# From Here to There:
Applications of the Distance Formula

Many problems in applied mathematics involve finding the distance between points. If we know the coordinates of a pair of points (x_1, y_1) and (x_2, y_2), it is easy to find the distance between them by using the distance formula, which is a restatement of the Pythagorean Theorem.

$$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

In this activity you will use a pair of Motion Detectors. They will record the Cartesian x, y coordinates of a rod moving in a star-shaped pattern. The data collected by the detectors will be used to test the distance formula.
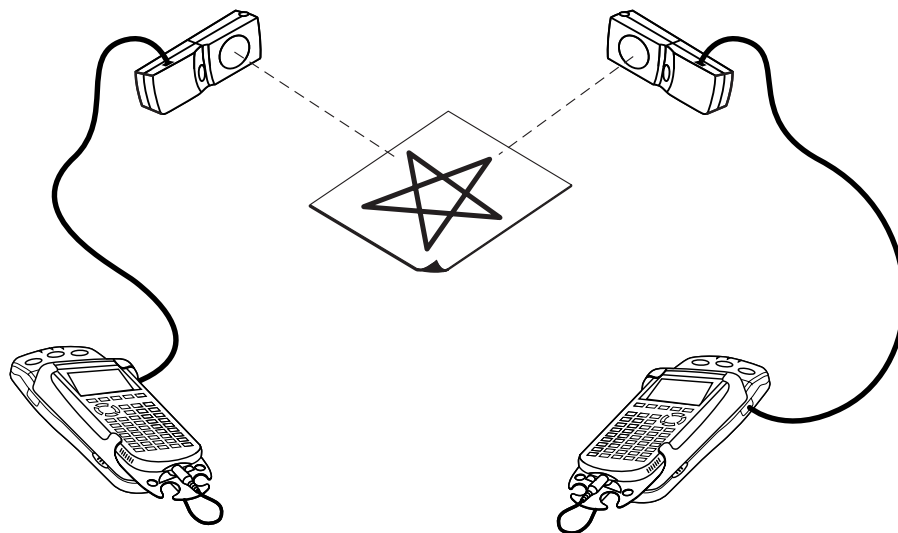
OBJECTIVES

- Record the x- and y-coordinates of a rod moving in a star pattern.
- Use the recorded coordinates to calculate the distances moved between the vertices of the star.
- Compare the calculated distances with direct measurement on the star pattern.

MATERIALS

TI-83 Plus or TI-84 Plus graphing calculator(s)*
EasyData application
two CBL 2 and two Motion Detectors
    or
two CBR 2 or Go! Motion with direct calculator cables
    or
one Vernier LabPro and two Motion Detectors
dowel rod or plastic pipe, about 50 cm by 1 cm
meter stick
masking tape

*Two calculators are needed if using CBR 2, Go! Motion, or CBL 2. One calculator is needed if using a Vernier LabPro.

PROCEDURE

This activity can be done with a variety of combinations of motion detectors and data-collection interfaces. Determine the combination you will be using and carefully read the instructions for your combination.

1. Set up the Motion Detector and calculator.

    a. Turn on your graphing calculator(s).
    b. Open the pivoting head of the Motion Detectors. If your Motion Detectors have sensitivity switches, set them to Normal as shown.
    c. Connect the Motion Detectors to the calculators(s). (This may require the use of a data-collection interface.)
        *   If you are using two CBL 2 data-collection interfaces, connect the Motion Detectors to the DIG/SONIC port of each.
        *   If you are using two CBR 2 or Go! Motion with direct calculator cables, connect the Motion Detectors directly to the calculators.
        *   If you are using a LabPro, connect the Motion Detectors to the DIG/SONIC 1 and DIG/SONIC 2 ports (use Port 1 for the *x*-detector).

2. Remove the star figure sheet from your activity packet. It is a pattern sheet of a star with the vertices marked with letters. Tape the pattern to the table to keep the sheet from moving.

3. Set up the Motion Detectors on a table or desk as shown in the picture. Use the meter stick to place each detector 50 cm from the points indicated on the star pattern sheet. Make note of which detector will collect *x*-data and which will collect *y*-data. Each detector must have an unobstructed view of the star region.

4. Set up EasyData for data collection. If you are using two calculators, do this on both.

    a. Start the EasyData application, if it is not already running.
    b. Select ⌐File⌐ from the Main screen, and then select **New** to reset the application.
    c. Select ⌐Setup⌐ from the Main screen, then select **Time Graph…**
    d. Select ⌐Edit⌐ on the Time Graph Settings screen.
    e. Enter **0.2** as the time between samples in seconds and select ⌐Next⌐.
    f. Enter **50** as the number of samples and select ⌐Next⌐.
    g. Select ⌐OK⌐ to return to the Main screen.

