Measuring Motion Of An Object At Uniform Motion Using the Formula of

Speed= Distance/Time

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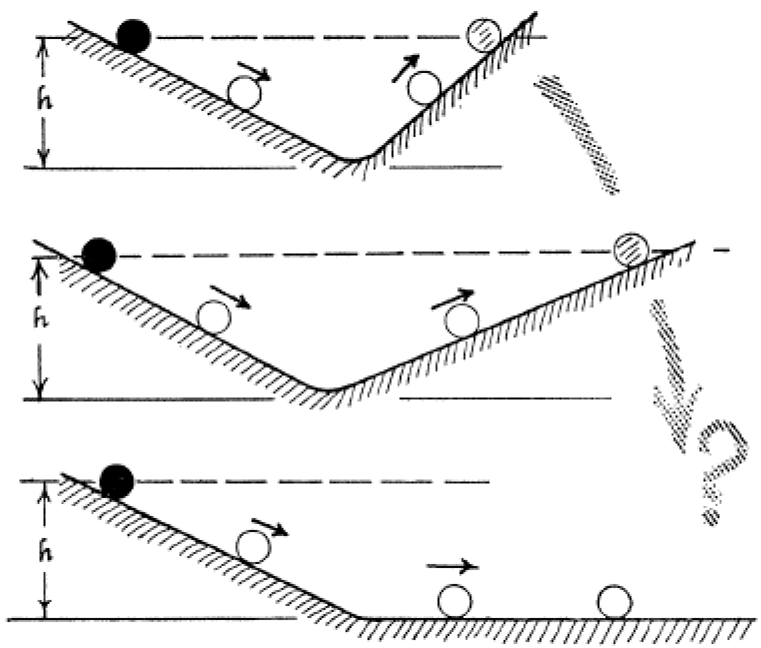
Uniform motion was given birth by Italian astronomer named Galileo Galilei. Galileo developed a concept called inertia around the seventeenth century. After years of research, he claimed that eventually all moving objects will come to a stop due to a force called friction. He defined friction as a force that is going in an opposite direction than the moving object and slows it down. Galileo experimented and learned that when a ball is rolling off the inclined planes facing each other the ball would go close to the original height on the other plane. This led Galileo to believe that the force not letting the ball reach the other side to the exact point was inertia. Galileo claimed that if there was no friction then the ball would land at the same height as the ball was being dropped.



Sir Isaac Newton then backed up Galileo's claims with his first law of motion which states: An object at rest stays at rest and an object in motion stays in motion with the same speed and the same direction unless acted upon by an unbalanced force." An example of this law in place is the five-ball Pendulum. This real-life model of Sir Isaac Newton's Law demonstrates how without any friction, the balls would keep on moving at a uniform motion. (Inertia: Resistance of an object to a change of velocity.) An example of inertia is when two cars crash, and the inertia stop both from moving. Newton's Law and the idea of inertia weren't as popular with others. Almost everybody seemed to disagree with Sir Isaac Newton as they believed that even with no friction a moving object would slow down eventually, and an external force was needed to keep it at a uniform motion. Nearly 200 years later Albert Einstein Would then back up newton's laws with his postulates.

Albert Einstein had two major postulates. His first postulate stated that "All velocities are measured relative to some frame of reference." An example of this was that a planet's orbit is measured from the start it is orbiting around.

RESEARCH QUESTION

Research Question: How can the Formula of Speed = Distance/Time be used to calculate the motion of a ping pong ball that is traveling at an almost uniform motion to prove the given formula.

HYPOTHESIS: If a ping pong ball is released from a cannon, then it will prove that Speed= Distance/Time, because there is no friction and very little acceleration because the ball is being shot in the air and is not in contact with any object external force acting upon it. Therefore, there is no real variable to act as an external force to tamper the ping pong ball's motion and to change its property from a uniform motion to either an accelerated or decelerated motion.

EXPERIMENTAL METHOD

DESIGNING A REPEATABLE EXPERIMENT

To design a repeatable experiment, a pressurized air cannon will be needed along with a ping pong ball, a soda can, and a recording device that can measure frame to frame. The ball will be shot out of the pressurized air cannon at a uniform motion and would be recorded frame to frame. The ball's speed will be calculated with the formula of Speed= Distance / Time.

