Name: _____

Class Period: _____

Date: _____

WALK-RUN ACTIVITY

SHAKE, RATTLE and ROLL OPTIONAL LEARNING ACTIVITY: C—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).

You can find this activity from which our version was adapted at **http://www.eas.purdue.edu/~braile/edumod/walkrun/walkrun.htm**

Objectives

1. To model how earthquake waves travel through the Earth at different speeds.
2. To construct and utilize a graph to characterize the relationship between distance and time of travel of seismic waves (a travel time-curve).
3. To use the constructed time-travel graphs to locate the epicenter of a simulated earthquake by triangulation.

QUESTIONS

Questions after you graph data and draw maps:

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

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?

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?

Formative Assessment/Challenge Questions:

1. If the actual arrival time of the P- wave at station number 1 was 10 hours and 0 minutes local time, what was the origin time of the earthquake?

2. The travel-time curves for the **Walk – Run** times (Figure 1) are approximately straight lines because the Walkers and Runners have approximately constant pace. For seismic waves in the Earth, the travel-time curves for P- and S- waves are curved. What can you infer from this observation?

3. The Epicenter is the point on the surface of the Earth above the focus (hypocenter) of the Earthquake. What effects would a non-zero depth of the earthquake have on our simulation and the travel times of P- and S- waves?

4. If the epicenter of the simulated earthquake was located "outside of the array of timers" (outside of the square area shown in Figure 2), would the earthquake still be able to be located by triangulation? How would an earthquake located outside of the array of seismographs affect accuracy of the triangulation location? (Try constructing some circular arcs around the stations that correspond to epicenter locations relatively far from all stations.)

Data Table 1. Travel-time (T-X) observations for Walk and Run [or Slow Walk and Walk] times.

Distance (m)	Walk [or Slow Walk] Time (s)	Run [or Walk] Time (s)	Walk minus Run [or Slow Walk minus Walk] Time (s)
0 [0]	0	0	0
10 [2]			
20 [4]			
30 [6]			

Data Table 2. Earthquake data -- Walk minus Run [or Slow Walk minus Walk] times at three stations and inferred distances to epicenter.

Station	Walk-Run [or Slow Walk - Walk] Time (s)	Inferred Epicenter to Station Distance (m)
1		
2		
3		

1.

