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Conservation of Momentum

Physics 1730

11/3/2020

Section 501-516

**Conservation of Momentum**

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3, November, 2020

**Abstract**

The experimental that will be tested and calculated for inquires about what happens to the coefficient of friction at varying angles of incline. From the lab data and using:

It was possible to calculate the coefficient of kinetic friction between the object and the inclined plane that allowed the object to overcome the force acting against it and start moving it. For instance, it was found that an incline at an angle of 45 degrees and measuring a block only yielded a coefficient of 0.295 versus an incline angle of 15 degrees which yielded a coefficient of only 0.203. This experiment will be verified by using an inclined plane, a wooden block and a set of weights to see how the different masses effect the experiment hence effecting the coefficient of kinetic friction of the object on the inclined plane. The results will be verified by calculating the percent difference between the coefficients of friction when the block with no additional weight at angle 0 and when the block is measured at 15, 30 and 45 degrees. The percent differences that were recorded between an inclined plane at 0 degrees compared to an inclined plane at 15, 30 and 45 degrees were as follows:

0 and 15 degrees: 1.95%

0 and 30 degrees: 10.53%

0 and 45 degrees: 35.05%

These results are both low and high and could be this way because of errors when performing the experiment or with miscalculations. This lab is very important because it must be understood how coefficient of kinetic friction effects all objects small and large. Friction can be expressed in every day real life when you are driving a car. Imagine you are travelling at 70mph on a straight road and you realize that roughly 200 feet in front of you the light is red and there is cross traffic and you must stop. Depending on your reaction time and your coefficient of friction you may stop at soon enough or not causing a wreck or successfully stopping in time.

**Introduction**

Since all objects that are moving possess momentum and kinetic energy we must perform a series of calculations in order to fully understand the experiment that is being performed. The first equation has deals with force which is equal to mass times acceleration. This can be read as:

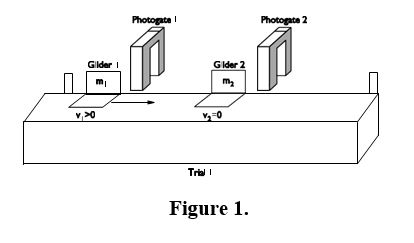
The next equation has to do with objects that are in motion. Objects that are in motion have kinetic energy as well, thus we have to calculate for this and the equation can be read as:

This next equation uses two velocities and masses of each gliders and adds them together before the collision which gives us the answer in the form of momentum. This can be read in equation form as the following:

This next equation is very similar to the previous equation, except this equation gets the total momentum of the two gliders after the collision:

Secondly, The equation can be read as:

Now we have the final equation which is.



**Figure 1:** The image above depicts a picture of the experiment in which we have two photo gates and two gliders that have two different masses

The image above depicts a picture of an inclined plane setup similar to the one used in this experiment. This image is included to help the reader to understand what is taking place when performing this experiment. As you can see there is an inclined plane, with a weight that is on the end of a string that is adding force to the object that is in question. You can also see that there is a spot on the object for an additional weight. This is also something that is included in the lab, there is a 500 gram mass that you can place on top of the object to add more weight to the object instead of the pulling force.

**Apparatus**

This lab uses different objects to observe friction and the angle that is required for a wooden block to slide down an inclined plane given a specific mass that is working against it. In this lab an adjustable inclined plane will be used, a set of gram weights, two meter sticks, one 1kg mass, a weight hanger, a wooden block with precut holes for holding weights and one 500 gram mass.

**Procedure**

I will now explain the setup and experimental procedures for this lab.

*Setup Procedure*

In this lab the list of things that will be used are: adjustable inclined plane, a set of gram weights, two meter sticks, one 1kg mass, a weight hanger, a wooden block with precut holes for holding weights and one 500 gram mass to demonstrate the effects of friction on two objects that are working against each other. An inclined plane will then be setup by placing it on a flat surface and placing the wooden block on the plane with a string attached to one of the precut holes and attaching one of the multiple variables weights to the end of the string. This will help us demonstrate the effects that the different weights have on the coefficient of friction. Once all of the objects are in place the experiment is ready to go.

*Experimental Procedure*

After the setup procedure is complete, different configurations of blocks and weights will be used to determine the coefficient of friction and pulling forces required to move the block. For the first procedure of the lab it will only be using only the wooden block which has 189434 dynes of weight. Then, using the wide side of the block and placing it on the inclined plane at 0 degrees and measure the pulling force and then calculate the coefficient of friction. After this step the variable that will be changed is the object moved by adding additional weights and adjusting the incline of the plane in specific degrees that will want to be tested for.