SELECTING VARIABLES, CONSTANTS, AND CONTROLS

The Independent variable in this experiment is the time in the ping pong ball lab. In the experiment, the time is being changed as it is going through frame by frame and changing the time to measure the distance of the ping pong ball. Controls in the experiment would fall in the same category as the constants of the experiment. The dependent variable is the distance the ping pong ball traveled from frame to frame. Constants in the experiment:

1. Ping Pong Ball
2. Pressurized Air Cannon
3. Soda Can
4. Recording device
5. Setting that the Launch is being taken place in

Materials:
Pressurized Air Cannon
Ruler
Stopwatch
Ping Pong Ball
Soda Can
Protective Gear
A recording device that can measure Frame by Frame

Lab Notebook and pencil to note down everything
There are some safety issues when it comes to this lab. One would be the danger of getting hit by shrapnel from the soda can. There is a high chance of such a thing as this happening because the ball is going at such a high speed. To be safe from this, goggles must be worn, and the tester must stand behind protective glass or a wooden board. Another safety issue is fire. There is always a fire hazard in speed experiments so the tester should make sure that there are no highly flammable objects near the testing area.

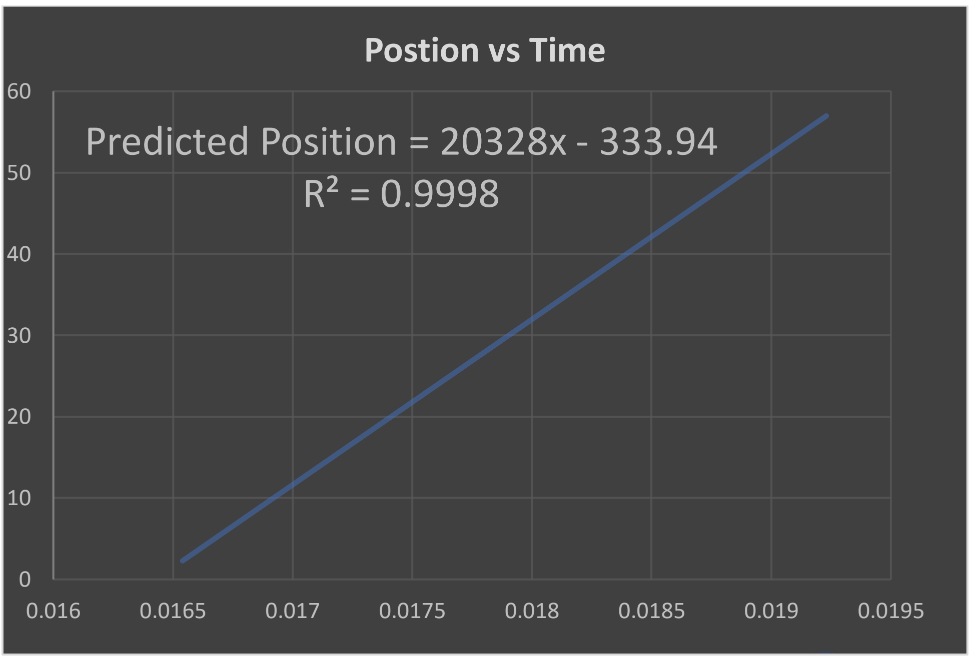
Method Context: The original question is if the formula of Speed= Distance/Time is valid in the experiment done. It was hypothesized that the ping pong ball cannon was a great way to accurately prove that Speed=Distance/Time because there is none to very little friction or acceleration and the ping pong ball is moving at a uniform motion so the formula will be proven true when used to calculate the distance traveled frame by frame.

DATA PRESENTATION: (I changed the formatting of my tables)

Full Table With Predicted Speed, Measured Speed and Error (Speed was derived from the formula of Speed=Distance/Time)

FRAME	time (sec)	position (cm)	Measured Speed Δx/Δt (cm/sec)	Predicted Speed (cm/sec)	Predicted Position(cm)	Position Error % Theoretical -observed/theoretical -observed * 100%
0						
43	0.01654	2		20328	336.22512	
44	0.01692	10	21053	20328	343.94976	-3.6%
45	0.01731	18	20513	20328	351.87768	-0.9%
46	0.01769	26	21053	20328	359.60232	-3.6%
47	0.01808	34	20513	20328	367.53024	-0.9%
48	0.01846	41	18421	20328	375.25488	9.4%
49	0.01885	49	20513	20328	383.1828	-0.9%
50	0.01923	57	21053	20328	390.90744	-3.6%

Graph Representing Speed Increasing In An Almost Uniform Motion: X axis: time, Y axis: Distance.



		Test Data		
FRAME	position (cm)	time (sec)	Predicted Speeds cm/s	
51	63	0.01962	3211	cm/s
52	68	0.02	3400	cm/s
53	73	0.02038	3582	cm/s
54	78	0.02077	3755	cm/s

The ball is not moving at a perfect uniform speed because of unaccounted minor acceleration & regression. The ball does not start at a constant speed nor does it end at one. It gradually speeds up, reaches a maximum, and then begins to slow down. That is why the data might seem off from the Model Data, when, it is only because of acceleration and regression that it seems this way.

