Level A Investigations

A-1 Time and Distance

How do we measure the world around us?

This investigation is an introduction to using the CPO Timer. In addition, accuracy and precision in measurement is discussed along with metric and English systems of measurement.

A-2 Investigations and Experiments

How do we ask questions and get answers from nature?

Students learn how to identify the variables in an experiment. They also learn the basic principles behind experimental design including asking good questions, selecting the experimental variable, and controlling other variables.

A-3 Speed

What is the meaning of speed?

Students learn how to calculate the speed of the car as it rolls down the ramp. Through their exploration, they come to understand the meaning of speed.

A-4 Describing Motion

Does the speed of the car change as it moves down the ramp?

Students learn how to describe the motion of the car by calculating its speed and by graphing speed vs. time. Through their graph, they can see that the speed of the car is changing as it moves down the ramp.

A-5 Gravity

Does gravity cause cars of different weights to travel at different speeds as they roll down a ramp?

Students compare the speed of the car with different numbers of weights, graph the speed of the car vs. the number of weights, and calculate the change in speed of the car.

Level B Investigations

B-1 Time and Distance

How do we measure and describe the world around us?

This investigation is identical to the same title in Level A and should be used to introduce the CPO Timer and making accurate and precise measurements.

B-2 Investigating Speed

How do we ask questions and get answers from nature?

Students learn how to design and conduct good experiments by controlling variables in the car and ramp experiment. They learn how to calculate the speed of the car on the ramp and then design their own speed experiments.

B-3 Using a Scientific Model to Predict Speed

Can you predict the speed of the car at any point on the ramp?

Students measure the speed of the care at different points along the ramp. They make a speed vs. distance graph from their data and learn how to predict the speed of the car at other points on the ramp from their graph. They test their predictions and determine their percent error.

B-4 Distance and Time

How do you model the motion of the car?

Students model the motion of the car with a distance vs. time graph. They measure the slope of the graph at three different points and discover that the slope of the line is equal to the speed of the car on the ramp.

B-5 Acceleration

How is the speed of the car changing?

Students examine their data from Investigation B-4 and learn how to determine the acceleration of the car. They also learn how to determine the acceleration of the car from the speed vs. time graph.

B-6 Force, Mass, and Acceleration

What is the relationship between force, mass, and acceleration?

Students discover the mathematical relationship between force, mass and acceleration.

B-7 Weight, Gravity, and Friction

How does increasing the mass of the car affect its acceleration?

Students investigate how adding weight affects the acceleration of the car.

B-8 Equilibrium, Action and Reaction

What makes an object move?

Students learn that Newton's third law of motion explains the physics of common objects and activities. All forces come in pairs and that means whenever we push something, there is a reaction pushing back on us.

Level C Investigations

C-1 Uniform Accelerated Motion

How do we describe and predict accelerated motion?

Students derive and test a theory that predicts the speed, acceleration, and position of the car on the ramp.

C-2 Newton's Laws of Motion

What do the three laws of motion mean?

First, students explore the meaning of the first and third laws using the car and ramp. Next, they collect car and ramp data for force, mass, and acceleration. Finally, they derive the mathematical relationship between force, mass, and acceleration and describe how their findings support the second law.

C-3 The Inclined Plane

How is the angle of the ramp related to the motion of the car?

Students apply trigonometry and vectors to create a theoretical model for the motion of the car on the ramp. They investigate different models for friction and determine how friction affects motion. they incorporate friction into a theory which will predict the acceleration of the car to within 3%.

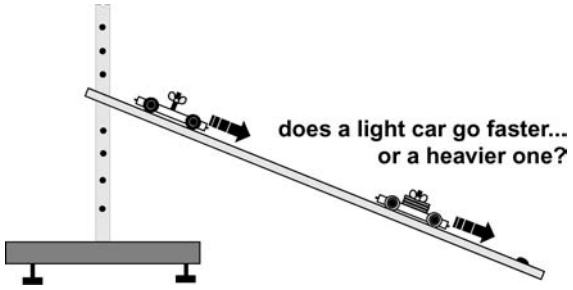
Question: How does increasing the mass of the car affect its acceleration?

In this Investigation, you will:

1. Explore how added weight affects a car's acceleration.
2. Discuss and learn whether or not heavier objects fall faster than lighter objects.
3. Investigate friction and how friction affects motion.

