Acceleration: Galileo's Inclined Plane Teacher's Notes

Main Topic	Motion
Subtopic	Acceleration
Learning Level	High
Technology Level	Low
Activity Type	Student

Description: Use a water clock to measure a ball's acceleration as it rolls down an inclined plane.

Required Equipment	Inclined plane, ball, buret, buret stand, beaker, funnel, water
Optional Equipment	Stopwatch

Educational Objectives

- Measure short time intervals using a water clock.
- Calculate the acceleration of a rolling ball.

Key Question

- What happens to the acceleration of a ball as it rolls down an incline?

Concept Overview

In Galileo's time, stopwatches had not been invented. He needed a way to measure the short time it took for a ball to roll down an incline. The set-up you will use is nearly identical to what Galileo would have used. Just like Galileo, students will measure the time it takes for a ball to roll down an incline by the amount of water released during the roll. We will use this time measurement to calculate the acceleration of the ball at different heights and compare them.

Lab Tips

An ideal inclined plane has a groove to contain the ball and markings at least at 100cm, 75cm, 50cm, and 25cm from the bottom. If student groups use different incline angles and/or different sized balls, they can compare results at the end and see that acceleration of the ball is constant for every group.

The lab can be easily modified to use a regular stopwatch for timing. It is less authentic, but the results are the same.

Acknowledgements

Thank you to Dwight Putnam for his assistance in developing this lab.

Acceleration: Name: ___________________

Galileo's Inclined Plane Class: ____________________

Pre-Lab Questions:

1. Write an equation relating distance, time, and acceleration.

2. Arrange the equation to solve for acceleration.

Goal:

Without using a stopwatch, determine if a rolling ball's acceleration is constant, increasing, or decreasing.

Materials:

Inclined plane, ball, buret, buret stand, beaker, funnel, water

Setup:

Galileo was known to use dripping water to measure the time it took for an object to fall. Because stopwatches like we know them had not been invented yet, Galileo needed a way to measure the short time it took for a ball to roll down an incline. The set-up you will use today is nearly identical to what Galileo would have used. Just like Galileo, we will measure the time it takes for a ball to roll down an incline by the amount of water released during the roll. We will use this time measurement to calculate the acceleration of the ball at different heights and compare them.

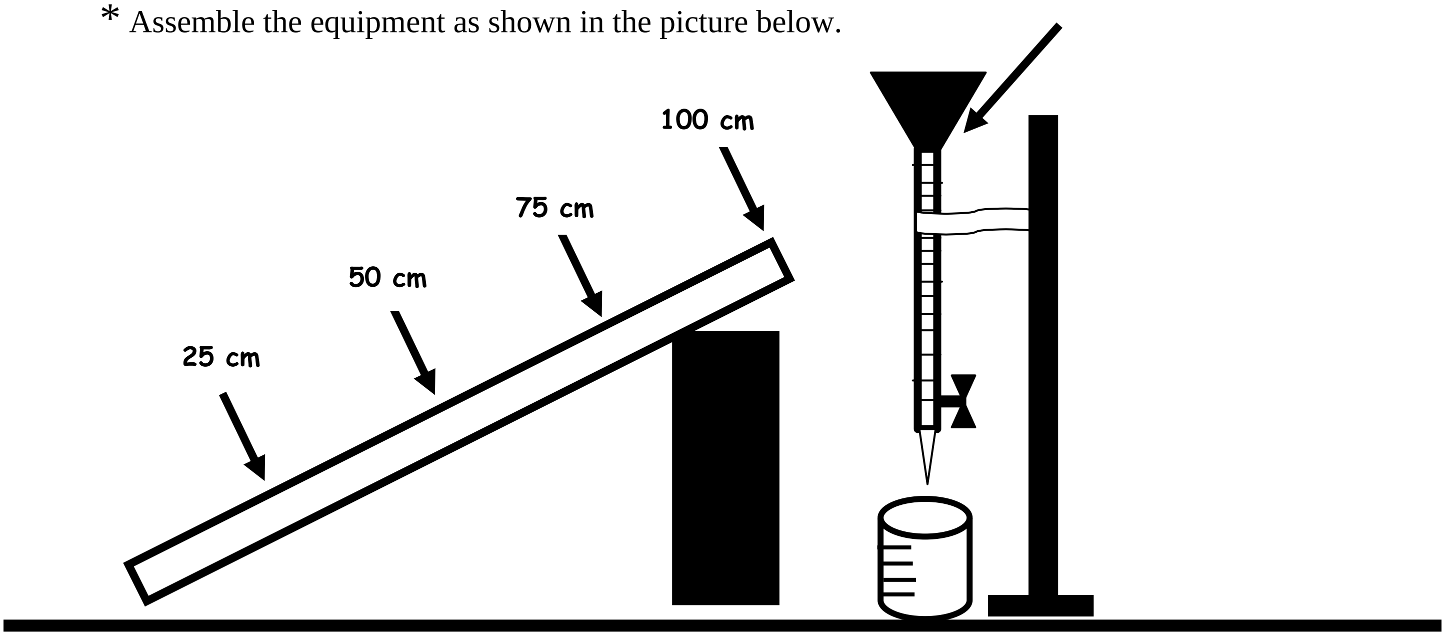
Water Clock

Acceleration: Galileo's Inclined Plane

Name: ____________________

Class: ______________________

* Assemble the equipment as shown in the picture below.



Procedure:

1. Pour water into the funnel of the water clock to the top marked line. To make your data as accurate as possible, refill the water to this mark before each trial. Notice that the buret is designed to measure the amount of water released.
2. To control the stopping and starting of your water clock, turn the valve vertically to release the water & horizontally to stop its flow.
3. Place the ball on the **100 cm** mark. **At the same time**, release the ball and the valve. Stop the water flow at the moment the ball reaches the bottom of the ramp.
4. Record the "time" the ball took to roll the distance, in mL of water released. Read the number from the buret.
5. It is important that you work together in your lab groups. You may want to practice a few times before you start taking data. For each height marked on the incline, **time** the fall of the ball 6 times and average your results.

Data Time Sheet for Galileo's Experiment

Trial #	100 cm	75 cm	50 cm	25 cm
1				
2				

3				
4				
5				
6				
average time (ml)				

6. Use the formula from Pre-lab question 2 to determine the ball's acceleration for each release distance.

distance (cm)	**average time (ml)**	**average time^2 (ml)^2**	**acceleration (cm/ml^2)**
100 cm			
75 cm			
50 cm			
25 cm			

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Questions

1. Did the velocity of the rolling ball change?
2. Did the acceleration of the rolling ball change?
3. If a skateboarder has a constant acceleration of 5 m/s^2, how fast is he going after 1 second?
4. If a skateboarder has an constant acceleration of 5 m/s^2, how fast is he going after 2 seconds?
5. A bowling ball rolls down a straight 20m steel ramp and reaches a velocity of 30 m/sec at the end of the ramp in 8 seconds.
    a. What is the bowling ball's V_i?
    b. What is the bowling ball's V_f?
    c. What is the bowling ball's acceleration?
    d. What is the bowling ball's acceleration when it is ½ way down the ramp?
    e. What is the bowling ball's acceleration ANYWHERE during the roll?