Name____Date__________________

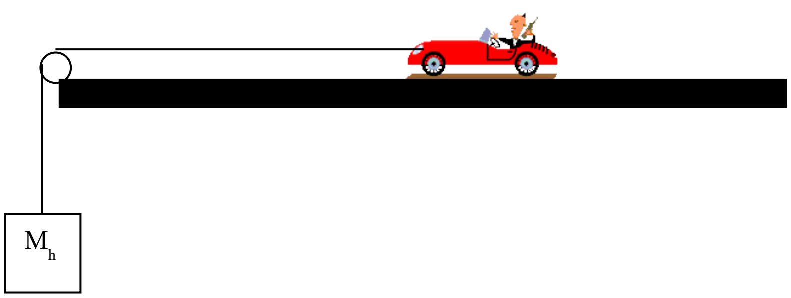
Lab: The Atwood Machine, Newton's Laws of Motion, and Conservation of Energy

Introduction: Refer to the following figure of the two connected objects. The weight (force due to gravity, M_h g) of the hanging mass causes the acceleration of both masses (M_c+M_h) since they are connected by a string (Note: the hanging mass is M_h and the cart mass is M_c). Using Newton's second law and ignoring friction, we will find an expression for the distance traveled in terms of acceleration and final velocity, then the acceleration in terms of distance and final velocity. This will be worked on the board. The acceleration equation is also written further down.

d =__________________________

a =__________________________

In lab you will set up this track system with car and hanging mass, and measure the acceleration of the system (a_{meas}). Then compare the measured acceleration to the results from Newton's second law (a_{theory}).



Picture by Dr. Colbert of Augusta University.

NOTE: This lab uses grams and cm for its units! The short distance traveled and low masses make these units easier to work with, but you do need to be aware of it.

Procedures:

1. Arrange your track so that it is level and attach a pulley to the end of the track as indicated in the figure. The string must be just long enough so that the cart hits the end of the track just as the hanging mass reaches the floor. That way both the objects that are tied together will accelerate for the entire trip. You will use a photogate to measure the final speed of the car just before the hanging mass hits the floor. Make sure that your string is not rubbing on anything other than the pulley.

2. Place the 2 black bars in the cart. Use a scale to check that this masses 1500 g.

3. Place the striped plastic bar in the slot on the cart, ensuring that the 2 off-set stripes are on top.

4. Place the photogate near the end of the track. Ensure the 2 off-set stripes will pass between the little bulbs in the gate when the cart moves through them. Also ensure the plastic bar will not knock into the gate.

5. Measure the distance x traveled. Choose a convenient point where there is a marking for the starting position of the front of the cart. The starting position for the distance is then at the mid-point between the 2 off-set stripes. The final position for the distance is the at the point between the bulbs of the photogate.

6. Connect the photogate to the Smart Timer in port 1. Place the timer in "Speed: One Gate" mode. Note its output will be in cm/s.

7. Place a total hanging mass M_h of 50g (the hanger itself has a mass so account for this).

8. Pull the cart back to the starting position. Position photogate so you know the distance traveled.

9. Release the cart and measure the final speed using the photogate. Repeat several times to make sure it is consistent. You will see a small amount of variation, but if done correctly you should have 2-3 digits that do not change. Record your data below with these digits.

10. Do the above steps again but with a hanging mass of 100g.

Newton's Laws Analysis:

1. (50 g): Photogate V_f = ____________cm/s

2. (100 g): Photogate V_f = ____________cm/s

3. What is the distance traveled? x=___________cm

   (This should be the same for both masses.)

4. Use $\mathbf{a_{measured} = (1/2)\ V_f^2/\Delta x}$ to find the measured acceleration of the 50g hanging mass, and again for the 100g hanging mass.

a(50g) = ________________cm/s²

a(100g) = ________________ cm/s²

5. Find the theoretical acceleration(a_t) using Newton's second law. F=MA or A = F/M

   F(50g) = M*g = 50g*980 cm/s² = _________________; F(100g) = M*g = _________________

   M(50g) = Total cart+hanging mass = ______________g M(100g) = Total cart+hanging mass = ________________g

   a_{theory}(50g) = F(50g)/M(50g) = ____________ cm/s²

   a_{theory}(100g) = F(100g)/M(100g) = _____________ cm/s²

6. For each result what is the percent difference (absolute value of difference between the theory value (see introduction) and measurement value/(theory) all x100%).

$([a_{theory}(50g) - a_{measured}(50g)] / a_{theory}(50g)) *100 =$ ________________%

$([a_{theory}(100g) - a_{measured}(100g)] / a_{theory}(100g)) *100 =$ ______________%

Conservation of Energy:

For this segment, you will need to convert everything in to kg and m. For instance, m(hanging) = 100 g becomes m(hanging) = 0.1 kg.

The distance 'x' traveled by the cart is also the distance fallen by the hanging mass.

The initial energy of the system is the gravitational potential of the hanging mass, U = mgh. h = x so our initial potential energy is m(hanging) gh = m*9.8*x

Remember to put everything in kg, m, and s!

7. U_i (0.05 kg) = ________________________ Joules

U_i (0.1 kg) = ________________________ Joules

The final energy of the system is the kinetic energy of the cart plus hanging mass. This is found as follows:

$$K_f = \frac{1}{2} (m_{hang} + m_{cart}) v_{cart}^2$$

8. K_f (0.05 kg)= _____________________________ Joules

K_f (0.1 kg)= _____________________________ Joules

9. How much energy was lost or gained in each case? Note: it is possible you gained a bit of energy due to the tables not being perfectly level. It should not be much.

10. You should have lost a little bit of energy. Assuming energy was lost, what form did it primarily wind up in?