Navigation Lab

Objectives:

- To use **coordinates** (latitude and longitude) to locate geographic positions on Earth.
- To read marine **charts** (maps) to determine geography, distance, direction, and position.
- To use a **compass rose** to determine **heading.**
- To distinguish between **magnetic** and **true** compass headings.
- To use **vectors** to plot a ship's **course** and **heading** (taking into account ship and current speed and direction).

Introduction

In a “Cartesian” system, object positions are plotted on a two-dimensional (flat) grid.

“X” is the horizontal measurement.

“Y” is the vertical measurement.

Any position on the grid can be stated by its x, y position. The grid is really a **chart** (map) and we can assign a direction (north, south, east, or west) to each axis. The position of the house in **Figure 1** is stated “2 north, 7 east.” (*Latitude* is traditionally is stated before *longitude* and direction is also stated.)

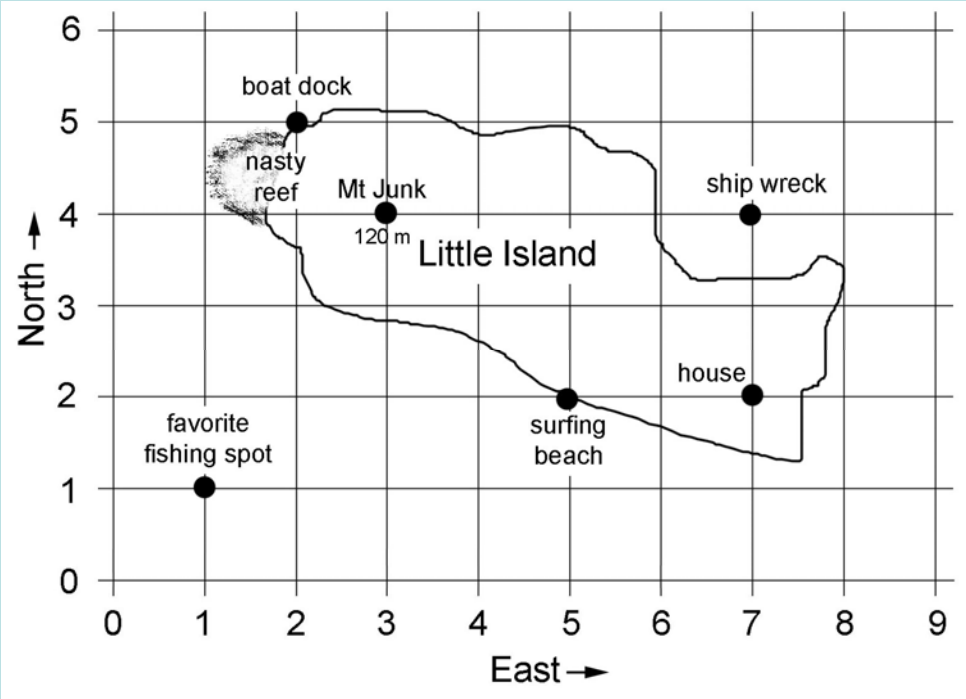

Figure 1. A Cartesian (x,y) Map

The "***heading***" is the *direction* you are going. On **Figure 1**, the *heading* from the house to the shipwreck is *north*. The *heading* from the boat dock to Mt. Junk is *southeast*.

A "***scale"*** for determining distances is shown on all accurate charts. Assume the distance between lines on the y-axis (the "scale") is exactly one mile (**Figure 1)**. If true, then the distance from the *house* to the *shipwreck* is 2 miles. The distance from the *house* to the *surfing beach* is also 2 miles. (Here vertical and horizontal scales are the same. Warning *horizontal* and *vertical* are usually not the same!)

