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Honors Physics

Date:

ACCELERATION LAB: USING A TICKER TAPE TIMER TO DETERMINE THE ACCELERATION OF A FALLING OBJECT

INTRODUCTION

Velocity is the speed of an object in a given direction. Every object in motion or at rest, has a velocity. When the object's velocity changes, it is called acceleration. Acceleration is the increase of rate or speed of an object over time.

Acceleration can be an increase or decrease in an object's motion. Acceleration is calculated by (final velocity-initial velocity)/time. In physics, acceleration is the rate of change in velocity per unit of time. One way to calculate the acceleration is by using a ticker timer.

A ticker timer needs a magnet, carbon paper disc, power input, coil, vibrating bar, and ticker tape. Ticker tape is a strip of paper that is thin enough and long enough to fit through the carbon disc. A ticker timer is a machine that places dots on a piece of paper tape at a constant rate. The ticker timer places a dot on the paper tape every 60th of a second. The ticker timer places dots further apart on the paper tape, as the acceleration increases.

A ticker timer is often used to help calculate the acceleration. The acceleration of the ticker tape is easily shown by the dot placings. As the acceleration increases, the dots are placed further apart on the ticker tape. The ticker tape is pulled through the ticker timer at a faster rate, causing the dots to be further apart. A ticker timer is an easy machine to help someone calculate the acceleration.

The purpose of this lab was to was to calculate the rate of acceleration of a lacrosse ball, by using a ticker timer. We hypothesize that the acceleration caused by gravity could be measured using two methods the first method was through the use of three equations (Final Velocity, Total Time, and Acceleration). The second method was through the use of graphing of final velocity versus time and determining the slope, which would be acceleration. We would accept our hypothesis if just one of our trial was within 10% of the true value for acceleration 9.81 m/s^2. We reject based on the data that our percent error was over 10% of the true value for acceleration. Our percent error for trial 1 was 13.1%, trial 2 was 14.1%, and trial 3 was 29.7%.

MATERIALS AND METHODS

Ticker Timer: The ticker timer was plugged into an outlet on the wall so it could be turned on when the experiment was to be conducted. A slip of paper was fed through the ticker timer and attached to a lacrosse ball by tape. When the ticker timer was turned on, the ball was dropped from the height of a lab bench of 0.750 meters. When the ball hit the ground, the timer was turned off, and the rest of the paper was pulled through and out of the machine. The total number of dots on the slip of paper were then counted. The distance between the last two dots were measured and the distance from start for intervals of 5, 10, 15, and 20 dots was measured..

Equations: Final velocity was then calculated by the equation Vf=(distance last two dots)/0.0167s. The distance between the last two dots on the slip of paper were measured in meters and plugged into this equation, producing a final velocity. Initial velocity would be 0m/s because the object dropped started from rest. The time transpired was found by taking the total number of dots counted from the slip of paper and dividing it by 60. The acceleration of the falling object was then calculated using final velocity, initial velocity, and the time transpired as seen in the equation $a = (Vf - Vo) / t$. Once the acceleration was calculated, experimental distance was calculated as well using the equation $D = ½at^2$.

Ti Graphing: Using the STAT function on a Texas Instrument calculator (TI-84 Plus CE), calculations were made to plot speed vs. time and obtain a linear regression. L1 consisted of the number of dots from the start (5, 10, 15, 20). L2 showed of the time it took the object to fall from the start of the dots to a certain dot position. It was calculated by taking L1 and multiplying it by 0.0167. L3 consisted of the distance in meters the object fell for each number of dots from start shown in L1. L3 was measured directly from the slips of paper. L4 calculated the average velocity in m/s the object fell from the beginning of the dots to a particular dot position by dividing L3 by L2. L5 showed final velocity. It was calculated by multiplying L4 by 2. Calculations were also made to plot a distance vs. time graph, which was created by using L2 and L5.

