The Relationship Between a Lacrosse Ball's Drop Height and the Percent Rebound Height

Contents

Background .:. Top

As far back as 1650 BC or earlier, bouncy balls have featured as forms of entertainment in sports. The "rubber ballgame is one of the most fundamental features of ancient Mesoamerica, a pre-Columbian cultural region encompassing Guatemala, Belize, most of Mexico, and western Honduras and El Salvador" (ScienceAdvances). The game involved hitting a rubber ball with the hips instead of the hands, and the goal of the game was to keep the ball in play for as long as possible. It was such an important part of their culture that it has been featured in monumental art and was believed to be one of their only ball games that required a formal court to play in. The rubber balls were also often found buried next to other ritualistic objects, which implied they were also used in religious or ritualistic contexts (Internet Archive).

Even today, bouncy balls feature as important objects in sports, such as basketball, soccer, or lacrosse. In lacrosse, a competitive team game involving throwing the ball through the opponents goal using sticks with baskets at the end, the ball used is made of solid rubber, though the earliest versions of the game involved balls made from buckskin, wood, or sometimes rock. Over time, as lacrosse developed, the modern lacrosse balls are made of rubber, or more specifically, vulcanized rubber, which is a much stronger material than traditional rubber (Signature Lacrosse). The elasticity in a lacrosse ball is valued, as

it causes the ball to bounce higher and is more easy to play with. “Elasticity is the tendency of something to return to its original shape if it gets deformed” (Science World). The more elastic an object is, the quicker it will return to its original shape, and with great force behind it. This concept applies to a bouncy ball, which has an elasticity that allows it to have a higher rebound height as a higher drop height allows a bigger deformation with the ball’s shape. Also, as the ball hits the surface, it generates heat and sound, as well as losing kinetic energy. The loss in kinetic energy causes the rebound height of the ball to reach the original height from where it was dropped, as long as the ball was dropped without an external force acting on it like a hand pushing on it.

The behavior of a bouncy ball complies with projectile motion, which is the motion of an object when thrown into the air. There are several different variables that can affect the rebound height of a ball, including but not limited to, the surface it was dropped onto, the material the ball is made of, and the temperature of the ball or room. As there are many variables that could influence the rebound height, the experiment conducted focused on the effect of the drop height on the rebound height of the ball.

Statement of the Problem .:. Top

The purpose of this investigation is to find the relationship, if any, between the drop height of a ball and the percent rebound height. The drop height is defined as the height measured at the bottom of the ball. The percent rebound height is also defined as the height measured at the bottom of the ball at the highest rebound height reached. The controlled variables include but are not limited to the surface the ball is dropped onto, the temperature of the room, the ball used, and the usage of the bottom of the ball as the height of results.

Hypothesis .:. Top

If a lacrosse ball is dropped from different heights from 25 cm to 250 cm with increasing increments of 25 cm, then the graphical representation of the percent rebound height will resemble an upwards exponential curve. This will happen because the higher the drop height, the higher the rebound height will be.

Method .:. Top

In order to start the experiment, I first scoped out and prepared the area that I was going to use to conduct the experiment. After wandering around my house for a few minutes, I settled with the large slightly awkward empty space in between the interconnected living room and dining area. I planned on collecting all of my data in one go to avoid possible differences in temperature in the ball that I was planning to use, which was a lacrosse ball I borrowed from my awesome and very hilarious physics teacher. This is because temperature can affect the bounce height of the ball, as warmer temperatures will cause a higher bounce while cold temperatures cause the opposite. The size and mass of the ball stayed the same throughout the entire experiment as I used the same ball throughout. For the surface where I dropped the ball onto, it also stayed the same throughout the experiment. I began preparing my setup, which included a tape measure, a 12 inch plastic ruler, the lacrosse ball, and a phone stand.

