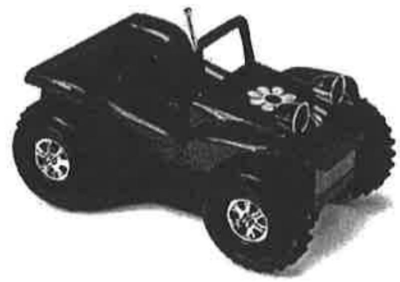
Constant Velocity Car

44-1090



BACKGROUND:

The Constant Velocity Car can be used as an introduction to motion and speed. The battery-powered car can be used for a variety of activities.

Here is a sampling of relevant national and state science education standards:

- An object's motion can be described by tracing and measuring its position over time.
- The motion of an object can be described by its position, direction of motion, and speed. That motion can be represented on a graph.
- Analyze examples of uniform and accelerated motion including linear, projectile, and circular.

PRODUCT INFORMATION:

The Constant Velocity Car requires 2 C batteries (not included). For some experiments, you may wish to have two different speeds available. You may cut a dowel rod the length of one battery. Cover it with 2-3 layers of aluminum foil. Replace one of the batteries with the dowel rod. Make sure that the aluminum foil contacts the battery and the copper contact at the end of the battery compartment. (It does not matter in which end the dowel rod is placed.) The car will now operate at a slower speed.

ACTIVITIES

- Use a Fiber Glass Tape Measure and Digital Stopwatch to measure the motion of the car. Divide distance by time to get the speed of the car. Try it with both speeds. Use the measurements as examples for speed problems. Have the students calculate how far the car will travel in a given time based on its speed.

- Use the car with the Electronic Spark Timer to measure the speed of the car. Tape ½ to 1 meter of Spark Sensitive Tape to the back of the car and feed it through the timer so that the car will pull the tape through the timer. Choose the 10 Hz setting on the timer. Turn the timer on then turn the car on and let it go. Because the car was stationary at the beginning, the first dots may not be distinguishable. Mark the first clear dot (2 side by side dots) as the 0 point. Have the students measure the distance (x) from 0 to each dot. You may also have them measure the distance between each successive point (Δx, 0 to 1, 1 to 2, 2 to 3, etc.). Make a data table and graph. The graph should be a straight line (or very nearly). The speed can be found at any point by dividing the Δx by 1/10 sec.(the time between dots). (See below)

  $$v = \frac{\Delta x}{\Delta t}$$

  The average speed can be found by dividing x by the total time traveled. (See below)

  $$\bar{v} = \frac{x}{t}$$

  You may repeat the experiment at a slower speed (see Product Information).

- Use the car with the **Go Motion Sensor** (P4-2400). The included software allows you to analyze and graph the motion of the car.

- Show independence of vectors. Put the car on a piece of poster board. Record the time that it takes to cross the board. Pull the board to the side at a constant speed. Record the time that it takes to cross. Show that the times are the same. You may also mark the starting and stopping points of each trial and show how the vectors for the board's velocity and car's velocity add to get the resultant velocity.

- Tie a string around the pole of a ring stand. Tie the other end of the string onto one side of the windshield of the car. The car will move in a circle around the ring stand. You now have a vehicle with constant speed and constantly changing direction. Therefore, it has a constantly changing velocity.

  Calculate the car's centripetal acceleration by using $a_c = \frac{v^2}{r}$ or $a_c = \frac{4\pi^2 r}{T^2}$

- Use the car to measure the coefficient of friction (μ). Put the car on a board. Turn the car on. Slowly raise the end of the ramp while the car goes up. You may have to pick up the car and return it to the bottom. Record the angle (θ) of the ramp when the wheels of the car start slipping. Use the angle to find the coefficient of static friction $\mu = \tan\theta$. To find the coefficient of sliding friction, start the ramp at a slightly higher angle than the one found for static friction. Start the car at the top of the ramp. The car should slide down the ramp. Lower the ramp slowly until the wheels are moving and slipping so that the car remains stationary on the ramp. Record the angle and use the same equation to find the coefficient of sliding friction. Alternatively, you may use a string to attach a *Spring Scale* to the headlights of the car. Turn the batteries around so that the car will run in reverse. Record the weight of the car (in Newton's) by hanging it from the scale. The normal force (F_N) is the same magnitude as the weight. Reset the zero on the scale and hold the end of the spring scale while the car pulls. With the wheels slipping and the car stationary, record the force on the spring scale (F_f). Use the equation $F_f = \mu F_N$ to find the coefficient of sliding friction. Try different surfaces.

- Remove the batteries. It does not matter how the switch is set. Push the car along a surface. The lights will still light up. The motor has become a generator. With the batteries still removed, use a wire to connect the battery terminals. Turn the switch to 'on' and push the car again. Now the lights do not light up. Why? The motor, lights, and battery terminals are wired parallel to each other. When a wire connects the battery terminals, there is much less resistance through the wire than through the lights. Not enough current flows through the lights to light them.

- Connect the alligator clip leads of a *Genecon Hand Generator* to the battery terminals. (This is not always easy. You may have to wedge one "jaw" between the contact and the side.) The clips should be entirely inside the battery compartment so that they do not hinder the motion of the car. Turn the handle of the Genecon. The car will move and the lights will light up. Turn the handle the other direction and the car will move the other direction. Push the car. The lights will light up and the handle of the Genecon will turn (but not much.)

