

“Operation Navigation”

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2014 Submarine Force Museum & Historic Ship *Nautilus* STEM-H Fellowship**

Instructional Goal

The two activities in the lesson are designed for Algebra and Geometry teachers looking for an application activity on geometric construction, unit conversion, angle measures and circles. Students will learn about the navigational techniques used by U.S. Navy submarines to calculate the position and heading of their own vessel and other vessels.

Common Core State Mathematic/Literacy Standards:

CCSS.MATH.CONTENT.5.G.A.2: Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

CCSS.MATH.CONTENT.7.G.A.1: Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

CCSS.MATH.CONTENT.HSG.CO.D.12: Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.).

CCSS.MATH.CONTENT.HSG.CO.A.1: Know precise definitions of angle, circle, perpendicular line, parallel line, and line segment, based on the undefined notions of point, line, distance along a line, and distance around a circular arc.

CCSS.MATH.CONTENT.HSN.Q.A.1: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

CCSS.ELA-LITERACY.RI.9-10.2: Determine a central idea of a text and analyze its development over the course of the text, including how it emerges and is shaped and refined by specific details; provide an objective summary of the text.

CCSS.ELA-LITERACY.L.9-10.4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on *grades 9-10 reading and content*, choosing flexibly from a range of strategies.

Background Knowledge:

Students should have geometry construction knowledge and measuring skills. They should be confident in their ability to use the following tools: compass, protractor, ruler and Cartesian planes. Students should also be able to calculate unit conversions.

Navy Background: websites and videos:

See <http://www.usssnautilus.org> for the Submarine Force Museum and Historic Ship *Nautilus*, plus http://www.usnavymuseum.org/Ex2_Navigation.asp for additional submarine navigation background, and <http://timeandnavigation.si.edu/multimedia-asset/uss-alabama> from a recent Smithsonian Museum exhibit for submarine navigation aboard Trident submarines.

For Lesson Activity Part 1:

<http://hamptonroads.com/2008/03/hightech-submarine-uses-oldfashioned-navigation> on navigation; <https://www.youtube.com/watch?v=Di2bJhkw7p0> on **night piloting**, surface navigation;

For Lesson Activity Part 2:

<https://www.youtube.com/watch?v=eOqalX5FJ2c> on emergency blows; <https://www.youtube.com/watch?v=oeUD5SAWltw> on USS *Greenville* and *Ehime Maru* collision; plus <http://www.boatsafe.com/nauticalknowhow/gloss.htm#Y> and http://en.wikipedia.org/wiki/Glossary_of_nautical_terms#B on nautical vocabulary.

Lesson Activity Descriptions

Activity 1: Operation Navigation

- Students will read an article; *High-tech Submarine uses Old-fashioned Navigation*, and watch video *Night Piloting - Surface 1943 Navy Navigation Training Film* about the navigation systems used on the surface. Followed by a class discussion.
- Students are given a scenario that places them on a submarine trying to navigate its way through the Thames River.
- Using a Long Island Sound nautical chart overlapped by a Cartesian plane, students are required to find the location of three markers (Ledge Lighthouse, Race Rock Lighthouse and Little Gull Lighthouse).
- Using geometric construction with a compass and unit conversions, students will locate the position of the submarine in relation to the three markers. Students will also discuss the number of possible locations represented by overlapping circles.
- Students will reflect on the efficiency of the navigational method used. Class discussion of other technologies utilized by the submarine force to navigate can relate class activities to the article read at the beginning of the lesson.
- Lastly, students will locate the three lighthouses using Google Maps.

