Latitude, Longitude, and Time

Session Time: Two, 50-minute sessions

DESIRED RESULTS

ESSENTIAL UNDERSTANDINGS

Comprehensive preflight planning is an integral (and regulatory) component of safety for all flights.

A wide range of resources is required when planning a flight.

Planning a safe and successful flight involves compliance with applicable Federal Aviation Regulations and guidance from the Aeronautical Information Manual.

ESSENTIAL QUESTIONS

1. How are latitude and longitude used to name precise locations?
2. Why is Coordinated Universal Time important to aviation?

LEARNING GOALS

Students Will Know

- How to specify a location using latitude and longitude.
- How to locate a position given latitude and longitude.
- How to determine local time when given Coordinated Universal Time (UTC).
- How to determine UTC when given local time.

Students Will Be Able To

- *State* position using latitude and longitude. [DOK-L1]
- *Show* the location of an object identified in the Aeronautical Chart Bulletin on a sectional chart. [DOK-L2]
- *Calculate* local time and Coordinated Universal Time. [DOK-L1]

ASSESSMENT EVIDENCE

Warm-up
Using the Memphis Sectional Chart found on SkyVector.com, students will work in groups of two to identify the airports or terrain features corresponding to four sets of latitude and longitude coordinates. Students will be asked to identify the class of airspace associated with one of those sets of coordinates.

Formative Assessment
Students will complete a quick-check quiz to review what they have learned about latitude and longitude.

Summative Assessment
Students will answer questions that require them to find latitude and longitude coordinates and convert between local and coordinated universal time.

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LESSON PREPARATION

MATERIALS/RESOURCES

- Latitude, Longitude, and Time Presentation
- Latitude, Longitude, and Time Student Activity 1
- Latitude, Longitude, and Time Student Activity 2
- Latitude, Longitude, and Time Student Activity 3
- Latitude, Longitude, and Time Student Activity 4
- Latitude, Longitude, and Time Teacher Notes 1
- Latitude, Longitude, and Time Teacher Notes 2
- Latitude, Longitude, and Time Teacher Notes 3
- Latitude, Longitude, and Time Teacher Notes 4

LESSON SUMMARY

Lesson 1: Advanced Aeronautical Charts
Lesson 2: Latitude, Longitude, and Time

The lesson will start with a short warm-up exercise in which students will be asked to locate airports and terrain features that correspond to given latitude and longitude coordinates. Students will then be instructed on how to interpolate locations that fall between minute marks on the sectional chart. The different methods that SkyVector and the FAA have of writing latitude and longitude will also be discussed. Various teaching tips will be included to alert the teachers to the "hidden" functions of SkyVector. A brief review of Lesson 1 of this unit will remind students of the definitions of *latitude*, *longitude*, *equator*, *prime meridian*, and other terms and concepts associated with global location identification. The first part of the lesson will end with a brief Formative Assessment, which will allow students to demonstrate what they have learned so far in this lesson.

During the next part of the lesson, the concept of distance as related to latitude and longitude will be introduced, and miles will be equated to degrees, minutes, and seconds. The importance of understanding the latitude-longitude system will be emphasized, and students will be encouraged not to depend entirely on electronic devices and GPS for location information.
Students will be instructed on how to find a location on a sectional chart given that location's coordinates.

The lesson will continue with instruction on time zones and how, in most parts of the world, it is later in the eastern zones than in the western zones. A demonstration of this concept can be done using a darkened room, a globe, and a flashlight. The 24-hour clock system will be introduced, and Zulu time will be explained and demonstrated, with students answering in-class questions covering the material. An activity will then follow, with students solving a few problems involving latitude and longitude.

Finally, students will answer a series of exam questions taken from the FAA Private Pilot Knowledge Exam and complete a Summative Assessment.

BACKGROUND

The first attempts to develop a system of global positioning based on a surface grid were undertaken by the Greeks in the centuries before the common era. By 600 BCE, the Phoenicians were using basic latitude calculations to determine their north/south positions. The development of a reliable longitude system, however, required accurate timepieces (clocks), and so had to wait several more centuries. In 1761, the first successful voyage employing both latitude and longitude calculations was completed, an event that earned John Harrison, an amateur English clockmaker, a sizeable cash prize put up by the British Parliament and a place in world history.