RELATED PRODUCTS:

- Use a durable **Stopwatch/Timer** (52-3200) to measure the time for experiments.
- Instead of meter sticks, use a 1.5 meter **Fiber Glass Tape Measure** (01-3985) or a 10 meter **Wind-Up Fiber Glass Tape Measure** (01-3900) to measure distance.
- The **Electronic Spark Timer** (P1-8000) can be used to make measurements in motion experiments. It runs on a standard outlet and has two timing rates.
- Use a **Genecon Hand Generator** (P6-2631) to power the car instead of batteries. The Genecon can be used alone or with many available accessories to study electricity and energy.
- Use one of our durable **Spring Scales** (01-6960 through 01-6965, depending on strength) to measure the force from a Constant Velocity Car or many other forces.

ACKNOWLEDGMENT:

We would like to thank **Mark Davids** of **Grosse Pointe South High school** for contributing the *"Constant Velocity"* lab on the next page.

Constant Velocity Lab Name: ______________________________

PROCEDURE

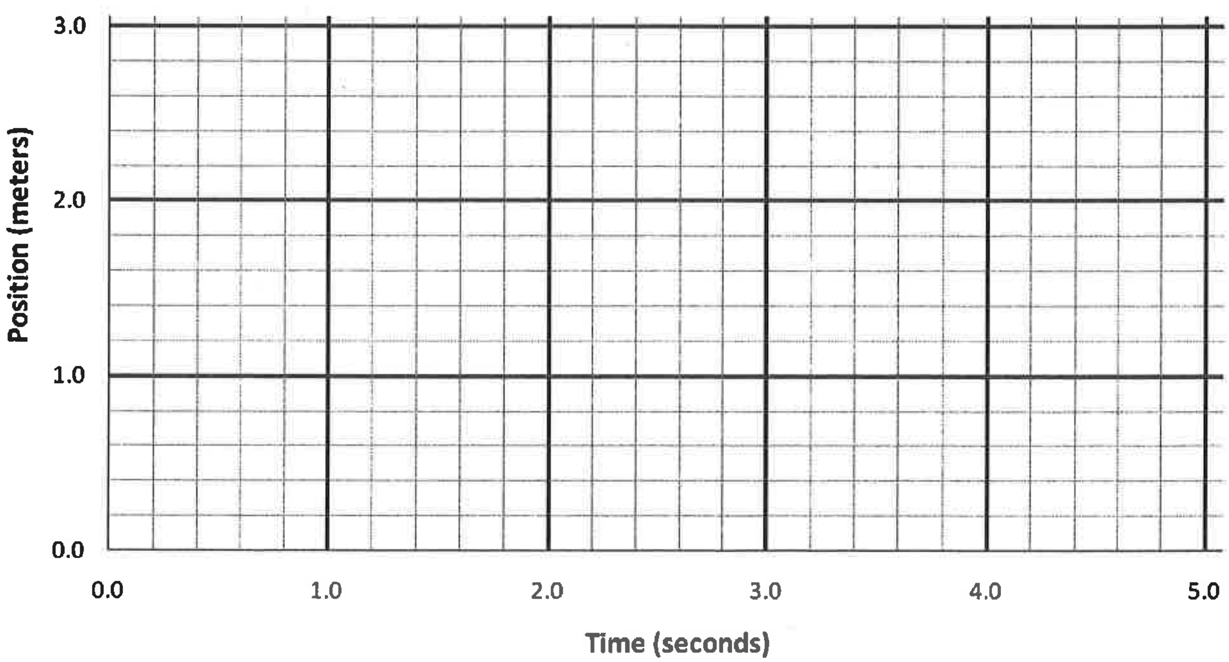
A stomper is a battery operated toy car. You will analyze the motion of the stomper as it moves across the floor. Start by drawing a line about 30 cm long on the floor with an erasable marker. This is your reference line. The reference line is defined as having a position of 0.0 meters. Your teacher will have a tone that sounds every 1.0 seconds. After turning on the stomper car, place it 10 to 15 cm (you don't have to be exact) <u>behind</u> the reference line. Release the stomper so it will move perpendicular across the line and then across the floor away from the line. After the stomper crosses the line, use an erasable marker to mark the position of the stomper each time the tone sounds.

MEASUREMENT

Label the first mark <u>past</u> the reference line as 0.0 seconds. Label the next mark 1.0 seconds, the next 2.0 seconds, etc. Use the meter stick to measure the distance of each mark from the reference line. Record each distance and time in the table below and graph your results in the space provided.

TABLE

Time (sec)	Position (meters)
0.0	
1.0	
2.0	
3.0	
4.0	
5.0	



 Name: ______________________

____

Analysis (All answers must be in complete sentences):

1. Do the data points fall on a straight line?

2. What does this tell you about motion?

3. Using a straight edge, draw the best straight line through the data points (the line does not have to go through all the points).

4. Find the slope of this "best-fit" line (do not use data points!!). Show the rise and run on the graph (make sure these points are as far away as possible from each other). Write the equation and show substitution – be sure to include your units in the calculation.

5. What is the word for the slope of a position vs. time graph? ____________________

6. Should your line go through the point (0,0)? Explain your answer?

7. Let's assume that you are going to conduct the same experiment again with the same stomper. In what ways would you expect the data to be similar and different from the experiment you have already conducted?

8. Let's assume that you conduct a similar experiment as the first, except this time you start the stomper several meters away from your reference line and have it move toward the reference line. Use a colored pencil to graph the predicted motion on the graph you already created.