Main Topic	Motion
Subtopic	Velocity, Acceleration
Learning Level	Middle
Technology Level	Data Logger
Activity Type	Student

Description: Use photogates to measure the instantaneous speed and average acceleration of a car rolling down a ramp.

Required Equipment	Physics Workshop Car & Ramp, Workshop Stand, Data Logger, Photogates
Optional Equipment	

Educational Objectives

- Use photogates to find the speed and acceleration of a moving car.

Key Question

- What is the instantaneous speed of a car on an inclined plane?
- What is the acceleration of a car on an inclined plane?

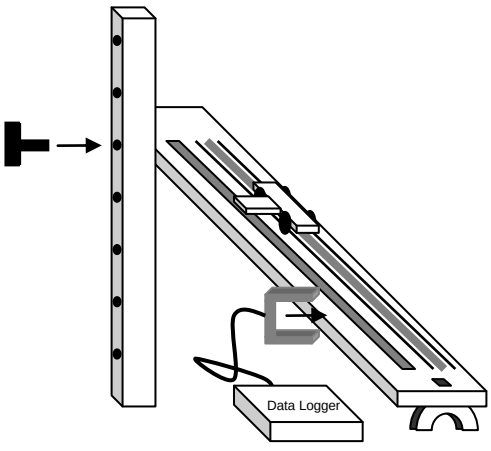
Concept Overview

This experiment will use photogates to find the speed and acceleration of a car rolling down a ramp. Photogates use a single beam of ultraviolet light which goes from one arm of the gate into a receiver in the other arm. A data logger connected to the photogate will record the time that the beam is blocked by an object passing through the gate. Photogates allow us to accurately measure times that would be too short to measure with a stopwatch.

Lab Tips

Assembly:

1. Push the attachment bolt through the Workshop Stand at the desired height of the top of the ramp.



2. Screw the bolt into the side of the ramp, tightening the ramp against the side of the stand.
3. Push the "foot" up through the hole in the bottom of the ramp.
4. Place the car on the ramp so that the wheels rest in the grooves and the rubber bumper extends down through the hole between the grooves. The bumper is designed to stop the car at the bottom of the ramp without allowing it to fall off.
5. Orient the car so that the side flag extends over the wide hole, toward the printed scale. This

flag will block a photogate beam so that students can find its speed at different points on the ramp.

6. The car is designed to accommodate the 500g and 200g masses from the Hooked Mass Set. Secure the masses by stretching the rubber band through the two top hooks and over the mass.
7. Arrange photogates so that the beam goes through the wide hole and will capture the motion of the car's flag as it moves. Support photogates with ring stands or by clamping them directly on the ramp.
8. The angle of the ramp can be adjusted simply by attaching it to different heights on the stand. Angles greater than 45° are not recommended due to possible damage to the car or ramp at the end of the trip.

 Name: _____
Class: _____

Car & Ramp: Speed and Acceleration

Objective: To use photogates to find the speed and acceleration of a moving car.

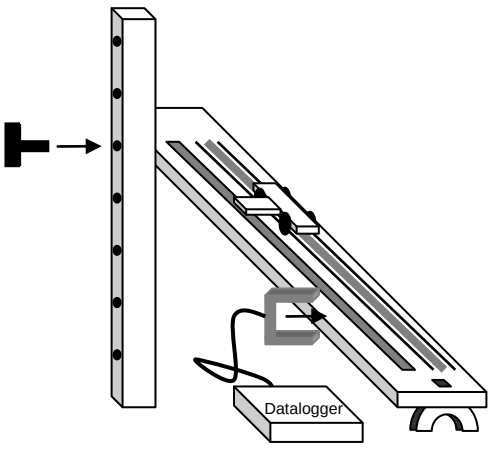
Materials: Workshop Stand, Ramp, Car, Bolt, EasySense Datalogger, 2 Photogates.

Background:

This experiment will use photogates to find the speed and acceleration of a car rolling down a ramp. Photogates use a single beam of ultraviolet light which goes from one arm of the gate into a receiver in the other arm. A datalogger connected to the photogate will record the time that the beam is blocked by an object passing through the gate. Photogates allow us to accurately measure times that would be too short to measure with a stopwatch.

Procedure:

1. Push the attachment bolt through the Workshop Stand, using the 5th hole from the bottom.



2. Screw the bolt into the side of the ramp, tightening the ramp against the side of the stand.
3. Push the "foot" up through the hole in the bottom of the ramp.
4. Place the car on the ramp so that the wheels rest in the grooves and the rubber bumper extends down through the hole between the grooves.
5. Orient the car so that the side flag extends over the wide hole, toward the printed scale.

Finding Speed

6. Place a single photogate at the 80-cm mark on the ramp.
7. Program the datalogger to measure the time that the photogate is blocked.
8. Hold the car at the top of the ramp and release it, so that the flag blocks the photogate when the car gets to the 80-cm mark.
9. Record the time that the photogate was blocked. _____
10. Roll the car back up to the photogate. Move it slowly toward the gate. Record the position of the front of the car when the flag begins to block the gate. _____

11. Record the position of the front of the car when the flag just leaves the gate. _____
12. How far did the car move while it was blocking the gate? _____
13. In general, the distance that you will use in calculations with photogate readings is the length of the object that blocks the light beam. In this case, that is the flag. Measure the length of the flag. _____ (Hopefully this agrees with your answer in #12.)
14. An object's speed is the distance it travels in a certain time. Calculate the car's speed as it passed through the gate.

$$v = \frac{d}{t}$$

15. Move the photogate to each of the positions indicated in the chart below. Record the time and calculate the speed at each point.

Photogate Position	Photogate Time	Distance (flag length)	Car Speed
30cm		5cm	
50cm		5cm	
70cm		5cm	

16. What happens to the car's speed as it goes farther down the ramp? _____

Finding Acceleration

17. An object's acceleration is the change in its speed over a certain amount of time.

$$a = \frac{v_2 - v_1}{t}$$

What was the car's acceleration between 30cm and 50cm? You already know the two speeds. Now you need to know the amount of time it took for the car to get from the first speed to the second one. To find that, you will need another photogate.

18. Position one photogate at 30cm and another one at 50cm.
19. Program the datalogger to record the time from one gate to the other.
20. Hold the car at the top of the ramp and release it. Record the time between the gates. _____
21. Use the speeds from the table above and the time from #20 to calculate the car's acceleration.

22. Now position the photogates at 50cm and 70cm, repeat the experiment, and calculate the acceleration again.

23. Compare the accelerations from #21 and #22.

_____
_____

Questions

1. How does a car's speed change as it rolls down a ramp?

_____
_____

2. How does a car's acceleration change as it rolls down a ramp?

_____
_____

3. How would the results of this experiment change if the flag on the car were longer? Explain.

_____
_____
_____
_____