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Los Angeles Math Circle

Geometry of Time

Question 1 *What do our clocks and watches show? Hint: they do not show time.*

Question 2 *Why are there 24 hours in a day, but 12 hours on the faces of most of our clocks and watches?*



A 24-hour mechanical clock from USS Mullinnix, a Forrest Sherman-class US Navy destroyer, decommissioned in 1983.

Question 3 *What is a meridian? Hint: “dia” means “day” in the modern day Spanish. Spanish is quite close to Latin.*

Question 4 *How many grid meridians are there on the globe? Why?*

Question 5 *Why does the zero meridian pass through a neighborhood in South-East London, called Greenwich?*



Greenwich Royal Observatory, commissioned in 1675 by King Charles II.

Question 6 *What is the meaning of the AM and PM abbreviations?*

Example 1 *What is the time difference between Los Angeles and New York City?*

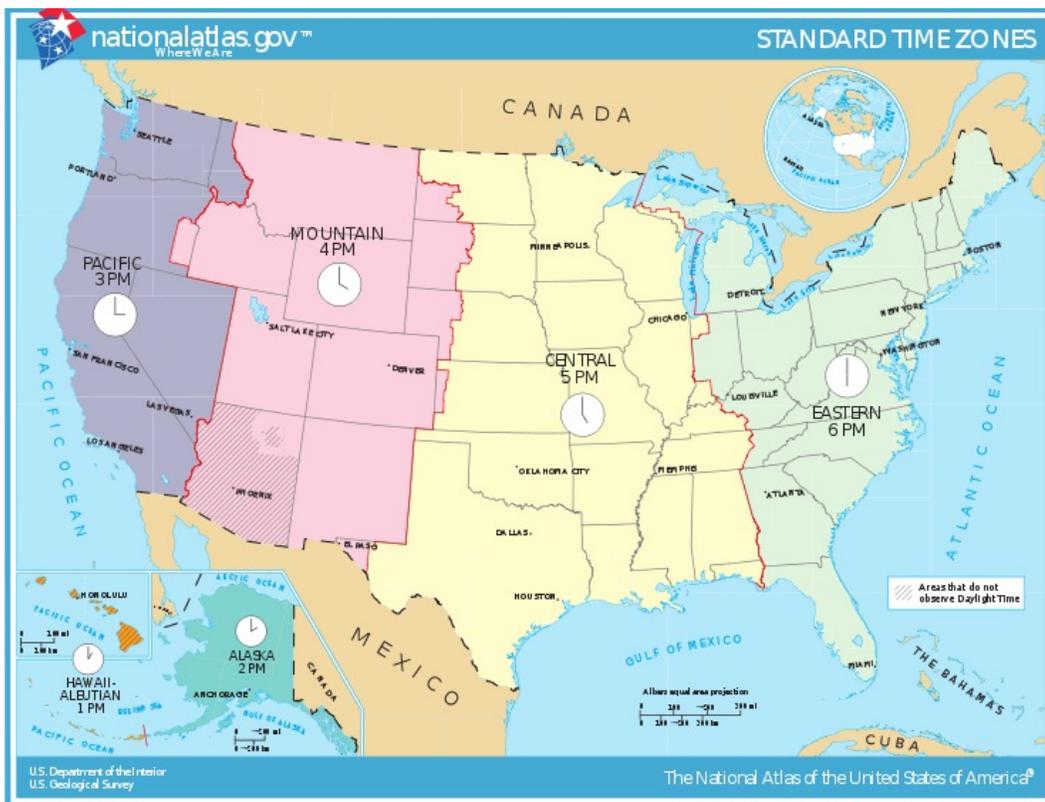
Let us take a look at the globe. Los Angeles is to the West of Big Apple, so the Sun comes there later. For example, when the Sun is at the top of the sky in New York, it's still going up

in Los Angeles. Both cities are located near the grid meridians, Los Angeles three of them away to the West. Thus

$$LA\ time = NY\ time - 3.$$

If it is, say, 5 P.M. in New York City, it's 2 P.M. in Los Angeles.

Question 7 *Why do we need time zones? How are they marked?*



US time zones.

