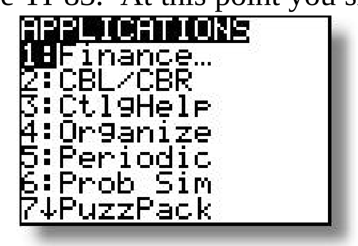
CBR Activity for Determining Velocity

In the activities we did today we assumed that certain objects moved with a constant velocity. Moreover, we simply gave you some of the velocities. An activity you could do before doing these is to experimentally determine some of the velocities used in the time/distance exploration. Such as walking, jogging and how fast that little toy moved. We can, of course, mark off a standard distance and time the students walking that distance or time the toy over that distance. Another way to determine these speeds is to use the Calculator Based Ranger (CBR) attached to one of the TI calculators. This will give you a graph of the distance the object is from the ranger with respect to time. It also gives you an opportunity to discuss the relationship between a distance verses time graph and what the object might be doing.

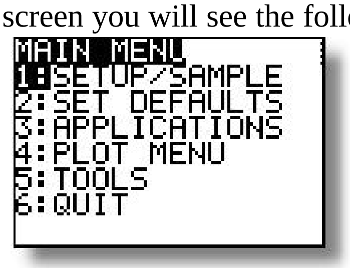
The following is a short description of how you can use a CBR with the TI-83 Plus *Silver Edition* to experimentally find the velocity of the toy.

1. First plug the Ranger into the TI-83.
2. Select the APPS key on the TI-83. At this point you should see the following menu.



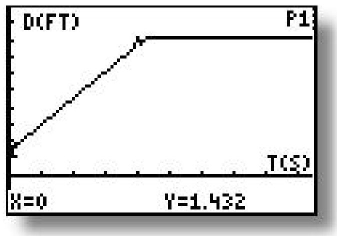
3. Select option 2, CBL/CBR.
4. After the introductory screen you will see the following menu.

5. Select Ranger.
6. After another introductory screen you will see the following menu.



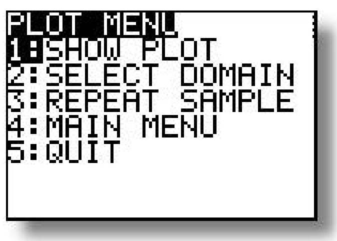
7. Select Setup/Sample.
8. The next menu lets you set the options for the distance data collection. I would suggest you set Real-time to Yes, Begin On to [ENTER] and the units to feet.
9. When you are ready use the up arrow to select Start Now and press Enter.

10. Another screen will come up telling you to press Enter when you are ready to start collecting data.
11. Turn the toy on and place it in front of the ranger moving outward from it. Then quickly press the Enter key to start collecting the data.
12. You will see the data being displayed as the toy moves. When we did it we got the following image.

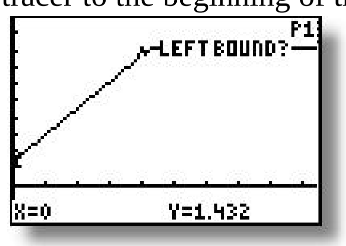


This shows that the toy was moving at a relatively constant rate until a point where it seems to have stopped abruptly, it hit the wall. So our experiment has shown that the toy does maintain a fairly constant rate if it does not have any obstacles in its way.

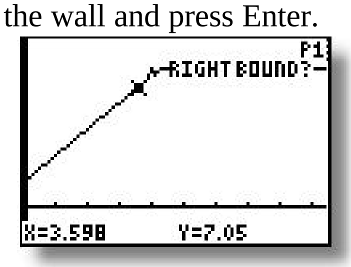
13. Our next step would be to find the velocity of the toy. We can do this in a number of ways but first we need to clean up a few things. We do not want the portion of data where the toy hit the wall so we will eliminate it. Press Enter to go back to the Plot Menu.



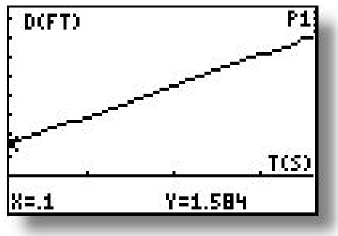
14. Select, Select Domain. At this point the graph will reappear and it will be asking for the Left Bound. Move the tracer to the beginning of the graph and press Enter.



15. Then the calculator will ask for the Right Bound? Move the tracer to the portion of the graph just before it hit the wall and press Enter.

