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NEWTON'S 2ND LAW FORCE AND ACCELERATION LAB

PART I – CHANGING MASS

Purpose: *To investigate the effect of increases in mass on an accelerating system with a constant force.*

Materials:

- Car, ramp and physics stand
- Photogate timer
- 3 weights for car
- 50-gram hooked mass hanger
- Triple-beam balance
- 10 g disc
- String
- Paper clips (optional)

Procedure:

1. Set up the ramp on the Physics Stand so that it is horizontal.
2. Using a triple-beam balance, determine the mass of the car with no weights. Determine the mass of each of the 3 weights you will be using. Record all 4 individual **masses** in Data Table 1.
3. Attach a string to the car and suspend the string over the pulley on the ramp. There will be some friction involved with this experiment. To offset as much as we can, we will suspend a 10 g disc from the opposite end of the string. Add enough mass to the string so that when the empty car is pushed slightly it moves at a constant speed.
4. Add a 50-g hook mass hanger to the counterweight. This falling mass/weight will remain the same at all times for this experiment to provide a constant force to the car.
5. Attach the two photogates to the ramp at least 10 cm from either end. Make sure that the photogate nearest the physics stand is placed before the wing of the car when the mass hanger is on the floor.
6. Measure and record **the distance between the two photogates** and the **length of the "wing" on the car** below Table 1.
7. Release the mass hanger and let the falling mass accelerate the car. In a new table, record the **time through photogate A** and the **total time from photogate A to photogate B**.
8. Repeat for 3-5 trials, recording the times for each trial in Data Table 2.
9. Repeat the procedure 3 more times, each time adding an additional weight to the car.

Data Analysis:

1. Calculate and record the **total mass** for each situation (car + each weight) in a new table (Table 3).
2. Next, calculate **average time through A** and **average time from A to B** and record in Table 3.
3. Calculate the **initial velocity** of the system. Record this in Data Table 3 for each situation.
4. Next, calculate the **accelerations** of the system. *(Hint: you know distance, initial velocity, and time)*. Record the acceleration in Data Table 3 for each situation.
5. Make a graph of showing the relationship between **mass and acceleration**. Include an appropriate best-fit trend line/curve that matches our understanding of physics. *(Hint: Newton's 2nd Law!)*

Conclusion Questions:

1. Qualitatively describe your graph. Is it a straight line or a curved line? What does the graph tell you about the relationship between mass and acceleration?
2. What did we ensure did not change in this experiment? What was the numerical value of this constant variable?
3. If you have a constant applied force, theoretically how does increasing the mass of an object affect its acceleration? Compare this theoretical result to you actual results.
4. Make a new graph and this time linearize the graph so you have a straight line **with an upward slope** that shows us a constant force is being applied. *(Hint: Newton's 2nd Law!)*

PART II – CONSTANT MASS, CHANGING FORCE

Purpose: *To investigate how increasing the applied force affects an object's acceleration.*

Materials: (*new materials needed)

- Car, ramp and physics stand
- Photogate timer
- 6 slotted masses (car masses not needed)*
- 50-gram hooked mass hanger
- Triple-beam balance
- String
- Paper clips
- Masking Tape*

Procedure:

1. Use the same car, ramp and photogate set-up as Part I. Set up the string and paper clip counterweight the same way as was done in Part I.
2. This time we will be keeping the mass of the system the same and changing the applied force (the weight of the falling masses). We will start by having the 6 masses taped to the car itself.
3. In a new Data Table 4, record the **total mass** of the falling hanger (including mass of the hanger itself). For trial 1 there will be no additional mass on the hanger.
4. Measure and record **the distance between the two photogates** and the **length of the "wing" on the car** below Table 4.
5. Release the mass hanger and let the car accelerate. Again, record the **time through photogate A** and the **total time from gate A to gate B** in Data Table 5. Repeat for 3 trials.
6. For the 2nd situation, move one of the slotted masses from the car to the mass hanger. In doing so, the mass of the system stays the same but the applied force changes. Again, record the mass of the falling hanger, release and record the time data for 3 trials.
7. Repeat this until all slotted masses have been moved from the car to the mass hanger.

Data Analysis:

1. In a new Data Table 6, calculate an **average time through photogate A** and **average time between photogates**.
2. Then calculate the **total weight** of the falling masses on the hanger for each situation.
3. Using the same procedure as part I, calculate the **initial velocity** and the **acceleration** of the car for each different falling weight.
4. Make a graph of showing the relationship between **force and acceleration**. Include an appropriate best-fit trend line/curve that matches our understanding of physics. *(Hint: Newton's 2nd Law!)*

Analysis Questions:

1. Describe the relationship between force and acceleration.
2. Consider the following questions:
   a. Was the mass of the accelerating system always constant?
   b. If so, explain why and report the mass of the system. If not, explain why not.
3. In conclusion, apply your results from both part I and part II to write, in your own words, a general relationship between force, mass and acceleration (without just stating Newton's second law of motion)