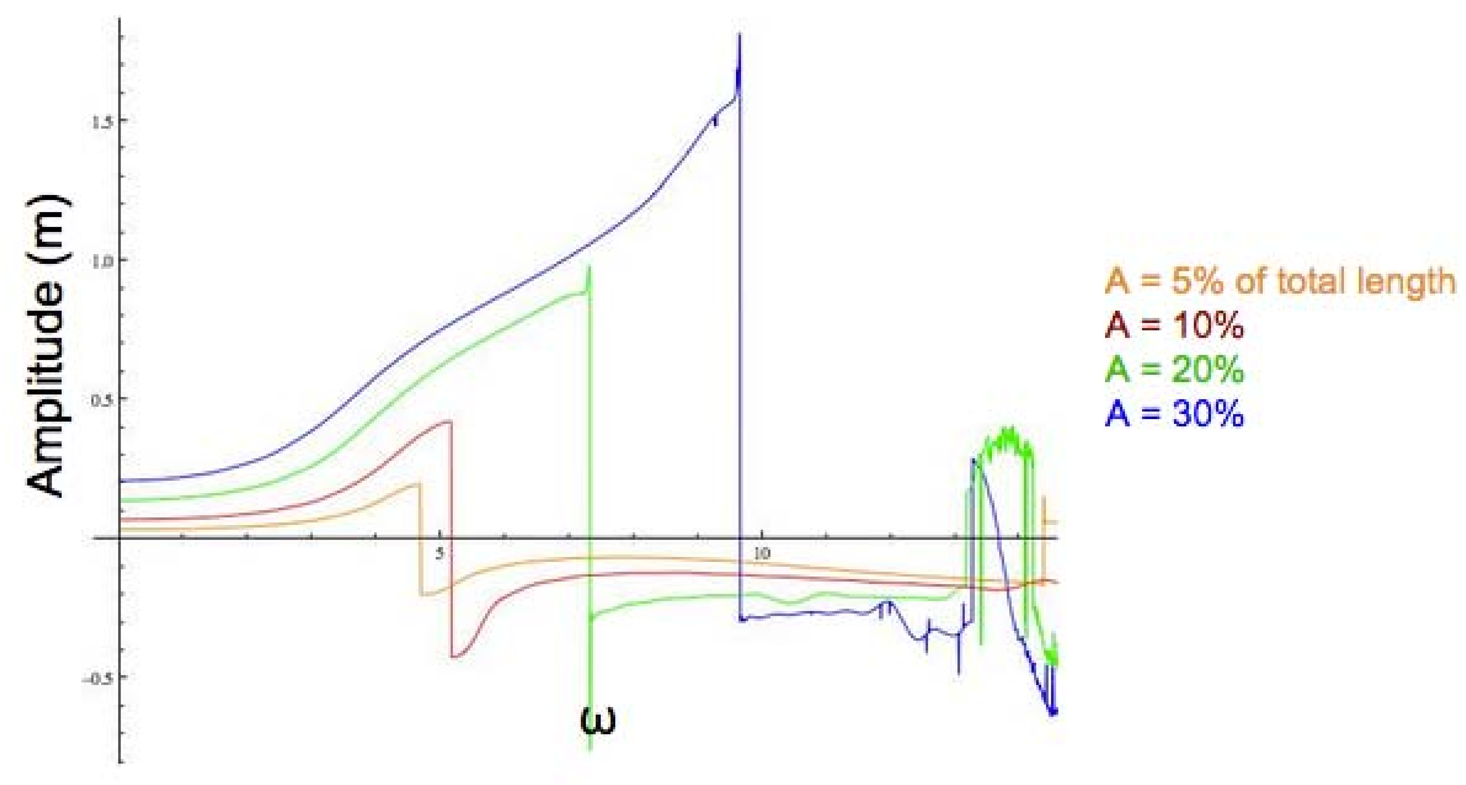
