Stories of the Present

How do we know?—Seismic wave lab

Earth Science Essentials

by Russ Colson

You will need to have 2 long bungee cords, one ¼ diameter (about 20-24') and another 3/16" diameter (15-20'). You will need a spring balance that can measure >= 8 oz. You will need a timing device.

In prehistoric times, the ancient Hevea, a race of scholars, inhabited the world, leaving behind ruins and weathered stone texts as testimony that they were once here. One of the most mysterious of the ruins is the Great Bungee, a bungee cord stretching across the Bungee Sea from the Great Pole on the west coast of Brasiliensis. The Seismea, the race presently inhabiting the world, have never crossed the Bungee Sea. Without knowing the width of the sea, they fear to cross in their small boats.

The Seismea have finally translated the ancient stone texts and have discovered that the Great Bungee crosses the entire sea. Part way across, the Great Bungee passes an island that the ancient Hevea used as a way station on their journeys across the sea. From the Great Pole on the western shore, a 3/16 bungee stretches to the island, where it is stitched to a second ¼" bungee that continues the rest of the way across the sea. The ¼" bungee is attached to a second Great Pole on the other side.

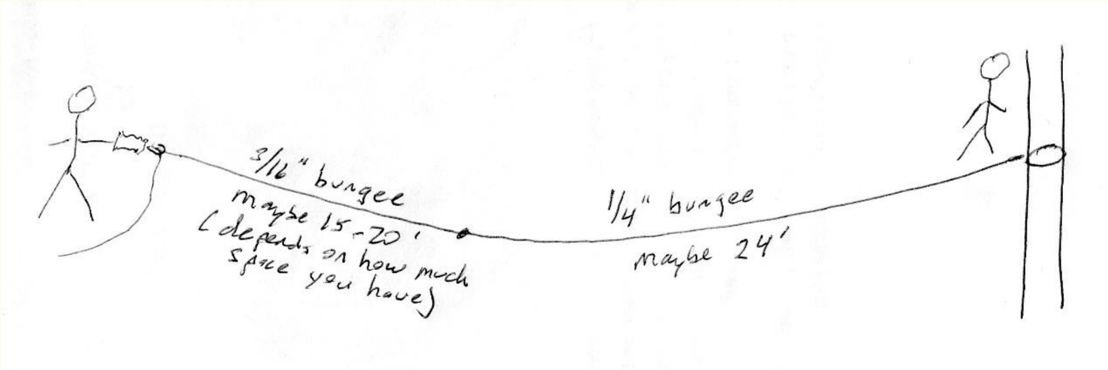
One curious Seismean twangs the Great Bungee and times how long it takes for the wave to return. She observes a reflected wave in 3 hours and 21 minutes. She observes a second reflection in 4 hours and 32 minutes. She recognizes that the second wave is not due to the wave bouncing back and crossing a second time, because it is not twice as long as the first return time. She infers that the first returned wave was the time for the wave to travel to the island on the 3/16" bungee and return. The second reflection is the time for the wave to travel to the island, then cross the second part of the sea on the ¼" bungee, and then return.

She realizes that by measuring the velocity of the waves through bungee cords with the same properties as the Great Bungee, she can determine both the distance to the island and the distance across the sea without ever having to cross the sea. She measures the tensional force on the Great Bungee and finds it to be 8 oz of force.

She then begins her experiments.

Initially she tests her mental model for how the waves cross the sea on the Great Bungee.

1) Take your Bungee cords and spring balance. Tie the Bungee cords together. Tie the ¼" bungee end to something solid and stretch out the cord to 8oz of force.



Experiment with the two bungee cords to confirm that some energy from the wave reflects back from the join between the two bungees and some of the energy continues on. It might be helpful to have a partner help with this.

Write down an explanation for how you confirmed that some of the energy reflects and some continues on at the join between the bungees. You should also include a measurement of how long it takes a wave to travel to the join in the bungees and back, and also how long it takes the wave to travel the entire distance of the bungee cord.

Next, measure the velocity of waves in the two different varieties of bungee cord. One way to do this is to untie the two bungee cords from each other, and then, for each one, tie one end to something solid, stretch it out to its full length at 8oz of force, and measure how long it takes a wave to travel a known distance (remember, velocity = distance/time). A big source of error in your measurements will be your ability to time something that happens quickly. Therefore, I recommend that you let the wave bounce back and forth a few times so as to increase the time and make your measurement more precise. Of course, to calculate the velocity, you also need to adjust the distance the wave traveled accordingly. For example, if your cord is 22 feet long, and you time how long it takes the wave to go down and back three times, the distance the wave traveled is 22 feet * 6 = 132 feet = 1584 inches. Report your results below (including calculated velocity for each type of cord in units of inches per second).

Based on your measured velocities, you should be able to calculate a predicted value for travel times in the first part of this activity when the two bungee cords were joined together. Remember that travel time = distance/velocity. Given the lengths of each part of the cord when they were connected together, and your measured velocities, you should be able to predict how long the wave took to travel each segment. How do the predicted values compare to your measured values?

Calculate the distance to the island in the Bungee Sea (in miles: there are 5280 feet in a mile and 12 inches in a foot).

Calculate the distance across the Bungee Sea (in miles: there are 5280 feet in a mile and 12 inches in a foot).