

Lab 6: Newton's Laws Part Two

PHYS 211L

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1 Introduction

With Newton's laws and a decent way to measure accelerations, we have a means to accurately measure the angle of a slope. In this lab we will consider two different systems. One where a mass is pulled up a frictionless incline and another where a mass is pulled down a frictionless decline. In both cases, we will measure the acceleration of the system and calculate the angle of the slope.

2 Procedure

1a. Finding the formula of the angle i. Using the diagram in Fig. 1 and Newton's second law, $F = ma$, produce a system of equations for both masses. Refer to Newton's Laws Part 1 introduction if you need help with this. Note that not all forces are represented in the diagram. Show all of your work. ii. Combine your equations to formulate a solution for the incline angle. The formula for the angle should include both masses and the acceleration of the masses but not the tension force. Show all of your work. iii. Your final result should look like this: $\theta = \sin^{-1} \left[\frac{m_2 g}{m_1 + m_2} \right]$ 1b. Find the angle of the inclined ramp experimentally i. Place two textbooks under the air track support post closest to the pulley. Set the hanging mass to 25g. Remember the mass of the holder. Tie the holder in such a way that the hanging mass will hit the ground BEFORE the cart reaches the pulley! This will lessen the impact of the cart on the pulley and protect the equipment. ii. Use the knowledge you've acquired from previous labs to record the position vs time of the cart. iii. Copy and paste the data into excel and find the acceleration of the system. iv. Repeat steps i. - iii. two more times with hanging masses of 45g and 65g. v. Calculate the average acceleration. vi. Use the formula you found in part 1a to find the experimental angle of the air-track. vii. Using the measuring stick at your table, measure the height of the of the air track at both ends and the length of the track. Use these measurements and some trig to calculate the angle of the incline of the air track. viii. Find the percent error between the experimental angle and the actual angle. 2a. Finding the formula of the angle i. Using the diagram in Fig. 2 and Newton's second law, $F = ma$, produce a system of equations for both masses. Refer to Newton's Laws Part 1 introduction if you need help with this. Note that not all forces are represented in the diagram. Show all of your work. ii. Combine your equations to formulate a solution for the decline angle. The formula for the angle should include both masses and the acceleration of the masses but not the tension

force. Show all of your work. iii. Your final result should look like this:

$$\theta = \arcsin \left[\frac{m_1 a - m_2 (g - a)}{m_1 g} \right] \quad (1)$$

2b. Find the angle of the declined ramp experimentally i. Place two textbooks under the air track support post furthest to the pulley. Set the hanging mass to 25g. Remember the mass of the holder. Tie the holder in such a way that the hanging mass will hit the ground BEFORE the cart reaches

the pulley! This will lessen the impact of the cart on the pulley and protect the equipment. ii. Use the knowledge you've acquired from previous labs to record the position vs time of the cart. iii. Copy and paste the data into excel and find the acceleration of the system. iv. Repeat steps i. - iii. two more times with hanging masses of 45g and 65g. v. Calculate the average acceleration. vi. Use the formula you found in part 2a to find the experimental angle of the air-track. vii. Using the measuring stick at your table, measure the height of the of the air track at both ends and the length of the track. Use these measurements and some trig to calculate the angle of the decline of the air track. viii. Find the percent error between the experimental angle and the actual angle.

3 Data and Plots

The data is included below. I was provided the calculated angles and some excel data, and no angle measurement. Thus, I cannot do a lot of the results. Even still, partial credit is better than no credit.

4 Calculations

I didn't really do the calculations for the fit, rather the fit was given to me. I did not receive the height of the air track or the length, or the measured angle. I intend to provide the best level of qualitative analysis I can to earn hopefully some credit here.

5 Error Analysis

I find it difficult to quantify error in this experiment, as I do not have a control or any knowledge of the tolerances or precision of the equipment used. However, I

am able to qualitatively describe the likely sources of error and how it would affect the data. The ultrasonic sensors have been characterized as unreliable and touchy, as well as the air rails with dead spots, which would make it difficult to trust the precision of the data collected, especially within the messy conditions that Phys I lab is performed in. From a completely qualitative perspective, though, the level of precision necessary for our purposes is achieved.

6 Results

For the first test, it is calculated that the first angle is 5.42° .

7 Questions

7.1 Would Miners or Civvies use this method?

I could see a situation where a mining engineer would use this method to measure an angle.

7.2 What are potential sources of error in the field?

8 Conclusions

This lab was a whirlwind. I am off my meds and on two pots of coffee. The data felt incomplete but I did my best. Some credit is better than no credit.

one.png

two.png