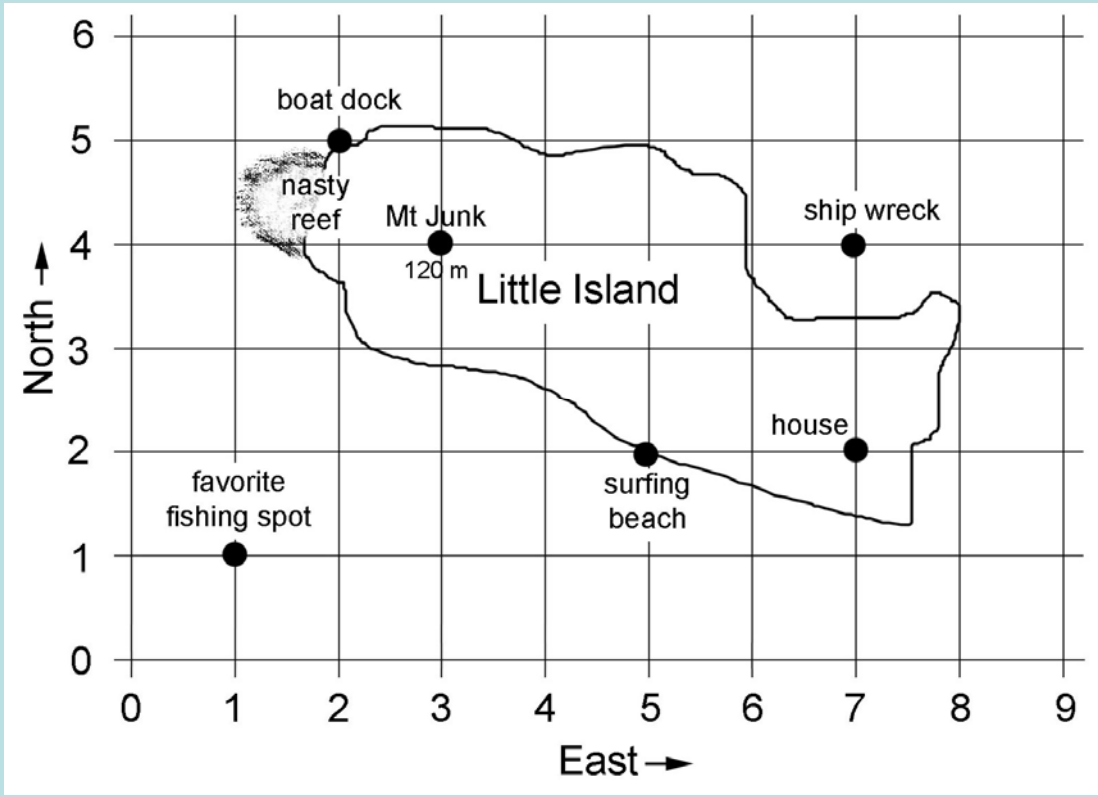

Figure 1. A Cartesian (x,y) Map

Navigation Practice

Let's go from the *house* to the *favorite fishing spot*. Draw arrows on **Figure 1** (either print off the figure or draw them electronically if you know how) to indicate your progress as you complete the following navigational steps.

1. Start at the *house* and head northwest 5.8 miles to the *boat dock*.
2. Using the boat, head "**due**" (exactly) west 1 mile (boat speed is 5mph).
3. Go due south 4 miles to the *favorite fishing spot*.

If you walk at 5 miles per hour from the house to the boat dock it will take 1 hour and 10 minutes. Total trip is 2 hours 10 minutes (1 hour to walk to the *dock* + 1 hour sailing time from the *dock* to the *favorite fishing spot*).

Real Earth Coordinate Systems

The Cartesian coordinate system we just described works for a flat surface but not the *spherical* Earth. Wrapping a flat map around a sphere simply won't work (the paper wrinkles and folds). Instead, we use a system called **polar coordinates**. This system covers our planet with imaginary lines called **parallels** and **meridians** (Figure 2).

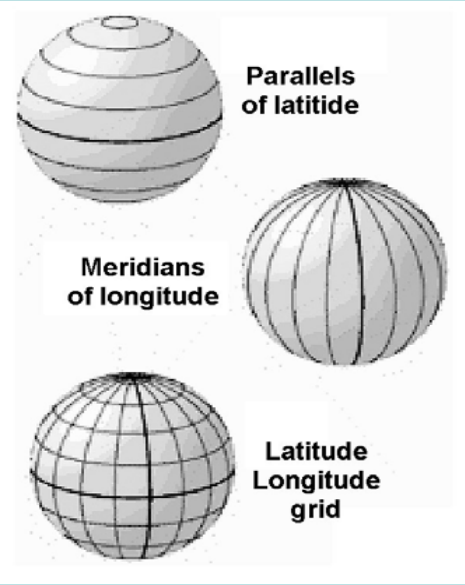

Figure 2. Latitude and longitude grid lines

Real Earth Coordinate Systems

The ***equator*** is designated as the **origin** (starting point) for the lines of latitude.

