Newton's Second Law

Name _____

Introduction:

Newton's Second Law relates the net force on an object to its acceleration. Specifically, we have discovered in class that the relationship is :

$$\sum \boldsymbol{F = ma} \qquad (\textbf{\textit{eqn. 1}})$$

where $\boldsymbol{a}$ represents the acceleration of an object with mass $\boldsymbol{m}$. For a cart of mass $\boldsymbol{m_1}$ (see figure 1) on a horizontal track attached by a string over a pulley to a mass $\boldsymbol{m_2}$, the net force on the entire system is the weight of the hanging mass :

$$\boldsymbol{F = m_2 g} \qquad (\textbf{\textit{eqn. 2}})$$

We will assume that friction is negligible. According to Newton's Second Law then, we have :

$$F = ma$$

$$F = (m_1 + m_2)a = m_2 g$$

$$\boldsymbol{m_2 g = (m_1 + m_2)a} \qquad (\textbf{\textit{eqn. 3}})$$

You will verify that this is true by calculating the acceleration measuring the time it takes for the cart to travel a measured distance($\boldsymbol{d}$). Assuming acceleration is constant :

$$\boldsymbol{d = \frac{1}{2}at^2 \Rightarrow a = 2\frac{d}{t^2}} \qquad (\textbf{\textit{eqn. 4}})$$

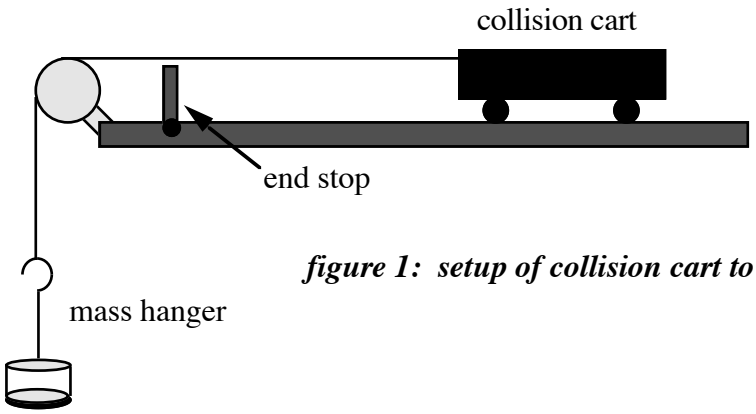

figure 1: setup of collision cart to measure acceleration

Procedure:

Record the mass of the cart using the beam balance.

Now, prepare the cart and track for the experiment. Set up the track and cart as pictured. Make sure the piece of string connecting the cart and mass hanger is long enough so that the cart

hits the stopping block before the mass hanger hits the floor. **You may have to put the track up on chairs to give the hanging mass enough room to fall.**

Measure the initial position of the cart when the mass hanger is almost touching the pulley. This will be your initial position for all trials. Measure the final position of the cart when it is resting against the end stop block. Then, add mass to the hanger until the cart takes about 2 seconds to travel from the beginning to the end of its run. (Less than 2 seconds and your reaction time will cause non-negligible error, but if the cart moves too slowly friction becomes non-negligible)

Record the time with your stopwatch for 5 trials, add mass to the ***cart*** and repeat the procedure.

Initial Position _____cm _____ m

Final Position _____cm _____ m

Total Distance_____m

(cart) m_1 ***(kg)***	m_2 ***(kg)***	***trial 1 (s)***	***trial 2 (s)***	***trial 3 (s)***	***trial 4 (s)***	***trial 5 (s)***	t_{avg} ***(s)***

Table 1: Collision Cart Data for Measuring the Acceleration of System

Data Analysis:

Using equations from the introduction, calculate the quantities requested in the table.

m_1 ***(kg)***	***Acceleration*** (m/s^2)	$(m_1+m_2)a$ ***(N)***	$m_2 g$ ***(N)***	***% difference***

Table 2: Calculations to Verify Newton's Second Law

Questions:

1. Did the results of your experiment verify Newton's Second Law (i.e. was your % error large or small)? Explain possible sources of error in the experiment.

2. Draw a force diagram for the hanging mass and the cart. Now indicate how equation 3 would change if you considered friction?