Name(s): _____

_____

_____

_____

My Car is Faster than Yours!

You may have played with Hot Wheels or Matchbox cars when you were younger. Part of the fun may have been racing your cars against your friend's cars. Did you or your friend have a favorite car that was faster than the rest and almost never lost? In this lab we will explore reasons why your favorite car may have been so fast.
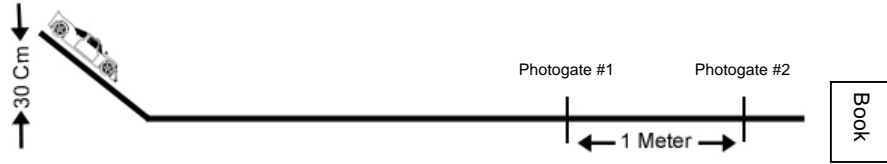

Figure 1

Objectives

- Measure the speed of Hot Wheels cars using Photogates.
- Determine whose car is fastest and give possible explanation why it is the fastest.
- Explore the relationship between speed and mass of Hot Wheels cars.

Materials

- ❑ TI Graphing Calculator
- ❑ LabPro Interface
- ❑ DataGate Program
- ❑ 2 Vernier Photogates
- ❑ Hot Wheels Track Set
- ❑ 4 Hot Wheels Cars
- ❑ Metal Physics Pole *or extra ring stand*

- ❑ 2 Ring Stands
- ❑ Buret Clamp
- ❑ 2 Thermometer Clamps
- ❑ Triple Beam Balance
- ❑ Meter Stick
- ❑ Textbook
- ❑ Penny & Tape

Vocabulary

1. During this lab you will need to be familiar with some vocabulary. Using your textbook please look up and enter the definitions to the following words.

Acceleration: _____

_____.

Force: _____

_____.

Mass: _____

_____.

Speed: _____

_____.

Velocity: _____

_____.

Weight: _____

_____.

Procedure

1. Working in groups of four, record the name, color, and weight of each of your four Hot Wheels cars in the data tables found on page 7.

2. Hypothesize with your group which car you think will be the fastest and why.

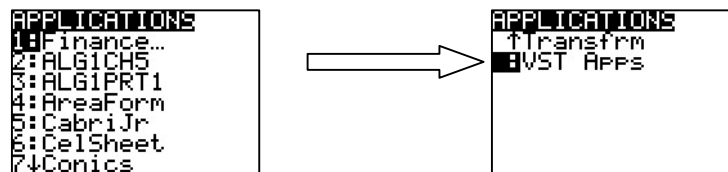   Hypothesis: If _____ (independent variable) _____

    _____

    _____, then _____ (dependent variable) _____

    _____.

3. Set up track as demonstrated by your teacher and as shown in Figure 1.

    a. Connect all segments (5 long and 2 short pieces) of track using the six track connectors.

    b. Place a metal physics pole into the socket at the far end of the lab bench. Attach a buret clamp to the pole. Attach the Hot Wheels track clamp to the buret clamp.

    c. Attach the track to the track clamp. Raise or lower the buret clamp until the track surface is elevated 30cm above the table top.

    d. Place your textbook at the end of the track to block the cars from falling onto the floor during the time trials.

4. Position the Photogates over the track so the cars roll through the two gates.

    a. Attach one photogate to each of the two ring stands using a thermometer clamp for each.

    b. Raise each photogate so that it is about 1cm above the table top. This height can be achieved easily by sliding the meter stick under the photogate since it is about 1 cm thick, while adjusting the thermometer clamp. When an object passes through a Photogate, it blocks the passage of light from one side to the other. *If the photogate is resting on the tabletop it will*
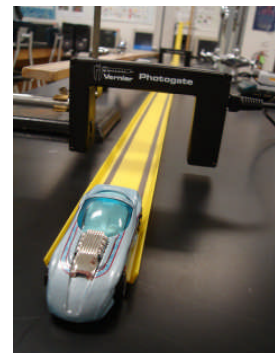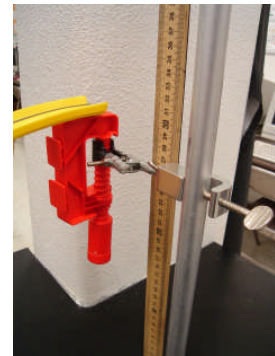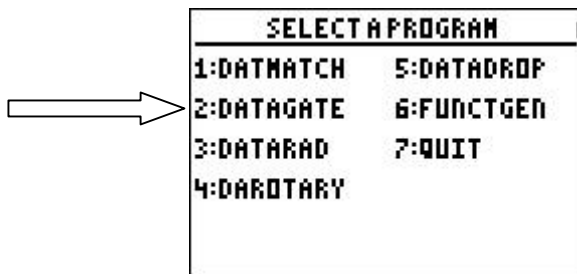
> *be too low and the walls of the Hot Wheel track will block the sensor. If the photogate is too high it may miss detecting your car altogether.*

   c. Position the Photogates so that they are exactly one meter apart from each other.

