LECTURE 8: NEWTON'S SECOND LAW – CONSTANT MASS

1. The purpose of the experiment:

The purpose of this activity is to determine what happens to an object's acceleration when the net force applied to the object increases but the mass of the system is constant.

2. The Equipment

For this lab you will be using these equipments:
- 1 PASPORT Motion Sensor PS-2103
- 1 1.2 m PASCO Track
- 1 GOcar ME-6951
- 1 Super Pulley with Clamp ME-9448A
- 1 Hooked Mass Set SE-8759
- 1 Balance SE-8723
- Braided Physics String SE-8050
- 1 Weight hanger

3. Background

Newton's First Law of motion states that if no net force acts on an object, the velocity of the object remains unchanged. The Second Law deals with what happens when a net force does act on an object. Newton's Second Law of motion describes the behavior of everything that changes its motion due to a net force -- from the trajectory of a baseball to the motion of a planet.

While a net force acts on an object, the velocity of the object changes–in other words, it accelerates. When more force is applied, the greater force produces a greater acceleration. Newton's second law states that the acceleration is directly proportional to the net force acting on the object and in the same direction as the net force.

Newton's Second Law also states that the acceleration is inversely proportional to the mass.

$$a : F_{net}$$

$$a : \frac{1}{m}$$

$$a = \frac{F_{net}}{m}$$

Prediction

1. What will happen to an object when you apply a net force to it?

2. What will happen to the motion of an object if it has a constant mass but you change the magnitude of the net force on it?

4. Procedure

4.1. Equipment Setup

1. Add several masses to the cart: 500-g, 50-g, 20 g, and 10-g. Measure and record the mass of the cart plus the extra masses.

2. Place the track on a horizontal surface and level the track. (Place the cart on the track. If the cart rolls one way or the other, adjust the track to raise or lower one end.)

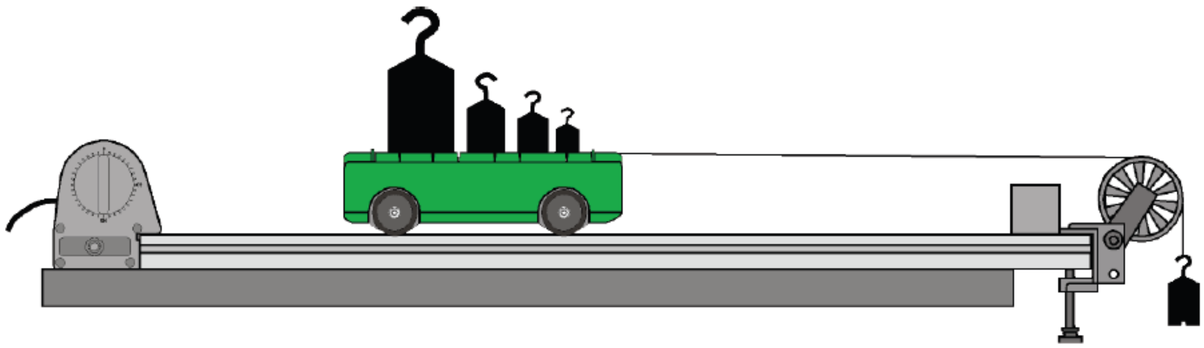
3. Attach the Motion Sensor to one end of the track. Attach the Super Pulley with Clamp at the other end of the track. Place a block in front of the pulley to protect it from being hit by the cart.

4. Place the cart about 15 cm from the sensor. Aim the sensor at the cart.

5. Get a piece of string that is about 20 cm longer than the distance from the floor to the top of the pulley. Tie the sting to the end of the cart and place the string over the pulley. Tie a loop in the other end of the string.

6. Measure and record the mass of a 20-g hooked mass and hang the mass from the loop at the end of the string.

7. Adjust the string if needed so that when the cart is at the pulley, the hooked mass on the end of the string almost reaches–but does not touch–the floor.



4.2. Part 1: No Mass Transfer–20 g Hanging

1. Pull the cart back so the mass is just below the pulley (but make sure that the cart is at least 15 cm away from the sensor).

2. Press Start to start recording data. Release the cart so it moves toward the pulley.

3. Press to stop recording data just before the cart reaches the end of the track.

4.3. Part 2: First Mass Transfer–40 g Hanging

1. For Run #2, move 20 g from the top of the cart to the hanging mass. Record the total mass hanging at the end of the string.

2. Press Start to start recording data. Release the cart so it moves toward the pulley.

3. Press to stop recording data just before the cart reaches the end of the track.

4.4. Part 3: Second Mass Transfer–60 g Hanging

1. For Run #3, move the two 20-g masses back to the top of the cart and move the 50-g and 10-g masses to the end of the string (for a total of 60 g hanging). Record the total mass hanging at the end of the string.

2. Record the motion of the cart as before.

4.5. Part 4: Third Mass Transfer–80 g Hanging

1. Finally, for Run #4, transfer a 20-g mass to the masses at the end of the string (for a total of 80 g hanging). Record the total mass hanging at the end of the string.

2. Record the motion of the cart as before.

LECTURE 8: NEWTON'S SECOND LAW – CONSTANT FORCE
REPORT

Name:…………………………………………………………………….
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1. Purpose:

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2. Results:

2.1. Predict

1. What will happen to an object when you apply a net force to it?

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2. What will happen to the motion of an object if it has a constant mass but you change the magnitude of the net force on it?

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2.2. Data

Sketch a graph of position versus time for one run of data. Include labels and units for your y-axes and x-axes.

Sketch a graph of velocity versus time for one run of data. Include labels and units for your y-axes and x-axes.

2.3. Calculations

Calculate the theoretical acceleration when the mass is constant and the net force is changed and record the calculations in the Data Table 3.

• The theoretical acceleration is the ratio of the net force divided by the total mass.

$$a = \frac{m_{hanging} g}{m_{cart} + m_{hanging}}$$

• For runs #2, #3, and #4, the net force (hanging mass x 9.8 N/kg) increases but the total mass of the system (mass of cart + hanging mass) remains constant.

• Assuming no friction, the net force is the weight of the hanging mass (mass x 9.8 N/kg). Find the percent difference between the theoretical and experimental acceleration and record it in the data table.

$$\%difference = \left| \frac{theoretical - experimental}{theoretical} \right| x100$$

2.4. Data table 1

Item	Mass (kg)
Run #1: Initial mass of cart + masses (m_{cart}):	
Run #1: Initial mass of the hanging mass ($m_{hanging}$):	
Run #2: Total mass of hanging masses (0.02 kg + 0.02 kg):	
Run #3: Total mass of hanging masses (0.05 kg + 0.01 kg)	
Run #4: Total mass of hanging masses (0.05 kg + 0.02 kg + 0.01 kg)	

2.5. Data table 2: Experimental Acceleration

Run	Acceleration (m/s^2)
#1	
#2	
#3	
#4	

2.6. Data table 3

F_{net}, (net force) = hanging mass x 9.8 N/kg

Run	Hanging cart (kg)	F_{net} (N)	Acc., theory (m/s^2)	Acc., exp. (m/s^2)	%difference
#1					
#2					
#3					
#4					

2.7. Questions

1. Why did the slope of velocity versus time change for each run?

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2. For the runs, what did you observe about the slope of the Linear Fit as the net force increased but the total mass remained?

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3. What happens to an object's acceleration if the net force applied to the object increases but the total mass of the system remains constant?

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