Activity 2: Operation Avoid Collision

- As a hook, the students will watch a YouTube video of a submarine performing an emergency blow.
- Students will watch a YouTube informational video on USS *Greenville* and *Ehime Maru* collision due to an emergency blow. Followed by a class discussion.
- Accompanied by a nautical chart visual, students will define nautical terms required to continue the lesson successfully. The vocabulary will familiarize students with submarine lingo used. Followed by a class discussion.
- Students are given another scenario that places them on a submarine trying to avoid collision with a cruise ship in the Thames River.
- Using the Long Island Sound nautical chart overlapped by a Cartesian plane from before, students will calculate a submarine and cruise ships position.
- Angle measures with a protractor and unit conversions will aid students to calculate the submarine and cruise ship's heading. In order to determine their point of interception.



Some locations, like the North Pole above, have few ships to avoid, but other navigation hazards.

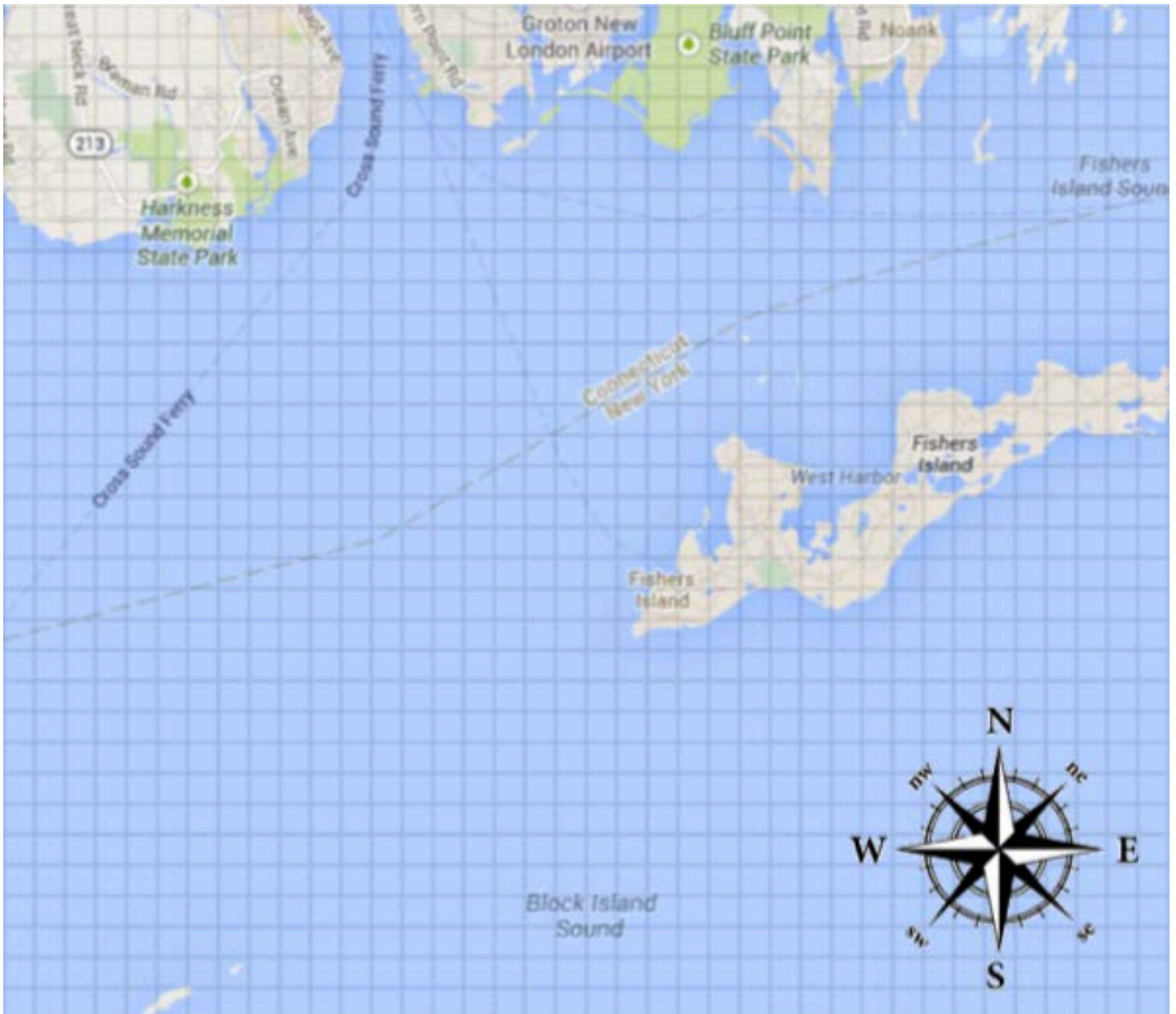
Student Handouts

Operation Navigation Chart (Activity 1 and 2)

