

Activity 8

Seven Speedy Pieces

Math Concepts

- ◆ Measurement
- ◆ Data analysis

Science Concepts

- ◆ Data collection
- ◆ Physical science

Materials

- ◆ TI-73, CBL™, CBR™, data link cable, and CBR to CBL link
- ◆ Ramp at least 1.5 meters long
- ◆ A meter stick
- ◆ Masking tape
- ◆ 7 toy rolling cars small enough to fit on the board

In this activity you will:

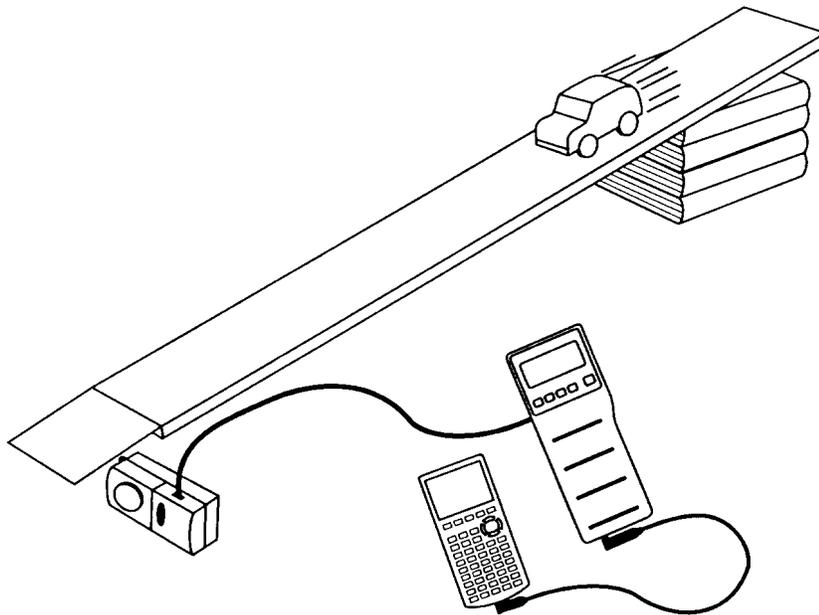
- ◆ Collect data with the CBR and construct graphs
- ◆ Estimate distances and take measurements and read decimal values from a gauge
- ◆ Experimentally determine the effect of position up an inclined plane in relation to the coasting distance traveled

Introduction

Most of you have peddled a bicycle up a hill in anticipation of making it to the top and then getting to coast down. What a great feeling to get to relax and enjoy the ride down without having to peddle. When you arrive at the bottom of the hill and are riding on flat land, how far can you travel before you have to start peddling again? There are many factors that determine your coasting distance. Would coasting distance be important enough for automobile manufacturers to research? How could coasting distance affect a car's performance? In this activity, you will investigate different toy cars and their coasting distance.

The Problem

Our hypothesis: The distance up an inclined board will affect the coasting distance of a car. The increase in coasting distance will be predictable by moving the given car up the inclined plane. You will determine the car(s) with the greatest coasting distance at three different positions on the inclined plane.



Activity

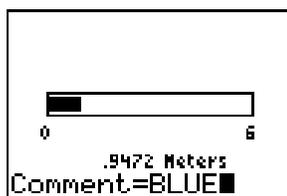
Collecting Data

1. Attach the TI-73 to the CBL™ and CBR™.
 - a. Connect the calculator link cord into the port at the bottom of the TI-73 and the other end into the bottom of CBL.
 - b. Connect the CBL to the CBR.
 - c. Use the CBR to CBL link cord and plug into sonic port on CBL.
 - d. Plug the other end in the slot on right side of CBR unit.
 - e. Place the CBR at the bottom of the ramp so that it may record the distance that the cars coast after leaving the ramp.
2. You will use the data collection equipment in Multimeter/Gauge mode to find the distances traveled for the seven cars.
 - a. With the CBL turned on, press **[APPS]** on the TI-73, from the **APPLICATIONS** menu select **2:CBL/CBR** and press any key.
 - b. From the **CBL/CBR APP:** menu select option **1:GAUGE**.
 - c. Highlight the following, leaving the cursor on **GO** at the bottom.

```

PROBE:Temp Light
Volt Sonic
TYPE: Bar Meter
MIN:0
MAX:6
UNITS: █ Ft
DIRECTNS: █ Off
GO...
    
```

