Physics 250 Laboratory:
Slinky Dim Sum
(Forces, Oscillations & Waves)

Score: _____

Section #:______

Name:______________________________

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Lab-Specific Goals:

- To analyze elasticity, oscillations and waves using a Slinky! (and have some fun)

Equipment List:

- Slinky Jr.
- Ruler
- 50 g mass hanger
- Stopwatch, GLX or other timer

Figure 1: 1999 Slinky USPS Stamp

Introduction:

The Slinky is the official state toy of Pennsylvania. Invented by a native of Altoona (Richard T. James), the Slinky was first demonstrated to the public in Philadelphia in 1945. Betty James (Richard's wife) coined the name Slinky and recognized its potential as a toy. She promoted the Slinky all her life until her death in November 2008. (See the Slinky page on Wikipedia for more of the fascinating background and history of the Slinky: http://en.wikipedia.org/wiki/Slinky). According to *Toys! Amazing Stories Behind Some Great Inventions* by Don Wulffson (Henry Holt and Company, 2000), the Slinky makes a good scarecrow, has been played with by astronauts in the space shuttle, and was even used as radio antennas by soldiers in Vietnam.

The Slinky is a classic example of a spring (our model of many elastic objects). We have used springs throughout this entire course:

- An example of elastic objects described by Hooke's Law: $F_s = -k\Delta L$.
- A microscopic model for the Normal force (n)
- An object that can have elastic potential energy ($U_S = \frac{1}{2} k(\Delta L)^2$)
- An example of a simple harmonic oscillator ($\omega^2 = k/m$)
- An example of a wave medium ($v^2 = T_s/\mu$, where $\mu = m/L$)

In the lab today, you will use a Slinky, a common type of spring, to do a variety of mini-experiments involving elasticity, energy, oscillations and waves. Thus, the Slinky provides a good review of many of the concepts we have studied throughout this semester. Each experiment is a little treat that only takes a few minutes to do and requires minimal calculations. Have fun!

Activity 1: The Hanging Slinky

Hold your Slinky so that it is hanging vertically. Examine the Slinky closely and sketch below what you see.

Now explain what you observed in terms of Newton's Second Law and Hooke's Law. (Hint: Is the fact that the Slinky has mass important?)

Activity 2. Hooke's Law

By examining the Slinky hanging vertically (no additional mass added), how can you estimate the spring constant k of the Slinky? (Hint: Effectively a Slinky with mass M hanging on its own is the same as a massless Slinky with a mass M/2 hanging from it.)

Now hang a weight from the Slinky and determine the spring constant k from this experiment.

Average k for the Slinky to use in the rest of the lab: k = _________________ N/m

Activity 3. Young's Modulus

Calculate the Young's Modulus for your Slinky.

Activity 4: Elastic Potential Energy

How much elastic potential energy is stored in the Slinky if you stretch it to a *total length* of 1 m?

Activity 5. Oscillations of a Slinky

Predict the oscillation frequency of your Slinky (just hanging down with no other mass attached). (Note: for complicated reasons we won't get into here, the effective mass of a Slinky for oscillations is only one third its actual mass.)

Now measure the oscillation frequency of the Slinky – how well does it compare to your prediction?

If you use only half the Slinky, it has *double* its original spring constant (the shorter Slinky is stiffer than the longer Slinky). What should happen to the oscillation frequency of a Slinky if you only oscillate half the Slinky? (Remember, the mass has been halved because only half of the Slinky is oscillating.) AFTER you make your prediction, determine the oscillation frequency for the half-Slinky and compare to your prediction.

Activity 6: Wave Speed

Predict the wave speed of the Slinky if you stretch it to a length of 1 meter. (Remember, that ΔL for the Slinky will *not* be 1 meter.)

Then predict the time it will take a pulse to travel from one end of the Slinky to the other end.

Do the experiment and see if you are right! (Does it matter if you send a transverse or longitudinal wave?) Note: the time is rather short, so you may wish to time how long it takes a pulse to travel back and forth a few times (it reflects when it hits and end).

Activity 7: Standing Waves

From your results from Activity 6, predict the fundamental frequency of the Slinky at this length.

Predicted Frequency = ________________ Hz, Predicted Period = ______________ s

Now test it out!

Measured Frequency = ________________ Hz, Measured Period = ______________ s

Activity 8: Slinky Sounds

Hold one end of the Slinky to your ear and pluck the other end. Can you hear the sound reflecting back & forth along the Slinky?