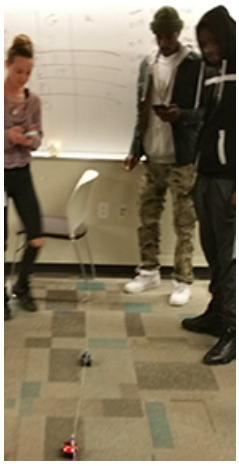


Phast Car, Slow Car (P and S cars)
Seismic Racers

Introduction:
Two cars arrive at your location, but at different times. You know that one driver likes to drive fast and the other slow. If they both left from the same place and at the same moment, can you tell how far they drove?
Find out how to solve this problem with toy cars and a mini-raceway.

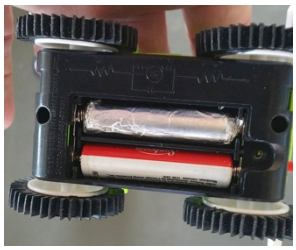
This activity can help in understanding how P and S seismic waves are used to pinpoint an earthquake's epicenter.

Tools and Materials:

- Two toy cars that run at a constant velocity. Cars need to at have capacity for at least two batteries.
- String
- Smooth flat floor
- Straws
- Batteries- fully charged
- One dead Battery or slug
- Tape
- Pen
- At least 2 Timers (or timers on cellphones)
- Aluminum foil
- Attachments to tie string too (Shown in materials are two ring stands, but chair legs or drawer handles will work too)

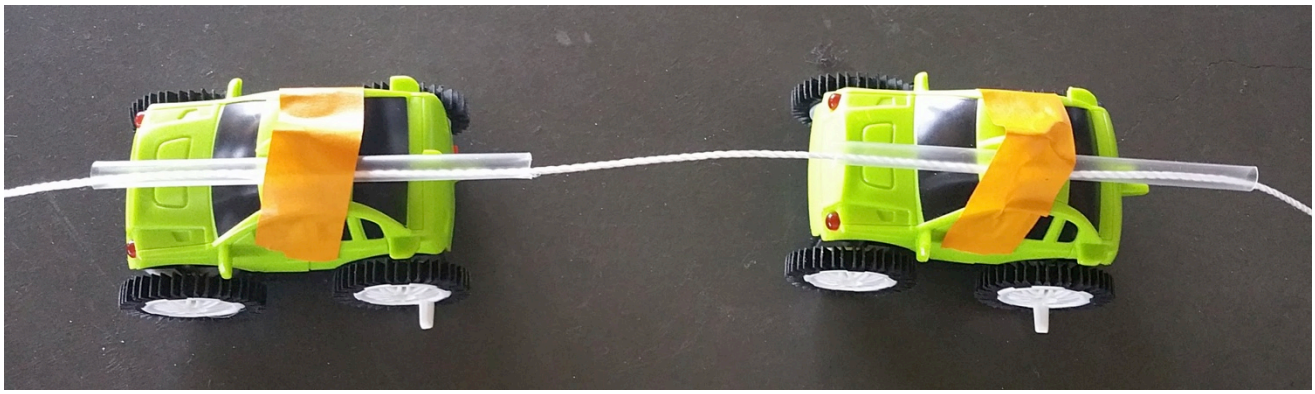
Assembly:

1. In one toy car, insert the required number of fresh batteries. This will be called your "P-car"
2. In the other car, insert a dead battery or better yet, wrap the dead battery in foil, then insert it. This will be called your "S-car."
3. Test the cars, making sure that both run, but that the S-car, with the dead battery, runs significantly slower.



4. Tie one end of the string to a secure hold a few inches (centimeters) off the floor. In the following images, we tied it to a chair leg.
5. Extend the string several meters (a minimum of 6 meters) from where you tied it. Make sure the path is clear and straight.
6. Cut a straw in half and run the other end of the untied string through both sections of straw. These pieces of straw are intended to help guide your cars along the string as they move.

7. With both cars pointed in the same direction, with the P-car in the lead and the S-car following, tape the straw sections to the tops of each cars.

