

3A Positive and Negative Position

How do we measure position in two dimensions?

We often use positive and negative numbers to tell right and left or forward and backward. In this investigation you will be measuring distances in two dimensions around your classroom.

Materials

- Meter stick
- Index cards with directions and questions prepared in advance

1 Describing direction in two dimensions

Your *position* is your location compared to a starting point or *origin*. The origin can be any point you choose. For example, when giving the position of your school, you may choose your house to be the origin. The position of your school might be 2 kilometers east of your house. When specifying a position, both the distance and the direction must be given.

The compass directions north, south, east and west can be used to tell direction. Positive and negative x and y-coordinates can also be used to give directions. The x-coordinate tells the east-west position. East is in the positive direction, and west is in the negative direction. The y-coordinate tells the north-south position. North is in the positive direction, and south is in the negative direction. Coordinates can be written as an ordered pair (x,y).

For example, suppose the grocery store is 2 km east and 1 km south of your house. You would specify the position of the grocery store as (+2, -1) km.

2 Classroom scavenger hunt

1. Look around the floor of your classroom and locate the pieces of tape marked A, B, C, etc. Each of these letters will be used as an origin from which you will make measurements. The front of your classroom will correspond to north or +y direction.
2. Your teacher has a pile of index cards that correspond to the letters. Each index card has a letter on one side and instructions on the other side. Choose one of the index cards. Find the card's letter on the floor of your classroom.
3. Read the instructions on the card. The instructions will tell you the distance and direction you must walk from the origin. Once you reach the final position, answer the question on the card. Write your answer in Table 1.

Table I: Answers to card questions.

Origin point	Answer to question
A	
B	
C	
D	
E	
F	

4. Return the index card and choose another one. Complete cards A through F.

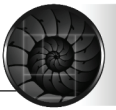
3 Thinking about position

- a. Which compass direction corresponds with the positive x direction? _____
- b. Which compass direction corresponds with the negative y direction? _____
- c. Which compass direction corresponds with the negative x direction? _____
- d. Which compass direction corresponds with the positive y direction? _____
- e. You start at the origin and walk 3 meters north and 5 meters west. What are your coordinates in (x,y) form?

- f. You start at the origin and walk 2 meters south and 1 meter east. What are your coordinates in (x,y) form?

- g. How would you walk to get to the position (-1,-4)m?

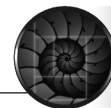
- h. How would you walk to get to the position (+2,-5)m?



4 Making your own scavenger hunt

1. Choose one of the lettered points in the classroom as your origin. Make a scavenger hunt card that gives directions from the origin to a destination in the classroom. Write a question to be answered at your destination.

2. Trade scavenger hunt cards with another group. Follow their directions and answer the question at the destination.



3B Position, Speed, and Time Graphs

What kind of motion happens when an object rolls down a hill?

Scientists and engineers use two graphs to quickly describe motion. One is the graph of position versus time. The other is the graph of speed versus time. In this investigation you will make both graphs for the car on the ramp.

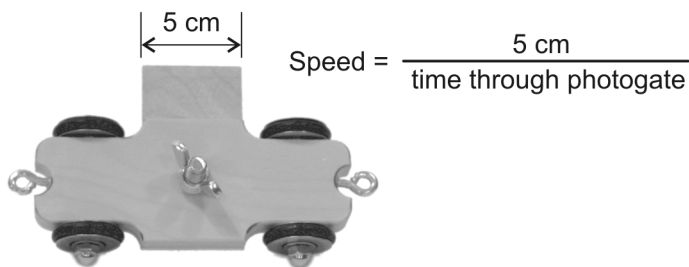
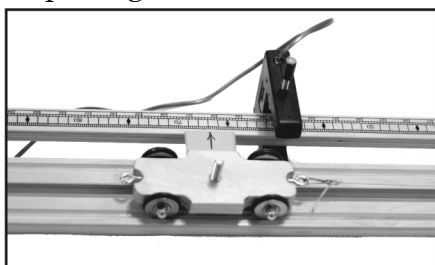
Materials

- CPO Timer and 2 photogates
- Car and ramp
- Physics stand

1 Finding the speed of the car at different points along the ramp

Using two photogates far apart gives you a measure of the average speed of the car between the photogates. The car could be going faster at the lower photogate and slower at the upper one. To get a true picture of how the speed of the car changes, you will need to measure the speed with one photogate.