RESULTS

In this experiment, groups of four persons were formed to work together and used ticker timers to determine the acceleration of a dropped lacrosse ball from the height of a lab bench of 0.750m. After performing the activity (dropping the lacrosse ball) for a total of three trials, each piece of paper used in the ticker timer was examined, and the total number of dots for each trial was determined, as well as the distance between the last two dots and the distance between the start of the dots to a certain number of dots. All of this information was used to determine the acceleration of the dropped lacrosse ball, the (experimental) distance it fell, and the percent error of of the actual acceleration of the ball and the actual distance the ball fell (based on the height on the lab bench). The average velocities and final velocities for each trial was also determined via calculator. The absolute value of the difference in accelerations was also found using information calculated by the raw data of the experiment and information retrieved using calculators imputed with raw data.

The acceleration of a free-falling object is $9.81 m/s^2$. Accelerations that were calculated in this experiment show a smaller free-falling acceleration than the actual acceleration due to gravity. This is because the friction of the paper against the wood on the ticker timer when the ball was falling. So, in summary, no group's acceleration was completely accurate because of the friction against the paper and ball in free fall. However, the acceleration of the ball was still constant. The accelerations calculated were then used in percent error compared to the actual acceleration due to gravity. Group 3's accelerations for trial 1 and 2 were $8.32 m/s^2$. It's acceleration for trial 3 was $8.90 m/s^2$. Because of the friction of the ticker timer, group 3's accelerations were slightly less than the actual free-fall acceleration due to gravity. The group's percent error for trial 1 and 2 were 15.2%, and it's percent error for trial 3 was 9.28%. The acceleration of the dropped lacrosse ball was determined by the raw data collected from the ticker timer.

Each group was given a ticker timer and three strips of long tape-like paper. They each threaded one of their pieces of paper through the ticker timer, and then taped it using masking tape to one side of an ordinary lacrosse ball. Plugging the cord of the ticker timer into an outlet and turning it on, each group dropped their lacrosse ball, causing the paper to slide through the machine due to the weight impact of the lacrosse ball. The ticker timer, when turned on, ticks dots using ink at a constant speed. When the lacrosse ball was dropped and slip of paper filed through the machine, the dotter on the ticker timer dotted dots on the slip of paper. Because the ball was accelerating, the dots on the piece of paper became more and more spread apart from each other, showing the ball's increase in acceleration by the growing distance between dots. After each group had performed three trials, they counted the total number of dots and the distance between the last two dots, as well as the distance between the start of the dots and a certain dot position later on. When group 3 performed this activity, they found that for all three trials they had a total of 25. For trials 1 and 2, group 3 found that the distance between their last two dots was 0.0850 meters. For their third trial they measured the distance between the last two dots to be 0.0620 meters. They then found the distance between a certain dot position (5, 10, 15, 20) on the paper and the start of the dots and used it to calculate graphs on their calculators.

By using data derived from the experimental trials, each group calculated the acceleration of the lacrosse ball dropped for each of their trials. They found this acceleration by taking the total number of dots and dividing it by 60 to get time in seconds, by taking the distance between the last two dots and dividing it by 0.0167 seconds in order to calculate final velocity, by using 0m/s as initial velocity, and finally by plugging all of this information into the acceleration equation a = (Vf – Vo) /t in order to find the acceleration of the ball that was dropped. By taking the total number of dots, 25, and dividing it by sixty, time is calculated; in this case, the time was 0.417 seconds. The final velocity, 3.47m/s, was calculated by taking the distance between the last two dots, 0.0580 meters, and dividing it by 0.0167 seconds. Initial velocity was 0m/s because the ball's acceleration was being calculated from rest. Using the acceleration equation, a = (Vf – Vo) /t, the data calculated was plugged in, resulting in the acceleration of 8.32m/s^2. All of the initial raw data was found by using a ticker timer from which a ball was dropped.