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The coordinate system that grew out of these early developments enabled the identification of any point on the globe by listing a specific line of latitude (north or south) and another specific line of longitude (east or west). Where these lines cross intersect is the indicated location.

Lines of latitude and longitude are described in degrees, minutes, and seconds from a beginning reference point. For latitude, that reference point is the equator, an imaginary line running east and west that encircles the widest part of the globe: all lines of latitude are measured in degrees from 1 to 90, both north and south from the equator.

Lines of longitude are measured in degrees, minutes, and seconds from the Prime Meridian, an imaginary line that runs north and south from the poles through Greenwich, England. This is the zero-degree line of longitude: all longitudinal lines (meridians) are described in degrees, east and west, from this Prime Meridian.

All modern navigation, including GPS, is based on this system of coordinates. While pilots rarely use latitude and longitude directly these days, it is important that they understand the system as the basis for all electronic navigation.

MISCONCEPTIONS

GPS devices quickly locate airports, waypoints, obstructions, etc.; students may assume that this modern technology has nothing to do with the "old fashioned" system of latitude and longitude, but in fact all modern systems of navigation, including GPS, are based on the latitude-longitude system of coordinates.

Students may assume that locating places on an aeronautical chart is like using a road atlas. In fact, the grids used on road atlases are totally different from the system that pilots use. Road maps typically use a letter-number grid system to define a block within which a location can be found. Pilots need precision, so latitude and longitude are used to find objects on charts.

Students may assume that there is no need for pilots to know any time system other than local time. In fact, communication between pilots and ATC and other ground support is facilitated by referencing a universally agreed-upon time system known as Coordinated Universal Time, centered in Greenwich, England. (Note that the abbreviation for Coordinated Universal Time is UTC.)

DIFFERENTIATION

To ensure students have fluency with www.SkyVector.com, perform a demonstration of how to use the site and give students an opportunity to practice before beginning the warm-up activity.

To support student comprehension, have students create personal Quizlets with simple terminology or questions. Some terms may include meridian, parallel, equator, etc. Simple problems may include: "If it is currently 13:50 UTC in NYC, what UTC time is it in Seattle?" Students may engage in review activities with a partner using their Quizlets.

Allow students to engage in additional practice with latitude and longitude beginning with simple, whole number meridians and parallels and building to increasingly specific coordinates.

LEARNING PLAN

ENGAGE

Teacher Material: Latitude, Longitude, and Time Presentation

Session 1

Slides 1-3: Introduce the topic and learning objectives of the lesson.

Slide 4: Conduct the **Warm-Up**.

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Warm-Up

Working individually or in small groups, students will refer to the Memphis sectional chart on SkyVector.com and write down the answers the following questions:

1. What airport is closest to N34°43 W92°13'?
   Bill and Hillary Clinton National/Adams Field

2. What structure is closest to N35°0 W91°15'?
   Coffee Plant

3. What terrain feature is closest to N30°47 W92°0'?
   Greers Ferry Lake

4. What airport is closest to N33°38 W88°26'? (Bonus: What class airspace is this?)
   Columbus Air Force Base (Class C)

[DOK-L2; *apply*]

Teaching Tips

REMINDER: When using www.SkyVector.com, right-clicking ("secondary clicking") an aeronautical chart display allows a person to mark any point using latitude and longitude. A small pop-up appears to allow the user to select the nearest airport, navigation aid, intersection, or latitude/longitude coordinates for the exact point.

Also, SkyVector.com features a search window at the top left of the sectional or TAC chart view. Entering an airport identifier in that window will center that airport on the page, making it easier to find.

Recall that TAC charts are larger in scale so show greater detail for any area. Estimating seconds in determining coordinates may be better done using TAC charts.

The FAA's VFR Raster Charts website (https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/) allows anyone to download, for free, the most current sectional charts. One sectional chart file is large, so students should be patient if downloading a chart. These sectional charts do not have the functionality of the SkyVector charts; however, the FAA digital charts are a very high resolution, so students can zoom in to see details.

EXPLORE

Teacher Materials: Latitude, Longitude, and Time Presentation, Latitude, Longitude, and Time Teacher Notes 1
Student Material: Latitude, Longitude, and Time Student Activity 1

Slide 5: Students will watch the video. This video will be a refresher on the basics of latitude and longitude, and will prepare students to respond to the questions in **Slide 6**.