Name: _____

Date: _____

Class: _____



Scale: 2 centimeters = 1 nautical mile

Activity 1: Operation Navigation

(How submarines determine where they are in the water?)

Read the Article below:

<http://hamptonroads.com/2008/03/hightech-submarine-uses-oldfashioned-navigation>

Night Piloting - Surface 1943 Navy Navigation Training Film

<https://www.youtube.com/watch?v=Di2bJhkw7p0>

Class Discussion

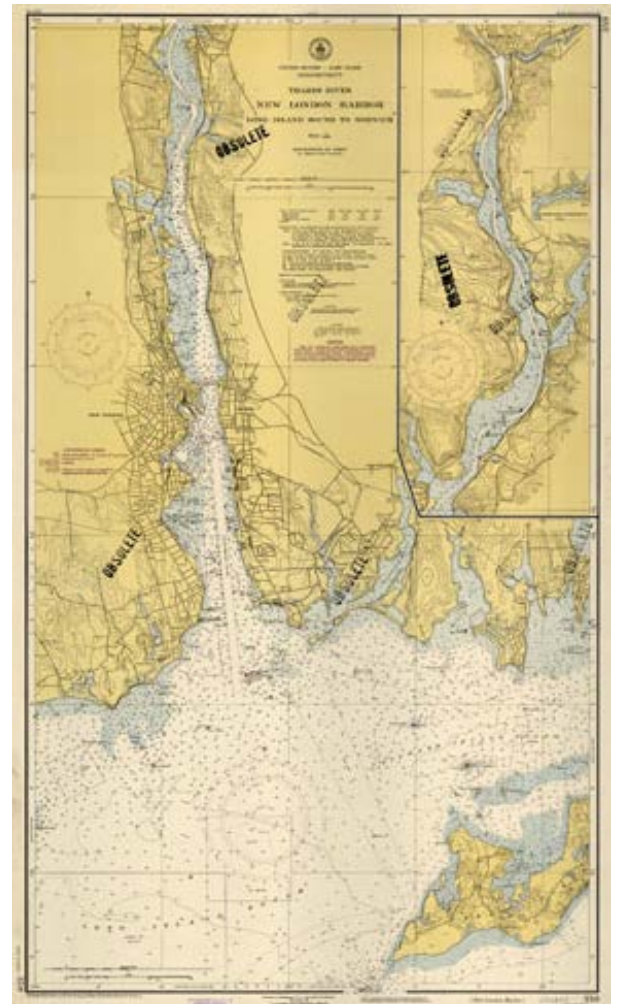


Imagine the scenario that you are aboard USS *Virginia* on the surface of the water as you approach the Groton-New London area.

What hazards would you need to avoid on your approach?

Why would the submarine need to surface in order to approach the Thames River?

What technologies would the boat need to pilot into the Thames River?





Ledge Lighthouse is located 2 nautical miles East of Harkness Memorial State Park. How many centimeters does that represent on the chart? Mark and label Ledge Lighthouse on the chart.

USS *Virginia*'s radar data indicates that Ledge Lighthouse is $2\frac{1}{2}$ nautical miles away from the submarine's location. How many centimeters does that represent on the chart?

Using a compass, construct all of the possible locations of the USS *Virginia* on the chart. How many different possibilities are there? What possible locations would we ignore? Explain your reasoning.



