**“Experiment 1: Uniform Acceleration”**

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**Experiment 1: Uniform Acceleration**

**Worksheet:**

**2. Plots**

Figure 1: Acceleration of a 3.0g Mass. A scatterplot of the velocity data over time for a 3.0g mass attached to a glider. The fit line (the purple dotted line) has slope 8.1102 which indicates the acceleration of the system is 8.1102

Figure 2: Acceleration of a 5.0g Mass. A scatterplot of the velocity data over time for a 5.0g mass attached to a glider. The fit line (the purple dotted line) has slope 13.699 which indicates the acceleration of the system is 13.699

Figure 3: Acceleration of a 20.0g Mass. A scatterplot of the velocity data over time for a 20.0g mass attached to a glider. The fit line (the purple dotted line) has slope 53.881 which indicates the acceleration of the system is 53.881

Figure 4: Acceleration of a 25.0g Mass. A scatterplot of the velocity data over time for a 25.0g mass attached to a glider. The fit line (the purple dotted line) has slope 62.391 which indicates the acceleration of the system is 62.391 .

Figure 5: Acceleration of a 36.0g Mass. A scatterplot of the velocity data points over time for a 36.0g mass attached to a glider. The fit line (the purple dotted line) has slope 96.345 which indicates the acceleration of the system is 96.345.

**3. Data Table**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Trial | Hanging Mass  (g) | Glider Mass  (g) | Fit Acceleration  () | Predicted Acceleration  () |
| 1 | 3.0 ± 0.5 | 389.0 ± 0.5 | 8.11 ± 0.04 | 7.5 ± 0.3 |
| 2 | 5.0 ± 0.5 | 389.0 ± 0.5 | 13.70 ± 0.05 | 12.4 ± 0.4 |
| 3 | 20.0 ± 0.5 | 389.0 ± 0.5 | 53.8 ± 0.3 | 47.9 ± 0.9 |
| 4 | 25.0 ± 0.5 | 389.0 ± 0.5 | 62 ± 2 | 59 ± 4 |
| 5 | 36.0 ± 0.5 | 389.0 ± 0.5 | 96 ± 1 | 83 ± 2 |

Table 1: Comparison of Fit vs. Measured Accelerations. The predicted and fit accelerations from each trial. Note that the fit acceleration is the slope of the fit line from Figures 1-5 and the predicted acceleration was found using Equation 1.1 and the measured values for the mass of the weight and glider.

**4. Derivations**

**Equation 1.1:**

Where:

m = the mass of the weight suspended

M = the mass of the glider

g = the acceleration due to gravity (9.79 )

a = the acceleration of the system

We derive this equation by using Newton’s second law:

Therefore, the sum of all forces on the mass suspended in the y-direction is:

and the sum of all forces on the glider in the x-direction is:

We substitute the second equation into the first to get:

**Propagating Uncertainties:**

To find we take in to account the various operations undergone in Equation 1.1:

Notice that multiplication, division and addition are all undergone. The uncertainty calculations of these operations are combined to find an equation for the uncertainty of like so:

We know the methods for deriving the uncertainties of these calculations:

**Addition/Subtraction**

Take, for example:

x+y =z

can be expressed as:

**Division/Multiplication**

Take, for example:

x/y =z

can be expressed as:

We combine the appropriate knowns to derive the equation for the uncertainty of any *a* found from Equation 1.1:

Where is 9.7955 and is 0.0003

**5.Conclusions**

|  |  |
| --- | --- |
| Trial | Percent Error |
| 1 | 8.1% |
| 2 | 10.2% |
| 3 | 12.3% |
| 4 | 5.1% |
| 5 | 15.7% |

Table 2: Percent errors for the measured acceleration vs the expected acceleration. Percent errors were calculated using the non-trunicated acceleration data from Table 1.

