

Student Name _____ Date _____

Time Zone Mathematics

1) 15:15 Wednesday

- 7:25 Wednesday

Time difference

2) 09:15 Pacific Time Zone, Friday

- 09:25 Eastern Time Zone, Friday

Time difference

3) 23:25 Mountain Time Zone, Tuesday

+ 9h 35m Added time

(give answer both in Mountain
and in Alaska Time Zones)

4) 04:25 Monday

+ 51h 18m Added time

5) 18:35 Friday

- 63h 21m Subtracted time

6) 03:25 Monday

+ 584h 47m Added time

7) Make up a scenario where you would have to use time zone math. Write down your story and its equation, and show how you solved it. For example, you are vacationing in Hawaii in December. You want to call your friend Pat in New York at noon Hawaii time to report the whales you saw today. What time will it be for Pat? The equation would be:

12 noon Hawaii Standard Time

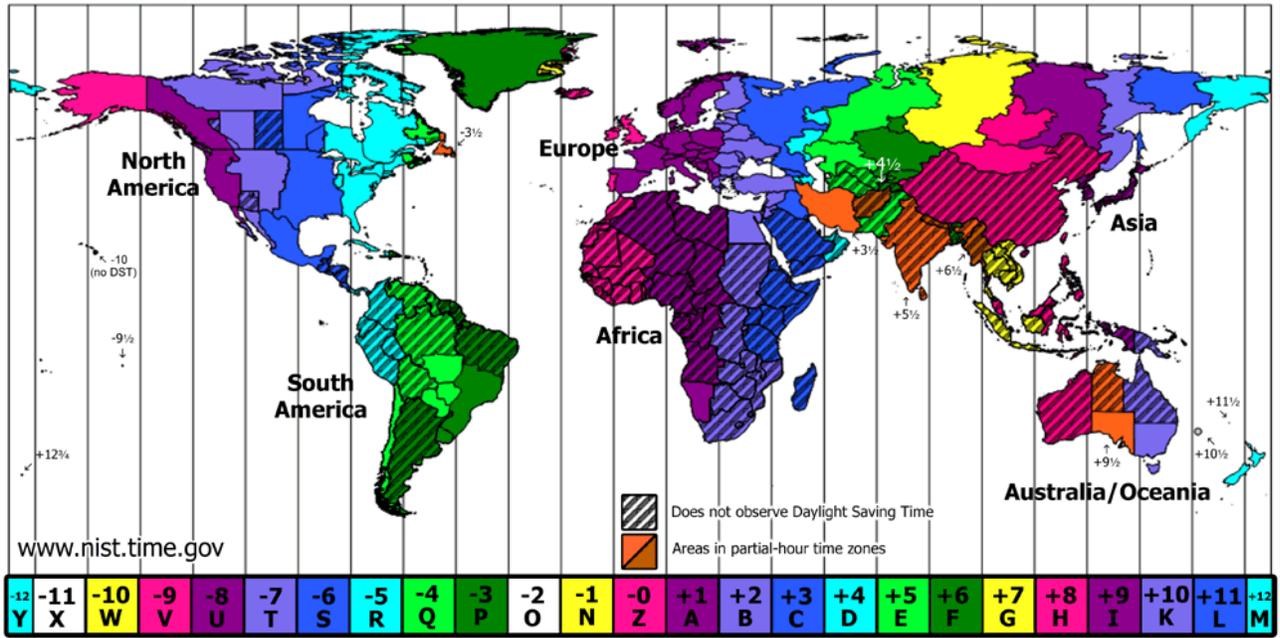
+ five hours

= 5 pm Eastern Standard Time

We add **five** hours because December is during Standard Time in New York. *

**Not all parts of the US use Daylight Standard Time. If you were vacationing in Hawaii in August, say, we would add six hours because it would be during Daylight Savings Time in New York—but not in Hawaii, because Hawaii doesn't participate in Daylight Savings Time.*

Universal Time



The above diagram shows the 24 time zones around the world. If you live in New York and want to call someone in San Francisco, you have to remember that the local time in San Francisco (Pacific Standard Time) is three hours BEHIND New York Time (Eastern Standard Time). By counting the time zones between the locations and keeping track of “ahead” or “behind” you, you can figure out the correct local times anywhere on the planet. Suppose an astronomer in Texas is viewing the Sun—with a special solar filter to protect her eyes—and notices a bright flash coming from a spot on the Sun (a solar flare) at 6:00 AM Central Standard Time near sunrise. Meanwhile, an astronomer in India spots the same solar flare at 17:00 India Time near sunset. Answer the following questions:

- 1) How can exactly the same event be seen at two different times on Earth?
- 2) What time would an astronomer with a solar telescope in West Africa (in the “z” time zone) have seen the same solar flare according to his local time?