The car going through one photogate

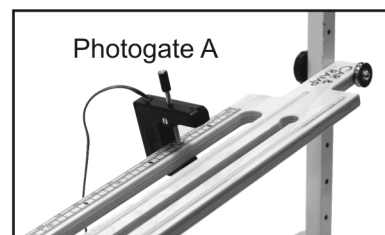


Remember, with one photogate the timers measure the time that the beam is broken. As the car passes through the photogate, the light beam is broken for the width of the wing. The speed of the car is the width of the wing (distance traveled) divided by the time it takes to pass through the light beam (time taken). The advantage to this technique is that it is easy to move a single photogate up and down the ramp to make measurements of the speed at many places.

2 Position versus time

1. Set up the ramp and physics stand at an angle given by your teacher.
2. Put photogate A at the 10 cm position.
3. Move photogate B to different positions 10 cm apart along the track.
4. For every position of photogate B, record the time through the beam at photogates A and B and also the time from A to B.
5. Take at least 8 data points along the ramp being careful to start the car the same way every time.

Set photogate A at 10 cm and leave it there for the whole experiment



Move photogate B in steps of 10 cm all the way down the ramp.

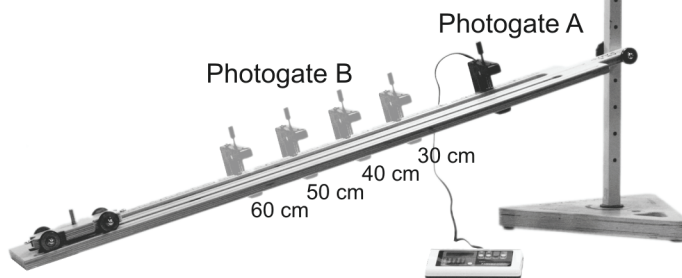
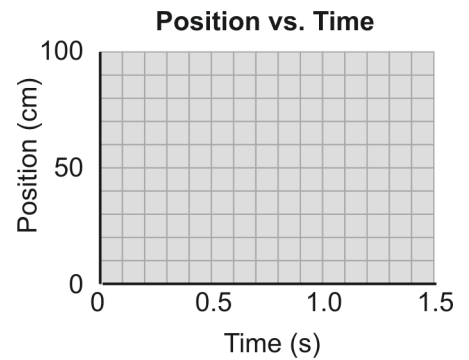


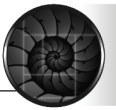
Table 1: Position versus time data

Position of photogate B (cm)	Time through photogate A (sec.)	Time through photogate B (sec.)	Time from photogate A to B (sec.)