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- “Latitude and Longitude” (Length 3:14)
  https://video.link/w/0AAw

For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=swKBi6hHHMA

Teaching Tips

Note that at 0:55 in the video, the distance between degrees of latitude is shown to be “69 miles.” Remind the students that this is statute miles. Since pilots use nautical miles, it should be emphasized that the approximate distance between degrees of latitude is 60 NM.

The method of writing a specific location using degrees, minutes, and seconds is shown at 2:34 with San Diego, California, as the example.

Slide 6: In the latitude-longitude system, Earth is divided into a grid, with lines running both horizontally and vertically. The horizontal lines are called lines of latitude, and they provide location information relative to the equator (also known as 0° latitude). All other latitudes are measured in degrees north or south of the equator: 90° north latitude is the North Pole, and 90° south latitude is the South Pole. All other latitudes fall between 0° and 90° and are measured in degrees, minutes, and seconds. The alternative decimal system measures seconds as hundredths of a minute, and it is used by SkyVector, Google Maps, and aircraft GPS systems.

Latitude lines are called *parallels* because they remain parallel to each other from north to south, unlike longitude lines, which curve together toward the poles.

Slide 7: Lines of longitude run from the North Pole to the South Pole and define locations along east-west coordinates. The Prime Meridian runs through Greenwich, England, and defines the 0° longitude starting point from which all other lines of longitude are measured. This Prime Meridian also is the starting point for measuring Coordinated Universal Time (UTC), the time system used by aviation worldwide.

Like lines of latitude, longitude lines are measured in degrees, minutes, and seconds (or degrees and decimal minutes) beginning at 0° and proceeding both east and west around the globe. From 0° to 180° west longitude defines locations west of the Prime Meridian, and from 0° to 180° east longitude defines locations east of the Prime Meridian.

Any point on the globe can be identified by its distance from the Prime Meridian and the equator: that is, its latitude and longitude. This latitude-longitude system has formed the basis for all navigation for centuries, including today’s methods that employ modern electronic and GPS technologies.

Teaching Tips

You may want to relate the coordinate grid from geometry to latitude and longitude. 0°N 0°W (or 0°S 0°E) would be equivalent to the origin of an x/y axis coordinate grid.

- East values for longitude and north values for latitude would be comparable to quadrant 1.
- West values for longitude and north values for latitude would be comparable to quadrant 2.
- West values for longitude and south values for latitude would be comparable to quadrant 3.
- East values for longitude and south values for latitude would be comparable to quadrant 4.

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Some cartographers use positive and negative values for latitude and longitude to indicate east (+), north (+), west (-), and south (-).

Slide 8: This **EXPLORE** activity is an opportunity for students to use SkyVector, the Sporty's Sectional Training Chart, or an online version of the FAA sectional chart (https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/) to find the latitude and longitude coordinates for two airports and a navigation facility known as a VOR.

The expectation is that students will use the lines of longitude and latitude on the charts to determine the positions of the facilities. This likely will result in whole-number minutes in the coordinates. This activity should open a discussion about how positions are determined more precisely: with either degrees, minutes, and seconds or degrees and decimal minutes.

Teaching Tips

To roughly locate the facilities in the activity, students may use the search window in SkyVector to locate the facility (airport or VOR, as appropriate), then use the Sporty's Sectional Training Chart or a digital chart to determine the latitude and longitude coordinates.

Be prepared to remind the students about the Chart Supplement (introduced last semester) as a source of airport and facility data. Follow this link to the FAA's Chart Supplement page: https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dafd/

For this activity, you will select the CS SE (Chart Supplement Southeast U.S.) and CS SC (Chart Supplement South Central U.S.)

Questions

What are the coordinates at Memphis International Airport (KMEM)?

Students may answer with whole minutes: N35º03´ W89º59´
Actual coordinates: N35º02.54´ W89º58.60´
Chart Supplement Southeast U.S., page 404
Link to Chart Supplement Southeast U.S.: https://aeronav.faa.gov/Upload_313-d/supplements/CS_SE_20191205.pdf
You will have to scroll to page 404.

What are the coordinates at Carlisle Airport (4M3)?

Students may answer with whole minutes: N34º48´ W91º43´
Actual coordinates: N34º48.49´ W91º42.73´
Chart Supplement South Central U.S., page 36
Link to Chart Supplement South Central U.S.: https://aeronav.faa.gov/Upload_313-d/supplements/CS_SC_20191205.pdf
You will have to scroll to page 36.

