Experiment 4: Work & Energy

Table and Group: __________ Participants: ________________________________
Each group will turn in one common report. ________________________________

1. Record:
   Mechanical Step 4-5: Track height= ________ $g \sin(\theta)$= ________

   Analyze Data Steps
   Step 7: Average acceleration= __________
   Step 8: Velocity at A= ________ B= ________ C= ________
   Step 10: Position at spike= __________ At top= __________

2. Compare the average acceleration measured in Step 7 to $-g \sin(\theta)$. Careful students typically get values within 5% of the expected one. How well did you do?

3. Work/energy predicts that the speed after a trip up and down the incline will be smaller if there is a stopping force. Using your speeds at point B ($v_1$) and C ($v_2$) found in Step 8 and the distance $d$ found from the positions in Step 10, calculate $a_s = (v_1^2 - v_2^2)/4d$. Express your answer both as a number in $m/s^2$ and also as a percentage of the acceleration down the incline, $g \sin(\theta)$. Does your data show evidence for a non-zero stopping force?

(Continued on other side.)
4. Work and energy considerations also predict that the distance up the incline to the stopping point is given by \( d = \frac{v_B^2}{2(g \sin(\theta) + a_s)} \). Use your speed at point B and \( a_s \) (if non-zero) from the Question 3 to predict how far the cart should go up the incline before stopping. **Note:** For this part, it is typically more accurate to use the acceleration you found in Step 7 for \( g \sin(\theta) \) instead of your measured value using the height of the end of the track. Compare your predicted and measured values of \( d \).

5. If the interaction with the spring is perfectly elastic, the cart should leave the spring with the same speed it hits the spring. The correction due to \( a_s \) is tiny in this case because the distances involved are very small. Compare the speeds you find at points A and B. What is the ratio of the two kinetic energies \( KE_B/KE_A \)?

Step 12: Time when force starts to rise= ___________ Peak time= ___________

Step 13: Maximum force= ___________

6. The distance a mass on a spring moves from the moment it hits until it stops (i.e. the maximal distance the spring is compressed) is \( 2v\Delta t/\pi \), where \( v \) is the speed when it hits the spring and \( \Delta t \) is the time it takes to stop. Use this formula, the speed at point A, and the time for the spring to stop the cart found in Step 12 to find the spring compression. The maximum force found in Step 13 divided by the compression distance gives \( k \). Using Work/energy, you can show that for an object hitting a horizontal spring, the object stops where \( \frac{1}{2}kx^2 = \frac{1}{2}mv^2 \). Using 0.25 kg for the mass of the cart and your value for the spring constant and the spring compression, check if your data agree with this formula. Note that this formula ignores the potential energy of gravity and the work done by the stopping force since the distance moved is very small. A more accurate calculation would include those additional effects.