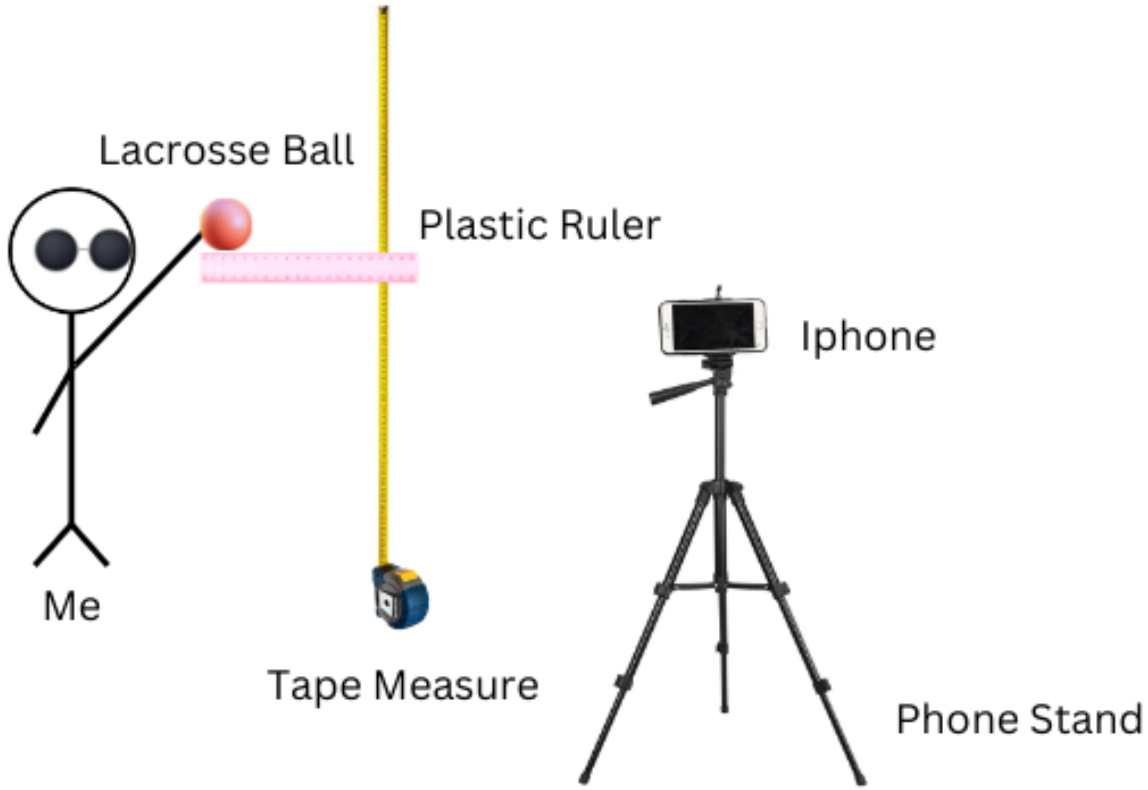
I measured out the length needed from the tape measure that I needed, then taped the tape measure to a wall, with the measurement of the entire length as 250 centimeters as that was the tallest height I needed to record for. Setting up the phone stand toward the tape measure with the measurements as visible as possible, I would record a video of when I dropped the ball. For each height, which was 25 centimeters to 250 centimeters with increments of 25 centimeters, I would record myself dropping the ball at least five times, though I usually did 7-10 just for safe measure. Five trials was easy to do and would give me sufficient amounts of data for possible trends to appear, and ten heights would also ensure

that the data points weren't clumped together too much. To make each trial as similar to each other as possible, I would take the plastic ruler and hold it horizontally with the height I wanted to record trials for. Then, I would position the lacrosse ball on the ruler, where the bottom of the ball would be the height of the drop. This is also the way I measured the rebound height where the bottom of the ball was the height recorded.

After recording, I would then rewind the video every time the ball reached its highest rebound height, then screenshot the five best trials. I then imported the photos into Sketchbook to use the ruler tool to draw a straight line of the highest rebound height to the tape measure, then input the height into a google spreadsheet. The data table I had then was the rebound height, though I actually needed the rebound percent height, so after I was finished collecting data, I then divided each recorded rebound height with the original drop height in order to make another data table for the percentages.

Some safety concerns were making sure none of my family members were near the area I was conducting the experiment, especially my grandma, as they could easily be hit by a wayward bounce of the ball or (my grandma) could slip on the ball. I also conducted the experiment around 8 pm to near 10 pm, and the lacrosse ball was very loud, so I would consider the noise to be an ethical concern to anyone's sleep and peace of mind.

