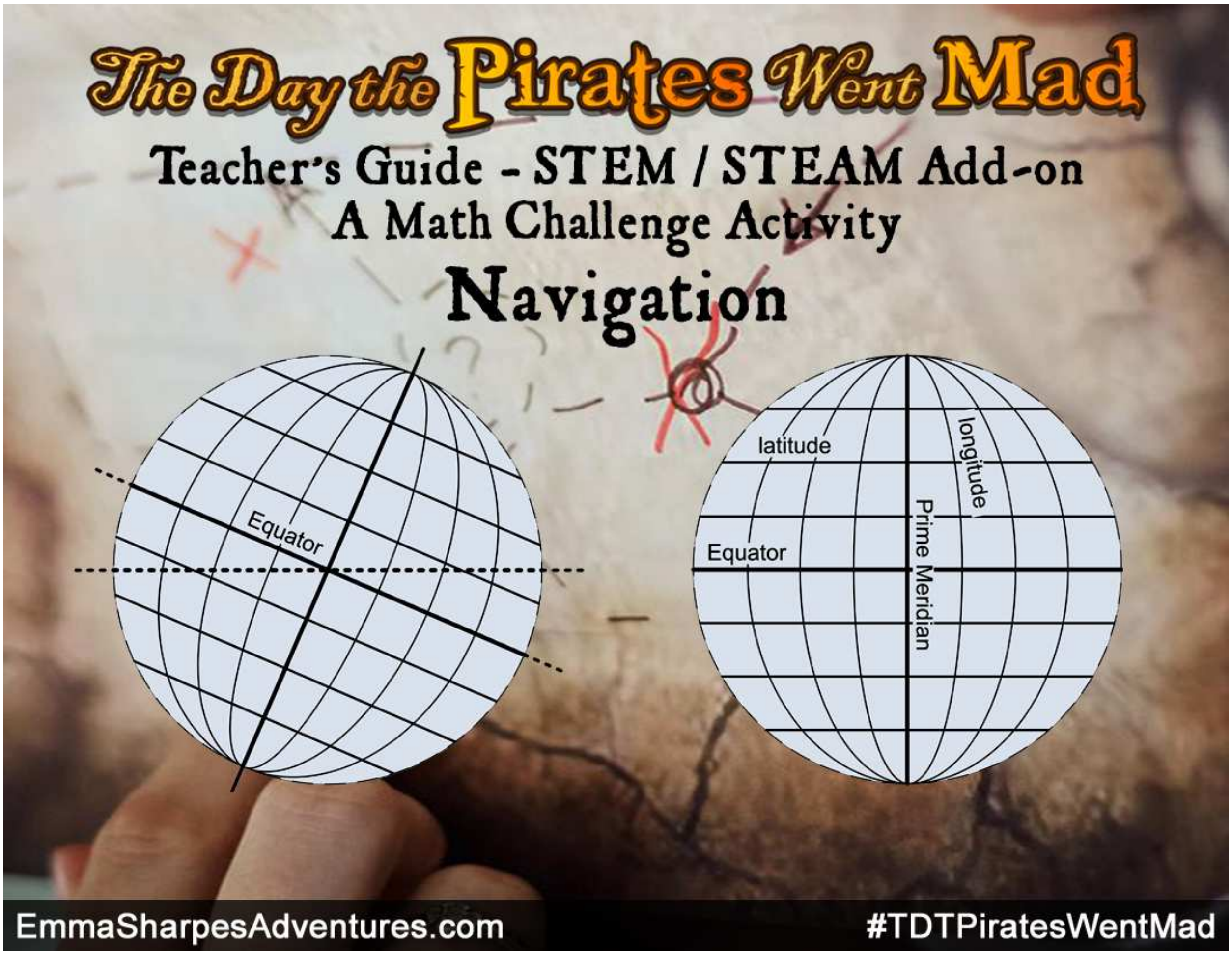
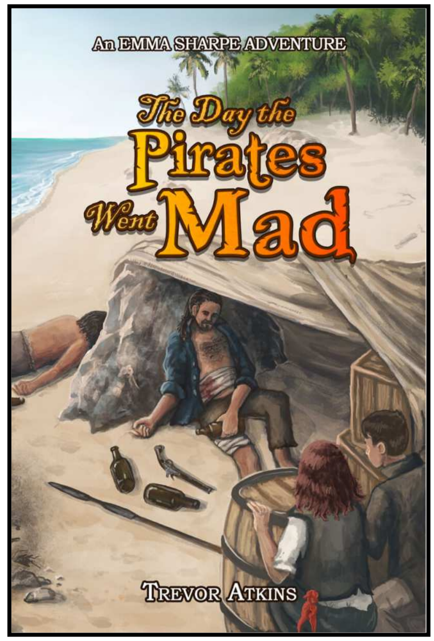


It is the first sunny day after the New Adventure has been blown off course. Where are they? Captain Garrett takes a noon sighting and consults his charts. With his navigation skills, he is able to determine they are likely due east of Trinidad and Tobago. Emma and Jack have been learning these skills too and they are excited to share with you some of what they know.

