Physics 2020 Laboratory

Experiment 2: Constant Acceleration on an Inclined Plane

Objective

To test the equations of constant-acceleration motion by measuring the motion of a small toy car rolling down an inclined plane.

Introduction

An object moving with constant acceleration obeys the kinematic equation

$$x = x_0 + v_0 t + \frac{1}{2}at^2.$$

If the object begins at $x_0 = 0$ and is released from rest, so that $v_0 = 0$, this becomes

$$\boxed{x = \frac{1}{2}at^2}.$$

Solving for the acceleration gives

$$\boxed{a = \frac{2x}{t^2}}.$$

If a toy car rolls down a fixed inclined plane with approximately constant acceleration, measurements made over different distances should give approximately the **same value of** a.

At this point, we will not attempt to predict the value of the toy car's acceleration. Our purpose is only to determine experimentally whether the acceleration is approximately constant.

Equipment

- Small toy car (such as a Hot Wheels car)
- Track or other inclined plane

- Meter stick or measuring tape
- Stopwatch
- Block or other support for raising one end of the track

Experimental Setup

Raise one end of the track slightly so that the toy car rolls smoothly down the incline.

Choose a starting point near the upper end of the track and mark it as

$$x = 0.$$

Measure and mark three convenient distances down the track, for example,

$$x = 0.50 \text{ m}, \qquad x = 1.00 \text{ m}, \qquad x = 1.50 \text{ m}.$$

Use distances appropriate for the track available in the laboratory.

Do not change the inclination of the track during the experiment.

Procedure

1. Place the toy car at the $x = 0$ starting point.
2. Release the toy car **from rest**. Do not push it.
3. Measure the time required for the toy car to travel from $x = 0$ to the first marked position.
4. Repeat the measurement **three times** and calculate the mean time.
5. Repeat this procedure for the second and third distances.
6. For each distance, calculate the acceleration using

   $$a = \frac{2x}{t^2},$$

   where t is the **mean measured time for that distance**.

If a distance was measured in centimeters, be sure to convert it to meters before calculating the acceleration.

Data

Distance 1

$$x_1 = \underline{\hspace{4cm}} \text{ m}$$

Trial	**Time (s)**
1	
2	
3	

$$\bar{t}_1 = \underline{\hspace{4cm}} \text{ s}$$

$$a_1 = \frac{2x_1}{\bar{t}_1^2} = \underline{\hspace{4cm}} \text{ m/s}^2$$

Distance 2

$$x_2 = \underline{\hspace{4cm}} \text{ m}$$

Trial	**Time (s)**
1	
2	
3	

$$\bar{t}_2 = \underline{\hspace{4cm}} \text{ s}$$

$$a_2 = \frac{2x_2}{\bar{t}_2^2} = \underline{\hspace{4cm}} \text{ m/s}^2$$

Distance 3

$$x_3 = \underline{\hspace{4cm}} \text{ m}$$

Trial	Time (s)
1	
2	
3	

$$\bar{t}_3 = \underline{\hspace{3cm}} \text{ s}$$

$$a_3 = \frac{2x_3}{\bar{t}_3^2} = \underline{\hspace{3cm}} \text{ m/s}^2$$

Results

Distance x (m)	Mean time $\bar{t}$ (s)	Acceleration a (m/s^2)

Mean acceleration:

$$\boxed{\bar{a} = \underline{\hspace{3cm}} \text{ m/s}^2}$$

Questions

1. Were the three calculated accelerations exactly equal?

Yes No

2. Should you expect them to be exactly equal? Explain briefly.

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3. Does your experiment support the hypothesis that the toy car moved with approximately constant acceleration? Explain.

4. If the toy car is released from rest and moves with constant acceleration, doubling the elapsed time should cause the distance traveled to increase by what factor?

Factor: ______________

5. Why is it important to release the toy car without pushing it?

Experimental Uncertainty

Human reaction time in operating the stopwatch introduces uncertainty into the measured times. Other possible sources of uncertainty include friction, small irregularities in the track, and difficulty releasing the toy car in exactly the same manner for every trial.

6. Which source of uncertainty do you think had the largest effect on your measurements? Explain briefly.

Comparison with Other Groups

If different laboratory groups used different toy cars, compare your mean acceleration with the values obtained by one or two other groups.

7. Did all of the toy cars have the same measured acceleration on the incline?

Yes No

8. If the measured accelerations differed, give one possible physical reason why two toy cars might accelerate differently on the same incline.

Conclusion

Experimental mean acceleration of the toy car:

$$\boxed{\bar{a} = \underline{\hspace{3cm}}\ \mathrm{m/s^2}}$$

Does the experiment support the constant-acceleration model?

Yes	No