Diagram .:. Top



Data Tables .:. Data File .:. Top

Table 1: Raw Data for Effect of Height (+/- 0.05cm) on Rebound Height (+/- 0.05cm)

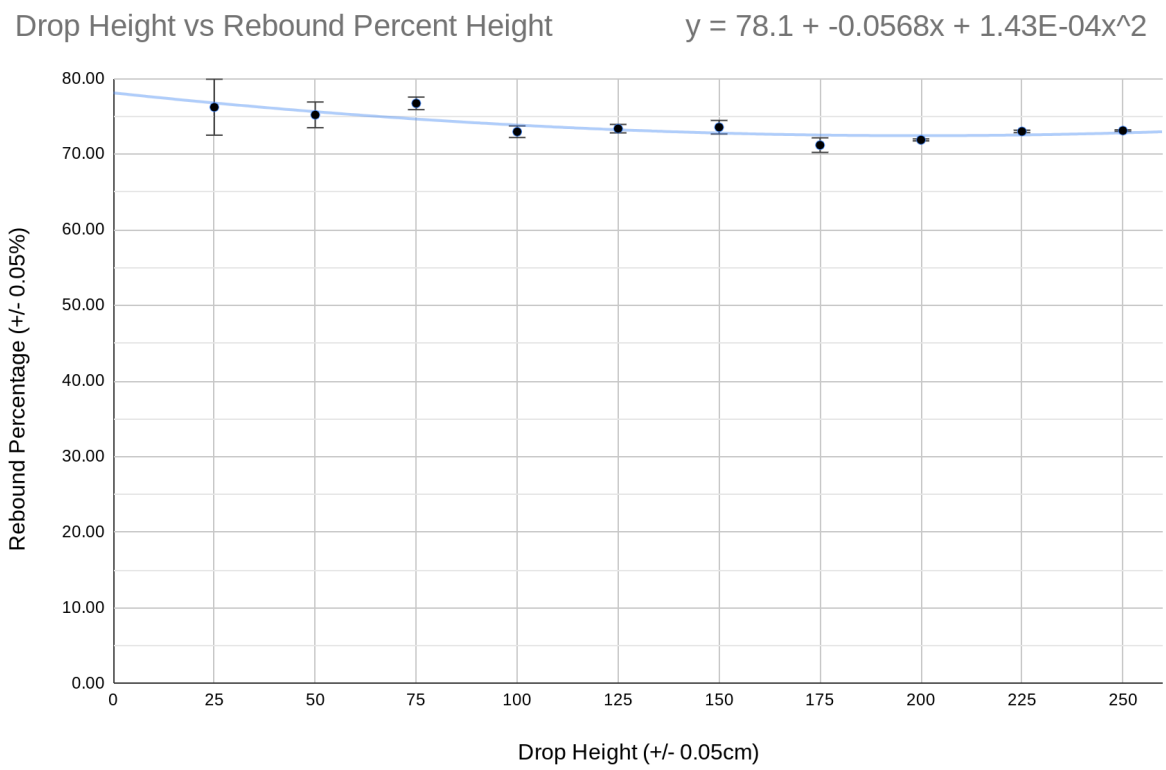
Trial	Height of Drop (+/- 0.05cm)									
	25	50	75	100	125	150	175	200	225	250
1	19.00	37.60	56.75	72.75	91.75	110.60	125.70	143.80	164.30	182.70
2	19.50	38.50	57.80	73.15	92.50	110.45	123.00	144.00	164.65	182.50
3	17.95	37.00	57.70	73.00	90.60	109.30	126.35	143.75	163.95	182.85
4	19.80	38.10	57.45	73.75	92.45	112.00	124.00	143.50	164.20	183.00
5	19.02	36.80	58.00	72.20	91.30	109.40	123.95	143.80	164.25	182.90
Average	19.05	37.60	57.54	72.97	91.72	110.35	124.60	143.77	164.27	182.79

