

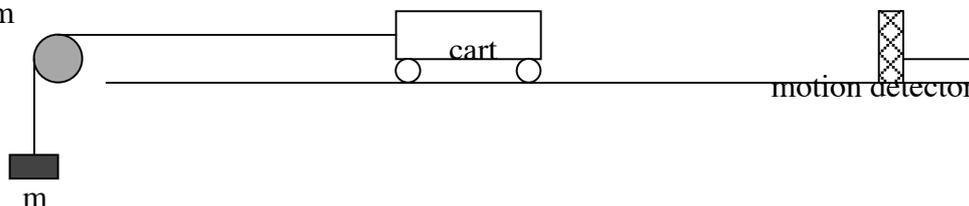
Physics: Lab B2 - Newton's Second Law (Predicting Acceleration)

Complete the following sections of the lab report: *Evidence, Analysis, and Evaluation (part 1 and 2)*.

Problem

Does Newton's second law ($F_{\text{net}} = ma$) accurately predict the acceleration of an object?

Diagram



Experimental Design

A small mass, m , is attached to a dynamics cart and passed over a pulley as shown in the diagram. As the mass falls the cart will be accelerated over the track or table surface. As long as the string is not too elastic and there is no slack, both the falling mass and the object will have the same acceleration. The resulting acceleration of this system will be determined experimentally, and this value will be compared to the acceleration predicted by Newton's Second Law. A motion detector connected to a computer interface (Vernier LabPro) will be used to produce velocity - time and acceleration - time graphs and the mean experimental acceleration of the cart can be determined from these graphs.

Assuming the surface is level (horizontal) Newton's Second Law ($F = ma$) predicts that the acceleration of this system will be theoretical value of the object's acceleration can be calculated using Newton's second law.

$$F_{\text{net}} = (M_{\text{total}})(a) , \text{ but } F_{\text{net}} = mg \text{ (weight of falling mass) } , \text{ therefore}$$

$$mg = (M_{\text{total}})(a) , \text{ and } \vec{a} = \frac{m\vec{g}}{M_{\text{total}}} * \text{ (theoretical acceleration)}$$

Note: M_{total} is the total mass of the system (mass of object and falling mass)

Important details

- 1) Start the cart from the same place for each trial.
- 2) The total mass of the system must remain the same. If a mass is removed from the end of the string place it on the bed of the cart.
- 3) Perform at least three trials for each mass in order to get a reliable average.

Materials

- | | |
|--|--------------------------------------|
| -meter stick | -mass set (1, 2, 5, 10, 20 g masses) |
| -pulley and clamp | -dynamics cart |
| -string & paper clip | -mass balance |
| -Motion detector | -LabPro interface and computer |
| -dynamics track or level table top surface | |

Procedure

1. Set up the pulley, cart, and a bumper of some sort to prevent the cart from hitting the pulley at the end of its run. Add all the masses to the bed of the cart.
2. Carefully level the track such that the cart has no tendency to drift or accelerate in either direction along its run.

3. Put a loop in one end of the string and place this loop over the spring release trigger on the dynamics cart. Drape the string over the pulley and adjust the pulley so the string is level.
4. Adjust the length of the string so the masses will not hit the floor before the cart has reached the end of its run. Put a loop at this end of the string and connect to a paper clip.

Compensating for friction

The dynamics cart and track have a very low friction coefficient but it is still necessary to compensate for as much of the friction as possible.

5. Hang enough of the small (1 and 2 g) masses on the paper clip and the end of the string until the cart will just continue to move without apparent acceleration when barely nudged. The small mass added will compensate for friction in the system and will be ignored in the following calculations. The small masses will remain attached to the paper clip throughout the experiment.
6. Connect the motion detector to the LabPro interface (DIG/SONIC 1) and the computer and start the LoggerPro program. Open the file “39 Newtons Second Law” from the *Physical Science with Computers* folder.
7. Position or fasten the motion detector in line with the track and at least 45 cm behind the starting position of the cart. Always start the car from the same place. Tape a card to the back of the cart in order to give a larger surface area for the motion detector to focus on.
8. Move a 10 g mass from the bed of the cart to the paper clip and place the string over the pulley. Place your cart at your decided starting position (at least 45 cm from the motion detector).
9. Click “Collect” and release the cart after you hear the clicking sound coming from the detector. Catch the cart before it hits the bumper at the end of the track.
10. Determine the mean acceleration of the cart from the velocity-time and acceleration-time graphs. Find the part of the velocity-time graph where the cart was moving across the track or table and highlight it by clicking the mouse and dragging it across the graph. Click the statistics button and record the mean acceleration.
11. Repeat steps 8 – 10 two more times to get a reliable average. Be sure to start the cart from the same place each trial.
12. Repeat steps 8 – 11 for at least 5 different masses attached to the paper clip (i.e. 15 g, 20 g, 25 g, 30 g, 35 g). Remember to start the cart in the same place each time.
13. Excluding the pulley, determine the total mass of your system, M_{total} . (cart, added masses, string, paper clip). Ignore the small masses used to compensate for friction. You may want to measure the masses of the 5, 10, and 20 g masses attached to the paper clip but they should be very close to the specified values

Evidence/Analysis

1. Complete an evidence/analysis table to include all measured and calculated data. The small masses (5, 10, 20 g) can be reported to the 0.1 precision (i.e. 10.0 g).
2. Determine the theoretical acceleration and average experimental acceleration. For each trial. Include sample calculations.
3. Determine the percent difference for the experimental acceleration.
4. Answer the problem in sentence form.

Evaluation

Complete part 1 and 2 in the Appendix B outline.