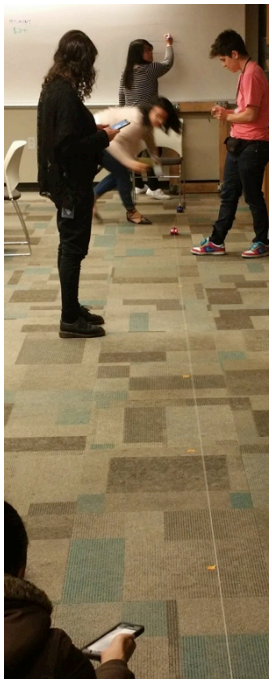


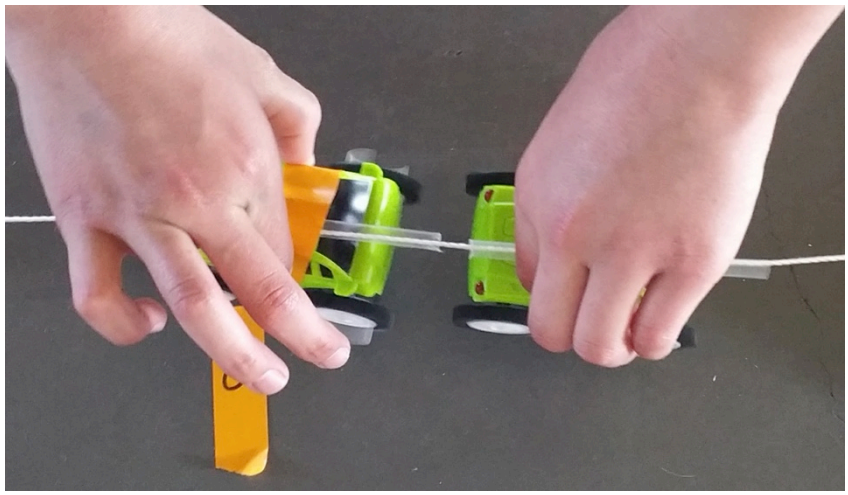
P car **S-car**

8. Tie off the other end of string. Making sure the string is taut. This is your raceway.
9. Just in front of the lead car and on the floor, use tape to mark the starting line or zero meter mark. Mark the floor every 2meters to the end of the string.
10. The last meter mark is your finish line.
11. Get your timers set and have a way to collect data.

To do and notice:

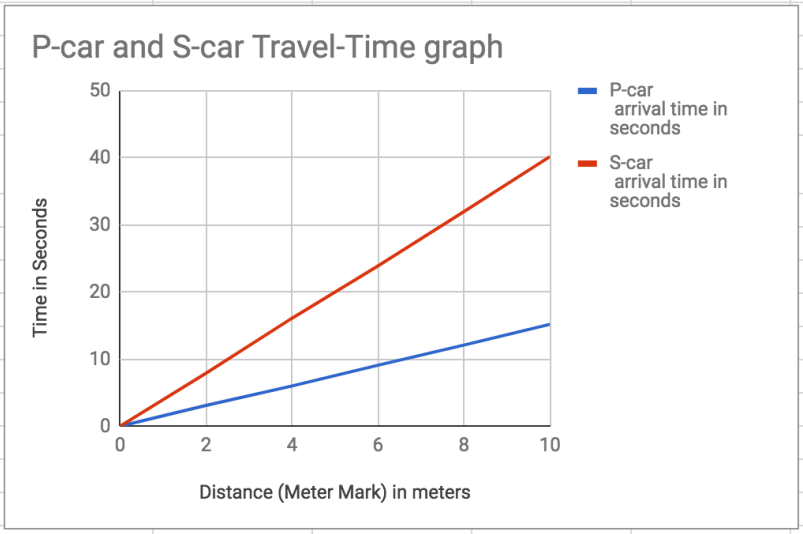
You're ready to race!
Turn on both cars and hold them just above the floor.
When you say "Go!" start timing and let both cars run!
Note: Release both cars at the same time.
Collect time data for each car as it passes each meter mark.
Obviously, the S-car, with less battery power will be taking up the rear, but keep timing until both P and S cars pass the finish line.





Make a table and graph of your data. Here's a sample table and graph.
Note: typically, on this type of graph, distance is on horizontal axis

Distance or Meter mark	P-car arrival time in seconds	S-car arrival time in seconds
0	0	0
2	3.1	7.9
4	6	16.1
6	9.1	23.9
8	12.1	32
10	15.2	40.2

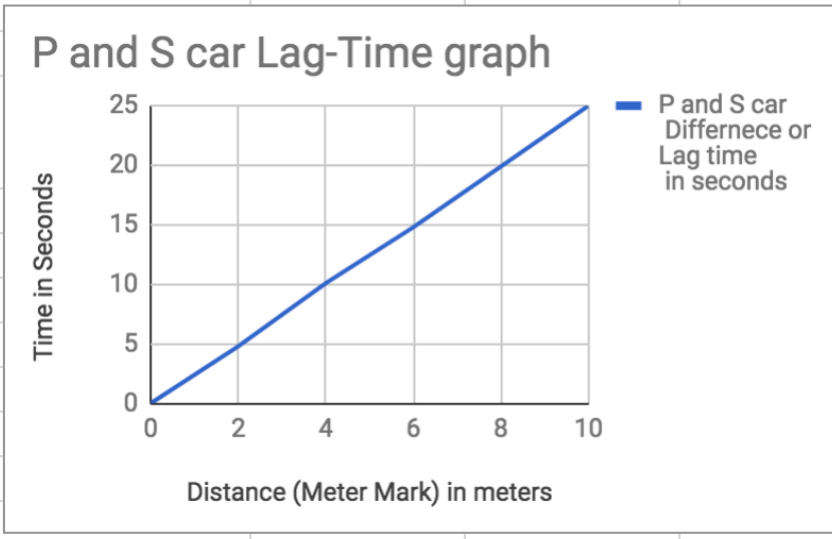


Calculate the time delay between P and S-car arrival, at each meter mark. This simple calculation is called the "lag-time."