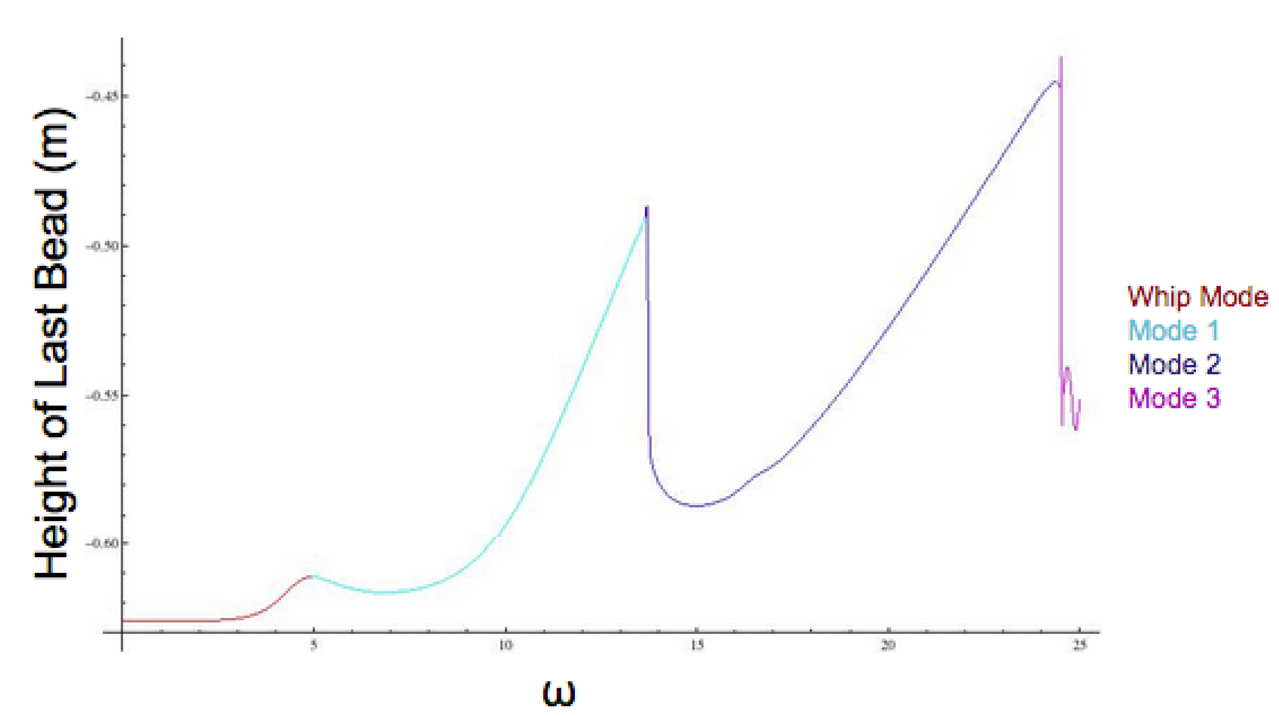