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- 3) What time in Universal Time (UT) did the solar flare occur?
- 4) Would an astronomer with a solar telescope in Central Australia have seen the flare? How about an astronomer in Alaska?
- 5) Suppose a solar flare happened at 10:31 UT. What time would the event have happened in California according to Pacific Standard Time?
- 6) A satellite registers a major solar explosion that lasts from 15:15 to 16:26 UT. A solar scientist monitoring the satellite data decided to go grab a cup of coffee between 7:00 AM and 7:45 AM Pacific Standard Time.
 - a) How long did the explosion last?
 - b) Did the scientist know about the flare before he left for coffee?
 - c) How much of the flare event did the scientist get to see in the satellite data as it happened?
 - d) Should the scientist have gone for coffee?

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The Aurora: October 29-30th, 2003

In this exercise, you will examine a number of aurora photographs taken around the world by amateur photographers on October 29th and 30th, 2003. These observers were located at a number of different locations and latitudes. We will use photographs assembled from the photographs at the October, 2003 spaceweather.com aurora gallery and located at: http://ds9.ssl.berkeley.edu/themis/gallery_auroras.html

We will be studying the major “Great Aurora” that was viewed on October 29-30, 2003.

1. Create a table with 15 rows, and four columns.
2. Label the columns as follows: location, latitude, description, substorm phase.
3. Visit the above website and fill in the information in Columns 1 (location) and 3 (description) from the information provided in each picture’s caption. For example, in Row 1, use the aurora photographed by Lionel Bernardi. In Column 1, enter “Tromsø, Norway.” In Column 3 enter a description of the aurora, including color. Use the standard terms described in the photo gallery provided by your teacher. For example, this first row aurora could be described as “purple, white, and yellow corona.”
4. From your descriptions in Column 3, assume the aurora was part of an auroral substorm and estimate the phase of the auroral substorm. Write this in Column 4 (substorm phase) using the descriptions provided by your teacher (quiet, growth, expansion, recovery phases). For example, Row 1 would be an expansion phase aurora.
5. When you are finished with the web gallery for pictures taken on October 29 and October 30, in Column 2 enter the latitudes of the locations given in Column 1 by using a map. Or, use a web page that gives the latitudes for a given location. Latitude degrees need only be integers, not decimals. For example, instead of writing “35.47 degrees” just round it to “35 degrees.” For this first aurora in Row 1, you would write 69 degrees since Tromsø, Norway is located at 69 degrees.
6. When complete, answer the following questions:

Question 1 – Geographically, for which latitudes were the most diffuse aurora seen by observers?

Question 2 – What was the lowest latitude from which observers reported aurora?

Question 3 – What was the lowest latitude from which expansion-phase aurora were seen?

Question 4 – What were the most common expansion phase features that were seen?

Question 5 – Where would you have to live in the USA to see expansion phase features?

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Aurora of 1859

On August 28, 1859, people all over Earth saw spectacular aurora (Northern and Southern Lights.) It was reported in all the major newspapers, poems were written about it, and famous artists painted its shapes and forms. It also caused severe problems with telegraph networks at the time, which lasted for many hours worldwide. Although scientists gave detailed reports of the changing forms of this vivid display, many ordinary citizens offered their own impressions of this event too. Two of these descriptions, as seen from two different locations, are written below. Read these descriptions and respond to the following questions and instructions.

Galveston, Texas:

“August 28 as early as twilight closed, the northern sky was reddish, and at times lighter than other portions of the heavens. At 7:30 PM a few streamers showed themselves. Soon the whole sky from Ursa Major to the zodiac in the east was occupied by the streams or spiral columns that rose from the horizon. Spread over the same extent was an exquisite roseate tint which faded and returned. Stately columns of light reaching up about 45 degrees above the horizon moved westward. There were frequent flashes of lightning along the whole extent of the aurora. At 9:00 PM the whole of the streaking had faded leaving only a sort of twilight over the northern sky.”

London, England.

“At 0:15 AM on August 28th the auroral light in the north assumed the form of a luminous arch, similar to daybreak, and in the southwest there was an intense glare of red covering a very large extent of the sky. At 00:20 AM streamers appeared; at 00:25 AM the streamers rose to the zenith and were tinged with crimson at their summits. At 00:45 AM frequent coruscations appeared in the aurora. At 01:20 AM the arch which had partially faded began to reform and the body of the light was very strong but not bright enough to read newspaper print. At 1:30 AM the light had begun to fade. By 2:00 AM the aurora was very indistinct.”

When organizing observations from different places around the world, a common problem scientists face is that observers tend to note when things happened by their local time. Scientists simplify these accounts by converting them into Universal Time, which is the local time in Greenwich, England, also called Greenwich Mean Time (GMT). To make time calculations easier, UT is expressed in the 24-hour clock format —so that 11:00 AM is written as 11:00 UT— but times after noon such as 1:00 PM are written as 13:00 UT. 10:00 PM is written as 22:00 UT. Since London is very close to Greenwich, the times mentioned in the London account above are already in Universal Time and only need to be converted to the 24-hour format. For Galveston, Texas, the time is 5 hours behind UT so to get the equivalent UT for Galveston, first convert the Galveston times to the 24-hour format, then add 5 hours. See Activity 11 for more details.

