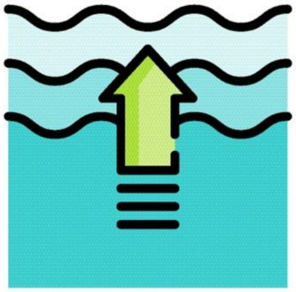
Tidal Math



7:30 a.m. I was sitting on a driftwood log on the beach of Hammersley Inlet. The inlet is a sliver of the Puget Sound where the Pacific Ocean makes its way into Washington State, flowing past Seattle, Tacoma, and dozens of other smaller cities and communities in the northwest corner of our country. The water line was at my feet, and the tide was receding as I watched. Rocks that had been submerged were gradually uncovered.

Barnacles—tiny crustaceans that had been waving their feathery legs in the water to grab for the food swept along by the current—were closing their shells as the tide went out and they prepared to be high and dry on the beach until the tide returned to cover them up again.

7:35 a.m. I was surprised at how quickly the water level was dropping; more and more beach was showing every minute. I made a mark on a stick and pushed the stick into the sand a few feet out in the water so that the water line was at the mark.

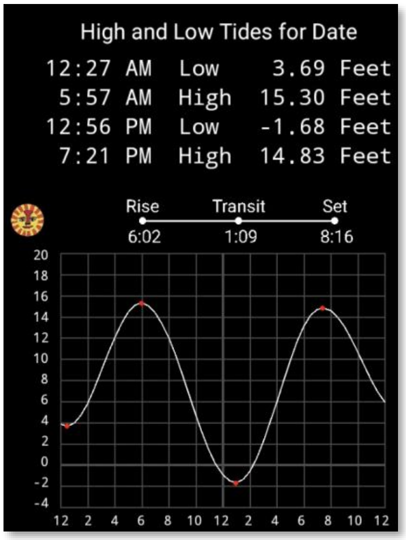
7:45 a.m. The water was nearly down to the bottom of the stick 10 minutes later. I grabbed the stick and broke it off at the water line to make a record of how far the water level had fallen in those 10 minutes. It looked to me like about 10 centimeters (cm), a handy number, so I made some mental calculations: 10 cm in 10 minutes is a rate. Could Hammersley Inlet, part of Puget Sound that is connected to the Pacific Ocean, really be draining at the rate of 1 cm per minute? It seemed like a lot.

I knew from the tide app on my phone that there had been a high tide of about +15 feet and that we were headed toward a low of about –1.5 feet. That was a swing of over 16 feet. Since any 24-hour period typically has two low tides and two high tides, that swing must be accomplished in about 6 hours—a little longer for the larger swings and a little shorter for the smaller, but 6 hours makes a reasonable estimate when you are on the beach. Converting the 6 hours to minutes is $6 \times 60 = 360$ minutes. At the rate of 1 cm per minute, the water level would change by about 360 cm, or 3.6 meters (m), in 6 hours. If

1 m is about 1 yard, or 3 feet, this is equivalent to about 11 feet. That is not enough. The rate must be even greater!

This made me think: I was there on the beach at a time not far past the high-water mark. At the exact moment of the high tide, the rate at which the water was receding had to have been zero and must now be increasing. It made sense, then, that the rate was a little slower at this time. This reminded me of how the speed of the current in the inlet is affected by the tides. Everyone who travels on the waters of the inlet is aware of this. Barges that make their way between the lumber mill in Shelton and the wider waters of the Puget Sound use the currents to ease the strain on their engines. Kayakers do more or less the same.

8:30 a.m. As I was leaving, I paced off the distance between the water's edge and where it had been one hour earlier—about 22 feet. I wondered about the average slope of the beach. Knowing that the rate at which the water level was falling must be a little more than 1 cm/minute, I estimated 1.2 cm/minute and multiplied by 60 minutes to conclude that the water level had fallen a little over 70 cm in 1 hour. Converting 22 feet is a little over 6.5 m, or 650 cm. So, the slope of the beach, in this case quite literally the rise over the run, was a little more than a 1:10 ratio, a 10 percent grade. By comparison, the maximum allowable grade on our freeways is 6 percent. For wheelchair ramps, the grade is a little over 8 percent.



8:35 a.m. I got back to the cabin and fetched a tape measure to determine the actual length of the stick I had used to estimate the drop in the water level. The water had fallen 5 and 1/8 inches, about 13 cm. Later that day I consulted an online tide table and looked at a graph of water level versus time. I could see how the rise and fall roughly resembled sinusoidal waves.

What is to be gained by thinking these thoughts and doing these back-of-the-envelope calculations? Is the quality of my life improved in any way if I can apply simple mathematics to the situations that surround me? The same question may be asked with regard to history, literature, science, art, and all of the subjects we study in school and beyond. Does knowing the dates of the potato famine in Ireland and understanding the consequences for immigration rates in mid-19th century America enable me to speculate more productively about the current furor over immigration? Sometimes graffiti catches our eye and sometimes it doesn't. Does an understanding of complementary colors make a walk through an alley downtown a little more interesting? When knowledge of facts is supported by an understanding of the implications of these facts, conclusions may be drawn and predictions made. Sometimes these predictions and conclusions are important, and sometimes they are trivial, but the ability to make them and the inclination to do so are some of the things that schools should foster.

When we are able to observe, explain, and predict using the tools of any discipline, we enrich our lives. Walking back up from the beach, I realize that my day is made a little larger and more interesting by the fact that I know, understand, and can apply some simple mathematics to make sense of the world.

Lesson Plan

Learn more about implementing Tidal Math in your classroom by exploring the Illuminations lesson here! Then, share your experiences using Math Sightings on social media with the hashtag #MathSightings.