The ***prime meridian*** (passing through Greenwich, England) is designated as the **origin** for the lines of longitude.

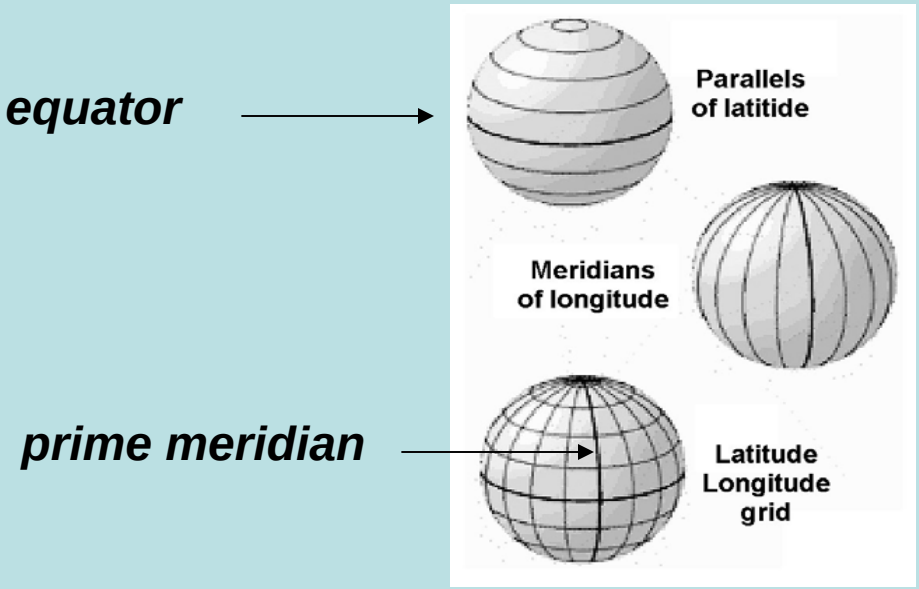

Figure 2. Latitude and longitude grid lines

Real Earth Coordinate Systems

Latitude lines make circles that **parallel** one another and decease in circumference toward the poles.

Longitude lines make circles having the same circumference that **converge** at the poles.

Great Circles divide Earth into 2 equal hemispheres (all longitude lines and the equator).

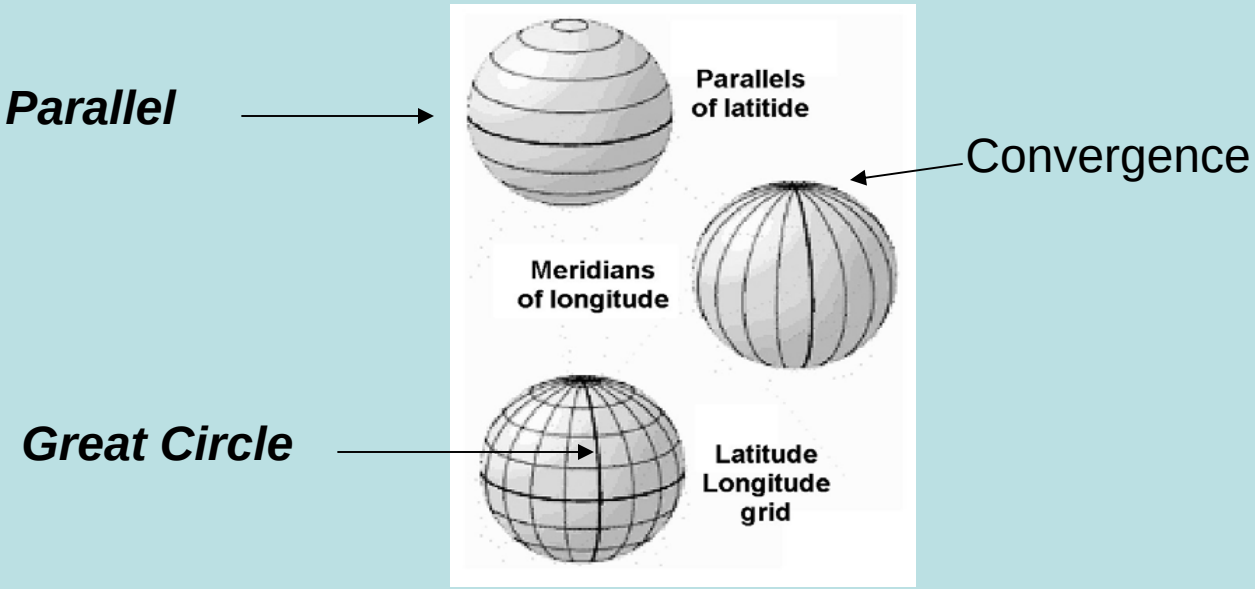

Figure 2. Latitude and longitude grid lines

Real Earth Coordinate Systems

Meridians of longitude are named by their *angles from* the Prime Meridian and whether they occur *east* or *west* from the Prime Meridian (Figure 3).

