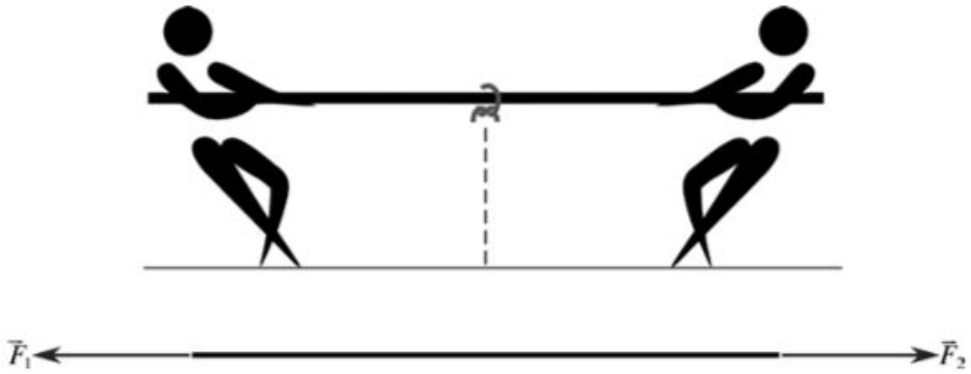
Force and Motion: How Do Changes in Pulling Force Affect the Motion of an Object?

Introduction
A force can be described simply as a push or pull that acts on an object. For example, when you push or pull on a doorknob, you are applying a force that moves the door. In addition to a push or a pull, forces can be described as contact or non-contact. Pushing a box across the floor is an example of a contact force; the force to move the box is being applied by your hands, which are in contact with the box. However, non-contact forces can act on objects without having to actually touch the object. For example, a magnet can push or pull another magnet without the two ever touching each other. Similarly, gravity is a non-contact force that pulls objects closer together, such as when something falls toward Earth.

When you apply a force to an object, that object often will move. Sometimes, however, when you apply a force to an object it doesn't move. It is relatively easy to apply enough force to slide a box across the floor, but it is much more difficult to push a car down the road. The motion of an object is determined by the strength of the force applied to move it, the weight of the object, and any other forces that might be acting to move the object in a different direction. Consider a game of tug-of-war (see figure below): if both people pull with equal strength, then the rope doesn't move, but if one person pulls harder, the rope moves in that direction.

In a game of tug-of-war, the overall movement of the rope is based on the strength of the pull in both directions.



Isaac Newton (1642–1727) was a physicist who studied the motion of objects. He is perhaps most well known for the laws of motion he developed after extensive observa- tion of the planets in our solar system. Newton described that (1) a stationary object will remain stationary unless an external force acts on it, (2) the change in an object's motion is proportional to the force acting on it, and (3) every force has an equal and opposite force. The motion of an object is the result of all the different forces that are pushing or pulling on that object. When all the forces are acting in the same direction, the object will move in that direction. If all the forces acting on an object are balanced, then the object either will not move or will move with a constant speed. When there are forces acting in different direc- tions on the same object but they are not the same strength, then the forces are unbalanced; the object will move, but how it moves (e.g., fast, slow, constant speed, speeds up, or slows down) depends on the relationship of all the forces acting on the object.

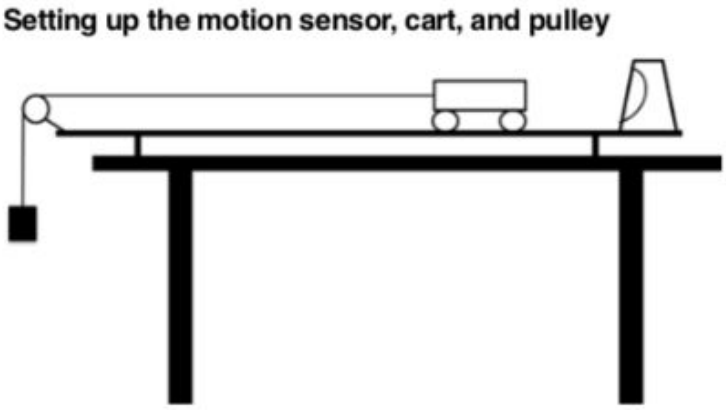
Your Task
Use what you know about forces, systems, and stability and change to design and carry out an investigation that will allow you to predict how different pulling forces (hanging weights) influence the motion of a cart (e.g., does it speed up, slow down, or travel at a constant speed).
The guiding question of this investigation is: **How do changes in pulling force affect the motion of an object?**

Materials

You may use any of the following materials during your investigation:

- Pull cart
- Pull car track or flat table
- Pulley
- Pulley clamp
- String
- Hanging weights
- Meterstick
- Balance
- Motion sensor with interface

Getting Started



To answer the guiding question, you will need to plan an investigation to measure the motion of a cart as it is pulled across the tabletop. The figure above shows how you can set up the cart and motion sensor to col- lect your data; however, to accomplish this task, you must determine what type of data you need to collect, how you will collect it, and how you will analyze it.

To determine *what type of data you need to collect,* think about the following questions:

- What information do you need to describe the motion of the cart?
- What information or measurements do you need to calculate the speed of the cart?

To determine *how you will collect your data,* think about the following questions:

- What equipment will you need to collect the data you need?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect?
- How will you organize your data?

To determine *how you will analyze your data,* think about the following questions:

- What type of calculations will you need to make?
- What type of table or graph could you create to help make sense of your data?
- How will you determine the effect of different pulling forces on the cart's motion?

Report

Once you have completed your research, you will need to prepare an investigation report that consists of four sections (be sure to have section headings):

1. Introduction: Give some background information on the topic. Explain what question were you trying to answer and include a hypothesis. (Background info, research question and hypothesis)
2. Procedure: What did you do during your investigation and why did you conduct your investigation in this way? (How you collected and analyzed data)
3. Data: Include a data table and/or graph to show your results. Be sure to include a title for your table or graph with labels for the variables.
4. Conclusion: What is your argument? (Claim - Evidence - Reasoning)

Your report should answer these questions in two pages or less. The report must be typed, and any diagrams, figures, or tables should be embedded into the document. Type your report on Google Docs (12 point font, double-spaced) and share it with your teacher. Your report will be graded based on the rubric in the class syllabus.