5. Hold the rod vertically with the tip resting on point A of the star pattern. Keep your hands and arms out of the beams of the Motion Detectors. Practice moving the rod along the star pattern, point A to point B to point C and so forth, keeping the rod vertical the entire time.

6. Select ⌐Start⌐ (on both calculators simultaneously if you are using two) to begin data collection. Move the rod as you practiced. You will have ten seconds to complete the motion. It is all right if you end the pattern with a few seconds to go. Keep the rod at point A until data collection ends.

7. When data collection is complete, a graph of distance versus time will be displayed. (If you are using LabPro with one calculator, select ⌐Plots⌐, and then select **DIG2:Dist(m) vs Time**. to see the second graph.)

8. Examine the distance versus time graphs. The graphs should show smooth back and forth motions with no large spikes. Check with your teacher if you are not sure whether you need to repeat the data collection.

   To repeat data collection, select ⌐Main⌐ and repeat Steps 6 and 7.

9. Once you are satisfied with the graph, select ⌐Main⌐ to return to the Main screen. Exit EasyData by selecting ⌐Quit⌐ from the Main screen and then selecting ⌐OK⌐.

10. Use the meter stick to measure the distance from the *y*-motion detector to point A on the star. Record the value in the Data Table on the D*ata Collection and Analysis* sheet. Round this (and all other data) to three significant figures.

ANALYSIS

1. (Skip this step if you are using LabPro with one calculator.)

   To complete the analysis, you need to move the distance data from one calculator to another. In order to avoid overwriting data, you will first copy the data to a new location in the calculator, and then send it to the receiving calculator. Use the *y*-data calculator as the sending calculator, and the *x*-data unit as the receiving calculator. Be sure you know which is which!

   a. Disconnect the calculators from the Motion Detectors or data-collection interfaces, and directly connect the two calculators with a black link cable. Firmly press in the cable ends.
   b. On the sending calculator, copy the distance data to a new list name. To do this, press ⌐2nd⌐ [L6] ⌐STO▸⌐ ⌐2nd⌐ [L2].
   c. You will now have the expression L6 → L2 on the home screen. Press ⌐ENTER⌐ to copy the distance data in L6 to L2.
   d. Press ⌐2nd⌐ [LINK].
   e. Press the number adjacent to List to select a data list.
   f. Press ⌐▾⌐ until L2 is highlighted. Press ⌐ENTER⌐ to select it.
   g. Press ⌐▸⌐ to highlight the TRANSMIT menu.
   h. On the receiving calculator, press ⌐2nd⌐ [LINK].
   i. Press ⌐▸⌐ to highlight RECEIVE, and press ⌐ENTER⌐. The receiving calculator will show Waiting.
   j. On the sending calculator, press ⌐ENTER⌐ to actually transmit the list.

    k. The receiving calculator may display a message screen headed DuplicateName. If it does, press the number adjacent to Overwrite. The receiving calculator will show Done.

2. Display a graph of the *y*-values versus the *x*-values. If you completed Step 1, use the receiving calculator.

    a. Press ⟨ 2nd ⟩ [STAT PLOT] and press ⟨ENTER⟩ to select Plot 1.

    b. Change the Plot1 settings to match the screen shown here. Press ⟨ENTER⟩ to select any of the settings you change.

    (If you are using LabPro with one calculator, use L9 instead of L2. To enter L9, press ⟨ 2nd ⟩ [LIST], scroll to L9, and press ⟨ENTER⟩ to paste it to the stat plot screen.)
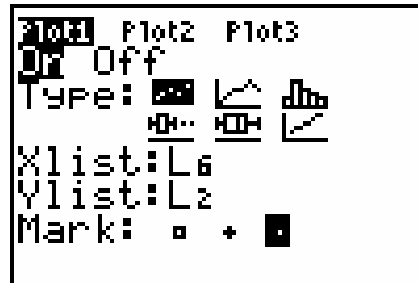
    c. Press ⟨ZOOM⟩ and then select ZoomStat (use cursor keys to scroll to ZoomStat) to draw a graph with the *x* and *y* ranges set to fill the screen with data. The graph you get is nearly, but not quite, what you want, for the proportions of the *x* and *y* scales are not the same.

    d. Press ⟨ZOOM⟩ and select ZSquare to re-plot your data with equal-size *x*- pixels and *y*-pixels.

    e. Press ⟨TRACE⟩ to determine the coordinates of a point on the graph using the cursor keys.