Recommended grade level: this activity about navigation involves map reading using latitudes and longitudes, measuring angles and performing triangulation using a compass or protractor, performing a noon sighting experiment outdoors, and undertaking one or more enriching inquiry projects.

Have a question about this add-on activity or about Emma's adventures in *The Day the Pirates Went Mad*? Send an email to publishing@silverpath.com, making sure to include "The Day the Pirates Went Mad" in the subject line.

Introduction



The Day the Pirates Went Mad was written to be an entertainingly educational 'cozy' historical fiction, conveying a 'boatload' of learning about the life and times of those sailing the seas 300 years ago, during the Age of Sail. Though intended for ages 10-12, older readers can also enjoy this story and it is suitable for sharing with younger readers when supported by an adult.

The Day the Pirates Went Mad
A historical novel by Trevor Atkins

ebook: https://www.amazon.com/Day-Pirates-Went-Mad-ebook/dp/B091JMKVG3/

paperback: https://www.amazon.com/Day-Pirates-Went-Mad/dp/1989459021/

This document is an add-on activity to the main Teacher's Guide. Add-ons like this will use a scene or action from the book as context for STEM/STEAM learning. This activity is about navigation, specifically latitude and longitude, triangulation, dead reckoning, and noon sightings.

This add-on activity is comprised of four (4) questions, each focusing on a different navigation concept, and a few project ideas to help further the learning:

1. Finding where places are in the world with **latitude and longitude**.
2. Using **triangulation** to describe a location in relation to nearby landmarks.
3. Navigating with **dead reckoning** and discussing the challenges it has.
4. Performing a **noon sighting** and correcting for **axial tilt**.
5. Three (3) **inquiry projects** are suggested for further enrichment on this complex topic. And there is plenty to learn, if students have their own questions they wish to investigate.

Printing Instructions: This document is intended to be printed double-sided.
You may wish to remove the Answer Key before distribution.

Look for more STEM/STEAM activities with Emma Sharpe in the future. Activities include math challenges, cooking/baking, solving navigation problems, laying on supplies, training with the cannons, constructing a model ship, acting out a scene from the story, and more! https://emmasharpesadventures.com

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Where are you?

Emma is in the captain's cabin working on the practice navigation problems he has put together for her. She knows that to be an independent captain herself one day, she must be able to determine more than which way is north. Emma practices the theory with problems like these so that, once the doldrums are past and the *New Adventure* is underway again, Captain Garrett can have her do the calculations for real.

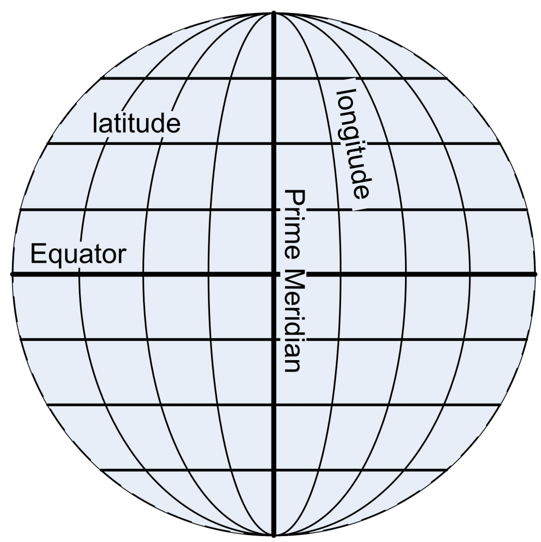
> *"For the next hour, she worked through the clues the captain had given her. Sometimes she had to find a location given a noon sighting. Other times she had to find a likely place to stop in order to lay on supplies. This she calculated from the distances between locations, the average speed of the ship, and the rate of consumption of food and drink by the crew. Slowly, the route of the long journey began to take shape."*
>
> – Emma Sharpe, The Day the Pirates Went Mad, Chapter 11: Killing Time, pg 97.

Latitude and longitude form a coordinate system with which one may describe the location of any place on the Earth's surface. Both latitude and longitude are often expressed in degrees, minutes, and seconds (DMS).

Latitudes measure the angular distance of a point north or south of the equator, while longitudes measure the angular distance of a point east or west of the Prime Meridian (located in Greenwich, London, England).

The distance between each degree can be calculated by dividing the circumference of the Earth by 360 degrees:

- **Latitude** (horizontal): circumference at the equator is ~40,075 km (or ~24,900 miles) which gives ~111 km / degree of latitude (~69 miles / degree)
- **Longitude** (vertical): circumference around the poles is ~40,007 km (or ~24,860 miles) which gives ~111 km / degree of longitude (~69 miles / degree)



– https://en.wikipedia.org/wiki/Earth%27s_circumference

***Note:** As you move north or south of the equator, the distance between the lines of longitude gets smaller until they actually meet at the poles.*

> **Remember "Ladder"-tude**
>
> "To remember the difference between degrees of latitude and longitude, just think of a ladder. The latitude lines are the rungs and the longitude lines are the "long" lines that hold those rungs together."
>
> – *"Latitude or Longitude" by Matt Rosenberg.*

Latitudes may have a suffix of N for locations above the equator or S for those below it. Likewise, longitudes may have a suffix of E for locations east of Greenwich or W for those to the west. Alternatively, the degrees may be notated as positive for northerly and easterly locations and negative for those to the south or west.