TABLE 1: Data from equation method to determine acceleration

Trial	Total Dots[A]	Time Transpired[B] (seconds)	Distance Last Two Dots[C] (m)	Finale Velocity[D] (m/s)	Acceleration[E] (m/s^2)	Percent Error[F] (%)
1	24	0.400	0.0570	3.41	8.52	13.1
2	23	0.383	0.0540	3.23	8.43	14.1
3	26	0.433	0.0500	2.99	6.90	29.7

A= Measure from Ticker Timer

B= Total number of Dots/60

C= Measure in Meters

D= Distance of Last Two Dots/0.0167

E= (Final Velocity/Total Time)

F=(|Derived Acceleration-9.81|)/9.81

TABLE 2: Trial 1 Distance traveled from start (meters) to determine acceleration via graphing

Dot Position[L1]	Distance Traveled from Start[L3] (meters)	Time Transpired[L2] (seconds)	Falling Average Velocity[L4] (m/s)	Falling Final Velocity[L5] (m/s)
5	0.0320	0.0835	0.383	.766
10	0.124	0.167	0.742	1.48
15	0.277	0.250	1.10	2.21
20	0.493	0.334	1.48	2.95

Footnotes correspond to the listing columns no a TI-84 Plus calculator.

L1= Dot Position

L2= L1 · 0.0167

L3= Distance from start

L4= L3/L2

L5= L4 · 2

TABLE 3: Trail 2 Distance Traveled from start (meters) to determine acceleration via graphing

Dot Position[L1]	Distance Traveled from Start[L3] (meters)	Time Transpired[L2] (seconds)	Falling Average Velocity[L4] (m/s)	Falling Final Velocity[L5] (m/s)
5	0.0300	0.0835	.359	0.718
10	0.110	0.167	.659	1.32
15	0.210	0.250	.838	1.68
20	0.408	0.334	1.22	2.44

Footnotes correspond to the listing columns no a TI-84 Plus calculator.

L1= Dot Position

L2= L1 · 0.0167

L3= Distance from start

L4= L3/L2

L5= L4 · 2

TABLE 4: Trial 3 Distance traveled from start (meters) to determine acceleration via graphing

Dot Position[L1]	Distance Traveled from Start[L3] (meters)	Time Transpired[L2] (seconds)	Falling Average Velocity[L4] (m/s)	Falling Final Velocity[L5] (m/s)
5	0.300	0.0835	0.359	.718
10	0.101	0.167	0.659	1.32
15	0.237	0.250	0.838	1.68
20	0.408	0.334	1.22	2.44

Footnotes correspond to the listing columns no a TI-84 Plus calculator.

