Experiment 2: Forces

PH 2021H

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**Introduction**

The objective of this experiment is to obtain a value for acceleration due to gravity on a gilder, sliding on a track, using Newton’s third law. This is done in different ways in each part of the experiment. Newton’s third law states that an object at rest will remain at rest until acted upon by an external force and an object in motion will remain at constant velocity until acted upon by an external force. This law is understood through the equation: .

Part A of the experiment was a used to calculate earth’s gravitational pull () by using a variable mass to accelerate the glider down the track. The mass of the weight (), the mass of the glider (), and the acceleration (), found using the instantaneous velocities at the gates, allow us to calculate the entire force on the system giving us the power to pull out ().



In part B the variable mass was replaced with tilting the track allowing us to still get .The equation  where  was the tracks angle to the table and  was acceleration, gives us our relation between gravity and acceleration.  was found using two sets of elevation/position measurements on the air track. The equation for this was.  represents the elevation of one measured point on the track over the other while  represents the distance from one point to the other. We use these two equations to derive a third which we use to calculate .



**Initial Data**

Part A: Pulling force

 is the hanging mass and  are the times for which photo-gates 1 and 2 are respectively blocked.  is the width of the glider flag and  is the distance between the gates.  is the mass of the glider and  is the initial position of the glider on the air track.  represents the uncertainty in position measurement while  and  represent uncertainty in the hanging mass and glider mass measurements respectively.



Part B: Component Force

 and  are the length of time for which gates 1 and 2 were blocked by the flag, whose width is .  is the difference between the height measured at two points on the air track.  is the distance between these two points on the track itself.  is the distance between the photo-gates and is the starting position of the glider on the air track. , , , and  each represent uncertainty in flag width, position measurements, height measurements, and time measurements respectively.

**Analysis**

Part A: Pulling Force

1. (instantaneous velocity at each photo-gate)
   1.  (velocity at gate 1)
   2.  (velocity at gate 2)
2.  (acceleration of glider)

3-5.

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As shown in the table,  and  are 5.38 (m/s­­2) and 0.177 (m/s2) respectively.

Part B: Component Force

1. (average blocking times for both gates)
   1. 
   2. 
   3.  (glider width)
   4.  (uncertainty in glider width)
   5.  (average velocity at gate 1)
   6.  (average velocity at gate 2)
   7.  (acceleration)
2.  (calculated gravitational acceleration)
3.  (track angle)
4.  (uncertainty in acceleration due to uncertainties in v1, v2, and x21)
   1.  (uncertainty in blocking time of gate 1)
      1.  (standard deviation of gate 1 blocking time)
   2.  (uncertainty in blocking time of gate 1)
      1.  (standard deviation of gate 2 clocking time)
   3.  (uncertainty in acceleration due to uncertainty in v1)
      1. 
         1. (uncertainty in velocity due to uncertainty in blocking width)
         2. (uncertainty in velocity due to uncertainty in time)
   4.  (uncertainty in acceleration due to uncertainty in v2)
   5.  (uncertainty in acceleration due to uncertainty in x21)
      1.  (uncertainty in x21 due to uncertainty in x)
5. (uncertainties in track measurements)
   1.  (uncertainty in xh due to uncertainty in x)
   2.  (uncertainty in h21 due to uncertainty in h2 and h1)
6. (uncertainties in  due to uncertainties in , , and )
   1.  (uncertainty in  due to uncertainty in )
   2.  (uncertainty in  due to uncertainty in )
   3.  (uncertainty in  due to uncertainty in )
7.  (uncertainty of g)  
   \*conflicting instructions regarding number of  values. Here it is assumed there is only one.
8.  (uncertainty in due to uncertainty in  and )
   1.  (uncertainty in  due to uncertainty in )
   2.  (uncertainty in  due to uncertainty in )

**Results**

Part A:

Acceleration due to gravity ; uncertainty 

Part B:

Acceleration due to gravity ; uncertainty: 

Angle ; uncertainty: 

**Conclusion**

Part A:

The value we calculated for g was far off from given value of gravity even with it margin of uncertainty. We found a major systematic error to be the cause of this issue. After conducting the experiment we found that the pulley string system had a massive amount of friction causing the string to slide rather than the roll with the pulley. With this in mind one could find the actual experiment value of gravity by measuring the force of friction in that situation, but the tools for that were not parts of the experiment.

Part B:

In part B the major issue noticed was human error. When releasing the cart I unintentionally pushed the cart cause a much inflated value. Otherwise this experiment was very close to the expected value.