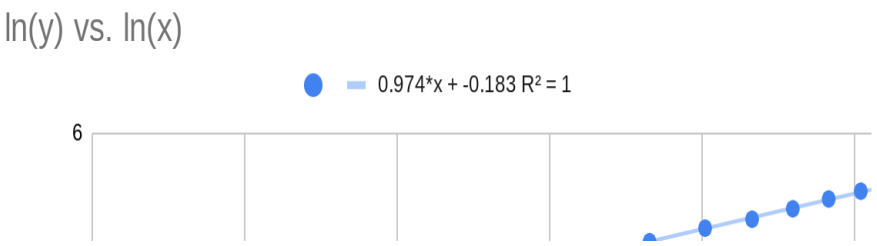
Uncertainty	0.93	0.85	0.63	0.77	0.95	1.35	1.68	0.25	0.35	0.25

Table 2: Effect of Height (+/- 0.05cm) on Rebound Percentage (+/- 0.05%)

Trial	Height of Drop (+/- 0.05cm)									
	25	50	75	100	125	150	175	200	225	250
1	76.00	75.20	75.67	72.75	73.40	73.73	71.83	71.90	73.02	73.08
2	78.00	77.00	77.07	73.15	74.00	73.63	70.29	72.00	73.18	73.00
3	71.80	74.00	76.93	73.00	72.48	72.87	72.20	71.88	72.87	73.14
4	79.20	76.20	76.60	73.75	73.96	74.67	70.86	71.75	72.98	73.20
5	76.08	73.60	77.33	72.20	73.04	72.93	70.83	71.90	73.00	73.16
Average	76.22	75.20	76.72	72.97	73.38	73.57	71.20	71.89	73.01	73.12
Uncertainty	3.70	1.70	0.83	0.77	0.76	0.90	0.96	0.13	0.16	0.10

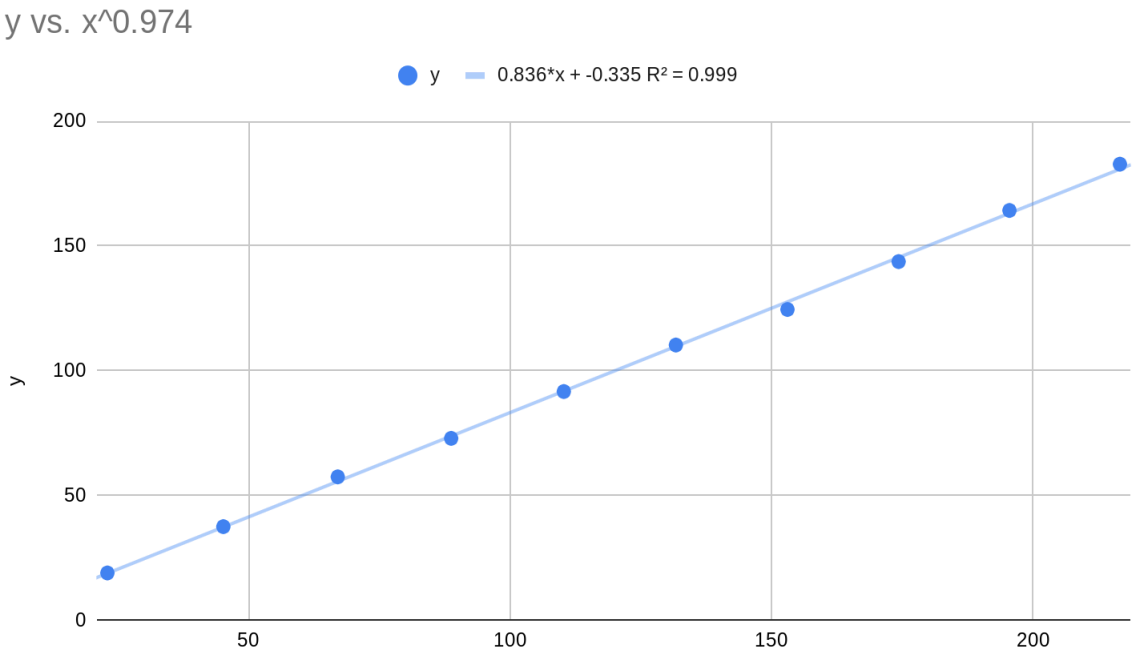
Graphs .:. Top





$A \approx 0.833$

$n = 0.974$



Conclusion .:. Top

The purpose of the experiment was to determine if there was a relationship, if any, between the drop height of a ball and the resulting percent height rebound. The results of the experiment did not support my hypothesis, which predicted that the resulting graph would display an increasing exponential curve. Instead, the results visually had an almost linear relationship, though a polynomial line fit the data best. All the data points were in the 70% to 80% range, displaying that the rebound percent height has a relation with the drop height, as each were roughly around that 70 to 80 percent range with small uncertainties, meaning that the results were quite precise. I think this is because the initial kinetic energy generated by the drop height causes the amount of kinetic energy lost by the ball impacting with the ground to be proportional, increasing with the amount of kinetic energy it originally had. That causes the height of the rebound height to be higher in proportion with the kinetic energy it initially had, which is why the percent bounce height averages to be located in a similar range.

