

Stride Pattern Analysis Laboratory

Introduction: Footprints left at the crime scene can provide valuable evidence. In addition to the pattern of the treads on the shoes, they can enhance the overall picture a crime scene investigator has when recreating the crime. For instance, by measuring the distance between footprints left at the crime scene, you should be able to determine if this distance increases, decreases or stays the same. Depending on the results of your measurements, you can determine whether the suspect was running or walking with constant speed or acceleration. You might also use stride length to determine the approximate height of the suspect.

By using the Calculator-Based Ranger 2 (CBR2), you can plot the distance-time graph of a walking or running person. This will allow you to determine velocity and average stride distance of each person in your team and compare that to the stride pattern left at the scene and compare it with the normal stride of each suspect. From this comparison, you can determine which suspect's stride most closely matches the strides left at the crime scene.

Objectives:

Students will be able to:

- Create experimental distance-time plots for individuals while running and while walking at constant pace.
- Develop mathematical models for these plots and determine speed of the individuals for each case.
- Determine if there is a correlation between stride length and speed of the person.
- Determine if there is a correlation between stride length and height of the person.
- Based on measurements and results of explorations:
 - a. determine the speed at which the perpetrator exited the crime scene (show your work)
 - b. determine if the perpetrator was walking or running while exiting the crime scene (show your work)
 - c. determine the approximate height of the perpetrator (show your work)

Materials:

CBR2	TI-83+/84/84+	CBR-calculator or unit-to-unit link cable
Duct Tape	Poster board	Meter Stick or Metric Tape Measure
Masking Tape	Stride Pattern left at the Crime Scene	

Analyzing the Stride Data left at the Crime Scene

In this part of the lab you will be taking measurements of the stride pattern left at the crime scene.

1. Using masking tape, mark the line along the exit path of the perpetrator. This is your reference line.
2. Mark a point at the front of the first footstep. With the masking tape mark a perpendicular from this point to the reference line. Mark point of intersection on

the reference line as A.

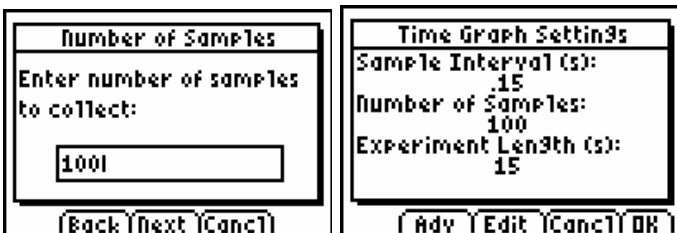
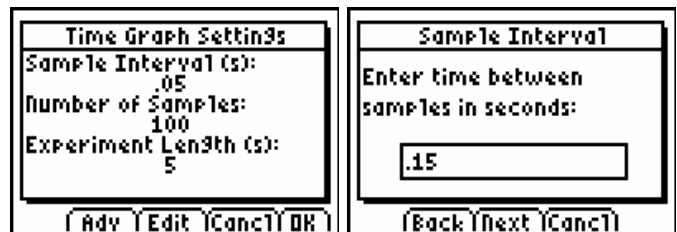
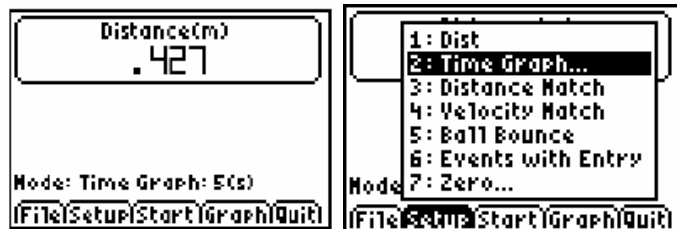
- Repeat the same procedure for each footprint and mark the corresponding points on the reference line as B, C, D, etc.
- Measure the stride distance for each stride and record that in the table below.
- For better precision, you can repeat the same procedure for the back of footsteps and take the average of stride distances for each stride.

