Name:

Skill Sheet 28-C Finding an Earthquake Epicenter

The location of an earthquake's epicenter can be determined if you have data from at least three seismographic stations. To find the epicenter, you need to know the arrival times and speeds of the P- and S-waves. The only other items you need are a calculator and a compass.

1. The equation for finding the epicenter

To calculate the distance to the epicenter for each station, you will use the equation:

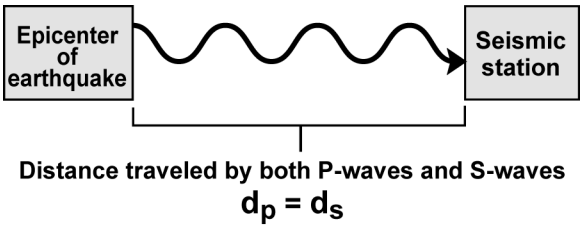
$$\text{Distance} = \text{Rate} \times \text{Time}$$

Table 1 lists the variables that are used in the equation for finding the distance to the epicenter. This table also tells you which values are given to you and which values you need to calculate.

Table 1: Variables for the equation to calculate the distance to the epicenter

Variable	What it means	Given	Need to calculate
d_p	distance traveled by P-waves	r_p = 5 km/sec	d_p, t_p, and d_s
r_p	speed of P-waves	r_s = 3 km/sec	
t_p	travel time of P-waves	t_s = travel time of P-waves plus the time between the P- and S-waves	
d_s	distance traveled by S-waves		
r_s	speed of S-waves		
t_s	travel time of S-waves		

For each of the practice problems, assume that the speed of the P-waves will be 5 km/sec and the speed of the S-waves will be 3 km/sec. Also, because the P- and S-waves come from the same location, we can assume the distance travelled by both waves is the same.



$$\text{distance traveled by P-waves} = \text{distance traveled by S-waves}$$

$$d_p = d_s$$

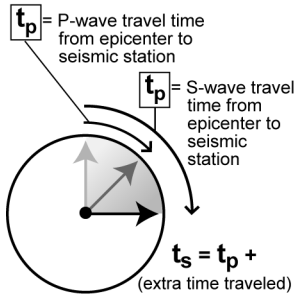
$$r_p \times t_p = r_s \times t_s$$

Since the travel time for the S-waves is longer, we can say that,

$$\text{travel time of S-waves} = (\text{travel time of P-waves}) + (\text{extra time})$$

$$t_s = t_p + (\text{extra time})$$

$$r_p \times t_p = r_s \times (t_p + \text{extra time})$$



2. Practice problems

For each of the practice problems, assume that the speed of the P-waves is 5 kilometers per second, and the speed of the S-waves is 3 kilometers per second. The first problem is done for you. Show your work for all problems.

1. S-waves arrive to seismographic station **A** 85 seconds after the P-waves arrive. What is the travel time for the P-waves?

$$\frac{5\ \text{km}}{\text{sec}} \times t_p = \frac{3\ \text{km}}{\text{sec}} \times (t_p + 85\ \text{sec})$$

$$\left(\frac{5\ \text{km}}{\text{sec}}\right) t_p = \left(\frac{3\ \text{km}}{\text{sec}}\right) t_p + 255\ \text{km}$$

$$\left(\frac{2\ \text{km}}{\text{sec}}\right) t_p = 255\ \text{km}$$

$$t_p = 128\ \text{sec}$$

2. S-waves arrive to another seismographic station **B** 80 seconds after the P-waves. What is the travel time for the P-waves to this station?

3. A third seismographic station **C** records that the S-waves arrive 120 seconds after the P-waves. What is the travel time for the P-waves to this station?

4. From the calculations in questions 1, 2, and 3, you know the travel times for P-waves to three seismographic stations (**A**, **B**, and **C**). Now, calculate the distance from the epicenter to each of the stations using the speed and travel time of the P-waves. Use the equation: distance = speed × time.

5. **Challenge question:** You know that the travel time for P-waves to a seismographic station is 200 seconds.

   a. What is the difference between the arrival times of the P- and S-waves?

   b. What is the travel time for the S-waves to this station?

3. Practice problems: Locating the epicenter

Table 2 includes data for three seismographic stations. Using this information, to perform the calculations that will help you fill in the rest of the table.

Table 2: Calculating the distance to the epicenter

	Variables	Station 1	Station 2	Station 3
Speed of P-waves	r_p	5 km/sec	5 km/sec	5 km/sec
Speed of S-waves	r_s	3 km/sec	3 km/sec	3 km/sec
Time between the arrival of P- and S-waves	$r_s - r_p$	70 seconds	115 seconds	92 seconds
Total travel time of P-waves	t_p			
Total travel time of S-waves	t_s			
Distance to epicenter	d_p, d_s			

Once you have calculated distance to the epicenter for three stations, you can use a map to locate the epicenter. The steps are as follows:

Step 1: Draw a circle around each seismographic station. The radius of the circle should be proportional to the distance to the epicenter.

Step 2: The place where all three circles intersect is the location of the epicenter.

1. In Table 2, you calculate the distance to the epicenter for three seismographic stations. Convert each of these distances in kilometers to centimeters using the scale, 200 kilometers = 1 centimeter. Use proportions to perform the calculation:

$$\frac{1 \text{ cm}}{200 \text{ km}} = \frac{x}{\text{distance to epicenter in km}}$$

2. Now, use the values you calculated in question (1), the graphic below, and a geometric compass to make circles around each station. Remember that the radius of each circle is proportional to the distance to the epicenter.