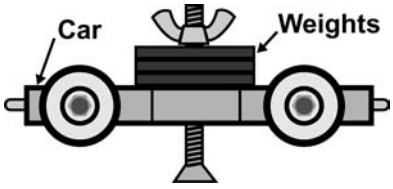
So far, you have learned that the car accelerates as it moves down the ramp. That is, its speed increases over time. In the last Investigation, you explored what happened to the acceleration of a car when more force was applied to it.

The force that you used in the last Investigation was gravity. Gravity pulls all objects toward the center of Earth with a force we call weight. The more mass an object has, the greater its weight. If you increase the weight of the car, how will acceleration be affected? Do heavier objects fall faster than lighter ones?



1 Do you think adding weights to the car will change its speed?

a. You can add up to three weights to the car for this experiment. Weights are attached to the top of the car using the wing nut.



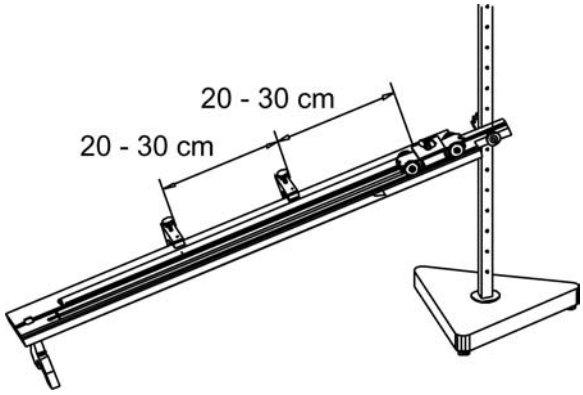
b. Roll a car down the ramp with different amounts of weight and watch it, without using photogates. Does the change in mass seem to make a difference in the speed?

Safety tip: Keep your fingers away from the ramp when the car is rolling. Especially, keep your hands away from the bottom of the ramp until the car stops.

2 Testing your hypothesis

It is difficult to know for sure that the car is going faster (or not) without making measurements. Set up the car and ramp with two photogates. The photogates should be about 20 centimeters apart. Set the angle at the seventh hole from the bottom of the stand.

You will want to measure the mass of the car with no weights, and with one, two, and three weights. On the data table, record the masses and the speeds at which the car rolled between the two photogates.



Mass and Speed Data

Mass (g)	Distance from A to B (cm)	Time from A to B (sec)	Speed (cm/sec)

3 Graphing and analyzing the data

a. Make a graph of speed vs. mass using your data.

b. Which is the dependent variable? On which axis does it go?

c. Which is the independent variable? On which axis does it go?

d. From your graph, what can you say about the effect of increasing mass on the speed of the car? Did the speed change by a lot or by a little? Did the mass change by a lot or a little?

4 Friction

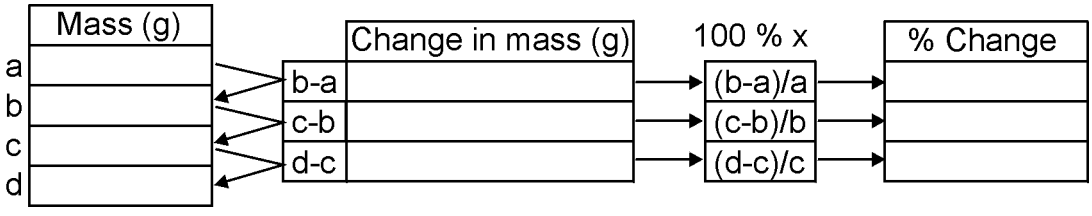
Try the following experiment. Take a steel weight and a flat sheet of paper. Drop them both and the steel weight will hit the ground before the paper every time. Next, crumple the sheet of paper and do the experiment over. They should hit the ground about the same time.

a. The crumpled paper has the same weight as the flat sheet of paper. What is the explanation for why the crumpled sheet fell fast and the flat sheet fell slowly?

b. The car has friction, even though the wheels have ball bearings. Can you think of a way to increase the friction in the car? See if you can create enough friction so the car does not accelerate, but keeps the same speed from one photogate to the next.