3. The rear end of the car being tested should be placed on the 0.5 meter start line.
 - a. Release the car.
 - b. Press **[ENTER]** on the TI-73 after the car has stopped.
 - c. Make sure the distance on the gauge bar seems reasonable and is steady.
 - d. When ready, press **[ENTER]** again to capture and store this distance in meters and then next to **Comment =**, type in the name of the car (using the text editor). No quotes are needed.
- Record the data on Table 1 of the student data sheet for the first car.



4. Repeat with cars 2 - 7.
 - Record distances traveled in Table 1 of the student data sheet.

The gauge creates a categorical list called **DCMNT** containing the names of the cars and a second list called **DIST** containing the coast distances. This **DIST** list must be saved using another name or it will be overwritten with new data containing the coast distances.
5. To create a new list:
 - a. Display the list editor by pressing **[LIST]**.
 - b. Use the cursor keys to move to the first blank unnamed list.
 - c. Use the text editor to name the list **HALFM** to represent half of a meter up the ramp.
 - d. With the cursor at the top of this new list, copy the data from the **DIST** list by pressing **[2nd] [STAT]**, scrolling to the list named **DIST**, and pressing **[ENTER] [ENTER]**.

L5	L6	NAME ?
-----	-----	
Name=HALFM		

L5	L6	NAME ?
-----	-----	1.3029
-----	-----	1.5773
-----	-----	1.3325
-----	-----	.76612
-----	-----	1.0252
-----	-----	1.2348
-----	-----	.9154
HALFM = {1.30285, 1...		

- e. Insert the **DCMNT** list in front of list **HALFM** by highlighting **HALFM** and pressing **[2nd] [INS] [2nd] [STAT]**.

f. Scroll to the list named **DCMNT** and then press **[ENTER]** **[ENTER]**.

LG	DCMNT	TAMON	B
-----	JEEP	1.3029	
	TRUCK	1.5773	
	VELLO	1.3325	
	VIPE1	.76612	
	VIPE2	1.0252	
	BLUE	1.2348	
	BIGHH	.9154	
HALFM = {1.30285, 1...			

- Repeat the experiment with the seven cars (in the same order), moving the rear end of each car up the ramp to the 1.0 meter mark. You will need to begin the application over again to start another set of the two lists (**DCMNT** and **DIST**). Press **[APPS]** and follow the same instructions as above.
- Record the results in Table 1 on the student data sheet.
- After the seven cars have made their second run, go to the right of **HALFM** in the list editor and name a new list **METER** to represent the 1.0 meter up the ramp trials. Paste the **DIST** list data in **METER** as done earlier. This **DIST** list data should be new data.

DCMNT	HALFM	METER	B
JEEP	1.3029		
TRUCK	1.5773		
VELLO	1.3325		
VIPE1	.76612		
VIPE2	1.0252		
BLUE	1.2348		
BIGHH	.9154		
Name=METER			

DCMNT	HALFM	METER	B
JEEP	1.3029	2.384	
TRUCK	1.5773	3.4662	
VELLO	1.3325	2.4674	
VIPE1	.76612	1.8264	
VIPE2	1.0252	2.4894	
BLUE	1.2348	2.7319	
BIGHH	.9154	2.0591	
METER = {2.38398, 3...			