The **International Date Line** is where east meets west at (180°). This meridian passes through the Pacific Ocean.

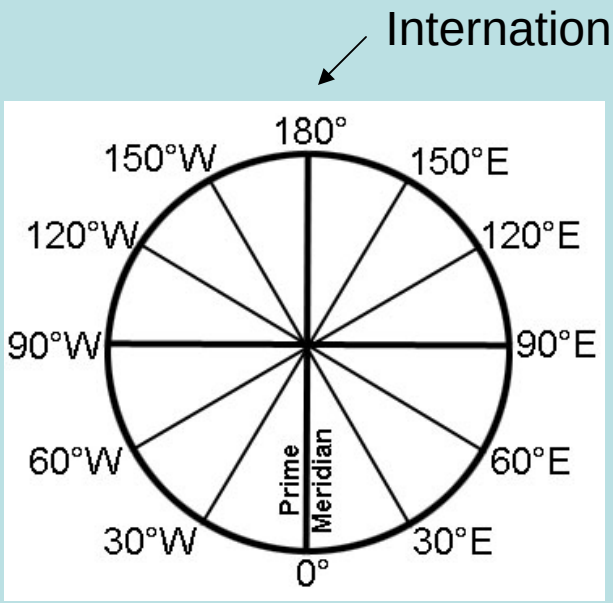

Figure 3. Meridians of longitude
- Looking down at the North Pole

Real Earth Coordinate Systems

Parallels of **latitude** are measured as angles north and south from the equator (“0” parallel).

Figure 4 shows the system used to determine latitude.

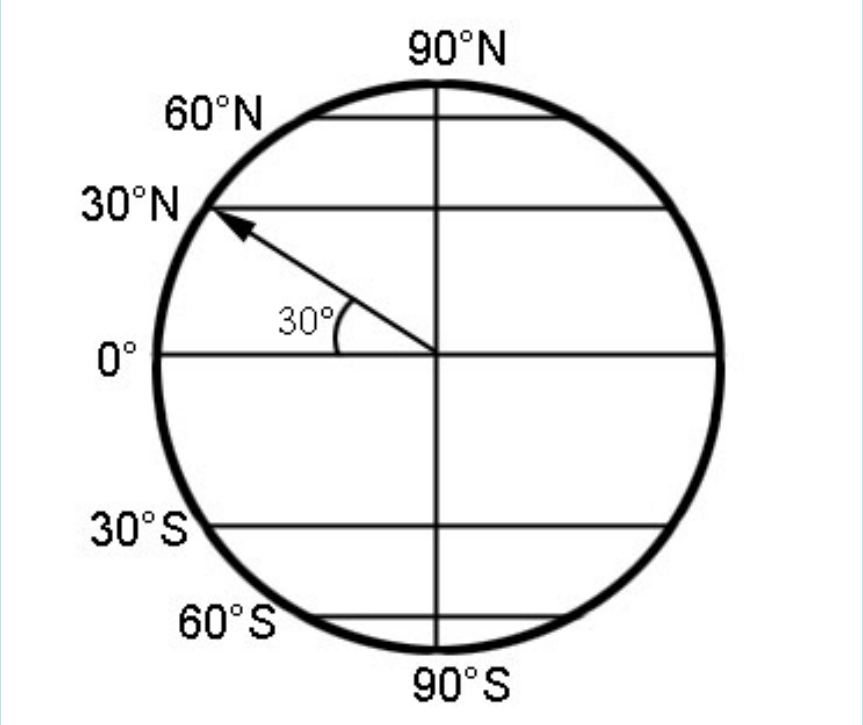

Figure 4. Parallels of latitude

Determining Distance on a Globe

Q. What distance is represented by 1 longitudinal degree of arc *along the equator*?

A. Since there are 360 degrees around the equator (**Figure 3**), the length of 1 degree of arc is equal to the total length (the circumference of Earth) divided by 360.

