Lab 1

Uncertainties in Measurements:

The Ping Pong Ball

Experiment done by: Ameera Syed

Partner: Holly Rybarik

Results:

A table of numbers

Description automatically generatedA graph of a number of blue bars

Description automatically generated with medium confidence

There is great variety within the test cases taking place. This may be a result of the angle at which the meter was held, whether the ping pong was exactly at the top of the meter, inaccurate start and stop times for the stopwatch, inaccurate readings, systematic errors and many other reasonings. The average time between the first and second bounce of the ping pong ball resulted in being approximately 0.7403 seconds, or 74.03 x 10^2 seconds. Using this, we were able to determine the difference between each trial from the mean. The sum of those errors resulted in approximately 0 seconds. To calculate the sample standard deviation, or the typical number of seconds for which the ping pong balls deviated from the mean, we squared the result of our errors, as seen in the final column of our test cases. The summation resulted in approximately 789 hundredths of a second squared, which was then taken the square root of and divided by 29 in order to calculate the sample standard deviation of 0.95 hundredths of a second.

Conclusions

In conclusion, considering that the experiment may have been biased or flaw due to errors during trial, with the test results, we are able to find that the uncertainty of the number of seconds between the first and second bounce is 74.03 +- 0.95 hundredths of a second.

Lab 3

An Object in Free Fall

Experiment done by: Ameera Syed

Partners: Holly Rybarik and Jonathan Burroughs

Results:

A table of numbers with green border

Description automatically generatedA graph of a person and person

Description automatically generated with medium confidence

The results show a curved position graph, indicating that the object is accelerating and it’s velocity increases over time. This is also seen in the velocity graph, representing a linear line that shows that the acceleration of the object is constant and that the velocity is increasing. The graphs did not follow the trendline 100%. This may be due to errors in determining the position of each dot, systematic errors, inaccuracy, and also chance itself, as the sample will not 100% represent the expected linear line. The trendline itself represents the line that best fits the data.

Conclusions:

In summary, the motion of the object begins at -2.3162 cm and after 23/60 seconds later, the object falls to 136 cm. y(t) = -2.3162 + 2.5084t + 0.1358t^2. Based on this equation, the acceleration is 0.2716 cm/3600s^2, or 977.76 cm/s^2. v(t) = 128.3 + 12.482t. According to this equation, the acceleration of the object is 748.92 cm/s. Based on the velocity graph, the graph represents more of a constant acceleration, like gravity, making it the better representation of acceleration.

Lab 5

Propagation of Uncertainties:

The Pendulum

Experiment done by: Ameera Syed

Partners: Holly Rybarik and Jonathan Burroughs

Introduction and Abstraction

This lab focuses on the idea that uncertainties in measured quantities can be used to calculate actual quantities that correlate or are in relation with the measured values. By calculating the uncertainty, it is possible to reverse calculate and then calculate the expected value using the experimental value and uncertainty. The experiment focuses on finding the value of constant acceleration towards the earth, being 9.8 meters per second. By taking in several trials of measurements, we can determine the error within the individual measurements and then use it to find the error in our calculated downward acceleration. By using the measurements and their averages, we can calculate the experimental gravity and then find the error from the measurements and their standard deviation to see how we deviated from the actual g value of 9.8 meters/second.

Random and systematic errors tend to affect the uncertainties of measured quantities. By calculating the uncertainties, we can determine how much the actual measurement varies from the measurements recorded. Through this, hypothetically, tracing back and finding the expected measurements should be possible. In this experiment, the errors resulting from systematic and random errors are minimized through repetitive trials and calculations of the length, radius, time, and many other variables in the lab. Through this, a variety of data was obtained, allowing it to be used to calculate averages, including an uncertainty from the actual measurements of the length and time. Although errors, such as random and systematic error cannot be removed completely; by repeating the experiment several times, this is minimized and the data points can be calculated to find the mean values and the standard deviation, therefore calculating the uncertainty. The calculations in our experiment varied from the mean to the standard deviation. With this, the uncertainty in the experiment would be the mean + or – the standard deviation, creating an uncertainty of 2\* standard deviation. This value determines the range of values ranging from 1 standard deviation on each side of the averages. Using this, an experimental g value can be calculated, using the average length, average period time, and the uncertainties of each.