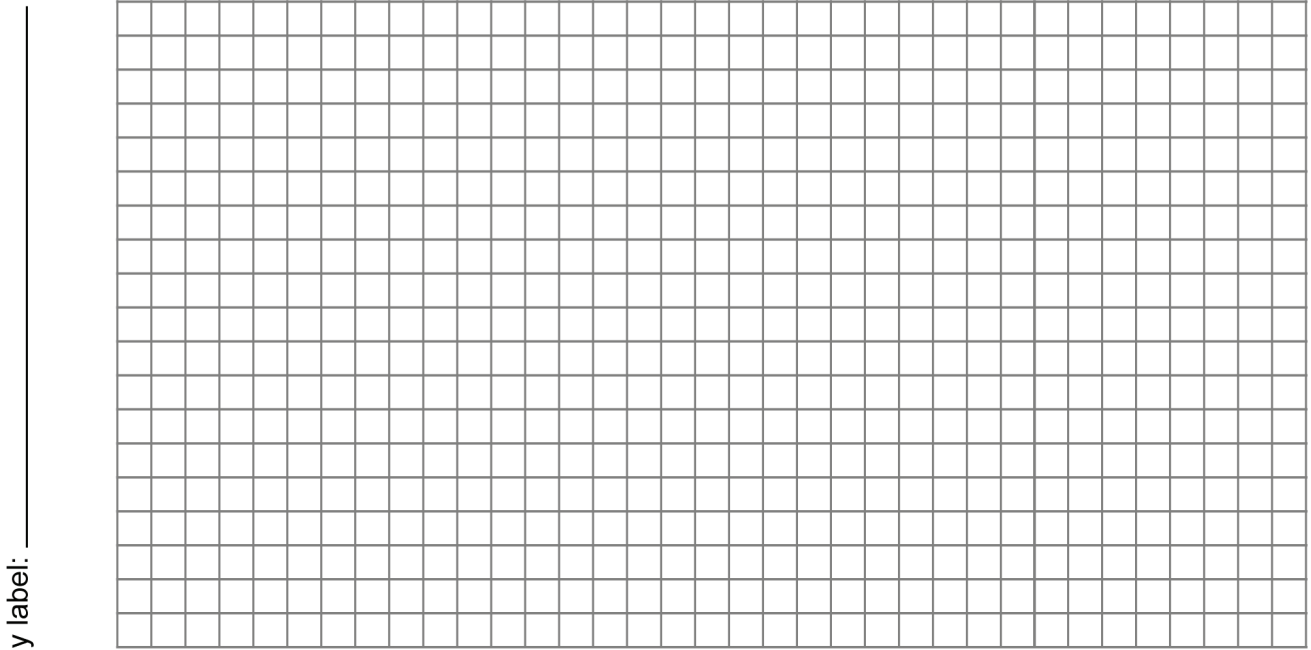
3 Making the position versus time graph

- a. The y-axis of your graph is going to be the position of photogate B. Choose a scale for the y-axis that goes from zero to your largest position.
- b. The x-axis of your graph is the time from A to B. Pick a scale for the x-axis that fits all your time data.
- c. Plot the position of photogate B versus the time from A to B.





Title: _____



x label: _____

4 Stop and think

a. What shape does the position versus time graph have? Your answer could use words such as “curved,” “straight,” “increasing,” or “decreasing.”

b. Calculate the average speed of the car from the graph or your data.

c. How long would it take the car to travel a distance of 2 meters at its average speed?

- d. You recorded the time from photogate A each time you moved photogate B. What do you notice about the photogate A times? How is this information useful?

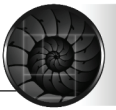
5 Find the car's speed from data in Table 1

Another way to describe the car's motion is to show how its speed changes with each new time interval from A to B. You will create a second data table, using some data from Table 1, and also entering some of your own calculations.

1. Copy the following data from Table 1 into Table 2: position of photogate B, time from A to B, and time through photogate B.
2. How far did the car travel as it went through photogate B each time? It is equal to the width of the car's wing. Record this distance in the third column of Table 2.
3. How fast is the car going at each photogate position? Calculate the speed of the car at each different position of photogate B. Use the distance and time you already have listed in Table 2 for your speed calculations. If you are confused about this calculation, re-read part 1 of this investigation for an explanation of how it works.
4. Go to part 6 to create your graph of speed versus time.

