Demo 02-03 Rolling Ball Incline

In this demonstration a ball is rolled down an incline, illustrating motion with a constant acceleration. Lights located at carefully chosen points along the incline flash once per second, marking the position of the ball at one-second intervals.† The system is set up so that the first flash occurs at time $t=0$, just as the ball is released. *Figure 1* is a graph of position x versus time t for the rolling ball. By taking the difference between positions for two successive one-second time intervals, we obtain the mean speed of the ball as a function of time and plot it in *Figure 2*. Using measured $x(t)$ values at time intervals of one second,

$$\Delta x_1 = x(1) - x(0) = x(1) \qquad v_1 = \frac{\Delta x_1}{1s}$$

$$\Delta x_2 = x(2) - x(1) \qquad v_2 = \frac{\Delta x_2}{1s}$$

$$\Delta x_3 = x(3) - x(2) \qquad v_3 = \frac{\Delta x_3}{1s}$$

$$\Delta x_4 = x(4) - x(3) \qquad v_4 = \frac{\Delta x_4}{1s}$$

Taking the difference between speeds for two successive one-second intervals, we obtain the acceleration as a function of time and plot it in *Figure 3*.

$$\Delta v_1 = v_2 - v_1 \qquad a_1 = \frac{\Delta v_1}{1s}$$

$$\Delta v_2 = v_3 - v_2 \qquad a_2 = \frac{\Delta v_2}{1s}$$

$$\Delta v_3 = v_4 - v_3 \qquad a_3 = \frac{\Delta v_3}{1s}$$

† Sutton, *Demonstration Experiments in Physics,* Demonstration M-77, Timed-interval Inclined Plane, page 39.

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When plotting the values of x and v versus t-, we take care to plot each value at the center of the time interval covered. Thus v_1 is plotted at $t=\frac{1}{2}s$, v_2 is plotted at $t=1\frac{1}{2}s$ and so forth; a_1 is plotted at $t=1s$, a_2 is plotted at $t=2s$, and so forth, as indicated in *Table I.*

For this case the acceleration a_1 is constant, so the velocity v increases linearly with time,

$$v = at$$

and the position of the ball increases quadratically with time, so the position versus time graph is a parabola:

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

Table I

t (sec)	x (units)	v (units/s)	a (units/s^2)
0.0	0		
0.5		1	
1.0	1		2
1.5		3	
2.0	4		2
2.5		5	
3.0	9		2
3.5		7	
4.0	16		

Equipment

1. Inclined track with lights positioned at one, four, nine, sixteen, and twenty-five units, equipped with a ball catcher at far end of track.
2. A timing/release mechanism to permit the ball's rolling descent to begin at the same moment that the lights flash in unison.
3. A steel ball.
4. Magnetic strips of appropriate lengths to show all x's, Δx's, and Δv's.
5. Ferrous background for graphic display of strips.

Rolling Ball Incline

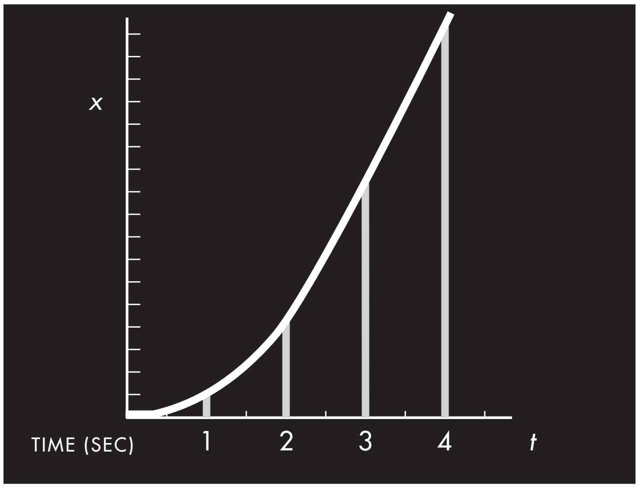

Figure 1

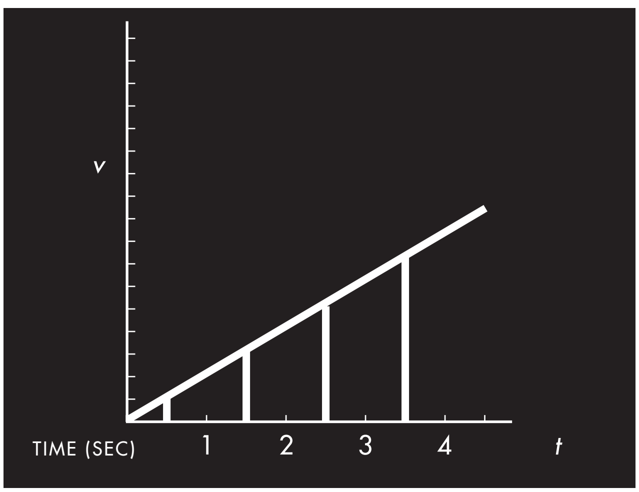

Figure 2

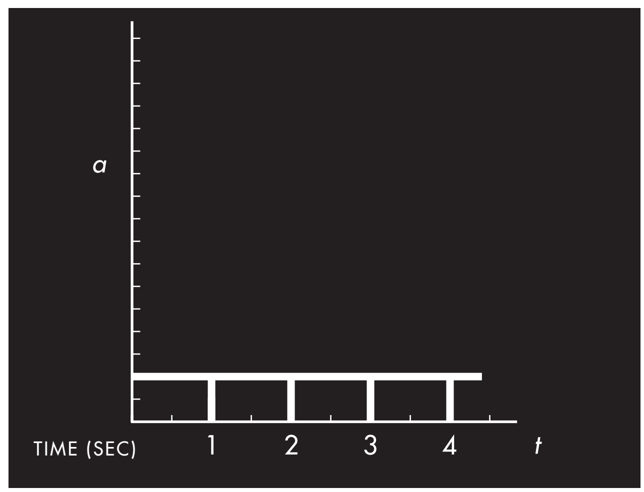

Figure 3

Demo 02-03 Rolling Ball Incline / Script

A ball rolling down a long incline will be used to show how position, velocity, and acceleration of the ball change as it moves down the incline.

Five lights arranged along the length of the track flash simultaneously once per second.

As the ball rolls down it is directly above each of the lights just as they flash. This gives us a record of the positions of the ball at one-second intervals.

This is how far the ball traveled in the first second.

This is how far the ball traveled in the first two seconds.

Three seconds.

Four seconds.

We will move this distance up to a graph to keep track of position vs. time.

Does position change linearly over time?

Next we will graph the average velocity of the ball during five different intervals to see how velocity varies as the ball rolls down the incline. The ball moved this far during the first second.

It moved this far during the next second.

This far during the third second.

The fourth second.

This gives us a graph of the velocity of the ball over time. Does velocity increase linearly?

Now we will graph the changes in velocity vs. time by graphing the differences in successive velocities.

What does this tell us about the acceleration of the ball?

The acceleration is constant.