Exploring Maps — Navigation

How do we know where we're going?

Travel depends on the ancient skill of navigation—the ability to find a way from one place to another and back. Columbus was not sure how far he had to go. In his journal he recorded his latitude observations and estimates of distance traveled underreporting this distance to the crew, "lest the trip be long."

Polar explorers depended on navigational data for survival, as well as success. Sir Ernest Henry Shackleton, who attempted to reach the geographic South Pole several times between 1902 and 1922, was once marooned on a moving ice shelf and his ship was crushed; Shackleton's survival depended on the latitude and longitude observations that described the motion of the ice.

Travelers on land need somewhat different information from those at sea. Travelers on solid ground can follow circuitous routes between important landmarks using schematic maps (for example, the A.D. 250 Peutinger map). Seagoing voyagers need more from their maps, as the ocean moves beneath them and the wind and waves push the ship across a featureless surface (for example, the A.D. 1502 Cantino Planisphere, a portolan chart). Sailors on the open sea have kept track of absolute position using the only reference points they have: the Sun and stars.

The globe is the best way to show the relative positions of places, but a globe that can fit in a ship's cabin cannot show the detail needed for navigation. Flat maps distort the placement of features, but can show great detail and are portable.

The transformation of map information from a sphere to a flat sheet can be accomplished in many ways, called projections. Map-makers have invented projections that show distances, directions, shapes, or areas as they are on a globe, at least partially. Different projections have different advantages and disadvantages.

Orthographic projections, for example, show shapes as they appear when the globe is viewed from space. Equal-area projections do not distort the size of areas but do distort their shapes. Conformal projections are those on which the scale is the same in any direction at any point on the map.

Many projections retain one geometric quality, and a few retain more than one quality, but no single projection can accurately portray area, shape, scale, and direction. (A map projections poster available from the USGS Earth Science Information Center illustrates the features of the most common map projections.)

The Mercator projection was designed by Flemish cartographer Gerardus Mercator in 1569 to show compass directions as straight lines in all directions from all points on the map. This was an important breakthrough in mapping. Using a Mercator projection, navigators could draw a straight line to a destination, sail in that direction, and expect to reach it, allowing for the effects of ocean currents and other factors.

Mercator made longitude lines parallel and increased the distance between latitude lines away from the equator. As a result, extreme northern and southern areas appear enlarged. For example, Greenland looks larger than South America, although South America is eight times as large in reality. This distortion at high latitudes (north and south) also makes the distances appear larger than they are. Even with these disadvantages, this projection remains one of the most commonly used.

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Activity I: Make a Mercator Projection

Follow the directions below to make a close approximation of the normal Mercator projection. A few activities with the map are included to demonstrate the important characteristics of this projection.

Time:

One 50-minute period for steps 1-10.

After photocopying in step 11, one 50-minute period for steps 11-14.

Materials per person:

- Protractor
- Compass
- Ruler
- Two sheets of 11 x 17 inch paper
- Transparent tape
- Sharp pencil
- Fine point pen, preferably black

Procedures:

1. Tape the two pages together along the 17-inch sides and orient the paper as shown in illustration A, with the tape on the reverse side.

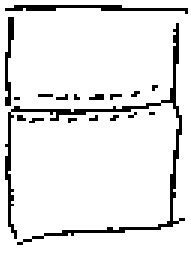

Illustration A

2. The joint between the two pieces of paper will be the "equator." Lay the protractor on the paper with the flat side on the left. Place the zero point and the 90-degree mark on the equator (see illustration B). Use the compass to draw a semicircle with a

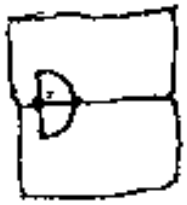

Illustration B

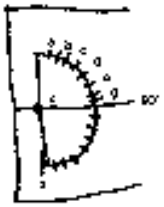

Illustration C

6-inch diameter, flat side on the left. Mark the center (the zero point, Z) on the diameter. IMPORTANT NOTE: *Make all marks lightly in pencil, unless otherwise instructed.*

3. Using a protractor, mark every 10 degrees around the semicircle (see illustration C). Starting at the top, label these points A, B, C, ..., S.

4. Beginning at Z, measure left along the equator 2/5 of a radius (in this case, 1.2, inches) and mark a new point, T, as shown in illustration D.

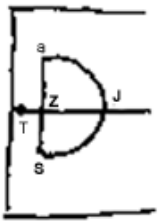

Illustration D

5. Using the protractor, draw the westernmost line of longitude perpendicular to the equator and tangent to the original semicircle at point J (see illustration E).

Illustration E

6. Set the spacing of the lines of latitude as follows: With the left end of your ruler on point T, align the right side to point I on the semicircle; mark where this line (TI) intersects the westernmost longitude line. Beginning again at point T, mark points on the westernmost longitude for lines through points H, G, F, E, D, and C (see illustration F). Each point marks 10 degrees of latitude.

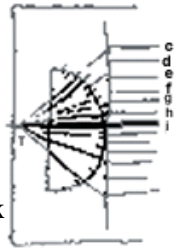

Illustration F

7. Draw latitude lines parallel to the equator through these new points. To make the latitudes parallel, measure the distances between marks on the westernmost longitude line; copy these measurements and mark equivalent points on the easternmost longitude line. Connect pairs of points (a western and an eastern), preferably beginning closest to the equator.

8. Repeat steps 6 and 7 for latitudes south of the equator. Notice that on this projection, lines of latitude are parallel and spacing between them

increases away from the equator. Latitudes 90°N and 90°S cannot be shown on a Mercator projection, because they arc infinitely far from the equator (although this approximate construction does not show this).

