ACTIVITY 14

Get on the Stick

Math Objectives:

- Graph and interpret boxplots
- Generate a five-number summary of single variable data

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Stick with plate taped to end

OVERVIEW

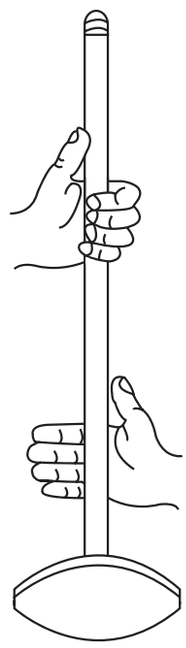
Imagine you are standing in the batter's box waiting for the pitch from someone who throws a fastball at approximately 90 miles per hour or 150 km per hour. The pitcher's mound is 60.5 feet or 18.4 meters from home plate. In the time it takes for the ball to get from the pitcher's hand to the plate (about 2 seconds), you must decide whether or not to swing the bat, where to swing the bat, or whether you need to dive out of the way to avoid getting hit by the ball.

How long do you think you have to make those decisions? You will figure that out later in this activity. Until then you will determine your own reaction time using a meter stick, a CBR 2 motion detector, and a TI-84 Plus calculator.

You will use the CBR 2 to measure reaction times. One group member will drop the stick without warning. Another group member will stand ready to catch it as soon as possible after the drop. The reaction time will be measured and recorded. You will plot and analyze single-variable data using a boxplot. You will analyze a five-number summary of single-variable data and calculate the drop distance from the reaction time. Demo the setup and run one sampling for the class.

SETUP

1. Divide the class into groups of three and assign the following tasks:
   - **a.** Drop the stick
   - **b.** Catch the stick
   - **c.** Set up and run the calculator and record the data
2. Set up the activity as shown in the picture. Tack or tape a paper plate or note card to the end of a broom handle or yard/meter stick.
3. Position the CBR 2 on the floor directly under the plate. You will be measuring the distance from the floor to the plate. Link the CBR 2 directly into the TI-84 Plus. You can use either the I/O unit-to-unit cable or the mini-USB cable. Set the sensitivity on the CBR 2 to Normal.
4. The EasyData App will launch automatically if using the mini-USB cable. If using the I/O unit-to-unit cable you will need to press the APPS key, scroll down to highlight the EasyData App, and then press ENTER.



5. Press the [Y=] key to access the **File** menu and select **1:New** by pressing [1] or since **1:New** is highlighted, you can just press [ENTER]. This resets the program and clears out old data. **See Figure 1.**

Figure 1

6. The default unit of measurement on the EasyData App is meters. You may do this activity in feet or meters. The sample will be done in meters. If you want to change the units of measurement, press the [WINDOW] key on the top row of the calculator to select the **Setup** menu soft key. From the **Setup** menu, choose **1:Dist** by pressing [1] or [ENTER] since **1** is highlighted. **See Figure 2.**

Figure 2

7. From the **Units** menu, select **2:(ft)** by pressing [2] or by pressing the down arrow key until the **2** is highlighted and pressing [ENTER]. Then select **OK**. You will receive a confirmation screen noting your choice. Select **OK** to continue. **See Figure 3.**

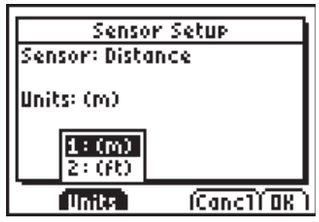


Figure 3

8. This puts you back on the main screen of the App. Select **Setup** again and choose **2: Time Graph**. You will be shown the current settings for a time graph on the EasyData App. The default setting is to take readings every .05 of a second and to take 100 samples giving a total collection time of 5 seconds. **See Figure 4.**

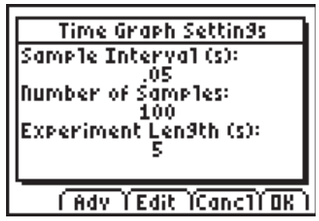


Figure 4

9. We only need 3 seconds for this activity so select **Edit** and adjust the Sample Interval to .03. Select **Next** and leave the number of samples at 100. **See Figure 5.**

