Lab 4: Newton's 2nd Law

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INTRODUCTION

Forces are interactions between objects in nature. Two classes of forces are contact and field forces (Serway). Contact forces are interactions that involve physical contact between two objects. An example of this is one's fingers typing keys. Field forces are interactions that do not involve physical contact. An example of this is the gravitational force. Newton developed laws to describe motion caused by forces. Newton's second law is number one on the table below. This equation states that the acceleration of an object is directly proportional to the force acting on it and inversely proportional to its mass. This force is the net force, or the vector sum of all the objects acting on the object (Serway). An application of Newton's laws is Hooke's law. Hooke's Law is number two on the table below. "K" represents the spring constant of the spring. "X" represents the displacement from equilibrium. The force is directly proportional to the displacement from equilibrium. The negative sign indicates that the force is always directed towards equilibrium. This force is a restoring force. The two hypotheses that are being tested are:

H_0: *Mass of an object is equal to the net force divided by its acceleration*

H_0: *The spring constant is equal to the net force divided by displacement from equilibrium.*

Newton's 2nd Law (1)	Hooke's Law (2)
$F = ma$	$F = -kx$

PROCEDURES

To test the Hooke's Law hypothesis, a cart with a force sensor is placed on a track. The track is angled at 9 degrees from the table. The force sensor is attached to a spring. A string is attached to the end of the cart and to a pulley. The pulley string is pulled on to extend and compress the spring. The motion sensor collects displacement values and the force sensor collects the force of the spring. A force vs. displacement graph is produced to show the linear relationship. The slope of this graph is the spring constant. We do not know the actual spring constant so the slope will approximate it.

To test the Newton's 2nd Law hypothesis, the track is laid flat on the table and the spring is removed. The string is attached to the pulley and to the hook on the cart. A force is applied by hand to the hook to move the cart back and forth. Meanwhile, data is collected to measure the force and acceleration. On a force vs. acceleration graph the slope is the mass of the object. To test the hypothesis a t-test was performed in order to see if the average of our experiment mass was significantly different from the actual mass. The actual mass was measured on a scale.

RESULTS

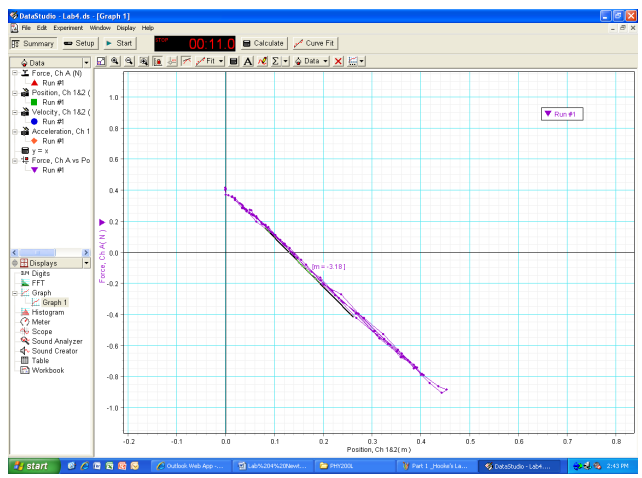

Figure 1: Hooke's Law Hypothesis. Force vs. Displacement graph. Slope of this graph is -3.19 and is equal to the spring constant.

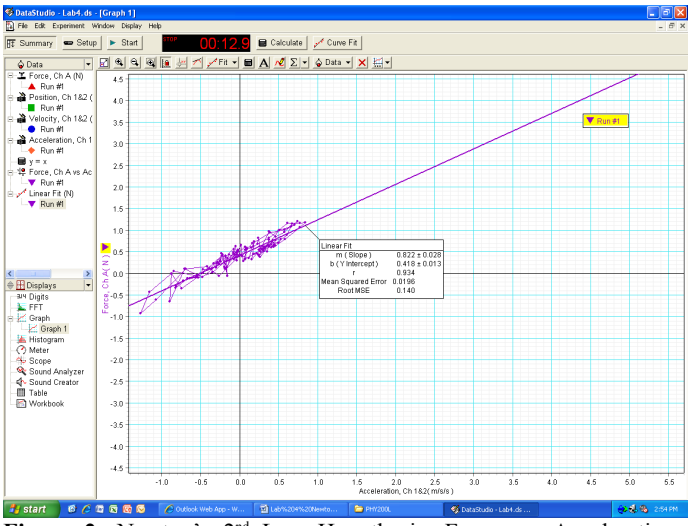

Figure 2: Newton's 2nd Law Hypothesis. Force vs. Acceleration graph. Slope of this graph is 0.822 ± 0.028 and is equal to the total mass of cart and force sensor.

The spring constant obtained from our data is 3.19 N/m (Figure 1). The absolute value is taken because the negative sign indicates it is a restoring force. There is no error associated with the spring constant because the actual spring constant is unknown.

The mass obtained from our data is (0.822 ± 0.028) kg (Figure 2).

DISCUSSION AND SUMMARY

The hypothesis, ***H_0:*** *Mass of an object is equal to the net force divided by its acceleration*, should not be rejected. A t-test was performed and there is significant evidence that the actual mass of the cart and sensor equals the experimental mass. The hypothesis, ***H_0:*** *The spring constant is equal to the net force divided by displacement from equilibrium,* should not be rejected. There was no actual spring constant so our experimental spring constant is used to approximate a value. Our findings can be suspect to error. The motion of someone's hand pulling on the string or hook could have been unsmooth. This can result in some bad data points. These hypotheses are related to the major laws of physics. It proves that Newton's 2nd Law and Hooke's Law can be applied for analyzing systems in nature.

REFERENCES

Serway and Jewett, Physics, Thomson 2004
DeGoede, Lab 4: Newton's 2nd Law, 2002