Wilberforce Pendulum

The Wilberforce Pendulum is a coupled pendulum in which energy is transferred between two modes of vibration, longitudinal ("bounce') and torsional ("twist"), on a spring. When properly tuned (the right mass, and the right distribution of this mass), the pendulum will transition from all bounce with no twist, to all twist with no bounce, and back again. It will continue this behavior with ever-decreasing amplitude until it finally stops. It's an unusual example of energy transformation, and is fascinating to watch.

Materials

Spring -- a small metal slinky-like spring with a 1 1/4 in diameter was used here -- spring needs to be loose, not stiff

1 piece 1/2 inPVC pipe, 2 ft long	2 piece 1/2 inPVC pipe, 5 in long	3/16 in dowel, 6 in long
1 piece 1/2 inPVC pipe, 7 in long	2 piece 1/2 inPVC pipe, 3 in long	2 micro binder clip
1 piece 1/2 inPVC pipe, 4 in long, with slit cut to hold spring as shown in Figure 3a		3 mini binder clips
5 PVC 1/2 in 90 deg elbows	1 PVC 1/2 in T	2 small binder clips

Assembly: See photos. Use a mini binder clip to attach the spring. You might start with 2 small binder clips for masses.

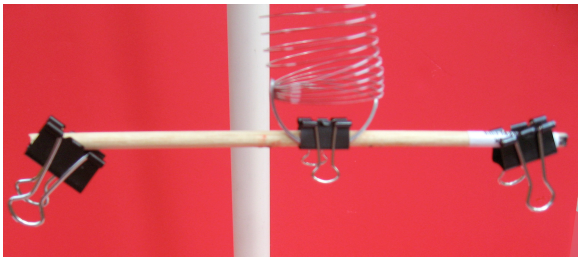

Figure 2a: Cross-bar

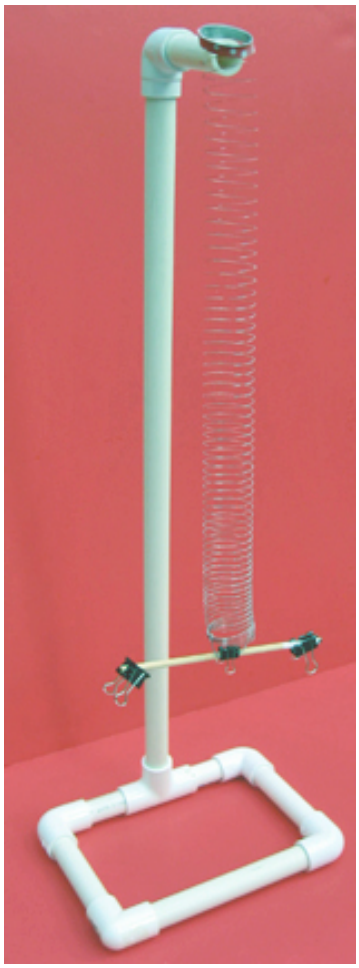

Figure 1: Whole Assembly

To Do and Notice: Lift the bar a few inches and let it drop. Then just watch!

What's Going On: When the periods of the pendulum's two individual modes of vibration are close to equal, the "beat" frequency (the difference between the two individual frequencies) is low. This makes the period of the pendulum's overall cycle relatively long, and enhances the dramatic effect of the transitions between pure longitudinal vibration and pure torsional vibration. The tuning is accomplished by finding the appropriate combination of total mass hanging from the spring, and the distribution of this mass on the cross-arm (i.e., moment of inertia) which gives the desired behavior for the particular spring. Relatively long, loose springs are normally used.

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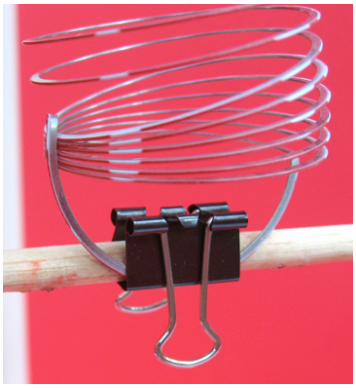

Figure 2b: Cross-bar Attachment

Going Further: Try adjusting the length of the spring by inserting a different coil in the slot. See what this does to the tuning , and what adjustments are necessary to re-tune. Try different masses (binder clips), and different positions of the masses on the cross-bar. Try other springs. Try Googling *Wilberforce Pendulum*.

Figure 3b: Spring coil inserted in slit

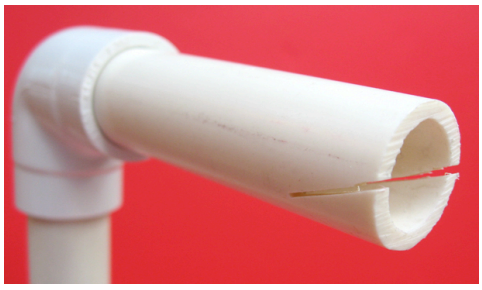

Figure 3a: Slit for hanging the spring

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Spring Winding & Wilberforce Pendulum

Figure 1
Spring winder and spring wire (sold as Music Wire). Glove is essential to keep wire from cutting hand.

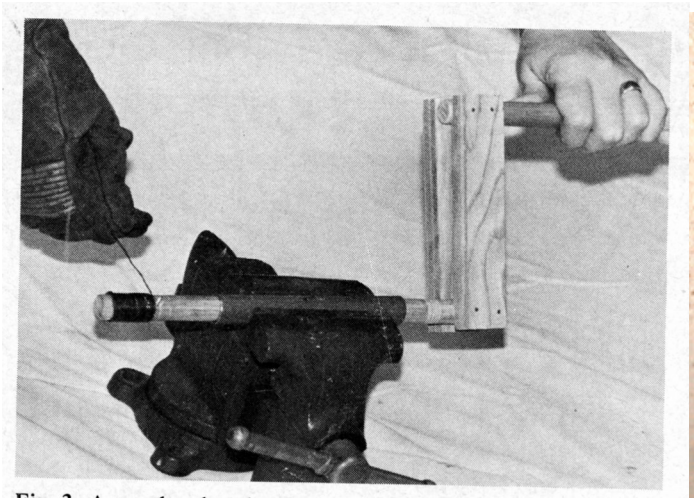

Figure 2
The spring-winding process. (Photo from The Physics Teacher, April, 1983. See reference below.)

Figure 3
Homemade spring and Wilberforce pendulum. Not visible is a lead fishing weight in the film can to provide mass.

References

Doing Physics (Earl Zwicker, Section Editor), in **The Physics Teacher**, AAPT, April 1983, pp. 257-258. How to wind a spring and make a Wilberforce pendulum. The photo in Figure 2 is taken from this article.

Googling *Wiberforce Pendulum*.will provide access to a wealth of material available online.

Materials Sources

Spring wire for winding your own springs (sold as Music Wire -- see Figure 1 above) can be obtained in a number of different diameters/gauges from Grainger Industrial Supply, which has several branches in the Bay Area. The article referenced above recommends 0.029 in.(12 gauge) wire, and this was the size wire used for the spring shown in Figure 3.

Ready-to-use metal springs can be obtained from US Toy Company, www.ustoy.com. Search for item # DM37. These are listed as Magic Springs, and are 1" diameter mini-slinky-like metal springs, $9.95/dozen at this writing. You may also be able to find springs like this in party stores or novelty stores, but supplies are unpredictable.

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