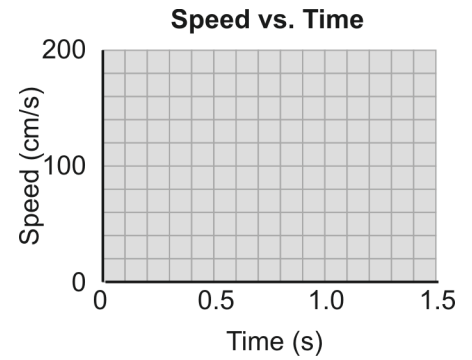
Table 2: Speed of the car at photogate B

Position of photogate B (cm)	Time from photogate A to B (s)	Distance car traveled as it went through photogate B (cm)	Time through photogate B (s)	Speed of car at photogate B (cm/s)

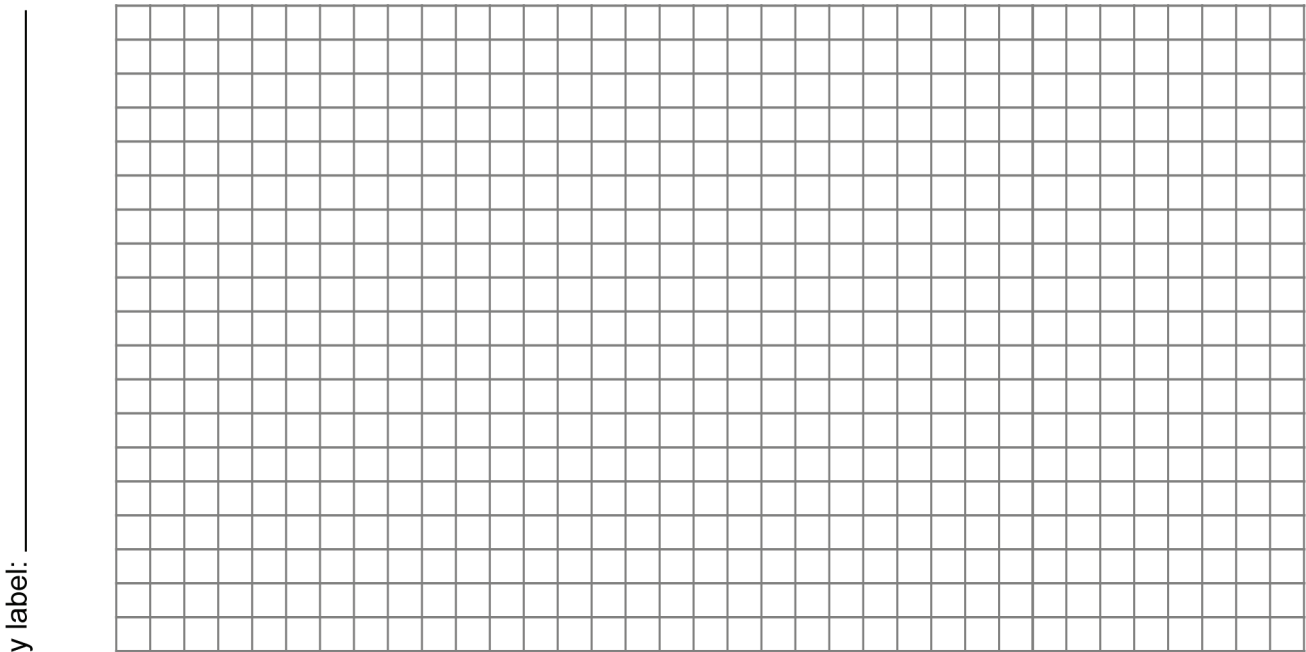


6 The speed versus time graph

- a. The y -axis of this graph is going to be the speed of the car at photogate B. Choose a scale for the y -axis that goes from zero to your largest speed.
- b. The x -axis of your graph is the time from A to B.
- c. Plot the speed at B versus the time from A to B.



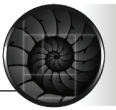
Title: _____



x label: _____

- d. What shape does the speed versus time graph have? Your answer could use words such as “curved,” “straight,” “increasing,” or “decreasing.”

- e. How does the speed of the car over the whole ramp compare to its average speed?



4A What is a Newton?

What is force and how is it measured?

