# Investigating Velocity using the M-09 Fast and Slow Constant Speed Buggies

## OVERVIEW:

In this lesson, students will focus on motion at a constant velocity by measuring the average velocity of an electric toy car during five time intervals. Students will predict and experimentally compare how graphical data will change for cars at different constant velocities. After gathering distance vs. time data for both fast and slow cars, students will calculate the average velocity of each car by determining the slope of a position vs. time graph. Note that the motion in this lab is straight-line motion in one direction; the differences between distance, displacement, speed, and velocity will not be investigated in this lab. **Note: Either M-09-F or M-09-S may be used for this activity. The speed is varied by the number of batteries (see below).**

## TIME NEEDED TO COMPLETE ACTIVITY: 120 minutes

## MATERIALS (for each group):

M-09 Slow Toy Buggy (1) w/ 1 "C" battery
M-09 Fast Toy Buggy (1) w/ 2 "C" batteries

Conducting Material the length of one "C" battery. (Nail, screw, aluminum or copper rod, cardboard covered with foil (See #2 under Preparation)
Tape Measure(s)
Marker Sticks (6) or Tape
Stopwatch

## PREPARATION:

1. Find suitable areas in the classroom or hallway to create multiple 4-5 meter lanes.
2. The slow buggy runs using only one battery by substituting conducting material in place of the second battery. The fast buggy runs using two batteries. **Do not tell the students that the slow buggy has only one battery inside!** *Be sure that all buggies have new batteries before beginning the activity.*
3. Give each group only one buggy at a time, starting with the fast buggy and later exchanging it for the slow.

> ***Trouble-shooting tip****: If a buggy is moving backward, reverse the battery (+/- orientation). If a slow buggy runs continuously when the switch is off, move the battery to the other end.*

## PRE-LAB:

1. Depending on space and number of students, form 4-6 groups. In each group students will select
    - 1 student to operate the buggy
    - 1 student to operate the stopwatch
    - 1 students to place marker sticks
    - 1-2 students to measure distances between markers
    - 1 student to record the measurement

2. **Lead a discussion** about what measurements the students will need to take and outline a procedure for taking them. This discussion could first be done in small groups. A sample data table is shown on the next page. Other examples of data tables and analysis techniques are included in the addendum.

| Time Interval | Distance Traveled by Fast Buggy | Distance Traveled by Slow Buggy |
|---|---|---|
| 0 to 3 seconds | cm | cm |
| 3 to 6 seconds | cm | cm |
| 6 to 9 seconds | cm | cm |
| 9 to 12 seconds | cm | cm |
| 12 to 15 seconds | cm | cm |

3. Students should answer pre-lab question #2. The '**independent variable' is time** and the '**dependent variable' is distance**.

## LAB PROCEDURE:

Student Procedure #1: Observing the Motion of the Fast Buggy

Students will set the fast buggy in motion along the course as the 'time keeper' calls out time intervals of 0,3,6,9,12 and 15 seconds. As the times are called out, a student with marker sticks will place them on the floor next to the **buggy's rear tires**. **Students should observe the spacing between the markers to determine if the buggy is moving at constant velocity.** If not, they should re-examine their procedure, make adjustments, and repeat the exercise.

Student Procedure #2: Measuring the Motion of the Fast Buggy

Students then measure the distances between the markers and record on their lab sheet. A sample data table and data is shown below:

| Time Interval | Distance Traveled by Fast Buggy | Distance Traveled by Slow Buggy |
|---|---|---|
| 0 to 3 seconds | ***74 cm*** | ***42 cm*** |
| 3 to 6 seconds | ***69 cm*** | ***39 cm*** |
| 6 to 9 seconds | ***70 cm*** | ***35 cm*** |
| 9 to 12 seconds | ***75 cm*** | ***41 cm*** |
| 12 to 15 seconds | ***69 cm*** | ***38 cm*** |

Student Procedure #3: Graphing the Data

Students will create a graph of Total Distance vs. Time, remembering to add successive distances for each time interval. See the sample graph and addendum for techniques that will help students with the mathematics. Students should clearly draw and label the best-fit line or smooth curve.

Student Procedure #4: Predicting the graph of the Slow Buggy

Check student predictions individually, asking the reason for their prediction. Exchange the fast buggy for a slow buggy.

Student Procedure #5: Measuring the Motion of the Slow Buggy

Students follow the same procedure as the fast buggy.

