OVERVIEW

The main focus of this activity is recognizing a trend in a time series graph and using that trend to make predictions. Specifically, students will explore how the gold-medal times for an Olympic event have decreased over time.

This activity may be challenging for students in grades 4–5 because time series graphs may be new to them. (These are the same as *line graphs*.) To help students for whom this is an unfamiliar representation, the worksheet has step-by-step instructions for creating the necessary plot.

This activity is well suited for students in grades 6–8 because it gives students an opportunity to recognize and describe the relationship that exists between two attributes. You could challenge older students to find a line (or curve) of fit for the data.

Activity Time: One class period

Objectives

- Represent and summarize data with time series graphs.
- Justify predictions based on trends in time series data.

Common Core Standards Addressed

Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

Grade 8, Statistics and Probability Standard 1

Prerequisites

- Students should have had some experience with graphs that use two axes to compare two attributes, such as *line graphs* or *scatter plots*.
- This activity contains step-by-step instructions for creating the plot, so it requires little or no experience with TinkerPlots.
- Students need to be comfortable ordering and estimating *decimal numbers* as almost all of the Olympic results are recorded with decimals—specifically, the 100-meter dash times are recorded in tenths and hundredths of a second.

Materials

- Men’s 100-Meter Dash at the Olympics worksheet (one copy per student)
- **Olympics 100 Meter.tp**

LESSON PLAN

Think About It (5 minutes)

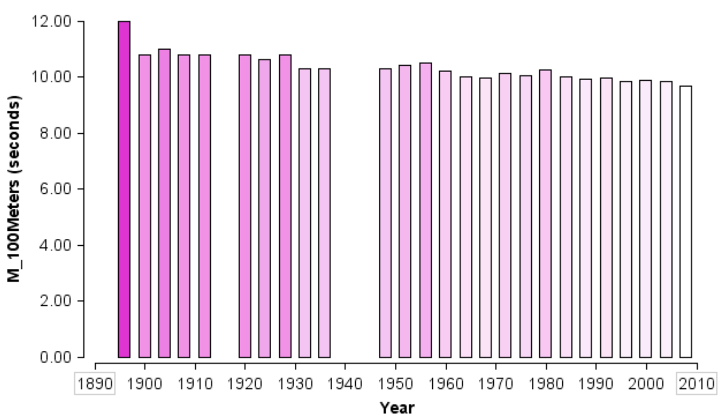
Hand out the Men's 100-Meter Dash at the Olympics worksheet. Read through the introduction as a class.

Encourage students to work in pairs or small groups to write answers for the Think About It questions, or have students write individual answers and then discuss them in groups. Involving students in group discussions will foster communication, help make apparent common expectations about the data and questions, and illuminate alternative ideas.

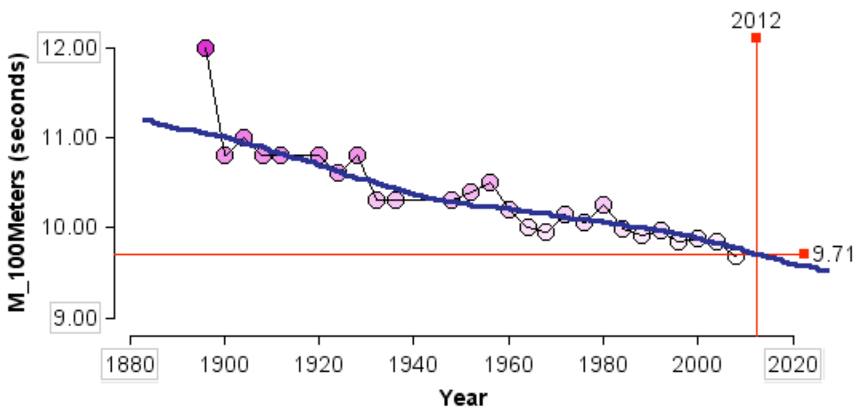
Plot and Investigate (30 minutes)

Have students move to computers and open the file **Olympics 100 Meter.tp.**

For students unfamiliar with time series graphs, you might want to have them explore alternate representations of the data before jumping into Steps 3–8. For example, students might find it easier to begin by looking at a value-bar plot (see the graph below). Here, students can use both the height of the bars and the color gradient to see that the times decrease as the years increase. This is best done as a class demonstration. Ask students to imagine putting a point at the top of each bar and connecting the points—this is exactly what the time series graph does. When students switch the case icons from value bars to circle icons, they can see the graph "morph" into the scatter plot. (*Note:* To see this animation, you will first need to have made the time series graph using circle icons with both attributes fully separated, as described in the activity. To improve the clarity of the animation, set the minimum of the vertical axis to 0 by double-clicking the axis endpoint and entering 0 in the dialog box. Now change the icon type to **Value Bar Vertical.** You should see a smooth animation between these two plot types. When you switch again to circle icons, the plot will smoothly animate back.)



As students explore Step 12, they may find it helpful to add horizontal and vertical reference lines. The intersection of these lines gives the coordinates of points in the plot. Some students might "eyeball" a location for the point, while others might use the **Drawing** tool to sketch a line or curve through the data. This sample plot shows how you could approximate 9.71 seconds for 2012. (*Note:* Adding reference lines slightly compresses the graph to give room for the reference values. So, students should add the reference lines before drawing a line of fit.)



