Lab 16 – Forces: Hooke's Law

Name ____

Partner's Name ____

1. Introduction/Theory

Consider Figure 1a, which shows a spring in its equilibrium position – that is, the spring is neither compressed nor stretched. If we push a block against the spring as in Figure 1b, the spring is compressed a distance of x. In order to compress the spring, we must exert on the a force of magnitude F = kx, where k is a constant for a particular spring called the *spring constant*. For a flexible spring, k is a small number, whereas for a stiff spring, k is large. The equations F = kx says that the more we compress the spring, the larger the force we must exert. Since we are exerting a force on the spring, the spring must likewise exert an equal and opposite force (Newton's third law) of $F_s = -kx$. This equation of F_s, describing the force exerted by a stretched or compressed spring is called *Hooke's Law*, after Sir Robert Hooke, who discovered the relationship between F_s and x.

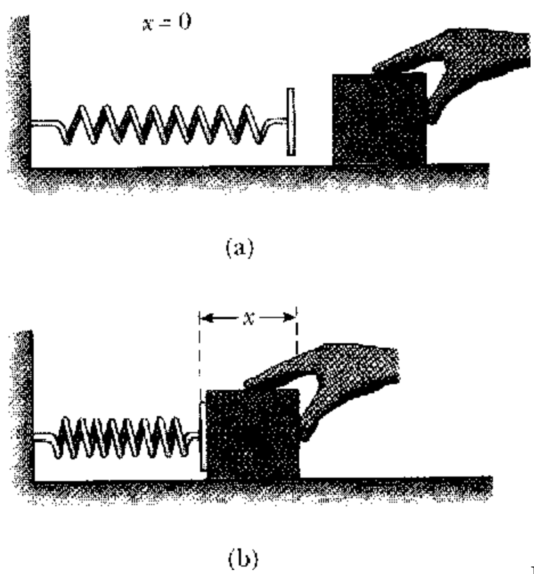

Figure 1

2. Equipment

Base, Support Rod, and Hanger
Springs (weak, medium, and stiff)
Meter Stick
Mass Set
Triple Beam Scale

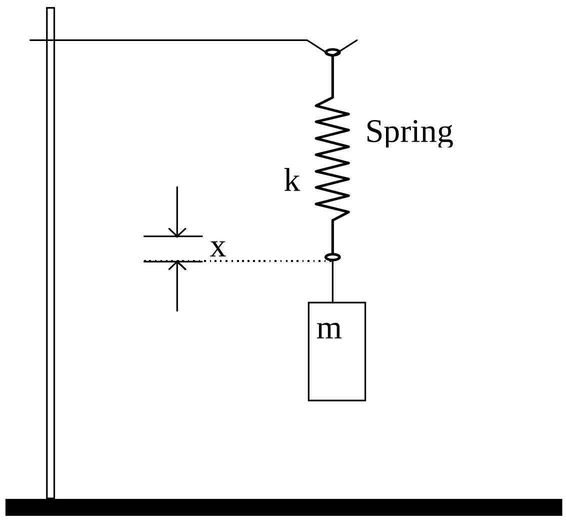

Figure 2: Equipment Setup

3. Procedure
   a. Set up the hanging apparatus as shown in Figure 2.
   b. Hang the weak spring on the apparatus.
      i. From the bottom of the spring hang a 10 g mass. Measure the (relative) vertical displacement of the bottom end of the spring and record in Table 1.
      ii. Increase the hanging mass to 20 g. Measure the vertical displacement of the bottom end of the spring and record in Table 1. Make sure these relative measurements of displacement are consistent!
      iii. Continue increasing the mass in 10 g steps and recording displacements in Table 1 until a mass of 50 g is reached.
   c. Hang the medium spring on the apparatus.
      i. From the bottom of the spring hang a 50 g mass. Measure the (relative) vertical displacement of the bottom end of the spring and record in Table 1.
      ii. Increase the hanging mass to 100 g. Measure the vertical displacement of the bottom end of the spring and record in Table 1. Make sure these relative measurements of displacement are consistent!
      iii. Continue increasing the mass in 50 g steps and recording displacements in Table 1 until a mass of 250 g is reached.
   d. Hang the stiff spring on the apparatus.
      i. From the bottom of the spring hang a 100 g mass. Measure the (relative) vertical displacement of the bottom end of the spring and record in Table 1.
      ii. Increase the hanging mass to 200 g. Measure the vertical displacement of the bottom end of the spring and record in Table 1. Make sure these relative measurements of displacement are consistent!
      iii. Continue increasing the mass in 100 g steps and recording displacements in Table 1 until a mass of 500 g is reached.
   e. Estimate the uncertainty that each measurement has. All measurement are made in a similar fashion, thus they should all have a common uncertainty. Record this uncertainty in the Data section.
   f. Using the scale verify the masses are correctly labeled. Adjust Table 1 mass values as necessary. Convert all mass values in Table 1 to forces ($\mathbf{F} = m\mathbf{a}$) and record.

