Range vs. Height

Lab Report

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Course: PHYS141

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Abstract

The task was to drop a ball from a varied height drop plate onto a bounce plate which then would fall onto a piece of carbon paper, recording the distance from landing spot to the bounce plate, horizontally. Three different methods of dropping were employed, and the height of the drop plate was varied to determine if there was any effect on the average range and standard deviation. From the Kinematic equations, we derived a formula that gave us the range of the ball from drop plate to landing spot. We also came up with two graphs that plotted the average range versus the height and average range versus a function of height.

Introduction

The experiment involves dropping a small ball from a drop plate onto a bounce plate, with the height from drop plate to bounce plate changing to determine if the change in height had any effect on the standard deviation and average range of the ball’s landing spot measured horizontally from the bounce plate. It also involved using different methods and procedures when dropping to determine if there was any effect it had on the landing spots of the ball and their standard deviations. Changing various variables such as the height of the drop plate and the methods of dropping will help us determine a final method that will allow for the least variation among landing spots, providing consistent, accurate, and precise results.

Procedure

1. Set up the bounce plate 20 cm above the table.
2. For the first part of experiment, set the drop plate 20 cm directly above the bounce plate so that there is a straight drop from the drop plate directly onto the bounce plate.
3. Place the paper that will be used to record the landing spots of the ball in the direction that the ball might drop and do a small test run to see if the ball lands somewhere in the middle of the paper.
4. If it does, hold the paper in place with two pieces of tape on opposite sides and place the carbon paper on top of the recording paper.
5. Drop the ball from the drop plate for a total of 18 times using your fingers as the method of dropping the ball, holding it directly on the drop plate and letting go.
6. Once the ball has been dropped 18 times, remove the carbon paper, and use a ruler to record how far each landing spot is from the bounce plate, horizontally. This will give us the distance of the landing spot from the bounce plate.
7. In the table provided, calculate the sum of ranges, and the accumulated average for each respective drop.
8. To calculate the standard deviation, take the six points that are furthest from the center, three on the far side and three on the side closest to you. Then calculate the distance from the two furthest points and divide that distance by two. This will give you the standard deviation for our landing spots results.
9. Now for the second part of the experiment. Maintaining the height of both the drop plate and the bounce plate, come up with two different methods of dropping the ball from the drop plate. Drop the ball a total of 18 times for each respective method. Examples of methods may include using a magnet to hold the ball and slide it along the hole of the drop plate to drop it or using a metal plate to hold the ball in the drop plate till ready to drop.
10. Similar to the first part of the experiment, record the distance of the landing spot horizontally from the bounce plate for each method, and then determine the standard deviation using the same method in step 8.
11. The third part of the experiment involves keeping the height of the bounce plate constant, while changing the height of the drop plate from the bounce plate, i.e. using heights such as 30 cm, 25 cm, 20 cm, 15 cm, 10 cm, and 5 cm. Use one of the three methods mentioned earlier, a) using your hands to drop, b) using a magnet to drop, or c) using a metal plate to drop. It is recommended to pick the method that resulted in the lowest standard deviation as it provides the most precise results.
12. Again, similar with the first and second part, record the distance using the method in step 6, and the standard deviation using the method in step 8.

Theory

Using the two Kinematic equations above, we can derive a series of equations to help us find the distance of the ball’s landing spot from the drop plate.

From the first equation, we can find the velocity of free fall, when the ball drops from the drop plate onto the bounce plate. That distance (h) is affected by gravity (a, or in this case g), and the initial velocity being 0, we get the following equation:

Now using the second equation and solving for t (time), and again ‘a’ being gravity (g), delta x the distance from the bounce plate to the landing spot (y), we are able to find the amount of time it takes for the ball to go from the bounce plate to the landing spot. We then get the equation as follows

If we then substitute equation (3) and (4) into equation (2), we get the final equation that will give us the range of the ball, shown as

Where h is the height of the drop plate to the bounce plate and the change in y is the distance from the bounce plate to the landing spot on the carbon paper.

Sample Calculations and Result

From the equations that we have we can get an example calculation for one of the parts of the experiment. For example, using the first part, with a fixed drop plate height of 20 cm and a fixed bounce plate height of 20 cm, alongside one of the distances from the bounce plate horizontally to the landing spot, we can then find the distance the ball traveled from the drop plate down to the landing spot. So if h = 40 and y = 38, we get the following:

With x being the total distance the ball travels from the drop plate to the landing spot.

Discussion and Conclusion

To conclude, there is a correlation between using different methods of dropping the ball as well as the height of the drop plate above the bounce plate, with both affecting the standard deviations of the results taken as well as the average range. From the experiment and the data collected, it is plausible to argue that the method of using the metal plate to hold the ball in place before dropping is the most effective at reducing the number of errors and providing near accurate results. Although there is still some error involved such as the speed when you move the metal plate affecting the spin on the ball which can then dictate how the ball might drop onto the bounce plate, perhaps causing the ball to change its trajectory ever so slightly; the metal plate dropping method has proved to be the most consistent when it comes to collecting accurate, precise results. When it came to the height of the drop plate above the bounce plate, the data shows that the lower the difference in height, the smaller the standard deviation. From the third part of the experiment, we can see a clear pattern of the standard deviation decreasing as we decrease the height of the drop plate. Granted there was a slight discrepancy with the height of 25 cm as it produced a standard deviation of 2.25 cm, which when compared to the standard deviations of the 30 cm (0.9 cm) and 20 cm (1.2 cm) it appears that something must have affected the data to cause such a big jump from one standard deviation to another.

Graphs

Figure : Graph 1 plots the average range of the ball from bounce plate to landing spot versus the drop plate height. Error bars for the standard deviation are also shown on each plot.

Graph 1 shows the data collected for part three of the experiment. The table below shows the raw data that was used to plot each point as well as the standard deviation for the error bars.

|  |  |  |
| --- | --- | --- |
| **Drop Plate Height (cm)** | **Average Range (cm)** | **Standard Deviation (cm)** |
| 30 | 42.89 | 0.9 |
| 25 | 35.858 | 2.25 |
| 20 | 35.847 | 1.2 |
| 15 | 31.79 | 0.8 |
| 10 | 24.908 | 0.65 |
| 5 | 17.267 | 0.5 |

Figure : Graph 2 still plots the average range of the ball from bounce plate to landing spot, however, instead of the drop plate height being the x axis, we instead used the formula shown on the graph and used the drop plate height as the x values.

Graph 2 is similar to Graph 1 except that the height is now part of the formula shown on the graph. Plugging in the height gave us a new set of average ranges, which are within one standard deviation of the average ranges found above. Table below shows this new data.

|  |  |
| --- | --- |
| **Drop Plate Height (cm)** | **Average Range (cm)** |
| 30 | 43.214 |
| 25 | 38.499 |
| 20 | 33.784 |
| 15 | 29.069 |
| 10 | 24.354 |
| 5 | 19.639 |