The length of the string was calculated by measuring it from the top of the pendulum to the top of the ball. The radius of the ball was then added to this length to find the length of the pendulum. This is repeated 5 times to remove systematic errors and random errors. Although it will not completely remove these errors, it will minimize it. The length of the pendulum will then be the average of the 5 measurements. The ball will then be held at a constant angle and released 5 times as well, recording the time it takes for 20 complete oscillations. The angle will not be the same each time, which may result in systematic errors, however, by repeating the experiment 5 times and then finding the average of the time it takes to complete a period, this error will not influence the outcome greatly.

The actual T value, or time it takes for 1 period will then be the average of the time + or – the standard deviation of the 5 t values. This is also used to find a better-expected length or L of the pendulum. The experimental acceleration of the pendulum can then be calculated using 4pi^2(length)/(T^2). This equation was derived by rewriting the equation period= 2pi \* sqrt(length/g). Upon finding g experimental, we can find the uncertainty in g by substituting g, L, the uncertainty of L, T, and the uncertainty of T. The equation for this is the uncertainty of g = g \* (the uncertainty of L divided by L + 2 \*the uncertainty of T divided by T). This equation indicates the relations between the relative uncertainty in g as the sum of the relative uncertainty in length and double that of T. T is doubled because it is squared in the equation to derive g.

Experimental Technique

The experiment was conducted by taking 5 measurements of the length of the string, using different people and different meter sticks, or a combination of the 2 to minimize systematic errors. This was also done to measure the length of the radius of the ball. The ball was then held at an angle, 10 degrees to the left of the middle of the pendulum which stood at 90 degrees. The ball was released at an angle of 80 degrees and then was left to complete 20 full oscillations back and forth while being timed. This was done 5 times and recorded each time. The data collected was placed in Excel to keep organized. The time to calculate 1 period was then calculated by finding the average number of seconds to complete 1 oscillation. The experiment also included finding the average of the total length, consisting of the length of the string and the radius of the ball. Upon finding the averages of the total length and the time of 1 period, the standard deviation of all data points was found. The upper and lower uncertainties of these 2 variables were also calculated by adding or subtracting the standard deviation by each variable. Upon finding this, the total uncertainty of both variables was found by subtracting the upper uncertainty from the lower uncertainty. These values were then used to approximate g and then calculate the uncertainty of g as well.

Results

A screenshot of a graph

Description automatically generated

Excel shows the 5 trials and lengths of the string and radius of the ball, along with the time in seconds for the 20 oscillations and the time for 1 period. The time for a period was calculated by finding the average seconds, therefore dividing the time for 20 oscillations by 20. 5 trials were done for each to minimize systematic errors. Along with several trials, the conductor of the experiment was switched out each trial and the tools used were as well. In the case of a ruler having a bent end, the meter sticks were switched throughout the trials to account for this. Although these considerations minimize systematic errors, random errors may still occur, and human error, including misreading and incorrection representations of the correct measurement. For example, the timing to stop the stopwatch may be off due to an error and the measurement of the string and radius may be as well as we had to estimate the measurement to the closest hundredths place. The standard deviation is used to see how far each data point typically deviates from the average. The uncertainty is double the standard deviation. This is because the standard deviation shows from both positive and negative sides of the average, meaning, 1 standard deviation to the right of the average is found by adding it on. To find the value 1 standard deviation to the left of the average, it is subtracted from the average. This is then inputted into the equations listed before calculating the g experiment and the uncertainty of g. Our calculations did not include the accurate evaluation of g being 9.8 when adding the uncertainty of g to g, however, this is due to underestimating the uncertainty. This was accounted for by reevaluating the value of g by multiplying it by (1 + 0.25sin^2((theta2)^2)). This uses the first-order correction term to then account for the error.

