Teacher Guide: Distance-Time Graphs

Learning Objectives

Students will…

- Observe the relationship between a running person and a graph of distance vs. time.
  - Learn what the slope and *y*-intercept of the graph indicate about the runner.
  - Calculate the speed of the runner based on the graph.
- Interpret a graph showing the distances and times of two runners.
- Use distance-time graphs to solve word problems involving distance and speed.

Vocabulary

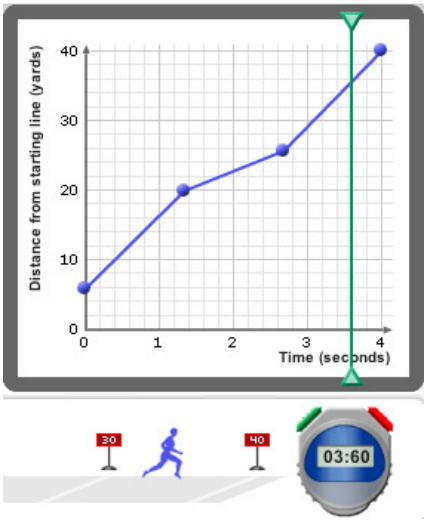
speed, *y*-intercept

Lesson Overview

The *Distance-Time Graphs* Gizmo™ shows a runner on a track and a graph that represents the runner's position over time. By manipulating the points on the graph, students can control the speed and direction of one or two runners. Students will gain graph sense as they manipulate graphs and compare them to the runner's motions.

The Student Exploration contains three activities:

- Activity A – Students see how position and time are shown on a graph.
- Activity B – Students explore how a graph shows the direction and speed of a runner.
- Activity C – Students interpret graphs of two runners and use graphs to solve problems.



Runner and graph

Suggested Lesson Sequence

1. **Pre-Gizmo activity: Make a distance-time graph** (45 – 60 minutes)
   Introduce the Gizmo by graphing your students' movements. You will need a track or field marked off in 10-yard increments, several stopwatches, and students volunteering to be timers, recorders, and runners.

   First, position a student with a stopwatch at each 10-yard marker. Position the runner at the starting line, and yell "Go!" The "timers" should all start their stopwatches at "go," and stop their watches when the runner passes by. The recorder can then record the distance and time coordinates for that runner. Do this for fast runners, slow runners, walkers, and people who vary their pace as they go along the course.

   Graph the data, with time on the *x*-axis and distance from the start on the *y*-axis. Discuss how each graph shows the runner's position and speed.

2. **Prior to using the Gizmo** (10 – 15 minutes)
Before students are at the computers, pass out the Student Explorations and ask students to complete the Prior Knowledge Questions. Discuss student answers as a class, but do not provide correct answers at this point. Afterwards, if possible, use a projector to introduce the Gizmo and demonstrate its basic operations. Demonstrate how to take a screenshot and paste the image into a blank document.

3. **Gizmo activities** (10 – 15 minutes per activity)
Assign students to computers. Students can work individually or in small groups. Ask students to work through the activities in the Student Exploration using the Gizmo. Alternatively, you can use a projector and do the Exploration as a teacher-led activity.

4. **Discussion questions** (15 – 30 minutes)
As students are working or just after they are done, discuss the following questions:
   - How does the graph in the Gizmo show the direction a runner is moving?
   - What does a horizontal line on the graph indicate?
   - What would a vertical line on the graph indicate? Is this possible?
   - How does the graph show that a runner is going fast? Slow?

5. **Follow-up activity: Can you run that graph?** (30 – 45 minutes)
Project the *Distance-Time Graphs* Gizmo to the front of the classroom, and ask for two volunteers: a "programmer" and a "runner." The programmer creates a graph on the Gizmo, and the runner tries to perform the animation that will go with the graph. Once the runner has done this, play the Gizmo to see how close the runner has come to the actual animation. For a fun challenge, have the runner try to match the movements of the Gizmo runner as the Gizmo is playing. Students can also switch roles, so that the runner performs a set of movements and the programmer tries to create a graph to match. Keep going until everyone has had a turn as either a runner or programmer.

   Several Gizmos can be used as a follow-up to the *Distance-Time Graphs* Gizmo. The *Elevator Operator* Gizmo shows a graph of the vertical motion of an elevator. The *Distance-Time and Velocity-Time Graphs* Gizmo introduces the concept of a velocity-time graph. The *Modeling Linear Systems – Activity A* Gizmo uses a "cat chasing a mouse" scenario to graph a system of equations. See the **Selected Web Resources** on page 3 of this document for links to these Gizmos.

Sports Connection: The "Lightning Bolt" from Jamaica
In the 2008 Olympics in Beijing, China, the Jamaican sprinter Usain Bolt electrified the world by setting records and blowing away his competition in the 100- and 200-meter races. Bolt ran the 200-meter race in 19.30 seconds, an average speed of 10.4 m/s (37 km/h, or 23 mph).

