Lab Report #1: Motion with Constant Acceleration

Objective:
The experiment’s objective is to study the motion of an object with constant acceleration.

In this case, the objective is to study the motion of an object being accelerated only by the force of gravity.

Summary:
In this experiment a dynamics cart was set on a track with an incline angle of 3°. Timing paper from a tape timer was attached to the cart. The tape timer was set to 10Hz and turned on after making sure it had a carbon disk on. The cart was released and the tape timer was off after the cart had stopped. The process was repeated with inclines of 5° and 7°. Since the only force acting on the cart was gravity, then it must have had a constant acceleration due to gravity. The average acceleration of the cart for each incline was found by examining the dots in the timing paper. They were 0.46m/s², 0.69m/s², and 1.39m/s² respectively. These results represented experimental errors of 9.8%, 18.8%, and 16.8%. These errors might have been caused by an inconsistence in the actual inclines or by miscalculations when examining the timing papers.

Data:

<table>
<thead>
<tr>
<th>Elapsed Time t(s)</th>
<th>Displacement ∆x (m)</th>
<th>Time Interval ∆t (s)</th>
<th>Average Velocity Vavg=∆x/∆t(m/s)</th>
<th>Acceleration Aavg=∆v/∆t(m/s²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3°</td>
<td>5°</td>
<td>7°</td>
<td>3°</td>
</tr>
<tr>
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<td>0</td>
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<tr>
<td>1.40</td>
<td>.062</td>
<td>0.10 .03 .03</td>
<td>0.30</td>
<td>0.30</td>
</tr>
</tbody>
</table>
Calculations/Results:

Average Velocity = \frac{\text{final position - initial position}}{\text{final time - initial time}} = \frac{x_f - x_i}{t_f - t_i}

\begin{align*}
0.03\text{m} - 0.027\text{m} &= 0.03\text{m/s} \\
0.20\text{s} - 0.10\text{s} &= 0.10\text{s}
\end{align*}

\begin{align*}
\text{Acceleration} &= \frac{\Delta v}{\Delta t} \\
&= \frac{0.03\text{m/s}}{0.10\text{s}} = 0.3\text{m/s}^2
\end{align*}

Analysis Questions:
1. Make a plot of V_{avg} vs. t. Draw a best fit line.

![Average Velocity vs. Time](image)

2. What is the slope of the best fit line on the plot of V_{avg} vs. t? What does it represent?
   The slope of the line is 0.77. The line’s slope represents the cart’s acceleration. In other words it is the first derivative of the velocity. Since the curve is a straight line, then the acceleration must be constant.

3. Make a plot of A vs. \sin \theta and draw a best fit line through the data. Extend the best fit line so that it intersects the point at \sin \theta = 1.

![Acceleration vs. \sin \theta](image)

4. What is the general equation for acceleration on an inclined track as deduced from the plot?
Following the general format for the equation of a line $y=mx+b$ we deduced the equation to be $A=9.85\sin\theta+A_0$. In this equation, $A_0$ would represent an initial acceleration. Then, the fragment $9.85\sin\theta$ would represent the slope of the line multiplied by the independent variable $\sin\theta$.

5. **What is the slope of the best fit line for the plot of A vs. $\sin\theta$? What is the value for acceleration of A at $\sin\theta=1$. How are they related?**

As it was stated in the previous question, the slope of the best fit line would be 9.85. The value for acceleration at the point where $\sin\theta=1$ would be $9.85\text{m/s}^2$. This is an expected result for two reasons. One is that the worked-out formula $A=9.85\sin\theta+A_0$ would provide that result. Also, since the $\sin\theta=1$ when the incline is set $90^\circ$ above the horizontal, which means that acceleration would only be occurring vertically because of the force of gravity.

6. **The magnitude of the acceleration due to gravity is 9.8m/s². What is the % difference between this value and your experimentally determined value?**

$$E_{eq} = \left| \frac{\text{accepted value-calculated value}}{\text{accepted value}} \right| \times 100$$

$$\left| \frac{9.8\text{m/s}^2-9.85\text{m/s}^2}{9.8\text{m/s}^2} \right| \times 100 = 0.51\%$$

The experimental value for acceleration due to gravity would be 0.51% above the actual value of 9.8m/s²

**Conclusion:**
The experiment showed that the cart had a constant acceleration. This was shown by comparing the object's acceleration to the $\sin\theta$ (incline). At $\theta=3^\circ$ the acceleration was 0.46m/s² but at the point where $\theta=90^\circ$ the acceleration would be 9.85m/s². This means that if the cart had been dropped vertically, its acceleration should have been the acceleration due to gravity which was 0.51% below our result. If the cart was subject to acceleration due to gravity only, then its acceleration must have been constant at all times. Therefore the experiment was valid since it
allowed us to study the motion of an object with constant acceleration (which was the objective) and we only had an experimental error of 0.51%. I believe we could have improved our results only by making sure the angles of inclination were extremely accurate and by conducting more trials with different inclinations so that we could have more data.
Lab Report #2: Measuring Acceleration Due to Gravity

Objective: The experiment's objective was to determine acceleration due to gravity.