L1= Dot Position

L2= L1 · 0.0167

L3= Distance from start

L4= L3/L2

L5= L4 · 2

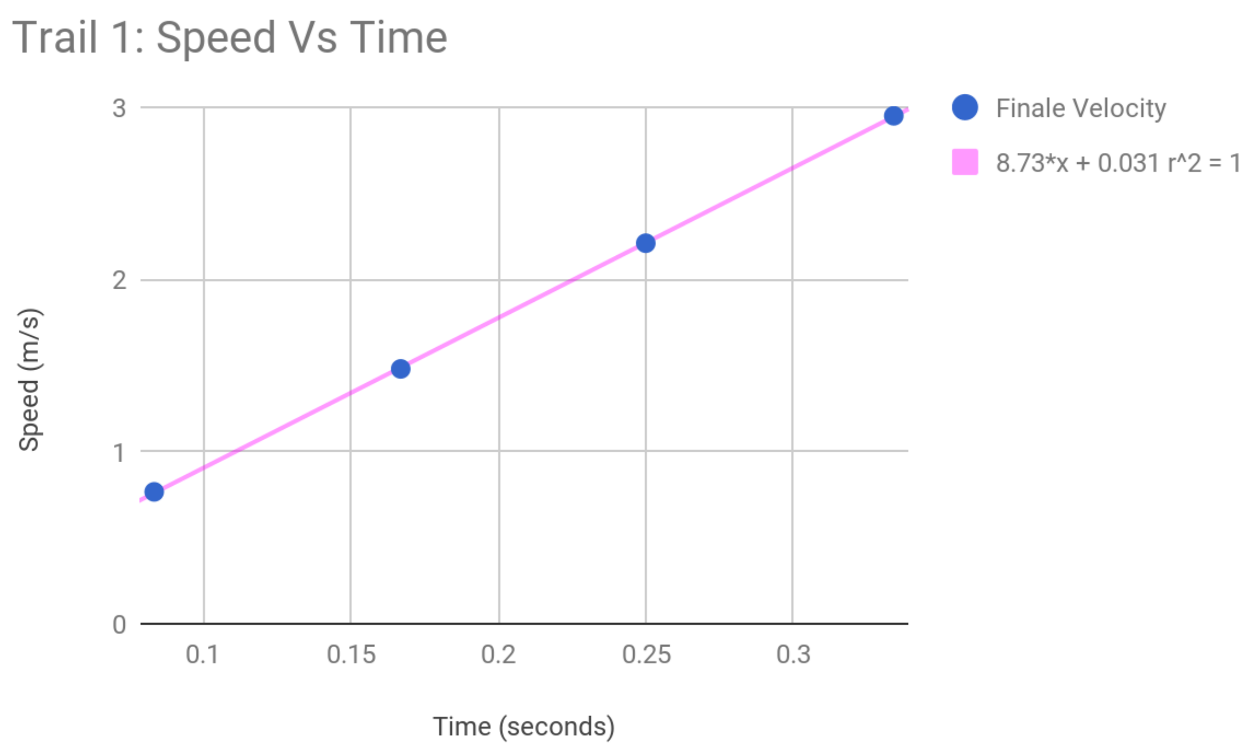

Figure 1: Trail 1: Speed in m/s Vs time slope is equal to the acceleration of the ball using the timer.

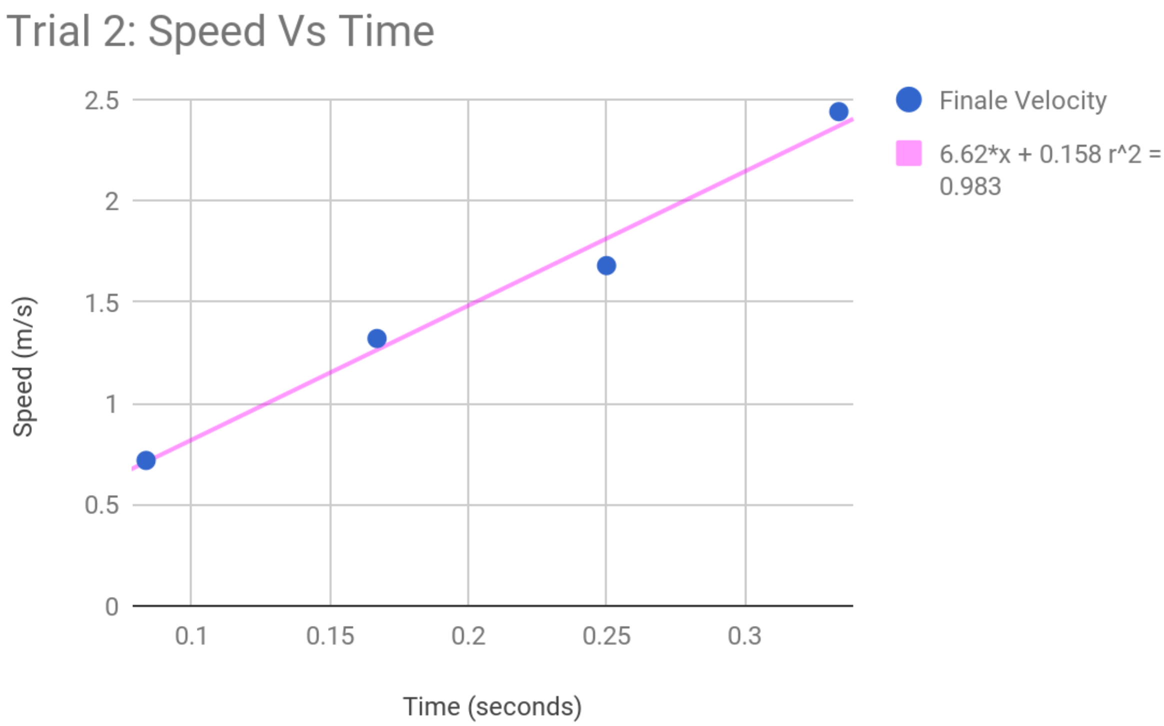

Figure 2: Trial 2: Speed in m/s Vs time slope is equal to the acceleration of the ball using the timer.

