

Physics Lab: Uniformly accelerated motion.

(Bring your calculator to the lab)

Part 1

Theory: When an object moves with a constant acceleration, the position of the object is given by the equation

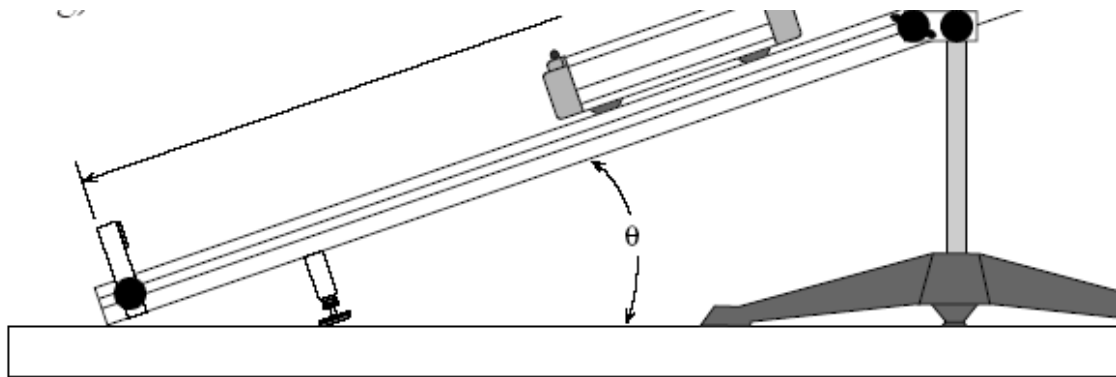
$$X = X_0 + V_0 t + \frac{1}{2} a t^2$$

We will choose an initial position and initial velocity equal to zero (starting from rest).

Objective: To analyze the motion of an object undergoing constant acceleration, to better understand what it means to say that the position varies with the square of the time, and to compare this to the velocity function, which is directly proportional to the time.

Equipment setup:

- 1) Set up the track as shown in figure 1, raising the end of the track without and end. **We will perform this experiment for 2 different angles of inclination, 2 and 4 degrees.**



- 2) Set the motion sensor in the upper end of the track, and get the computer ready to start collecting data **distance vs. time**, in 0.1-second intervals.
- 3) This is a team project. One person should be in charge of the Start/Stop button of the computer, another person will be in charge of releasing the cart from the top of the track and another person will stop the cart before it hits the end of the track (collisions damage the carts severely!)
- 4) Press the Start button, and release the cart when the computer starts collecting data. Press Stop when the cart reaches the end.
- 5) Repeat procedure at least 5 times, or until you feel confident your data is correct. Avoid moving the table or interfering with the sensor while data is being collected.
- 6) **Copy your data to Excel and average your values. Create a graph distance vs. time. What is the shape of this graph? Calculate and record the equation that fits the data.**
- 7) Your data will be in 0.1-second intervals. In the table in Excel, create a column (column C) with the rate of change for each one of those intervals ($\Delta X / \Delta t$). Create a graph with this values vs. time. **What does this graph represent?**

- What is the shape of this graph? Calculate and record the equation that fits the data. What physical quantity does the slope of your graph represent? Record that number (the slope)**
- 8) Create another column (column D) with the rate of change between the intervals in column C. Create a graph with this values vs. time. **What does this graph represent? What is the shape of this graph?**
 - 9) The equation $X = X_0 + V_0 t + \frac{1}{2} a t^2$ does not take into consideration the effect of friction in uniformly accelerated motion. **How can you “visually” determine that there is friction in this experiment? How would the cart move if there was no friction?**
 - 10) **Determine the Force of Friction that affects the cart. Compare the theoretical acceleration with the acceleration you obtained in part 8. The difference between these 2 values is the loss in acceleration due to friction.** (use the equation $F = m a$ to determine that force.
 - 11) **Draw a complete force diagram of the cart when is moving. Draw the components of those forces that are parallel and perpendicular to the track.**
 - 12) The component of the weight of the cart that is perpendicular to the track is called the Normal force (N). **Calculate the weight of the cart, determine the value of the normal force (N). Calculate the value of the coefficient of friction dividing the value of the force of friction by the normal force ($\mu = F_f / N$).** The coefficient of friction is a characteristic of the surface of the materials. A small value of μ means the surface is smooth.
 - 13) Repeat steps 1 through 8 for 4 degrees of inclination.
 - 14) **Print a copy of all the questions in bold and submit them at the end of the session, with the name of all the members of your group.**

Part 2

The purpose is to study how the acceleration of an object down an incline depends on the angle of the incline.