Race Rock Lighthouse is $3\frac{3}{4}$ nautical miles South and 1.5 nautical miles East of Ledge Lighthouse. Mark and label Race Rock Lighthouse on the chart.

Base on the chart, the Submarine is 6.5 cm away from Race Rock Light House. How many Nautical Miles would that represent?

Using a compass, construct all of the possible locations of USS *Virginia* on the chart. Now how many different possibilities are there? Do we know the exact location of the submarine? Why or why not?

To find the exact location, what would the submarine need to do? Explain your reasoning.



Little Gull Island Lighthouse is 12.75 centimeters South and $3\frac{1}{4}$ centimeters West of Ledge Lighthouse. Mark and label Little Gull Island Lighthouse on the chart.

USS *Virginia*'s radar data indicates that Little Gull Island Lighthouse is 4.25 Nautical Miles away from the submarine's location. How many centimeters does that represent on the chart?

Using a compass, construct all of the possible locations of USS *Virginia* on the chart. How many different possibilities are there? Do we know the submarine's location? Explain your reasoning.

How many markers (in this case we used lighthouse) did the submarine have to use in order to find its exact location? Explain your reasoning

What scenario would allow the submarine to use fewer markers? Explain your reasoning

Other than lighthouses, what could a submarine use for a marker?

How long did it take you to find the location of USS *Virginia*? Is this an effective way of finding your location? (Keep in mind; the submarine is in motion) Referring back to the article, what technology was utilized to expedite this process?

Show students the three lighthouses using Google Maps. (<https://maps.google.com/>)

Activity 2: Operation Avoid Collision

(How submarines determine where others are in the water?)

Hook - Watch YouTube video on Emergency Blow: <https://www.youtube.com/watch?v=eOgalX5FJ2c>

History - Watch YouTube video on USS *Greeneville* and *Ehime Maru* collision: <https://www.youtube.com/watch?v=oeUD5SAWltw>

Class Discussion

Imagine: USS *Hartford* (a *Los Angeles Class* attack submarine) is lining up for approach to the entrance of the Thames River on its way to the Groton, CT Submarine Base. However, the *Dawn Princess* cruise ship is also coming into the Thames River on the Cross Sound Ferry route. To avoid collision, the submarine must locate its position using radar.