What are the coordinates for the Gilmore VOR (GQE)?

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Students may answer with whole minutes: N35º21´ W90º29´
Actual coordinates: N35º20.82´ W90º28.69´
Chart Supplement South Central U.S., page 48
Link to Chart Supplement South Central U.S.: https://aeronav.faa.gov/Upload_313-d/supplements/CS_SC_20191205.pdf
You will have to scroll to page 48.

How do we account for these decimals in the Chart Supplement?

Students may answer that the facilities do not exactly line up with minutes of longitude and latitude, so the decimal amounts represent more accurate position information.

Slide 9: This slide allows you to review the answers to the questions on Slide 8 with the students. The coordinates are all copied from the Chart Supplements.

EXPLAIN

Teacher Material: Latitude, Longitude, and Time Presentation

Slide 10: There are two ways of expressing latitude/longitude coordinates. The first, and oldest, method utilizes degrees, minutes, and seconds. This is called the DMS system. There are 60 minutes in every degree and 60 seconds in every minute. By using this method, any location on Earth can be identified to an accuracy of about 100 feet.

The other method also uses degrees and minutes, but it uses decimal values of minutes instead of seconds. Since there are 100 increments between minutes in this method (rather than the 60 seconds between minutes in the DMS system), it can identify locations with considerably more accuracy.

In our North latitude examples on the slide, note that 15 seconds is 25% of a minute, so the seconds placeholder in the traditional method is written 15, while the decimal example is expressed as .25 (or 25% of a minute). In the Westerly portion of the sample coordinates, 45 seconds is 75% of a minute. The traditional depiction shows as 45 of longitude, while the decimal equivalent is expressed as .75 (75% of a minute).

SkyVector and other map and chart developers have adopted the decimal method as the preferred way to express latitude-longitude coordinates. Both systems work fine in most cases, but the decimal values allow for greater accuracy.

Slide 11: Lead a detailed discussion about how to convert between the two systems. On sectional charts, the finest detail on the lines that form the quadrangles is in minutes, so users are left on their own to try to estimate seconds between the minute marks. On the other hand, if the SkyVector sectional charts are used, right clicking on any location on a chart will bring up a window that displays that location in degrees and decimal minutes. It is a fairly simple process to convert those tenths or hundredths of minutes to seconds, and vice versa:

- To convert to decimal from DMS: Divide the seconds by 60: i.e., seconds/60 = decimal value

Example: The seconds listed in the coordinates is 42. 42/60 = .70. Stated in decimals, the seconds would be displayed as .70 after the minutes.

- To convert to DMS (degrees. minutes, seconds) from decimal: Multiply the decimal number by 60: i.e., decimal 60 = DMS

Example: The decimal value stated in the coordinates is .45. .45 x 60 = 27 seconds. Stated in DMS, the seconds would be listed as 27 after the minutes.

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Slide 12: Students will complete **Latitude, Longitude, and Time Student Activity 1**. Sample answers are located in **Latitude, Longitude, and Time Teacher Notes 1**.

Teaching Tips

Remind students of the meaning of the symbols found in lat/long coordinates:

° = degrees
= minutes

= seconds

.xx = hundredths of minutes (optional method of citing seconds)

Also note that some cartographers put the N and W (north and west) designators at the beginning of a statement of coordinates, and some put them at the end.

- Example: N34°35.43 W92°28.77, vs 34°35.43'N 92°28.77W

Both formats are correct.

SkyVector tip to obtain the correct coordinates for an airport.

1. Right-click the airport to see a Location Information box appear.
2. Click the link next to the small airport symbol at the top of the list in the pop-up box.
3. A new page will appear with the airport's identifier and name at the top. The latitude and longitude will be listed near the top as well.

Slide 13: What do pilots do when the location on the chart falls between minute marks of latitude or longitude? Since the sectional chart quadrangles are marked in degrees and minutes, the pilot is left to estimate the seconds between the minute marks. Recall that there are 60 seconds between each minute mark, so it can be quite challenging to estimate the location down to the second on a sectional chart. Terminal Area Charts, available for airspace surrounding large airports, are scaled to twice the size of sectional charts, so a better estimate of DMS can be attained using TACs rather than sectionals.

The best way to attain truly accurate coordinates for any point on a chart is to use SkyVector or a similar service that provides pinpoint latitude and longitude data for any location. Frequently, digital maps use a form of right-clicking on any point to display a window featuring the coordinates for that location in decimal format.