Problem 1 *It's 2 P.M. in Los Angeles. What time is it in London, the UK? In Moscow, Russia?*

London time = _____

Moscow time = _____

Problem 2 *Write down the formulas relating the EST, CST, MST, and PST to the Greenwich time, the UTC (a.k.a. GMT).*

EST = UTC _____

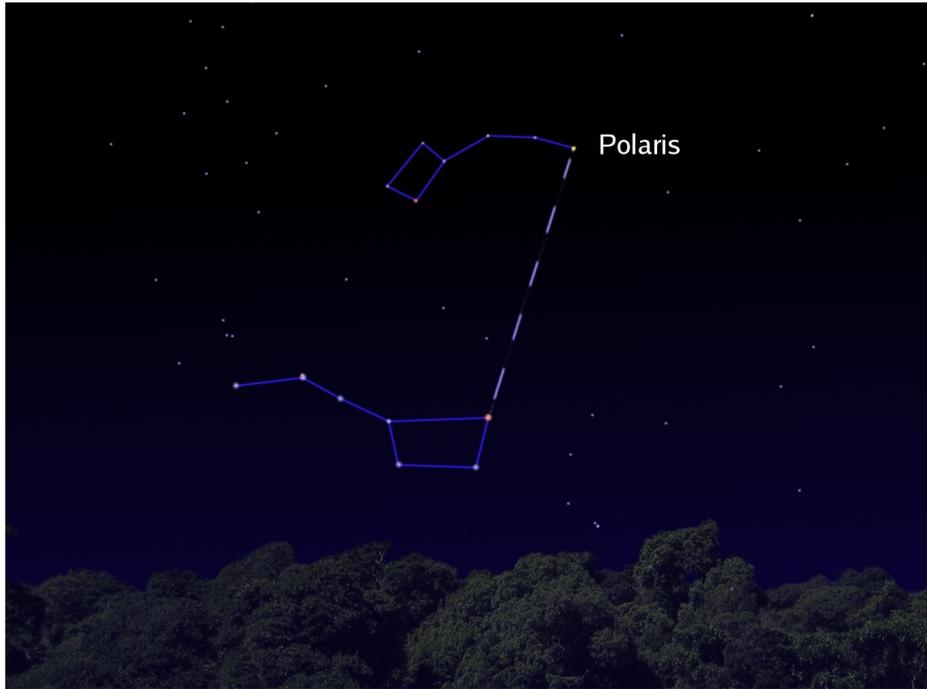
CST = UTC _____

MST = UTC _____

PST = UTC _____

Problem 3 *A flight from Moscow, Idaho to New York City departs Moscow at noon and lands in NYC at 8:00 PM. On the way back, the plane leaves NYC at midnight and lands in Moscow, ID at 4:00 AM. How long is the flight?*

Question 8 *What is the Northern Star, a.k.a. Polaris, and how to find it?*

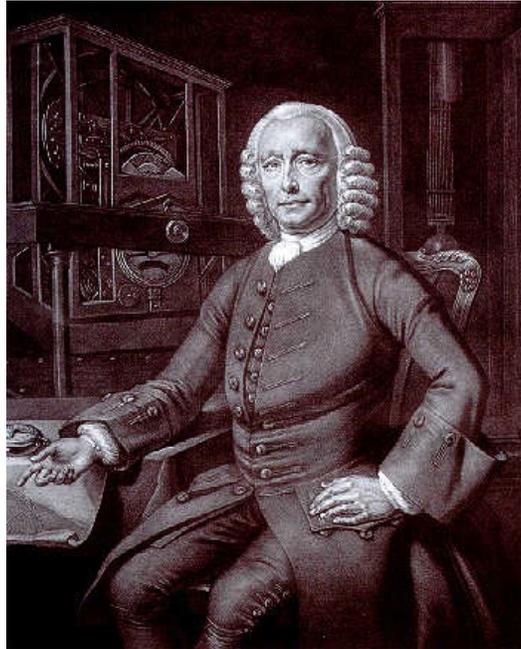


Question 9 *What is a latitude and how to figure it out?*

Figuring out one's longitude used to be a hard problem that had impeded marine travel for a few thousand years. In fact, the problem was considered so hard that the British Parliament offered a prize of £20,000 (comparable to \$5 million in modern currency) for the solution. The riddle was solved in the 18th century by John Harrison¹, the English clockmaker who invented the first functioning *marine chronometer*, a very precise timepiece designed to keep its precision regardless temperature fluctuations, humidity, and mechanical interference caused by

¹1693-1776

the waves tossing the ship.



John Harrison.