- Repeat the experiment a third time with the seven cars (in the same order), moving the rear end of each car up the ramp to the 1.5 meter mark. You will need to begin the application over again to start another set of the two lists (**DCMNT** and **DIST**). Press **[APPS]** and follow the same instructions as above.
- After the seven cars have made their third run, go to the right of **METER** in the list editor and name a new list **MANDH** to represent the meter and a half distance up the ramp trials. After the list has been named, paste the **DIST** list data in **MANDH** as done earlier. This **DIST** list data should be new data.
- Record the data on Table 1 of the student data sheet.

HALFM	METER	MANDH	B
1.3029	2.384		
1.5773	3.4662		
1.3325	2.4674		
.76612	1.8264		
1.0252	2.4894		
1.2348	2.7319		
.9154	2.0591		
Name=MANDH			

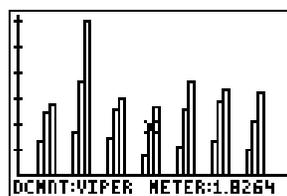
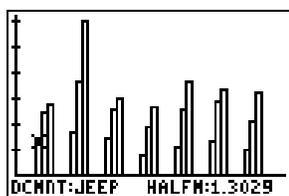
HALFM	METER	MANDH	B
1.3029	2.384	2.6781	
1.5773	3.4662	5.7558	
1.3325	2.4674	2.9185	
.76612	1.8264	2.5168	
1.0252	2.4894	3.5365	
1.2348	2.7319	3.2456	
.9154	2.0591	3.1315	
MANDH = {2.67814, 5...			

10. Create a statistics plot (bar graph) of the data collected.
- First, make sure you have cleared out all equations in the $\boxed{Y=}$ editor (move to each line and press $\boxed{\text{CLEAR}}$) and turned off all stat plots (press $\boxed{2\text{nd}} \boxed{\text{PLOT}} \boxed{4:\text{PlotsOff}} \boxed{\text{ENTER}}$).
 - Press $\boxed{2\text{nd}} \boxed{\text{PLOT}} \boxed{\text{ENTER}}$ and select the following:

```
Plot1  Off
Type:    
Cate9List:DCMNT
DataList1:HALFM
DataList2:METER
DataList3:MANDH
Menu Hor 1 2
```

11. Press $\boxed{\text{TRACE}}$ and discuss.

- ✎ Answer questions 1 - 4 on the student data sheet.



Analyzing the Data

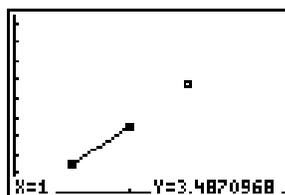
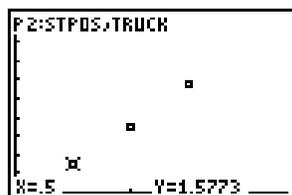
- Use the data on the two cars with the greatest coasting distances and determine if there is a relationship between their starting positions and the distance traveled. You will use a scatterplot to plot the data points as coordinate pairs.
- Record data in Table 2 on the student data sheet.
- Create three lists in the List editor, **STPOS** (to represent the car's starting position on the inclined plane), and the other two named after the two chosen cars. In **STPOS**, enter the three starting positions of 0.5 meters, 1.0 meter, and 1.5 meters. In the other two lists, enter the car's corresponding data.

STPOS	TRUCK	VIPE2 4
0.5	1.5773	1.0252
1	3.4662	2.4894
1.5	5.7558	3.5265
----		-----
VIPE2(4) =		

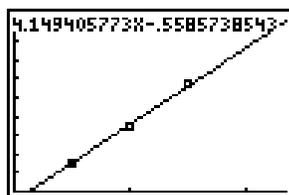
- Turn off all stat plots as you did in step 10 above. Then, press $\boxed{2\text{nd}} \boxed{\text{PLOT}} \boxed{2:\text{Plot2}}$ and define Plot 2 as shown below.

```
Plot2  Off
Type:    
Xlist:STPOS
Ylist:TRUCK
Mark:  + .
```

