Which Way?  When you move toward or away from an object, your distance from that object at any time can be plotted. From this graph, you can study how different types of motion affect the behavior of your plot. Changes in direction and other factors affect the shape of your plot.

Objectives
In this activity you will:

• Observe the effect of moving away from the CBR on a Distance-Time plot.

• Observe the effect of moving toward the CBR on a Distance-Time plot.

• Observe the effect of not moving on a Distance-Time plot.

You'll Need
• CBR unit

• TI-82 or TI-83 and calculator-to-CBR cable
Math and Science in Motion

**CBR Setup**

Connect the CBR to the calculator using the link cable.

Turn on your calculator. If you have not already loaded the RANGER program into your calculator, follow these steps:

1. Press `2nd [LINK] [ENTER] [FORMAT]` The calculator displays Waiting...
2. Press the `8` transfer button on the CBR.
3. Run the RANGER program on your calculator:
   - Press `PRGM`
   - Choose RANGER
   - Press `ENTER`.
4. From the MAIN MENU, select 2: SET DEFAULTS.
5. With the selector arrow at START NOW, press `ENTER`.

**Collecting the Data**

The plot that you are about to make will have a horizontal axis representing the time in seconds that has elapsed since the data collection began and a vertical axis representing the distance in meters, from the walker to the CBR. When collecting data in these observations, be sure to stand between 0.5 and 6 meters from the CBR. Remember always to stay directly in front of the CBR and not to move to the side.

**Trial 1**

Stand a minimum of 0.5 meters, but not more than 1 meter, from the CBR. You will move directly away from the CBR at a slow and steady rate. The CBR will collect data for 15 seconds. Try to end up at a distance of approximately 5 meters from the CBR when time is up.

![Graph](image)

Press `ENTER` when you are ready to collect data. Your data should look like a straight line rising from left to right. If you are satisfied with your plot, sketch it on the axes to the right and go to Trial 2. If not, press `ENTER` choose 3: REPEAT SAMPLE, and then try again.

**Trial 2**

1. Press `ENTER` and choose 3: REPEAT SAMPLE.
2. Stand approximately 5 meters away from the CBR. You will move at a slow constant *rate* toward the CBR. You have 15 seconds to walk. Be careful not to get closer than 0.5 meters to the CBR.
3. Press [ENTER] when you are ready to begin data collection. Your data should look like a straight line falling from left to right. If you are satisfied with your plot, sketch it on the axes to the right and go to Trial 3. If not, press [ENTER] choose 3: **REPEAT SAMPLE**, and then try again.

**Trial 3**

1. Press **[ENTER]** and choose 3: **REPEAT SAMPLE**.

2. In this trial, stand approximately 2 meters from the CBR. During data collection you should remain motionless for the entire time that the data is being collected.

3. Press **[ENTER]** when you are ready to collect data. The plot should be a flat line. If you are satisfied with your data, sketch the plot on the axes to the right and go to the next section. If not, press **[ENTER]** choose 3: **REPEAT SAMPLE**, and then try again.

**Looking at the Results**

1. Why does the plot of Trial 1 go up as it moves from left to right? (Be sure to use the words "time" and "distance" in your explanation.)

2. Why does the plot of Trial 2 appear to be moving downward? (Be sure to use the words "time" and "distance" in your explanation.)

3. Why is the plot of Trial 3 a flat line? (Be sure to use the words "time" and "distance" in your explanation.)
4. Write a short paragraph summing up how the direction in which you move affects a plot of your distance from the CBR with respect to time.

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Going Further

*Answer these questions on a separate sheet of paper. Show all work.*

1. If you combined the three previous trials into one trial by first walking away, then standing still, and finally walking toward the CBR, describe in words what the resulting plot would look like.

2. Make a sketch of the motion you described in question 1.

3. Next, try the trial. Make a sketch of the plot you created. Discuss any differences between the prediction that you made and the plot that resulted from the data collection by the CBR.
Activity 2

Match Me!  By moving in a specific way in front of the CBR, you can attempt to make a motion plot that matches a given Distance-Time plot. You can change the shape of the plot by adjusting your starting position, speed, and the direction in which you move.

