**Problem Of the Week**

Consider a pencil that stands upright on its tip and then falls over. Idealize the pencil as a mass $m$ sitting at the end of a massless rod of length $l$. Assume that the pencil makes an initial (small) angle $\theta_0$ with the vertical, and that its initial angular speed is $\omega_0$. The angle will eventually become large, but while it is small we can assume $\sin \theta \approx \theta$.

- Using this assumption, find $\theta$ as a function of time.

Can you make the pencil balance for an arbitrarily long time by making the initial $\theta_0$ and $\omega_0$ sufficiently small? You might think so, but no. Heisenberg’s uncertainty principle $\Delta x \Delta p \gtrsim \hbar$ (to within a factor of order unity) puts a constraint on the initial position and momentum of the particle.

- Using the uncertainty principle, find the maximum time for your solution $\theta(t)$ to become of order 1. (Assume $m = 0.01$ kg, and $l = 0.1$ m.)

This is roughly the maximum time the pencil can balance.

Check your answer at the undergraduate news blog:

www.physics.ncsu.edu/undergraduate/newsblog.php

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