You can think of force as a push or pull. Objects interact with each other (and you) through forces. It takes force to start an object's motion, and also force to stop an object in motion. This investigation will explore the precise definition of force and measure the strength of forces.

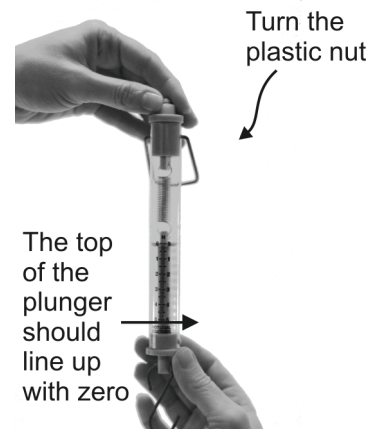
Materials

- Spring scale (0 - 5 N)
- 15 round metal washers (1/2 inch inner diam.)
- loop of string
- electronic scale (or triple beam balance)

1 Measuring forces

Forces have two important properties: strength and direction. In the English system of units, the strength of a force is measured in pounds. When you measure your own weight in pounds, you are measuring the force of gravity acting on your body. In the metric system, the strength of a force is measured in newtons (N). A quarter-pound hamburger has a weight of about 1 newton (1 lb = 4.448 N).

1. In the laboratory, you can measure force with a spring scale. Before using the spring scale however, you must be sure it correctly starts at zero. Calibrate the spring scale by turning the nut on the top until the plunger lines up with the zero mark.
2. Pull on the hook so the spring extends. When you pull, you are applying a force. Can you make a force of two newtons (2 N)?



2 Weight: the force of gravity

Weight is one of the most common forces. Objects that have mass can also have weight. Weight comes from the action of gravity on an object's mass.

1. Attach 3 steel washers to a loop of string.
2. Use a calibrated spring scale to measure the weight of the washers in newtons (N).
3. Use an electronic scale or triple beam balance to measure the mass in grams (g). Convert each mass in grams to kilograms (divide by 1000 or move decimal point three places to the left).
4. Repeat the experiment for 6, 9, 12, and 15 washers.



Find the weight in Newtons



Find the mass in grams, then convert to kilograms

Table 1: Weight and Mass Data

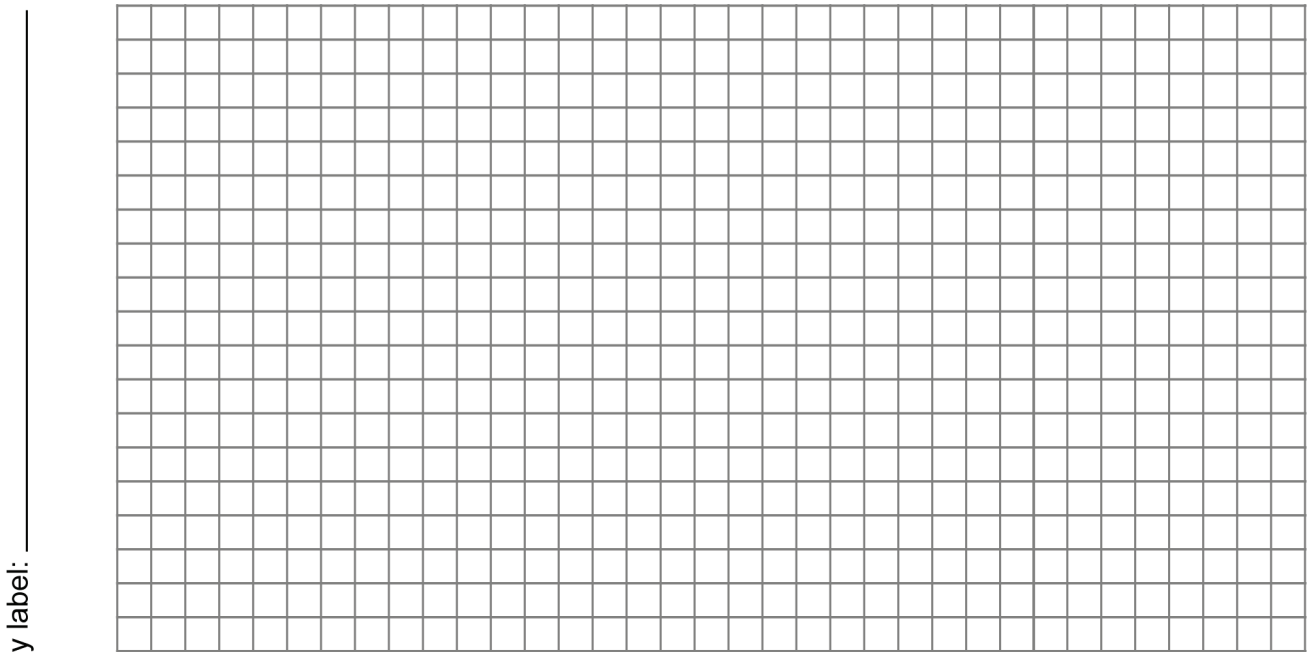
Number of washers	Weight (N)	Mass (kg)
3		
6		
9		
12		
15		