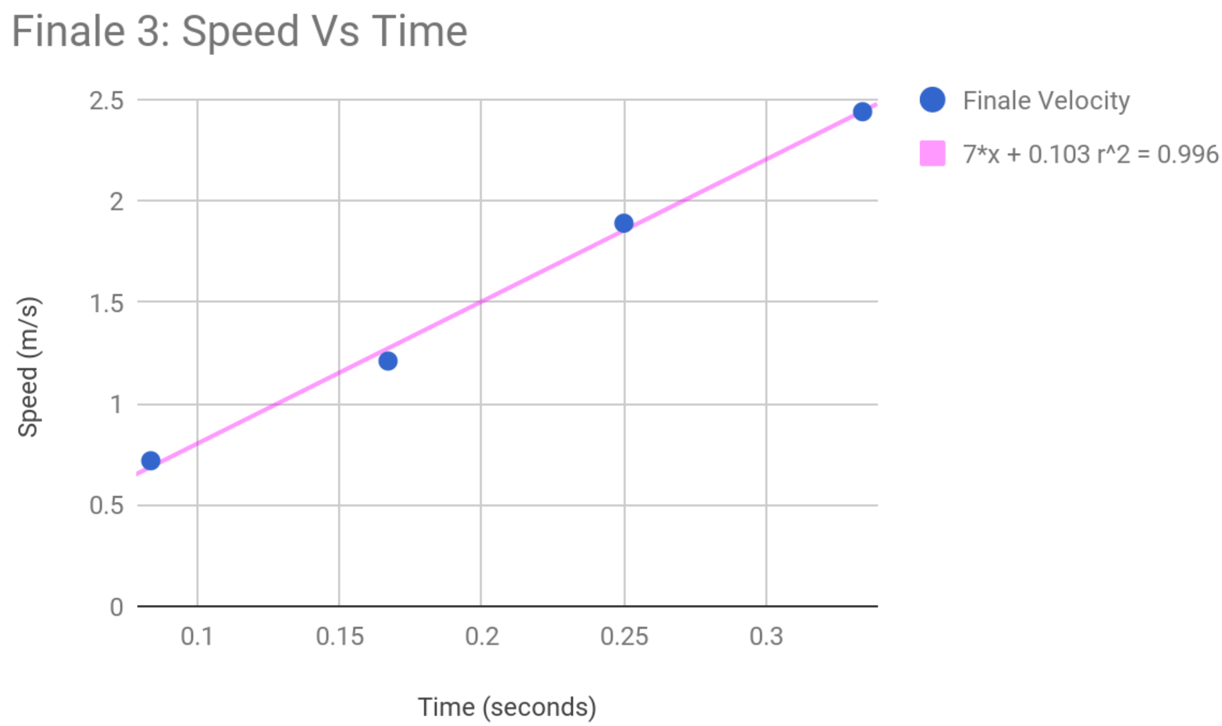

Figure 3: Trial 3: Speed in m/s Vs time slope is equal to the acceleration of the ball using the timer.

CONCLUSION

Our group, did not have data that accepted the hypothesis. Our data was 3.1%, 4.1%, and 19.7% over the accepted percent error. I think that our data disagreed with the hypothesis because there was human error. The last trial was 15.6% and 16.6% higher than the other two trials. Our percent error was 13.1% for trial 1, 14.1% for trial 2, and 29.7% for trial 3. There were two larger problems that occurred during the experiment. The first one was that our machine would either not have dots or have a solid line. We were able to fix this problem by getting a new machine for trial 3, which could have contributed to the different data. Our second problem was that my calculator would graph a line and dots at the same time. This problem only affect me in the group, but it was solving by borrowing somebody else's calculator. I think that if we were to redo this experiment, I would do more test to find more consistent data. We had consistent data in trial 1 (8.52 m/s^2) and trial 2 (8.43 m/s^2), but our acceleration for trial 3 (6.90 m/s^2) was not consistent. Overall, I think our experiment was able to be conducted without any major problems.