For example, **Vancouver, BC, Canada** can be found at
49°15′40″N, 123°6′50″W or at 49°15′40″, -123°6′50″.

In modern representations, you may also see latitude and longitude expressed as decimal degrees (DD), where the minutes and seconds are represented as a fraction of a degree, eg: 49.261111° N, 123.113889° W or 49.261111°, -123.113889°.

To convert between degrees-minutes-seconds (DMS) and decimal-degrees (DD), you need to know that 1 degree (°) is equal to 60 minutes (') or to 3600 seconds ("), eg: 1° = 60' = 3600".

Using the following calculations, we can make the conversions.

DD = degrees + (minutes/60) + (seconds/3600)	Example: 49 +15/60 + 40/3600 = 49.261111°
Converting to DMS takes three steps: • Degrees = integer(DD) • Minutes = integer((DD - degrees) × 60) • Seconds = (DD - degrees - minutes/60) × 3600	Example: • integer(49.261111) = 49° • integer((49.261111 - 49) × 60) = 15′ • (49.261111 - 49 – 15/60) × 3600 = 40″

Note(s): *Integer(x) returns the whole number part of input value x. All latitudes and longitudes for places given in this document are per their individual entries in Wikipedia / GeoHack.*

Question #1

Use a website/app like Google Maps, Google Earth, or an atlas or a world map to determine the latitude and longitude of the following:

a) Indentify where you are right now (in both DMS and DD formats).

____

____

b) Find the latitude and longitude of the following locations mentioned in the book (in DMS).

- Bristol, UK______________________________
- Port Royal, Jamaica______________________________
- Stone Town, Zanzibar, Tanzania______________________________
- Warri, Nigeria______________________________

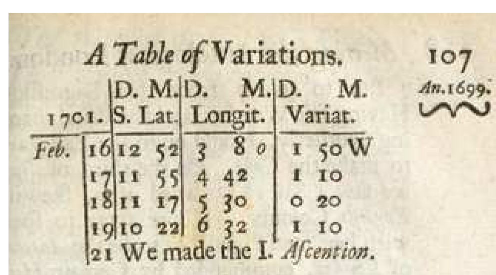
c) Determine the place names from the book at the following coordinates:

- 5°36′15″N, 0°11′14″W
- 7°56′46″S, 14°21′21″W
- 14°54′50″N, 24°22′54″W
- 11°17′53″N, 60°30′8″W

d) From the locations mentioned in part A and B above, which two are closest in terms of latitude? In terms of longitude?

e) Find the coordinates of at least three (3) other locations mentioned in the book (in DMS).

f) **Bonus:** As one clicks around in Google Earth, you are given coordinates down to the second. In Google Maps, you can even get to tenths of a second. Would you need this level of precision to reach your destination in the 1700's? Explain.



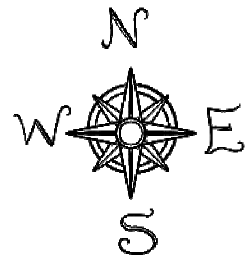
A Table of Variations. 107

*An.*1699.

1701.		D. M. S. Lat.	D. M. Longit.	D. M. Variat.
Feb.	16	12 52	3 8 *0*	1 50 W
	17	11 55	4 42	1 10
	18	11 17	5 30	0 20
	19	10 22	6 32	1 10
	21	We made the I. *Aſcention.*		

Excerpt from "A Voyage to New Holland, &c., In the Year 1699" by William Dampier , pg 107