5. Photogate #1 is the gate closest to the top of the Hot Wheel track. Photogate #2 is the gate at the bottom of the track closest to the end. Connect Photogate #1 to the DIG/SONIC 1 port of the LabPro interface. Connect Photogate #2 to the DIG/SONIC 2 port of the LabPro interface.

6. Make sure that the car does not strike the side of either of the Photogates. Adjust the Photogates if necessary making sure that they are still one meter apart from each other.

7. Turn on the calculator and press the ⬭APPS⬭ button. Scroll down ⬇ until you see the VST Apps program. Select VST Apps and press ⬭ENTER⬭.

```
APPLICATIONS
1█Finance…
2:ALG1CH5
3:ALG1PRT1
4:AreaForm
5:CabriJr
6:CelSheet
7↓Conics
```
⟹
```
APPLICATIONS
↑Transfrm
█VST Apps
```

8. Press **2** on the calculator number pad to start the DATAGATE program.

```
    SELECT A PROGRAM      |
1:DATMATCH    5:DATADROP
2:DATAGATE    6:FUNCTGEN
3:DATARAD     7:QUIT
4:DAROTARY
```

Press ⬭CLEAR⬭ to reset the program.

9. Set up DATAGATE for the pulse mode.

   a. Press **1** to enter setup from the main screen.

```
DIG1:PHOTOGATE  --□--    |


MODE:MOTION
─────────────────────────
1:SETUP        4:ANALYZE
2:START        5:QUIT
3:GRAPH
```
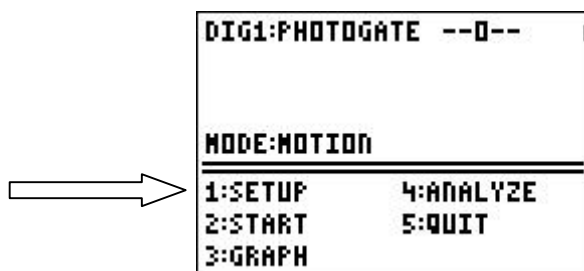
b. Press **4** to select Pulse mode from the PHOTOGATE SETUP screen. Pulse mode is used to measure the time between successive blocks of the two gates.
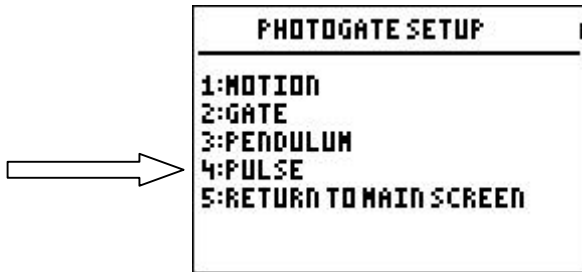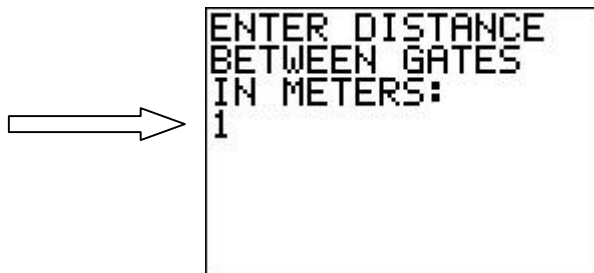
```
     PHOTOGATE SETUP      ▮

1:MOTION
2:GATE
3:PENDULUM
4:PULSE
5:RETURN TO MAIN SCREEN
```

c. Press **2** to select Two Photogates from the HOW MANY PHOTOGATES? screen.

```
HOW MANY PHOTOGATES?    ▮
1:ONE PHOTOGATE
2:TWO PHOTOGATES
```
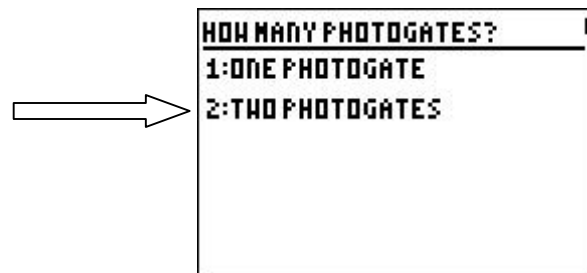
d. DATAGATE will prompt you to enter the distance between gates in meters. In two gate mode the distance between gates can be entered to calculate a velocity based on time interval. Enter the distance between gates as **1** meter and press ⬚ENTER⬚.

```
ENTER DISTANCE
BETWEEN GATES
IN METERS:
1
```

