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Hour 4

AP Physics

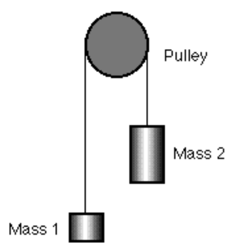
Atwood's Lab

Introduction:

The purpose of this lab is to study Newton's second law of motion and to derive a numerical value for gravity. By using Atwood's machine to study the relationship between two masses, acceleration, and net forces, in order to determine the acceleration of gravity experimentally.

Diagram of Machine:

There are two masses each of different values on each side of the pulley.



Procedure:

1. Set the pulley on the table, and determine the distance between the pulley and the ground. This distance will not change.
2. Next, place your chosen weight on one side of the string. Then, choose another mass that is similar in weight and place it on the other side of the string like shown in the diagram above.

3. For the next step, you will need two people. One who starts the timer, and the other who releases the mass. Hold the heavier weight as high as possible next to the pulley and then release the mass. The timer should begin the stop watch when the weight is released and stop it as soon as it reaches its lowest point.
4. This process should be repeated at least three times for every mass to get an accurate reading. Then, the mass should be changed around five more times to complete the graph.
5. Remember, only to modify the mass of the weight, not the height, timer, or person dropping the mass.

Data:

Mass 1 (kg)	Mass 2 (kg)	Distance (m)	Individual Times (s)	Average Time (s)	Acceleration (m/s^2)	Slope (kg)
0.055	0.050	1.27	2.29 2.23 2.15	2.22	0.52	-0.048
0.065	0.060	1.27	2.36 2.37 2.35	2.36	0.46	-0.040
0.075	0.070	1.27	2.75 2.66 2.63	2.68	0.35	-0.034

0.085	0.080	1.27	2.81 2.81 2.86	2.85	0.31	-0.030
0.095	0.090	1.27	3.26 3.09 3.15	3.17	0.25	-0.027

<u>Analysis:</u>

Equation for the first mass: $m_1 g - T = m_1 a$

Equation for the second mass: $T - m_2 g = m_2 a$

In order to find the acceleration, add these equations together and set them to equal $(m_1 + m_2)$a. The tension on both sides cancelled out, and then divide $(m_2 - m_1)g$by $(m_1 + m_2)$ in order to get acceleration by itself. Once this is done, you get $a = \frac{g(m_2 - m_1)}{(m_1 + m_2)}$. For the graph, we will be using just the values of mass and excluding g from our equation so the units would be kilograms.

Then, in order to calculate the acceleration, use Newton's second law equation $x = x_o + v_o + \frac{1}{2}at^2$. Then, cancel out all the values that would equal zero, and you should be left with $x = \frac{1}{2}at^2$. Next, solve for a which should lead you to $a = \frac{2x}{t^2}$. Use this equation and plug in all the values listed in the data chart from above.

Derivation:

Example calculations: Using the first set of data

Use this equation to find the acceleration and plug in all the corresponding values $a = \frac{2x}{t^2}$

2(1.27) = 2.54 m

(2.22)^2 = 4.93 s

$a = \frac{2.54}{4.93} = 0.52\, m/s^2$

Next is to find the slope by using $\frac{(m_2 - m_1)}{(m_1 + m_2)}$

The values should look like this for the first data set: $\frac{(0.05 - 0.055)}{(0.05 + 0.055)} = - 0.048$

After repeating these two steps, the results obtained were:

Gravity found: -12.99 $m/s^2/kg$

Y-intercept: -0.087 $m/s^2/kg$

These values were calculated by plotting the acceleration of the masses on the y-axis and the force on the x-axis.

Reasons for error:

This value that was calculated is a bit high compared to the true value of acceleration. The skew in the data could be attributed to a number of different factors. By far the most obvious error would be made by the timer. A systematic error, the person who is in charge of the stopwatch could have drastically impacted the data. Depending on their reaction time and what they deemed at start and stop, this person's hand-eye coordination would affect the readings. The next error, which is random, is the mass hitting against the pole. As each mass dropped, it sometimes slightly brushed against the pole of the Atwood machine. Although this may seem insignificant, in the long run it could affect the data. Each time the mass came in contact with the rod, it increased the amount of time by the millisecond. Another random error also includes the stand. Depending on its balance, the stand could possibly rock from side to side. This can especially occur as the weight increases. The last reason for error involves the machine and the force of friction. In the experiment, we assume that friction is negligible, another systematic error. However, in real life this is not the case. Unfortunately, determining the force of friction is hard to calculate. All of these minor errors add together quickly, and is most likely the source of our calculated acceleration being higher than its true value.

Percent Error: $\left|\frac{-12.99 - -9.8}{-9.8}\right| = 0.33 \ = \ 33\%$

This percentage calculated means that our value that we derived for gravity is off by 33%.

Conclusion:

Once all of the points were graphed, the relationship between acceleration and force proved to be liner. By using the linear fit on the graph, the slope was calculated to be -12.99 $m/s^2/kg$. After computing all this data relating to the mass, acceleration and net forces, a straight line was formed as the best fit, which tells us the acceleration due to gravity while using the Atwood machine.

Acceleration determined by Atwood's machine