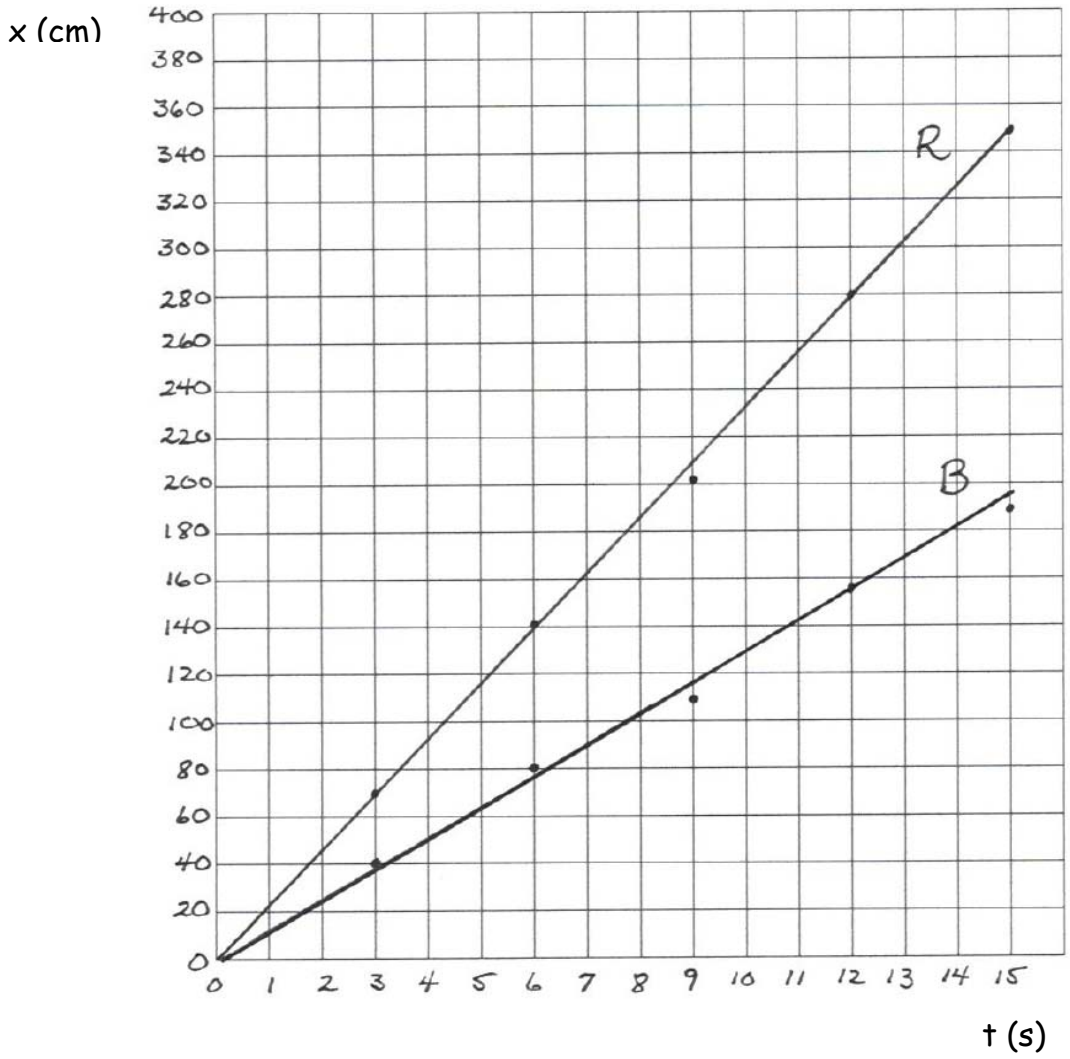
Student Procedure #6: Graphing the data

Students will draw and label a best-fit line or smooth curve.

Name: ***Sample Student Data/Graph***

*A proper title simply lists the y axis measurement vs. the x axis measurement*

Position vs. Time



## CALCULATIONS:

*SAMPLE:*

a. Displacement = ***350 cm***
b. Total Time = ***15 sec.***
c. Calculation of Average Velocity:

$$\text{Average Velocity} = \frac{350\ cm}{15\ sec} = 23\ \frac{cm}{sec}$$

## CONCLUSION:

The graph shows motion at constant velocity because the graph is linear. In other words, the distance traveled by the buggy was constant per unit time. The steepness of the line is directly related to the velocity of the buggy. The steeper the slope, the faster the velocity. In other words, the distance traveled by the faster fast buggy was longer than the slower slow buggy for the same time interval.

## POST LAB:

1. What could cause the fast buggy to go faster than the slow buggy? The students should brainstorm about how the buggies may be different. Encourage the students to discuss the forces or energy involved. After discussion, **reveal the mystery behind the fast and slow buggies by opening the battery compartment of each buggy**.

2. No student response for this question.

   Strobe Diagram for **fast buggy**:

3. a) Sample strobe diagram for **slow buggy**:

   b) Explain how you decided on the spacing between the cars:

   *Since the slow buggy is traveling half the velocity of the fast buggy, it travels half the distance in the same amount of time.*

4. Sample strobe diagram for **super fast buggy**: