

<b>Compelling Question</b>	<b>How did advances in marine navigation, from the 13<sup>th</sup> century C.E. through the 18<sup>th</sup> century C.E., help to catapult Western Europe into global preeminence?</b>			
<b>Standards and Practices</b>	<p><i>C3 Historical Thinking Standards – D2.His.1.9-12.</i> Evaluate how historical events and developments were shaped by unique circumstances of time and place as well as broader historical contexts.</p> <p><i>C3 Historical Thinking Standards – D2.His.2.9-12.</i> Analyze change and continuity in historical eras.</p> <p><i>Common Core Content Standards – CCSS.ELA-LITERACY.WHST.9-10.1.B</i> Develop claim(s) and counterclaims fairly, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.</p>			
<b>Staging the Question</b>	How do advances in marine navigation technology help nations develop and sustain world influence?			
<b>Supporting Question 1</b>	<b>Supporting Question 2</b>	<b>Supporting Question 3</b>	<b>Supporting Question 4</b>	
Why has the sea been crucial to the fate of nations, empires, and civilizations?	What is navigation and what special challenges does the sea pose to travelers?	How does being posed with a challenge lead us to innovation and progress?	How did STEM confer advantages to a society's ability to navigate the world's oceans?	
<b>Formative Performance Task 1</b>	<b>Formative Performance Task 2</b>	<b>Formative Performance Task 3</b>	<b>Formative Performance Task 4</b>	
<p>1) Look at the planet's physical geography, build an argument that the sea was better at connecting cultures than the land.</p> <p>2) View <i>Power of the Sea</i> video (03:12 min) (<a href="http://reach.ieee.org/multimedia/power-at-sea/">http://reach.ieee.org/multimedia/power-at-sea/</a>) and discuss the implications of using the sea for trade.</p>	<p>1) In pairs ask your partner to draw you a map from school to a specific location in your town.</p> <p>2) After reviewing the map, which landmarks were used to help you get to your destination?</p> <p>3) View <i>Lost at Sea</i> video (04:04 min) (<a href="http://reach.ieee.org/multimedia/lost-at-sea/">http://reach.ieee.org/multimedia/lost-at-sea/</a>) and discuss how traveling</p>	<p>1) <b>Compass Lesson Plan</b> (<i>Lesson is located below all the Print Documents</i>)</p> <p>Discover how the magnetic compass evolved from a mystical object to a precise and reliable instrument for travelling across the world's oceans.</p> <p>2) View <i>Latitude</i> video (05:08 min) (<a href="http://reach.ieee.org/multimedia/latitude/">http://reach.ieee.org/multimedia/latitude/</a>) and discuss how</p>	<p>1) Drawing connections to the last three questions, view the <i>Longitude</i> video (07:05 min) (<a href="http://reach.ieee.org/multimedia/longitude/">http://reach.ieee.org/multimedia/longitude/</a>) and analyze the longitude challenge, how it was addressed by different societies, and what advantages were achieved.</p> <p>Students may also further investigate resources on</p>	

	<p>the sea is different than traveling land.</p> <p>4) Based upon this information and after watching the <i>Lost at Sea</i> Video, discuss how Rhett might get his friends home safely knowing that current technologies are not available to him?</p>	<p>and why navigational technologies changed and evolved to determine latitude and why these new technologies were important to seafarers.</p> <p>3) View the short GPS video (01:28 min) (<a href="http://reach.ieee.org/multimedia/gps/">http://reach.ieee.org/multimedia/gps/</a>). How do the challenges of the past inform the technologies of today?</p>	<p>the topic. Some sources are listed below.</p> <p>2) Teacher Choice: Classroom Activity - Teachers will choose from various sources to help students identify and realize the global consequences of regional responses to new navigational technologies</p>
Featured Sources	Featured Sources	Featured Sources	Featured Sources
<p>1A. Google World Map <a href="https://www.google.com/maps/d/u/0/viewer?mid=1WouvrIFG1Z_aTy_zDf1HcMrI1sQ&amp;hl=en_US">https://www.google.com/maps/d/u/0/viewer?mid=1WouvrIFG1Z_aTy_zDf1HcMrI1sQ&amp;hl=en_US</a></p> <p>1B. Power of the Sea video (03:12 min) <a href="http://reach.ieee.org/multimedia/power-at-sea/">http://reach.ieee.org/multimedia/power-at-sea/</a></p> <p>1C. Cantino World Map, 1502. "Cantino Planisphere." Wikipedia. (Accessed: 13 Nov. 2016) <a href="https://en.wikipedia.org/wiki/Cantino_planisphere#/media/File:Cantino_planisphere_(1502).jpg">https://en.wikipedia.org/wiki/Cantino_planisphere#/media/File:Cantino_planisphere_(1502).jpg</a></p> <p>1D. Map of Earth, circa 1507. "Exploring the Early Americas, Waldseemüller Maps." 1507 World Map. (Accessed: 13 Nov. 2016) <a href="https://www.loc.gov/exhibits/exploring-the-early-">https://www.loc.gov/exhibits/exploring-the-early-</a></p>	<p>2A. <i>Lost at Sea</i> video (04:04 min) <a href="http://reach.ieee.org/multimedia/lost-at-sea/">http://reach.ieee.org/multimedia/lost-at-sea/</a></p> <p>2B. "The First Voyage round the World, by Magellan" : Pigafetta, Antonio, Ca. 1480/91-ca. 1534. Primo Viaggio Intorno Al Globo Terraqueo. English : Free Download &amp; Streaming : Internet Archive." Internet Archive. (Accessed: 11 Nov. 2016) <a href="https://archive.org/details/firstvoyageround00piga">https://archive.org/details/firstvoyageround00piga</a></p> <p>2C. Cooke, James Herbert, FSA 1889 "The Shipwreck of Sir Cloudesley Shovell, on the Scilly Islands in 1707: From Original and Contemporary Documents Hitherto Unpublished" (Read at a Meeting of the Society of Antiquaries, London, 1 Feb. 1883) (Accessed: 5 Nov. 2016) <a href="http://www.pastscape.org/hob.aspx?hob_id=1436004">http://www.pastscape.org/hob.aspx?hob_id=1436004</a></p>	<p><u>Compass lesson plan:</u> (<i>located below the printed documents</i>) includes the following featured sources: <i>Power of the Sea</i> video, <i>Lost at Sea</i> video, <i>Compass</i> video, <i>Latitude</i> video, evolution of compass and portolan charts, and a compass hands-on- activity. <a href="http://reach.ieee.org/hands-on-activities/compass-hands-on-activity/">http://reach.ieee.org/hands-on-activities/compass-hands-on-activity/</a></p> <p>3A. <i>Power of the Sea</i> Video (03:12 min). <a href="http://reach.ieee.org/multimedia/power-at-sea/">http://reach.ieee.org/multimedia/power-at-sea/</a></p> <p>3B. <i>Lost at Sea</i> video (04:04 min). <a href="http://reach.ieee.org/multimedia/lost-at-sea/">http://reach.ieee.org/multimedia/lost-at-sea/</a></p> <p>3C. <i>Compass</i> video (05:25 min). <a href="http://reach.ieee.org/multimedia/the-compass/">http://reach.ieee.org/multimedia/the-compass/</a></p> <p>3D. <i>Latitude</i> video (05:08 min). <a href="http://reach.ieee.org/multimedia/latitude/">http://reach.ieee.org/multimedia/latitude/</a></p>	<p>4A. <i>Longitude</i> video (07:05 min). <a href="http://reach.ieee.org/multimedia/longitude/">http://reach.ieee.org/multimedia/longitude/</a></p> <p>Additional Resources for investigation:</p> <p>"Cambridge Digital Library." Papers of the Board of Longitude. (Accessed: 11 Nov. 2016) <a href="https://cudl.lib.cam.ac.uk/collections/rgo14/">https://cudl.lib.cam.ac.uk/collections/rgo14/</a></p> <p>"Density of Ship Log Entries, 1750-1810." Density of Ship Log Entries, 1750-1810. (Accessed: 4 Nov. 2016) <a href="https://people.hofstra.edu/geotrans/eng/ch2en/conc2en/ship_log_density_17501810.html">https://people.hofstra.edu/geotrans/eng/ch2en/conc2en/ship_log_density_17501810.html</a></p> <p><u>Asia Classroom Activity</u> (<i>multiple sources within lesson document</i>)</p> <p><u>Middle East Classroom Activity</u> (<i>multiple sources within lesson document</i>)</p>

<p><a href="http://americas/interactives/waldseemuller-maps/worldmap1507/index.html">americas/interactives/waldseemuller-maps/worldmap1507/index.html</a></p> <p>1E. Mappa Mundi <a href="http://www.themappamundi.co.uk/mappa-mundi/">http://www.themappamundi.co.uk/mappa-mundi/</a></p> <p>1F. Monmonier, Mark. <i>Rhumb lines and map wars: a social history of the Mercator projection</i>. University of Chicago Press, 2010.</p> <p>1G. Heitzmann, Christian. <i>Europe's image of the world in old maps: Globalization in the Age of Discoveries</i>. Wolfenbüttel: Herzog August Library (2006).</p>	<p>("+" <i>More Information and Sources</i>)</p> <p>2D. Sobel, Dava. <i>Longitude: The true story of a lone genius who solved the greatest scientific problem of his time</i>. Bloomsbury Publishing USA, 2007.</p>	<p>3E. GPS video (01:28 min). <a href="http://reach.ieee.org/multimedia/gps/">http://reach.ieee.org/multimedia/gps/</a></p> <p>3F. "Chaucer's Astrolabe Treatise - Chirurgeon's Point." (Accessed: 9 Nov. 2016) <a href="http://www.chirurgeon.org/files/Chaucer.pdf">http://www.chirurgeon.org/files/Chaucer.pdf</a></p> <p>3G. Vardalas, John. "A History of the Magnetic Compass." <i>The Institute, Tech History</i> (blog). Entry posted 8 Nov. 2013. (Accessed: 30 Oct. 2016) <a href="http://theinstitute.ieee.org/tech-history/technology-history/a-history-of-the-magnetic-compass">http://theinstitute.ieee.org/tech-history/technology-history/a-history-of-the-magnetic-compass</a></p>	<p><u>Europe Classroom Activity</u>(multiple sources within lesson document)</p>
<p><b>Summative Performance Task</b></p>	<p><b>Argument</b></p>	<p>Construct an argument that assesses the value of navigation technology as a source of power. Use specific claims and relevant evidence from historical sources, while acknowledging competing views.</p>	
	<p><b>Extension</b></p>	<p>Debate how science and technology contribute to modern life and whether or not they have moved society forward or backward.</p>	
<p><b>Taking Informed Action</b></p>	<p><b>UNDERSTAND:</b> Identify and describe which navigational capabilities might define world preeminence in the future.</p> <p><b>ASSESS:</b> Consider how a society's willingness to embrace new ideas and technologies can impact its standing in a global society.</p> <p><b>ACTION:</b> Choose an issue that exists today – related to navigation and its associated technologies – and propose a viable solution.</p>		

## TO THE TEACHER

All *REACH* Instructional Units are intended to be “classroom-ready.” Each unit begins with a *Unit Plan* in the form of a [C3 Inquiry Design Model](#). The *Unit Plan* includes learning objectives, content standards, formative and summative tasks, links to primary and secondary resources, and a warm-up activity.

Units are organized around a *Compelling Question* designed to inspire curiosity and promote discussion among students. To that end, we have also included a brief student introduction to the topic entitled, *Staging the Question*. Once students have been introduced to the topic, any number of *Formative Performance Tasks* may be completed using the included *Document Excerpts* (teachers may elect instead to utilize full-text documents linked within the *Featured Sources* section). *Document Excerpts* are print-ready in single-sheet format and keyed to the citations in the *Featured Sources* section of the *Unit Plan*. Teachers should select the *Formative Performance Tasks* and accompanying *Sources* that best suit their own instructional needs – content requirements, performance goals, student readiness, and time constraints. Upon the completion of each unit, students should be adequately prepared to complete the *Summative Performance Task* and *Taking Informed Action* sections of the *Unit Plan*.

To further assist the teacher, we have included a more thorough *Background Information* section. This document is intended to serve as professional reading prior to implementing the unit. Teachers may also wish to read the full-length primary and secondary sources from which the shorter excerpts were taken.

## STAGING THE QUESTION

The world's seas and oceans have been a compelling paradox in the story of humanity. Covering 71 percent of the planet's surface, the world's oceans are extremely hostile to human existence. Storms when they rage over an ocean are far more dangerous and terrifying than their land-based equivalents. Drowning is a terrifying prospect. On the ocean, winds blowing over great distances produce waves that easily engulf and sink ships. As humans ventured further and further out into the ocean, they had to worry about the basic needs of human existence: food and water. Humans developed ships as life support systems that would sustain them as they travelled across this inhospitable environment. The challenges of navigating across oceans compounded the dangers of drowning, dying of thirst, or perishing from malnutrition and disease.

And yet, despite their alien and very inhospitable nature, the vast oceans of our planet, as much or if not more than the land, became the axes around which much of the story of humankind has turned. They have been, according to the eminent world historian Felipe Fernandez-Armesto, "the supreme arena of the events that constitute global history." Peter Padfield, one of the today's leading naval historians, takes it a step further. "Maritime supremacy", writes Padfield, "is the key which unlocks most, if not all, large questions of modern history. Certainly the puzzle of how and why we – the Western democracies – are as we are." Why then is the sea so important in history? Philip de Souza, in his book "Seafaring and Civilization", offers a very concise explanation: "maritime networks have linked societies and civilizations together, providing conduits for the exchange and distribution of goods, the projection of political and economic power and the diffusion of ideologies and cultures." To Souza's list should also be added that these conduits enabled the magnification of military might. They have been possible because:

- From antiquity, through to the advent of the railway in the 19th century, the sea provided the fastest and cheapest way to move large quantities of goods from one point to another on the planet. Even within the borders of a nation, moving goods along the coast or down rivers was far more economical than over land.
- Connectivity by ocean made it easier to break trade monopolies. Access to distant suppliers no longer depended on a chain of "middlemen." Generally, this meant greater profits and potentially lower prices for consumers.
- Capacity to Project Power - Direct access to any place on the planet by way of the sea confers great advantages to any nation with a powerful navy. Such direct access may enable a nation to more easily influence and control events halfway around the world without having to control the intervening territories. Harbors could easily be blockaded. Land-based empires could not do this.
- The sea gave, and still gives, a nation the logistical capacity to move and support its armies on distant lands.
- The sea also had important cultural influences. Nations who committed their fortunes to the sea through maritime trade tended to be more outward looking. It was hard to suppress new ideas when merchants traded around the world. Some historians have argued that a nation who gambled its material and political future on sea power tended to be more open and more outward looking than land based empires. Padfield argues that "seafaring and trade beget merchants; merchants accumulate wealth and bring the pressure of money to bear on hereditary monarchies and landowning aristocracies, usually poor by comparison; and sooner or later merchant values prevail in government. Chief of these are: dispersed power; open and consultative rule because the concentrated power and the arbitrary rule of closed cabals are unresponsive to the needs of trade

and fatal to sound finance... The other distinguishing mark of merchant power is freedom ... Liberty has always been the pride and rallying cry of powers enjoying maritime supremacy.” Though Padfield’s position invites debate and charges of Western exceptionalism, it is nevertheless worthy of serious discussion within the high school world history class, particularly because of its relevance to current events.

Maritime supremacy was about gaining the most favorable terms of trade. As Sir Walter Raleigh proclaimed, at the close of the 16th century: “Hee that commands the sea, commands the trade, and hee that is Lord of trade of the world is Lord of the wealth of the world.” To command this hostile environment advances in science and engineering were essential. Better life support systems (i.e. commercial and naval vessels) had to be designed. Finding one’s way across the oceans was far more difficult than navigating on land. And the penalty for error was often deadly. The very difficult challenge of navigating across the world’s vast an undifferentiated oceans had to be mastered.

### **What is Navigation?**

Navigation is about the know-how, skills, and tools needed to get from point A to point B on the Earth’s surface, in the most economical (in time and money) and safest manner, i.e. the ability to formulate and execute a plan for moving between any two locations, wherever they be on the planet. The details of any navigational plan will depend on the purpose of the journey (pleasure, adventure, war, profits, or gaining knowledge), the mode of transport (by foot, animal conveyance, vessel, car, and plane), and knowledge of the physical environment through the person would travel.

Though navigating over land can, at times be challenging, it still remains far easier than navigating over water. On land we have a plethora of fixed visible cues in the landscape to help orient ourselves as we move from one point to another. But out at sea, far from the sight of land, the traveler is faced with a world without any useful, distinguishing features. It is so much easier to get disoriented and lost at sea than on land. Errors in navigation usually lead to far more dire consequences at sea than on land. The dangers from being disoriented are compounded by the ocean’s vastness and fundamental inhospitable nature. Dangers lurk even close to shore. Fog and poor weather can conceal deadly hazards that can easily sink a ship and kill all on board.

When out at sea, humans turned to celestial bodies for their reference points. Translating the movement and locations of celestial bodies into a reliable and accurate basis for navigation required considerable science and technology. When the day and night skies were heavily overcast, navigators became quite anxious. The invention of the magnetic compass, one of the greatest inventions of all time, was the perfect complement to the stars. Mastering navigation also required the development of accurate ways to depict the surrounding space and one’s location in this space. Thus, advancing the science and technology of cartography was essential to good navigation. But at sea, where there were no physical reference points, the application of cartography to navigation required visualizing the surface of the earth in terms of coordinates of a sphere, latitude, and longitude. Measuring and portraying latitude and longitude at sea became powerful engines driving science and engineering.

## PRINT DOCUMENTS

### Document 1C



SOURCE: Cantino World Map, 1502. "Cantino Planisphere." Wikipedia. (Accessed: 13 Nov. 2016) [https://en.wikipedia.org/wiki/Cantino\\_planisphere#/media/File:Cantino\\_planisphere\\_\(1502\).jpg](https://en.wikipedia.org/wiki/Cantino_planisphere#/media/File:Cantino_planisphere_(1502).jpg).

### Document 1D

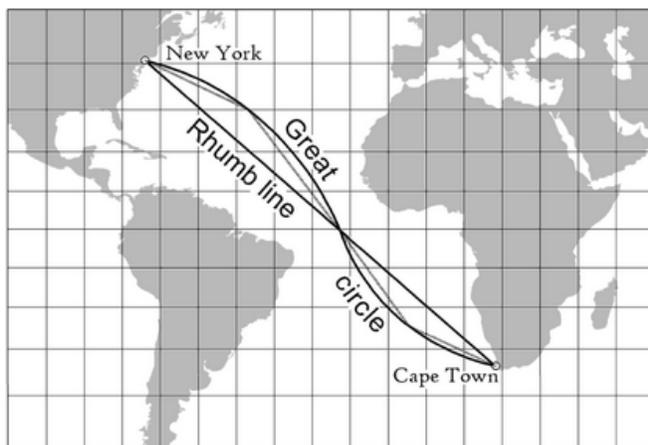
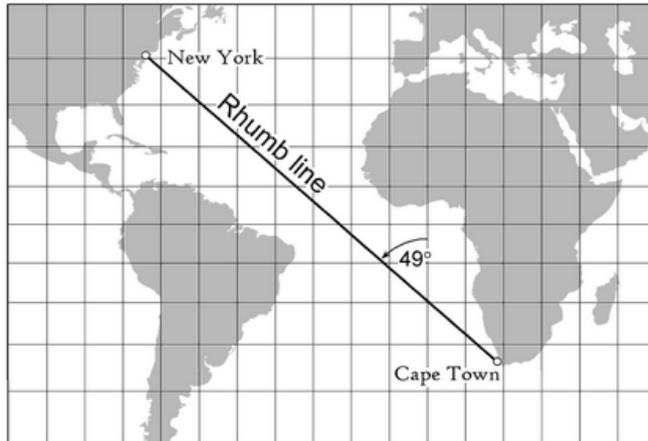


SOURCE: Map of Earth, circa 1507. "Exploring the Early Americas, Waldseemüller Maps." 1507 World Map. (Accessed: 13 Nov. 2016) <https://www.loc.gov/exhibits/exploring-the-early-americas/interactives/waldseemuller-maps/worldmap1507/index.html>.