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Aurora of 1859

QUESTIONS AND INSTRUCTIONS:

Write your responses to each of these questions and instructions in your lab book.

- 1) From the two descriptions, extract the time and description of specific events in each narrative. Write these down, including the given times converted to Universal Time. Note the stories' similarities.
- 2) From the sequences of events in each description, create a storyline for the aurora display that fits the most details. Draw pictures to help illustrate the storyline.
- 3) Rewrite the timeline using the auroral substorm phases. Would you call this an auroral substorm?
- 4) Describe your ideas for why the aurora was observed to reach closer to zenith (directly overhead) in London than in Galveston?
- 5) Telegraphs work in general by using long wires and electromagnetic devices at each end. At one end, the telegraph operator sends an electrical current through wires that causes a magnetic needle to move at the receiving end and then a device measuring the change in the magnetic field (magnetometer) indicates how much current was sent from the sender. Based on the fact that telegraph networks were disturbed during this time of spectacular auroras, describe how your hypothesis about what causes aurora is validated or needs to be changed.
- 6) If you have not done so already, also think and write about where the energy to make such unusually brilliant and far-reaching auroras might come from.

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The Magnetosphere

The goal of this activity is for you to become familiar with the main terms that scientists use to discuss Earth's magnetic field. Review the information at the following website, which contains discoveries made by the IMAGE satellite, and the definitions for magnetospheric terms:

<http://image.gsfc.nasa.gov/poetry/IMAGEdisc.html>

Start a lab book. In your lab book, provide definitions to the following terms, and locate them on the accompanying figure. You will be referring back to the entries in this book as your main source of basic information in the weeks to come.

Magnetosphere

Bow Shock

Magnetopause

Magnetotail

Polar Cusp

Plasma Sheet

Auroral Oval

Ring Current

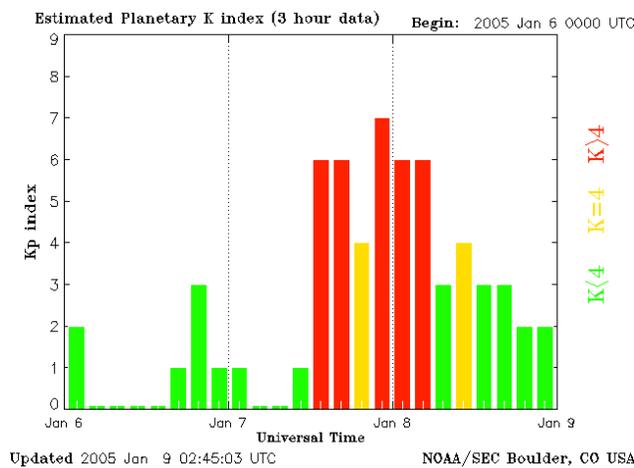
Solar Wind

Inquiry Problem - Pick one of the terms and write a short essay in your own words about why scientists are trying to learn about it.

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Magnetic Storms

Below is a plot of the Kp index for a storm obtained from the NOAA data archive and put on the following website: http://ds9.ssl.berkeley.edu/themis/classroom_kp2005.html Scientists use the Kp index to identify the strength of magnetic storms. The bar graph shows the Kp index from January 6, 7, and 8, 2005. On January 7th, there was a strong magnetic storm with Kp=7. In this activity, you will examine similar plots from an on-line data archive and determine how common it is to find storms at various levels of the Kp index, beginning January 1, 2005. **See the example below for an explanation for how to tally.**



From the Kp website above, tally **the maximum Kp reached each day**. This will give you the number of days that magnetic storminess reached the following levels during 90 days:

- Calm Conditions: Kp = 4
- Minor storm conditions: Kp = 5
- Moderate storm conditions: Kp = 6
- Strong storm conditions: Kp = 7
- Severe storm conditions: Kp = 8
- Extreme storm conditions: Kp = 9

Example: The plot shows one bar for every 3-hour interval starting at midnight on January 6. There are 8 bars for each day. The tally for the above plot would indicate for January 6, no counts. For January 7, one count for Kp=7, and for January 8, one count for Kp=6.

Kp Index	Number of days in January	Number of days in February	Number of days in March
9			
8			
7			
6			
5			
4			

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Magnetic Storms

Question 1: From your 90-day sample, what percentage of days had either Severe or Extreme magnetic storm conditions?

Question 2: From your answer to Question 1, what is the chance (in percent) that your magnetometer will see at least a moderate magnetic storm tomorrow?

Question 3: What percentage of days are considered “stormy” during this period?

Inquiry Problem - 2005 was near sunspot minimum.

1. Find a year of sunspot maximum.
2. Repeat your tabulations of stormy days in a new chart, using the data from <http://www.sec.noaa.gov/ftplib/warehouse>.
3. Compare your answers during sunspot maximum and sunspot minimum.