5 Thinking about the results

Suppose you have a jar of 1,000 marbles. If you lose one marble, it is hard to notice because 1 out of 1,000 is a small change. If you only had 5 marbles in the jar, you would immediately notice if one were missing because 1 out of 5 is a much larger change.



a. We often express change in percent. One out of 5 is a change of 20 percent ($1/5 \times 100\%$). The percent change is the change divided by what you started with, times 100 percent. Calculate the percent change for the weight experiment.

b. Does the percent change have anything to do with how much the speed changed as you added the second and third weights?

Name:

B-7 Weight, Gravity, and Friction

Question: How does increasing the mass of the car affect its acceleration?

1 Do you think adding weights to the car will change its speed?

a. You can add up to three weights to the car for this experiment. Weights are attached to the top of the car using the wing nut.

b. Roll a car down the ramp with different amounts of weight and watch it, without using photogates. Does the change in mass seem to make a difference in the speed?

2 Testing your hypothesis

Mass and Speed Data

Mass (g)	Distance from A to B (cm)	Time from A to B (sec)	Speed (cm/sec)

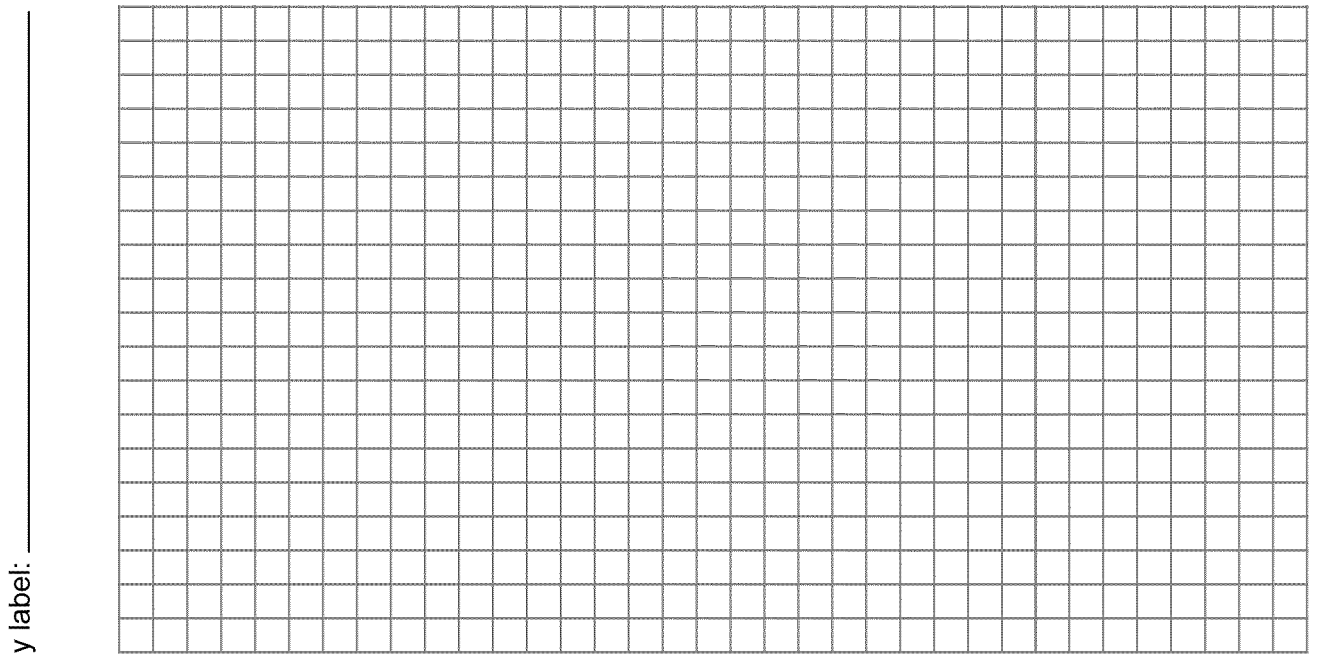
3 Graphing and analyzing the data

a. Make a graph of speed vs. mass using your data (the blank grid is on the next page).

b. Which is the dependent variable? On which axis does it go?

c. Which is the independent variable? On which axis does it go?