Conclusions

In conclusion, uncertainties in measurement can be used to find the uncertainty in calculations which can then be used to approximate the acceleration of gravity of 9.8 m/s. Random and systematic errors impact uncertainties, however, these uncertainties are usually unmeasurable. This experiment focused on finding the uncertainties to then calculate acceleration with it. Although the initial calculation of g was inaccurate, accounting for underestimation fixed the calculation by reevaluating g and accounting for the error. Upon recalculating g, the actual value of g was within the accepted range of values.

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Description automatically generated

Lab 6

Friction

Experiment done by: Ameera Syed

Partners: Holly Rybarik and Jonathan Burroughs

ResultsA table of numbers and symbols

Description automatically generated

A graph with a line

Description automatically generated

The graph of μk vs average speed shows that the coefficient of kinetic friction depends on the object's speed. This is proven by looking at the graph and seeing that as the average speed increases, the coefficient of kinetic friction decreases, resulting in acceleration increasing and the object slowing down less. The coefficient of kinetic friction was calculated using the formula (m1g)-(m1a)-(Ma) where a is acceleration, m1 is the mass in grams of the weights and the holder, M is the mass in grams of the sled, and g is 9.8 m/s^2. The acceleration used in the formula was obtained by solving for acceleration using the distances and time for the timers. This is done by using the formula a = (sqrt(2x1)- sqrt(2x2))^2/ (t2-t1)^2. By rewriting the original equations x = .5at^2, we were able to solve for a. Acceleration was found by using the pulley using different weights and seeing how they impacted friction from preventing the object from moving.

Conclusions

In conclusion, the coefficient of kinetic friction is impacted by acceleration and therefore also impacted by the object’s speed. As the object’s speed increased, the coefficient of kinetic friction decreased, allowing the object to accelerate more.

Lab 7

Air Resistance

By: Ameera Syed

Partners: Holly Rybarik and Jonathon Burroughs

Results

A screenshot of a computer

Description automatically generated

5 trials of dropping the paper with paper clips is dropped for each clip added. The picture displays the trials for 0-2 paper clips, however, there are more trials beneath. There is a summary of the experiment on the right side of the excel graph in which time, velocity, the drag force, and the natural log of the velocity and drag force are calculated. The calculations of time may differ from the actual value due to human error when stopping and starting the stop watch. In consideration of this, there were several data trials taken in order to use the average as time, rather than relying on a single trial. With this, the error resulting from systematic and human error is minimized but not completely removed. With this in consideration, an approximation can be used to calculate and approximate k value. The average velocity was found by dividing the position by the average time. The position of all these trials remained 2 meters and therefore, the velocity was calculated by dividing 2 by the time. The drag force was calculated by multiplying the mass by g, 9.8 meters/second. Mass was calculated by adding the weight of the paper along with each paper clip’s mass. Drag force is seen increasing as a result of adding more mass as well. To find k, a graph was created, showing the linear relationship between the natural log of the drag force and the natural log of the velocity. The slope of these graph represents how velocity impacts the drag force and the intercept is used to find k. Upon finding the intercept, k is calculated by finding e^ intercept and the k value is found in (N \* s^n)/m^n where n is the number of paper clips.

Conclusions

The results of the graph show that the intercept represents a turbulent flow. The graph appears to be linear which shows that this is best represented using an exponential graph and the value of k can be interpreted as 13.17868 (N\*s^n)/(m^n).

Lab 8

Conservation of Mechanical Energy

By: Ameera Syed

Partners: Holly Rybarik and Jonathon Burroughs

Results

A screenshot of a graph

Description automatically generated

A graph with different colored lines

Description automatically generated

Based on the data and the graph shown, adding kinetic energy and potential energy results in a constant E. The graph and data is not exactly constant, and this is because of systematic errors and miscalculations when measuring the height of the block and the balance. Small errors in measurements such as the one listed above impact the data and results shown. Errors in measurements may also impact the x position in which timing was calculated, along with the alignment of the photogate timer. As a result, the data may be slightly skewed or inaccurate. The graph shows that as kinetic energy increases, potential energy decreases by approximately the same rate. As a result of this, mechanical energy does not change unless force acts upon it, such as friction. In this case, the blower and glider creates an environment for which friction is minimized, making its impact to be assumed as 0. Kinetic energy was found by using the equation .5mv^2 in which velocity was calculated by the width of the flag by the amount of seconds it took to pass the photogate timer. Potential energy was calculated by multiplying the max by g, 9.8 m/s^2 and then multiplying that by y. Y in this case is the h riser, or the height of the riser block and then divided by the x position at which each timestamp was taken.

