Experimentally determining the acceleration due to gravity of an object in free fall

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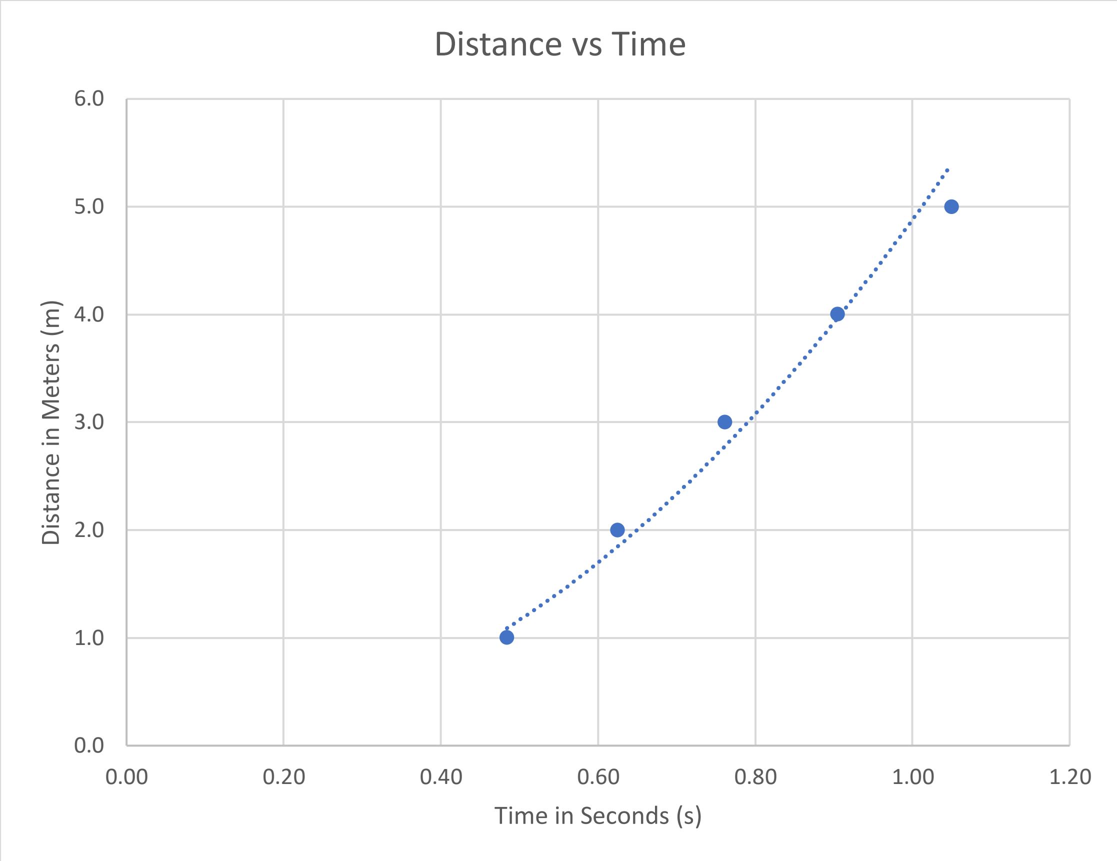
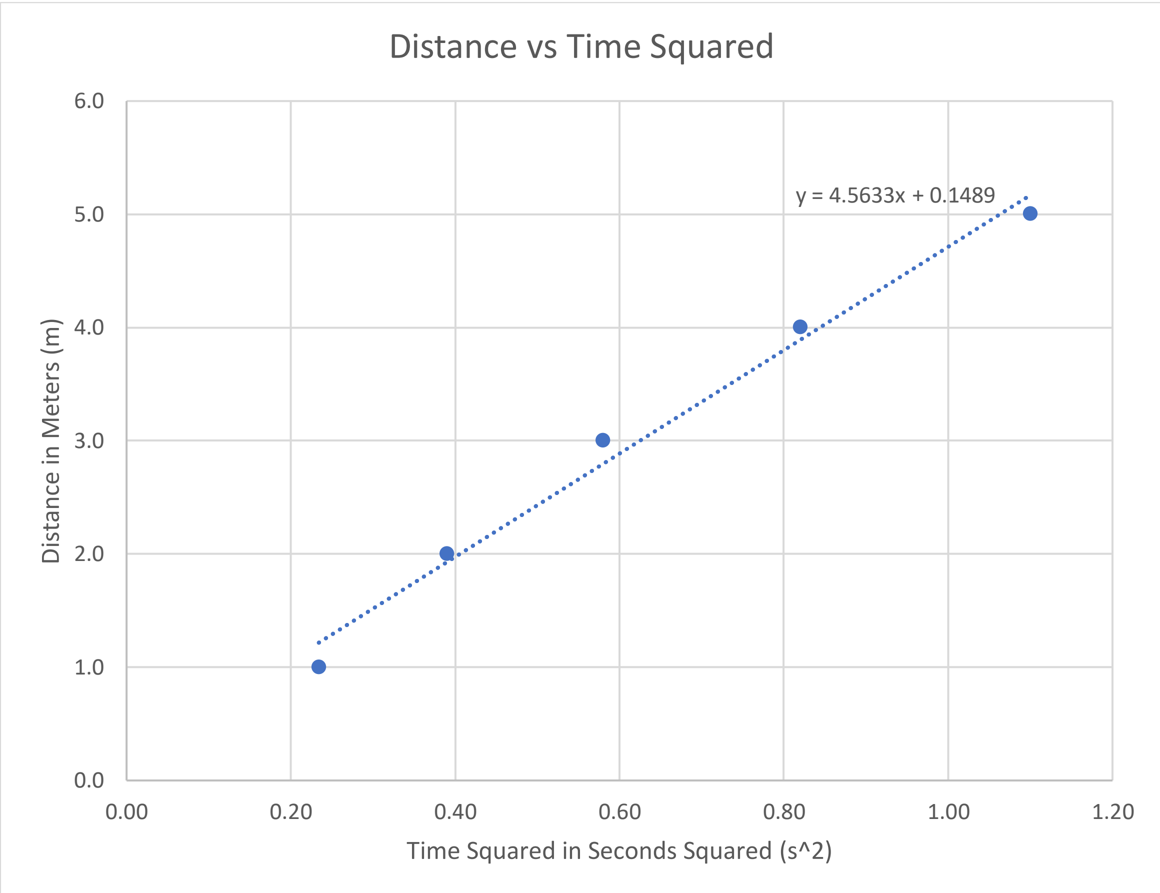
Purpose:
The purpose of this investigation is to determine the value for acceleration due to gravity by dropping a ball from different heights and timing how long until the ball hits the ground.