Objectives

In this activity you will:
• Make Distance-Time plots to match various plots.
• Make connections between types of movements and characteristics of Distance-Time graphs.

You'll Need

• CBR unit
• TI-82 or TI-83 and calculator-to-CBR cable
• Meter stick
• Masking tape

CBR Setup

1. Connect the CBR to the calculator using the link cable.

2. Turn on your calculator. If you have not already loaded the RANGER program into your calculator, follow these steps:
   a. Press [LINK] [1]. The calculator displays Waiting...
   b. Press the [→] transfer button on the CBR.

3. Run the RANGER program on your calculator:
   a. Press [PRGM]
b. Choose RANGER.

c. Press.

4. From the MAIN MENU select 3: APPLICATIONS.

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5. From the **UNITS?** menu, choose 1: **METERS.**

6. From the **APPLICATIONS** menu, select 1: **DIST MATCH.**

7. Press , to display the graph to match.

**Collecting the Data**

In this activity, you will use a wall as the target for the CBR. Use a meter stick to measure 1-meter intervals from the wall. Mark each interval on the floor with a piece of masking tape for a total distance of 4 meters.

1. Think about how you need to move to match the graph generated by **DIST MATCH.** Remember that the CBR will measure the distance from you to the wall during the experiment.

2. Hold the CBR in one hand and the calculator in the other. Aim the CBR at the wall.

3. When you are ready, press , and begin walking. The scale markers on the vertical axis of the plot are at 1-meter intervals.

4. Sketch the given graph generated by **DIST MATCH** at the right. Then sketch your match plot. Use two different colors (or solid and dotted lines) to distinguish the plots and label them as "Graph" and "Match."

**Looking at the Results**

1. Describe the way you had to move in order to match each segment of the graph.

   ________________________________________________________________

   ________________________________________________________________

2. How well did you match the given graph? Describe how you could improve each segment of your match plot. Be specific.

   **Trial 1:**  

   ________________________________________________________________

   ________________________________________________________________
3. Now you will have the chance to practice matching other graphs. In order to perform a second trial, press \( \) on your calculator and select 2: \textbf{NEW MATCH} from the \textbf{OPTIONS} menu. Draw the given graph with your match plot in the figures below. Repeat this procedure for a third trial.

For each trial, describe how you walked to match the given graph. If your plot did not match well, tell how you could make it better.

\textbf{Trial 2:}

\textbf{Trial 3:}

4. Complete the statements to make some conclusions about the types of motion needed to make specific plots.

a. The steepness of the line segments is affected by the \underline{ } of the walker.

b. The slant (upward or downward) of the line segments is affected by the \underline{ } of the walker.

c. A person standing still in front of the CBR is represented by a \underline{ } line segment on the plot.
**Going Further**

*Answer these questions on a separate sheet of paper. Show all work.*

1. Write a few sentences to tell a short story explaining the kind of motion the plot shown might represent. Be creative.

2. Draw a possible motion plot for the story described below.

Stacy walks at a constant rate from her house to the school bus stop. With about a quarter of the distance left, she sees the bus coming, so she runs at a constant rate to try to catch it. She gets to the bus stop, but misses the bus. After a short rest, Stacy turns around and walks back home at a constant rate.
ACTIVITY 4

As you move in front of the CBR your motion can be recorded using the CBR. A plot of this motion can easily be seen on your TI graphing calculator. Speeding up, slowing down, or moving at a constant rate are some of the factors that can affect a plot. In this activity, you will explore the effects those factors have on a plot.

Objectives
In this activity you will walk away from the CBR to:

• Observe the effect *speeding up* has on a Distance-Time plot.

• Observe the effect *slowing down* has on a Distance-Time plot.

• Observe the effect moving at a *constant rate* has on a Distance-Time plot.

You'll Need
• CBR unit
• TI-82 or TI-83 and calculator-to-CBR cable
CBR Setup

1. Connect the CBR to the calculator using the link cable.

2. Turn on your calculator. If you have not already loaded the **RANGER** program into your calculator, follow these steps:
   a. Press `[LINK] [ENTER]` The calculator displays `Waiting...`
   b. Press the `<8/>8` transfer button on the CBR.