Conclusions

In conclusion, when friction is essentially 0 and there is no extra force upon an object, the conservation of mechanical energy is the same at any point. This is proven by the data and the graph in which mechanical energy of the object remains the same because as kinetic energy increases, potential energy decreases and vice versa. This is only applicable when all nonconservative forces are neglectable. Although the graph does not represent a completely constant mechanical energy, it is relatively constant and the differences in values are due to errors, rather than the actual experimental values.

Lab 9

Momentum and Energy in Collisions

By: Ameera Syed

Partners: Holly Rybarik and Jonathon Burroughs

Results

A screenshot of a computer

Description automatically generated

Unfortunately, due to time, several trials with different masses were uncalculatable. As a result, the data that was obtained may be likelier to cause errors and is likelier to be inconsistent. The data obtained shows a vast difference in data, however, the velocities of all data stay relevantly consistent. Time is a little bit inconsistent, impacting the momentum of the gliders. This may be due to the starting and ending time of the stopwatch. As a result of this, the time is inconsistent and not as accurately portrayed. Errors may also have occurred by accidental tampering with the air flow of the machine, along with moving of the photogate and of the starting position. Although the photogate remained approximately in the same spot, along with the starting position, small changes may have impacted the results. Momentum and velocity were calculated prior to and after the collision, for both elastic and inelastic conditions. Elastic conditions show results that represent momentum and kinetic energy being conserved. The inelastic conditions show that momentum is conserved, however, kinetic energy is not because the combined mass typically impacts the velocity in a negative way. Unfortunately, the data in this lab did not represent the expected velocities and results. This is due to errors in the experiment, such as air flow change from 2 to 5 and from the rubber band being switched out part way through the experiment. The experiment was meant to show consistent momentum for both results. The results, however, are semi consistent. The results were also meant to show that elastic conditions result in faster velocity, however, this was not the case as the air flow being changed part way through the experiment allowed the inelastic conditions to move at a faster speed. The air flow was changed partially through as the current settings did not allow for enough movement, preventing the gliders from colliding at all. The velocity for both tests are semi consistent with each trial though, as a result, P for both is also relatively consistent. Changes were calculated by subtracting the final momentum by the initial moment. Velocity was calculated using the photogate and dividing the width of the flag by the time. Kinetic energy was not calculated, however, knowing that kinetic energy is dependent on velocity, the kinetic energy would have shown that inelastic collisions had a higher kinetic energy. This is due to the errors and should not have happened. Changes in momentum are not zero, however, they are relatively around it.

Conclusion

The results are semi consistent considering the data, however, the inelastic collision ended up having a greater velocity which should not have happened. This is due to errors in the experiment and changes part way through. Friction should have impacted the speed of the objects. Friction did impact these objects, however, the results do not represent them well as the change in air flow allows the data to appear as though inelastic conditions were faster. If both collisions occurred at the same air flow setting, the elastic conditions would have represented the data with velocity being faster, however, because this was not the case, the inelastic conditions represent a faster velocity. With the 2 gliders at the same air flow setting for both inelastic and elastic conditions, the inelastic conditions prevented any movement of the gliders, showing that the velocity was meant to be slower if conditions were kept consistent. With errors in mind, the results are not consistent with what the data should have shown, however, this is with the knowledge that the inelastic collision was unrecordable at the setting the air flow was at. At the same setting of 2 for the air flow, the velocity of the inelastic collisions was approximately 0, preventing them from colliding.