**Data**

The following two tables have been put together as part of the lab experiment and show the respective recorded results for the Conservation of Momentum lab.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trial** | ***m1*** | ***m2*** | **P** | **P**´ | **% Difference** | **Ave.% Diff** |
| 1 | ***216.4 g*** | ***209.5 g*** | ***0.059 kg\*m/s*** | ***0.053 kg\*m/s*** | 10.714 | 12.037 |
| 1 | ***216.4 g*** | ***209.5 g*** | ***0.068 kg\*m/s*** | ***0.058 kg\*m/s*** | 15.873 |
| 1 | ***216.4 g*** | ***209.5 g*** | ***0.066 kg\*m/s*** | ***0.060 kg\*m/s*** | 9.524 |
| 2 | ***316.4 g*** | ***209.5 g*** | ***0.091 kg\*m/s*** | ***0.083 kg\*m/s*** | 9.195 | 8.359 |
| 2 | ***316.4 g*** | ***209.5 g*** | ***0.091 kg\*m/s*** | ***0.081 kg\*m/s*** | 11.628 |
| 2 | ***316.4 g*** | ***209.5 g*** | ***0.072 kg\*m/s*** | ***0.069 kg\*m/s*** | 4.255 |
| 3 | ***216.4 g*** | ***209.5 g*** | ***0.047 kg\*m/s*** | ***0.043 kg\*m/s*** | 8.888 | 7.617 |
| 3 | ***216.4 g*** | ***209.5 g*** | ***0.056 kg\*m/s*** | ***0.052 kg\*m/s*** | 7.407 |
| 3 | ***216.4 g*** | ***209.5 g*** | ***0.063 kg\*m/s*** | ***0.059 kg\*m/s*** | 6.557 |
| 4 | ***316.4 g*** | ***209.5 g*** | ***0.092 kg\*m/s*** | ***0.069 kg\*m/s*** | 28.571 | 28.673 |
| 4 | ***316.4 g*** | ***209.5 g*** | ***0.107 kg\*m/s*** | ***0.080 kg\*m/s*** | 28.877 |
| 4 | ***316.4 g*** | ***209.5 g*** | ***0.100 kg\*m/s*** | ***0.075 kg\*m/s*** | 28.571 |

**Table 1:** need data

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Trial** | ***m1*** | ***m2*** | **KE** | **KE´** | **% Difference** | **Ave.% Diff** |
| 1 | ***216.4 g*** | ***209.5 g*** | ***0.008 kg\*m2/s2*** | ***0.003 kg\*m2/s2*** | 90.999 | 89.985 |
| 1 | ***216.4 g*** | ***209.5 g*** | ***0.011 kg\*m2/s2*** | ***0.004 kg\*m2/s2*** | 93.333 |
| 1 | ***216.4 g*** | ***209.5 g*** | ***0.010 kg\*m2/s2*** | ***0.004 kg\*m2/s2*** | 85.714 |
| 2 | ***316.4 g*** | ***209.5 g*** | ***0.013 kg\*m2/s2*** | ***0.007 kg\*m2/s2*** | 59.999 | 59.945 |
| 2 | ***316.4 g*** | ***209.5 g*** | ***0.013 kg\*m2/s2*** | ***0.006 kg\*m2/s2*** | 73.684 |
| 2 | ***316.4 g*** | ***209.5 g*** | ***0.008 kg\*m2/s2*** | ***0.005 kg\*m2/s2*** | 46.153 |
| 3 | ***216.4 g*** | ***209.5 g*** | ***0.005 kg\*m2/s2*** | ***0.004 kg\*m2/s2*** | 20 | 10.37 |
| 3 | ***216.4 g*** | ***209.5 g*** | ***0.007 kg\*m2/s2*** | ***0.007 kg\*m2/s2*** | 0 |
| 3 | ***216.4 g*** | ***209.5 g*** | ***0.009 kg\*m2/s2*** | ***0.008 kg\*m2/s2*** | 11.11 |
| 4 | ***316.4 g*** | ***209.5 g*** | ***0.013 kg\*m2/s2*** | ***0.011 kg\*m2/s2*** | 15.38 | 16.93 |
| 4 | ***316.4 g*** | ***209.5 g*** | ***0.018 kg\*m2/s2*** | ***0.015 kg\*m2/s2*** | 16.66 |
| 4 | ***316.4 g*** | ***209.5 g*** | ***0.016 kg\*m2/s2*** | ***0.013 kg\*m2/s2*** | 18.75 |

**Table 1:** The table above shows measurements that are made when moving the block with varying weights and forces. In the farthest column you can see the coefficients of friction based on the data.

**Calculations & Graphs**

Here are the calculations that were used in this lab report. You can use the following explanation to understand how my equations are laid out.

