PHYSICS LAB EXPERIMENT – 8

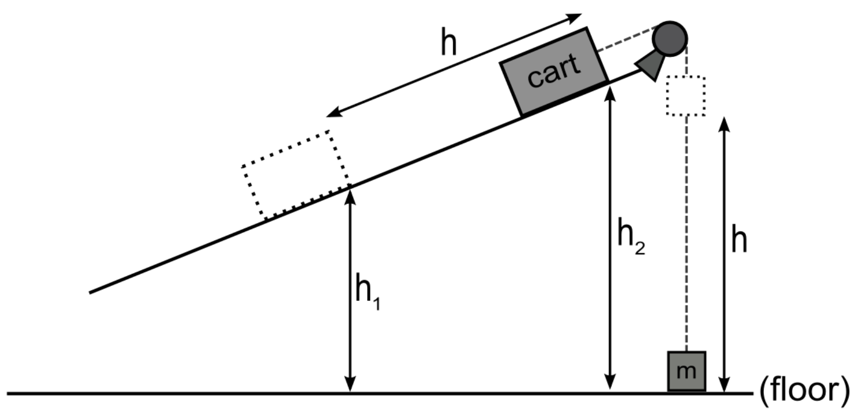
CONSERVATION OF ENERGY WITH TWO OBJECTS

OBJECTIVE: Measure the acceleration, kinetic energy, and change in potential energy of a glider on an air track when connected to a hanging weight.

APPARATUS: Air track, air track cart, blower, hanger, thread, double-sided tape, wooden blocks, meter stick, balance, timer, hanging mass, and protractor.

THEORY: Conservation of energy is a principle which states that energy can neither be created nor destroyed, only changed in form. In this lab, we'll specifically be looking at *mechanical* energy, which is dependent on the movement and position of objects. We will observe mechanical energy being transformed from gravitational potential energy ($PE_g = mgh$) into kinetic energy ($KE = \frac{1}{2}mv^2$) and vice versa. Using these two quantities, we can formulate expressions that describe the total mechanical energy of the situation we have in this lab. Once this expression is derived, we can do a lot to predict and describe the behavior exhibited by the lab apparatus.

The apparatus is sketched out below. During today's procedure, the air track cart will be attached to a hanging mass by a thread. The hanging mass will then be released, and the (nearly) frictionless air track will let the cart be dragged up the track by the falling mass. *The "initial" and "final" positions of the objects are represented by the dotted outlines and the solid shapes respectively.*



Before the cart and hanging mass are released ("initial" positions), we can write down the two objects' potential energies. There will be no kinetic energy, because there is no movement.

$$E_0 = m_{cart}gh_1 + mgh$$

In their final positions (solid shapes), they will both have some common velocity and their potential energies will have changed.

$$E_f = m_{cart}gh_2 + \frac{1}{2}(m_{cart} + m)v^2$$

Note that the potential energy of the hanging mass (*m*) is zero, because we have set our reference level at the floor. All the quantities in these expressions are easy to measure with the tools we have available to us. If the initial energy (E_0) equals the final energy (E_f), then we can say that the mechanical energy of this two object system is *conserved*. In practice, it is likely that some of the initial energy will be converted to other forms of energy by *nonconservative* forces like friction on the surface and in the pulley, drag from the air, and slight pushes or pulls during the release of the cart.

PROCEDURE:

1. Measure the mass of your cart (or 'glider') and record it above the data tables.
2. Position the air track so that the end with the pulley is at the edge of the desk. Raise the legs of the air track onto a block. Measure the angle – it should not be very large (< 10 degrees).
3. Affix a string to the glider, pass the string over the pulley, and attach its free end to a hanger. Make sure that the string is long enough that the weight is near the pulley when the glider is near the bottom of the incline, and that the hanger hits the floor when the glider is near the top of the incline.
4. Connect the blower to the air track by attaching the hose to its end. Pressure and a twisting motion will help to get the hose seated properly on each connector (one on the track, one on the blower).
5. Turn on the blower and check that the glider/cart moves with minimal friction over the whole range of its movement between its start and end points. *The end point of the glider's motion should correspond to the hanging mass hitting the ground.*
6. Hold the glider so that it sits just below the start point. Turn on the blower. Release the glider at the same time as starting your stopwatch, and end the timing when the glider reaches its end point. If this seems far too fast to accurately time, consider reducing the hanging mass or increasing the mass of the glider.
7. Measure the distance between the start and end points (*h*). This should match the distance from the bottom of your hanging mass to the ground (also *h*) if you've set up properly.
8. You are ready to take data! Do six trials with the current setup, measuring h_1 and h_2 and time as indicated on the tables below.
9. Repeat using a larger hanging mass for increased velocity, and then repeat again for a larger track angle. You'll need to re-measure one or more of your heights (*h*, h_1, and h_2) for each of these sets of trials. Also for the larger track angle, you'll need to figure out a different mass that is capable of pulling the glider up the incline.

Data for the first hanging mass (*m* = _______).
h = _________ h_1 = __________ h_2 = _________ Mass of glider/cart = ________

Time (s)	Distance *h* (m)	$V_{average}$ (m/s)	V_{final} = $2V_{average}$ (m/s)	
				Averages

Data for the second hanging mass (*m* = ______).
h = _________ h_1 = __________ h_2 = _________ Mass of glider/cart = ________

Time (s)	Distance *h* (m)	$V_{average}$ (m/s)	V_{final} = $2V_{average}$ (m/s)	
				Averages

Data for a *different angle*.
h = _________ h_1 = __________ h_2 = _________ Mass of glider/cart = ________
Hanging mass (*m*) = __________ Angle of Track = _____

Time (s)	Distance *h* (m)	$V_{average}$ (m/s)	V_{final} = $2V_{average}$ (m/s)	
				Averages

DATA ANALYSIS:

Use the setup from the theory section at the beginning of the lab sheet to calculate the total mechanical energy of the cart/glider (1) prior to its release, and (2) as the hanging mass reaches the ground. Do this for each data set above.

Data Set #1: E_0 = __________ E_f = ___________ % Difference = ________

Data Set #2: E_0 = __________ E_f = ___________ % Difference = ________

Data Set #3: E_0 = __________ E_f = ___________ % Difference = ________

For each case, answer the questions: *Is energy conserved? If so, state how you can tell. If not, where did the 'missing' energy go?*

QUESTIONS:

1. In this experiment, which forces are doing work on the glider/hanging mass system? Which of these forces is *conservative*?

2. 1.20×10^3 J of work is done by a force of magnitude 40 N in moving a luggage carrier a distance of 55.0 m. At what angle θ is the force oriented with respect to the ground?

3. A 4.00 kg stone accidentally falls from a building under construction from a height of 20.0 m. Ignoring air resistance, determine the potential energy. kinetic energy, and the total mechanical energy of the stone at heights of a) 20.0 m, b) 10.0 m, and c) 0.0 m.

4. A person jumps from a 10.0 m diving board and falls to the water below. If the change in the person's potential energy is *negative* 5000 J, what is the person's weight?

5. An object has a mass of 2.0 kg and a speed of 15 m/s. Only one external force acts on the object. After this force acts, the speed of the object is 7.0 m/s. What is the work done by the force?