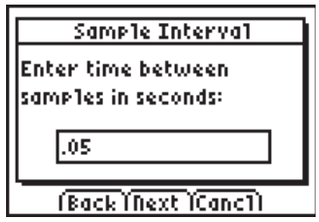


Figure 5

10. Select **Next** again. This will give a confirmation of the new settings. Select **OK** and you will be taken back to the main screen of the App. You will hear the CBR 2 resume its clicking as it begins to take readings of the closest thing in its path. The readings, although displayed across the top of the screen, are not yet being recorded. **See Figure 6.**

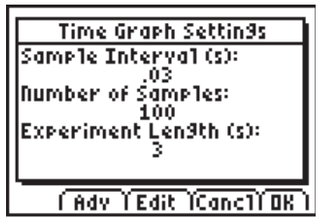


Figure 6

DATA COLLECTION

1. Have one partner hold the meter stick so that the plate or note card is approximately one meter from the CBR 2. Make sure the plate/note card is directly over the CBR 2 sensor.
2. Another partner should be ready to catch the meter stick with his/her finger and thumb when the stick is released. Students should take care when dropping and catching the stick to assure nothing else is in the path between the CBR 2 and the plate.
3. A third partner should have set up the CBR 2 and the EasyData App setting, and the partner holding the meter stick should be the one to select **Start** when ready to start collecting data. The partner assigned to catch the stick should watch the stick and catch it as quickly as possible after it starts to fall. The catcher should also try to hold the stick steady after the catch. Remember that the CBR 2 will collect data for three seconds, so the person releasing the stick can slightly vary the release time from trial to trial. Do not let the partner catching the stick know when it will be dropped.
4. After the CBR 2 finishes collecting data, the TI-84 Plus displays a "Please Wait, Transferring Data" screen**,** and then a distance/time graph appears. **See Figure 7.**

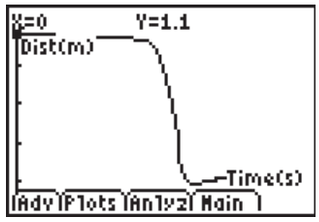


Figure 7

5. Press the right arrow key until the cursor is on the last data point before the graph starts dropping. The **X**-value at the top of the screen represents the starting time. Record this data in the table on your worksheet for **Trial 1, Start Time**. **See Figure 8.**

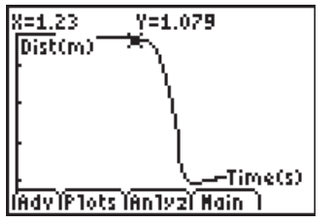


Figure 8

6. Continue to press the right arrow key until the graph levels off again. Record this **X**-value (**End Time**) in the data table as well. Subtract the two numbers to determine the **Reaction Time** for that trial and record it. **See Figure 9.**

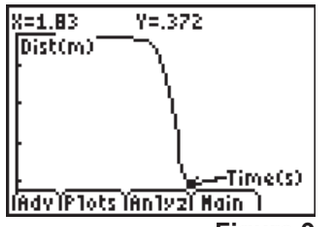


Figure 9

7. To repeat the activity, select **Main** and then **Start**. A warning screen appears about overwriting the latest data, but the data has been recorded on the worksheet. Select **OK** when you are positioned to measure the reaction time again and the CBR 2 will begin to run the new data collection. Each person should perform 5 trials and record the time for each trial in the data table. **See Figure 10.**

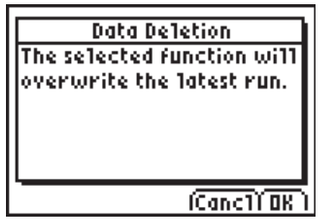


Figure 10

8. After each person in each group has had 5 trials, calculate the average reaction time from the 5 trials for each person and record that average in the data table.

9. Provide a table/list where each student can write his/her average reaction time along with all of their classmates' average reaction time. When all of their trials have been completed, select **Main, Quit,** and then **OK.** This will exit the App and take you to the TI-84 Plus Home screen.

DATA ANALYSIS

1. Have the students enter the average reaction times for all of their classmates into the TI-84 Plus so the data can be analyzed.

2. Press [STAT] [ENTER]. You will be taken to the Stat List Editor window. If **L1** is not empty, press the up arrow key until **L1** is highlighted, and then press [CLEAR] [ENTER]. **L1** should be cleared.

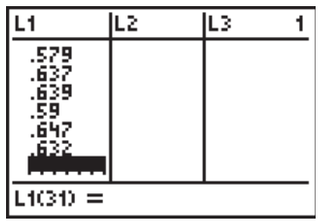


Figure 11

★ **NOTE** *For more help with lists, see Appendix B.*

3. Have the students enter the average reaction times for each student into **L1**. **See Figure 11.**

4. Press the [Y=] key and remove any equations you may have in your TI-84 Plus by using the up and down arrow keys, and then pressing [CLEAR].