Triangulation



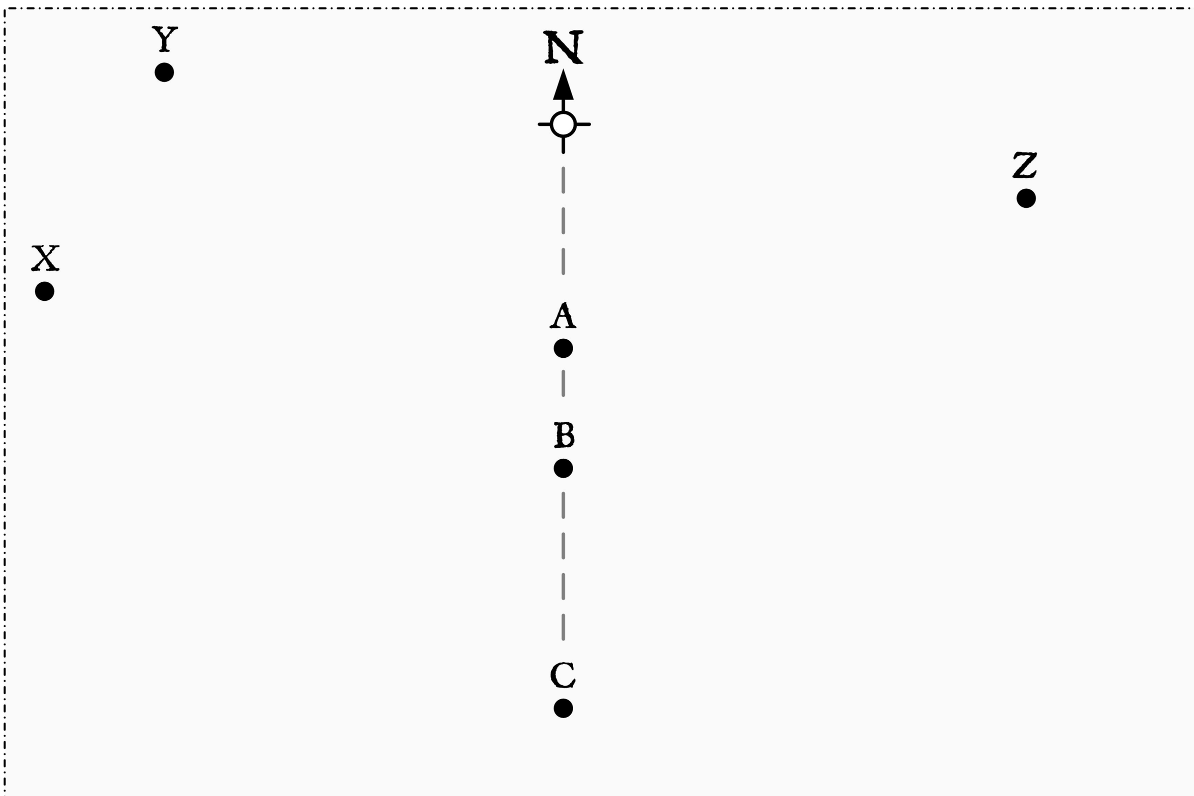
Triangulation is the technique of using known landmarks or reference points to determine the location of another unknown point on a map or chart by measuring the angles between two landmarks, or between each reference point and North (or South), from the viewpoint of your unknown location. Marking your map or chart with a line drawn from each landmark at the measured angle will cause an intersection at the unknown location, identifying it on your map.

***Note:** well made, accurate maps were valuable treasures to explorers & sea captains in general.*

Question #2

Use a compass, protractor, or the small paper cutout from the **Appendix** to measure your angles in the following:

a) Consider the following chart. If from your position, point Y is 55°W and point Z is 70°E, then where are you? (circle your answer)



b) Using the same chart, describe the location of **point B** in terms of landmarks X, Y, and Z.

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c) If you are at a latitude of 50°N on the following chart and the closest land you can see is to the northwest, then its latitude is? And therefore, according to your table of known locations (below), that headland is nearest to which city? Label it on the chart.