e. Press **1** for OK from the SETTINGS screen to return to the main screen.

```
        SETTINGS         ▮
MODE:PULSE- TWO GATES
DIST.BETWEEN GATES(M):
1



1:OK
2:CHANGE SETTINGS
```
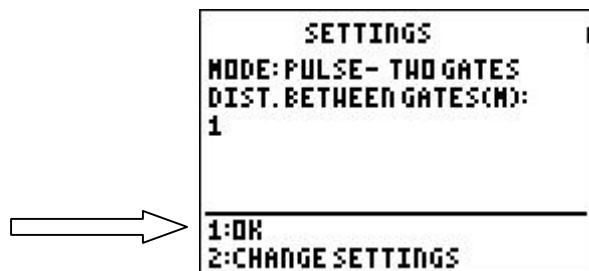
10. Observe the reading on the calculator screen. Block a Photogate with your hand; note that the Photogate is shown as blocked (--X--) on the calculator screen. Remove your hand and the display should change to unblocked (--0--).

```
DIG1:PHOTOGATE  --0--
DIG2:PHOTOGATE  --0--


MODE:PULSE
─────────────────────
1:SETUP      4:QUIT
2:START
3:GRAPH
```
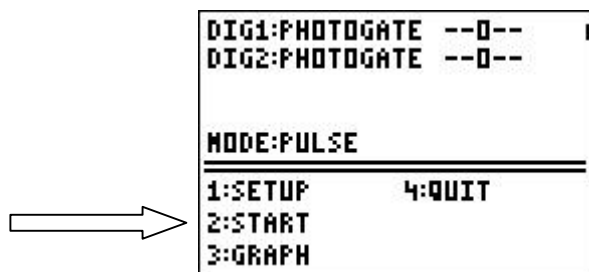
```
DIG1:PHOTOGATE  --X--
DIG2:PHOTOGATE  --X--


MODE:PULSE
─────────────────────
1:SETUP      4:QUIT
2:START
3:GRAPH
```

11. The calculator will measure the length of time between when the first photogate was blocked and when the second photogate was blocked. You can see how this works by sending a Hot Wheel car down the track. Prepare the calculator to do this.

   a. Press **2** to select START from the main screen.

```
DIG1:PHOTOGATE  --0--
DIG2:PHOTOGATE  --0--


MODE:PULSE
─────────────────────
1:SETUP      4:QUIT
2:START
3:GRAPH
```
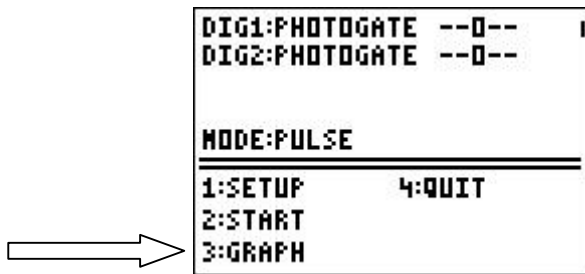
   b. Send a car down the track. Note that the Trial Number and Time(s) are recorded. Since this was the first time you sent a car down the track it is recorded as Trial Number 1 followed by the time interval in seconds (s) that it took the car to go through both gates. Send another car down the track and note that the calculator records the event as Trial Number 2 followed by a new time.

   c. Press ⬭STO▸ to end data collection.

12. **Lab Team Job Rotation.** Have one person release a car at the top of the track while one person at the bottom of the track uses the calculator, one person catches the car, and the fourth person records times on the data table. Rotate jobs after each person has completed the time trials for his or her car.

13. Please remember that when you "*release*" the car, you are letting go of the car, *__not__* "*pushing*" it down the track. Press **2** to START data collection. Send your first car down the track four times. Record each time interval in the Data Table for the first car. After the last trial, press ⬭STO▸ to end data collection and return to the main screen.

14. Press **3** to select GRAPH from the main screen.

```
DIG1:PHOTOGATE --0--    |
DIG2:PHOTOGATE --0--

MODE:PULSE
───────────────────────────
1:SETUP         4:QUIT
2:START
3:GRAPH
```

15. Select PULSETIME and press ⊂ENTER⊃. The Pulse Time graph gives you data points for each of your four time trials. You can move the blinking "x" cursor over the data point for each time trial by pressing the forward button ⊙ or the backward button ⊙. Note that the trial number appears on the x-axis and the time value appears on the y-axis. Compare these numbers with the times you entered into your data table. What did you discover?

    To exit the Pulse Time graph press ⊂ENTER⊃.

