Physics 122 - Lab 4

<u>Goal:</u> To understand the relationship between force and acceleration, and the relationship between friction and the normal force.

<u>Equipment:</u> Track, frictionless car, felt covered wooden block, pulley, masses and motion detector.

<u>Procedure</u>

1. First, **<u>we'll determine the car's mass</u>** by measuring its acceleration when acted on by known forces. Place the car on the horizontal track, attach a string to the end of the car which faces the pulley. Tie a known mass to the other end of the string & pass the string over the pulley. When the motion detector is ready to acquire data, release the mass allowing it to fall. Measure the car's acceleration. The best way of determining the acceleration is to 'curve fit' the velocity data. Repeat this measurement for several other known masses. **<u>Make the range of masses as large as you can.</u>** The best way to 'save' all of the data from the Logger Pro application is to <u>select all columns you wish to save and copy them directly into an Excel spreadsheet</u>.

2. Next, we're going to measure μ_k for the interface between the felt-covered wooden block and the track. First, you'll need to determine the mass of the wooden block <u>using the balance</u>. Attach the wooden block to the car and place a known mass atop the block. The block should be attached to the end of the car facing away from the pulley. Attach a known mass to the end of the car facing the pulley with string, passing the string over the pulley. When the motion detector is ready to acquire data, release the mass, allowing it to fall. Measure the car's acceleration. Repeat this measurement several more times, each time placing different known masses atop the wood block. <u>Suspend the same mass below the pulley for all measurements for this part of the lab</u>. It would be best to place the heaviest of the masses you wish to test on the wood block first and to use a relatively heavy suspended mass. **<u>Make sure to save all position and velocity data, we'll need it for the next lab (Lab-5)!</u>**

3. Devise a method to determine the coefficient of static friction, μ_s, of the interface between the wood block and the track. After you've decided how to do this, you may wish to discuss it with the instructor or TA to make sure it's sensible.

4. If you have time, you can do this part for 'extra credit'. Here, we'll investigate the 'directionality' of the kinetic frictional force. Set up as for part (2) of the lab.

This time, place the car at the end of the track nearest the pulley. When the motion detector is ready to acquire data, give the car a shove toward the motion detector. It's easiest to use the **'spring-loaded pusher'** to get the car started. Record the car's acceleration.

Analysis

1. Draw a free body diagram for the mass suspended below the pulley for part (1). Do the same for the car. Assuming that the pulley is massless and frictionless and that the string is massless and non-stretchable, find an expression for the mass of the car involving quantities you know or have measured. Use this expression to compute the mass of the car for each of the known suspended masses. Make a table of the system's acceleration, the suspended mass and the mass of the car you calculated. Find the average of the mass values you calculated for the car & use this value for the rest of your analysis.

2. Draw a free body diagram for the car, the wood block and the suspended mass. Find an expression for μ_k of the interface between the wood block and the track involving quantities you either know or have measured. Make a table of the acceleration of the system, the mass atop the wooden block and the value for μ_k you calculated. Find the average of the values for the coefficient of kinetic friction you calculated.

3. Draw a picture of your scheme for determining μ_s. Draw free body diagrams for all bodies used in the determination of μ_s. Determine μ_s.

4. If you did (4), to get the 'extra-credit' draw free body diagrams for all bodies for the (different!) cases of when the car is moving toward the motion detector and away from the motion detector.

Questions

1. What are some sources of error in your determination of the car's mass in (1) ? Which of these sources of error do you think are most important? Why? Which of the values you calculated would you expect to be the most accurate, i.e., the one found using the heaviest or lightest suspended mass. Why?

2. Make a plot of f_k vs. the mass supported atop the wooden block using the value of μ_k you determined in (2). Is it linear? Why or why not? Does it intercept the horizontal axis at zero? Why or why not? For which values of the supported mass would you expect the calculated value of μ_k to be the most accurate?

3. Is $\mu_s > \mu_k$? Describe the motion of a body which has just overcome the static frictional force and begun to slide **if this were not true**.

4. If you did (4), describe the system's acceleration as a function of time. Is there anything 'unusual' about it? Can you conclude anything about the directionality of the kinetic frictional forces from the acceleration vs. time plot?

What you need to turn in

1. The free body diagrams you drew.

2. The plots you made.

3. The answer to the questions.

Including your drawings, free body diagrams and the lab report cover page, your lab report should not be longer than 7 pages. Please include the list of co-workers in your group on the cover page.