Theory

A cart on an incline will roll down the incline as it is pulled by gravity. The acceleration due to gravity is straight down as shown in Figure 8.1. The component of gravity which is parallel to the inclined surface is $g \sin \theta$, so this is the net acceleration of the cart, neglecting friction.

To measure the acceleration, the cart will be started from rest and the time (t) it takes for it to travel a certain distance (d) will be measured. Then since $d = (\frac{1}{2})at^2$, the acceleration can be calculated using

$$a = \frac{2d}{t^2}$$

Then a plot of acceleration versus $\sin \theta$ should give a straight line with a slope equal to the acceleration due to gravity, g.

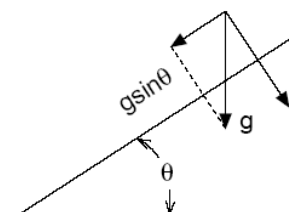
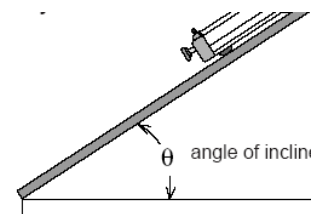


Figure 8.1

Procedure

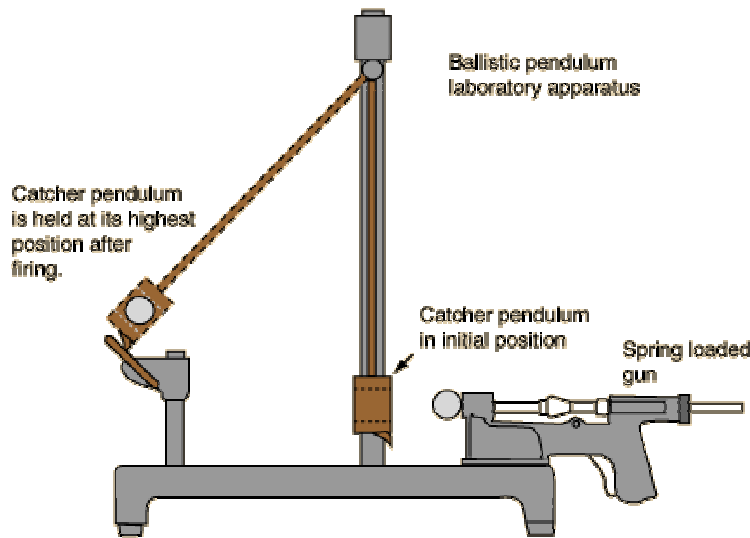
Procedure:

- 1) Set up the equipment similar to Part 1.
- 2) Collect values of distance and time for different inclinations of the track (ranging from 1 to 8 degrees), and register these values in Excel.
- 3) **Create a column that calculates the values of acceleration for the different inclinations.**
- 4) **Create a graph with these data (acceleration versus sine of the angle of inclination). Draw the best-fit straight line and calculate its slope.**
- 5) **Calculate the percent difference between the slope and the value of g .**
- 6) **If the mass of the cart is doubled, how are the results affected? Try it.**
- 7) **Print a copy of all the questions in bold and submit them at the end of the session, with the name of all the members of your group.**

Part 3. Ballistic Pendulum

You have studied projectile motion and have discovered that horizontal and vertical components of motion are independent. You will use these ideas to determine the muzzle velocity of a gun.

In the first part of the experiment, the spring gun attached to the ballistic pendulum apparatus will impart a horizontal velocity to the ball. By measuring the range, x , and determine the time, t , muzzle velocity, v_o , may be determined.



Objectives

Calculate the muzzle velocity of the ball by kinematics.

Materials

- Ballistic pendulum laboratory apparatus
- meter stick
- carbon paper
- plumb line

Procedure

- 1) Secure the catcher pendulum out of the path of the ball.
- 2) After having cleared the path of the ball, fire the gun and note where the ball lands.
- 3) Affix paper/carbon paper on the floor at the point of impact.
- 4) Fire the gun ten times, making sure that marks are being made on your paper.
- 5) Measure and record in a table the distance from the point directly beneath the release point of the ball to each of your ten marks.
- 6) Determine the average horizontal distance, x , that the ball travels.
- 7) Measure and record the vertical distance the ball drops. Use this height to calculate t according to $y = 1/2gt^2$.
- 8) Use this time and the average distance calculated in step 6 to calculate muzzle velocity according to $v_o = x/t$.