Competing Pendulums Teacher Guide

by Richard Born

This lesson provides an example of how previous ***gedanken*** (German for *thought*) experiments can now be easily performed in the classroom because of advances in technology. 3D printers allow us to now design and make two pendulums with the same length and same mass, but having different mass distributions.

This lesson was motivated by a puzzle in a book entitled ***Mad About Physics*** by Christopher P. Jargodzki and Franklin Potter. They point out that contrary to the predictions of many people, the simple rectangular rod without the large distribution of mass at the bottom has a shorter period. The Jargodzki puzzle was, in turn motivated by an article by Paul O. Hoffmann in the American Journal of Physics 23 (1955): 624.

For Middle School Students

Have the students make their predictions and then do the experiment with Voyager to determine the actual periods. It is best if they find the period of each pendulum by noting the time for ten complete cycles and then divide by 10. (They should note that the magnetic field strength will be at a maximum ***twice*** for each cycle.)

Many students will likely be surprised that their experimental results are contrary to their predictions. The teacher can then lead a qualitative discussion about how the larger distribution of mass at the bottom of the slower pendulum is related to a property known as moment of inertia. Perhaps have the students hold a heavy book in one hand and walk normally with both arms swinging. Which arm swings more easily?

For High School Students

For high school students you can be more quantitative in the discussion. Newton's second law F = ma has a corresponding law for rotation $\tau = I\alpha$, where τ is the torque, I is the moment of inertia, and α is the angular acceleration. This tells us that the angular acceleration is proportional to the ratio of the torque to the moment of inertia. The pendulum with the greater mass distribution at the end furthest from the pivot point has a greater moment of inertia. This results in a smaller angular acceleration and hence a longer period.

A more detailed but similar PocketLab lesson comparing a 3D printed ring and disk of equal mass can be found at:

https://www.thepocketlab.com/educators/lesson/moment-inertia-mass-contrasted