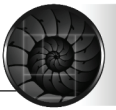
3 Stop and think

What do the results of your experiment tell you about the relationship between weight in newtons and mass in kilograms? Create a graph as described below to answer this question.

- a. Make a graph of your data from Table 1. Place weight on the y-axis and mass on the x-axis.

Title: _____





b. Describe the graph. What does it tell you about the relationship between mass and weight?

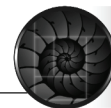
c. At Earth's surface, the strength of gravity is about 9.8 newtons per kilogram. What does this number mean?

d. If an object has a mass of 10 kilograms, how much does it weigh in newtons?

4 **Applying what you have learned**

a. Explain how you could estimate the weight and mass of seven of your steel washers.

b. Find the weight and mass for seven of your steel washers. How close is the actual value to your estimated value? Give reasons for differences.



4B Friction

How does friction affect motion?

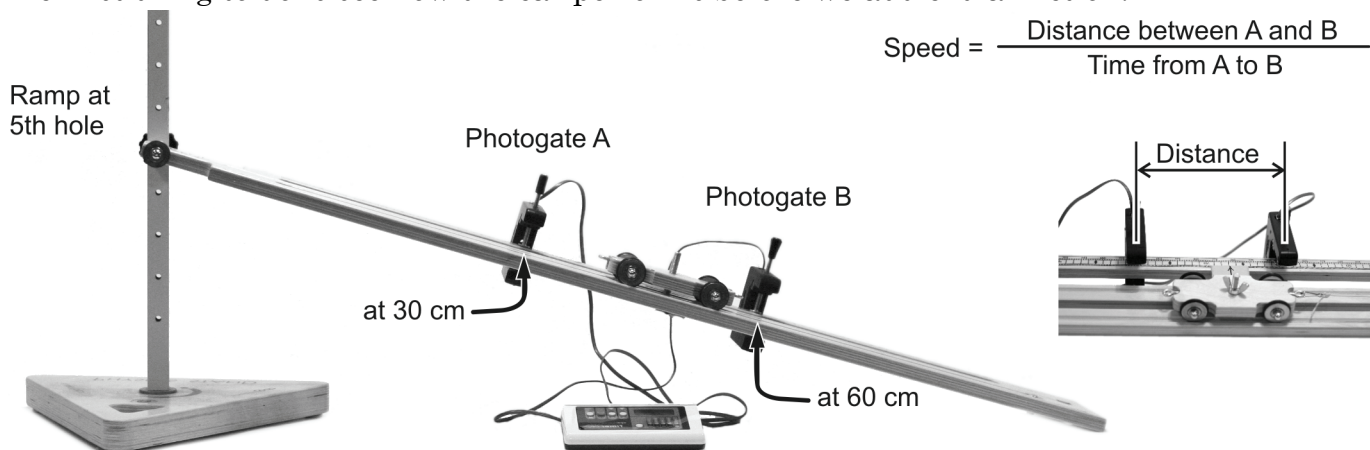
Friction is always present. It is a force that comes from motion — even through air! Sometimes friction is helpful — it's much easier to walk on a rough sidewalk than on a smooth patch of ice. Other times, we want friction to be small — oiling a bicycle chain reduces friction. This investigation will examine how air friction affects the car's motion on the ramp.