4. Data (include units!)

Weak Spring	Displacement	Force
Mass		
10 g		
20 g		
30 g		
40 g		
50 g		
Medium Spring		
50 g		
100 g		
150 g		
200 g		
250 g		
Stiff Spring		
100 g		
200 g		
300 g		
400 g		
500 g		

Table 1

Uncertainty in the Displacements ______________________________

5. Analysis

Use the lightest mass displacement as a reference position for each spring. For each measurement excluding the lightest mass, record the NET displacement and the NET force for each spring.

Weak Spring		Medium Spring		Stiff Spring	
Displacement	Force	Displacement	Force	Displacement	Force
__________	__________	__________	__________	__________	__________
__________	__________	__________	__________	__________	__________
__________	__________	__________	__________	__________	__________
__________	__________	__________	__________	__________	__________

Plot the data for each spring on a different graph. For each graph maximize the range of the graph. The graphs should include uncertainties in your displacements. With a ruler make a best fit line. Figure 3 displays this.

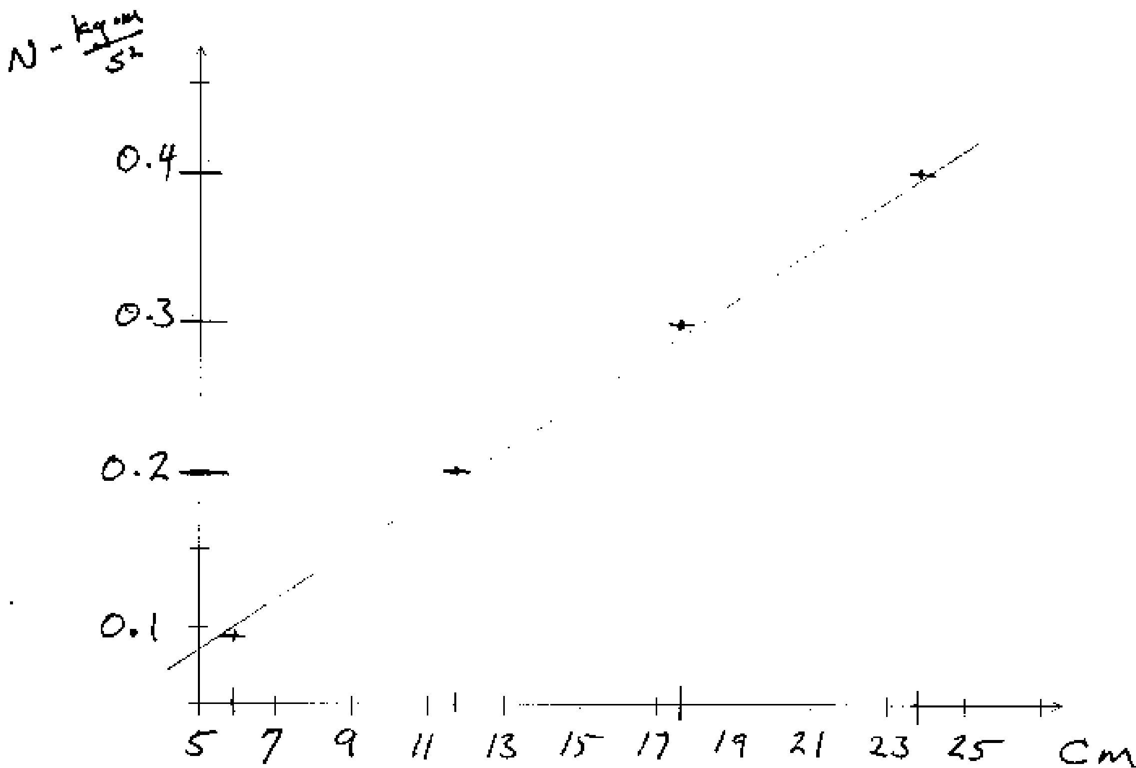

Figure 3

For each graph estimate the slope and uncertainty. Are the springs in agreement with Hooke's Law? Comment on that in the space below.

List your best estimate of the spring constant k with uncertainty for each spring

Weak Spring __________________±______________________

Medium Spring __________________±______________________

Stiff Spring __________________±______________________