4. To set an appropriate window, press **[ZOOM] 7:ZoomStat** or examine the data and key in appropriate values.
5. Press **[TRACE]** and observe the data points, looking for a pattern.
 - ✎ Answer question 5 on the student data sheet.
6. You can use the Manual-Fit option to fit a line to the data points.
 - a. To do this, you will need to assign the manual-fit line ($ax + b$) to **Y1** from the Home screen (**[2nd] [QUIT] [CLEAR]**).
 - b. Next press **[2nd] [STAT] [↓] CALC 3:Manual-Fit [2nd] [VARS] 2:Y-Vars**, then **1:Y1 [ENTER]**, sending you to the graph.
7. Fit the line by moving the cursor to where you think the line will begin.
 - a. Press **[ENTER]** and use the cursor keys to move to the proposed end point of the line and then press **[ENTER]** again.



- b. Adjust the line with the cursor keys, if necessary, and press **[ENTER]** when finished. (You may want to adjust the Mode to display fewer digits to avoid the long decimals.)



- c. View the line in the **Y=** editor if desired.
- ✎ Answer questions 6 - 11 on the student data sheet.
8. Repeat the process to investigate the relationship between starting position and the other chosen car.
 - a. Turn off all stat plots (**[2nd] [PLOT] 4:PlotsOff [ENTER]**) and turn off the **Y1** equation. (Place the cursor over the **=** sign in the **Y1** equation and press **[ENTER]**.)
 - b. Display the stat plots menu (**[2nd] [PLOT] 3:Plot3**). Define plot 3 as shown below.



- c. Press **TRACE** and explore the graph.
 - d. Go to the Home screen and assign the manual fit line to **Y2**. Fit a line to the data as done earlier.
9. From the Home screen, calculate the ratio of change in distance traveled to change in start position of both cars.
- a. Press **2nd** **[STAT]** **▶ OPS 5:ΔList(**, then **2nd** **[STAT]**, select the list named after the first car, and press **▶**.
 - b. Press **÷** **2nd** **[STAT]** **▶ OPS 5:ΔList(** **2nd** **[STAT]**, select the **STPOS** list, press **▶** and then press **ENTER**.
 - c. Find the average of these two numbers and compare them to the values in **Y1**.
 - d. Do the same with the second car.

```

ΔList(LTRUCK)/ΔL
ist(LSTPOS)
(3.7778 4.5792)
    
```

```

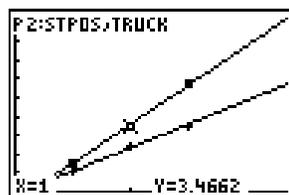
ΔList(LTRUCK)/ΔL
ist(LSTPOS)
(3.7778 4.5792)
(3.7778+4.5792)/
2
4.1785
    
```

✎ Answer questions 12 and 13 on the student data sheet.

10. Turn on Plot 2, Plot 3, and **Y1** and **Y2** by pressing **Y=** and highlighting as shown below. Then press **TRACE**.

```

Plot1  Plot2  Plot3
\Y1=4.1785000000
002x+-.578733333
3333
\Y2=2.5113x+-.16
093333333333
\Y3=
\Y4=
    
```



✎ Answer question 14.

11. Based on these equations, make predictions of the coasting distances for several other trials.

- a. Press **2nd** **[TBLSET]** and set up the table as shown below.

```

TABLE SETUP
TblStart=0
ΔTbl=1
Indent: Auto  [F5]
Depend: Table Ask
    
```