9. Set longitude lines as follows: Measure east 0.5 inches from the westernmost longitude and make a mark on the equator. This represents 10 degrees of longitude. Repeat this step 17 more times, and you will have 180 degrees of longitude. From each point on the equator, use the protractor to draw a perpendicular line. On the Mercator projection, longitude lines are parallel and equally spaced, as shown in illustration G.

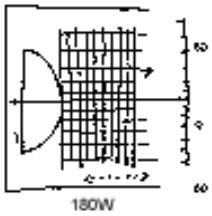

Illustration G

10. At this point, the map covers only half the planet (*a hemisphere*). Carefully trace this grid in ink.

11. To map the entire Earth, make two copies of the original and join the copies along the one's easternmost line of longitude and the other's westernmost (see illustration H). Lines should connect across the copies. These two lines both represent the Prime Meridian, the line of 0 degrees longitude.

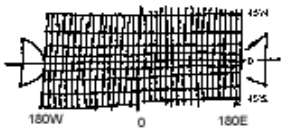

Illustration H

12. Label the latitude and longitude lines along the right and bottom of the map. The equator is 0 degrees latitude, and latitude values increase in increments of ten to the north and south. The westernmost longitude line is 180 degrees W; longitude values decrease in increments of ten to 0 degrees at the Prime Meridian, and increase again to 180 degrees at the eastern edge of the map (see illustration H). This map approximates the characteristics of the Mercator projection within about 2 percent.

13. Make a bar scale in the margin below the map. A bar scale is commonly centered below the map, in this case, below the Prime Meridian (see illustration I). To determine the scale at the equator, divide the Earth's equatorial circumference (24,902 miles; 40,075 kilometers) by 360 degrees; therefore, each degree of longitude and latitude at the equator equals about 69 mi (about 111 km). Ten degrees of longitude at the equator (about 690 miles) is represented by 0.5 inch on the map; one inch represents 1,380 miles. Draw a line representing 3,000 miles (about 5,000 kilometers).

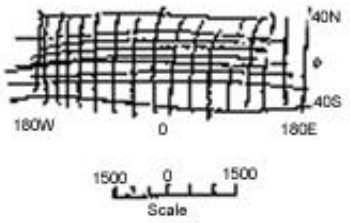

Illustration I

14. Sketch the outlines of the continents as shown on other maps available in the classroom. Plot the course between Columbus' home port and destination; your home town and the western coast of Africa; and the route of an oil tanker from Kuwait to Tokyo, Japan. Notice that you cannot plot polar explorations.

Extension:

Obtain a variety of world maps from the school library and compare the properties of the projections. Various atlases may prefer different projections. Which seem to be the most popular projections for world maps? For detailed maps?

Activity II: In the Wake of Lewis and Clark

In groups of three or four study the route of Meriwether Lewis and William Clark's travels and the important events in their journey.

Time:

One week (homework) to scan the journals of Lewis and Clark.

One 50-minute class period per step.

Materials per student:

- Copies of journals of Lewis and Clark (see bibliography)
- Notebooks and pencils

Materials per group:

- Highway maps of the western United States.
- Information about Lewis and Clark's expedition (see sources listed below)
- Colored markers
- Map showing State and national boundaries in 1804 and the Louisiana Purchase

Procedures:

1. List places visited by Lewis and Clark and categorize them as natural landmarks, native villages, sites of special events, pioneer outposts, etc. Mark these sites on a map of the western United States. Mark State boundaries and the western boundary of the United States as they were before the Louisiana Purchase.

2. Referring to Lewis and Clark's report, summarize their weekly progress, marking the map as well as possible. Use symbols for special places: important natural landmarks, the place where they met Sacagawea, major camp sites, major obstacles, sites where friendly natives provided important help, places where they suffered especially bad weather, places where they changed from river to overland travel, etc. Indicate the boundaries of native cultures along their route.

3. Plan an imaginary trip along part of the route of Lewis and Clark. How far can you travel in a week? What obstacles will you face? Where will you replenish your supplies? What will you take? How many are in your party, and what are each one's responsibilities? How much will this cost? How will you pay for the trip? What can you accomplish on this trip?

Extensions:

Keep a journal as if you were with the Lewis and Clark expedition for one week. Include feelings, experiences, discoveries, people met, etc. You may refer to events described for the time period selected.

Sources of further information about Lewis and Clark:

Lewis and Clark Trail Heritage Foundation, Inc.
P.O. Box 3434,
Great Falls, MT 59403
www.lewisandclark.org/

Lewis and Clark National Historic Trail,
National Park Service
1709 Jackson St.
Omaha, NE 68102
402-221-3471, 8 am - 4:30 pm Monday - Friday
www.nps.gov/lecl/welcome.htm

Lewis' and Clark's journals, their report, and secondary descriptive writings, which your local librarian can help you locate.

Additional activities:

1. Read a diary of another explorer or pioneer and write a two-page essay comparing this journey with that of Lewis and Clark.

2. Have a travel agent visit the class and discuss planning for a trip to a different continent, and how the travel business has changed in the past 40 years.

3. From the reverse of the poster, select two quotations that seem especially pertinent to this activity sheet, and write an essay that discusses the ideas of both writers.

Recommended Reading:

Biddle, Nicholas, ed. *The Journals of the Expedition under the Command of Capts. Lewis and Clark.* New York: The Heritage Press, 2 vols., 1962.

Map of the Conterminous United States Showing Routes of the Principal Explorers from 1501 to 1844.... U.S. Geological Survey United States map. 1983.

Map Projections. U.S. Geological Survey poster. 1992.

Maps of an Emerging Nation—The United States of America, 1775-1987. U.S. Geological Survey National Atlas Map. 1987.

Snyder, J.P. *An Album of Map Projections*. U.S. Geological Survey Professional Paper 1453, 1989.