Evaluation .:. Top

With any experiment conducted, there are possible errors that could occur that cause the experiment's results to differ from expected values. For example, as the ball was being dropped, instead of dropping straight down and rebounding perfectly straight up, there were times where the ball veered slightly to the side which could have impacted the resulting rebound height recorded. In order to fix this, instead of a person holding the ball and dropping it manually, we could instead put the ball in between two flat, hard objects, like a book, line those objects up to be as vertical as possible, and release the ball by pulling those objects away at the same time. Another solution would also to be conducting an increased number of trials and then picking out the ones where the ball bounces as close to straight as it can. Another possible cause of error was the method of measuring height with a measure tape, which isn't a very efficient nor completely accurate way to measure values as it only measures to millimeters, and is

difficult to see the values of due to the used Iphone's horrible quality in video. A way to fix this is to get a device that has high visual quality and can take videos in slow motion with this same quality in order to get the highest accuracy in height measurement. Some other sources of error include the cameras height. Due to the phone stand not being able to extend past a certain height, it caused a number of trials to be recorded at a lower height than the rebound height, which could have caused the data recorded from later trials to be inaccurate. To fix this, we could get another phone stand that has an extension height higher than the one used, or use various different items for the phone stand to be perched on. Additionally, another souce of error could be the temperature of the ball itself. As the ball bounces, heat is generated as the ball impacts with the surface of the ground. Over repeated trials and heights, the heat of the ball may have been different than the temperature of the ball at the beginning of the experiment. This may have caused different results to appear than if the ball returned to the same base temperature for every trial. To solve this, a wait between each trial could be implemented, such as a minute for the ball to go back to the same temperature as before if the ball is being bounced over and over without any wait.

If I conducted this experiment again, it would be interesting for me to have all the solutions suggested as sources of error implemented to see if the resulting data would differ all that much or if it would remain the same. I'd also like to reach higher heights for the drop height to see if the ball's percentage rebound height would decrease or not.

Sample Equations .:. Top

$$Percent\ Height\ =\ \frac{Rebound\ Height}{Drop\ Height}$$

$$A\ =\ e^{-0.183}$$

$$A\ =\ 0.8327681$$

$$Uncertainty\ of\ One\ Trial\ =\ \frac{max-min}{2}$$

$$Average\ of\ One\ Trial\ =\ \frac{Sum\ of\ trial\ results}{Number\ of\ trials}$$

Related Links .:. Top

- signaturelacrosse.com/blogs/news/what-is-a-lacrosse-ball-made-of - gives an explanation for the material and elastic properties of a lacrosse ball, which was what was used in the experiment
- https://www.scienceworld.ca/resource/how-high/#:~:text=Because%20bouncy%20balls%20are%20elastic,back%20into%20their%20original%20shape - explains the basic definition of elasticity and relationship between the elasticity of a ball and its resultant rebound height
- https://en.wikipedia.org/wiki/Bouncing_ball - wikipedia page about the the physics behind a bouncy ball and what forces causes it to bounce and rebound
- https://prathushascienceresearchproject.weebly.com/conclusion--discussion.html - experiment similar to this one but with a different variable that questions which surface a tennis ball rebounds highest on
- https://www.studysmarter.co.uk/explanations/physics/mechanics-and-materials/bouncing-ball-example/#:~:text=Bouncing%20Ball%20Example%20%2D%20Key%20takeaways,-The%20bouncing%20ball&text=It%20bounces%20in%20a%20semicircular,will%20continue%20this%20oscillatory%20motion. - in depth explanation of the the bouncing ball experiment, including the formulas and reasonings behind the motion of the ball

Bibliography .:. Top

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