Walk-in Lab 7
Nonconservative Work
Physics 121

CID(s): ____________________

Description

We all know about friction. Sometimes it is a good thing, like when your brakes slow your car down. But sometimes it is a pain, like when you crash on your bicycle and get scraped up by the road.

Friction is called a nonconservative force because it changes the mechanical energy of a system. Without friction, the sum of kinetic and potential energy is constant. With friction, it isn’t.

In this lab, you will actually measure the work done by friction and compare it to the mechanical energy of a system. The system is a car rolling down a little track. At the bottom of the track, the car slams on the brakes and skids to a stop. You have gravitational potential energy, kinetic energy, frictional forces, and a few other things. It’s kind of a mess. But don’t be afraid. We can figure this out. You can work in small groups, and email me suggestions to improve this lab. See you in class!

Objective: To measure the effects of nonconservative forces in a system.

Equipment: car, ramp, spring scale, laser/timer, triple beam balance, two-meter stick

Part A – Some background and preliminary measurements

The underlying principle here is the conservation of energy. The sum of all energy is conserved, meaning that it is constant in time. You can’t create or destroy energy. You can only change it from one form to another.

In this lab, a car with mass $m$ rolls down an incline from a height $H$. A trigger mechanism locks the brakes in the car at position 3. The car then skids to a stop in a distance $x$.

At position 1, the car has no kinetic energy and a lot of gravitational potential energy. As it rolls down the hill, it loses potential energy and gains kinetic energy. Friction converts some of the kinetic energy to thermal energy (heat) in the car and track. At the bottom of the track (position 2), the car has no gravitational potential energy and a lot of kinetic energy. But when the brakes are set (position 3), the remaining kinetic energy is transferred into thermal energy and the car eventually stops (position 4).

We can find the initial gravitational potential energy ($mgH$). We can get the kinetic energy at position 3 if we use the laser/timer thing to measure the car’s velocity. We can measure the frictional force between points 3 and 4 using the spring scale to drag the car. Let’s do all of that now.

1. Measure the height $H$. Write your answer here: $H =$ ________ (meters)
2. Use the triple beam balance to find the car’s mass. $m =$ ________ (kilograms)
3. Use the spring scale to drag the car (with brakes locked) over the distance $x$. This measurement is not terribly accurate, but do your best by dragging the car at a constant speed and estimating the reading on the spring scale to 2 or 3 significant digits. Write your answer here: $f =$ ________ (Newtons)
4. When the car rolls down the ramp, part of the car will pass through the light beam of the timer. To get the car’s velocity, we need to measure the time it takes for the car to pass through the light beam
that is the timer’s job). We also need to measure the length of the car that passes through the light beam. First, measure the length of the car that passes through the light beam and write your answer here: \( L = \) \( \text{meters} \)

5. Reset the timers and run the experiment. Record the time it takes for the car to pass through the light beam. Write your answer here: \( t = \) \( \text{seconds} \)

6. Use the 2-meter stick to measure the distance \( x \), which is how far the car skids before it stops. Write your answer here: \( x = \) \( \text{meters} \)

**Part B – The calculations**

I think we have all of the pieces that we need.

1. First, let’s calculate the car’s gravitational potential energy: \( U_g = mgH = \) \( \text{Joules} \)

2. Next, calculate the speed of the car at position 3: \( v_3 = \frac{L}{t} = \) \( \text{meters/second} \)

3. Calculate the car’s translational kinetic energy: \( K_{\text{tran}} = \frac{1}{2}mv_3^2 = \) \( \text{Joules} \)

4. The rotation of the wheels also contributes to the kinetic energy. We’ll cover this in a few more chapters, but for now we’ll just add a correction factor to get the total kinetic energy: \( K_{\text{total}} = 1.2K_{\text{tran}} = \) \( \text{Joules} \)

5. Calculate the work done by friction on the ramp and also by the trigger mechanism: \( W_{f,1\rightarrow3} = K_{\text{total}} - U_g = \) \( \text{Joules} \). This should be a negative number. (Why?)

6. Calculate the work done by friction between positions 3 and 4. This is equal to the force you measured on the spring scale in step 3 in Part A above multiplied by the distance \( x \). \( W_{f,3\rightarrow4} = fx = \) \( \text{Joules} \). This should also be a negative number. (Why?)

7. Check your answer. \(-W_{f,3\rightarrow4}\) should also be the same as \( K_{\text{total}} \). Compare these two numbers and calculate your percent error. If you are careful, typical errors should be 10 to 15%.