CRIME SCENE STRIDE DATA

Stride	Stride Distance (m)	Walking or Running?	Height (m)	Speed (m/s)
AB				
BC				
CD				
DE				
EF				

Equipment Setup

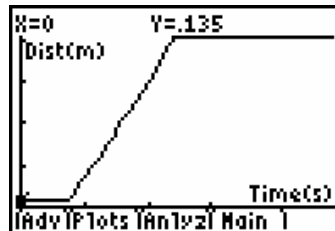
- Connect the CBR2 to the calculator using the input/output ports located on the side of the CBR2 and on the top edge (TI-84) or bottom edge (TI-83) of the calculator. Press the cable ends in firmly.
- Turn on calculator.
- The **EasyData** application will run automatically.
- Press **WINDOW** soft key to get into **Setup** menu. Choose **2: Time Graph**.
- Press **ZOOM** soft key to **Edit** the setup. Change the time between the samples to 0.15. Press **ZOOM** soft key to go to the **Next** screen.
- Enter number of samples to collect as 100. Press **ZOOM** soft key to go to the **Next** screen.
- Check displayed **Time Graph Setting**. The experiment length should be 15 seconds.
- Press **GRAPH** soft key to select **OK** and go to the main screen. CBR2 is now ready to start data collection.



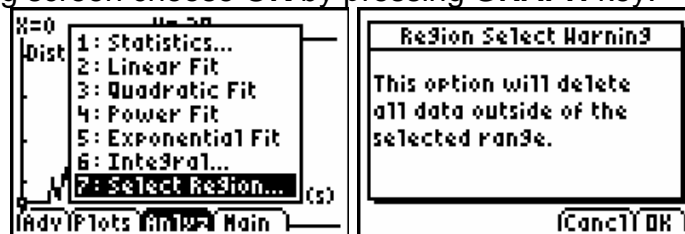
Experimental Procedure

Insure that you have a hallway or space long enough for you to run five strides (allowing room enough to stop, of course). Because of the conical wave pattern emitted from the CBR2, you need to insure that the space is wide enough so that the walls don't interfere with the ultrasonic pulses emitted by the CBR2.

1. Attach poster board to the back of the walking student using duct tape. The poster board will act as the reflective surface for the CBR2.
2. Flip the top portion of the CBR2 open and make sure that the sensitivity switch is in the short-range position.
3. Place CBR2 on a stationary support at the level of the poster board pointing toward the walking student, or have one of the students hold the CBR2 and calculator.
4. The walking student should prepare to walk away from the CBR2, being sure to walk at a normal pace. Remember to allow ample room to make the five strides.
5. Press **ZOOM** soft key on the calculator to **Start** data collection. The clicking sound and blinking green light on CBR2 indicates that data collection started. The walking student should start walking away from the CBR2 counting five strides and then he/she should stop and wait until CBR2 finishes data collection.
6. The calculator screen will display a piece-wise distance-time plot of the motion that should include a sloped linear segment corresponding to the walking part and two horizontal segments corresponding to the intervals of time when student was standing still.

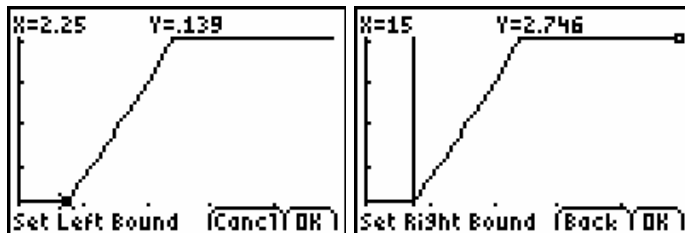


7. If the experimental plot does not have a sloped linear segment, repeat the experiment. In order to do that press **TRACE** soft key to return to the **Main Menu** and try again until the data are consistent with the walking pattern.
8. After data are collected and graph is displayed you will need to select the sloped linear part of your graph for analysis. Press **ZOOM** soft key in order to analyze the graph and select **7: Select Region** from the pop-up menu. On the Region Select Warning screen choose **OK** by pressing **GRAPH** key.