### Document 1F

Mariners share two fears: bad weather and getting lost. Their deep respect for the Mercator projection reflects the map's value for plotting an easily followed course that can be marked off with a straightedge and converted to a bearing with a protractor....

Picture yourself as a seventeenth-century navigator who knows where he is and where he wants to go. You plot both locations on a chart, join them with a straight line, and measure the angle your line makes with the map's meridians, which run due north. If the chart is a Mercator map, all its meridians are straight lines, parallel to one another, and the course you've just plotted is a rhumb line, also called a loxodrome....



When plotted on a Mercator grid, a rhumb line intersects all meridians at the same angle. In this example a constant bearing of forty-nine degrees west of north will take a ship from Cape Town to New York.

Mercator published his celebrated world map of 1569 as a set of eighteen sheets, which form a wall-size mosaic 48 inches (124 cm) tall by 80 inches (202 cm) wide. Its projection revolutionized navigation by straightening out rhumb lines on a flat map – not just the globe's meridians and parallels, but any rhumb line a seaman might plot. To accomplish this, Mercator progressively increased the separation of the parallels....

Relative size, which is preserved on map projections with a property called equivalence, is markedly misrepresented on Mercator charts because of the increased poleward separation of parallels required to straighten out loxodromes. Distortion of area is most apparent in the chart's inflated portrayal of Greenland as an island roughly the size of South America. On a globe Greenland is not quite an eighth as large.

Navigators began to use the Mercator map in the early 1600s....

**SOURCE:** Excerpted from Monmonier, Mark. *Rhumb lines and map wars: a social history of the Mercator projection*. University of Chicago Press, 2010.

Since the 12th or 13th century, there were hand drawn charts of the Mediterranean. The earliest evidence of the existence of such maps note that King Louis IX of France (r. 1226-1270) had used such a chart on his crusade against Tunis in 1270. These maps were drawn on parchment. The earliest surviving maps – from the late 13th century – come from Italy. In the 14th century, the Balearic Islands and Catalonia were the leading centers of production of such charts. Even then, several maps were sometimes assembled into atlases.

These late medieval charts are called *Portulankarten*. This name derives from manuals to mariners, the *Portulanen* (Italian - *Portolani*), which listed in consecutive order coastal towns and ports (Latin - *Portus*) along with their distances from each other and ... nautical-technical information about the landing sites. On the *Portulankarten*, numerous places are listed along the coasts. Their practical purpose was to lead the merchant maritime sector on safe routes to their destinations. Therefore, the coastline is reproduced as accurately as possible with all the bays, headlands, estuaries and harbors, where the coastline is composed of small, juxtaposed semicircles. The interior is usually given little attention.

On most *Portulankarten* are one or more wind or compass roses. Usually sixteen compass roses were arranged circularly around a central rose. Each of these is connected to the others by straight lines. These connecting lines (*Rhumben*) were used to navigate by compass on the high seas.

In the course of systematic expeditions, producing *Portulankarten* in Portugal and Spain became increasingly important in the 15th century. Until well into the 17th century, these chart forms remained an important medium for sailors. The ornate design of many of the resulting sheets indicated that these elaborate maps were perhaps originally created not only for practical, but for representative purposes and for collectors. In the 16th century Battista Agnese created in Venice a large number of atlases, which are compiled from *Portulankarten*. Agnese's *Portulanatlas* were magnificently illuminated and bound. As collector's items they found their way especially into princely collections. The Herzog August Bibliothek owns seven large *Portulankarten* acquired all by Duke August the Younger (1579 -1666). Within these, three are of the Mediterranean, two of the Indian Ocean, and two of America. ...

The map of the sea route to India is one of the oldest preserved documents of Portuguese cartography in the Age of Discovery. Since the early 15th century, the Portuguese systematically explored the African Atlantic coast. Under Prince Henry the Navigator (1394-1460), they regularly upgraded ships that successively penetrated to the south. The expeditions provided evidence that there was no impenetrable heat zone near the equator. In this way, piece by piece, the Portuguese extended their knowledge of the sea route along the African coast. The map follows the course of the African coast around the mouth of the Congo southwards to the Cape of Good Hope, which was circumnavigated for the first time in 1487 by Bartolomeo Diaz. In addition, the chart offers an accurate picture of the East African coast and its islands, the southern coast of Arabia, and the western and southern coasts of India. Among the places highlighted in India is Calicut, one of the main ports of call for the Portuguese in this time period.

**SOURCE:** Excerpted from Heitzmann, Christian. *Europe's image of the world in old maps: Globalization in the Age of Discoveries*. Wolfenbüttel: Herzog August Library, 2006.

Numerous Indian Ocean islands are located precisely positioned, although the Comoros, Seychelles and Maldives (red and blue dots) appear very schematically in detail. While the location of the island of Ceylon was well known, the areas further east were still uncertain. The outlines of a large island (next to an even larger landmass) suggest knowledge of the island of Sumatra and the Malaysian peninsula. Just twelve years after the Portuguese explorer Vasco da Gama reached India in 1498; the Portuguese had an astonishingly accurate knowledge of the newly opened Ocean. The information must certainly have been based on position provisions of Portuguese sailors, but whether knowledge of Arabic or Indian sailors was used is unclear. The seas under Muslim rule, difficult for the Portuguese to reach at that time, are represented inaccurately. The Red Sea (red) and the Persian Gulf (blue) are shown greatly distorted in their outlines. The course of the Nile inside Africa is schematically represented as hardly anything was known about the actual course of the river.

The Christian-European perspective of the cartographers is demonstrated by the fact that flying over Jerusalem, just at the north tip of the Red Sea, is a flag with the cross, although the town was continuously under Muslim domination since 1244. The building seen on the Arabian Peninsula at the site of the city of Mecca is like a small church with a bell tower. ... The Indian Ocean was the main area of interest of the Portuguese. Bypassing the Cape of Good Hope in 1487, Bartolomeo Diaz opened the sea route to India. By 1498, Vasco da Gama became the first European to reach the country by sea. In the Treaty of Tordesillas (1494), Portugal was awarded the entire Indian Ocean. In a short time, the Portuguese took over the transportation of spices from India to Europe and monopolized this profitable business for themselves.

**SOURCE: Excerpted from Heitzmann, Christian. Europe's image of the world in old maps: Globalization in the Age of Discoveries. Wolfenbüttel: Herzog August Library, 2006.**

**Document 2B**

*From a letter written by Anthony Pigapheta, Patrician of Venice and Knight of Rhodes to Lord Philip of Villers Lisleaden, Grand Master of Rhodes*

Monday, the third of October of the said year [1519], at the hour of midnight, we set sail, making the course auster [on the south wind], which the Levantine mariners call Siroc [Southeast], entering into the ocean sea. We passed the Cape Verd[e] and the neighboring islands in fourteen-and-a-half degrees, and we navigated for several days by the coast of Guinea or Ethiopia; where there is a mountain called Sierra Leona, which is in eight degrees latitude according to the art and science of cosmology and astrology. Sometimes we had the wind contrary and at other times sufficiently good, and rains without wind. In this manner we navigated with rain for the space of sixty days until the equinoctial line, which was a thing very strange and unaccustomed to be seen, according to the saying of some old men and those who had navigated here several times. Nevertheless, before reaching this equinoctial line we had in fourteen degrees a variety of weather and bad winds, as much on account of squalls as for the head winds and currents which came in such a manner that we could no longer advance. In order that our ships might not perish nor broach to [swing broadside to the wind or waves] (as it often happens when the squalls come together), we struck [lowered] our sails, and in that manner we went about the sea hither and thither until the fair weather came. During the calm there came large fishes near the ships which they called *Tiburoni* (sharks), which have teeth of a terrible kind, and eat people when they find them in the sea either alive or dead. These fishes are caught with a device which the mariners call hame, which is a hook of iron. Of these, some were caught by our men. However, they are worth nothing to eat when they are large; and even the small ones are worth but little. During these storms the body of St. Anselme appeared to us several times; amongst others, one night that it was very dark on account of the bad weather, the said saint appeared in the form of a fire lighted at the summit of the mainmast, and remained there near two hours and a half, which comforted us greatly, for we were in tears, only expecting the hour of perishing; and when that holy light was going away from us it gave out so great a brilliancy in the eyes of each, that we were near a quarter-of-an-hour like people blinded, and calling out for mercy. For without any doubt nobody hoped to escape from that storm.

**SOURCE:** Excerpted from Stanley, Henry Edward John Stanley, Baron. *The First voyage round the world, by Magellan, Translated from the accounts of Antonio Pigafetta, ca. 1480/91-ca. 1534*. London: Printed for the Hakluyt Society, 1874. Internet Archive. (Accessed: 11 Nov. 2016)

<https://archive.org/details/firstvoyageround00piga>

### **Document 2C**

TORBAY, Journal of Lieut. Field:

'Oct. 23rd. Hard gales, with hazy weather and rain. At 6 the Genll [General] made the signal to wear [turn away from the wind], w[hi]c[h] we repeated; at 7 the MONMOUTH made the signal of danger; at half past 7 on our weather bow we unexpectedly see ye breakers on the Bishop and Clarks [rocks off the coast of the Scilly islands]; we immediately wore and made the sigll of danger, which was very imminent, in wch we had infallible demonstrations of Almighty Providence, first our wearing sooner than usual with main and fore-course, 2ndly when we judg'd ourselves inevitable on ye rocks, yet preserved from ye mighty danger; at 9 ye lights of Scilly bore E by S half S [SSE], about 3 miles; we then steered between ye W[es]t and ye NW till 7 this morning. At 9 sounded and had 60 fathom water, then told 11 sail that followed us; God preserve the rest!' (13)(14)

ST GEORGE, Journal of Lieut. Wiscard:

'Oct. 23. At half past 7 we heard several guns fired, and at 8 we discovered ye breakers off from ye island of Silley, we wore ship and stood to ye westward; ye lighthouse of Silley bore ESE half S, distt 6 miles at 7 in ye morning. Tackt and stood to ye S at 9. Counted 6 sail. Admiral Shovell supposed to be lost.' (13)(14)