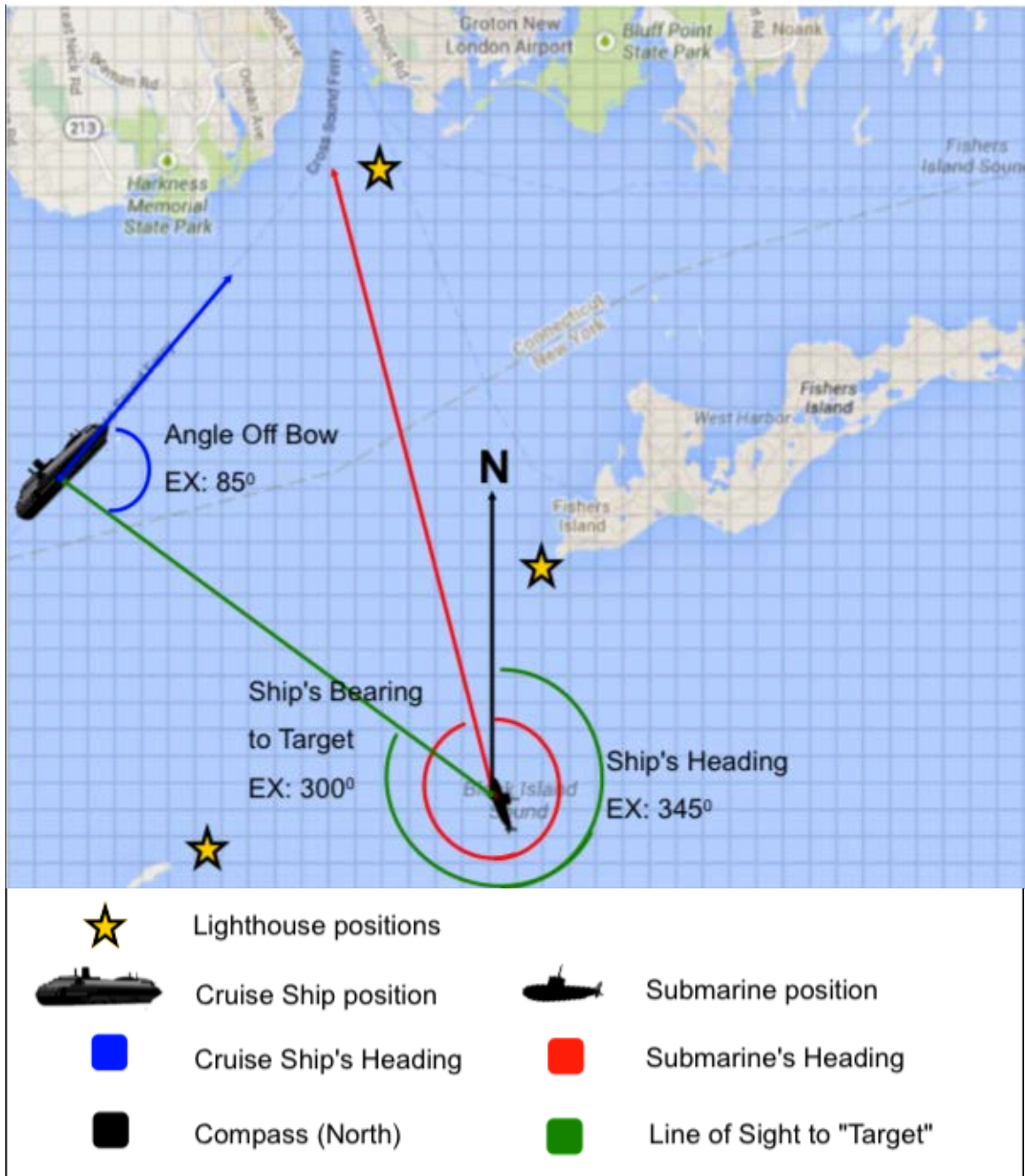
The Virginia-class, fast attack submarine U.S.S. Mississippi (SSN-782) approaches New London Ledge Lighthouse on its way out to sea as the Princess Cruise's cruise ship Dawn Princess arrives in New London bound for the Adm. Harold E. Shear State Pier in New London for a daylong stop for the passengers Tuesday, July 22, 2014. (<http://theday.com/article/20140722/NWS01/140729909/1017>)

Important VOCAB: Define the following words and refer to the visual below

Suggested websites: (<http://www.boatsafe.com/nauticalknowhow/gloss.htm#Y>)
(http://en.wikipedia.org/wiki/Glossary_of_nautical_terms#B)

- Heading
- Bearing
- Line of Sight
- Angle Off the Bow
- Nautical Miles
- Port
- Starboard
- Bow
- Stern
- Knots

Class Discussion



The submarine crew determines they are approximately due South of Race Rock Lighthouse and due East of Little Gull Lighthouse. Locate the USS *Hartford* and mark its position on a separate chart.

The submarine proceeds on the course of 342.5° . Draw the submarine's heading on your chart.

USS *Hartford* notices a cruise ship, the *Dawn Princess*, on the port side. It is estimated that the submarine's bearing to the "target" is 209° with a range of 5.75 nautical miles. Locate the *Dawn Princess* and mark its position on the chart.

The angle off the bow of the cruise ship is starboard 82° . Determine and draw the ship's heading on your chart.

Will the paths of the two ships cross? Where is that point of intersection? Explain your reasoning.

Determine the approximate distances to the intersection point from both ships. If the submarine is going 12 knots and the cruise ship is going 10 knots, could the vessels collide?

How close (as a unit of time) could the two vessels be to each other? Does the length of the ship make a difference?