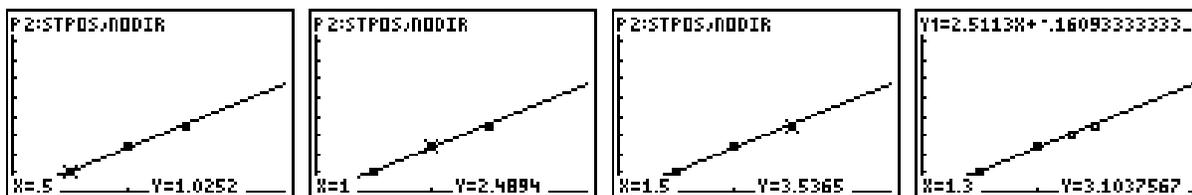
- b. Then press $\boxed{2\text{nd}}$ $\boxed{[\text{TABLE}]}$ and type in some test values such as 0.25, 1.25, 0.9.

X	Y1	
.25	4.6589	
1.25	4.6444	
9	3.1819	
X=		

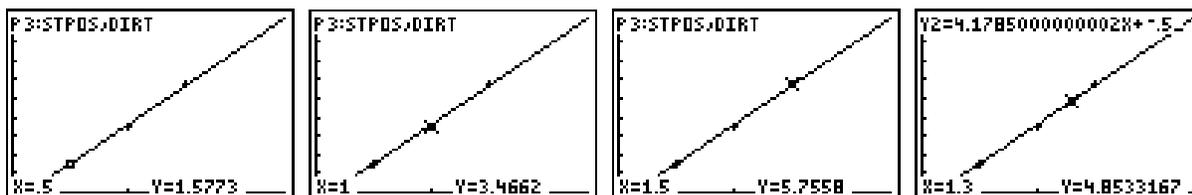
- c. Run the experiment from these starting positions and use the CBR™ as done earlier to measure the distance traveled.
- Complete Table 3 and answer questions 15 and 16 on the student data sheet.

Going Further

- In an automobile, what would be some possible benefits of an aerodynamic design?
- Shown below are four screen shots of the graph produced when an empty toy dump truck rolled down an inclined plane. Write a paragraph and explain the physical meaning of the three data points and the line.



- Shown below are four screen shots of the graph produced when the same toy dump truck was filled with dirt and rolled down the same inclined plane. Write a paragraph and explain the physical meaning of the three data points and the line.



- What conclusions can you make about the coasting distances of the dump truck without dirt versus the dump truck with dirt?

Student Data Collection
and Analysis Sheet

Name(s) _____

Date _____

Activity 8

Seven Speedy Pieces

Table 1

Name of car	Coast Distance(m) car position 0.5 m	Coast Distance(m) car position 1 m	Coast Distance(m) car position 1.5 m

1. What variables in the table above affected the cars coasting distances?

2. Which car or cars had the greatest coasting distances and were they consistently the greatest for all three start positions?

3. What variables dealing with the car's design may have affected the car's coasting performance?

4. What would be some possible changes you could make on a car's design to improve their performance?

Table 2

Starting position on inclined plane	Name of 1 st car	Name of 2 nd car
0.5 meters		
1.0 meter		
1.5 meters		

5. Do you notice a pattern in the data points? What pattern?

6. What was the change in starting positions for each trial?

7. What were the changes in distance traveled of the first car when moving from start position of 0.5 meters to 1.0 meters? _____
From 1.0 meter to 1.5 meters? _____
8. Divide the first answer in 7 by the answer in 6. _____
9. Divide the second answer in 7 by the answer in 6. _____
10. Find the average of the ratios in 8 and 9. _____
11. Compare this average to the values in the equation from the manual fit used to describe the first car's coasting distance. What similarities do you notice between this average and the equation?

12. Find the average of the change in the second car's coasting distance to the change in starting positions.

13. How does this average compare to the first car's average?

14. Describe the differences and similarities of the graphs of plot 2 and plot 3.

Table 3

Start positions(X)	Calculated distance for 1 st car in m (Y1)	Calculated distance for 2 nd car in m (Y2)	Actual distance of 1 st car in test in m	Actual distance of 2 nd car in test in m
0.25 m				

15. How close were the calculated distances to the actual distance?

16. What conclusions can you draw from the original hypothesis?

Teacher Notes

Math Strands: Measurement and Data Analysis

Data collection with the CBR™ and CBL™, and the construction of graphs of the data on the TI-73. Measurements will be taken in meters with and without the technology. Students will estimate distances and read decimal numbers off the TI-73 bar gauge.