16. Select VELOCITY and press ⊂ENTER⊃. The Velocity graph gives you data points for each of your four time trials. You can move the blinking "x" cursor over the data point for each time trial just like you did on the Pulse Time graph. Compare these Velocity numbers with the times you entered into your data table. What did you discover?

    Enter the Velocity for each time trial into your data table.

    After you have recorded your velocity data into your data table press ⊂ENTER⊃ to exit the Velocity graph.

17. Inspect your data. Did you get the same value every time?   Determine the average, maximum, and minimum times and velocities, and enter them in your Data Table. To calculate the average for each car add the four time trial values together and divide by four. What one value would be most representative of all four measurements?

18. Press **1** to return to the main screen. Repeat steps 12 – 17 for the remaining three Hot Wheels cars.

Data Tables

Car #1

Trial	Time (s)	Velocity (m/s)
1		
2		
3		
4		
Average		

Car #1 (name)	
Color	
Weight	grams
Maximum Time	(s)
Minimum Time	(s)
Maximum velocity	m/s
Minimum velocity	m/s

Car #2

Trial	Time (s)	Velocity (m/s)
1		
2		
3		
4		
Average		

Car #2 (name)	
Color	
Weight	grams
Maximum Time	(s)
Minimum Time	(s)
Maximum velocity	m/s
Minimum velocity	m/s

Car #3

Trial	Time (s)	Velocity (m/s)
1		
2		
3		
4		
Average		

Car #3 (name)	
Color	
Weight	grams
Maximum Time	(s)
Minimum Time	(s)
Maximum velocity	m/s
Minimum velocity	m/s

Car #4

Trial	Time (s)	Velocity (m/s)
1		
2		
3		
4		
Average		

| Car #4 (name)	
Color	
Weight	grams
Maximum Time	(s)
Minimum Time	(s)
Maximum velocity	m/s
Minimum velocity	m/s

Notes

Speed and velocity are rates. They tell us how much distance is covered in a unit of time. Velocity can be expressed by the formula

$$v = d/t$$

where v = velocity or speed (in m/s), d = distance traveled (in meters), and t = time (in sec). In this experiment, we study the velocity of a Hot Wheel car after it is released from the top of the track. The two photogates are used to measure the car's velocity.

Analysis

1. Using the grid below make a bar graph to show the average times paired with the average velocities of all 4 cars. Label the parts of your graph.
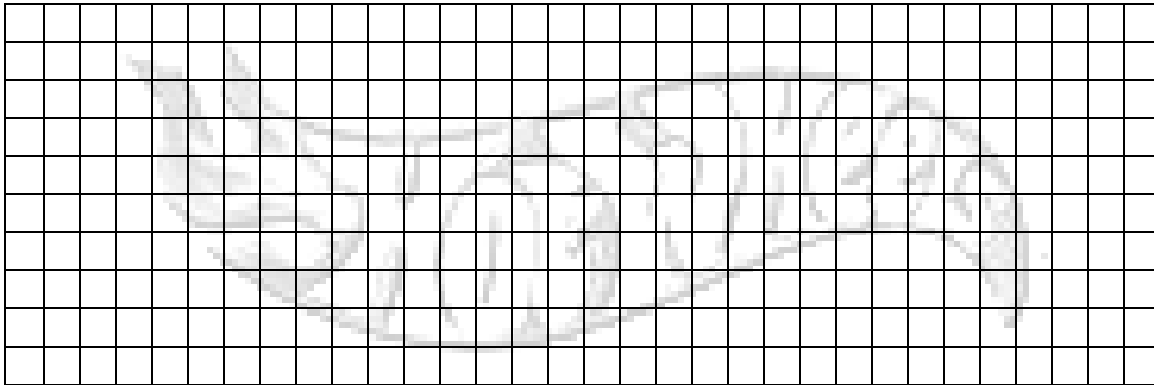
2. Discus your conclusions. Was your hypothesis correct? Why or why not?

3. Newton's first law of motion states that an object at rest will remain at rest. And an object that is moving at constant speed will continue moving at constant speed unless acted upon by an unbalanced force. When you released your Hot Wheel car at the top of the track what unbalanced force caused your car to go down the track?

4. Newton's second law of motion is best stated in the form of the equation:
   Force = Mass X Acceleration
   What role do you think mass or weight played in the outcome of your time trials?

5. Change the weight of your Hot Wheel car by taping a penny to it. Does the penny increase your car's speed? Explain.

6. Compare the Pulse Time (s) and Velocity (m/s) data for each of your cars. The time trial that gave the Minimum Time (s) for each car also produced the car's _____ Velocity (m/s). Explain how these results are related.