Title: _____



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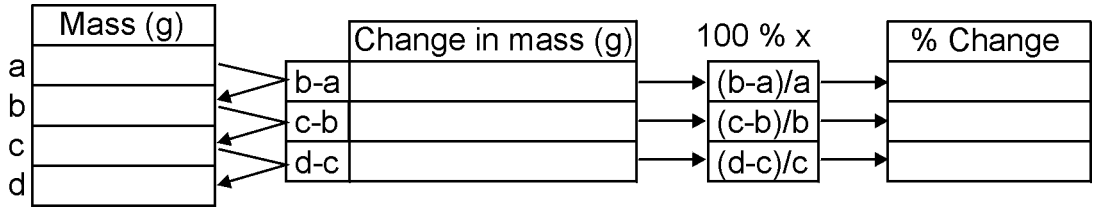

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b. Does the percent change have anything to do with how much the speed changed as you added the second and third weights?

Questions

1. What is the difference between the *mass* of an object and the *weight* of an object?

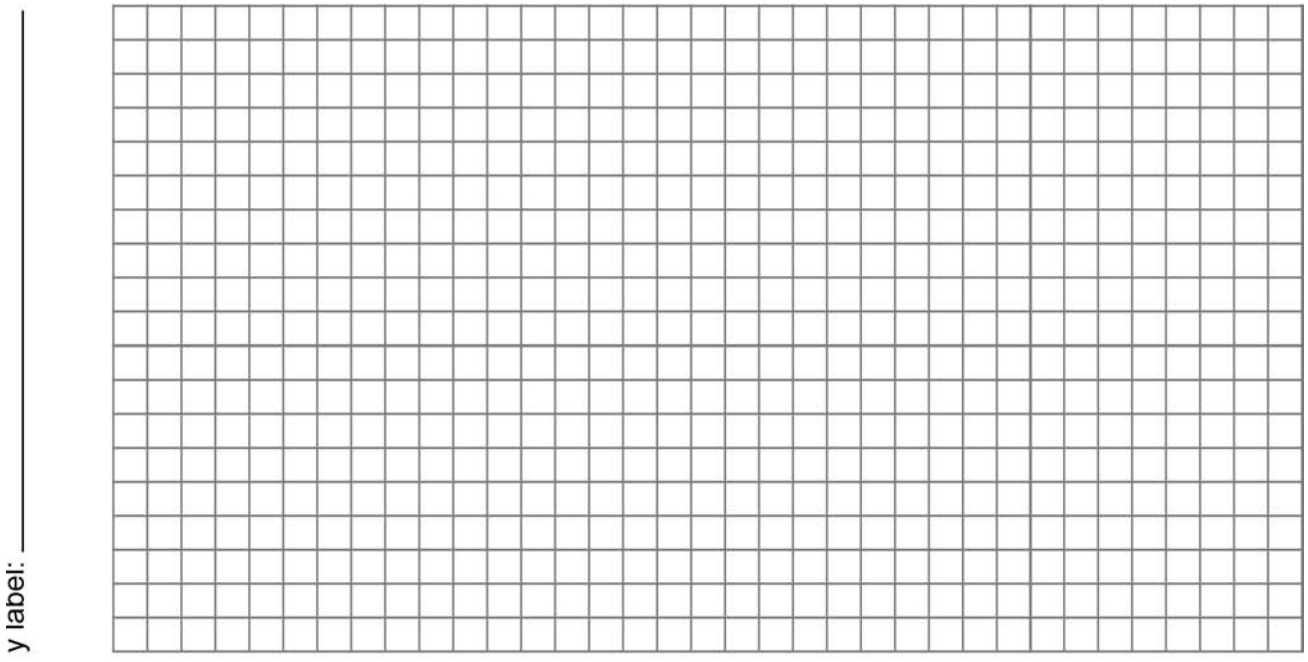
2. Sue is skateboarding on her sidewalk. Her speed as she crosses a "crack" (expansion joint) is 2.5 feet per second on the first block and 3.0 feet per second 5 blocks later. The per cent of increase in her speed is:

(a) 5% (b) 20% (c) 83% (d) 120%.

3. A group of students wanted to find out if heavier students would sled faster down a hill. Starting from the top of a hill, each student sled past a a friend who used a "speed gun" to determine their speed 20 meters after they have began to move. Prepare a speed vs. weight graph of their data.

Name	Speed (miles/hour)	Weight (pounds)
Seth	12	144
Leticia	16	121
Martin	18	154
Sandra	5	132
Kellie	18	112

Title: _____



x label: _____

Based on the data and your graph, can you reach a conclusion about weight and speed when sledding? Explain your answer.

Curriculum Resource Guide: Car and Ramp

Credits

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