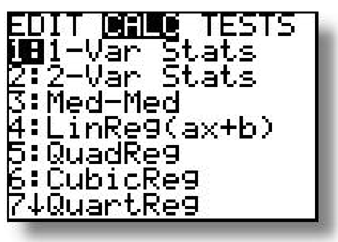


16. After the calculator analyses the new domain you should see something like the following image.



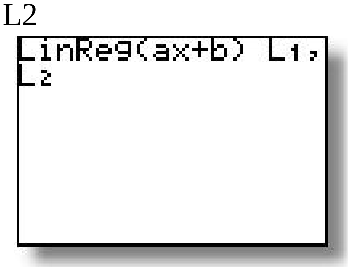
17. Now we can determine the velocity of the toy in a number of ways. First we could simply trace the data to find two points and then take the slope of the line between them. We could also use the statistical facilities to find the least squares line (best line) through the data. The slope of this line will be the velocity as well. We could also graph the velocity data instead of the distance data. Since the first option is trivial we will go through the last two. Press Enter to go back to the Plot Menu and then 5 to go to the main window.
18. Using the Statistical Features
    a) Select Stat

    b) Calc

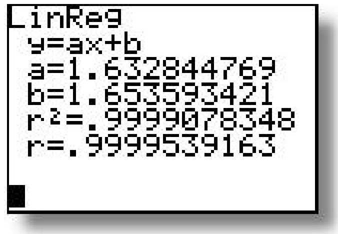


    c) LinReg(ax+b)

    d) Type in 2^{nd} L1 and 2^{nd} L2

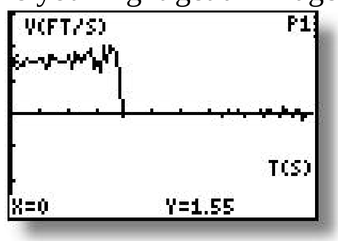


    e) Press Enter and the linear regression line information will appear.

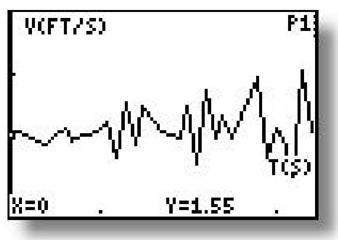


So this information tells us that the slope of the line is 1.632844769 which would mean that the toy was going 1.632844769 feet/second, or 19.59413723 inches/second.

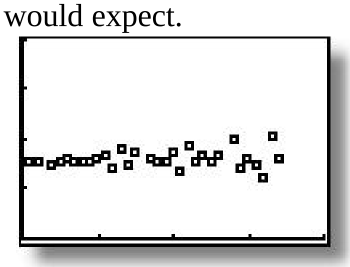
19. Using the CBR in Velocity Mode. Redo the data collection process above but this time in the Setup/Sample menu select VEL for the Display option. This will collect velocity data instead of distance data.
    a) When you rerun the sample you might get an image like the following.



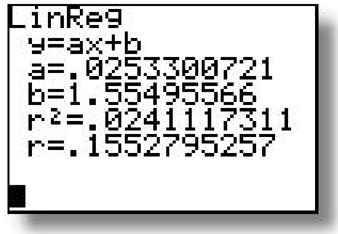
    b) Restrict the domain to the portion before the velocity drops sharply to 0, hit the wall again.



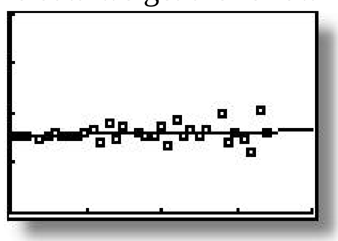
    c) This might look a bit chaotic but note that the data lies between just two tick marks, so it is probably close together. If we use the Stat Plot with the window set to [0, 4] in both the *x* and *y* directions the image looks like the following. This looks a bit more like we would expect.



    d) Using the linear regression on this data gives us



The *y*-intercept, which is our velocity, is 1.55495566, which is close to the one we generated looking at distance verses time. If we consider the correlation, we see that it is extremely low, mainly due to the slope being close to 0. If we display the least squares line with the data we get the following image.



All things considered in this experiment, we would probably go with the velocity calculated from the slope of the distance verses time graph. There seems to be less variability in the data.

You can do the same explorations with the other TI calculators but the key sequences will change.

The CBR is a great teaching tool for teaching elementary functions through Calculus. One of the activities we have had great success with is "Walking the Graph". We give students the graph of a function and from that they need to determine how they could move in front of the CBR in order to create that graph. This relates slope to velocity, concavity to acceleration and non-differentiability to abrupt velocity changes.