MONMOUTH, Journal of Captain Baker:

'Oct. 22. At half past 5 ye signall was made to make sail, wch we did, & endeavoring to get ye flag's light ahead of us we discovered a rock to leeward of us; we immediately wore ship and got clear of it, & in wearing I discovered ye light of Silley bearing E by Ndly, so I made ye signal of Danger and repeated it several times, so yt might be taken notice of, and made w[ha]t sail I could to the westward, w[hi]ch was only w[i]th my courses.' (13)(14)

SWIFTSURE, Journal of Captain Griffiths:

'Oct. 23. At 6 Sir Cloudesley Shovel made ye signal to wear, at the same time we all made saile, hauling up E by S, ESE and SE. At half past 7 fell in with ye islands of Scilly; the Genll fired one gun, as we plainly saw, and immediately lost sight of him; then Rear Admiral Noris fired four guns, hoisted several lights and wore, and put all his lights out, at ye same time made the light on St. Mary's under our lee bow. At 7am (on "23rd) saw seaven saile w[hi]ch I judg'd to be some of ye separated fleet.' (13)(14)

**SOURCE: Excerpted from Cooke, James Herbert, FSA 1889 "The Shipwreck of Sir Cloudesley Shovell, on the Scilly Islands in 1707: From Original and Contemporary Documents Hitherto Unpublished" (Read at a Meeting of the Society of Antiquaries, London, 1 Feb. 1883) (Accessed: 5 Nov. 2016)**

[http://www.pastscape.org/hob.aspx?hob\\_id=1436004](http://www.pastscape.org/hob.aspx?hob_id=1436004) ("+" **More Information and Sources**)

## **Document 2D**

“Dirty Weather,” Admiral Sir Cloudisley Shovell called the fog that had dogged him twelve days at sea. Returning home victorious from Gibraltar after skirmishes with the French Mediterranean forces, Sir Cloudisley could not bear the heavy autumn overcast. Fearing the ships might founder on coastal rocks, the admiral summoned all his navigators to put their heads together.

The consensus opinion placed the English fleet safely west of Ile d’Ouessant, an island outpost of the Brittany peninsula. But as the sailors continued north, they discovered to their horror that they had misgauged their longitude near the Scilly Isles. These tiny islands, about twenty miles from the southwest tip of England, point to Land’s End like a path of steppingstones. And on that foggy night of October 22, 1707, the Scillies became unmarked tombstones for almost two thousand of Sir Cloudisley’s troops.

The flagship, the *Association*, struck first. She sank within minutes, drowning all hands. Before the rest of the vessels could react to the obvious danger, two more ships, the *Eagle* and the *Romney*, pricked themselves on the rocks and went down like stones. In all, four of the five warships were lost.

Only two men washed ashore alive. One of them was Sir Cloudisley himself, who may have watched the fifty-seven years of his life flash before his eyes as the waves carried him home. Certainly he had time to reflect on the events of the previous twenty-four hours, when he made what must have been the worst mistake of judgment in his naval career. He had been approached by a sailor, a member of the *Association’s* crew, who claimed to have kept his own reckoning of the fleet’s location during the whole cloudy passage. Such subversive navigation by an inferior was forbidden in the Royal Navy, as the unnamed seaman well knew. However, the danger appeared so enormous, by his calculations, that he risked his neck to make his concerns known to the officers. Admiral Shovell had the man hanged for mutiny on the spot.

No one was around to spit “I told you so!” into Sir Cloudisley’s face as he nearly drowned. But as soon as the admiral collapsed on dry sand, a local woman combing the beach purportedly found his body and fell in love with the emerald ring on his finger. Between her desire and his depletion, she handily murdered him for it. Three decades later, on her deathbed, this same woman confessed the crime to her clergyman, producing the ring as proof of her guilt and contrition.

The demise of Sir Cloudisley’s fleet capped a long saga of seafaring in the days before sailors could find their longitude.... Launched on a mix of bravery and greed, the sea captains of the fifteenth, sixteenth, and seventeenth centuries relied on “dead reckoning” to gauge their distance east or west of home port. The captain would throw a log overboard and observe how quickly the ship receded from this temporary guidepost. He noted the crude speedometer reading in his ship’s logbook, along with the direction of travel, which he took from the stars or a compass, and the length of time on a particular course, counted with a sandglass or a pocket watch. Factoring in the effects of ocean currents, fickle winds, and errors in judgment, he then determined his longitude. He routinely missed his mark, of course – searching in vain for the island where he had hoped to find fresh water, or even the continent that was his destination. Too often, the technique of dead reckoning marked him for a dead man.

**SOURCE:** Excerpted from Sobel, Dava. *Longitude: The true story of a lone genius who solved the greatest scientific problem of his time*. Walker Books; Reprint Edition, 2007.

**Document 3F****Excerpt from *A Treatise on the Astrolabe***

Little Lewis, my son, I see some evidence that you have the ability to learn science, number and proportions, and I recognize your special desire to learn about the astrolabe. So, as the philosopher said, “he serves his friend who grants his friend’s wishes”, I propose to teach you some facts about the instrument with this treatise. There are several reasons for this treatise.

First, no one in this region has complete knowledge of the noble astrolabe. Another reason is that there are errors in the astrolabe treatises that I have seen and some of them present material too difficult for a ten year old to understand. This treatise is divided into five parts and is written clearly and in plain English, because your Latin is still not good enough, my little son. But the facts are the same in English as Greek was to the Greeks, Arabic to the Arabs, Hebrew to the Jews and Latin to the Romans, who learned them first from other diverse languages and rewrote them in Latin. And, as God wills, all of these facts have been completely learned and taught in all these languages, but by different methods, much as all roads lead to Rome. Now I ask every person who reads or hears this little treatise to excuse my crude editing and my excessive use of words for two reasons. First, it is hard for a child to learn from complex sentences. Second, it seems better to me to write a good sentence twice for a child so he will not forget the first. And Lewis, I get my satisfaction if my English treatise presents as many and the same facts as any Latin treatise on the astrolabe. And praise God and save the king, who is lord of this language, and all who obey him, each in his own way, more or less. But consider well that have not claimed to create this work from own work or energy. I am but a lewd compiler of the labor of old astronomers (astrologers) and have translated it into English only for your use. With this statement I slay envy.

First part - The first part of this treatise presents the parts of your astrolabe so you can become familiar with your own instrument.

Second part - The second part teaches practical uses of previous facts, as much as possible for such a small portable instrument, for every astronomer (astrologer) knows that the smallest fractions shown in special tables that are calculated for a specific reason are not visible on such a small instrument.

Third part - The third part contains various tables of longitudes and latitudes of fixed stars for the astrolabe, a table of declinations of the Sun, tables of longitudes of cities and towns, tables for setting a clock and to find the meridian altitude and other notable conclusions from the calendars of the reverend clerks, Brother J. Somes (John Somer) and Brother N. Lenne (Nicholas of Lynn).

Fourth part - The fourth part contains a theory to explain the movements of the celestial bodies and their causes. In particular, the fourth part contains a table of the moon’s motion for every hour of every day and in every sign from your almanac. A rule adequate to teach the manner of the working of the moon based on this table follows which allows you to know the degree of the zodiac that the moon rises in for any latitude and the rising of any planet based on its latitude from the ecliptic.

Fifth part – The fifth part shall be an introduction, following the style of our scholars, in which you can learn most of the general theory of astrology. You will find tables of equations of the houses for the latitude of Oxford and tables of dignities of the planets and other relevant things, if God and his Mother the Virgin wills, more than I am asked.

...On a winter's night when the sky is clear and filled with stars, wait until a fixed star is directly above the north pole and name that star A. Find another star that is directly under A and below the pole and call that star F. Note that F is considered only to establish that A is directly above the pole. Measure the altitude of A quickly and not the value. Let A and F rotate until near daybreak, go out again and wait until A is directly under the pole and under F (F will be directly above the pole and A will be directly beneath it). Measure the altitude of A and note it. When this is done, calculate how many degrees the first altitude is greater than the second, take half of the result and add it to second altitude. This is the altitude of the pole and equal to the latitude of your place because the polar altitude equals the latitude of a place. For example: Say the altitude of A in the evening is  $56^\circ$  and the second altitude taken near dawn is  $48^\circ$ , which is  $8^\circ$  less than  $56^\circ$ . Take half of the 8 and add it to 48 giving  $52^\circ$ . You now have the altitude of the pole and the latitude of the region. But you should understand to conduct this measurement correctly you must have a plumb line that hangs from a point higher than your head and this line must hang vertically between the pole and your eye. This will allow you to see when A is directly over the pole and F and when F is directly over the pole and A. (ed. This proposition tells you to measure the altitude of a star when it is directly above and below the pole and take the point halfway between as the pole. The method described is theoretically sound, if difficult to do accurately with an astrolabe. A finely divided and well-sited quadrant would be better. One infers that the suggestion for making the measurements in the winter is because the measurement requires 12 hours and a long night is needed to complete the process. Chaucer was apparently aware that measuring the altitude of Polaris was not sufficiently accurate in the 14th century. Polaris is much closer to the celestial pole now.)

**SOURCE:** Excerpted from Chaucer, Geoffrey. *Chaucer's Astrolabe Treatise*, ed. James E. Morrison. 1391. <http://www.chirurgeon.org/files/Chaucer.pdf> (Accessed: 9 Nov. 2016)

Or

**HTML version of the same source:** Chaucer, Geoffrey. *Chaucer's Astrolabe Treatise*, ed. James E. Morrison. 1391. <http://webcache.googleusercontent.com/search?q=cache:K-twcf8CJMj:www.chirurgeon.org/files/Chaucer.pdf+&cd=1&hl=en&ct=clnk&gl=us&client=safari> (Accessed: 11 Nov. 2016)

<http://theinstitute.ieee.org/tech-history/technology-history/a-history-of-the-magnetic-compass>

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## A History of the Magnetic Compass

This navigational instrument led to advances in trade, military might, and science

By JOHN VARDALAS 8 November 2013

Inhospitable as it can be, the sea has played an essential role in human history, and so did that indispensable navigation tool, the magnetic compass. The sea provided the cheapest way to move goods over great distances, generating wealth through trade. Navigating the oceans successfully also played a pivotal role for many countries in gaining political and military power. Along the way, the compass contributed to innovations in physics and electrical engineering.