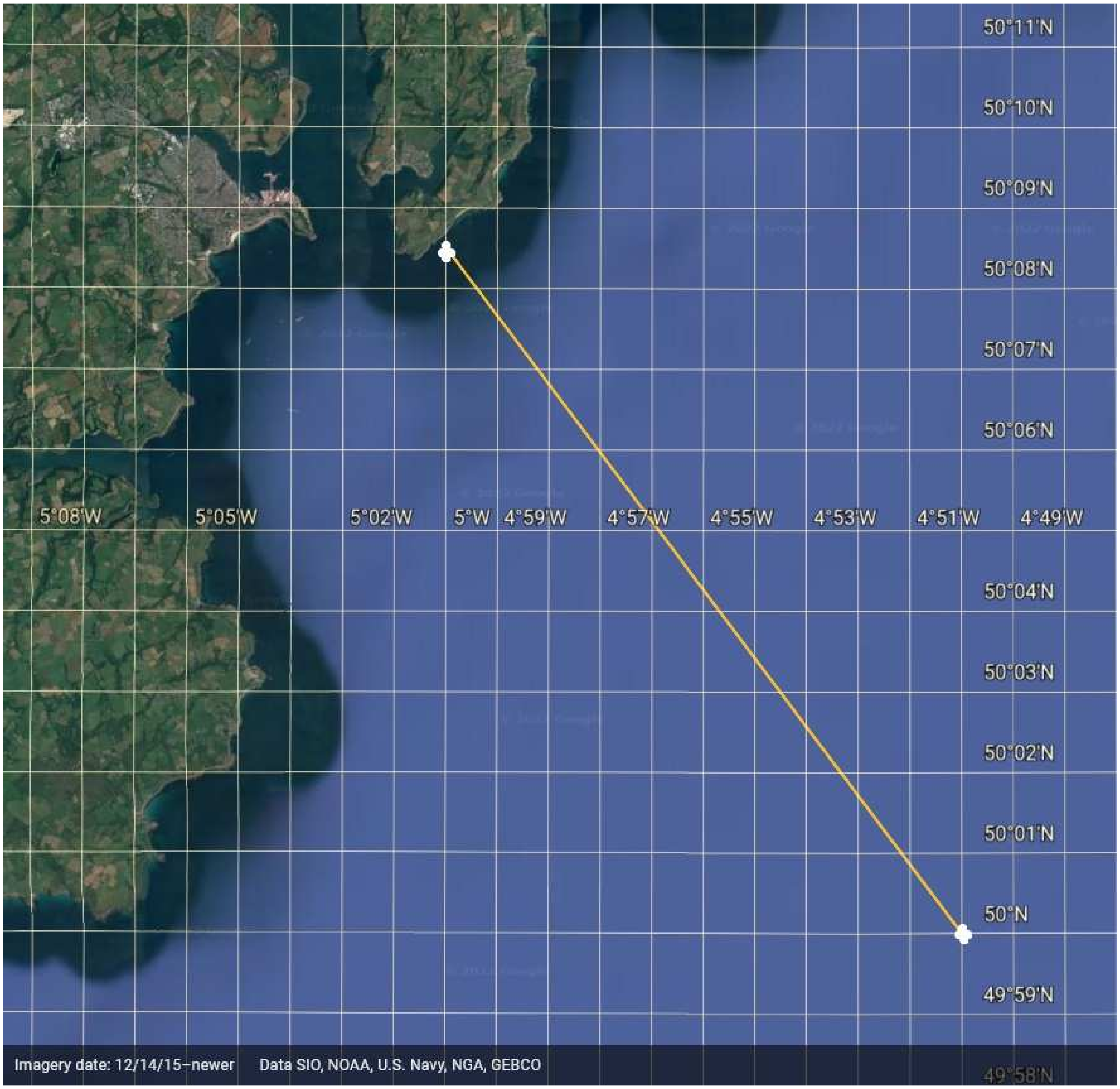


Table of Locations with Latitude and Longitude

Bristol	51°27′18″N	2°35′17″W
Cape Town	33°55′6″S	18°25′11″E
Falmouth	50°9′8″N	5°3′57″W
Nassau	25°02′41″N	77°22′2″W
Port Royal	17°56′12″N	76°50′28″W
Port-de-Paix	19°56′5″N	72°49′53″W
Stone Town	6°9′43″S	39°11′31″E
Warri	5°31′0″N	5°45′59″E

Dead Reckoning

Dead reckoning is a simple form of estimating your position without the aid of celestial observations. By tracking your speed, direction of travel, and the time you have been traveling in that direction from a known position, you can predict your new position. However, it does not account for currents or other factors affecting the position of the ship over time, and any mistakes will compound each other.

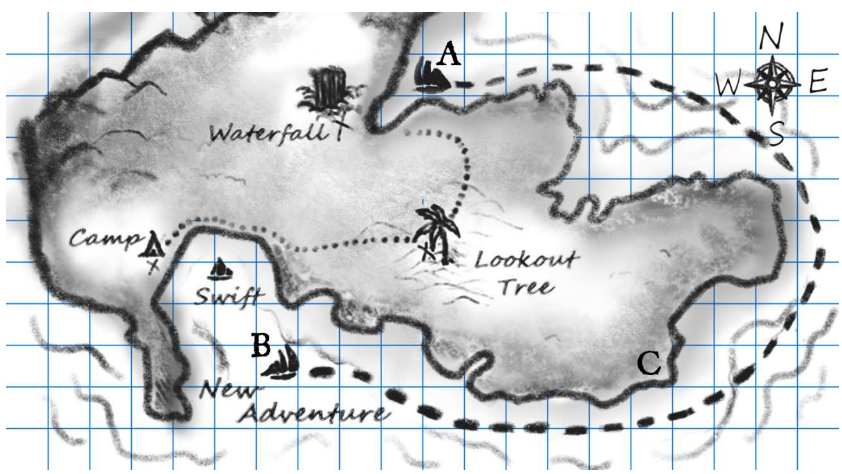
> Ships determined their course with their compass and their speed with a chip log. A log attached to a long line, knotted at regular intervals, would be dropped into the water. After a set time, the number of knots paid out would be counted and scaled to give the actual speed of the ship in "knots". https://en.wikipedia.org/wiki/chip_log
>
> *1 knot = 1 nautical mile per hour, which corresponds to traveling the arc length of one minute (1/60 of a degree) of latitude in an hour. 1 knot = ~1.15 mph = ~1.85 km/hr.*

Question #3

It is time for the *New Adventure* to meet up with Emma, Jack, and Doctor Thorne on Little Tobago. Just as the ship gets underway, a thick fog descends making it impossible to discern any landmarks. Trusting in his charts, Captain Garrett plots a course and continues on. Can you check his work?

a) Following the navigation steps below, map out the route on the chart. Can you clarify the route?