Science Strands: Data Collection and Physical Science

An experiment will be conducted on seven different toy cars to determine coasting distances if rolled from different fixed distances down an inclined plane set at a fixed angle.

Classroom Management and Safety

The room where the experiment is to be conducted must have an unobstructed area approximately 1 to 2 meters wide and 8 to 10 meters long (including the run and the ramp). If the ramp has been set up using a board propped up on books, care should be taken to stabilize the ramp so that it doesn't slide off its support. Students should watch their feet in case the board falls, and their hands as they handle the board to avoid splinters. If the ramp is one found around school, make sure that the students watch for traffic both up and down the ramp, and on the "coasting" run after the car leaves the ramp. In either case, avoid objects that the CBL might pick up over the car.

You may want to have students take turns collecting the data. One student can hold and release the car while another moves the CBR unit slightly to make sure it has detected the correct object and then press **ENTER** on the TI-73. Data collection will probably go smoother if all data is collected in one TI-73 unit and then transferred by linking. Another option would be to manually create named lists and manually enter data or to manually create named list and use the **GetCalc(** function on the TI-73 to transfer the list to other students.

If you wish to modify the groupings for data collections, having one group do the seven cars at one distance/height (0.5 meters, 1.0 meters, etc.) would work. In this case, the students could link with other groups, sending the list for the given height. It will be important that the students order the cars, and collect the data in that order. This will insure that the students will get ordered quadruples in the lists. If you wish to have one group do one car, that would also work, but would reduce the effectiveness of the investigations on several levels. This may be a necessary tradeoff, but using one station over several days of data collection might be a better arrangement.

The Set Up

A ramp that is inclined about 20 cm at the 1.0 meter point (12 degrees) might give best results.

If using an available ramp (such as a handicapped ramp), make sure there is enough room for the class to observe the data collection. With seven cars tested at three positions, all students should be able to get involved in helping collect data. Take a meter stick and tape a start line 0.5, 1.0, and 1.5 meters from the bottom up the ramp. If using a board as a ramp, tape the start lines at the same positions. Measure a distance 6 meters from the bottom of the ramp and put a tapeline to use as a reference line to help determine if the equipment is collecting the correct data. Have students come up with names for the seven cars using five characters or less. These names will become a categorical list of names that will be placed in the TI-73.

Note: Sample data is in a program named SEVEN.73p.

Student Data Collection and Analysis Sheet – Key

1. The direct variable that affects the coasting distance is the start position of the car.
2. The car that had the greatest coasting distance should be consistently the greatest at all three start positions.
3. Mass density, aerodynamics, wheels.
4. Add mass, remove a part.
5. They should be fairly linear.
6. 0.5 meters.
7. Both changes should be fairly close.
8. Answers will vary.
9. Answers will vary.
10. Answers will vary.
11. The average and the slope of the line should be very close. This is the acceleration rate.
12. Answers will vary.
13. Answers will vary.
14. You may prompt the students for a sketch. Plot 2 should be the car with the greatest acceleration rate and the line should be steeper.
15. The calculated distance should be fairly close to the actual distance.
16. The distance up an inclined board affected the coasting distance at a constant rate.

Going Further - Key

1. Better gas mileage, smoother and quieter ride
2. X is the start position and Y is the distance traveled from the bottom of the ramp. When started at 0.5 meters up the ramp the distance traveled from the bottom of the ramp was about 1.025 meters. The slope of the line is the change in distance traveled divided by the change in start distances.
3. Answers will vary.
4. The added mass increased the coasting distance.