Teacher Answer Sheet

WALK-RUN ACTIVITY

An S and P Wave Travel Time Simulation ("S minus P" Earthquake Location Method). Adapted from an exercise created by L. W. Braile and S. J. Braile© (June, 2000)--to model how earthquake waves travel through the Earth at different speeds.

Objectives

The primary objective of this activity is to model how earthquake waves travel through the Earth at different speeds. To do this, we will (1) construct and utilize a graph to characterize the relationship between distance and time of travel of seismic waves (a *travel time-curve*); and then (2) use the constructed time-travel graphs to locate the *epicenter* of a simulated earthquake by triangulation.

This concepts learned in Learning Experience 1b (Understanding the origin and types of seismic waves) will be reinforced by this activity and will lay the groundwork for Learning Experience 1c (Finding the epicenter location and magnitude of an earthquake).

Procedure

Part One: Constructing the Travel-Time Graph

Data Table 1: Travel time observations for Walk and Run times. Answers will vary.

Distance (Meters)	Walk Time (Seconds)	Run Time (Seconds)	Walk minus Run Time (Seconds)
0 m			
10 m			
20 m			
30 m			

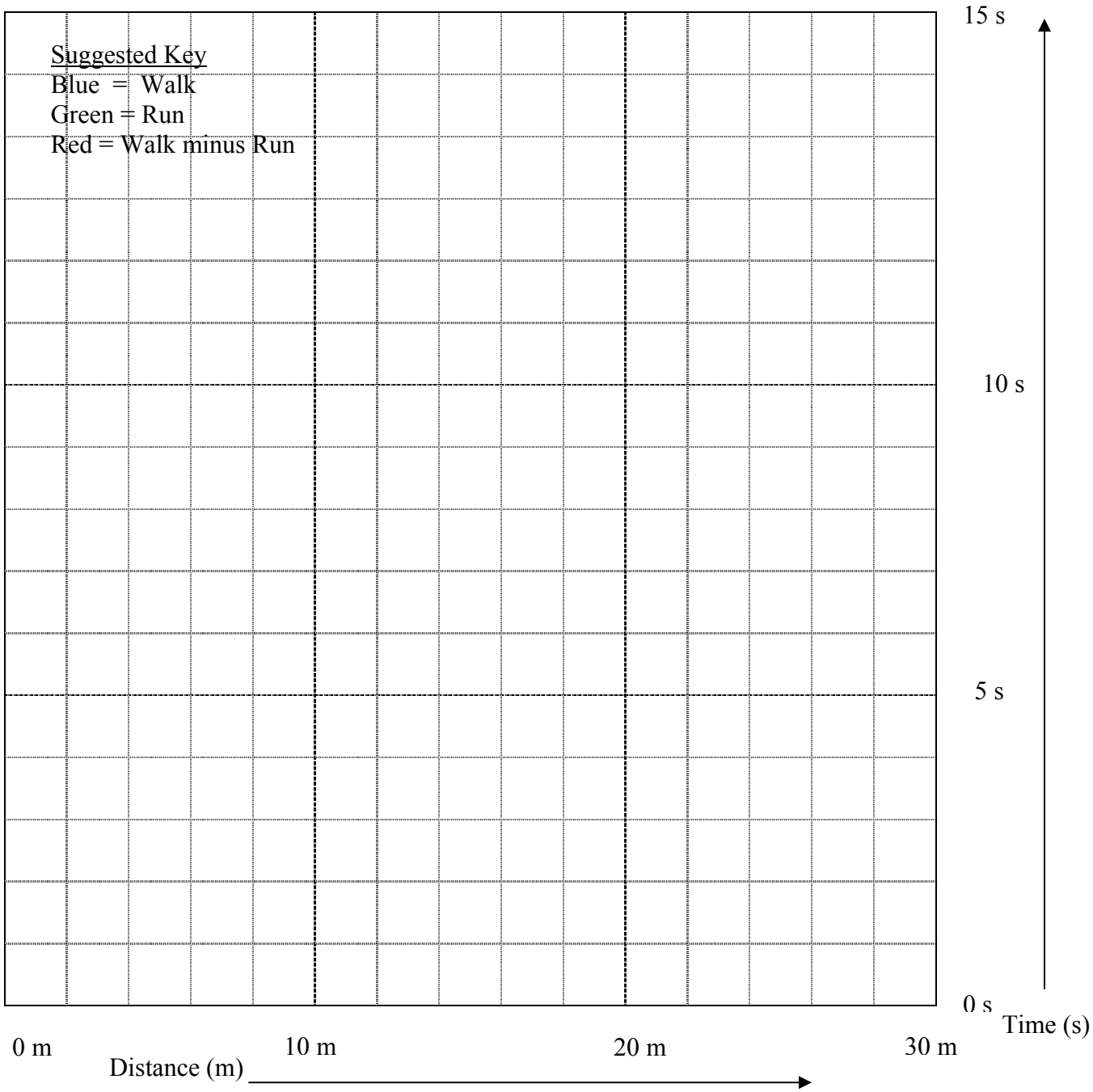
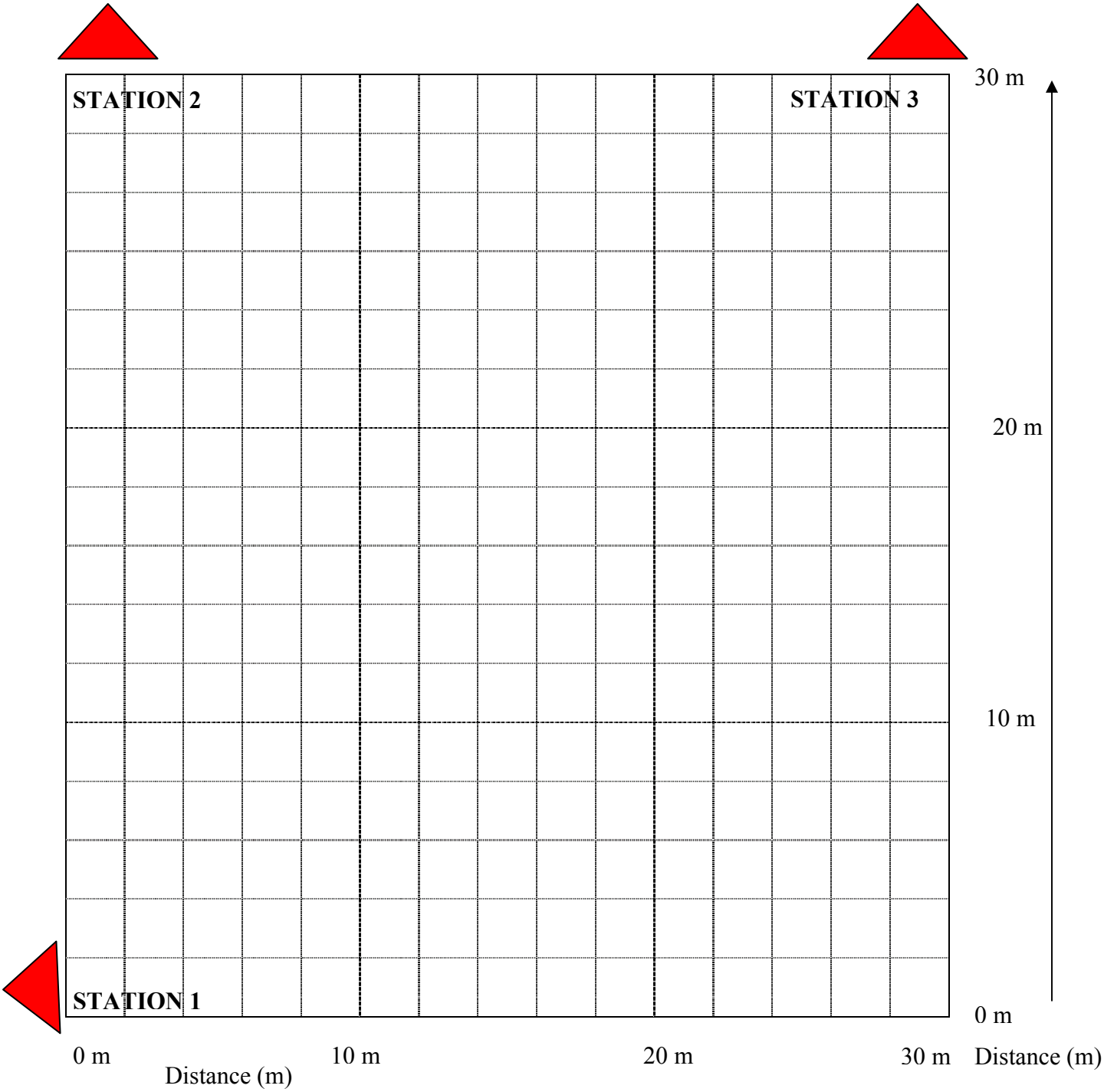


Figure 1. Travel time graph template for plotting the time of travel for Walk and Run times at three different distances (in addition to the zero distance). The graph is labeled for the Walk – Run method (30 m distance). Plot the times from Data Table 1 using colored pencils or the symbols. Draw a line through each of the data sets by connecting the points. Because the speeds of the Walkers and Runners should be approximately constant, the lines should be approximately straight lines.