3. Run the **RANGER** program on your calculator:
   a. Press `[PRGM]`
   b. Choose **RANGER**.
   c. Press `[ENTER]`

4. From the **MAIN MENU** select 2: **SET DEFAULTS**.

5. With the selector arrow `>` at **START NOW** press `[ENTER]`

Collecting the Data
During these observations you will explore the effects that gradually speeding up and gradually slowing down the rate at which you walk have on a Distance-Time plot. Time will be plotted on the horizontal axis, and the distance from the CBR to the walker (in meters) will be plotted on the vertical axis. When collecting data in these observations, be sure that you never come closer than 0.5 meters to the CBR and never move farther away than 6 meters from the CBR. Remember to always stay in front of the CBR and not to move to the side.

**Trial 1**

1. Stand approximately 0.5 meter directly in front of the CBR.
   Prepare to move in the following way when data collections begins. For the first 5 seconds, move away from the CBR at a steady, medium pace. During the next five seconds, this rate should slow down gradually until you have stopped moving completely. Then remain motionless until the CBR has stopped collecting data.

2. When you are ready to begin, press `[ENTER]` and collect the data. The plot should begin with a linear segment rising from left to right and then slowly level off until it becomes horizontal.

3. If you are satisfied with your results, sketch your plot to the right and move on to Trial 2. If not, press `[ENTER]` choose 3: **REPEAT SAMPLE**, and begin again with step 1.
Trial 2

1. Press [ENTER] and choose 3: REPEAT SAMPLE.
2. Stand at a point approximately 0.5 meter directly in front of the CBR.

Prepare to move in the following way when data collection begins. For the first 4 seconds, remain motionless. Next, begin moving slowly away from the CBR. Continuously increase the speed over the next 10 seconds, then move at a fast walk when data collection ends.

3. When you are ready to begin, press [ENTER] and collect your data.

The plot should start off flat, then begin rising slowly, and steadily become steeper. Do not worry if your plot goes out of the top of the viewing window.

4. If you are satisfied with your results, sketch your plot to the right and move to the next section. If not, press [ENTER] choose 3: REPEAT SAMPLE, and begin again with step 2.

Looking at the Results

1. Each plot in the preceding trials contains a section that is level or flat in appearance. What were you doing during this part of each plot?

2. In Trial 1, you began moving at a constant rate. What did you notice about the plot during this time?

3. Discuss the similarities between the two trials. What causes them to round off so smoothly? (Be sure to use the words "time" and "distance" in your answer.)
4. Summarize the effects that speeding up, slowing down, or moving at a constant rate while walking away from the CBR have on the shape of a Distance-Time plot of the motion.

5. Describe in words how the plots above would have looked if you started from across the room and moved toward the CBR with the same variations in speed as in Trials 1 and 2.

Trial 1:

Trial 2:

6. What would Trials 1 and 2 have looked like if the motion had been toward rather than away from the CBR? Sketch your predictions below.

7. Press [ENTER] and select 3: REPEAT SAMPLE. Repeat Trial 1 beginning about 5 meters from the CBR and moving toward rather than away from the CBR as described in number 5.

If you are satisfied with your data, sketch your plot on the axes to the right. If you wish to take another sample, press [ENTER] select 3: REPEAT SAMPLE, and collect another data set.

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Discuss any differences between your plot and the prediction you made in number 6 on the lines below.

8. Repeat number 7 for Trial 2.

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Going Further

Answer these questions on a separate sheet of paper. Show all work.

1. Describe what a plot of the following motion would look like. Stand approximately 5 meters from the CBR. When data collection begins, move toward the CBR at a medium pace but then slow down until you come to a stop about 0.5 meters from the CBR. This motion should take about 7 seconds. After a 0.5 second pause begin slowly moving away from the CBR. Then steadily increase speed until moving at the same medium rate that you began with. The total collection time will be about 15 seconds.

2. Make a sketch of your prediction in 1 on a set of axes. Next, try it. Make a sketch of the plot you created on a second set of axes.

3. Discuss any differences between your prediction in number 1 and your plot in number 2 and why the differences occurred.