Far from the sight of land, the sea is a seemingly endless, undifferentiated expanse. For most of history, getting lost at sea was a very real danger, often with disastrous consequences. Even when close to land, seafarers can become disoriented in bad weather. For ancient Greek and Roman sailors, weather conditions even limited visibility enough to shorten the sailing season in the Mediterranean Sea. The Roman military writer Publius Flavius Vegetius wrote in the fourth century that travel from June to mid-September was safe, but that sailing any other time was risky. He called the period between mid-November and mid-March *mare clausum*, or the time when “the seas are closed.”

Seafarers adhered to these guidelines until the early 14th century, when the magnetic compass made its first appearance in the Mediterranean. No longer completely dependent on landmarks, the mariner could now find his position relative to Earth’s magnetic field. With the Mediterranean now “open” for most of the year, trade increased substantially, which contributed to the rise of the Italian city-states.

### FIRST APPEARANCES

Though the behavior of lodestone, a naturally magnetized piece of the mineral magnetite, was observed by the ancient Greek philosophers Thales of Miletus and Socrates, the evidence is clear that the idea for using it in a compass first appeared in China. There are allusions in the manuscript *Wu Ching Tsung Yao*, written in 1040, to “an iron fish” suspended in water that pointed to the south. And the earliest reference to a magnetic direction-finding device for land navigation is recorded in a Song Dynasty book dated to 1040-44.

In 1088, Song Dynasty scholar Shen Kuo wrote that when “magicians rub the point of a needle with lodestone, then it is able to point to the south...It may be made to float on the surface of water, but it is then rather unsteady...It is best to suspend it by a single cocoon fiber of new silk attached to the center of the needle by a piece of wax. Then, hanging in a windless place, it will always point to the south.”

In Europe, the magnetic compass first appeared in Amalfi, Italy, around the turn of the 14th century. But it is not known if the magnetic compass was also invented in the West or if it migrated to Europe along trade routes from China. However, it is clear that because sea trade and military advantage were of far more strategic importance to Western nations, they pushed the technology of the magnetic compass far more intensely than did the Chinese. With the successive rise of the Portuguese, Spanish, Dutch, and English empires, development of the compass shifted to the European nations facing the Atlantic Ocean.

The biggest challenge raised by the compass was what we now call magnetic variation: the angular difference between geographic or “true” north and the magnetic north, or the direction in which a magnetized needle points. Under clear skies, one could find the geographic north-south axis for comparison with where the compass pointed by either referring to the polestar or looking at the sun at noon.

Across the Mediterranean, the difference between geographic north and magnetic north was relatively small. However, in the Atlantic, particularly in the northern latitudes, the difference was considerable. If this difference had been constant, there would be no problem, but it varied greatly as one traveled east to west. During his first voyage to North America from Spain in 1492, Christopher Columbus observed this mysterious behavior, but he kept it from his crew, fearing it would spook them.



In 1701, Edmund Halley produced the world’s first isogonic chart, which shows how the angle between magnetic north and true north varies at different points in the Atlantic Ocean.

Photo: IEEE

#### **FURTHER DISCOVERIES**

Beginning in 1698, with the support of England's Royal Society and the Admiralty, Edmund Halley, who would later be named the country's Astronomer Royal, set out on several long expeditions to measure Earth's magnetic variations across the northern and southern regions of the Atlantic Ocean. This data offered great advantage to the English Navy. In 1701, Halley produced the world's first isogonic chart, which shows how the angle between magnetic north and true north varies at different points in the Atlantic Ocean [see photo].

The study of magnetism set the stage for work in electrostatics. And the compass also served as a scientific instrument. With it, Danish physicist Hans Christian Ørsted observed in 1820 that an electric current from a battery flowing through a wire produced a magnetic field. This important discovery in electromagnetism paved the way for telegraphy.

In 1831, English scientist Michael Faraday showed that moving a conductor in a magnetic field produced an electric current, leading to advances in electric power generation. **James Maxwell** (<http://theinstitute.ieee.org/technology-focus/technology-history/did-you-know-someone-else-wrote-maxwells-equations>) combined the electric and magnetic phenomena in a set of elegant field equations. Heinrich Hertz's discovery of radio waves, a type of electromagnetic radiation, set the stage for wireless telecommunications. This great chain of discoveries and inventions was set in motion by the seafarer's compass, the tool that made it possible to voyage across Earth's inhospitable seas.

*The **IEEE History Center** ([http://www.ieee.org/about/history\\_center/index.html](http://www.ieee.org/about/history_center/index.html)), which contributed this article, is funded by donations to the **IEEE Foundation** (<https://www.ieee.org/organizations/foundation/>)*

## COMPASS LESSON PLAN – Formative Performance Task 3

### *Compass Lesson*

**Goal:** Discover how the magnetic compass evolved from a mystical object to a precise and reliable instrument for travelling across the world's oceans.

**Supporting Question #3:** How does being posed with a challenge lead us to innovation and progress?

### **Objectives:**

Students will be able to empathize with sailors of the Middle Ages by participating in a compass hands-on-activity and they will be able to draw connections between the development of the compass and global power.

### **Procedures:**

#### 1. Warm-up:

i. Watch the *Power of the Sea* video (03:12min). <http://reach.ieee.org/multimedia/power-at-sea>

ii. Using the attached map, have students identify the challenges of travel and navigation in general by answering the following questions: What is this a map of? Could you use this map for navigation? What are its strengths? What are its weaknesses?

2. Have students read the following statement: "When out at sea, humans turned to celestial bodies for their reference points. Translating the movement and locations of celestial bodies into a reliable and accurate basis for navigation required considerable science and technology. When the day and night skies were heavily overcast, navigators became quite anxious." Once students read this passage, have them answer the following questions: Do you ever feel anxious while traveling? Do you feel like you have a good sense of direction? Can you provide directions to your home right now in GREAT detail? Do your details help more during the day or at night? Would somebody need a special skill to follow your directions?

3. Ask: Do you think that travel on the water is different than travel on land? Show students the video titled "Lost at Sea" (04:04 min) (<http://reach.ieee.org/multimedia/lost-at-sea/>). Brainstorm ideas on how they might navigate their way home.

4. Conduct a close reading of Guyot de Provin's poem. Written around the 1180s or 1190s C.E., it gives a very precise description of the magnetic needle's navigational utility. De Provin was a monk in Clervaux and Cluny and travelled a lot. Have students answer the following questions:

1. What claims does the author make?
2. What evidence does the author use?
3. What language (words, phrases, images, symbols) does the author use to persuade the audience?
4. How does the document's language indicate the author's perspective?

(Question framework based upon the [Reading Like a Historian](http://readinglikeahistorian.org/) website)  
<https://sheg.stanford.edu/rlh>

5. Introduce the idea of the compass and how drastic a change it could bring to maritime exploration.

- i. View the *Compass* video (05:25min). <http://reach.ieee.org/multimedia/the-compass/>
- ii. **After completing steps 1-4 in the hands-on-activity below**, move students to the center of the room, explain how the needle was magnetized and show them how it points north. Students can confirm north with their cell phone compasses.

6. Navigation and the “magic needle:” In groups, students will engage in a series of activities in an open space:

- i. Student **Hands-On-Activity**. <http://reach.ieee.org/hands-on-activities/compass-hands-on-activity/>
- ii. Relate the above activities to the challenges of navigating from one point to another in the Mediterranean, across open water, in poor visibility, For example from Bengazi to Malta
  - **Side bar:** At some point the students can discuss the refugee crisis in Europe and the dangers that migrants face as they try to navigate to a better life.

7. Debriefing: Have students share their experiences and try to identify what difficulties still remained even though they used the compass. Show students various photos of the evolution of the compass. Show students a portolan chart and ask: What is this a map of? Could it be used for navigation? How do you know? Draw connections between the race for portolan charts/advanced navigational technologies and global power.

8. Closure: With the development of the compass, what new challenges will arise?

## Warm Up Map



SOURCE: Pietro Vesconte's World Maps, 1321, from Marino Sanudo's *Liber secretorum fidelium crucis* (oriented with East at the top), <http://www.henry-davis.com/MAPS/LMwebpages/228A.html> (Accessed: 31 Oct. 2016)

Guyot de Provins' poem

*“This same (the pole-) star does not move, and  
They (the mariners) have an art which cannot deceive,  
By the virtue of the magnet,  
An ugly brownish stone,  
To which Iron adheres of its own accord.  
Then they look for the right point,  
And when they have touched a needle (on it)  
And fixed it on a bit of straw,  
Lengthwise in the middle, without more,  
And the straw keep it above;  
Then the point turns just  
Against the star undoubtedly.  
When the night is dark and gloomy,  
That you can see neither star nor moon,  
Then they bring a light to the needle;  
Can they not then assure themselves  
Of the situation of the star towards the point? (of the needle)  
By this the mariner is enabled  
To keep the proper course;  
This is an art which cannot deceive.”*

**SOURCE: Donzey, Jean-Patrick. "The Online Compass Museum." Compassipedia. (Accessed: 10 May 2016) <http://compassmuseum.com/>.**

## Evolution of the Compass



1500's -- Info@gooii.com, Gooii Ltd. "The Collection." Mariner's Compass. (Accessed: 11 Nov. 2016) <http://collections.rmg.co.uk/collections/objects/42488.html>.

