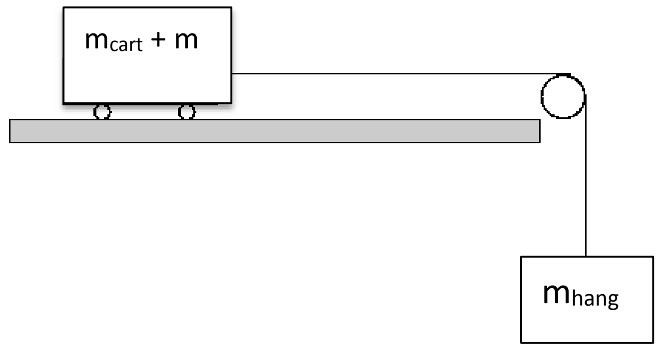
Inertia Lab
PSI Physics

Name:______________________________

OBJECTIVE:
- To verify Newton’s Second Law F=ma.
- To measure acceleration due to gravity, g.

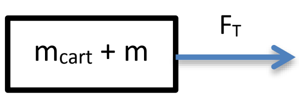
MATERIALS:
- Cart
- Pulley
- String
- Masses 0.2 kg – 1.0 kg
- Stop watch
- Meter stick
- Scale (spring or other)



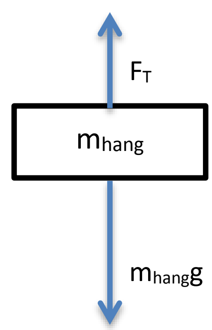
SETUP:
A cart of mass, m_{cart}, with an added mass, m, on a table is connected by a string to a mass, m_{hang}, hanging over a pulley that is fixed to the edge of the table. The length of the string, x, is just long enough for the hanging mass to touch the floor when the cart touches the pulley.

Free Body Diagrams and Newton’s Second Law Equations:

Cart



Hanging Mass



$F_T = (m_{cart} + m)\, a$ (1)

$-F_T + m_{hang}\, g = m_{hang}\, a$ (2)

adding (1) and (2): $m_{hang}g = (m_{cart} + m)a + m_2a$

$$\boxed{m_{hang}\, g = (m_{cart} + m + m_{hang})\, a} \quad (3)$$

PROCEDURE:
In this experiment you will measure the time for a cart to travel the distance x, as the mass added to the cart is changed. You will later calculate the acceleration from x and the average time for the cart with the different added masses.

All data and calculations should be entered on the data table attached to the end of this handout.

1. In preparation:
   - Weigh the cart, then determine its mass m_{cart} = ________ kg *(enter this in column 1)*
   - Hang a small mass (10 or 20 g) on the end of the string. Record the value of the hanging mass m_{hang} = _________ kg *(enter this in column 2)*
   - Measure the distance that the cart travels: x = ________ m (this should be the same as the distance from the floor to the top of the table) *(enter this in column 9)*

2. For each of the following 5 masses: m = 0.2 kg, 0.3 kg, 0.5 kg, 0.7 kg, and 1.0 kg:
   - Put the mass in the cart.
   - Pull the cart back until the hanging mass just touches the pulley.
   - Let go of the cart and time how long it takes for the cart to reach the pulley. Do this three times *(enter these times, t_1, t_2 and t_3, in columns 5, 6 and 7).*

ANALYSIS:

1. For each row in your data table, calculate the average time and *record the result in column 8*.

2. Recall that $x = v_0t + ½ at^2$. Manipulate this equation to get a formula for a in terms of x and t. (Hint: what is v_0 – the speed the moment the cart is released)

3. Use the above formula to calculate **a** for each of the total masses in the table using the appropriate average time. *Record your answers in the column 10*.

4. What happens to the acceleration of the cart as more mass is added?

5. Explain what inertia (mass) has to do with the acceleration of the cart.

6. For each of the rows in the table, calculate F = Ma and *record your results in column 11*.

7. Then calculate the average value of F=Ma and record your answer in the bottom right cell of the table.

8. Notice that F is approximately the same for all the rows. This force is also just the weight of the hanging mass, $F = m_{hang}g$.

    a. Given your average F, find the value of g.

    b. How does this compare with the accepted value of 9.8 m/s^2?

APPLICATION:

9. Another experiment is performed using the same apparatus. This time the cart with added mass is fixed, $m_{cart} + m = 1.2$kg and the hanging mass, m_{hang} changes. Calculate the acceleration of the cart for the 3 values of m_{hang} by completing the table below.

$m_{cart} + m$ (kg)	m_{hang} (kg)	$M = m_{cart} + m + m_{hang}$ (kg)	m_{hang} g (N)	a (m/s$_2$)
	0.01			
	0.02			
	0.04			

Use g = 9.8 m/s^2. Equation (3) on page 1 of this hand out may be helpful to you.

10. A 20 kg mass is connected by a 100 meter cable to a 1000 kg car that is at rest, with its brakes off, about 100 meters from the edge of the cliff. The weight is then hung over a pulley at the edge of the cliff and released.

    a. What is the acceleration of the car toward the cliff?

    b. How long will it take the car to reach the cliff?

    c. How fast will the car be traveling the moment it goes over the cliff?

Inertia Lab Data and Analysis Table

(1) Mass of Cart	(2) Hanging Mass	(3) Added Mass	(4) Total Mass	(5) Time 1	(6) Time 2	(7) Time 3	(8) Average Time	(9) Distance Traveled	(10) Acceleration	(11) Force
m_{cart} (kg)	m_{hang} (kg)	m (kg)	$M=m_{cart}+m+m_{hang}$ (kg)	t_1 (s)	t_2 (s)	t_3 (s)	t_{avg} (s)	x (m)	$a = 2x/t_{avg}^2$ (m/s^2)	$F = M \times a$ (N)
									Average F =	