Variables:
Independent: distance (d) the ball is dropped in meters (m)
Dependent: time (t) the ball is in free fall in seconds (s)
Control: Same ball used, ball dropped by holding the ball in a sideways grip, bottom of ball was level with top of ruler.

Results:

Time (t) in seconds (s)	Time Squared (t^2) in seconds squared (s^2)	Distance (d) in meters (m)
0.48	0.23	1.0
0.63	0.39	2.0
0.76	0.58	3.0
0.91	0.82	4.0
1.1	1.1	5.0


Distance vs Time
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Distance in Meters (m)
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Time in Seconds (s)


Distance vs Time Squared
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Distance in Meters (m)
y = 4.5633x + 0.1489
0.00
0.20
0.40
0.60
0.80
1.00
1.20
Time Squared in Seconds Squared (s^2)

Analysis of Data:
Based on the graph of the original data, distance and time form a squared relationship with distance proportional to time squared.

Equation of the straight-line graph

$y = 4.5633x + 0.1489$

$y = 4.6x$

$d = 4.6t^2$

Slope of straight line graph (m) = 4.6

If $d = ½ at^2$ and $d = 4.6t^2$

then

$½ a = 4.6$ and $a = 9.2$

therefore acceleration due to gravity is 9.2 m/s^2

Conclusion Statement:
When under constant acceleration due to gravity, distance travelled is equal to ½ the acceleration due to gravity times time squared, or $d = ½ (9.2) t^2$.

Discussion of Method:
I chose to control how I held the ball before dropping it so that I the ball would immediately start dropping in free fall without any initial downwards velocity (if I had flipped my hand over) or any delay in starting if I allowed the ball to roll out of my hand.
I made sure to use the same ball because tennis balls have a fuzzy coating and would likely be affected by air resistance differently than other types of balls.

To improve accuracy, we did five trials at each height and used the average time when making the graph.
To decrease systematic error, I made sure that the bottom of the ball was in line with the top of the ruler before each drop. This was important because it is the bottom of the ball that will strike the ground. If I had measured from the middle or top of the ball, it would not have fallen the entire distance that we were trying to measure and our times would have been lower than expected.
I also made sure I was at eye level with the ball and the ruler to decrease the chance of parallax error as I was lining up the bottom of the ball with the ruler.

One of the difficulties we encountered was accurately dropping from the three-meter height as it was hard to get in direct line of sight of where the ball was being dropped. To help fix this, we had someone stand on a bench and get as close to eye level as possible and directed the person holding the ball over the railing to move the ball up or down before dropping the ball.

We chose a lower limit of one meter because it was difficult to accurately record times much less than 0.5 seconds using a manual stop watch.
We chose an upper limit of 5 meters because it was the highest point we could (legally) access. This gave an overall spread of four meters which should be enough to see the relationship between distance and time.

There were two outlying pieces of data that were not included in the averages. Both were caused by a miscommunication between the person timing and the person releasing the ball. Part of the reason that we did five trials at each height was so that we could remove any outliers and still get a reportable average.

Several of the average data points do not sit exactly on the curve of best fit. There are two likely causes for this. First is that there are several places for human error to occur with this test. Using a stop watch to accurately record times of less than a second is greatly affected by human reaction time. We tried to alleviate this by doing multiple trials from each height, but it does not take into account the possibility that the timer may have consistently started or finished the time slightly early or late. This could make up part of the difference between or experimental result and the theoretical result.
The second main cause for error is wind resistance. This is negligible at low velocities, but when dropping an object from 5 meters, the overall times are probably longer than the theoretical value due to upward air resistance force and a decreased acceleration.

Our finding of a = $9.2m/s^2$ is similar to the expected value of $9.8m/s^2$. As mentioned above, our result is probably less than the expected value due in part to air resistance causing a decrease in acceleration as the ball moves faster when falling from greater heights. There could also be some random experimental error caused by unavoidable human factors, but it would be impossible to determine how that affected our results.

(there was no context given for this experiment)

Authenticity statement:
Copy and include the following statement
I, Daniel Bleckinger declare that this report is independently produced and is solely my own work.