5. To round all your calculated numbers to three decimal places (to the thousandth of a second), press [MODE] and make sure that everything on the left is highlighted except **Float**. Press the right arrow key on that line until **3** is highlighted, and then press [ENTER]. **See Figure 12.**

Figure 12

6. Press [STAT]. Arrow over to the right to highlight **CALC**. **1:1-Var Stats** is already highlighted. Press [ENTER]. Press [2nd] [1] to display **L1**, and then press [ENTER] again to execute the command. **See Figure 13.**

Figure 13

7. Press the down arrow a few times until you can see the five-number summary. Have students record their values in the table on their worksheets. **See Figure 14.**

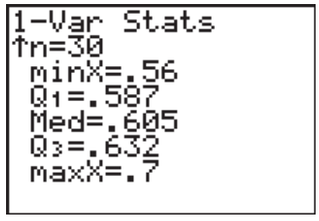


Figure 14

8. Press [2nd] [Y=] to access the [STAT PLOT] menu. Make sure **Plot1** is **On**, and **Plot2** and **Plot3** are **Off**. Press [ENTER] to select **1:Plot1.** Set **Plot1** to make a boxplot, as shown here. **See Figure 15.**

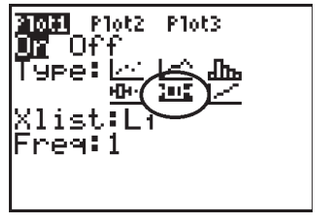


Figure 15

9. Press [WINDOW] and set the window using the values from the 1-Var Stats that you just recorded on your worksheet. Use the **minX** value recorded in the table for **Xmin** and the **maxX** value for **Xmax**. Set the **Ymin** at 0 and the **Ymax** at 5. **See Figure 16.**
10. Press [GRAPH] to see a boxplot of the data you entered in **L1**. Have students sketch their graph for question 4 on their worksheet. **See Figure 17.**
11. Press [TRACE], and using the right and left arrow keys, move from one part of the plot to another, paying attention to the data at the bottom of the screen. Have students place the screen data in the appropriate place on the plot they are sketching.

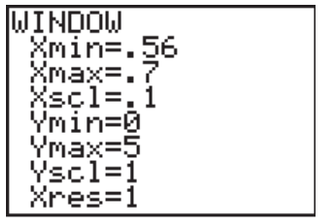


Figure 16

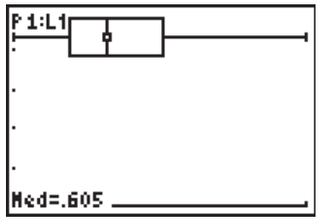


Figure 17

A boxplot is a data representation that divides a data set into four regions with equal numbers of data points. The boxplot allows you to focus your attention on a few important features without the clutter that results when all data values are displayed. The median, or second quartile, separates the set into two halves. The first quartile is the median of the lower half and the third quartile is the median of the upper half. If you have an even number of data points, the median is found by finding the average (mean) value of the two data points in the middle. One half of the data falls between the first and third quartiles.

The 1st quartile (Q1) value tells you that 25% of the values (in this case, the average times) are equal to or lower than Q1. The 3rd quartile (Q3) value is the point where 75% of the values are equal to or lower than Q3. This means that 50% of the class data is between Q1 and Q3. A shorter box means that the middle half of the data is clustered, and a longer box means that the data is more spread out. When the median line is in the center of the box, you can say that the data in the middle is symmetrically distributed.

The whiskers also give you information about how the data is distributed. If you have one whisker significantly longer than the other, it represents skewed data in the direction of the longer whisker. This means the data is clustered near the shorter whisker.

EXTENSION

Just a small amount of alcohol in your bloodstream can slow your reaction time by as much as 30%. Using this information, describe some dangers of alcohol use as they relate to your life's activities.

WORKSHEET ANSWERS

Most answers will vary depending on the data collected. Answers that will not vary are provided here.