24,900 miles / 360 degrees = 69.17 miles/degree

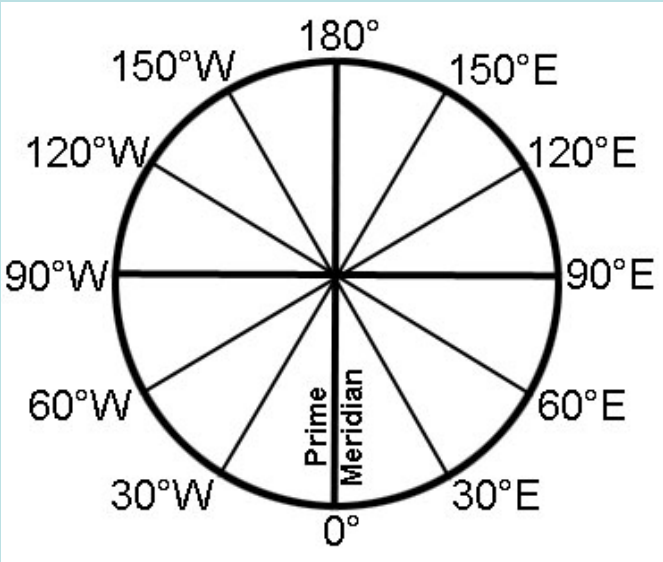

Figure 3. Meridians of Longitude - Looking down at the North Pole

Determining Distance on a Globe

69.17 miles is not a convenient unit of measure. To simplify the measurements, mapmakers defined another unit of measurement, the **nautical mile** (nm).

A nautical mile is equal to 1/60th of a degree.

Therefore, 1 degree of arc *along the equator* equals 60 nautical miles.

The name for “freeway miles” is **statute miles**. 1 degree of arc = 1.15 statute miles.

1 nautical mile (nm) = 1.15 statute miles

Determining Distance on a Globe

1 **latitudinal** degree of arc is always equal to 60 nautical miles, no matter where you are on the planet (all **great circles** have the same circumference).

1 **longitudinal** degree of arc is more complex. As you proceed toward the poles, the longitude lines converge, and the distance between them decreases (at the poles it becomes zero). In other words, all **parallels** do not have the same circumference (**Figure 5**).

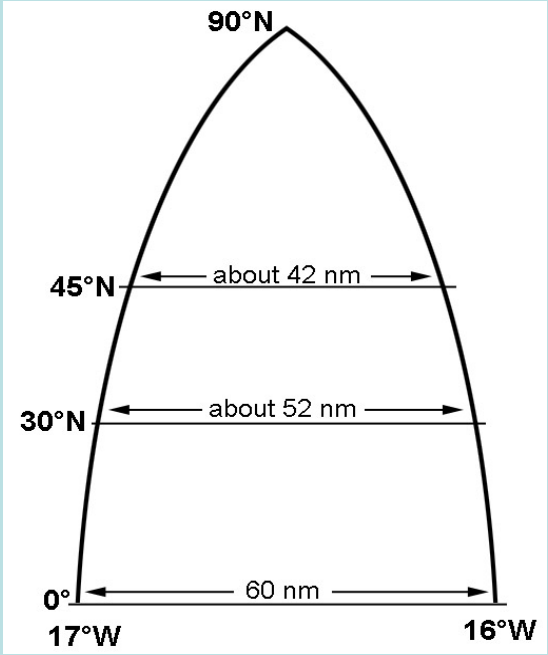

Figure 5. Length of one longitudinal degree at different latitudes

Determining Distance on a Globe

Because all great circles have (approximately) the same diameter as the equator,

1 latitudinal degree of arc always = 60 nm

Therefore, when using a scale to determine distance, always use the north south (latitudinal) scale, not the east-west (longitudinal) scale!

Pre-Lab Questions

1. Where do you end up after 2 hours and ten minutes? After following the navigational directions on page 3?

   a. Mt. Junk b. Nasty reef c. Surfing beach d. Favorite fishing spot

2. Which lines form circles having the same circumference?

   a. Latitude b. Longitude c. Parallels d. Meridians e. b & d

3. Why are the scales usually not the same for degrees of latitude and longitude?

4. One degree along a longitude line equals:

   a. 1 nm b. 1 statute mile c. 1.15 nm d. 1.15 statue miles e. a & c