Lab 10

The Ballistic Pendulum

By: Ameera Syed

Partners: Holly Rybarik and Jonathon Burroughs

Results

A table with numbers and symbols

Description automatically generated

The experiment was used to calculate the velocity of A, the steel ball. This was found by finding the final velocity of the pendulum and steel ball combined and then solving for the velocity of A. The equation is was used to find this. The conversation of momentum states that . Using these equations, the velocity of A was found. The equation represented potential energy and was set equal to the loss in kinetic energy, . Kinetic energy was portrayed using this equation but was also represented using . By setting the 2 equal, the final velocity of the 2 masses combined was found. In the equations, h is represented by , in which L is the distance from the axis of rotation of the pendulum to its center of mass. H represents the distance the pendulum moved away upon firing the steel ball. L was calculated to be 0.29 meters, was found to be 67 grams and was found to be 240.8 grams. The total mass is 307.8 grams. The height was calculated for each trial and then the average height was used to calculate the final velocity in the equation. The final velocity was calculated as 0.52 meters/second after rewriting the equations. The velocity of the steel ball was then calculated using the conservation of momentum, . By substituting the final velocity and the masses of each, and combined, the velocity of A can be found by treating the velocity of the pendulum as 0. Velocities were calculated for all trials and the average velocity of the steel ball was found to be 2.3 meters per second. The average standard deviation in was found using Excel as 0.55 meters per second. The calculations of velocity and height may differ from the actual value due to errors in calculating the length of the pendulum from the center of its mass. Errors may also have occurred by preventing the majority of the lab from remaining constant. Small errors include accidentally having the steel ball fully into the further zone rather than the short distance one. Although this should not impact the data, it may lead to some errors due to inconsistency. There were several trials done of this experiment to prevent errors from occurring and several remeasurements and weighing of the masses to ensure the least number of errors. However, because this is an experiment, errors are still susceptible due to systematic errors in the weighing machine, problems with the pendulum, and zeroing the machines used. Some of the measuring errors were limited by using different rulers and rechecking the measurements, however, it does not completely remove all possibilities of errors.

Conclusion

In conclusion, angular equations can be used to solve for variables in linear collisions. Although the two are different, they are related to one another through a series of formulas and conversions and can be used to calculate variables in either type of motion. In the case of this experiment, the moment of inertial and the angular velocity can be used to help rewrite equations to solve for the linear motion velocity of A, the steel ball. By combining the moment of inertial, the rotational kinetic energy, and the angular momentum, the equations can be used to calculate linear momentum and velocity due to the conservation of moment and energy. Linear and angular quantities are related to one another, allowing them to be used to find different values in each motion.

Lab 11

Measuring Diameter and Uncertainty

By: Ameera Syed

Partners: Holly Rybarik and Jonathon Burroughs

Abstract

This experiment focuses on finding the diameter and uncertainty of the diameter of a hidden cylinder in a block. 2 blocks are given, of the same material. The blocks are made of 4 layers and in 1 of the blocks is a 2-layer hole in the shape of a cylinder. The experiment focuses on finding the diameter of this hole and is done so by using density and other measurements of the 2 blocks.

Introduction

The experiment doesn’t come with a procedure and therefore, the experiment consisted of creating a procedure to find the diameter. To find the diameter, the mass of both blocks were found, along with the volume of the blocks. The container with the blocks consisted of a block A and a block B, both with H2 written on the blocks. Measurements are taken regarding the mass, length, width, and height. The volume is then found by multiplying the measurements found for width, height, and length. This was done for each of the 2 blocks, 2 times for the 2 trials. The experiment consists of 2 trials, which is done in order to calculate the uncertainty of the diameter. Upon finding the volume of block A, the full block, the density was calculated by dividing the mass by volume. The 2 blocks are the same material, therefore, the density for the 2 blocks are equivalent to one another. The volume of block b can not be measured due to the invisibility of the cylinder. However, the volume of the block can be found by using the density formula. Since the 2 blocks have the same density, block B’s mass can be used to find the total volume of block B. The formula for density is mass/volume and it can be rewritten to solve for volume as mass/density. The volume can then be used to solve for the diameter by using the formula of a cylinder. The formula of the volume of a cylindrical surface is V= πr^2h and can then be rewritten to solve for radius as r = . The radius can then be doubled to find the diameter of the hidden hole. The height can be found by dividing the height of the block by 2. This is because of the hidden cylindrical hole takes up 2 layers of the block. The block consists of 4 layers, therefore, the cylindrical hole’s height covers half of the block’s height. The experiment is concerned with finding diameter of the cylindrical hole in block 2. It is also concerned regarding being able to create and follow a procedure. In the experiment, the following procedure was established.

