2.3 Accelerated Motion

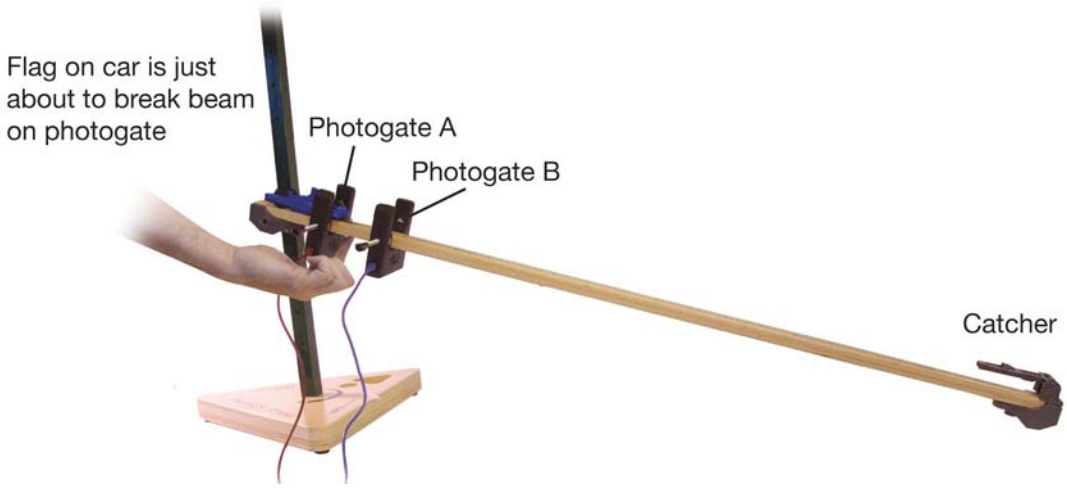
What happens to the velocity of an object as it moves downhill?

An object that is changing velocity is accelerating. By measuring an object's velocity and examining at how its velocity changes, the object's acceleration can be calculated. In this experiment, you will use two methods to calculate the acceleration of a car rolling down a track.

Materials List

- DataCollector
- Two photogates
- Distance-Velocity sensor
- SmartTrack
- Energy Car

1 Setting up the experiment



1. Attach the SmartTrack to the sixth hole from the bottom of the physics stand.
2. Position photogate A so it is attached at the 10 cm mark of the SmartTrack, and position the photogate B at the 20 cm mark on the SmartTrack.
3. Connect both photogates to the DataCollector.
4. Select timer mode on the DataCollector's home screen.
5. Select interval function by tapping on the "I" icon. "I" is short for interval. Interval function is the default function in timer mode, but check the menu bar at the bottom of the screen to ensure that the "I" icon is illuminated. The status bar at the top of the screen will say Interval.

2 Collecting data

1. Place the car with no marbles in it at the top of the SmartTrack and use the hold button on the underside of the SmartTrack to keep the car in place.
2. Release the hold button to allow the car to roll down the ramp.
3. Record the time (t_A) for the car to move through photogate A in Table 1.
4. Record the time (t_B) for the car to move through photogate B in Table 1.
5. Record the time (t_{AB}) for the car to move from photogate A to B in Table 1.

6. Move photogate B 10 cm down the ramp to the 30 cm mark. Release the car in the same manner as you did for the previous step. Record t_A, t_B, and t_{AB} for each trial in Table 1.
7. Repeat for a total of eight different A-to-B distances—10 cm to 80 cm.

Table 1: Distance and time data

Distance from A to B (cm)	Time through photogate A t_A (s)	Time through photogate B t_A (s)	Time from A to B t_{AB}(s)
10			
20			
30			
40			
50			
60			
70			
80			

3 Analyzing your data

Table 2: Velocity and acceleration

Distance from A to B (cm)	Velocity through photogate A (cm/s)	Velocity through B (cm/s)	Acceleration (cm/s^2)
10			
20			
30			
40			
50			
60			
70			
80			

a. Use the time through photogate A and the length of the flag on the top of the car (1 cm) to calculate the velocity of the car when it passed through photogate A for each trial. Record your result in Table 2.

b. Use the time through photogate B and the length of the flag on the top of the car (1 cm) to calculate the velocity of the car when it passed through photogate B for each trial. Record your result in Table 2.

c. Use the velocity at A, the velocity at B, and the time it took the car to move down the ramp (t_{AB}) to calculate the car's acceleration for each trial. Write out a sample calculation to show how you found the acceleration. Record your result in Table 2.

d. Were the calculated accelerations roughly the same or were they different? What does this tell you about the car's velocity as it rolled down the ramp?

4 Making and analyzing a graph

a. Make a velocity vs. time graph using your data. Plot the time from A to B on the *x*-axis and the velocity at B on the *y*-axis. Draw a best-fit line and be sure to label the axes and title the graph.

b. The slope of a line is found by dividing the rise (vertical change) by the run (horizontal change). What is the meaning of the slope of your velocity vs. time graph?

c. Should your graph show a straight line or a curve? What would be the difference between the two?

d. How does your answer to the previous question relate to the acceleration of the car that you calculated at the eight different locations on the SmartTrack?

e. Calculate the slope of your best fit line. Use the end points of your best fit line to calculate its overall slope. If the line made by your data is essentially straight, just use the velocities you calculated and the t_{AB} data you collected to determine the line's slope.

f. How does this value compare to the average of all the accelerations you calculated in Table 2?

g. Suppose the car had rolled along the ramp at a constant velocity. What would your velocity vs. time graph have looked like?

h. Suppose the car had decreased in velocity while rolling along the ramp. What would your velocity vs. time graph have looked like?

5 *Challenge*: Checking your data

a. What additional equipment and sensors do you have that may allow you to check the work you have done in this investigation up until this point? Describe the process you would follow to check the data you collected in part 2, and the calculations you made in part 3.

b. How could you check the graph you made in part 3? Describe the process you would follow to check your graph.

c. Follow your own steps and perform the checking activities you came up with above for your data, your calculations and your graph.

d. Describe how your data, calculations, and graph compare to the results you saw in your checking activities.

e. Discuss the possible causes of any discrepancies you may have found during your checking activity.

f. Is there anything you could have done differently to improve the accuracy or precision of your data collection in part 2?