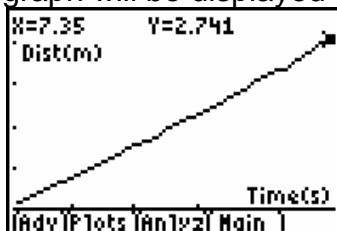


9. On the next screen use the right arrow to move the cursor to the left bound of the sloped linear piece of the graph. When cursor is at this point record the initial position of the student (y – value) in the data table below and choose **OK** by

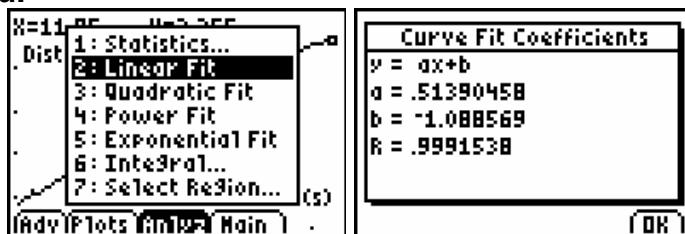
pressing **GRAPH** soft key. The vertical line through left bound will be displayed on the screen.



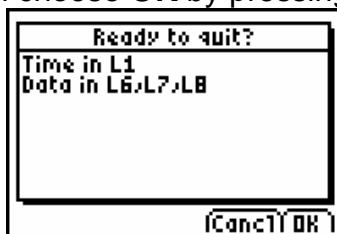
10. Select the right bound by using left arrow key and moving cursor to the top point of the sloped linear piece of the graph. Record the final position of the student (y – value) in the data table below and choose **OK** by selecting **GRAPH** soft key. The selected region of the graph will be displayed on the next screen.



11. In order to calculate the slope of this line, choose **Analyze** by pressing **ZOOM** soft key and select **2: Linear Fit** from the pop-up menu. The calculator will display the best-fit line for the data. Record the value of slope that represents the velocity of the walking person in the Table 1 below. Then choose **OK** to return to the **Main Menu**.



12. Repeat steps 1 – 11 for each student in your group while walking five strides. Record the results of the experiment for you below.
13. Repeat data collection while running. You may have to limit the number of strides to 2-3 in this case or change CBR2 sensitivity switch position. Record the results for you in the Table 2 below.
14. After you collect all data, **Quit** the application by pressing **GRAPH** soft key. On the **Ready to Quit?** screen choose **OK** by pressing **GRAPH** soft key.



15. Measure your own height and record it in the data section below. (***This measurement must be taken in meters.***)

Data

Name _____

Height _____ m

TABLE 1. STRIDE DATA (WALKING)

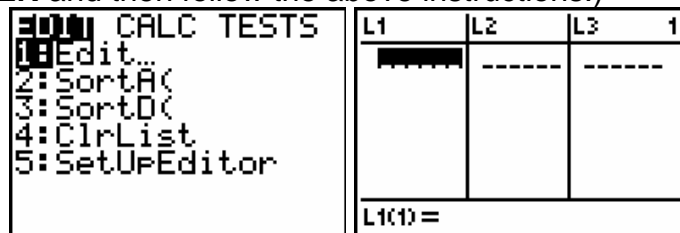
Number of strides	Initial Position (m)	Final Position (m)	Total Distance (m)	Avg. Stride Length (m)	Slope (Speed) (m/s)

TABLE 2. STRIDE DATA (RUNNING)

Number of strides	Initial Position (m)	Final Position (m)	Total Distance (m)	Avg. Stride Length (m)	Slope (Speed) (m/s)

Data Analysis

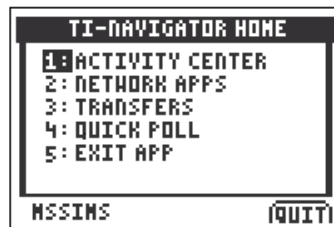
1. To enter the data from the table in the activity into your calculator, press **STAT** key and select **1:Edit** to access the List Editor window. Be sure to clear any existing data in the lists by highlighting the list name and pressing **CLEAR**. (If you see a list other than L1 through L6, press and select **STAT**, **5:SetUpEditor** and then **ENTER** and then follow the above instructions.)