Recall that degrees of longitude get larger the farther west one goes on the chart, such that locations to the left are described with larger coordinate values than locations on the right.

Questions

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Where is 74°0015W compared to 74°0045W?
The first point is slightly east of the second.

Teaching Tips

SkyVector features interactive sectional and TAC charts for all areas of the United States. Using a chart from your local area may engage students better than the example Memphis chart used in this lesson. Of course, teachers would have to adapt the Activities and other exercises to accommodate the local airports and terrain features.

Slides 14-23: Students will complete the Formative Assessment. As a class, present each slide and ask students to vote on their preferred answer; then, click to the next slide to reveal the answer.

Formative Assessment

Students will answer the following questions as a classroom discussion.

Slides 14-15: In which directions do lines of latitude run?

1. North and south
2. *East and west*
3. Perpendicular through the equator

Slides 16-17: In which directions do lines of longitude run?

1. *North and south*
2. East and west
3. Diagonally through the Prime Meridian

Slides 18-19: Where is 0° latitude found?

1. *At the equator*
2. At the Prime Meridian
3. Through Greenwich, England

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Slides 20-21: What is the definition of the Prime Meridian?

1. The line of 0° latitude
2. *The line of 0° longitude*
3. The time system used by aviation worldwide

Slides 22-23: What is an advantage of the decimal system of latitude and longitude over the system that uses minutes to define location?

1. Decimals take up less space on a chart.
2. Decimals are the system used by aviation worldwide.
3. *Decimals allow for greater accuracy in pinpointing a location.*

[DOK-L1; *define, recall*]

Slide 24: Lines of latitude are separated by equal distances, since these lines are parallel and do not converge at the poles like longitude lines do. Each degree of latitude is approximately 60 nautical miles (NM) from the next degree of latitude.

Since there are 60 minutes in each degree, each minute represents approximately 1 NM of latitude.

Sixty seconds in each minute computes to each second being approximately 101 feet. By listing the seconds as decimals, the distances between lines can be decreased as needed to identify the location of even the smallest objects on the earth.

Slide 25: Lines of longitude work differently. The only location where lines of longitude are perfectly parallel is at the equator. At all other locations, longitude lines "bend" as they curve toward the poles from the equator eventually converging and joining at the geographical North and South Poles.

At the equator, one degree of longitude is approximately 60 NM (69 statute miles), one minute is roughly 1 nautical mile, and one second is about 101 feet (just as with latitude). Going north and south from the equator, however, this distance shrinks until, at the poles themselves, there is zero distance between lines of longitude.

Slide 26: The lines that make up the grids of latitude and longitude appear on sectional and TAC charts as thin black lines, running from top to bottom and left to right on the charts. These full-length lines appear as whole-degree marks; they also mark each whole-degree-plus-30-minute location. These lines are then subdivided into smaller units, depicted as short hash-marks between the lines of whole degrees. Small hash marks depict individual minutes, with slightly wider hash marks every 5 and 10.

Teaching Tips

On sectional charts, the whole-degree lines of longitude and latitude are labeled with their associated degrees; however, the 30-minute lines are not labeled. Students should note which line they are using when determining positions on charts with the printed lines.

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Slide 27: When horizontal parallels join with vertical meridians to form rectangles on a chart, that rectangle is known as a quadrangle. Quadrangles are formed every 30 (half degree) of latitude and longitude. On TAC charts, these quadrangles are formed every 15 of lat/long (i.e., each side of the quadrangle is 15 long).

Printed inside each quadrangle on the chart is a Maximum Elevation Figure (MEF), depicting the highest elevation within that quadrangle, plus a safety buffer.

Slide 28: In this age of electronic navigation and GPS, students may question the usefulness of learning about a centuries-old system like latitude and longitude. The truth is that all modern navigation methods, including GPS, are based on latitude and longitude in one way or another. Pilots can use coordinates to identify user waypoints: that is, points on the chart not labeled but of interest to the pilot, such as their home, favorite fishing spot, or point of navigation for use in the future. Emergency services, like fire and police departments, use coordinates to search for and locate people in need of help.

Additionally, Aeronautical Chart Bulletin updates (found in Chart Supplements) often list changes to sectional, TAC, and area charts in terms of lat/long coordinates. Being able to identify the location of the listed changes is crucial for pilots to avoid inadvertent deviations from regulations and other errors. Chart Supplements, and their associated Aeronautical Chart Bulletins, are updated every 56 days.