Summary:
In the experiment we found acceleration due to gravity by calculating the time it took for water drops to fall from a certain height. We placed a burette one meter above the ground by using a stand. Then, we poured 26 milliliters of water into the burette. We measured the time it took for ten drops of water to fall one meter into a metal pan. We used this information in order to find the time it took an individual drop of water to fall into the metal pan. We performed this process three times and then found the average acceleration (9.58 m/s²) by using the formula \( g = \frac{2h}{t^2} \), where \( h \) is height and \( t \) is time. We discovered our calculations to be 2.24% lower than the accepted value for acceleration due to gravity (9.8 m/s²).

Data:

<table>
<thead>
<tr>
<th></th>
<th>Elapsed Time for 10 drops(s)</th>
<th>Elapsed Time for 1 drop(s)</th>
<th>Distance from Burette to Pan (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.51</td>
<td>0.451</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>4.61</td>
<td>0.461</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>4.59</td>
<td>0.459</td>
<td>1</td>
</tr>
<tr>
<td>Avg</td>
<td>4.57</td>
<td>0.457</td>
<td>1</td>
</tr>
</tbody>
</table>

Calculations:
\[
g = \frac{2h}{t^2} = \frac{2(1m)}{(0.457s)^2} = 9.58 m/s^2
\]

Analysis Questions:

1. Determine the acceleration due to gravity for each of the sets of experimental data.

\[
g(0.451s) = \frac{2(1m)}{(0.451s)^2} = 9.83 m/s^2
\]
By comparing the accepted value of acceleration due to gravity to the value calculated in the experiment, we concluded the percent error of our calculation to be 2.24% below the accepted value.

4. Discuss possible reasons why your measured value for the acceleration due to gravity may not exactly agree with the accepted value.

As I mentioned in analysis question #2, there are three possible reasons for the experimental error. The first possible reason is that the pre-established distance of one meter above the ground could have been a little off. The next possible reason is that as the water pressure in the burette decreased, the rate at which the water drops fell also decreased resulting in a different falling rate for each drop. The final possible reason for the experimental error is that our recorded times were not as accurate as they should have been (0.45 second per drop).

Graphs:

![Acceleration vs. Time](image)

Conclusion:

The experiment's results showed that objects in free fall (water drops in this case) have an acceleration of 9.58m/s². In comparison to the actual value for acceleration due to gravity our resulting value is 2.24% below. On average the water drops fell at a rate of 0.457 seconds. According to the formula \(g = \frac{2h}{t^2}\) an object should take 0.452 seconds to fall one meter (in free fall motion). This means that we had an experimental error of 1.1% above the accepted value of
\[ g(0.461s) = 2(1m)/(0.461s)^2 = 9.41\text{m/s}^2 \]

\[ g(0.459s) = 2(1m)/(0.459s)^2 = 9.49\text{m/s}^2 \]

The acceleration due to gravity for the first set of data was 9.83m/s². This represents an experimental error of 0.31%. Acceleration for the second set of data was 9.41m/s² which is 3.98% below the accepted value. Acceleration for the last set of data was 9.49m/s². This represents a percent error of 3.16% compared to the acceleration due to gravity 9.8m/s².

2. Discuss why your three determinations of acceleration due to gravity may not exactly agree. What are possible errors?

Our determinations for the acceleration due to gravity according to the three sets of data may be different for a couple of reasons. First of all, the distance from the burette to the pan could have been a little more or a little less than one meter. Second, the pressure of water in the burette changed as drops fell. This caused the following drops to fall at a somewhat slower rate. Another error might have occurred when recording the time drops took to fall. Our calculations could be somewhat greater or smaller than the actual time it took for ten drops to fall one meter.

3. Determine the percent difference between the average of your measured value of the acceleration due to gravity and the accepted value of 9.8m/s².

\[
E_{\%} = \left| \frac{\text{accepted value} - \text{calculated value}}{\text{accepted value}} \right| \times 100
\]

\[
= \left| \frac{9.8\text{m/s}^2 - 9.58\text{m/s}^2}{9.8\text{m/s}^2} \right| \times 100 = 2.24\%
\]
time. Since our percentages for experimental error were very small, I would consider the experiment to be valid. Our results and calculations are very similar to the actual values of acceleration due to gravity and time, so I believe we could improve the results by maintaining the burette’s water at a constant level and conducting more trials.