Car & Ramp: Gravity & Motion

Main Topic	Motion
Subtopic	Gravity, Acceleration
Learning Level	High
Technology Level	High
Activity Type	Student

Description: Use components of gravity to predict the acceleration of a car on a ramp. Measure the acceleration with photogates.

Required Equipment	Workshop Stand, Ramp, Car, Bolt, Hooked Masses, EasySense Datalogger, 2 Photogates, Balance (electronic or triple-beam).
Optional Equipment	

Educational Objectives

- To investigate the effects of changes in mass and slope on the car's acceleration.
- To predict the car's acceleration using components of gravity.

Key Question

- How does changing a car's mass affect its acceleration when rolling down a ramp?
- How does changing the slope of the ramp affect a car's acceleration?

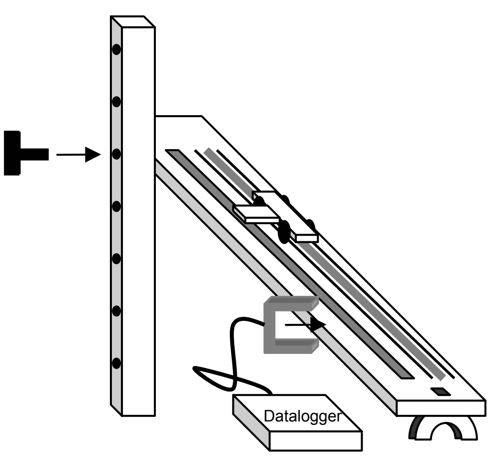
Concept Overview

When a car is on a ramp, a portion of its weight works to roll it down the ramp. Another portion works to hold it down to the ramp. These two portions, or component forces, are perpendicular to one another and can be found by using the car's weight and the angle of the ramp. If students wish to calculate the car's acceleration (as in this lab) they will notice that the mass term cancels out of their calculations, leaving only the angle and acceleration due to gravity. Students will predict the acceleration of a car on a ramp at different angles. Then they will measure the actual acceleration and evaluate their predictions.

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.

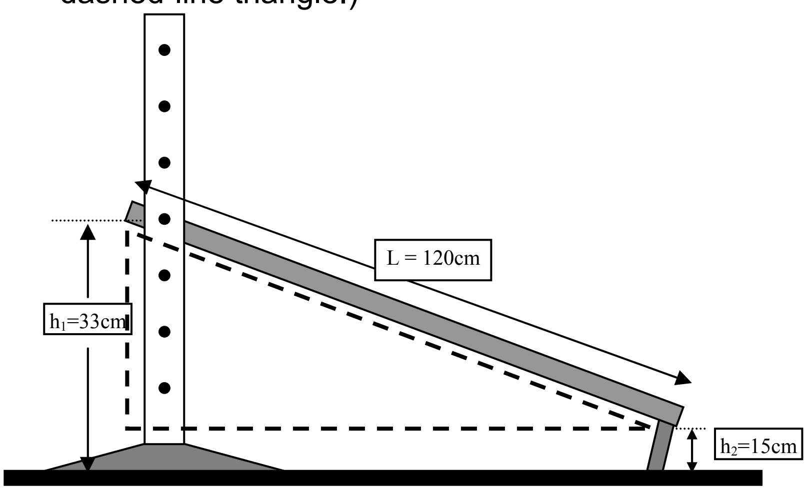
Car & Ramp: Gravity and Acceleration:
Predictions Using Components

Objective: To investigate the effects of changes in mass and slope on the car's acceleration.

Materials: Workshop Stand, Ramp, Car, Bolt, Hooked Masses, EasySense Datalogger, 2 Photogates, Balance (electronic or triple-beam).

Pre-lab Questions:

1. Find the angle at which the ramp in the diagram is inclined. (Hint: Use the dashed-line triangle.)



2. Give a general formula for the angle Θ in terms of h_1, h_2 and L.

3. For a 1kg mass sitting on the ramp above, find the component of the gravitational force which pushes it down the ramp.

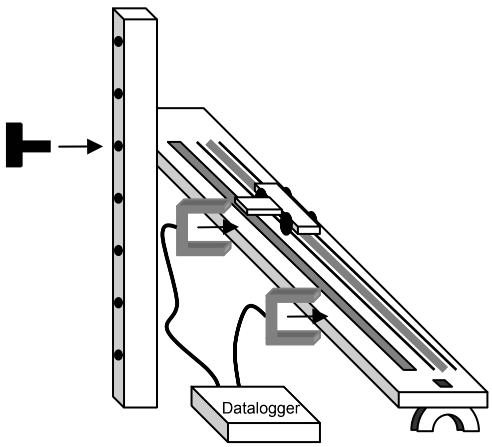
4. Calculate the acceleration of the mass in #3, neglecting frictional forces.

Physics Workshop Name: ___________________

Car & Ramp: Gravity & Acceleration Class: ____________________

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.

Predicting Acceleration

6. Calculate the angle Θ for the ramp attached to the 5th hole using the formula you developed in the pre-lab exercise.

7. Measure and record the mass of the car. __________
8. Record the weight of the car in N. __________
9. Calculate the component of the weight that causes the car to go down the ramp.

10. Predict the acceleration of the car.

11. Position one photogate at 30cm and another one at 70cm.
12. Program the datalogger to find the acceleration between the two gates.
13. Hold the car at the top of the ramp and release it. Record the car's acceleration. __________
14. How does your prediction compare with the experiment results? Describe possible sources of error.

15. Derive a formula for the car's acceleration in terms of only the angle Θ and g. (Use m*g to represent the weight. What happens to the mass term?)

Changing Slope

16. Predict the acceleration of the car as you attach the ramp to successively higher positions on the stand, as in the table below. Fill in the shaded columns. (You already have data for the first row.)

Hole #	h_1	h_2	L	Θ	Predicted Acceleration	Measured Acceleration
5						
6						
7						
8						
9						

17. Program the datalogger to find the car's acceleration as before and record the result in the table, repeating the experiment for the 6^{th}-9^{th} holes in the stand.
18. As the slope of the ramp increases, the car's acceleration __________.
19. On a separate sheet (or using a computer), make a graph of the height difference (y-axis) vs. the car's acceleration (x-axis).
20. Use your graph to predict the car's acceleration when the ramp is attached to:
    a. The 3^{rd} hole. __________
    b. The 10^{th} hole. __________
21. Measure the car's actual acceleration when the ramp is attached to:
    c. The 3^{rd} hole. __________
    d. The 10^{th} hole. __________
22. How accurate were your predictions? Explain. Compare the accuracy of calculated predictions vs. graphical predictions.

23. Identify sources of error. Be specific. (Do not just say "friction." Where is the friction?) What design features of this equipment are intended to reduce error?