Slide 29: Many aeronautical charts use latitude and longitude to identify landmarks and waypoints that either cannot be identified using any other system or that require sophisticated onboard GPS equipment. For example, when flying around the Grand Canyon, landmarks such as THE KEY, THE SQUARE, and TEN X MEADOW can only be identified using latitude and longitude coordinates. On the other hand, the GPS waypoint called ZUNI ALPHA (also identified as VPGCH) may be found in the database of most aircraft GPS receivers, but it can also be identified by its latitude and longitude coordinates.

Slide 30: Finding the location of any latitude and longitude coordinates on a paper chart is a simple process. All you need is a straight edge, like a ruler or a plotter, and a pen or pencil (pencil is better, since it can be erased later).

Note the coordinates defining the location you're looking for. Now, draw a horizontal line along the line of latitude specified in the coordinates. Next, draw a vertical line along the line of longitude stated in the coordinates. Where these two lines cross (intersect) is the location specified by the coordinates.

Session 2

Slides 31-32: Not all locations in the world, or even in the United States, are on the same time. For instance, when it is noon in San Francisco, it is 3:00 PM in New York and 4:00 AM the following day in Beijing. The reason for this is simple: as Earth rotates on its axis, the sun is overhead in different locations at different times; thus, when it is morning in one place, it is afternoon in another and evening in a third.

As illustrated in the image on Slide 31, there are six time zones in the United States: from east to west they are 1) Eastern 2) Central 3) Mountain 4) Pacific 5) Alaska 6) Hawaii-Aleutian. The first four time zones cover the 48 adjoining states (also known as the conterminous states), the Alaska time zone covers most of the state of Alaska, and the Hawaii-Aleutian time zone covers the state of Hawaii as well as the nearby Aleutian Islands.

There is one hour of difference between each U.S. time zone. The Eastern time zone is typically five hours behind Coordinated Universal Time; the Central time zone is typically six hours behind UTC; and so on through the Hawaii-Aleutian time zone, which is typically ten hours behind UTC.

Why "typically"? From March through November in the United States, many states and locales adopt daylight savings time (DST), which moves the clock forward one hour in March, then back an hour to resume standard time in November. This happens to allow for more daylight following normal working and school hours. During the summer, for example, the sun may set at 7 PM standard time, but by moving the clock ahead to 8 PM DST, we get an extra hour of

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sunlight. (On the other hand, the sun also rises an hour later, but this effect is less noticeable during the summer months, when the days are longer overall.)

Each time zone covers approximately 15° of longitude, but there are exceptions. Time zones are not divided by neat lines of longitude; they resulted from agreements between states and regions. Some regions, states, even nations, may not subscribe to time zones at all. Mainland China, for instance, has one giant time zone for the entire country.

Slide 33: This video explains in greater detail why time is different in different places:

- "Time Zones" (Length 5:19)
  https://video.link/w/TPgx

For teachers unable to access Safe YouTube links, the video is also available here: https://www.youtube.com/watch?v=kTht_MxbUx4

Basically, Earth rotates west to east at the rate of about 15° per hour, so the sun strikes the eastern part of the country (e.g., New York or Boston) before it lights up the western parts of the country (e.g., San Francisco or Los Angeles). In fact, the sun illuminates San Francisco approximately three hours after it illuminates New York; as a result, New Yorkers experience a particular time three hours before San Franciscans—it is three hours later in New York than in San Francisco.

This principle can also be demonstrated with a globe, a flashlight, and a dimly lit room. The flashlight will simulate the sun:

1. Shine the flashlight so that it illuminates half of the globe.
2. Slowly rotate the globe counterclockwise (looking down on the North Pole from above) until the illuminated area just touches New York.
3. Note that San Francisco is still in the dark.
4. Continue to rotate and note how new areas are illuminated over time.

Slide 34: Aviation, as well as the military and some businesses, use a 24-hour clock instead of the more common AM /PM system. With the 24-hour clock, the time is simply stated as the number of hours and minutes past midnight. Under this system, if somebody says, "I'll meet you at 6," you don't have to wonder if they mean 6 AM or 6 PM; they mean 6 AM. (To remove all ambiguity, they might say, "I'll meet you a oh-six-hundred" imagining the time to look like 0600.) On the 24-hour clock, 6 PM is represented as 1800: 18 hours past midnight. The slide provides further examples for students.