The following section is related to the calculations that were performed in order to achieve the data that you find in throughout tables 1and. The first equation relates to the finding the coefficient of friction which can be achieved by dividing the pulling force by the normal force. The second equation relates to parallel force and how it is found. The third equation relates to the frictional force and how it is found by using the parallel force. Finally, the fourth equation relates to the kinetic coefficient of friction when the plane in inclined at an angle. You can read them below:

|  |  |  |
| --- | --- | --- |
|  |  | (1) |

|  |  |  |
| --- | --- | --- |
|  |  | (2) |

|  |  |  |
| --- | --- | --- |
|  |  | (3) |

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

|  |  |  |
| --- | --- | --- |
|  |  | (4) |

For table one all that had to be done was calculate the coefficient using calculation number 1. Here are the resultant values.

|  |  |  |
| --- | --- | --- |
|  |  | (1.1) |

|  |  |  |
| --- | --- | --- |
|  |  | (1.2) |

|  |  |  |
| --- | --- | --- |
|  |  | (1.3) |

|  |  |  |
| --- | --- | --- |
|  |  | (1.4) |

|  |  |  |
| --- | --- | --- |
|  |  | (1.5) |

|  |  |  |
| --- | --- | --- |
|  |  | (1.6) |

Table two is a little different, here is where the parallel force is calculated, the friction force as well as the coefficient of kinetic friction. Those equations with numbers follow.

|  |  |  |
| --- | --- | --- |
|  |  | (2.1) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.1) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.1) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.2) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.2) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.2) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.3) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.3) |

|  |  |  |
| --- | --- | --- |
|  |  | (2.3) |

For the third table will be calculating for the coefficient of kinetic friction first by diving height by base. Then the second time by evaluating tangent of theta. Here are the equations for the third table.

|  |  |  |
| --- | --- | --- |
|  |  | (3.1) |

|  |  |  |
| --- | --- | --- |
|  |  | (3.1) |

|  |  |  |
| --- | --- | --- |
|  |  | (3.2) |

|  |  |  |
| --- | --- | --- |
|  |  | (3.2) |

|  |  |  |
| --- | --- | --- |
|  |  | (3.3) |

|  |  |  |
| --- | --- | --- |
|  |  | (3.3) |

**Graph 1:** As you can see, the coefficient of kinetic friction is not affected by the side of the block that is used.

Graph one proves that the coefficient of kinetic friction is not affected by the side of the block that is used during the experiment.

**Graph 2:** As you can see, the coefficient of friction increases as the degree of incline increases

Graph two above shows the position versus time data collected during part A of the experiment.

**Graph 3:** As you can see, the coefficient of kinetic friction increases as you increase the height of the inclined plane

Graph three shows how the coefficient of kinetic friction increases as the height of the inclined plane increases. This directly goes to show that the higher the inclined plane, the higher the coefficient of kinetic friction will be.

**Discussion**

Many different measurements were taken during this lab and have been evaluated through graphs and other data. The data of block only and at angle 0 were that gave a coefficient friction as well as the block only at varying angles such as 15 degrees, 30 degrees and 45 degrees as well as that coefficient to calculate the percent difference of the data. For the first percent difference for the block only and angle 0 degrees is where the value .207 comes from. The second value was achieved by copying the coefficient of kinetic friction when the angle was at 15 degrees and it was the block only which yielded .203. Those values were used to calculate percent difference which yielded a 1.951% difference. For the second percent difference for the block only and angle 0 degrees is where the value .207 comes from. The second value was achieved by copying the coefficient of kinetic friction when the angle was at 30 degrees and it was the block only which yielded .230. Those values were used to calculate percent difference which yielded a 10.53% difference. Finally, the third value was achieved by copying the coefficient of kinetic friction when the angle was at 30 degrees and it was the block only which yielded .295. Those values were used to calculate percent difference which yielded a 35.05% difference. The random error percentages were much higher than anticipated except for the last two data recordings. Some of these errors could be because of inconsistencies when actually performing the experiment. It was determined that there was no difference between using the wide side and the narrow side of the block when testing because the numbers came out the same when running the calculations. Use graph 1 to confirm my findings. One of the most important things to gather from graph one is that the coefficient of kinetic friction stays the same no matter what side is used for calculations. For graph two you can see that there is a slightly positive slope as far as the data for that graph goes. The correlation that was intended to be made was that there was certainly a link between the degree of incline and the coefficient of kinetic friction. It is believed that the higher the degree of incline the higher the coefficient of kinetic friction. Not only does graph 1 support graph 2, graph 2 further supports graph 3 seeing how all three graphs have uptrends and are related in coefficient to degree inclines. Graph 3 contains 3 points that are related to the coefficient of friction and the height of the incline and this further proves that the higher the incline, the higher the coefficient of friction. The standard deviation between all of the data tested is 0.038. From the data that has been calculated and tested it has been determined that the coefficient of friction will always be a larger number for surfaces that have a rough texture. It has also been determined that theta has an effect on the coefficient of friction in a positive way. As the angle was increased the more friction happened.

**Conclusion**

The objective was definitely verified. In the lab the data was successfully calculated. The data that was included in these calculations were the coefficient of kinetic friction given different data. Once again, the data was verified by performing percent difference calculations. The percent differences that were recorded between an inclined plane at 0 degrees compared to an inclined plane at 15, 30 and 45 degrees were as follows:

0 and 15 degrees: 1.95%

0 and 30 degrees: 10.53%

0 and 45 degrees: 35.05%

It is known that this assumption is correct because, logically it makes sense, as the incline increases, the coefficient of friction increase, making it easier for the object to move. In the future, errors can be reduced by performing more repetitions of the experiment and which will improve the dataset that was used for these calculations.

**References**

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