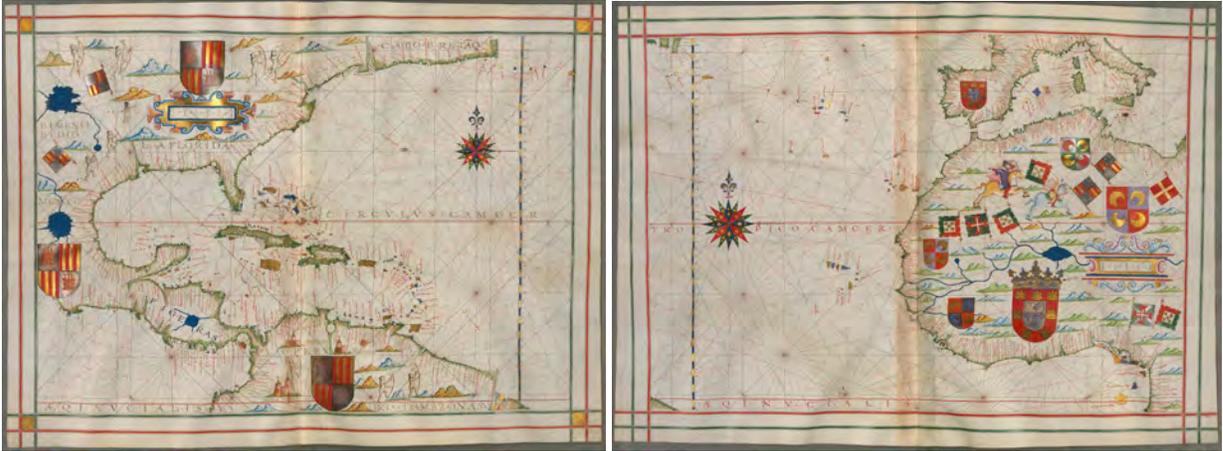


1750 -- Info@gooii.com, Gooii Ltd. "The Collection." Mariner's Compass. (Accessed: 11 Nov. 2016) <http://collections.rmg.co.uk/collections/objects/42590.html>.



1760 (Chinese Compass) -- Info@gooii.com, Gooii Ltd. "The Collection." Mariner's Compass. (Accessed: 11 Nov. 2016) <http://collections.rmg.co.uk/collections/objects/42452.html>. (NOTE: The Chinese divided their compass into 24 points)

## Portolan Chart



SOURCE: Dourado, Fernando Vaz 16th Century. "Atlas." WDL RSS. (Accessed: 5 Nov. 2016) <https://www.wdl.org/en/item/14159/>.

What does this map depict? Could you use it for navigation?

### Follow-up lesson

**Goal:** Discover how the magnetic compass evolved from a mystical object to a precise and reliable instrument for travelling across the world's oceans.

**Supporting Question #3:** How does being posed with a challenge lead us to innovation and progress?

### **Objectives:**

Students will be able to analyze various types of maps and portolan charts to identify their similarities and differences and to predict their purposes.

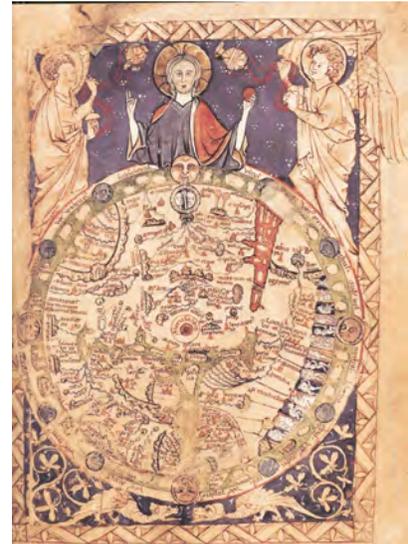
Students will be able to draw connections between the development of the compass, the improvement of maps and global power.

### **Procedures:**

1. Examine the images below. (11<sup>th</sup> century Islamic world map, 1260 Psalter map, 13<sup>th</sup> century Christian Ebstorer World Map, 1150, 1150 al-Idrisi world map). Describe what you see? What are the similarities and differences? What do you think were the intended purpose of these maps?



A.



B.



C.



D.

#### SOURCES:

A. "Mahmud Al Kashgari." Wikipedia. (Accessed: 5 Nov. 2016)

[https://en.wikipedia.org/wiki/Mahmud\\_al\\_kashgari](https://en.wikipedia.org/wiki/Mahmud_al_kashgari).

B. "Psalter World Map." Wikipedia. (Accessed: 5 Nov. 2016)

[https://en.wikipedia.org/wiki/Psalter\\_world\\_map](https://en.wikipedia.org/wiki/Psalter_world_map).

C. "Early World Maps." Wikipedia. (Accessed: 5 Nov. 2016)

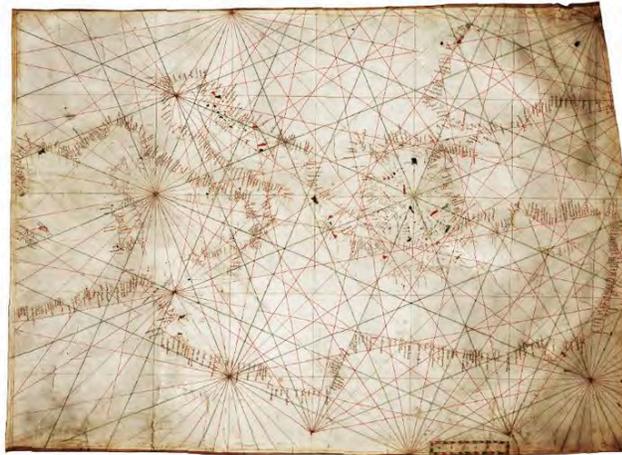
[https://en.wikipedia.org/wiki/Early\\_world\\_maps](https://en.wikipedia.org/wiki/Early_world_maps).

D. "Al-idrisi world map" Wikimedia. (Accessed: 5 Nov. 2016)

<https://commons.wikimedia.org/w/index.php?curid=98320>

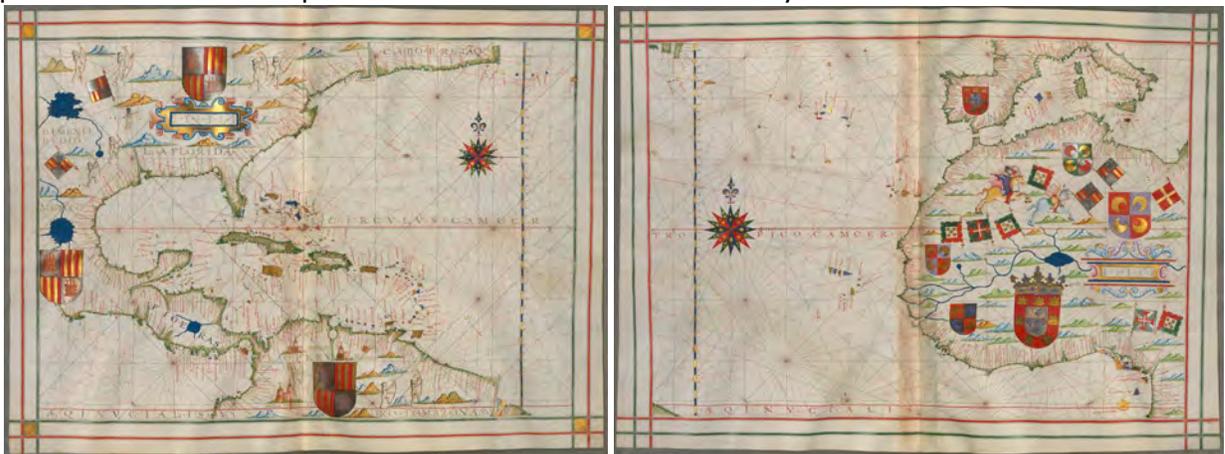
(Note: al-Idrisi's map was oriented with south at the top.)

2. A.) Explore the image below from 1350. What do you see? How does this image differ from the preceding ones? What do you think was its purpose? Is there a connection between this image and another technological development of the Medieval period?



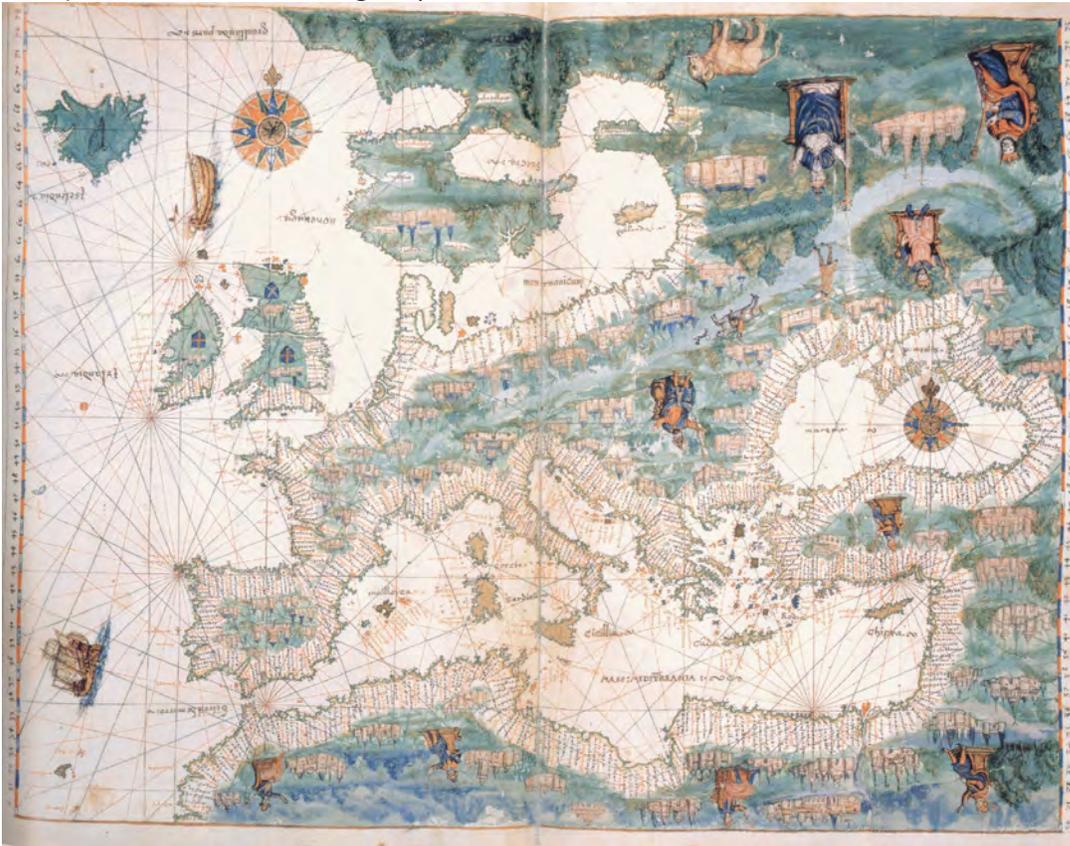
SOURCE: "[Portolan Chart of the Mediterranean Sea Ca. 1320-1350: Manuscript Chart of the Mediterranean and Black Seas on Vellum]." The Library of Congress. (Accessed: 13 Nov. 2016) <https://www.loc.gov/resource/g5672m.ct000821/>.