- The y-axis represents how far away the bottom bead of the helicoseir was positioned.
- The x-axis represents the angular velocity, or how fast it was spun around.
- The abrupt shift in shape shows the point when the helicoseir changed modes.

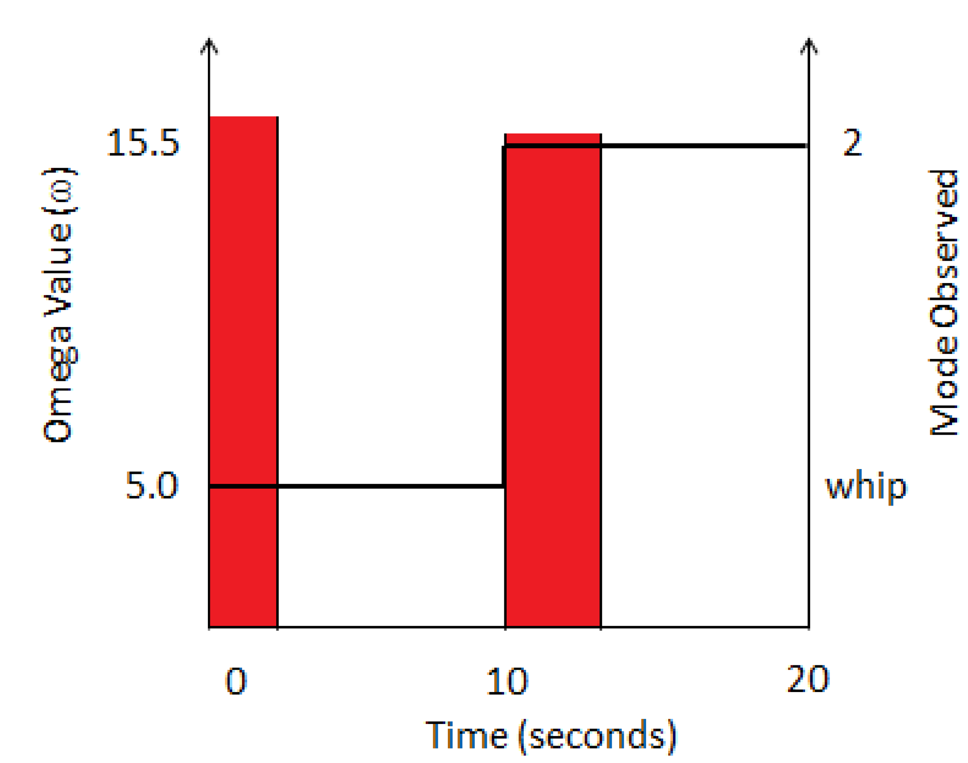


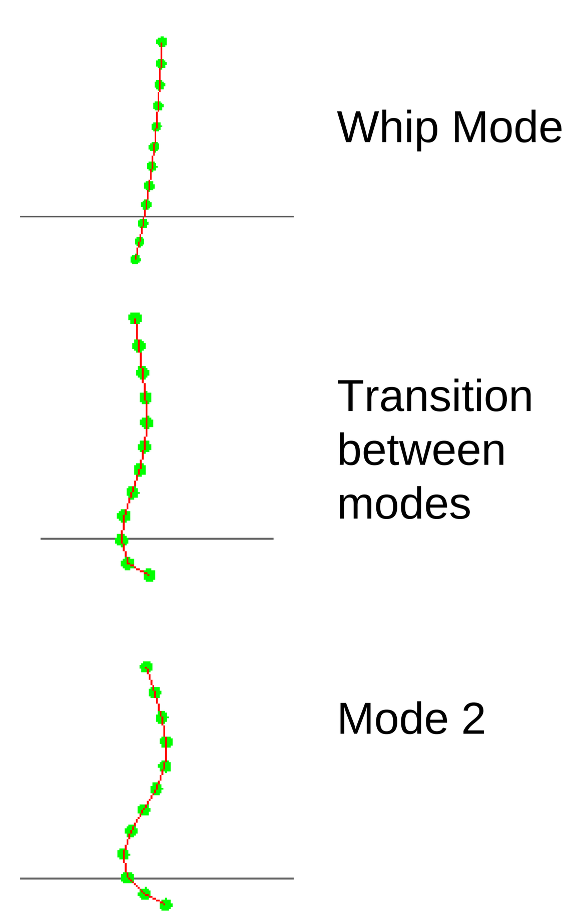
- The y-axis represents the height of the last bead as the helicoseir was spun around.
- The x-axis represents how fast it was spun around.
- The different colors represent the different modes, which would occur as the helicoseir was sped up.

Once the masses were added to the code, it was adjusted so that the omega value could be changed halfway through the simulation and it could be observed if the bead chain shifted from one mode to another or if it stayed in one mode.

The x and y plots were changed to piecewise functions where the first part of the function was the first omega value and the second part of the function was the second omega value. A shift needed to be added to the second part of the function so that the movie would play smoothly and not jerk back to the starting position when the omega value changed.

All of the models showed that the system should end in the mode of the second omega value. The most interesting of the changed were the one that had to make a large jump (such as whip mode to mode 2). These took longer to settle in, as did most of the transitions from a higher mode to a lower one.





The red areas on the graph above denote where the modes were in transition and not completely settled in.

These results are different from what was found in lab. When the mode change was tested the chain did not switch modes like the Mathematica model had shown.