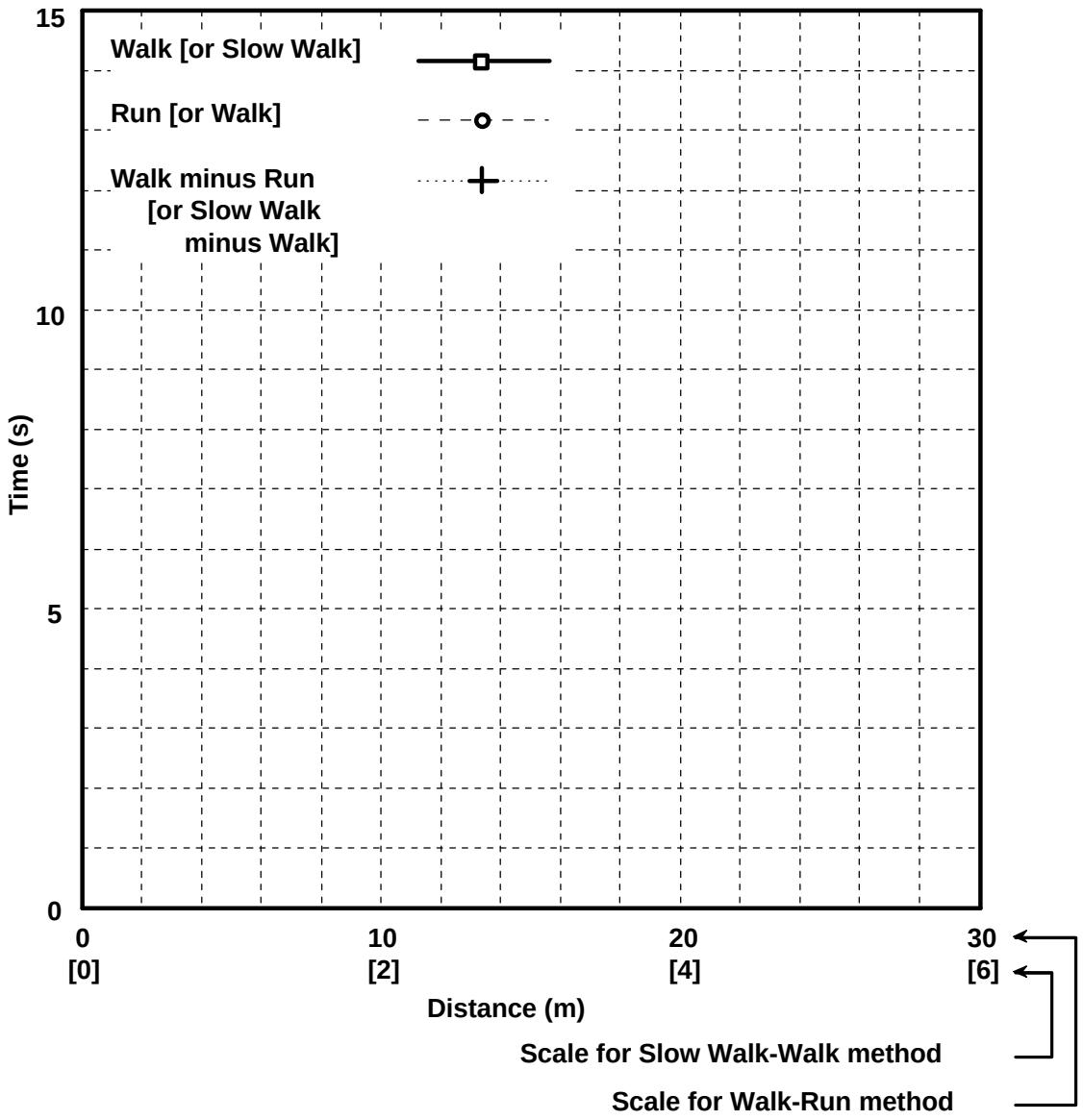

Figure 1. Travel time graph template for plotting the time of travel for **Walk** [or Slow Walk] and **Run** [or Walk] times at three different distances (in addition to the zero distance). The graph is labeled for the **Walk – Run** method (30 m distance) and for the Slow Walk – Walk method (in brackets [ ], 6 m distance). Plot the times from Data Table 1 using colored pencils or the symbols indicated in the legend in the upper left hand corner of the graph. Draw a line through each of the data sets by connecting the points. Because the speeds of the Walkers [Slow Walkers] and Runners [Walkers] should be approximately constant, the lines should be approximately straight lines.