The height of block A, the width, and the length are to be measured 2 times. This is done to allow for 2 trials. Several measurements of the same measurement will not take place to remove errors, however, taking more trials allows the experiment to find the uncertainty which may account for errors. The mass of block A is also measured and then the density of block A is calculated by finding the volume of the block. In trial 1, the same process is done for block B. Block B’s height, width, and length are calculated. The true volume of block B can’t be measured due to the missing cylinder. However, the volume, when considering the missing cylinder as part of the volume is calculated. This is done by multiplying the height, width, and length of the block. The true volume is then calculated using the density. As stated earlier, because the 2 blocks are made of the same material, they have the same density. Using the mass of black b, upon measuring it, the volume can be solved for. This is again, done by dividing the mass by the density. The volume of the cylindrical hole is then the volume of the block, calculated using length, width, and height, subtracted by the volume of block B using density. This is because, the volume using length, width, and height accounts for if the cylindrical hole was part of the block, impacting the mass. The density calculated volume calculates the actual volume of the block which can be used to find the missing volume. After finding the volume of the cylindrical hole, the radius of hole can be solved for, using h with the formula stated earlier. Using the radius calculated, diameter can be found and then the uncertainty of this diameter can be calculated by finding the difference in diameters between the 2 trials. The difference is then divided by 2 to find the actual uncertainty.

Experimental Technique

The experiment consisted of 2 blocks regarding the same material but different masses, height, width, and length. The blocks were made of 4 layers and 1 block was completely solid, while the other block had a cylindrical hole with a height of 2 layers. To find the diameter of the missing hole of the block, the volumes of both blocks were found, along with the density using mass. The missing part’s volume was then calculated using the formulas and procedures listed above. After finding the volume, radius was then calculated and then doubled to find the diameter. 2 trials of this was taken in order to find the difference in diameters, which was then used to calculate the uncertainty by finding the difference and dividing it by 2.

Results

A math equations on a white background

Description automatically generatedA math formula with numbers and symbols

Description automatically generated with medium confidence

A screenshot of a math problem

Description automatically generatedA screenshot of a math problem

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Description automatically generated

The images above summarize the data collected. In each trial, the components of volume were calculated for each block using the formulas listed prior. Density = mass/volume, volume = mass/density or height \* width \* length. The 2nd equation of volume was used to calculate the volume of block A and the density version was used to calculate the volume of block B. The volume of the missing cylinder was then calculated by finding the difference between the expected volume of block B and the actual volume of block B. This is shown as 8.09 - 6.487 inches^3. 8.09 represents the expected volume of block B, found by multiplying the height, width, and length and the 6.487 in trial 2 is the volume calculated using density and mass. Experimental errors in the experiment include inaccurate measurements. This can be seen by looking at the trials themselves as the measurements were different. Another example of an error in the experiment includes improper equipment. This includes inaccurate markings on the ruler and an uneven block. For example, the block is not perfectly straight, it holds small curves and dents, as a result, the measurements may be slightly off, leading to inaccurate approximations. Calculator approximations may also lead to errors as they may lead to a greater approximation, leading to a bigger error. This can be represented by the number of decimal points at which calculations were rounded at. The weighing machine may also have been improperly calibrated. The reading for block A for the 2 trials produced slightly different masses. As a result, the density was slightly different and therefore the volume and diameter as well. Although this may not be a significant difference, it represents that small errors such as the mass reading do occur, impacting the data. The hole in the center may also not be perfectly symmetrical, along with the blocks themselves. As a result, the measurements may be slightly skewed in their representation of the approximations. Even with slight differences in measurements, the difference in diameter between the 2 trials was calculated as 0.008 inches. This shows that even with the smallest differences in measurements, the calculation to find diameter may still be impacted. As a result, the uncertainty is approximately 0.004 inches in diameter. However, even with this uncertainty, it is unknown whether the actual diameter of the cylindrical hole is within bounded of the expected diameter. This is because there are only 2 trials, leaving bigger room for errors and miscalculations and measurements. Errors in using the wrong numbers may also impact this and sign changes when using the calculator. As a result, the approximated values can not be certain to the actual diameter of the cylindrical hole but may be relatively close.