3. Answers will vary but will match the 1st quartile and 3rd quartile values.
5. A shorter box means the data is clustered, and a longer box means the data is more spread out.
6. Answers will vary, but the median will show if the data is distributed evenly about the median (symmetrically distributed).
11. The data is clustered near the shorter whisker.
12. Since this value is bigger than the other reaction times, the whisker on the right would be extended, showing that the data is more spread out between the majority of the data and this extreme value.
17. You have about 0.4 seconds to make your decision. If a ball is coming at you at 115 km per hour, you have about 0.57 seconds to make your decision.
18. Answers will vary, but should include slower reaction when driving, reasoning, thinking, etc.

ACTIVITY 14

Name: _____

Get on the Stick

Math Objectives:

- Graph and interpret boxplots
- Generate a five-number summary of single variable data

Materials:

- TI-83/TI-84 Plus Family
- Calculator-Based Ranger™ (CBR 2™)
- Vernier EasyData™ Application
- Stick with plate taped to end

OVERVIEW

Imagine you are standing in the batter's box waiting for the pitch from someone who throws a fastball at approximately 90 miles per hour or 150 km per hour. The pitcher's mound is 60.5 feet or 18.4 meters from home plate. In the time it takes for the ball to get from the pitcher's hand to the plate (about 2 seconds), you must decide whether or not to swing the bat, where to swing the bat, or whether you need to dive out of the way to avoid getting hit by the ball.

How long do you think you have to make those decisions? You will figure that out later in this activity. Until then you will determine your own reaction time using a meter stick, a CBR 2 motion detector, and a TI-84 Plus calculator. Your teacher will outline the procedure for you.

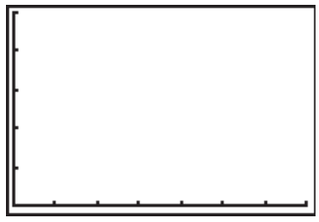
DATA COLLECTION AND ANALYSIS

1. Record the reaction times in the table below.

	Student #1			Student #2			Student #3		
Trial	**Start Time**	**End Time**	**Reaction Time**	**Start Time**	**End Time**	**Reaction Time**	**Start Time**	**End Time**	**Reaction Time**
1									
2									
3									
4									
5									
Avg.									

2. Record the five-number summary in the table below.

minX (the minimum time)	
Q1 (the first quartile)	
Med (the median value)	
Q3 (the third quartile)	
maxX (the maximum time)	



3. What is the range of values where the middle 50% of your data is located? _____

4. Sketch your boxplot on the axes shown.

5. Discuss the shape of the box part of your graph and what this shape tells you about the average reaction time of the class. _____

_____

6. Where is your median line? _____ What does the median line tell you about the data in the middle of your data set? _____

7. How many of your classmates were in the list? _____

8. How many were in the 1st quartile? _____ 2nd quartile? _____ 3rd quartile? _____ and 4th quartile? _____

9. How many classmates were between the 1st and 3rd quartile? _____

10. What are the shortest and longest average reaction times for the class? _____ , _____

11. If the plot has a whisker that is shorter, explain what this means about the reaction times for the class.

_____

12. What would happen to the boxplot if someone had a reaction time that was longer than any of the other times? How would this change the boxplot? _____

_____

13. Look back at the data for your 5 trials. Is there a trend in the data? Did you get faster from one trial to the next? Did you get slower? Explain what may have caused the variation. _____

_____

14. Compare your average reaction time from the 5 trials to the boxplot. Where does your reaction time fit on that plot? _____

15. Use the following equation to determine how far the meter stick fell before you were able to catch it: $d = \left(\frac{1}{2}\right)gt^2$. Use your average reaction time in your calculation.

In this equation, *d* represents the distance the meter stick fell, *g* represents the pull of gravity on a falling object (9.8 meters/second^2 or 32 ft/sec^2), and *t* represents the time it took the meter stick to fall. So, the only number you need to calculate is how far the meter stick fell (*d*). Calculate that distance using your average reaction time. Show your equation and answer. _____

16. Distance the meter stick fell in meters: _____m. Distance the meter stick fell in centimeters: _____cm. Distance the meter stick fell in millimeters: _____mm.

17. Think back to the pitch coming at you at 150 km per hour. If the ball is released 18.3 meters from home plate, how much time do you have to make your decision where, when, and if to swing? _____ What if a ball is coming at you at 115 km per hour? _____ Hint: distance = rate times time

18. Just a small amount of alcohol in your bloodstream can slow your reaction time by as much as 30%. Using this information, describe some dangers of alcohol use as they relate to your life's activities. _____

NOTES