3. Trace across your graph to display the coordinates of the five vertices. Record the *x*- and *y*-coordinates of the vertices in the Data Table on the D*ata Collection and Analysis* sheet.

⟹ Answer Questions 1 and 2 on the *Data Collection and Analysis* sheet.

4. The star on the pattern sheet is composed of a number of line segments. Since you know the coordinates of each vertex, find the length of each segment using the distance formula. These lengths can be verified by direct measurement with a meter stick.

    a. Use the values in the Data Table, together with the distance formula, to find the length of each of the line segments listed in the Data Table. Record these measurements in the second column of the Data Table.

    b. Then use a meter stick to measure the length of each segment of the star on the pattern sheet. Round these measurements to the nearest 0.001 meter and record them in the last column of the Data Table.

⟹ Answer Question 3 on the *Data Collection and Analysis* sheet.

A

C

D
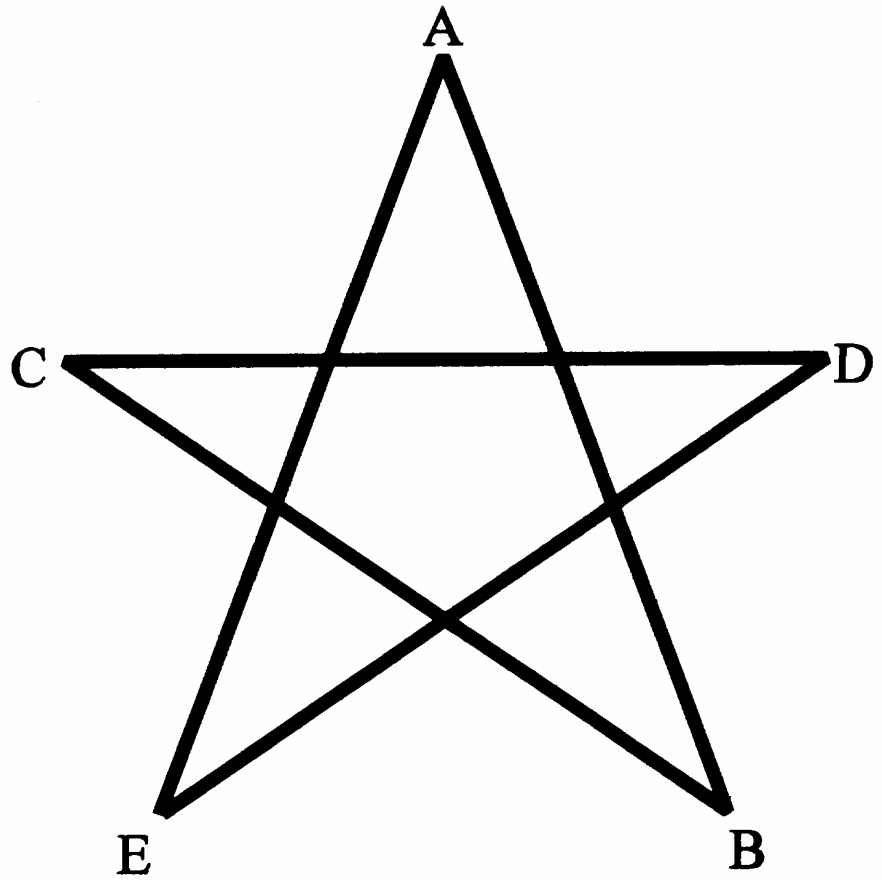
Place the x-calculator detector about
50 cm from this point

← ●

E

B

Place the y-calculator detector about
50 cm from this point
●
↓

DATA COLLECTION AND ANALYSIS

Name _____

Date _____

DATA TABLE

Distance to point A from *y*-detector	_____ m

Point	*x*-coordinate	*y*-coordinate
A		
B		
C		
D		
E		

Segment	Length using distance formula	Length using direct measurement
AB		
BC		
CD		
DE		
EA		

QUESTIONS

1. Compare the distance from the *y*-detector to point A (recorded in the Data Table) against the *y*-coordinate of point A. Are they similar? Should they be similar? Why?

2. Based on your answer to the previous question, what is the physical interpretation of the *y*-coordinates of the data? What is the physical interpretation of the *x*-coordinates?

3. How do the segment lengths calculated using the distance formula compare with those you found by direct measurement? Which method do you think is more accurate? Why?