The Effects Of Gravity On Acceleration

Research Question

When altering the release height of a golf ball with a constant initial velocity, will the relationship between the time of release and the time of impact to the ground be proportional and therefore verify the acceleration due to the force of gravity?

Rationale

The purpose of conducting this experiment was to determine how the acceleration due to the force of gravity affects the time taken for an object to fall. An experiment was conducted in class that measures the acceleration due to the force of gravity from various heights. It was expected that as the height increases it would form a linear relationship with the time taken, thus proving that the acceleration due to the force of gravity is constant.

It was expected that the data should reflect the theoretical relationship of g=GMR2

Where g is the acceleration due to gravity, G is the universal gravitational constant (9.8), M is the mass of the object and R is the distance (Study.com, 2019).

The Theoretical relationship was not supported by the data because the times were always less than predicted. One of the major errors identified in this experiment was the high factor of human error that was not taken into consideration. Research has revealed that the average human reaction speed is 248 milliseconds (Humanbenchmark.com, 2019).

As such, this experiment modifies the original experiment by redirecting it towards minimizing any errors in calculations. This will allow for a better relationship between the acceleration due to gravity and the time taken for each increment.

Method

Original Method

The original method records the times that a projectile will take to travel the different vertical differences.

Modifications

- Golf ball with a mass of 46gm was used as the projectile.
- A camera was used to decrease the error in timing the distance.
- The trail range was increased to 5 trials
- The heights were increased to range from 0.5 to 2.5 with a difference of 0.25 between each interval

Management of Risks

The most significant risk identified is the potential of the falling object causing injury. This risk was minimised by ensuring each examiner wore the appropriate closed footwear and avoiding the area where the ball is falling.

Results

Figure 1 - The values that are highlighted in black are classed as outliers due to them being 20% - 80% larger or smaller than the other 4 measurements. These outliers were calculated in the average and were graphed. With more time, these outliers would not be included in the calculations.

Sample Calculations

Mean for the 0.5m Height

a+b+c+d+e5

0.38+0.34+0.42+0.32+0.295

1.755

Absolute Uncertainty of the mean for the 0.5m Height

+ xMax - xMin2

+ 0.42 - 0.292

=+0.275

Percentage Uncertainty of the mean for the 0.5m Height

AUM100

0.2751.518 100

=18.12%

Figure 2 - The relationship between time average and the heigh. The uncertainty of the time and height were included in the form of error bars.

Figure 3 - The relationship between Height and Time ^2 is the closest to a linear relationship. Therefore the gradient will be used to find the acceleration due to gravity.

Using the graph in figure 3 we can use the gradient of the trend line to find the estimated force of gravity. Theoretically the force of gravity is 9.8m/s (Universe Today, 2019), therefore the expected calculations should be within 10% higher or lower.

To calculate the force of gravity in correlation with the data we need to consider that the gradient is equal to st2, this is then in turn equal to g2 , hence g = 2Gradient.

Calculations

Acceleration Due to Gravity’s Effect

2Gradient = Gravity

24.87 = G

9.74 m/s = G

Absolute error

Theoretical Force -Data Force =Absolute Error

9.8-9.74=AE

0.06=AE

Absolute Error Percentage

Absolute Error 100= Absolute Error Percentage

0.06 100 =AEP

6%

Analysis of Evidence

The theoretical plot of the data suggests the relationship is s?t2. s is the independent variable displacement which is directly proportional to t which is the dependent variable Time.

The data suggests that the relationship between time and height will be st2where s is the independent variable of displacement and t is the dependent variable of time.

Interpretation of Evidence

The aim of this investigation was to examine and verify the value of acceleration due to gravity on the earth's surface. The results showed that as the height increased from 0.5m to 2.5m the time increased from a minimum of 0.28 seconds to a maximum of 0.88 seconds or 1.2 seconds. As the height increased it is noticed that the time increased proportionally with the data.

The graph above shows the uncertainty of the measurements.

Evaluation of Experimental Process

Overall the measurements were relatively accurate. The percentage uncertainty of the experiment was over 15% for all heights. This suggests the precision of each individual measurement was high, however the calculations had significant errors.

The main error for this experiment was human error and wind resistance. This experiment was conducted in a classroom where it is impossible to control the environment. The air resistance, which added a force that was not accounted for in the initial theory. The aerodynamics of the golf ball make the air resistance minimal, however, there was still noticeable differences. The air resistance can not be manipulated into not affecting the data and therefore was ignored and any outliers were included within the data.

Human error was another big limitation in this experiment. When taking measurements of the dropping heights, aligning the ball correctly with the lines and timing the drop all involved the experimentees. There were steps taken to minimise these limitations including, the same person aligning the ball with the drop line, dropping the ball, filming and then timing. This however was ineffective of decreasing the error by a large amount.

It was assumed that the mass of the golf ball was 46g, however, with the use of different golf balls for two of the experiments, this has the possibility of increasing the time of vertical displacement. When dropping the golf ball, often times the ball was released in different ways and different trajectories. This changes the rotational inertia and therefore can change the projectile. Golf balls are also covered in little crates that can catch pockets of air and reduce the momentum further.

The Linear trend in Figure 3 which is relevant to the data: 4.87 which is the gradient of the line, should be 4.9. In the theoretical calculation 4.9 will equal the proven force of earth gravity; 9.8m/s. This change can be due to the limitations and errors listed above. The difference of 0.03 or 3% is a minimal error, however when calculating the error of the gravitational force, this error increased to 6%. This is error percentage can not be minimised unless this experiment is conducted in a perfect environment. This would be in a vacuum with no air resistance.

Conclusion

In conclusion, it is evident that the data suggests that the Time and Height are proportional. However, the exact mathematical nature of this relationship should have been 4.9. While the precision of the measurements was acceptable, the percentage error means it is not possible to justify this relationship with the data collected. Theoretically, the golf balls Dependent variable Time would dress evenly for each drop. However it was noticed that oftentimes there was extreme differences. Therefore, further investigations are recommended.