Galileo's inclined plane: d □ t^2

FizziQ activity · High school · 30 min

Scan to open in FizziQ

Students reproduce Galileo's experiment in the FizziQ Web inclined plane simulation, plotting d versus t^2 to extract acceleration and g. High school, browser.

Learning objectives

- Experimentally verify the relationship $d = ½ \times a \times t^2$ on an inclined plane
- Measure the acceleration of a ball for different inclination angles
- Verify the relationship $a = g \times \sin(\alpha)$
- Plot and interpret d versus t^2 graphs to extract the acceleration
- Determine the value of g from the slope of the a versus $\sin(\alpha)$ graph

Instruments and sensors

FizziQ Web Inclined Plane simulation

Materials

- Computer, tablet, or smartphone with FizziQ Web
- Note: the protocol remains adaptable to any comparable simulation or data-analysis tool.

Protocol

1. Open the Inclined Plane simulation in FizziQ Web (Experiment → Simulations → Inclined Plane).
2. Set the inclination angle to 30° and the travel distance to maximum. Start a recording (REC) and let the ball roll to the bottom.
3. The position-time data are automatically exported to the experiment notebook. Observe the graph: the curve is not a straight line but a parabola.
4. Add a calculated column to the table: t^2 (time squared). Plot the graph of distance versus t^2. This should be a straight line through the origin.
5. The slope of this line equals ½ × a. Calculate the acceleration a for the 30° angle. Note the value in a summary table.
6. Repeat the experiment for angles 10°, 20°, 40°, 50°, and 60°. For each angle, calculate the acceleration from the slope of $d(t^2)$.
7. Create a summary table with three columns: Angle, sin(angle), and Acceleration.
8. Plot the graph of Acceleration versus sin(angle). The curve should be a straight line through the origin.
9. The slope of this line gives the value of g. Compare your value with 9.81 m/s².
10. What happens at an angle of 90°? The acceleration should equal g: that is free fall!

Expected results

The d(t) graph is a parabolic curve, confirming non-uniform motion. The $d(t^2)$ graph is a straight line through the origin, confirming $d = ½ \times a \times t^2$. The acceleration increases with angle: approximately 1.7 m/s² at 10°, 4.9 m/s² at 30°, and 8.5 m/s² at 60°. The graph $a(\sin \alpha)$ is a straight line through the origin with slope $g \approx 9.81$ m/s². The mass of the ball does not affect the results.

Questions

- Why is the position-time graph a curve and not a straight line?

- What does the slope of the $d(t^2)$ graph represent?
- Why does the acceleration not depend on the mass of the ball?
- If you double the angle from 15° to 30°, does the acceleration double?
- What would change if there were friction between the ball and the plane?
- At what angle is the acceleration exactly half of g?

Going further

- Plot v(t) for a given angle and verify that velocity increases linearly with time
- Compare the times to travel the same distance at two different angles
- Predict the acceleration for a new angle before measuring it, then check your prediction
- Add friction in the simulation (if available) and observe how the acceleration changes
- Determine the value of g by using only two different angles