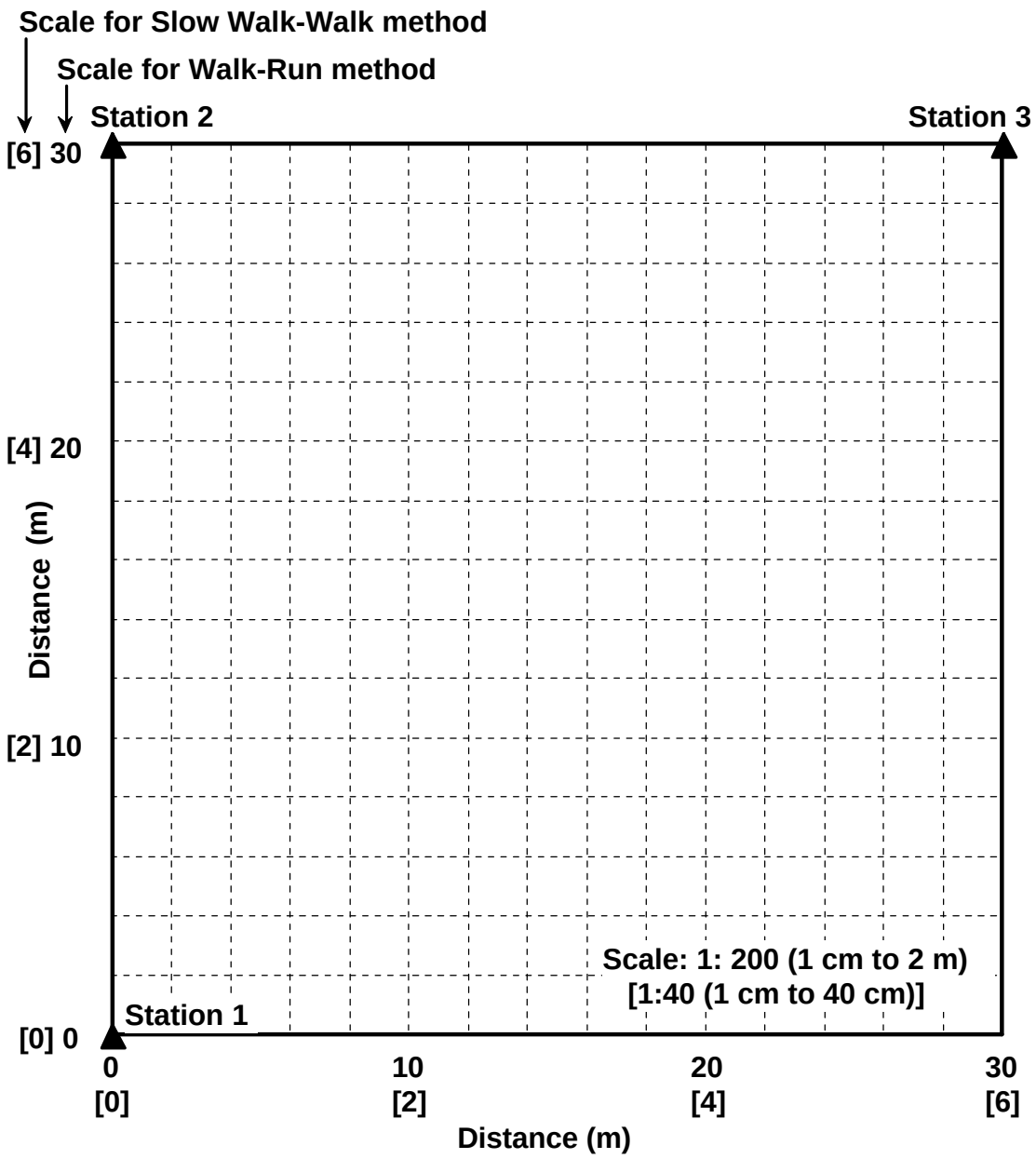

Figure 2. Graph (map view) of station (timer) locations in a 30 x 30 meter area [6 x 6 meter for the Slow Walk – Walk method]. For convenience, the stations are located at the corners of the square. Scales are provided for the **Walk – Run** and the Slow Walk – Walk (in brackets) methods. Use the graph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

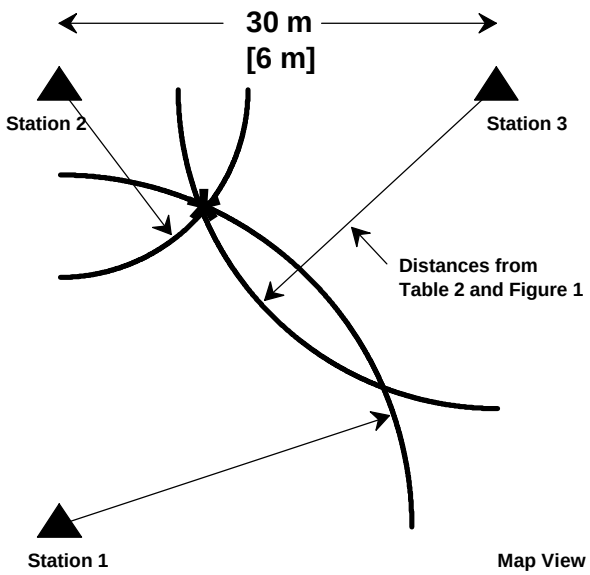

Figure 3. Example of a completed triangulation graph for the **Walk – Run** method. Circular arcs show the inferred distances (from the Walk minus Run times) from each station (timer). The arcs intersect approximately at a point which is the calculated location. The actual location (asterisk) is close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