Constant Velocity Car

44-1090

INSTRUCTIONAL GUIDE

Introduction

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 to demonstrate fundamental physical concepts like these:

- 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.

The Constant Velocity Car requires 2 **C batteries** (not included). For some experiments, you may wish to have two different speeds available. This is achieved by using one battery and a conductor like aluminum foil to complete the circuit. See #9 in the investigation for more details on how to do this.

Investigations

1. Use a tape measure and 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.

2. Use the car with the **Electronic Spark Timer (P1-8000)** to measure the speed of the car. Tape one meter of **Spark Sensitive Tape (P1-8000-01)** 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 point (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 #9)

3. Use the car with the **PocketLab Voyager 2 (P4-1001)**. The included software allows you to analyze and graph the motion of the car.

4. 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.

5. 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

$$a_c = \frac{v^2}{r} \quad OR \quad a_c = \frac{4\pi^2 r}{T^2}$$

6. 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:

$$\mu = tan\,\theta$$

7. 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 and insert a conductive spacer like a wedge of foil between the negative side of the batteries and the terminal 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 following equation to find the coefficient of sliding friction. Try different surfaces.

$$F_f = \mu F_N$$

8. Remove the batteries. 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.

9. 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.

10. Connect the alligator clip leads of a Genecon Hand Generator to the battery terminals. 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 (P6-2631)**. 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.)

Lab Procedure

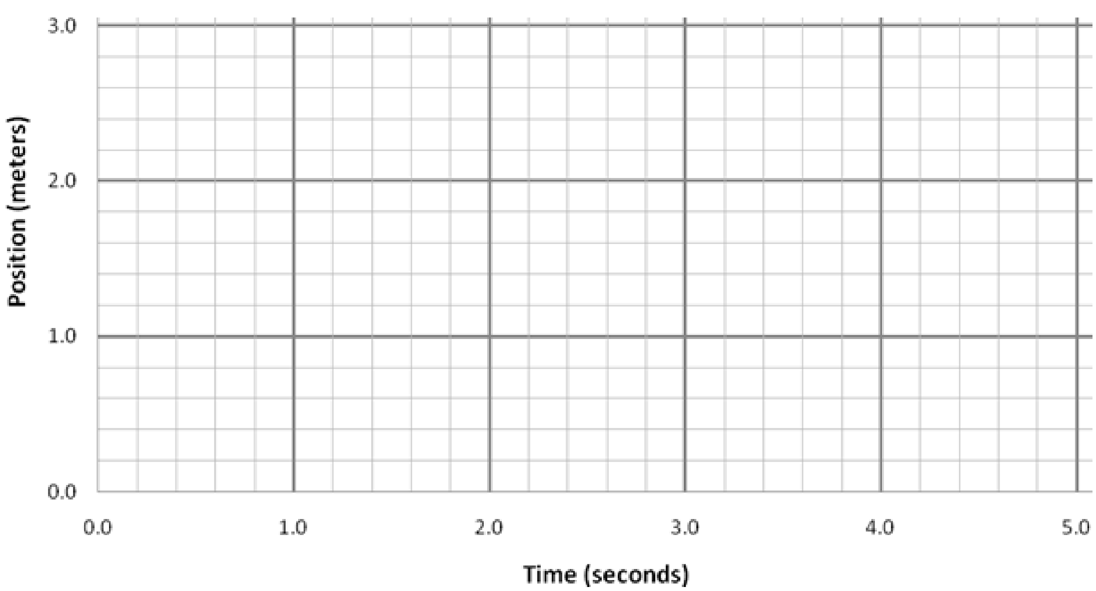
Analyze the motion of the Constant Velocity Car as it moves across the floor. Start by drawing a line about 30 cm long on the floor with an erasable marker. This is your reference line. The reference line is defined as having a position of 0.0 meters. Your teacher will have a tone that sounds every 1.0 seconds. After turning on the car, place it 10 to 15 cm (you don't have to be exact) behind 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.

Data Collection

Label the first mark past 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	



Data Analysis

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 car. 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 car 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.

Related Products

- Use a durable **Digital Stopwatch Timer (52-3200)** to measure the time for experiments.
- Instead of meter sticks, use a 1.5 meter **Fiber Glass Metric Tape Measure (01-3985)** to measure distance.
- The **PocketLab Voyager 2 (P4-1001)** can be used to make measurements in motion experiments. It connects with a single button to a smartphone, tablet, Chromebook or computer and instantly streams data that you can see and record.

Acknowledgment

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