The predicted speed using the position and the time of the ball travelled frame by frame by using the formula of Speed = Distance/ Time:

RESULTS

Analytic Context:
The results prove that the formula of speed=distance/time is true because when measured, the speed was able to be derived from the formula and there was less than a 4 percent margin error. There was a margin of error because there was some unaccounted acceleration and regression on the ball when it was moving. This is a hard problem to avoid because to shoot a ball at a perfect uniform motion it would take a lot of work and a very precise machine would be needed.

Analytic Content: The percent error was under a margin of 4 percent. This means that our hypothesis was accurate. A percent error was expected because it is very hard for a machine to shoot a ball at a perfect uniform motion. However, another reason that there was percent error that was unaccounted for was a slight acceleration and regression in the balls speed.

The results of the ping pong ball experiment led to the fact that the speeds from frames 43-50 are:

FRAME	Measured Speed $\Delta x/\Delta t$ (cm/sec)
0	
43	
44	20153
45	20513

46	21053
47	20513
48	18421
49	20513
50	21053

The Position Error is:

Position Error % Theoretical observed/theoretical-observed * 100%
-3.6%
-0.9%
-3.6%
-0.9%
9.4%
-0.9%
-3.6%

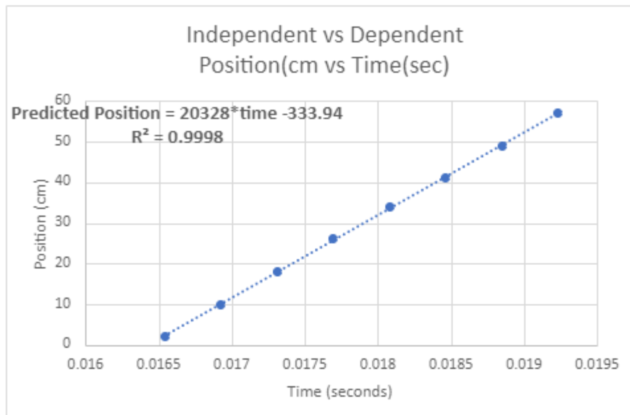
The Time measured from frame to frame is:

time (sec)
0.01654
0.01692
0.01731
0.01769
0.01808
0.01846
0.01885
0.01923

The Predicted Speed and the predicted Position are: (6 sig figs)

Predicted Speed (cm/sec)	Predicted Position(cm)
20328	336.225
20328	343.949
20328	351.877
20328	359.602
20328	367.530
20328	375.254
20328	383.182
20328	390.907

Graph showing almost exact uniform motion by deriving it from Distance/Time:



DISCUSSION

The data supports my hypothesis which was that the ping pong ball lab was a great way to prove that Speed=Distance/Time when there is no acceleration or friction and if it moves at a uniform motion. The data supports my hypothesis because the information for the predicted speed and the distance graphs were derived from using the formula Speed=Distance/Time. When calculated by using the formula there was a percent error of less than 4 percent because there could have been a little amount of acceleration that could change the motion of the ball. This supports Galileo's claim on inertia that stated that if a ball was dropped on two inclined planes that are facing each other if there was no inertia then the ball would end up in the same height on the other side as the side was dropped from. This also proves Newton's law which stated that any moving object would stay in uniform motion forever until an external force is applied to the moving object. This proves the fact that that the formula Speed=Distance/Time is a valid formula to be used when calculating the speed of a moving object at a uniform motion. Some limitations were that the experiment was done through a virtual testing system and not in real life. If done in real-time then any misinformation would cease to exist, and all the information would be more accurate, and more things will be considered when the experiment is done. The percent error was caused by not doing the calculations precisely when calculating the predicted speed and position and were mostly due to the unaccounted change acceleration and regression that faced the moving object. This experiment is very important because it proves that the formula of Speed = Distance/Time is a valid way to calculate the distance when studying a moving object that is at uniform motion. This can be used in many real-life situations as it is a simple but effective way of calculating the distance traveled of an object and a uniform motion. When acceleration comes into play, then the formula is not valid because the formula does not take the acceleration into account.

Formulas used in lab:

Speed= Distance/Time
: to calculate the motion of a ball that is in uniform motion.

Experimental Value * Theoretical Value / Theoretical Value

Citations:

Speed-distance-time concept builder. The Physics Classroom. (n.d.). Retrieved November 3, 2021, from https://www.physicsclassroom.com/Concept-Builders/Kinematics/Speed-Distance-Time/Concept-Builder.

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