Direction	□'s	□'s
East	4	
Southeast	5	
South	2	
Southwest	3	
West	5	
Northwest	3	
West	2	



b) *"Rocks ahead! Brace for collision!"* Instead of reaching the cove were Emma and Jack are waiting, the *New Adventure* is about to run up on the rocks under the cliffs just past the headland at **point C** on the chart. The ship had followed every course change in the plan! How could this have happened?

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Noon Sighting

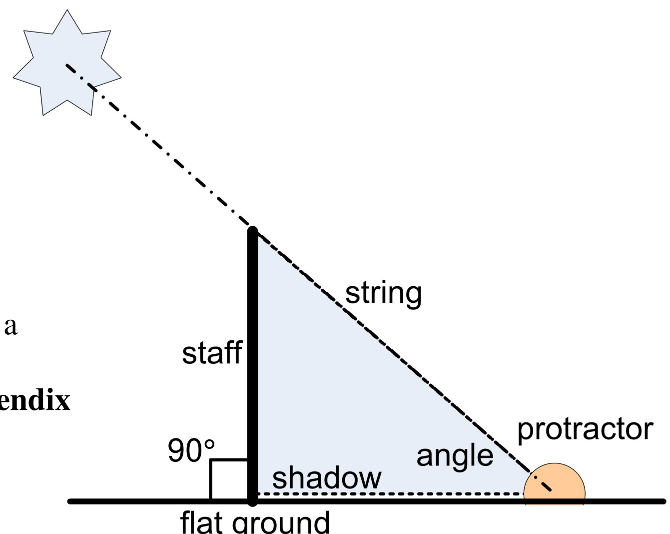
At the turn of the 18th century, one way to help make dead reckoning more accurate was to use a cross-staff, backstaff, or quadrant to take a noon sighting and double-check the latitude.

When the sun is at its zenith, at "solar noon", the shadows are the shortest. Solar noon is not necessarily at the same time as 12:00pm on your clock. Find it by dividing the time between sunrise and sunset or by watching for the shortest shadows of the day. This is when you can measure the angle from the horizon to the sun. Subtract that angle from 90° to get your latitude.

> Longitude is a different problem. One must know the difference in time between one's current position and Greenwich. During the 18th century, European maritime powers offered prizes for a method to determine longitude at sea. Eventually, a nautical almanac of lunar distances and various marine chronometers were made available.
> – https://en.wikipedia.org/wiki/History_of_longitude

Question #4

A benefit of being on solid ground is we can measure the angle to the sun without having to look at it.



a) Let's do our own "sighting" using the following procedure.

What you'll need:
- a staff-like object such as a ruler or a broom handle
- your large protractor from the **Appendix**
- a length of string or yarn

What you'll do:
- at solar noon, hold or otherwise secure your staff in a vertical position on a flat, level surface where a clear shadow can be cast
- hold or pin your string to the top of the staff and draw it down to the furthest extent of the shadow
- place your protractor next to the string such that you may observe what angle it makes with the ground

What you'll calculate:
- subtract the observed angle from 90° to determine your latitude

____

____

b) Compare your calculated latitude to the one you recorded in Question #1. What factors may be influencing the accuracy of your latest value?

____

____

____

c) One important factor is to adjust for the time of year. The earth is tilted a maximum of 23.4° towards or away from the sun in midsummer and midwinter, respectively. At the spring and fall equinoxes, the earth is level with respect to the sun so no adjustment needs to be made. For the rest of the year, appropriate fractional adjustments are required. Can you make the adjustment to your observed latitude value? Is it closer to Question #1 now?

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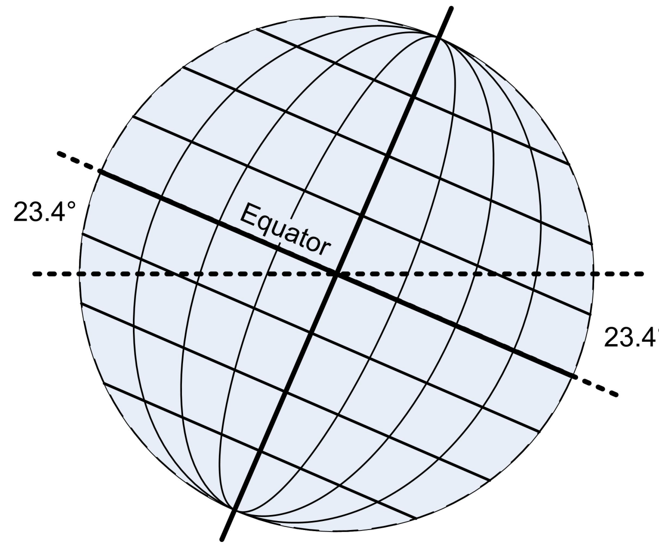

Month	**Adj.**	**Month**	**Adj.**
January 21st	___	July 21st	___
February 21st	-7.8°	August 21st	+7.8°
March 21st	0°	September 21st	0°
April 21st	+7.8°	October 21st	___
May 21st	___	November 21st	___
June 21st	+23.4°	December 21st	-23.4°

Note: *If you are in the southern hemisphere, the latitudes are negative values, so swap the signs above to adjust.*

d) **Extra Credit!** Using the information in the book and concepts covered above, can you determine the approximate latitude and longitude of where the *New Adventure* was in the Atlantic Ocean when Captain Garrett took the noon sighting on pg 125 in Chapter 14?