Materials

- Car and Ramp
- Physics Stand
- CPO Timer and photogates
- tongue depressor
- large paper plate
- tape

1 Control setup

The first thing to do is see how the car performs before we add extra friction.



$$\text{Speed} = \frac{\text{Distance between A and B}}{\text{Time from A to B}}$$

1. Attach the ramp to the physics stand at the fifth hole from the bottom.
2. Place photogate A at 30 cm, and photogate B at 60 cm.
3. Let the car roll down the ramp, and record the time from A to B.
4. Calculate the average speed of the car.
5. Repeat two more times, for a total of three trials.
6. Calculate the average speed from your three trials.

Table I: Control Speeds

Trial	Time A to B (s)	Speed (cm/s)
1		
2		
3		
Average Speed		

2 Create the “sail” car

A paper plate “sail” adds air friction (drag) to the car.

1. Tape a tongue depressor to the paper plate. Attach this assembly to the car as shown. Use enough tape to firmly attach the tongue depressor (remove the wing nut).



3 Your hypothesis

- a. Write a hypothesis that compares the speeds of the “sail car” and the normal car.

- b. Explain the reasoning behind your hypothesis.

4 Do the experiment

1. The ramp and photogates should be set up as in part 1.
2. Let the experimental car roll down the ramp, and record the time from A to B.
3. Calculate the average speed of the car.
4. Repeat two more times, for a total of three trials.
5. Calculate the average speed from your three trials.

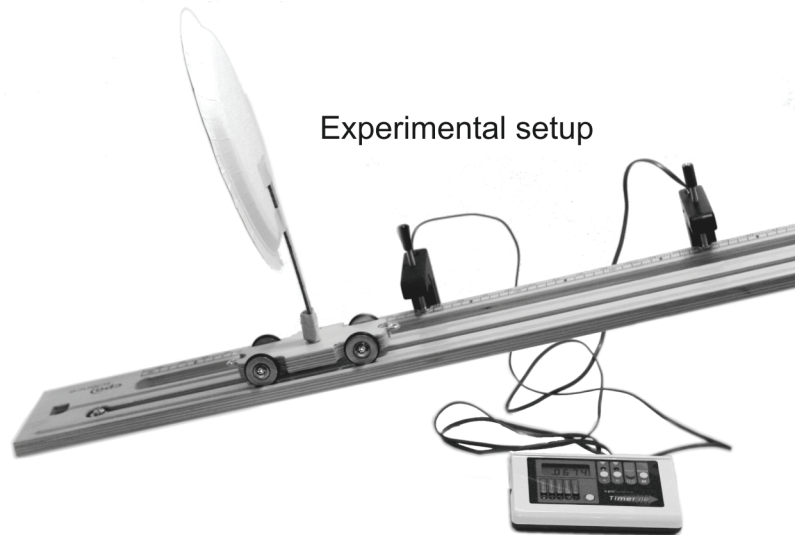
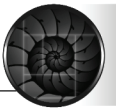


Table 2: Experimental Speeds

Trial	Time A to B (s)	Speed (cm/s)
1		
2		
3		
Average Speed		

**5 Stop and think**

- a. Did your results confirm your hypothesis? Explain.

- b. How did air friction affect the car's motion?

6 Applying what you have learned

- a. Friction is a force that opposes motion. Explain where the friction force on the sail comes from.

- b. Is the sail the only source of friction? Does the car have any friction forces acting on it other than air friction? Explain.