After you have constructed your graphs, answer the following questions.

1. Pick any point on the graph you have constructed for the *Walking* time or *Running* time. What does that point represent? The point represents the speed (rate of travel) for the simulated wave type.
2. What is the speed of the *Walking* students (representing S wave propagation) in m/s? **Answers will vary.**
3. What is the speed of the *Running* students (representing P wave propagation) in m/s? **Answers will vary.**
4. Compare these speeds to the speeds of P and S waves (P-waves travel about 6000-8000 m/s (6-8 km/s) and S-waves about 3500-4500 m/s (3.5-4.5 km/s) for propagation through the Earth's crust and upper mantle. **Our speeds are a lot slower than the actual speed at which P and S waves travel.**



Scale: 1 cm = 2 m

Figure 2. Graph (map view) of station (timer) locations in a 30 x 30 meter area [6 x 6 meter for the Slow Walk – Walk method]. For convenience, the stations are located at the corners of the square. A scales is provided for the Walk – Run method. Use the graph to plot circular arcs with a compass that correspond to the inferred epicenter to station distances from Data Table 2 and to plot the actual location of the simulated earthquake (epicenter).

Data Table 2: Simulated earthquake data--Walk minus Run times at three stations and inferred distances to epicenter. Answers will vary.

Station	Walk minus Run Time (s)	Inferred Epicenter to Station Distance (m)
1		
2		
3		

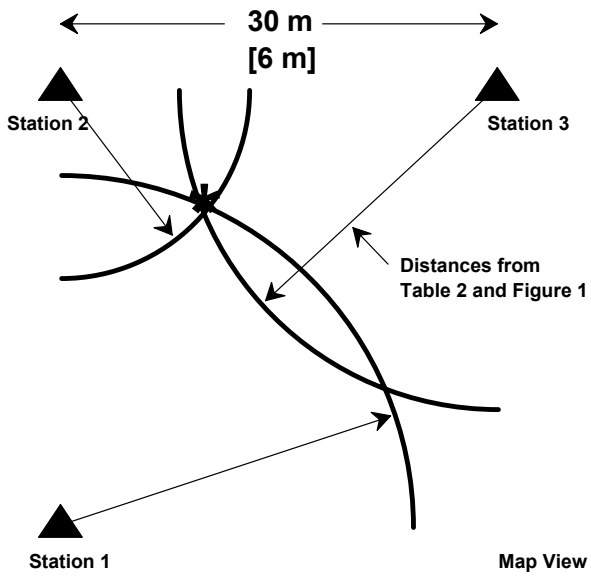


Figure 3. Example of a completed triangulation graph for the Walk – Run method. Circular arcs show the inferred distances (from the Walk minus Run times) from each station (timer). The arcs intersect approximately at a point which is the calculated location. The actual location (asterisk) is close to the location determined by the travel time differences and triangulation.

After you have drawn your map, answer the following questions.

1. In what ways were the Walking and Running students SIMILAR to P and S waves? In what ways were they DIFFERENT?

   The rate at which the Walking students traveled is slower than that of the Running students. This is similar to P and S waves since P waves propagate faster than S waves. P and S waves propagate much faster than the students were able to travel in this simulation.

2. What is the size of the error in the determination of the epicenter by triangulation? How large is the error compared to the distances from the stations to the actual epicenter (the distances traveled by the seismic waves)? What are the possible causes of the error?

   The size of the error in the determination of the epicenter by triangulation will vary each time the activity is carried out. This is also true for the magnitude of the error compared to the distances from the stations to the actual epicenter. Sources of error may include imprecise timing, the fact that the travel times were based on the averages of several different Walkers and Runners who were unable to achieve a constant speed each time they covered the distance.

3. What were some shortcomings in this activity that prevented us from determining the epicenter perfectly? Do you think these problems could be controlled? Do you have suggestions for how we could improve the experimental design?

   Answers will vary. Examples:

   - It is difficult to arrive at a precise rate of travel (speed) for our runners and walkers since their speed is slightly different each time they cover the distance.
   - We used several different runners and walkers and each individual moves at a different speed.
   - Perhaps if we used members of the school's track team, it might be possible to achieve more constant speeds for the Runners and Walkers.