The purpose of the 24-hour clock system is to remove all ambiguity, but it also serves as the basis for another time system that is used worldwide by aviation and other transportation industries, among others. After all, what if you were meeting a friend at the airport and she said, "pick me up at 0700." Does she mean 0700 New York time (where she came from), or 0700 Los Angeles time (where you are)? It's easy to see that, while the 24-hour clock standardize things a little better, there is still room for confusion, especially if you are communicating across time zones.

Slide 35: To eliminate all ambiguity and possible misunderstandings concerning time and time zones, the concept of a universal time zone, based on a 24-hour clock and a standard location, was developed. A team of map scientists working in the 19th century agreed that Greenwich, England (on the 0° longitude line) would be the location of this new, universal time zone. Whatever time it is in Greenwich is the time it will be worldwide. This time zone is Coordinated Universal Time (UTC) but may also be called Zulu or Greenwich Mean Time (GMT). In aviation Zulu is often used as is UTC. GMT has come to be classified as its own time zone. The military typically uses the term Zulu time to represent the time at 0° longitude.

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The table on this slide shows how to calculate standard and daylight savings time in the four conterminous U.S. time zones by adding a certain number of hours to Greenwich Mean Time.

Teaching Tips

If English-speakers refer to Coordinated Universal Time, why is the acronym "UTC"? Remind students that UTC is intended for all people, not only English speakers; in France, for example, the term is *temps universel coordonné*. Rather than have English speakers refer to "CUT," French speakers refer to "TUC," and so forth, people agreed to adopt the same acronym in all languages: "UTC."

Zulu and UTC may be used interchangeably.

Slide 36: To determine your time in the UTC system, follow these steps:

1. Determine your time zone.
2. Determine your local time in the standard AM/PM system.
3. Convert your local time to the 24-hour clock.
4. Add the offset: the appropriate number of hours, depending on your time zone, to Greenwich Mean Time (GMT). Remember to account for daylight savings time, if applicable!

For example, in the Pacific time zone, the offset for standard time is 8 hours. If the local time is 2 PM standard time, first convert to the 24-hour clock: 2 PM converts to 1400 (14 hours after midnight). Then, add the 8-hour offset. (It helps to think of each hour as another hundred.) The local time is 2200 Zulu, or 2200Z.

Slide 37: Because it's standardized worldwide, and because airplanes fly between time zones quite frequently, Zulu time is used a lot in aviation. For instance, all weather reports and forecasts (METARs, TAFs, graphical forecasts, etc.) state issuance and effective times in Zulu time. When pilots file flight plans, they list their departure and arrival times in terms of Zulu time. Likewise, all recorded weather products, like ATIS and AWOS broadcasts, always state their effective times in Zulu. Zulu is standardized time, so when a forecast calls for thunderstorms, for example, at 2300Z, there is no ambiguity as to time zone, because 2300 Zulu is universal and the same worldwide.

Questions

Have students discuss the following scenario in pairs, then discuss the correct answer as a class: An airplane departs an airport at 10 AM CST (Central Standard Time) and lands 2 hours later at an airport in the Pacific time zone. What time does the airplane land in Zulu time?

The departure time of 10 AM CST is 1600 Zulu (1000 + 0600)= 1600 Zulu. (Note that this is because of a 6-hour Zulu offset.)

Landing 2 hours later would make the destination time 1800 Zulu.

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In this example, it is not necessary to convert between time zones because Zulu is the universal time zone. All we need to solve this problem is the Zulu time at the departure airport and the duration of the flight: 1600Z departure time + 2-hour flight = 1800Z at destination.

EXTEND

Teacher Materials: Latitude, Longitude, and Time Presentation, Latitude, Longitude, and Time Teacher Notes 2
Student Material: Latitude, Longitude, and Time Student Activity 2

Slide 38: Provide students with **Latitude, Longitude, and Time Student Activity 2**, which applies many of the principles and time conversions covered in this lesson. Students will be asked to log into a travel reservation website (such as www.expedia.com), determine specific departure and arrival times for specified routes, determine flight durations, and convert those times to Zulu time. This exercise will reinforce student understanding of time zones (both international and within the United States), as well as encourage students to understand the benefits and simplicity of using Zulu time when traveling across multiple time zones. It would be beneficial to write the various conversions and scenario solutions on the board to better reinforce the steps needed to determine each time conversion. Suggested answers can be found in **Latitude, Longitude, and Time Teacher Notes 2**.