Conclusions

In conclusion, the diameter of the cylindrical hole may not be accurate due to errors, however, the diameter of the hole was calculated as 2.065 inches in trial 1 and 2.073 inches in trial 2. The difference between the 2 diameters is 0.008 inches, resulting in an uncertainty of 0.004 inches. Diameter of the hidden cylinder was found using volume and density because the 2 blocks were of the same material. Therefore, if mass, and density are known, volume can be found, even when the part to calculate volume for is missing or unmeasurable. This is because surrounding measurements and rewritten equations can be used to solve for the missing and hidden portion.

Lab 12

Simple Harmonic Motion

By: Ameera Syed

Partners: Holly Rybarik and Jonathon Burroughs

Results

A screenshot of a graph

Description automatically generated

Errors in this lab include systematic and random errors. Reaction time in starting and stopping the stopwatch may lead to incorrect readings of the period and measurements. Incorrect readings of the starting position and location of the cart for each weight measured may also impact the data. The number of oscillations counted may be incorrect. As there is a great number to keep track of, a few oscillations may have been misrepresented. Equipment may also lead to errors as friction and resistance may play part in changing the period and timings for each oscillation. This may be due to the setting at which the machine was set on not being strong enough to move the cart with added weight or may be due to complications in the machine itself. The spring acting with non-ideal behavior or stretching more or less than it should be impacts the distance at which the cart is pulled, impacting the time for each oscillation as well. This means that the experiment wasn’t completely elastic. Incorrect weight additions may also have impacted the measurements and data collected, along with the weights added not being the actual weight listed. The distance the cart was pulled away, prior to release may also impact the time because moving the cart too far or too little may impact the affect of a pendulum. Inconsistent readings and trials also play a part in this because the distance the cart is pulled away may be slightly different each time.

The results were obtained by placing the cart in the middle, attached with 2 springs, one on each side. The machine was then turned on, after releasing the cart upon pulling it a few centimeters. This movement then causes the cart to oscillate back and forth, moving a few centimeters away from equilibrium on both sides. The cart was time upon release until 50 oscillations occurred. The time that it took to complete the total number of oscillations was then divided by 50, the number of oscillations, to give the period T. The equation for period is in which m is mass and k is the force constant. Upon finding the period by dividing the time by the number of oscillations, the value can be substituted into this equation to solve for k. The mass of the air cart changes as more mass is added, however, so does the period. This means that k will not change and can be calculated using any of the measured trials. The equation F = -kx, Hooke’s law was also used. The mass action upon a force obeys this law, in which it oscillates and forth with a frequency determined by mass and the force constant. The graph of F vs x determines the force constant k. F is the weight, mass \* 9.8 meters/second suspended from the pulley. X in the equation is the distance the weight moves the air cart from the center. The slope of this graph is the force constant. The period can be found using this slope using the equation from before. Squaring T will allow the 2 k values to be compared and to see if they were the same or not. The x intercept of this graph is -b/m, where b is the y intercept and m is the slope of the graph T^2 v mass.

Finding the k values for both set ups result in consistent k values, however, the 2 k values themselves are drastically different. The k value using Hooke’s law was found by dividing the force, mg, by delta x. Delta x is the difference in x values from the equilibrium position, 0.987 meters to the x value the weight drags the cart to. This resulted in a k value of approximately 3.1 N/m. Solving for k using the T values, the k value is approximately 1.4 N/m. The x intercept in the graph T^2 vs m is 2.604/0.3272 which is approximately 8 grams. Regarding this value, the mass of the 2 springs combined is 24 grams. This makes relative sense and is close to the expected value of the 2 springs mass.

Conclusions

In conclusion, hanger motion and simple harmonic motions result in different k values, however, by doing the procedure correctly, a consistent k value should be found, not changing for any trials. The k value remains constant, or at least relatively constant for each type of test, ensuring that it indeed does not change and only impacts values such as the period if mass changes and impacts force only if mass changes as, it will impact the change in x values. The simple harmonic motion set up resulted in a k value of approximately 1.4 N/m and the hanger motion resulted in a k value relatively close to 3.1 N/m. These k values were found by rewriting the equations show above to solve for k.

