ED 5661 Mathematics & Navigation Teacher Institute

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Lesson Plan

Lines of Latitude and Longitude

Lesson Overview:

This lesson plan will introduce students to latitude and longitude along with local and universal time. This lesson will take 2 class periods.

Sources: R.Stephen Roblee, Professional Emeritus and Captain R/V Agassiz


http://www.wikipedia.org/

http://www.phy6.org/readfirst.htm

Materials Needed:

Each student will need their ipads with access to the internet. Students will also use the "notes" app on their ipad.

Vocabulary:

Latitude, longitude, Line of latitude, line of longitude (or meridian), co-latitude, equator, zero meridian ("prime meridian"), eastern and western hemispheres, (local) noon meridian, local time (LT), time zones, international date line, universal time (UT; of "Greenwich Mean Time" GMT), nautical mile, knots.

Focus Questions:

What is meant by latitude and longitude? Why do we use latitude and longitude to define location? What is the difference between local and universal time? What is the use of the international time line?

Learning Objectives: The student will

• Know how any location on Earth can be defined by its latitude and longitude.

• Learn the difference between local time and universal time, and the various adjustments made to "clock time," e.g. time zones, daylight saving time and the use of the international date line.

Content Standards and Expectations:

L2.3 Measurement Units, Calculations, and Scales

L2.3.1 Convert units of measurement within and between systems; explain how arithmetic operations on measurements affect units, and carry units through calculations correctly.
L2.4 Understanding Error

L2.4.1 Determine what degree of accuracy is reasonable for measurements in a given situation; express accuracy through use of significant digits, error tolerance, or percent of error; describe how errors in measurements are magnified by computation; recognize accumulated error in applied situations.

G1.6 Circles and Their Properties

G1.6.4 Know and use properties of arcs and sectors and find lengths of arcs and areas of sectors.

Standard III.1 Collection, Organization and Presentation of Data
Students collect and explore data, organize data into a useful form, and develop skill in representing and reading data displayed in different formats.

Standard IV.2 Representation and Uses of Numbers
Students recognize that numbers are used in different ways such as counting, measuring, ordering and estimating, understand and produce multiple representations of a number and translate among equivalent representations.

Standard V.1 Operations and Their Properties
Students understand and use various types of operations (e.g., addition, subtraction, multiplication, division) to solve problems.

Procedure:

The teacher will start the class with a map of the US on the computer projector.

Ask: what is special about the border between the US and Canada? ("About half of it is a straight line")

Of course, no line on the surface of the Earth is straight. What looks straight on the map follows a line of latitude, a line at a constant distance from the pole. In this case, it is the line of latitude 49 degrees. Any other boundaries that follow lines of latitude?

There are many. The best known ones are probably on the borders of Pennsylvania. The northern border follows the line of latitude 42° which also forms the southern borders of Idaho and Oregon (but not the northern borders of Connecticut and Rhode island--these are parallel, but a short distance
further north). But the southern border of Pennsylvania is more famous: it follows latitude 39° 43' (39 degrees, 43 minutes—60 "minutes of arc" in each degree). That is the Mason-Dixon line, which before 1860 formed the boundary between the "slave states" (a part of the US still called "Dixie") and the "free states."

One reason many boundaries follow lines of longitude—and the ones perpendicular to them, like boundaries of Utah and Colorado, lines of latitude—is that such boundaries are easy to define. Let us now look at these lines more closely.

Guiding questions used to present material
The questions below may be used in the presentation, the review afterwards or both, and suggested answers are provided.

This lesson is rather long, and it might be best to cover in 2 class periods.

What are latitude and longitude used for?

They are two numbers describing the position of any point on the surface of the Earth.

Latitude and longitude are angles. What units are used to measure angles?

Degrees, "minutes of arc" and "seconds of arc" (we add "of arc" only where we want to be sure these terms are not confused with units of time).

A right angle contains 90 degrees, written 90°.
(The angles formed by several lines meeting at a point all add up to 360°)
Each degree contains 60 minutes, written 60'.
Each minute contains 60 seconds, written 60".

What is the latitude at the equator, North Pole and South Pole?

The equator is at 0 degrees.
The North Pole is at +90 degrees or 90 degrees north.
The South Pole is at –90 degrees or 90 degrees south

The unit of distance "meter" was originally defined as one part in 10,000,000 of the distance between the pole and the equator. If that distance corresponds to 90°, to what distance does one degree correspond?

10,000,000/90= 111,111 meters.