EVALUATE

Teacher Materials: Latitude, Longitude, and Time Presentation, Latitude, Longitude, and Time Teacher Notes 3
Student Material: Latitude, Longitude, and Time Student Activity 3

Slide 39-58: The following slides contain sample test questions taken from the FAA Private Pilot Knowledge Exam. These questions mimic what is on the test, so they provide an excellent way to study for the actual test.

Slide 59: Conduct the **Summative Assessment**.

Summative Assessment

Students will complete a brief assessment of the knowledge presented in this lesson. Provide students with **Latitude, Longitude, and Time Student Activity 3**. Sample answers are in **Latitude, Longitude, and Time Teacher Notes 3**.

[DOK-L2; *apply*]

Summative Assessment Scoring Rubric

- Follows assignment instructions
- Responses show evidence of one or more of the following as appropriate:
    - Knowledge of basic concepts involved in the latitude/longitude coordinate system
    - Ability to read and understand coordinate markings on a sectional or TAC chart
    - Ability to locate objects on a chart when given the coordinates
    - Understanding of the concept of time zones, including UTC
    - Ability to determine UTC by applying time offsets to local time zones

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- Contributions show understanding of the concepts covered in the lesson
- Contributions show in-depth thinking including analysis or synthesis of lesson objectives

Points	Performance Levels
9-10	The student shows strong objective understanding; Answers all the questions correctly.
7-8	The student shows sufficient objective understanding; Answers 4 questions correctly.
5-6	The student shows a struggle with objective understanding; Answers 3 questions correctly.
0-4	The student shows a lack of objective understanding; Answers 2 or fewer questions correctly.

GOING FURTHER

Teacher Materials: Latitude, Longitude, and Time Presentation, Latitude, Longitude, and Time Teacher Notes 4
Student Material: Latitude, Longitude, and Time Student Activity 4

Slide 60: Present **Latitude, Longitude, and Time Student Activity 4**. This activity will enable students to demonstrate the depth of their knowledge about latitude and longitude, and sectional chart symbols. Students will apply their understanding of SkyVector and their ability to locate objects given latitude-longitude coordinates. The Going Further section asks students to express their opinion about the various navigation methods they've learned about so far, and to consider the pros and cons of each navigation system, including potential vulnerabilities. Sample answers are located in **Latitude, Longitude, and Time Teacher Notes 4**.

STANDARDS ALIGNMENT

COMMON CORE STATE STANDARDS

- **RST.11-12.2** - Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- **RST.11-12.4** - Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 11-12 texts and topics*.
- **WHST.11-12.6** - Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.
- **WHST.11-12.8** - Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.
- **WHST.11-12.9** - Draw evidence from informational texts to support analysis, reflection, and research

FAA AIRMAN CERTIFICATION STANDARDS

PRIVATE PILOT

I. Preflight Preparation

Task D. Cross-Country Flight Planning

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- Knowledge - The applicant demonstrates understanding of:
    - **PA.I.D.K3b** Estimated time of arrival to include conversion to universal coordinated time (UTC)

VI. Navigation

Task B. Navigation Systems and Radar Services

- Knowledge - The applicant demonstrates understanding of:
    - **PA.VI.B.K1** Ground-based navigation (orientation, course determination, equipment, tests, and regulations).
    - **PA.VI.B.K2** Satellite-based navigation (e.g., equipment, regulations, database considerations, and limitations of satellite navigation).
- Skills - The applicant demonstrates the ability to:
    - **PA.VI.B.S1** Use an airborne electronic navigation system.
    - **PA.VI.B.S2** Determine the airplane's position using the navigation system.
    - **PA.VI.B.S5** Recognize signal loss or interference and take appropriate action, if applicable.

Task C. Diversion

- Skills - The applicant demonstrates the ability to:
    - **PA.VI.C.S5** Utilize flight deck displays of digital weather and aeronautical information, as applicable.

REFERENCES

https://www.britannica.com/science/latitude
https://www-istp.gsfc.nasa.gov/stargaze/Slatlong.htm
FAA Pilot's Handbook of Aeronautical Knowledge, pp16-3 through 16-6
https://www.timetemperature.com/tzus/time_zone.shtml

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