B.) Describe all the elements in the images below. What changed from the 14<sup>th</sup> century portolans above to the portolans below from the 16<sup>th</sup> century?



SOURCE: Dourado, Fernando Vaz 16th Century. "Atlas." WDL RSS. (Accessed; 13 Nov. 2016) <https://www.wdl.org/en/item/14159/>.

C.) Examine the following map:



**SOURCE: "Dieppe Maps." Wikipedia. (Accessed: 13 Nov. 2016)**

[https://commons.wikimedia.org/wiki/File:Europe\\_and\\_northern\\_Africa.\\_HM\\_29.\\_PORTOLAN\\_ATLAS,\\_anonymous\\_\(Dieppe,\\_1547\).A.jpg](https://commons.wikimedia.org/wiki/File:Europe_and_northern_Africa._HM_29._PORTOLAN_ATLAS,_anonymous_(Dieppe,_1547).A.jpg)

**Another Source: [https://en.wikipedia.org/wiki/Dieppe\\_maps](https://en.wikipedia.org/wiki/Dieppe_maps).**

D.) After reviewing all the previous maps answer the following questions:

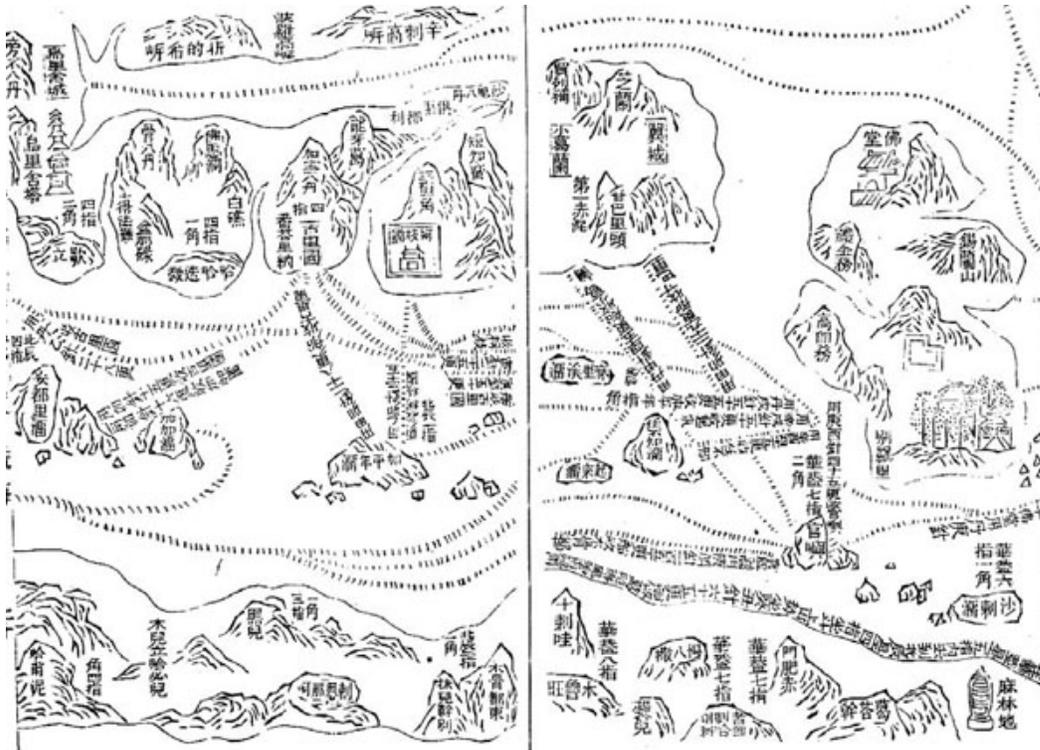
What is the know-how behind these depictions of geography? Scientific? Mathematical? Technological? Does this sequence of images represent an improvement in navigation technology? In answering this question, consider how these charts were used in navigation with a compass.

3. View *Latitude* video (05:08 min) (<http://reach.ieee.org/multimedia/latitude/>) and discuss how and why navigational technologies changed and evolved to determine latitude and why these new technologies were important to seafarers.

4. Closing: Using our exploration of navigational advances and the desire for world power, ask students to answer the supporting question: How does being posed with a challenge lead us to innovation and progress?

## CLASSROOM ACTIVITY – Formative Performance Task 4 – ASIA

**Activity 1:** Look at these 15<sup>th</sup> century Chinese navigation maps below. Compare them to the ones that you've seen from Western Europe. Would you say that they could be used to travel thousands of miles by sea?



**SOURCE:** Mao, Yuanyi, *Wu bei zhi*, Library of Congress. (Accessed: 17 Nov. 2016)  
<https://www.loc.gov/resource/g7821rm.gct00058/?sp=18>

**Background info for teacher:** After the students answer the above questions, inform them that these maps were from the famous voyages of the 15<sup>th</sup> century Chinese treasure ships led by Admiral Zheng He. These fleets were the largest the world had ever seen to that date. They managed to travel from China to the East Coast of Africa before the Portuguese ever rounded the Cape of Good Hope. How did they navigate with such maps?

This could lead to discussion about the differences between the very ethereal Chinese way of depicting space and the mathematical approach of Western Europe. How does one explain it? Culture? Or, technology appropriate to the geographical circumstances?

### **Activity 2: From Magic Needle to Sophisticated Instrument: The Magnetic Compass**

China may have been the first, but it failed to advance the needle's potential.

The lodestone, whose technical name is magnetite, is a naturally occurring mineral with magnetic properties. Knowledge of "lodestone's" ability to attract iron was known in ancient Greece. The Chinese however, first discovered the ability of this rock to point, in a preferred direction, when suspended. A small iron needle when rubbed against a piece of lodestone will point to a specific direction when floated in water. In China, this pointing ability of magnetic

material was framed in the mystical terms of Feng Shui. In this mystical system, spiritually significant buildings and even every day structures had to be oriented in space in such a way as to put them in harmony with the universe. The special pointing ability of the loadstone provided the correct directions. The early history of how and where this mystical pointing ability of magnetic material came to be harnessed as an instrument of marine navigation remains unclear.

The first step in the process occurred when people observed that a magnetized needle seemed to point to a specific geographic direction - North. Again the Chinese may have first noticed this.

“Magicians rub the point of a needle with lodestone; then it is able to point to the south. But it always inclines slightly to the east, and does not point directly south. It may be made to float on the surface of water, but it is then rather unsteady... It is best to suspend it by a single cocoon fibre of new silk attached to the center of the needle by a piece of wax. Then, hanging in a windlass place, it will always point to the south.” Shen Kua, *Meng Ch'i Pi T'an* (Mengxi bitan), 1088 A.D

1. What claims does the author make?

## CLASSROOM ACTIVITY – Formative Performance Task 4 – MIDDLE EAST

### Islamic and Chinese Sailing by Latitude

While the Europeans were still in the “Dark Ages” of the Medieval period, a rich and flourishing trade, mostly controlled by Arab mariners, existed across the Indian Ocean between Islamic and Chinese societies. Direct access to this trade was one of the motivations driving Portuguese exploration. The Arabs sailed by latitude but did not use angle measuring devices as the Europeans did. They used the kamal instead. The Chinese adopted it from the Arabs and it was used during the famous 15<sup>th</sup> century expeditions of Zheng He.

- What is a kamal? How did it work?

“The kamal is a simple navigation device used by Arab navigators in the Indian Ocean since ancient times. It consists of a small, rectangular card with a knotted cord passed through it. The purpose of the kamal was to determine latitude at sea by observing the distance between the horizon and a particular star at the same time each night. An alternative--or the original--method for the same purpose involved the use of fingers held parallel to the horizon. The concept is that these reference stars, observed at their highest point in the night sky, would always appear the same distance from the horizon if the position of the ship was at a certain latitude. At a higher or lower latitude (that is, closer to or farther from the equator) the distance would be greater or less. A navigator would hold the card at a measured distance from his face by means of a series of knots in the cord attached to the card. The cord would be held in the teeth. The card would appear smaller or larger depending on how far from his eye level it was. The kamal, or measurement with the fingers, was especially well suited to crossing the Indian Ocean on the monsoon winds, since they blow in a steady easterly or westerly direction during each of the two seasons for going out and returning. The pilot's job was to aim for a certain latitude where he knew that the port city lies. In this way, the knots on the cord would represent the latitude needed to reach a series of specific places.”

