Name: ______________________________ Section: __________ Date: ____________

Worksheet - Exp 7: Newton's Second Law Part 2

Objective: The objective of this lab is to explore the relationship between force, mass, and acceleration. The experiment will analyze the acceleration of a cart on an incline due to a mass attached by a string.

Theory: According to Newton's Second Law, the acceleration, $\vec{\mathbf{a}}$, of a body is directly proportional to the vector sum of the forces, $\Sigma\vec{\mathbf{F}}$, applied to the body:

$$\Sigma\vec{\mathbf{F}} = m\vec{\mathbf{a}}$$

This experiment will examine the acceleration of a cart on an inclined plane caused by an applied tension force. This is a variation of *Atwood's machine*.

1. Draw a force diagram for the system with the cart accelerating upward on the incline plane at and angle of 9.25°. Include all forces on the cart and hanging mass. Force vectors should be approximately to scale. (30 points)

2. Using Newton's Second Law, derive an equation for the acceleration of the system. (10 points)

Procedure:

Part 1: Vary the applied force

Trial #1

3. Measure the mass of the cart using the triple beam balance (turning it upside down will keep it from rolling off).
4. Calculate the mass of the cart with the two 500g masses and two 20g masses on top. This is m_A Record this in the table below.
5. Calculate the minimum hanging mass necessary to cause m_A to roll up the incline, round this up to the nearest 10 grams. This is m_B for trial #1.
6. Use a stopwatch to measure the time it takes for m_A to travel a distance Δx (or for m_B to fall the same distance Δy). Your data will be more accurate if Δx is as large as possible. *Do not allow the cart to hit the pulley!* Do this 3 times and record the distance and average time in the table below.
7. Calculate the acceleration of the cart during this motion using the following equations and record both in the table.

$$a_{Theo.} = (m_B \cdot g - m_A \cdot g \cdot \sin\Theta)/(m_A + m_B)$$
$$a_{Meas.} = 2 \cdot \Delta y/t^2$$

Show work from step 7

#	m_A (1 pt ea.)	m_B (2 pts ea.)	$a_{Theo.}$ (2 pts ea.)	$\Delta x = \Delta y$ (1 pt ea.)	Δt_{avg} (2 pts ea.)	$a_{Meas.}$ (2 pts ea.)
1						
2						
3						

Include units of measurement.

Trial #2

8. Remove one of the 20g masses from the cart and place it on the mass hanger. Record the new m_A and m_B in the table.
9. Repeat steps 6 and 7 for the altered system.

Trial #3

10. Remove the remaining 20g mass from the cart and place it on the mass hanger. Record the new m_A and m_B in the table.
11. Repeat steps 6 and 7 for the altered system.

Part 2: Graphing

Obtain data from the *Vary the Applied Force* section of the Newton's Second Law worksheet. These may be copied in the duplicate data table below, if necessary.

The entire cart/hanging mass system follows the same law, $\Sigma F = ma$. This means that plotting force vs. acceleration yields a linear relationship (of the form $y = mx$).

12. Open Graphical Analysis. Graph force vs. $a_{Meas.}$ for the *Varying Force* trials (be sure to include (0,0)). Apply a linear fit to the four data points. Print this graph. Be sure to label the axis and provide a title. (10 points)
13. Create a similar graph of force vs. $a_{Theo.}$ and print it as well. (10 points)
14. Staple both graphs to the datasheet.
15. Was each slope close to the mass ($m_A + m_B$) of the system? What were some sources of uncertainty that could cause them to be different? (10 pts)