How long is one minute of arc along a line from the pole to the equator (line of longitude)?
111,111/60 = 1852 meters, to the nearest meter.

This distance is also known as **nautical mile** and is widely used in measuring distances at sea. The **speed** of ships is traditionally measured in **knots**, and one knot equals one nautical mile per hour.

**At what latitude are we halfway between the equator and the pole?**

The latitude halfway between the equator and the North and South Poles is 45°, North or South.

**How do we define the latitude of a point P on the surface of Earth?**

We draw a radius from that point to the center of the Earth. The latitude is the angle between that radius and the plane of the equator—or else, 90° **minus** the angle between the radius and the axis of the Earth.

[Illustrate with a drawing on the board and have students note it in their ipads.]

**Riddle:** An explorer walked one mile south, one mile east, one mile north, and came back to the original point. Where did this happen?

The North Pole.

**Define the longitude of a point P.**

Draw a radius from the point to the center of the Earth. The radius and the axis of the Earth define a plane, like the side of a slice of an orange. [Illustrate with a drawing on the board and have students note it.]

The line along which that plane meets the surface of the Earth, on the side of the point P, is called the **meridian** of P, or its "line of longitude." Divide the circle of the **equator** into 360 degrees, with zero at the point where the "Prime Meridian" of Greenwich, England (at the eastern edge of London) crosses it.

The longitude of any point P is the angle at which its meridian cuts the equator. It is measured from 0° to 180° east of Greenwich, or from 0° to 180° west of it (sometimes marked 0° to −180°).

The Americas (north and south) are often called "the Western Hemisphere." Why?

The longitudes of the America's are all west of Greenwich.

**Can we specify a point on Mars by its latitude and longitude?**

As long as we can define the "Prime Meridian," we can.

**Discuss:**

**How would you define local time on a strict, astronomical basis?**

Local time is the time of the day, shifted so that noon occurs exactly when the Sun passes the north-south direction.

[More accurately, local time does so on the average. It ignores a shift of a few minutes due to the fact the Earth's orbital speed and distance from the Sun vary slightly along its orbit. Because of that variation, the length of time from noon to noon is usually very slightly different from 24 hours.]
Is local time the same at all points on a meridian?

Yes, the time is the same.

What are time zones?

If everyone used a strict astronomical definition for local time (LT), each community would usually have a different LT. Instead, LT is defined uniformly in strips of 15° wide, each strip including the meridian where it gives the correct LT and each typically differing by one hour from its neighbors.

Local time inside the strip may then differ by up to half an hour from the "precise" local time.

When the time is noon in New York City, it is 9 a.m. in San Francisco and 5 p.m. in London, England. Assuming all these cities are at the same latitude, how would you say the distances from New York–San Francisco and New York–London compare? If London is at longitude zero, what are the approximate longitudes of New York and San Francisco?

The distance to London is about 1 2/3 times as long from New York: 3 time zones from New York to San Francisco compared to 5 from New York to London. Each time zone corresponds to 360/24 = 15 degrees, so New York should be near longitude 75° west and San Francisco near longitude 120° west. Actual values, 73°58' and 122°21'.

What is Daylight Savings Time?

During the summer, when the Sun rises earlier, we make use of the extra daylight by shifting our clocks by one hour—e.g., what was labeled 6 am in the winter is now called 7 am. Each day people get up earlier (also go to sleep earlier) and enjoy sunlight for a longer time.

What is the International Date Line and why is it important?

As one crosses time zones moving westward, at each time zone boundary, one's local time jumps to one hour earlier. This may move us to an earlier day.

The International Date Line is a special time zone boundary, most of it following the line of longitude 180°. The line makes sure that in crossing time zones we always match the correct date at each location. Anyone crossing that line gains a day (crossing westward) or loses one day (crossing eastward).

Japanese war planes bombed Pear Harbor on Hawaii on December 7, 1941, and in doing so, pushed the US into war against Japan. Japanese war planes bombed US bases in the Phillipine Islands on December 8. Why did they wait an extra day?

They didn't! Hawaii is on the other side of the date line from the Phillipines. Actually the attacks occurred on the same day.

What is universal time (UT), and what is it used for?

Universal time, UT, is the local time at Greenwich, England, and anywhere else on the "Prime Meridian" of zero longitude. It is used when a single world-wide time system is needed, e.g. in timing events observed by a scientific spacecraft, or eruptions on the Sun.
Assessment: see attached worksheet