Across the Pole: Navigation During *Operation Sunshine*

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Background: In 1958, USS *Nautilus* (SSN571), the world's first nuclear powered submarine, also became the first ship to travel to the geographic North Pole. This was an amazing technological, navigational, and personal accomplishment.

Instructional Goal: Accurately perform calculations on speed and distance travelled for submarines to navigate from one point to another in a specified time frame?

Science Standard links:

- MS-PS2-2 Motion and Stability: Forces and Interactions (Next Generation Science Standards)
- CCSS.ELA-Literacy.WHST.6-8.3 (Common Core State Standards for Literacy in Science and Technical Subjects)

Preliminary Knowledge:

1. Students should have knowledge of the calculations involved in finding speed (s), distance (d) and time (t).

Teacher Note:

1. Activity is intended as a real world application of the formula s=d/t as a demonstration of mastery of skill.

Introductory Activities:

1. Watch the following two minute video about USS *Nautilus*: http://www.youtube.com/watch?v=30uGYBIGrVA
2. Take a virtual tour of USS *Nautilus* at: http://www.ussnautilus.org/virtualTour/nautilus/_flash/USS%20Nautilus_nautilus.html .

Activity: Transiting the North Pole Submerged

1. Watch the above 2 minute video link, if not yet completed.

2. Project a polar projection map and point out the Pacific Ocean, Bering Strait, North Pole, Greenland Sea, and Iceland.

3. Review the formula s=d/t and its transformations.

4. On July 23, 1958 USS *Nautilus* (SSN 571), left Pearl Harbor on a historic voyage that ended near Iceland. During this voyage USS *Nautilus* crossed 90° North Latitude (The North Pole). You will need to perform calculations to determine some of the historic voyage's times, distances, and speeds based on data from the journey. Time will be presented in days and hours using the 24 hour clock (1800 = 6:00 PM) and may need to be converted to hours. Distances are in Nautical Miles, and speed is shown in knots (nautical miles per hour).

Questions:

1. How would the formula s=d/t be transformed to find time? Distance?

2. On July 23, 1958 USS *Nautilus* left Pearl Harbor at 1100 on the first leg of its journey. It arrived in the Bering Strait July 29th at 1300, the distance traveled was 2,900 nautical miles. How long was the voyage and what was the average speed of USS *Nautilus* in knots?

3. From the Bering Strait to the Geographic North Pole, USS *Nautilus* traveled at a speed of 9.98 knots. The total distance traveled was 1,200 nautical miles and they left The Bering Strait at 1300 on July 29th, how long did that leg of the voyage take and on what day and time did they arrive?

4. From the Geographic North Pole to the Greenland Sea, USS *Nautilus* traveled at an average speed of 17.77 knots for 35.45 hours. What distance was traveled during this part of the trip (rounded up)?

5. In the Greenland Sea, USS *Nautilus* surfaced and traveled on to Iceland where the Captain was picked up to travel by helicopter to Washington DC to be recognized for the accomplishments made by USS *Nautilus* and her crew. This leg of the journey to meet the helicopter took 49 hours and covered 520 nautical miles. What was the speed traveled?

6. The entire voyage of USS *Nautilus* took just over 2 weeks time. What are some possible reasons for all the various speeds traveled by the submersible ship during this historic voyage?

Extensions: 1. (1 min)Observe USS Connecticut (SSN22) surface through the polar ice: http://www.youtube.com/watch?v=Z-aJxqxaLfU
2. (7 min) Learn about the U.S. Navy ICEX program: http://www.navy.mil/viewVideo.asp?id=16182

Answers:

1. t = d/s, d = s*t

2. t = 146 hours, s=d/t
   s= 2,900nm/146hours
   s= 19.86 knots

3. t = s*t
   t = 1,200 nm / 9.98 knots
   t = 120.25 hours
   arrived at North Pole August 3, at 23:15

4. d = s*t
   d= 17.77 knots * 35.45 hours
   d= 630 Nautical Miles

5. 5. t = 49.5 hours, s=d/t
   s= 520 nm/49.5hours
   s= 10.5 knots

6. Some possible answers are…..
   a. Ice thickness and depth of ice keels
   b. Unknown terrain below the water and shallow water in the Bering Strait
   c. Traveling on the surface is slower than submerged due to turbulence and drag.
   d. Ice floes and growlers

PANAPO = Pacific to North Atlantic via the North Pole.

(Any feedback or suggestions for improvement? Email tallen@ledyard.net)