Older students or those in pre-algebra or algebra might use the slope between two representative points and extrapolate. For example, a student could choose (1972, 10.14) and (2000, 9.87) as points for a line that might summarize the trend. The slope is about –0.01, or a decrease of one-hundredth of a second per year. Four years from 2000, the predicted time would decrease four-hundredths to 9.83 seconds. Eight years from 2000, the predicted time would decrease eight-hundredths to 9.79 seconds.

You might have students find the actual values for years not included in the data to see how well they did at predicting. They could add this case to the data set.

Wrap-Up (10 minutes)

Have students share their observations and approaches.

Extensions (optional)

1. Students can repeat the activity looking for relationships between *Year* and the other track-and-field events.

   Some events, notably the women's events, were not held in every year. If students use these attributes in a plot, they may encounter *excluded cases* for the first time. Explain that when a case does not have a value for a graphed attribute, the case's icon is stacked above an asterisk to the right of the plot.

2. Discuss whether environmental factors (altitude, temperature, humidity, etc.) might affect the gold-medal times and distances, and which events might be most affected. Students can make a list of conjectures and then turn to TinkerPlots to test some of them. The document **Olympics 100 Meter.tp** already has data about altitude; students will need to do their own research and add an attribute for any other factor they might suspect. They will probably not find data for the exact times in question (the weather in Seoul in August 1988, for example), but they can work with August averages for the cities. See the links at the TinkerPlots Online Resource Center.

3. Students in grades 6–8 could begin to explore bivariate relationships that are not time series: for example, men's 100-meter dash times versus men's 200-meter dash times, men's 100-meter dash times versus women's 100-meter dash times, or men's discus distance versus men's high jump distance. Students should first predict how they think the two groups will compare ("I think the 200-meter dash times will be about twice as long as the 100-meter dash

times"). After using TinkerPlots to plot the data, you might suggest that students look at how the slope of a line of fit would relate to the relationship between the data ("The 200-meter dash takes about twice as long to run as the 100-meter dash, and the slope of the line of fit is 2"). Some pairs of attributes, such as the 100-meter and 200-meter dashes, will have predictable relationships that are easy to justify ("The 200-meter dash is twice as far as the 100-meter dash, so it makes sense that it takes twice as long to run it").

4. Look at what happened to the gold-medal times and distances during periods when the Olympics were not held (during World Wars I and II). Students will find that most events suffered a setback or showed no improvement in the Olympics immediately following these gaps. Discuss factors that may have contributed to these setbacks, including lack of training during war years, lack of funding for training after the wars, or loss of athletes during combat.

Answers

1. Answers will vary depending on grade level and estimation skills. As a guidepost for answers, the Olympic data in **Olympics 100 Meter.tp** ranges from 9.84 to 12 seconds.

2. Students will likely guess that the time is shorter than in the past. Explanations may include improvements in training techniques (possibly even mentioning controversial topics such as steroids), improvements in equipment (such as better shoes), the athletes' desires to continually outperform records, the increasing number of countries and people participating, or genetic evolution.

9. Between 1896 and 1900. This is where the greatest distance (longest segment) between two consecutive points occurs.

   Students may like speculating why there was so much improvement between the first and second years of the modern Olympics. They might guess that the athletes didn't know what to expect the first year, so training was less than adequate. They could also see if this was true of other events.

10. At first, many students will have trouble seeing beyond individual data to the overall trend. Students might say, "The time series graph tells me the winning time each year," or "The graph tells me that the winning time usually changes from year to year." Even students who have had experience with linear functions may have trouble seeing a trend because the differences are not constant—they fluctuate from year to year.

    With appropriate prompting from you, all students should eventually see that the plot shows a decreasing trend overall—that as the years increase, in general, the gold-medal times decrease. Some students may be careful to qualify their observation by noting that although the overall trend decreases, there are many years when the time increased. Emphasize to students that phrases such as "tends to" or "in general" imply that there are exceptions to the pattern.

    Student answers will probably vary in sophistication by grade level. Students in grades 4–5 might just say that it "goes down," whereas students in grades 6–8 may begin to describe the trend as "linear" or "curved."

Some students might observe that 1896 is an “outlier,” and that the overall trend would look more regular if you removed that case.

11. Answers will vary depending on estimation skills and students’ assumptions. Reasonable answers can range from 9.80 to 9.90 seconds.

12. Answers will vary. Ideally, students will extend whatever trend they see to the next value, so their explanation should both summarize the trend and say how they are using it to predict the next value. Some students will instead try to guess mainly whether the new record will go up or down from the last one. Of course, there is no way to predict this for sure, though our best guess based on past results is that it will go down slightly. To help students eyeball where the next value is likely to be, suggest that they enlarge the plot, which will add more-detailed tick marks to the axes. Suggesting students look at the data in a case table may also help, as they can see all of the values at once. Students who are not proficient with decimal numbers may struggle to get a reasonable prediction.

13. Answers will vary. Explanations must include how the plot supports their answer.

If students see a strong linear relationship (as sketched in Step 12), then theoretically the time will keep decreasing rather than leveling off at a best time. However, with some prompting they will see that a human could never run 100 meters in 0 seconds or a negative amount of time, so the trend will have to level off eventually.

If students see the trend more as a curve that is leveling off (as sketched below), they may propose that eventually there will be no improvement of times. Some of them might even argue that there will always be improvements as long as our time measurements get more and more refined.