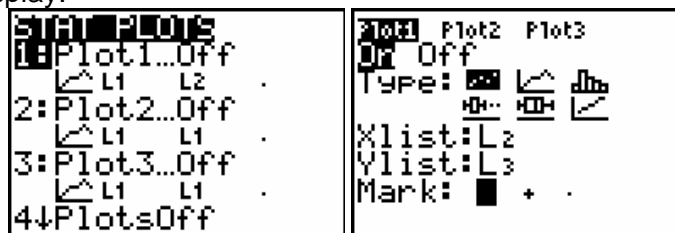
2. Enter your personal data in the following order:
 - a. Height in List 1
 - b. Walking speed in List 2
 - c. Average walking stride length in List 3
 - d. Running speed in List 4
 - e. Average running stride length in List 5
3. You will now share your data with the class. Press **APPS** key, select **NavNet**, press **ENTER**, and then any key to continue. The login screen will be displayed.



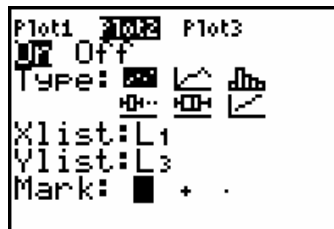
- After logging in the TI-Navigator Home Screen will be displayed. Choose **1:Activity Center**.



- If your teacher has already started the activity, then the Activity Center tool opens on your calculator. If the teacher has not yet started the activity, then the message “Waiting for teacher” appears. The Activity Center tool opens when your teacher starts it on his or her computer.
- You will send your data to the teacher and then receive combined class data from the teacher (Lists 1 – 5). After this task is completed quit application by pressing **GRAPH** soft key.
- Use **STATPLOT** to plot the average walking stride length of the whole class as a function of speed.
- Access the **STATPLOT** menu screen by pressing **2ND** and **Y=**. Select **1:Plot1** to get the screen shown above. Notice that **Plot1** and **On** are highlighted. To turn on or off any plot, place the cursor over the name, press **ENTER**, then select either **On** or **Off**, and press **ENTER** again. This process acts like a toggle switch to turn the plots on and off the graphing display.

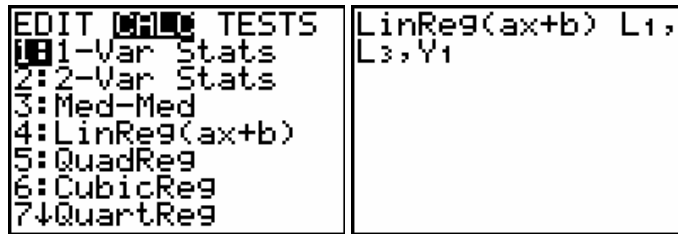


- Use arrows to move between different options on the screen. Place the cursor over the scatter plot and press **ENTER**. Choose List 2 as the **Xlist** and List 3 as **Ylist**.
- Press **Y=** and clear any equations listed. Press **ZOOM 9:ZoomStat** to automatically adjust the viewing window to display all the data.
- Explore the relationship between average stride length and the speed of motion. Looking at the scatter plot, does there appear to be a relationship between the average stride length and the speed of motion? Explain.
- Turn off **Plot 1** and plot the average walking stride length of the whole class as a function of height as **Plot 2**.



- Does there appear to be a relationship between the average stride length and height? Explain.

10. Find the regression equation that best fits this function. In order to do that, press **STAT** and select **CALC** and choose **LinReg** model followed by **ENTER**. On the home screen after the regression prompt, enter **2ND [L1]**, **2ND [L2]**, **VAR** right arrow **Y-VARS** > **Function** > **Y1** as shown.



11. Plot your data along with the regression equation by pressing **ZOOM 9**.
12. Use the TI Graph Link to print the graph data with the regression equation.
13. Repeat steps 5 – 11 for the average running stride length.
14. Compare the data you collected while **walking** versus **running**. What differences in speed and stride length do you observe between the data collected while walking versus the data collected while running?

Based on the evidence you collected within this laboratory, determine the speed of the perpetrator's exit and approximate height of the perpetrator. Which suspect do you think the footprints belong to? Explain your reasoning.