Question 10 *How do you use a chronometer to figure out the longitude?*

Problem 4 *Suppose that at the time of your local geographic noon, your GMT-set chronometer shows 10:20 A.M. What is your longitude?*

Question 11 *What is a function?*

Question 12 *Is time a function on the globe?*

Question 13 *Can you make yourself older or younger by walking around a pole?*

Question 14 *What is the International Date Line (IDL) and why do we need it?*



Problem 5 *Imagine that you are standing on an ice sheet facing the North Pole a few steps away from it in such a way that your feet are at the opposite sides of the 180° meridian. What is the time difference between your left and right foot?*

The 1° arch of the equatorial circle is 69 miles long (69.17 to be precise). To determine our position on the planet with more precision, we need some smaller measuring units. They are

called the *angular minute* ($1'$) and *angular second* ($1''$). There are 60 angular minutes in the 1° angle and there are 60 angular seconds in the $1'$ angle.

$$1^\circ = 60' \qquad 1' = 60''$$

The $1''$ arch of the equatorial circle is 34 (33.8 to be precise) yards long. This precision is good enough for navigation, so we do not need smaller units.

One more unit closely related to our discussion is the *nautical mile* (1 NM). 1 NM is the length of the $1'$ arch along any meridian. Let us compare the nautical mile to the “ground” one:

$$1 \text{ NM} = 1,852 \text{ m} = 2,025 \text{ yd} = 6,076'$$

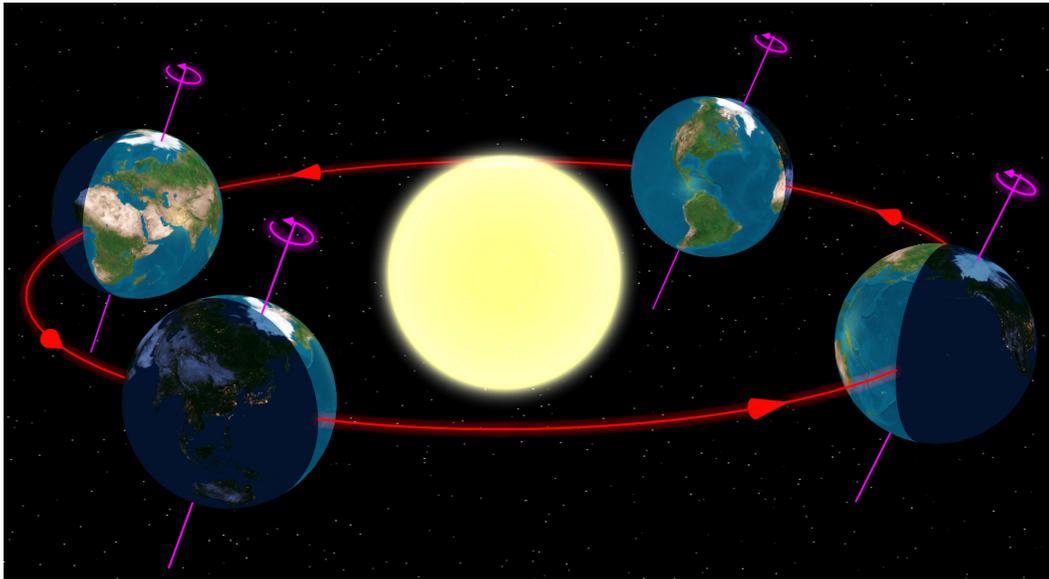
$$1 \text{ mi} = 1,609 \text{ m} = 1,760 \text{ yd} = 5,280'$$

Question 15 *Can we use the length of the $1'$ arch along a latitude line as a standard unit for measuring length? Why or why not?*

Problem 6 *Chasing a bear, a hunter went 10 miles South. Then the bear turned 90° East and trotted for another 10 miles. Then the bear turned 90° North and trotted 10 miles more. Following the bear, the hunter got to his starting point. What color was the bear?*

Problem 7 *A mechanical watch with a 12-hour face shows the time of 9:15. What is the angle between the hour and minute hands? Hint: the answer 180° is incorrect.*

A year is $365\frac{1}{4}$ days long. (This is why every fourth year is a leap year.) Suppose for simplicity that a year is exactly 365 days long. The Earth is spinning around its axis in the same direction it rotates around the Sun, please see the picture below.



Problem 8 *How many days were there in a year if the Earth spun around its axis in the opposite direction?*

Question 16 *What is time?*