The errors in Table 2 were calculated using the data from Table 1 regarding the measured acceleration and the predicted acceleration. The average percent error for all the trials was 10.3%. This is a desirable, but not excellent result. The results were found to be precise but not accurate. Some degree of error was expected because of the simplifications and assumptions taken during the experiment. For example, neither the mass of the pulley or the string nor air resistance were taken into account. It was also observed during the experiment that, though calibration was performed, the glider did still slightly move on its own towards the end with the pulley when not attached which implied the track was not entirely level. Though the discrepancies were not large, all of the predicted values were lower than the expected values. This implies that the relative crookedness of the track may have increased the measured acceleration. This implies a systematic uncertainty from the imperfect equipment. However, this effect did not entirely discredit the results as shown by the percent errors and, overall, the results were satisfactory for the purposes of this experiment.

**6. Extra Credit**

Figure 6: Acceleration of a 3.0g Mass. Using data from trial 1, this scatterplot of the instantaneous acceleration data points over time for a 3.0g mass attached to a glider. The fit line shows the approximation of the average of the points.

The mean of the acceleration data points was found to be 8.247 cm/s2 and the standard deviation for the data points was found to be 1.572 cm/s2. Therefore, the measured acceleration found using this method is 8 ± 2 cm/s2. This value is accurate but not precise at all. Comparing this to the data measured for the 3.0g mass using the first method in Table 1, 8.11 ± 0.04 cm/s2, we see that the first method had much less uncertainty. Therefore, since the first method is much more precise while being close to accurate, that is the best method to use. The high degree of noise seen in Figure 6 is consistent the high degree of uncertainty calculated. This second method of averaging the instantaneous accelerations is valid but, because of the poor precision, is just not as accurate as our first method.

**Presentation Mini-Report:**

**Transverse Waves that Drive Atrial Blood Flow and Pulse Pressure Amplification.**

Heart attacks and strokes, both primarily caused by atherosclerosis, are the leading causes of death in the United States. Together, they account for more deaths than all other causes combined1. As a result, the study of the development and progression of atherosclerosis and, by extension, the arterial diseases it causes is an important topic in many disciplines of research.

Atherosclerosis, which is the stiffening of the blood vessels, is the culprit behind most kinds of heart diseases and strokes. Blood vessels naturally have a degree of elasticity that regulates blood pressure and prevents clots. However, with age and poor lifestyle choices, the hardening of the blood vessels begins. Hypertension and high cholesterol levels are both causes and markers of atherosclerosis2.

In certain types of high blood pressure such as with isolated systolic hypertension, it is relevant to study the pulsatility, or the distribution and propagation of blood waves in the arteries rather than the standard blood pressure1. Blood pressure is a periodically oscillating wave that travels from the heart to outlying arteries. Instead of focusing on the pressure itself, we can instead study the wave created by it. The phenomenon of pulse pressure wave amplification is how these waves maintain their rhythm and normal pressure3. Given data about the change in the pressure wave refraction of the waves in a certain vessel, the stiffening can be quantified and targeted. However, this data can be a tricky to extract non-invasively, as many vessels in the body are inaccessible and you need both the peripheral and central blood pressure in order to extract the pulse pressure amplification. Additionally, there is still more research needed regarding what would be considered a “normal” value for pulse pressure amplification from various arteries.

Using the pulse pressure amplification, a medical professional can identify a case of hypertension that is caused by high intensity blood waves rather than solely high blood pressure, such as is the case with isolated systolic hypertension. This is advantageous because they then can prescribe drugs that will target this specific problem1. Certain hypertension drugs have been shown to reduce the pressure wave reflections and therefore reduce the intensity of the wave.

When a more targeted diagnosis is made, a more target treatment can be formulated. However, as mentioned earlier, though it is known that a measurement of the pulse pressure amplification can be useful, methods for extracting the central blood pressure and peripheral blood pressure, both of which are needed to calculate the amplification, are still in development. Calibration issues and invasiveness are the current hurdles needed to be overcome at a clinical level. Essentially, most of the theory-based research has been performed for this topic but extensive clinical research is still needed for the knowledge to be put to use.

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