____

Project Ideas

Expand upon your learning with one or more of the following project ideas!

Project #1 – Make a Treasure Map

Using each of the above navigation concepts, create a "treasure map" that guides a traveller from one location to another. There may be a treasure there or it could just be the destination that is special. Employ both illustration and instructive text as desired.

Project #2 – Timeline of Invention

Make a timeline of the invention and introduction of navigation tools and practices (including any significant books) and briefly describe the impact of each. Be sure to look at developments from around the world.

Project #3 – Celestial Navigation

In Chapter 14, Captain Garrett says he would begin teaching Emma and Jack how to navigate by the night sky. Research into how this was done during the Age of Sail and note the challenges faced by those exploring the globe. In a short presentation, highlight your key findings. Try searching "Celestial Navigation" and "Navigating by the North Star" to get started.

Inspired? Have an idea of your own, or a question you want to investigate? Go for it! There is so much to learn from our common history.

Howard Pyle, Public domain, via Wikimedia Commons

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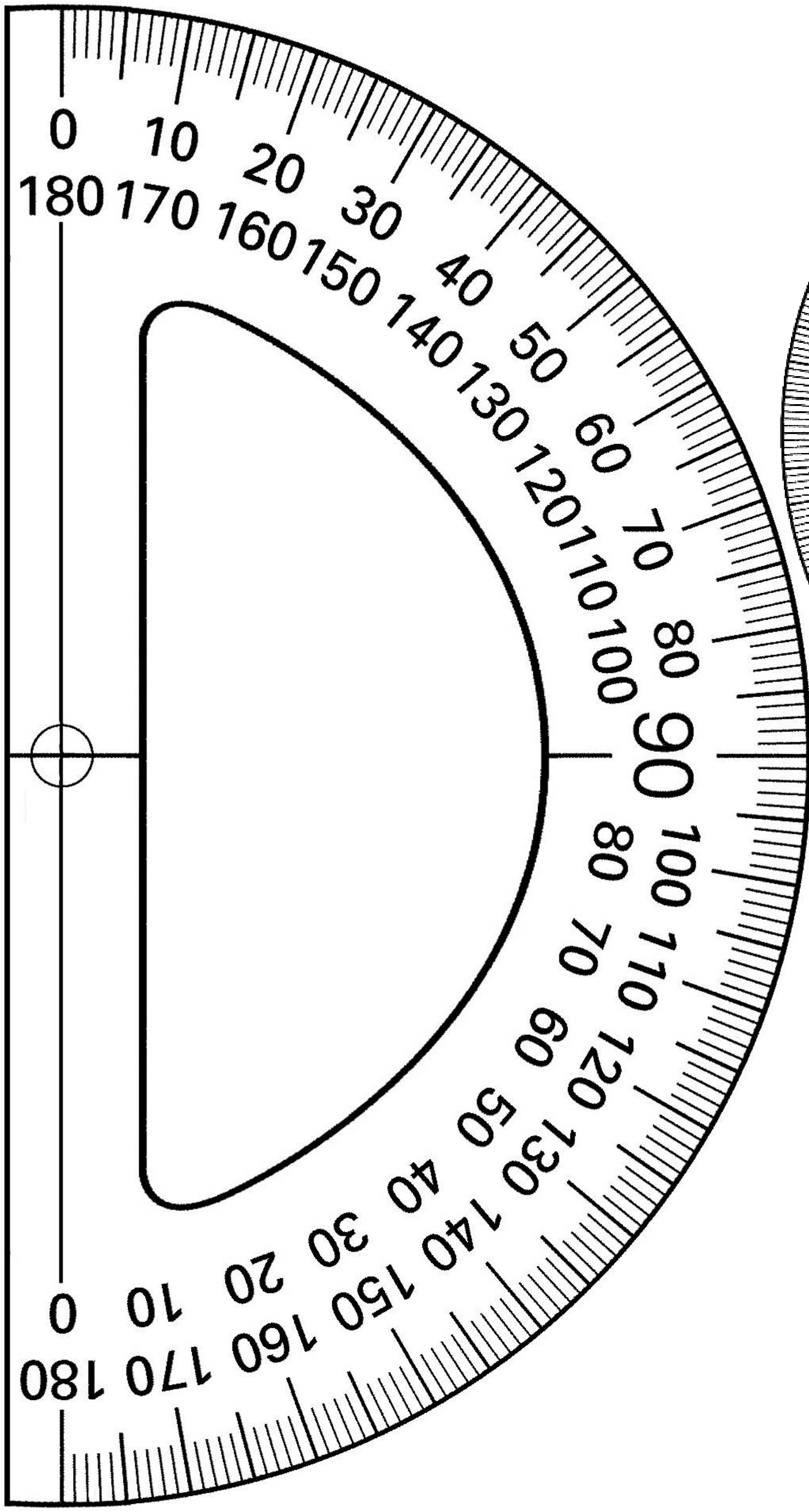
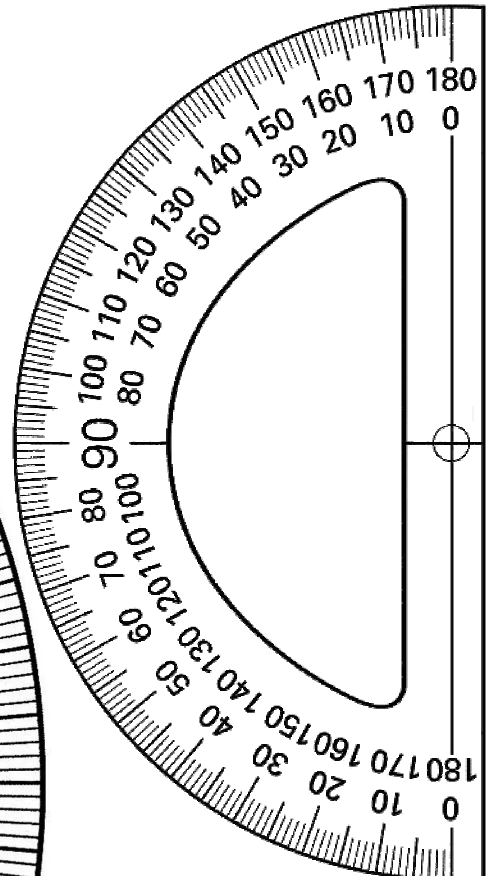
Appendix – Protractor Cut-out