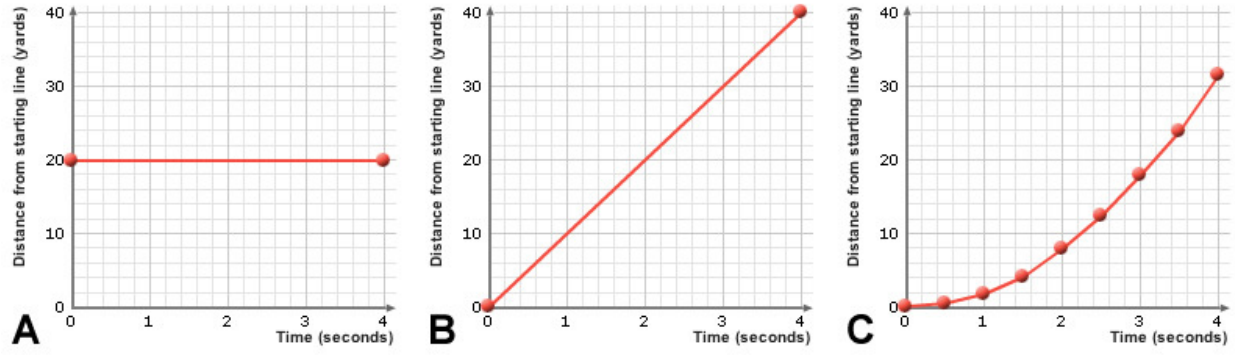
Bolt was born and raised in the small town of Trelawny, Jamaica. Bolt loved soccer and cricket, and his talent for running was soon apparent. Although he didn't always train seriously and loved practical jokes, Bolt steadily rose to the top in a sprinting-mad country. In Beijing, Bolt became as famous for his joyful dancing and other antics as for his stunning performances on the track. In the 100-meter race, Bolt had an untied shoelace and began celebrating victory with 20 meters to go in the race. In spite of this, he won and even set a new world record (9.69 s)!

Mathematical Background

The *Distance-Time Graphs* Gizmo shows a graph with time on the *x*-axis and distance from the starting line on the *y*-axis. This graph lets you describe and compare the motions of runners.

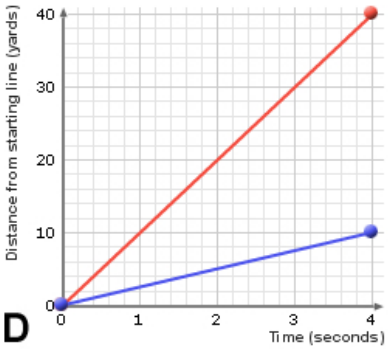
In reality, the graph in the Gizmo is probably best referred to as a *position-time graph*. The term *distance* can be misleading. In the Gizmo, we mean "distance from the starting line," so this value can increase or decrease, depending on which direction the runner runs. This should not be confused with "distance traveled," which can never decrease. (Think of your car's odometer.)

Several different situations can be shown on a position-time graph. A horizontal line (figure A) indicates that, as time goes by, position does not change. In other words, the object is standing still. A straight "uphill" or "downhill" line (figure B) means that, for each increment of time, the position changes by the same amount, so this object is moving at a constant speed. A curve (figure C) shows that the position is changing by more and more (or less and less) each time increment. This means that the speed is changing—the object is accelerating.



The *slope* of the line indicates speed. Figure D shows a graph of a slow-moving object (blue) and a fast-moving object (red). The fast-moving object moves 40 yards in 4 seconds, a speed of 40 ÷ 4 = 10 yds/sec. The slow-moving object goes 10 yards in 4 seconds, a speed of 10 ÷ 4 = 2.5 yds/sec.

The slope of the line can also indicate the direction of motion. A line with negative slope indicates that the runner is going backwards, moving back towards the starting line.



Selected Web Resources

Distance-time graphs:
http://www.broadeducation.com/htmlDemos/AbsorbPhysicsAdvd/DistanceTime/page.htm
Distance-time graphs: http://www.gcse.com/fm/dtg.htm
Position time graph: http://www.glenbrook.k12.il.us/GBSSCI/PHYS/CLASS/1DKin/U1L3a.html
Distance-time graph activity: http://graphs.mathwarehouse.com/distance-time-graph-activity.php
Distance-time game: http://www.sycd.co.uk/dtg/
Usain Bolt: http://www.usain-bolt.info/Biography.html

Related Gizmos:
Elevator Operator: http://www.explorelearning.com/gizmo/id?1017
Distance-Time and Velocity-Time Graphs: http://www.explorelearning.com/gizmo/id?301
Modeling Linear Systems – Activity A: http://www.explorelearning.com/gizmo/id?278