Lab 14

Heat Transfer by Radiation

By: Ameera Syed

Partners: Holly Rybarik & Jonathon Burroughs

Results

A white sheet with black lines and numbers

Description automatically generated with medium confidence

Equations:

Stefan’s law – . σ is a constant known as the Stefan-Boltzmann constant, which has a value of **5.67 x 10-8 Wm-2K-4**. “e” is the emissivity of the objects and determines the efficiency of radiation of power from a real object compared to an ideal blackbody radiator. An Ideal blackbody radiator has an e-value of 1 and a real radiator will have one between 0 and 1. The emissivity depends on the material the surface preparation, and a little bit on the temperature. In the experiment, the Tungsten filament has an e of 0.23, assuming that it is independent of the temperature. The net power radiation by an object in an environment is which can be rewritten as . In this, the P value is impacted specifically by the temperature of the object and the environment. If the temperature of the object is considerably higher than the environment, the environment’s temperature can be neglected as it will not impact the P value as much. Power can also be calculated using a voltage applied across the filament and the current through the filament. This is using the equation . This equation is used as the contents are easily measured. The surface area of the filament can be calculated using the temperature of the filament in the bulb. However, because this is hard to measure, it can indirectly be measured using resistance. is the resistance in ohms. Upon finding the resistance, it can be applied to find the temperature of the filament using the equation . R is the resistance of the filament and is the resistance of the light bulb at room temperature. This value will be measured before the experiment. This equation is most accurate using high temperature; therefore, it will only be used to calculate T values higher than 1250 K. The surface area of the filament can be calculated by rewriting the equation . By rewriting the equation, A can be found using the equation c This then can be rewritten as A=. The temperature of the environment is much less than the temperature radiated, therefore it can be omitted. will also be relatively the same as because of this. Upon finding A using i and V, P radiated was found using . A graph of the natural log of P v the natural log of T was created with a slope of 3.7486 which is relatively close to the expected slope of 4. The y-intercept is -25.419 which is meant to be. The average of the natural log of this is -27.29, however, this may be due to errors in the experiment.

Errors:

Errors in the experiment may have occurred if the DMM leads weren’t securely connected. Resistance changes may also impact errors and temperature accountability. Inaccurate or unstable readings with voltages due to improperly calibrated equipment or human error can impact the results of this data. Errors in calculation and implementations of equations on the Excel file may be overlooked, causing issues as well. Improper equipment, such as the DMM may be calibrated incorrectly or measure the incorrect measurement. Connection and procedure setup, along with damages to equipment can cause improper readings of data. Environmental factors, such as room temperature could also impact readings. Although the experiment is done in a controlled environment, this may still result in small errors. Using improper bulbs or not setting the voltage to the max can also impact this. Systematic and human errors are also common in this as the value may be listed incorrectly on the datasheet. Random errors may also arise. Measurement timing and experimental interference also play a role in this. The experiment should also be done using a bulb that is not burned out, ensuring that it is properly functioning.

Conclusions

The graph shows the calculated values using the equations listed above and the graph produces a linear plot. Although the value of the slope is not exactly 4, it is relatively close showing that the majority of the data aligns with the concept. The actual slope of the trend line is 3.7486 with a y-intercept of -25.419. This validates Stefan’s law as the relationship between the slope and temperature is shown to be a linear relationship. As temperature increases, so does power. Although the expected value was not the same, the relationship was still the same, representing that the experiment properly verifies Stefan’s law as the hot filament was relatively proportional to the fourth power of the temperature. The natural log of T to the fourth is simple 4ln(T). This shows that the difference between the natural log of P to the natural log of T should be 4x the natural log of P. Since the ln of P is equal to the ln of , it is also equal to the ln of each component individually. This means that it is equal to ln + + 4ln. Therefore, lnA is equal to -25.419- ln. This can then be simplified to A = e^(-25.419- ln) or A = (e^(-25.419))/ . Using this, A is approximately 4.38 x 10^-5 m^2.