Rolling Objects Down a Ramp

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Abstract

Rolling objects down an inclined plane in the natural world has several factors, such as air resistance and wind. In this study, we use two different masses of the same rolling object, a water bottle, in order to study the effect that mass has on the motion of rolling objects when faced by these natural factors. After a two sample t-test, we find that heavier rolling objects have a statistically faster clear time for a given inclined plane in comparison to lighter rolling objects.

1 Introduction

For many years, the effects of mass on objects rolling down a inclined plane have been studied and well known. Generally, having a greater mass means that a rolling object, such as a ball, will have a greater moment of inertia. Having a greater moment of inertia will require more energy in order for the object to begin accelerating rotationally. Heavier objects also have more potential energy at the top of the ramp, since *potential energy = mgh*. [2] [1]

In addition, heavier objects will be more resistant to the effects of air resistance and rolling resistance. With so many variables in play, we have decided to test the effects of mass on rolling objects on an inclined plane. On the MIT campus, "Aesop's Fables II" by Mark Di Suvero (See Figure 1) provides an excellent inclined plane to test our hypothesis that *heavier objects roll down an inclined plane in a shorter time than lighter objects.*

2 Materials and Methods

For this experiment, we utilized a Kirkland Signature Water Bottle (See Figure 2) as the rolling object. A ramp of "Aesop's Fables II" served as the inclined plane. We used two differing amounts of water (full and half filled) within the water bottle in order to vary the mass of the "rolling object." Using an empty water bottle proved to be ineffective as the slightest breeze would knock the bottle off the ramp.

The water bottle was released from the top of the ramp and was timed from the point of release to the bottom of the ramp. For each of the two varying masses of the water bottle, 15 trials were taken.

Figure 1: Aesop's Fables II

Figure 2: A Kirkland Signature Water Bottle

3 Results

From the 30 trials (15 for each varying mass of the water bottle), we obtained the following data.

Rolling Times (in seconds)	
Full bottle	Half Filled bottle
1.74	1.88
1.69	1.87
1.62	1.87
1.62	1.88
1.75	1.83
1.80	1.93
1.68	1.81
1.75	1.80
1.74	1.80
1.68	1.80
1.70	1.80
1.61	1.81
1.81	1.87
1.67	1.86
1.80	1.89

Since the hypothesis was that the heavier rolling objects would roll faster down an inclined plane, we utilized a one-sided two sample t-test to test this claim at a 5 percent significance level. For this statistical test, our null hypothesis was that the heavier rolling object would have the same ramp clear time as the lighter rolling object. $H_o = \mu_1 = \mu_2$. Our alternate hypothesis was that the heavier object would have a smaller ramp clear time than the lighter rolling object. $H_a = \mu_1 < \mu_2$. The equation we used for the test is shown below.

$$t = \frac{(\bar{x_1} - \bar{x_2})}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

The test statistic for this test was -6.727. $t = -6.727$ The p-value obtained from this t-statistic was $3.16 * 10^7$. $p = 3.16 * 10^7$ The p-value for this statistical test was essentially equal to zero, showing that the comparison was statistically significant.

4 Conclusion

Through this study, we found that the heavier water bottle indeed rolled down the ramp faster than the lighter water bottle did. From this, we could infer that heavier rolling objects roll down an inclined plane faster than lighter rolling objects.

Our results may have been attributed mostly to the fact that heavier objects are more resistant to air resistance. In addition, because the ramp was made out of steel, having a higher mass could have counteracted the rolling resistance that the slippery surface may have created. For future studies, we would make sure to use a more controlled environment with no wind and have more masses to use.

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References

[1] Batesville. Falling,sliding, and rolling. Available at http://www.batesville.k12.in.us/physics/phynet/mechanics/RotMechanics/fall_slide_roll.htm.

[2] N/A. Physics forum-rolling different masses down a hill. Available at http://www.physicsforums.com/showthread.php?t=318100.