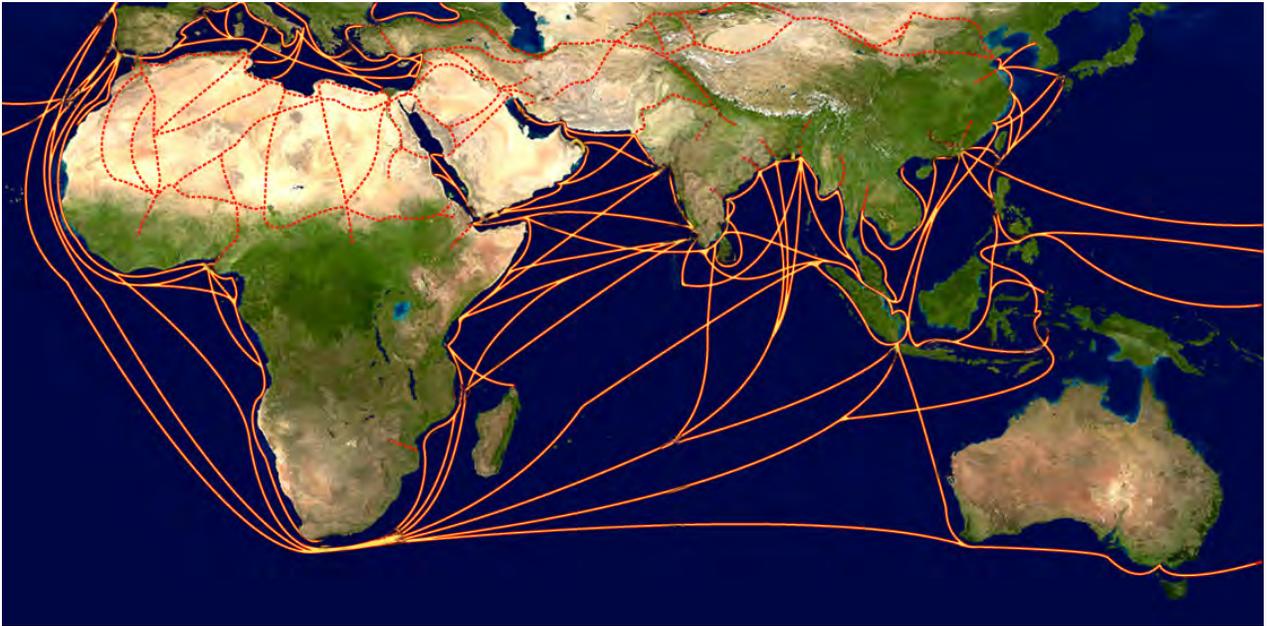
**Source: Indian Ocean in World History. (Accessed: 17 November, 2016)**

<http://www.indianoceanhistory.org/Student-Guide/Indian-Ocean-Overview.aspx>

[Jewel of the Muscat – on film, video #2, *Sailing the Treasure Ship* starting at 15:02 – 16:12 explains ancient use of the kamal.] <http://jewelofmuscat.tv/jewel-on-film/>

- The kamal was a simpler technology than the European approach. Does it mean that it was less effective? Can geography explain why the kamal was appropriate navigation technology for Indian Ocean maritime trade?

## CLASSROOM ACTIVITY – Formative Performance Task 4 – EUROPE



SOURCE: "First Global Era - Indianoceanhistory.org." *Indian Ocean in World History*. 2016. (Accessed: 13 Nov. 2016) [http://www.indianoceanhistory.org/assets/Site\\_18/files/Era Overviews/First Global Era.pdf](http://www.indianoceanhistory.org/assets/Site_18/files/Era%20Overviews/First%20Global%20Era.pdf).

(For more information on Indian Ocean trade and travel:  
<http://www.indianoceanhistory.org/LessonPlan/FirstGlobalEra.aspx>)

Throughout the Middle Ages and into the 16<sup>th</sup> century, the Arabs dominated maritime trade across the Indian Ocean and to China. They rarely used a compass to navigate and there is no evidence of any Islamic charts for the Indian Ocean. Could these absences represent ignorance of navigational theory or a practical use of technology well-adapted to the physical geography of the Indian Ocean?

### Additional Resources:

*Jewel of Muscat* videos, <http://jewelofmuscat.tv/jewel-on-film/>

*Book of Navigation, Sultan Suleiman, 1525*, World Digital Library. (Accessed: 5 Nov. 2016) <https://www.wdl.org/en/item/9210/>

## ACTIVITY 1

Examine the 1533 painting below by Hans Holbein the Younger. It memorializes two wealthy, educated and powerful young men. At the left is Jean de Dinteville, aged 29, French ambassador to England in 1533. To the right stands his friend, Georges de Selve, aged 25, Bishop of Lavaur, who acted on several occasions as ambassador to the Emperor, in the Venetian Republic and the Holy See. Identify and discuss the cultural and political symbolisms in this painting tied to navigation?



Treaty of Tordesillas  
demarcation line

## SOURCES:

1. The National Gallery, "The Ambassadors" 1533, Hans Holbein the Younger. (Accessed: 5 Nov. 2016) <https://www.nationalgallery.org.uk/paintings/hans-holbein-the-younger-the-ambassadors>
2. Detail of #1

## ACTIVITY 2

Find a Mercator map. Discuss how it is different from the map below. Why was this difference important to the story of European expansionism in the 16<sup>th</sup> and 17<sup>th</sup> centuries?



SOURCE: "Dieppe Maps." Wikipedia. (Accessed: 13 Nov. 2016) [https://en.wikipedia.org/wiki/Dieppe\\_maps](https://en.wikipedia.org/wiki/Dieppe_maps).

Another Source: [https://en.wikipedia.org/wiki/Dieppe\\_maps](https://en.wikipedia.org/wiki/Dieppe_maps).

### ACTIVITY 3

#### European Sailing by Latitude

The 15<sup>th</sup> century Portuguese explorers were the first Europeans to develop the technique of sailing by latitude.

- Describe the technique and why it was used.
- What navigational instruments did the Europeans use to sail by latitude?

### ACTIVITY 4

Study the two allegories in the images below. How do they relate to Sir Walter Raleigh's dictum "Hee that commands the sea, commands the trade, and hee that is Lord of trade of the world is Lord of the wealth of the world"?

Works of Sir Walter Raleigh, Kr., Vol. VIII. Miscellaneous Works. 'A Discourse of the Invention of Ships, Anchors, Compass &c' The Works of Sir Walter Raleigh, 325 (Accessed: 8 Nov. 2016)

[https://books.google.com/books?vid=OCLC02477824&id=JINIWfc2XV4C&pg=PA317&as\\_brr=1#v=onepage&q&f=false](https://books.google.com/books?vid=OCLC02477824&id=JINIWfc2XV4C&pg=PA317&as_brr=1#v=onepage&q&f=false)



1. National Library of Australia nla.map-ra300-s1-v 2.

#### SOURCES:

1. National Library of Australia, "Novus atlas Sinensis a Martino Martinus, Soc. Iesu : descriptus et serenmo. Archduci Leopoldo Guilielmo Austriaco dedicatus / cum privilegio S.C. Maj." (Accessed: 5 Nov. 2016) <http://nla.gov.au/nla.obj-230902529/view>

2. Heritage, Newfoundland and Labrador, "Geographical Knowledge at the Time of the Cabot Voyages." (Accessed: 5 Nov. 2016)

<http://www.heritage.nf.ca/articles/exploration/geographical-knowledge-cabot.php>

## ACTIVITY 5

Read the passages and answer the questions.

Alexander Neckam (1157-1217), an English monk, had studied and lectured at the University of Paris in the 1180s C.E. His work *De Naturis Rerum*, which was widely circulated by the end of the 12<sup>th</sup> century, describes what he saw, probably when crossing the English Channel sometime in the 1180s C.E.:

“The sailors, moreover, as they sail over the sea, when in cloudy weather they can no longer profit by the light of the sun, or when the world is wrapped it in the darkness of shades of night, and they are ignorant to what point of the compass their ship’s course is directed, they touch the magnet with a needle. This then whirls round in a circle until, when its motion ceases, the point looks direct to the north”.

In his other work, *De Utensibilis*, Neckam writes,

“They also have a needle placed upon a dart, and it is turned and whirled around until the point of the needle looks north-east [sic for North, but maybe he unintentionally observed variation]. And so sailors know which to steer when Cynosura\* is hidden by the clouds.”

\*Cynosura is the medieval name for the constellation Ursa Minor (Little Bear) in which Polaris the North Star resides.

1. What claims does the author make?
2. What evidence does the author use?
3. What language (words, phrases, images, symbols) does the author use to persuade the audience?
4. How does the document's language indicate the author's perspective?

(Question framework based upon the [Reading Like a Historian](https://sheg.stanford.edu/rh) website)  
<https://sheg.stanford.edu/rh>

## ACTIVITY 6

Edward Wright (1561 – 1615) was one of England’s most prominent mathematicians, a lecturer on navigation to the English East India Company, and the man who developed the theory for the first useful map for ocean navigation.

In his introduction to William Gilbert’s *De Magnet*, Wright underscores the importance of the magnetic compass to England’s maritime ambitions.

*In truth, in my opinion, there is no subject-matter of higher importance or of greater utility to the human race upon which you could have brought your philosophical talents to bear. For by the God-given favor of this stone has it come about that the things which for so many centuries lay hid— such vast continents of the globe, so infinite a number of countries, islands, nations and peoples—have been, almost within our own memory, easily discovered and oft explored, and that the whole circle of the globe has been circumnavigated more than once by our own Drake and Cavendish: which fact I wish to record for the undying remembrance of those men. For, by the showing of the magnetized needle, the*

*points North, South, East and West and the other points of the compass are known to navigators, even while the sky is murky and in the deepest night; by this means seamen have understood toward what point they must steer their course, a thing that was quite impossible before the wondrous discovery of the north-pointing power of the loadstone”.*

**SOURCE:** “William Gilbert of Colchester, Physician of London, on the Lodestone and Magnetic Bodies and on The Great Magnet The Earth. A New Physiology, Demonstrated With Many Arguments And Experiments, A Translation By Fleury.” (Accessed: 17, Nov. 2016) (Page: xxxvii – xxxviii) <http://www.lancaster.ac.uk/fass/projects/gilbert/docs/onloadstonemagne00gilbuoft>

Gilbert’s work opened the door to the value of mapping the magnetic variation over the entire Earth. With such a map, one could then make the magnetic compass an effective navigational tool anywhere on the planet. By the end of the 17<sup>th</sup> century, England was the first nation to fund a survey of the Atlantic Ocean to map the magnetic variation.



Importance of scientific study of magnetism to the State. William Gilbert explaining his work to Queen Elizabeth I.

**SOURCE:** The Project Gutenberg eBook, *An Introduction to the History of Science, by Walter Libby*. “Painting by A. Ackland Hunt DR. GILBERT SHOWING HIS ELECTRICAL EXPERIMENTS TO QUEEN ELIZABETH AND HER COURT” (Accessed: 5 Nov. 2016) [http://gutenberg.polytechnic.edu.na/4/0/7/0/40706/40706-h/40706-h.htm#CHAPTER\\_VI](http://gutenberg.polytechnic.edu.na/4/0/7/0/40706/40706-h/40706-h.htm#CHAPTER_VI)

1. Why was Gilbert’s work so important to navigation by the sea? Cite sources from the text.
2. What is Gilbert saying to Queen Elizabeth I? Write a short speech pitching his ideas. (There can be some variation...rap songs, etc.)

This inquiry is brought to you in Memory of John Meredith, and the Institute of Navigation.