(S-car time) – (P-car time) = Lag time

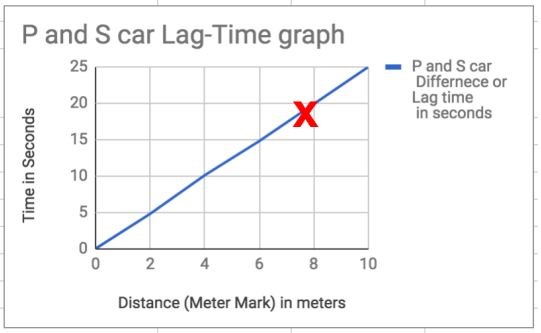
Sample table and graph using the same data as above.

Distance or Meter mark	P and S car Differnece or Lag time in seconds
0	0
2	4.8
4	10.1
6	14.8
8	19.9
10	25



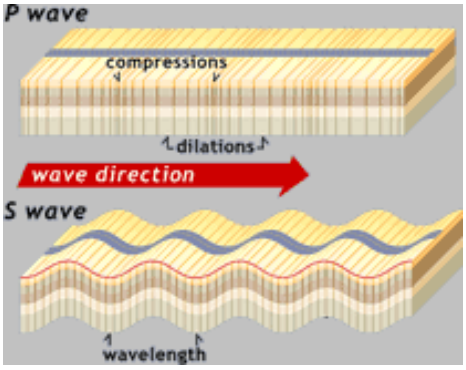
What's going on?
Each car has a constant, but different velocity. The further the distance from the starting point, the greater the gap or lag-time between car arrivals. This can be seen on the travel-time graph above. This lag-time also allows you to figure out how far the two cars have traveled.

Eric Muller: Exploratorium Teacher Institute – draft, copyright (2018)

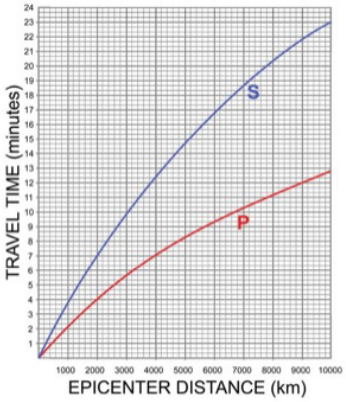


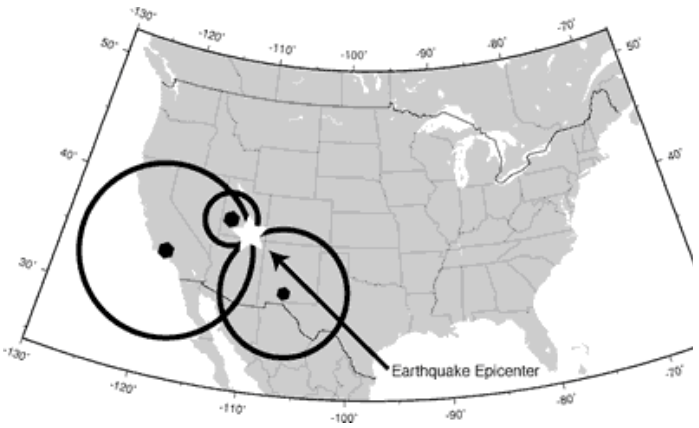
For example, using our sample data and graphs above, the lag-time graph shows that if the two cars arrive 20 seconds apart, then they are 8 meters from their starting location.

Going further:
Set up your cars so they drive from a location out of view, like from down a hallway. Allow students to only see the cars arriving. If they time the difference or lag between when the P-car and S-car arrive, can they figure out how far away they started?



This is how earthquake foci and epicenters are located!!!!
Two types of waves originate from underground seismic events, P and S-waves. These two waves travel at known, but different velocities, similar to your cars above, but much much faster (kilometers per second). Like the cars, the distance to an origination location can be determined. However, unlike your cars, which are attached to a string, earthquake waves radiate out in an expanding sphere. If the distance to an earthquake from three known locations can be determined, then it's starting location can be determined. This is call triangulation.





Resources:
Wave and triangulation images from: https://earthquake.usgs.gov/

P and S wave travel time graph from :
https://d32ogoqmya1dw8.cloudfront.net/files/mathyouneed/p-s_wave_plot.pdf