If you don’t have your own protractor, cut out these for use in the above questions.





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Answer Key

Question 1a: This depends on where you are in the world! Search your location in Google Maps and right-click to display the latitude and longitude in a decimal format and convert using the provided formulas. Or look it up in Wikipedia and view both formats via GeoHack.

Question 1b: The coordinates do not have to be exactly as given below. As long as the place name is reasonably nearby when the coordinates are entered in Google Maps / Google Earth.

a) Bristol, UK = 51°27′18"N, 2°35′17"W
b) Port Royal, Jamaica = 17°56′12″N, 76°50′28″W
c) Stone Town, Zanzibar, Tanzania = 6°9′43″S, 39°11′31″E
d) Warri, Nigeria = 5°31′0"N, 5°45′59"E

Question 1c: The place names from the book are:

a) 5°36′15"N, 0°11′14"W = Accra, Ghanna
b) 7°56′46"S, 14°21′21"W = Ascension Island
c) 14°54′50″N, 24°22′54″W = Fogo, Cape Verde
d) 11°17′53"N, 60°30′8"W = Little Tobago

Question 1d: The two closest in terms of latitude are Accra and Warri. The two closest in terms of longitude are Accra and Bristol.

Question 1e: Here are some additional locations from the book. There may be more!

Bridge Town = 13°06′23″N, 59°36′48″W
Charles Town = 32°46′37"N, 79°55′52"W
Lagos = 6°31′33″N, 3°22′42″E
Port-de-Paix = 19°56′5″N, 72°49′53″W
Cape Town = 33°55′6″S, 18°25′11″E
Falmouth = 50°9′8″N, 5°3′57″W
Nassau = 25°02′41″N, 77°22′2″W

Question 1f: No. Navigators were "eyeballing" their measurements with tools like the cross-staff and the quadrant. Given that a degree is ~111km/69miles and a sailor can see ~10 miles from a 75' lookout, anything in the 10's of minutes would be useful.

Question 2a: At point A.

Question 2b: Point X = 70°W, point Y = 45°W, and point Z = 60°E

Question 2c: Latitude = 50°8′30″N which is closest to Falmouth at 50°9′8″N in the given table.

Question 3a: Being consistent in where one measures to and from can improve the clarity of the route, eg: taking the mid-point of each square will result in a different set of numbers.

Question 3b: Maybe changes in currents and winds weren't included? Could there be a missing entry in the log? Or perhaps a mistake was made in recording speed or heading? Or…?

Question 4a: This depends on where you are in the world!

Question 4b: Was it "high noon"? How precise can you make your measurements? Are you at the exact location you recorded for Question #1? Time of year will be a big factor. What else?

Question 4c: Unless it is the Spring or Fall Equinox, then you will need to adjust for the time of year per the table.

Thank you for using this add-on to our Teacher's Guide for "The Day the Pirates Went Mad".

We hope it was useful and engaging.

For more behind-the-scenes and research-related information, visit us at https://EmmaSharpesAdventures.com

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