PHY 157
Transverse Wave Motion on a Spring
(Experiment 4)

Name: ______________________________

1 Introduction

In this lab you will observe the motion of transverse waves on a heavy spring, measure the wave speed as a function of the tension in the spring, and compare the measured speed to the speed predicted by theory.

2 Apparatus

- Long spiral spring
- Spring balance
- Tape measure
- Triple beam balance
- 500 g attachment for balance
- Stopwatch

3 Procedure

Please note that the spiral springs used in this lab are easily damaged. Please treat them gently. They are particularly vulnerable to over-stretching at the place where you hold them. To avoid damage to the spring, please avoid *large amplitudes*.

1. Wrap the spring loosely and place it on the balance pan of the triple beam balance. Since the mass of the spring is probably over 600 g, you will probably have to add the 500 g attachment to the balance. Measure and record the mass of the spring.

2. Use the following table to record your measured data.

Tension (N)	Length of spring (m)	Total travel time (sec)	# trips	Total distance traveled (m)	Wave speed (m/s)

3. Attach a spring balance to one end of the spring and stretch the spring out to a tension of 10 N. Assume that tension can be read to 0.1 N on the balance. Hold the spring balance comfortably in you hand *angled downward* so that the balance responds freely to the pull of the spring. The balance serves as a handle to hold the spring. Stretch out a tape measure, allowing it to sag to follow the shape of the spring, and measure the length of the spring. Carefully read the tape measure to the nearest 0.2 cm and record the tension and length in your data table.

4. Keeping the spring balance in your hand, set up a horizontal wave pulse of *small amplitude* on the spring and observe how it travels on the spring. It reflects from the far end and returns back to the spring balance, reflects from the balance and travels out again, making several round trips down and back along the spring. The person holding the balance can feel the return of the waves even after their amplitude is too small to observe. Thus, *the person holding the spring should also do the timing*. A partner can set the wave pulse in motion by pulling aside a section of the spring near the spring balance and releasing it (remember: small amplitudes). You can begin the timing when the first pulse returns to your hand. Set up a wave pulse and measure the time for at least 5 trips (if possible). Record your data in the data table and compute the total distance traveled and the wave speed.

5. Let a different person repeat these measurements for a tension of 12 N.

4 Analysis

Theory. Transverse waves travel on elastic materials with a speed that depends upon the tension in the material and the linear density of the material. The theoretical expression for the speed of a *transverse* wave on a string or spring is given by the expression

$$v = \sqrt{\frac{F}{m/L}}, \tag{1}$$

where F is the tension in the material in *newtons* and m/L is the linear density of the material in *kg/m*.

Analysis. Use the following analysis table for your analysis.

Tension (N)	Length of spring (m)	Linear density (kg/m)	Theoretical speed (m/s)	Directly measured speed (m/s)	Percent Difference

(a) For each tension, transfer the spring length from your data table and compute a value for the linear density of the spring. Use equation (1) to compute a value for the theoretical speed and record it into your analysis table. Transfer the directly measured speed from the data table and compare each theoretical speed to the directly measured speed.

(b) How well does equation (1) predict the measured velocity of the waves using the direct method?